1045
Y4.P96/10:94-2/pt.2

TENNESSEE VALLEY AUTHORITY OVERSIGHT HEARINGS

DOCUMENTS
NI 975
T... KANSAS ...RY ...IVERSITY
A11600 7542b4

HEARINGS

BEFORE THE

...MITTEE ON PUBLIC WORKS
...NITED STATES SENATE

NINETY-FOURTH CONGRESS

FIRST SESSION

MAY 8 AND 12, 1975

SERIAL NO. 94-H12

PART 2

Printed for the use of the Committee on Public Works

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

TENNESSEE VALLEY AUTHORITY OVERSIGHT HEARINGS

HEARINGS

BEFORE THE

COMMITTEE ON PUBLIC WORKS

UNITED STATES SENATE

NINETY-FOURTH CONGRESS

FIRST SESSION

MAY 8 AND 12, 1975

SERIAL NO. 94-H12

PART 2

Printed for the use of the Committee on Public Works



U.S. GOVERNMENT PRINTING OFFICE

54-380 O WASHINGTON : 1975

COMMITTEE ON PUBLIC WORKS

JENNINGS RANDOLPH, West Virginia, *Chairman*

EDMUND S. MUSKIE, Maine
JOSEPH M. MONTOYA, New Mexico
MIKE GRAVEL, Alaska
LLOYD M. BENTSEN, Texas
QUENTIN N. BURDICK, North Dakota
JOHN C. CULVER, Iowa
ROBERT MORGAN, North Carolina
GARY HART, Colorado

HOWARD H. BAKER, JR., Tennessee
JAMES L. BUCKLEY, New York
ROBERT T. STAFFORD, Vermont
JAMES A. McCLURE, Idaho
PETE V. DOMENICI, New Mexico

M. BARRY MEYER, *Chief Counsel and Chief Clerk*
BAILEY GUARD, *Minority Staff Director*
LEON G. BILLINGS and RICHARD D. GRUNDY, *Senior Professional Staff Members*
RICHARD A. HELLMAN, *Minority Counsel*
JOHN W. YAGO, JR., *Assistant Chief Clerk*; PHILIP T. CUMMINGS, *Assistant Chief Counsel*
HAROLD H. BRAYMAN, *Senior Professional Staff Member* (Minority)

Professional and research staff: KARL R. BRAITHWAITE, JAMES W. CASE (*Assistant Counsel*), PAUL CHIMES, TRENTON CROW, KATHERINE Y. CUDLIPP, PAUL F. EBELTOFT, JR., GEORGE F. FENTON, JR., RANDOLPH G. FLOOD, KATHALEEN R. E. FORCUM, ANN GARRABRANT, RICHARD T. GREER, RICHARD M. HARRIS (*Assistant Counsel*), WESLEY F. HAYDEN, RICHARD E. HEROD (*Assistant Counsel, Minority*), VERONICA A. HOLLAND, RONALD L. KATZ, JOHN D. KWAPISZ, MICHAEL MCFARLAND, LARRY D. MEYERS, JUDY F. PARENTE, JOHN B. PURINTON, JR., MARGARET E. SHANNON, CHARLENE A. STURBITTS, E. STEVENS SWAIN, JR., AND SALLY W. WALKER

CONTENTS

Baker, Hon. Howard H. Jr., U.S. Senator from the State of Tennessee, opening statement of ---- Page 1199

LIST OF WITNESSES

MAY 8, 1975

Carter, W. R., chairman, TVA Relationship Committee, Tennessee Construction Industry ---- 1097
Fordice, Kirk, chairman, Heavy Industries Division, Associated General Contractors; accompanied by Don Powelson, Tennessee Road Builders Association; Hugh Hammill, president, Road Builders, Inc.; and Bob Melton, State executive director, Associated Builders and Contractors ---- 1103
Prepared statement ---- 1107
Koch, Bradley R., director, Energy and Environmental Policy Department, National Rural Electric Cooperative Association ---- 1028
Prepared statement ---- 1032
Kurland, Norman, Washington counsel, Bangert & Co., Investment Bankers ---- 1039
Prepared statement ---- 1051
Merritt, J. W., president, Tennessee Valley Trades and Labor Council ---- 1116
Prepared statement ---- 1119
Radin, Alex, general manager, American Public Power Association, accompanied by Paul Ery, director of economics and research, American Public Power Association ---- 1002
Prepared statement ---- 1009
Schriber, George A., chairman and president of Public Service Co. of New Mexico; accompanied by Howard W. Phillips, in charge of corporate finance at Oppenheimer; Eugene W. Meyer, vice president and director of Kidder, Peabody ---- 987
Seeber, Lynn, general manager, TVA; Robert Betts, director of personnel; George Kimmons, manager of engineering design and construction; Robert Marquis, general counsel; and Herbert Sanger, deputy general counsel ---- 1077

May 12, 1975

Jenkins, William L., director, TVA ---- 1219
Wagner, Aubrey J., chairman; Don McBride, Director; William L. Jenkins, Director; and Lynn Seeber, General Manager, Tennessee Valley Authority Board of Directors ---- 1200

ADDITIONAL MATTER

"An Economic Analysis of Price Increases in the U.S. Coal Industry" ---- 1129
Appendix A, responses from TVA to additional written questions ---- 1271
Appendix B, letters and statements submitted for the record:
Ballal, Dr. S. K ---- 1367
Ross, Claybourne, executive secretary, Upper Duck River Development Association ---- 1375
Susman, Alan L., chairman, West Virginia, Senate Mines and Mining Committee ---- 1377
Wade, J. Robert, president, Kentucky Farm Bureau Federation ---- 1408
Appendix C, material referred to during the proceedings and supplied for the record ---- 1411

Page

National Electrical Contractors Association, statement of 1124
Kurland, Norman, Washington counsel, Bangert & Co., responses to written questions from Senator Baker 1068
Samuels, John S. III, chairman, Carbomin International Corp., letter to Senator Randolph relative to the testimony of George A. Schreiber 995
TVA, material supplied by:
Estimated capital cost per kilowatt for U.S. nuclear plants 1084
Hourly wage rates for carpenters and electricians 1080, 1081
Number of employees as of October 15, 1975 1092
Responses to written questions from Senator Baker 1095
The Tennessee Valley and the Energy Future: An overview 1205
Wages, prevailing rates paid on State of Tennessee projects, by county 1111

TENNESSEE VALLEY AUTHORITY OVERSIGHT HEARINGS

THURSDAY, MAY 8, 1975

U.S. SENATE,
COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The committee met at 10 a.m., pursuant to recess, in room 4200, Dirksen Senate Office Building, Hon. Howard H. Baker, Jr., presiding.

Present: Senators Baker and Domenici.

Senator BAKER. The committee will come to order.

We have today three groups of witnesses in our morning session panel, the American Public Power Association; the National Rural Electric Cooperative Association; Mr. George A. Schreiber, Utilities Group, Inc.; Bangert & Co., investment bankers, with a panel of two witnesses.

Senator DOMENICI. Mr. Chairman, I wonder if you would consider calling Mr. George A. Schreiber, Utilities Group, Inc., as the first witness. I don't think his testimony will be very long. I am not sure that if we don't do that that I would be here for his testimony because I have to be at budget conference at 11:30.

If it isn't too inconvenient for the other witnesses, I would ask the Chair if it would take Mr. Schreiber first.

Senator BAKER. I certainly understand and will be happy to do that to accommodate your schedule conflict, Senator Domenici. I hope there is no objection from the first panel. Thank you very much.

Mr. Schreiber, we are happy to have you. We look forward to receiving your statement. You have associates with you, and if you would introduce them for the record, we would appreciate it.

STATEMENT OF GEORGE A. SCHREIBER, CHAIRMAN AND PRESIDENT OF PUBLIC SERVICE CO. OF NEW MEXICO, ACCOMPANIED BY: HOWARD W. PHILLIPS, IN CHARGE OF CORPORATE FINANCE AT OPPENHEIMER; EUGENE W. MEYER, VICE PRESIDENT AND DIRECTOR OF KIDDER, PEABODY

Mr. SCHREIBER. Yes, sir, I will.

Good morning. Thank you very much. My name is George A. Schreiber. I am chairman and president of the Public Service Co. of New Mexico. Our company serves approximately 45 percent of the population of our State and is headquartered at Albuquerque.

Senator DOMENICI. Would you identify the two people with you?

Mr. SCHREIBER. I will do that in just a minute. I am appearing today on behalf of a consortium of private and public utilities known as "Utilities Group, Inc.," of which my company is a member.

Utilities Group has submitted a bid to purchase Peabody Coal Co. There are 13 utilities presently participating in Utilities Group, Inc., serving customers in 10 States. These 13 utilities have gross assets of over $3.5 billion and last year had net income after taxes of over $500 million.

It is a very strong and broadly based geographical group able both to purchase and operate Peabody for the good of a very large number of consumers of electricity. A list of members of Utilities Group is attached to my statement, and a more detailed description of each member is appended to our written statement which was delivered to the committee previously.

On behalf of the Utilities Group, I want to express our appreciation to the committee for this opportunity to express our views. I have divided my statement in two parts.

First, I will explain why Utilities Group wishes to acquire Peabody and why we believe it is in the national interest for us to be allowed to do so.

Second, I propose to look at the other side of the question and explain why we believe it is not in the national interest for the Tennessee Valley Authority to acquire control of Peabody, which is the largest producer and has more resources under its control than any other coal company in the United States.

I have intentionally omitted any references to the financial arrangements of the proposed acquisition because it is our understanding that these are matters more properly brought before the Federal Trade Commission rather than the Public Works Committee.

However, in anticipation of possible questions from the committee on these matters, I have asked our consultants to accompany me. I would like to introduce them at this time. We have retained the firms of Oppenheimer & Co., Inc., and Kidder, Peabody & Co., Inc., as financial consultants.

Mr. Howard W. Phillips is in charge of corporate finance at Oppenheimer, and Mr. Eugene W. Meyer is vice president and director of Kidder, Peabody. He is also director of the firm's utility corporate finance department.

At the conclusion of this testimony we will attempt to answer your questions.

Why is Utilities Group interested in acquiring Peabody Coal Co., and why do we believe it serves the national and public interest for the group to be allowed to do so?

Mr. Chairman and members of the Senate Public Works Committee, we see at least seven reasons. Acquisition of Peabody Coal Co., by Utilities Group would:

First. Assure the 13-member electric utilities of the group an adequate and reliable supply of coal at prices that are likely to be more stable than they have been in the past, especially the past 18 months. We believe that utility ownership of the Nation's largest coal producer will have a stabilizing effect on the widely fluctuating, mostly upward, prices of steam and metallurgical coal.

Second. By stabilizing prices, enable these utilities to maintain downward price pressure on the fuel clause portion of electric costs.

Third. Accelerate coal production at Peabody properties, and thereby contribute materially to reaching the national goal of reasonable energy self-sufficiency by the early 1980's. Peabody's production, for a variety of reasons, has remained essentially flat for the past several years at some 75 million tons per year. We propose to increase the level of production and to make the added production available to other utilities and the open market.

Fourth. Spread the economic and energy benefits of coal now owned by Peabody over a larger geographical area and to more consumers than would be the case if some other group or company should acquire Peabody. Peabody's minable deposits are scattered throughout 16 States. Utilities Group members serve almost 15.5 million people in 10 States.

Fifth. Guarantee the retention of the Nation's largest coal producer within the private sector. We regard this benefit as a "threshold" one, by which I mean that it is fundamentally so important it deserves some special attention. Accordingly, I will come back to it during my comments on the TVA proposal.

Sixth. Enable several member utilities to build electric generating plants near mined and to-be-developed coal deposits, thereby reducing the environmental and economic impacts of transporting coal over long distances.

Seventh. Assure that U.S. domestic coal markets—electric utility, metallurgical, and otherwise—have first call on Peabody production which, as I have already indicated, we would increase. Given the energy problems which the Nation faces, it would be indefensible public policy to place our largest coal producing company under the control of a group whose expressed public intent is to export a significant amount of its production.

Gentlemen, these are the seven reasons why Utilities Group is interested in acquiring Peabody Coal and why we believe it would serve the national interest if we were allowed to go forward.

Let me turn now to the second part of my assignment—the reasons why we are opposed to acquisition of Peabody by the Tennessee Valley Authority.

Let me observe at the outset that it would be intellectually dishonest and logically inconsistent not to recognize that TVA, as the Nation's largest electric utility, has bona fide reasons for wanting to acquire Peabody. After all, some of those reasons are the same ones I have just enumerated on behalf of Utilities Group.

Why then, you might well ask, would TVA's acquisition of Peabody serve the national interest any less than acquisition by Utilities Group?

Before I attempt to answer, let me say that I realize that coming from an electric utility executive, my argument may strike some of you as a thinly veiled attempt to resurrect the old public versus private power struggle.

Nothing could be further from the truth. We are not talking about public versus private power, or utilities at all. We are talking about ownership of the Nation's largest coal company. It is, of course, true that investor-owned and Government-owned electric utilities continue to have their differences, but it is also true that they have learned to live and work together on common problems. Witness the presence of such a publicly owned organization as Salt River Project, which is a member of the electric utilities group I am representing today, or consider the joint efforts of TVA and other publicly owned electric utilities and many investor-owned electric companies in trying to develop and bring onstream a safe, reliable, and commercially viable nuclear breeder reactor.

Returning to the question of TVA ownership and the national interest, it has to be addressed on at least two levels. The philosophic and the economic, and the answers likewise have to be given on those two levels.

Let me discuss the philosophic first. Here I return to the point mentioned earlier about the retention of the Nation's largest coal producer in the private sector. The acquisition of Peabody by TVA, in effect, amounts to nationalizing the company.

It is our position that such a step represents a fundamental change of direction in the relationship between Government and the private sector in this country's continuing economic development. Whether or not one favors nationalization it is unarguable that such action would mark a basic change in public policy in the United States.

Indeed, if the United States is to consider the nationalization of Peabody Coal Co., or any other important company or industry, that consideration and subsequent decisions should be taken consciously by the Congress, rather than by a regulatory agency. The entire subject should be given most careful and comprehensive public and congressional scrutiny.

We appreciate that such scrutiny may be beyond the scope of these hearings, but we strongly believe that it should be undertaken by the Congress if this committee favors raising TVA's statutory debt ceiling beyond $5 billion for the express purpose of borrowing sufficient funds to make the Peabody purchase.

As noted previously, the economic benefits of Peabody coal would tend to flow primarily to those people and communities served by TVA, rather than to the larger segment of the country's population served by Utilities Group members.

We of the Mountain West under whose land so much of Peabody's

low sulfur coal lies, might ask: Why should this coal be mined and shipped 1,500 or 2,000 miles eastward for the benefit of people in the Tennessee Valley, when we can use it to produce the electric power which we need to sustain a healthy economic climate and standard of living at home?

It is a fair question, one which people outside the TVA area are entitled to ask. In fact, some Governors of Western States are already asking it.

The tax status of Peabody as a TVA property would need to be defined. Will Peabody, like its parent, be exempt from payment of Federal, State, and local taxes? If so, what does that portend in terms of: (1) the loss of much needed tax revenues to the States where the coal would be mined; and (2) augmenting the tax exemption benefits which TVA and those it serves already enjoy?

The acquisition of Peabody by TVA could prove very disruptive to the supply side of what we all hope is to be an expanding coal market. This, of course, depends on how much of Peabody's production is in excess of TVA's requirements and presumably reaches the market.

Again, several questions arise: Will Peabody, already the Nation's largest producer, be able to market coal at subsidized price levels as a result of its tax exempt status? If so, what will that do to the profitability of competitors, and eventually to the national policy of expanding coal supply?

This is no trivial point, for the final order of the Federal Trade Commission with respect to Kennecott's disposition of Peabody specifically states what the purpose of that disposition shall be: "* * * to restore Peabody as a going concern and effective competitor in the mining, production, and sale of coal."

This committee undoubtedly has some antitrust questions relating to the Peabody acquisition, whether by Utilities Group or TVA. It has been called to our attention that there is some concern about the vertical integration which utility ownership of Peabody would entail.

First, let me say that since Peabody is such a large company and the purchase price is in the neighborhood of $1 billion, any company or group of companies purchasing Peabody would raise antitrust questions.

In other words, there is probably no company in the United States large enough that would be interested in buying a coal mining company which would not raise antitrust issues. However, it is the opinion of our attorneys that a properly structured utilities group giving adequate assurances to the FTC of making certain that Peabody remains a viable competitor in the coal mining business would make Utilities Group one of the best possible acquirers of Peabody.

Moreover, we recognize that it might be better to have companies other than utilities in our group. Accordingly, we have invited other nonutility corporations to join the group and I can say to you at this time that at least one other such company has agreed to join. Conversa-

tions are being held with other nonutility companies along these lines at the present time.

Let me close on two positive notes, ones on which I hope all of us, including TVA, would agree.

First, while Utilities Group wishes to acquire Peabody and opposes its sale to TVA for all the foregoing reasons, we feel even more strongly that it should not be sold to any group with substantial foreign participation.

Senators, this may not be within the immediate purview of the Public Works Committee, but I feel it is so important that we address ourselves to another one of the bidders for Peabody Coal.

A privately held company which was set up in 1973, ICM Carbomin is one of the three bidders with whom Kennecott has entered into conditional letters of intent. The president of ICM Carbomin has indicated in a number of public activities that it is his intent to export much of the Peabody coal to foreign countries.

In the Sunday financial section of the The New York Times on March 2, 1975, Mr. Samuels was quoted as follows:

> Our opinion is that the American coal industry should be more international than it is. Peabody's prices are artificially low because it is not in the international market.
>
> That is one of the reasons for its lack of strength and its lack of being a viable company. The American horizon is limited and it would be myopic to limit Peabody to American horizons.

In the May 1 issue of Forbes magazine, Mr. Samuels indicated that of his five partners, three are foreign steel companies.

It is our view that it would be inimical to the public interest to permit Peabody to be sold to a company which has a high degree of coal using foreign ownership and whose avowed purpose is to export significant amounts of coal.

It is manifestly in the national interest that Peabody's production be committed to domestic markets, at least for the time being. The "time being" in this case, gentlemen, is until the United States acquires a satisfactory degree of energy self-sufficiency, or the world energy supply and pricing situation changes to make it in our national interest to export coal.

Finally, there is the possibility of Utilities Group, Inc. having TVA as one of its members. This question has been discussed by the group at various times and no decisions were reached; obviously it is not a matter to be decided unilaterally by our group.

If the TVA were interested in joining the group, and if this were the best way to insure that we and they could be successful in acquiring Peabody Coal Co. from Kennecott Copper Corp., we would give it very serious consideration.

Again, Mr. Chairman, I want to thank you and the committee for the opportunity to testify. If there are any questions, my colleagues and I will do our best to answer them.

[Attachments to Mr. Schreiber's statement and a letter from John S. Samuels of ICM Corp., relative to that statement follows:]

Company	No. of Electric Customers 12-31-74	Total Assets 12-31-74 (000)	1974 Electric Sales kwh
Arizona Public Service Company	323,094	$ 1,048,884	8,692,304
Central Illinois Public Service Company	286,921	635,194	6,728,609
The Cincinnati Gas & Electric Company	533,079	1,191,566	11,871,000
Columbus and Southern Ohio Electric Company	421,742	812,015	7,767,444
Illinois Power Company	471,490	1,197,360	10,700,208
Louisville Gas & Electric Company	279,083	510,500	6,833,018
Minnesota Power & Light Company	99,600	297,526	5,400,762
Public Service Company of Colorado	653,091	1,232,906	10,602,250
Public Service Company of New Mexico	164,537	300,880	2,895,185
Salt River Project	239,431	879,925	7,629,000
Tampa Electric Company	266,655	667,645	8,296,598
Utah Power & Light Company	349,910	798,954	8,930,110
Wisconsin Power & Light Company	263,817	470,977	5,154,269
	4,352,450	$10,044,332	101,500,757

April 30, 1975

Dollars in Millions

	Current Credit Rating	1973 Sales	Net Income After Tax	Long Term Debt	Equity
Arizona Public Service	A	$ 225.0	$ 31.3	$ 377.2	$ 327.8
Central Ill. Public Serv.	AA	135.8	18.9	234.5	214.0
Cincinnati Gas & Electric	AAA	223.2	50.2	446.7	445.9
Columbus & Southern Ohio	A-BBB	158.4	25.9	304.4	245.5
Illinois Power	AA	294.4	47.2	480.6	434.1
Louisville Gas & Elec.	AAA	160.0	20.3	189.0	204.4
Minnesota Power & Light	A	82.0	10.1	121.3	99.1
Public Service of Colo.	AA	308.5	42.0	523.7	434.5
Public Serv. of New Mex.	AA	58.5	12.8	108.8	98.6
Salt River Project-Navaho	AA-A	104.7	12.8	322.9	-
Tampa Electric Company	AA	151.0	23.1	255.0	205.7
Utah Power & Light	A	132.7	27.9	316.0	287.2
Wisconsin Power & Light	A	137.0	17.0	161.0	195.6

ICM INTERNATIONAL CARBON AND MINERALS

Carbomin International Corporation, 25 Broadway, New York, N.Y. 10004 • (212) 943-2500
Cable Address "Carbomin New York" • WU 620218 • TWX (710) 581-2513

May 12, 1975

United States Senate
Senate Public Works Committee
Dirksen Senate Office Building
Room 4200
Washington, D. C.

Attention: Senator Jennings Randolph
Chairman

Dear Sirs:

I am Chairman of Carbomin International Corporation and represent the ICM/Carbomin International Group (the ICM Group), which is one of the three parties that has executed an agreement with Kennecott Copper Corporation for the purchase of Peabody Coal Company (Peabody). It has come to my attention that certain statements regarding the foreign participation and objectives of the ICM Group were made on May 8, 1975 during testimony before your committee by Mr. George Schreiber, Chairman and President of Public Service Company of New Mexico, who was speaking on behalf of his own company and twelve other utility companies interested in purchasing Peabody. I would like to take this opportunity to clarify for the record of the Committee the position of the ICM Group with regard to these matters.

If the ICM Group were to acquire Peabody, the primary objective will be to maintain Peabody as a viable, competitive coal producer. The ICM Group assures you of its support of United States energy policies and that it will use its best efforts to fulfill all of Peabody's domestic coal supply commitments. Nonetheless, the ICM Group believes that any large U.S. coal producer, to be effective and develop its capital so as to make use of the large western coal reserves that exist in this country, must involve itself in the international coal market. This means that at an appropriate time, which is when Peabody production is such that excess coal outside Peabody's current

commitment is available, export of a portion of such coal by Peabody will be undertaken. In addition to other considerations, such an objective creates a substantial quality U.S. export product which will contribute strongly to the United States balance of payments.

As to the issue raised concerning the participation of foreign firms in the ICM Group, it is the view of Carbomin that such firms bring with them, in addition to financial strength in their capital structure, significant expertise and patented processes in gasification and liquefaction of coal, formed coke processes and other techniques which may, in the future, expand the market for the use of U.S. coal. It is the opinion of the ICM Group that these processes and techniques will broaden the domestic market for Peabody coal and thereby expand Peabody's domestic customer base.

I would like to thank the Committee for this opportunity to clarify the ICM Group's position.

Very truly yours,

ICM/Carbomin International Group

By _____
John S. Samuels, 3d

Senator BAKER. Mr. Schreiber, thank you very much. I know the committee is happy to have your statement.

I would like to yield at this time, if I may, to Senator Domenici.

Senator DOMENICI. Thank you, Mr. Chairman.

Mr. Schreiber, if TVA should acquire Peabody and if they were given tax free status, although we have had testimony that there may be an in-lieu tax arrangement, but assume my question to be the fact, what would it cost the State that you are familiar with in loss of severance taxes and/or any other taxes that you are aware of?

Mr. SCHREIBER. Senator, the only State I can really speak for is the State of New Mexico. According to the information that we have, Peabody has an estimated 220 million tons of coal in New Mexico. We are currently paying about a dime for each ton that we produce so that if it is a tax-free, a loss of about $22 million for the State of New Mexico.

Peabody has approximately 9 billion tons of coal. Assuming the other States also have a tax in the neighborhood of a dime, and I have no information to confirm or deny this estimate, it would be a loss of $900 million to the States.

Senator DOMENICI. Mr. Schreiber, we have had some discussion about other potential buyers, including ICM group or they and others.

Are you aware of whether or not that group has any significant foreign ownership in its makeup and would you discuss your position regarding that group's potential acquisition of Peabody?

Mr. SCHREIBER. Senator, I would like to defer that to Mr. Phillips, who is very familiar with this, if I may.

Mr. PHILLIPS. According to our information, ICM was a private company. ICM was set up in 1973 and in that year did approximately $30 million of business. Last year, according to published press reports, they did approximately $300 million in business, mostly in the export market.

It certainly is not without some outside support capable of acquiring a $1 billion company. The president of ICM has indicated in a number of publications that it is his intent to export much of the Peabody coal to foreign countries. In the Sunday financial section of the New York Times on March 2, 1975, Mr. Samuels was quoted as follows:

> Our opinion is that the American Coal industry should be more international than it is. Peabody's prices are artificially low because it is not in the international market. That is one of the reasons for its lack of strength and the lack of being a viable company.
>
> The American horizon is limited and it would be my object to limit Peabody to American horizons.

In the May 1 issue of Forbe's, Mr. Samuels indicated that of his five partners, three are foreign steel companies.

We are led to believe from everything that we have learned that there is much foreign money, foreign bank money behind his group.

As to the fact that the Peabody coal prices are too low, nothing could be further from the truth. Peabody sells competitively in the market. They are locked into some long-term contracts that they entered into in the fifties and sixties. But they are trying to work their way out of those contracts. They expire over the course of the next

5 to 10 years. Any new coal they are selling in the current market price is about $25 a ton. The Utilities Group is dead set against ownership by ICM with its, as I say, envied intent to export Peabody coal. We think that is against the public interest until our national energy problems are solved.

Senator DOMENICI. Mr. Schreiber, are there any ongoing discussions between your utility consortium to expand or broaden the group?

Mr. SCHREIBER. Yes; there are, Senator. I would like to again defer to Mr. Phillips.

Mr. PHILLIPS. In discussions with our lawyers as Mr. Schreiber indicated earlier we have been told and we believe that we are one of the best potential acquirers of Peabody because of the broad consumer interests we serve. But it has also been pointed out that all of the present bidders are either 100-percent vertically or 100-percent horizontally owned mining companies such as some of the other groups are. Therefore we are in present discussions with nonutility industrial companies to broaden the base of ownership and operation of Peabody to make ourselves an even better competitor for its purchase.

Senator DOMENICI. We have had a great deal of explanation by TVA in past days as to how they will go about assuring the continuation of the ongoing contracts of Peabody. You would have much the same problem as the utility consortium. There are some long-term coal commitments that might involve companies that are not involved in your consortium. Have you given any thought as to how you will be able to live up to that kind of commitment?

Mr. SCHREIBER. I think we have no alternative but to honor those contracts.

Mr. PHILLIPS. We would intend to increase Peabody's production to over 100 million tons a year and as some of those contracts phase out within about 5 or 6 years there will be some 50 million free tons on the market. Certainly that amount of tonage is more than our utility group can use. That tonage would be made available to other customers.

Senator DOMENICI. TVA under questioning has indicated that they are really interested only in acquiring the reserves necessary for their program's growth and that they would not want it to be in the business of actually mining and selling coal. I don't find in your statement whether the utility consortium intends to follow that format or whether they will intend to be in the business of running a coal company and selling to customers others than the consortia owners.

Mr. SCHREIBER. I think our program, Senator, would be, as Mr. Phillips said, to increase production and there would be additional coal for sale. Do you want to add to that?

Mr. PHILLIPS. Yes. I think this is really contrary to the desire of the TVA which we think—the TVA statement is contrary to the desire of the TVA—which wants Peabody which is our largest coal company both in production and reserves to remain a very viable coal company. Our group would be a consortia ownership. We would bring in new management to increase production. The ownership would certainly be involved, not each utility, but the ownership. The only company would be involved in the production and mining and sale of company. Yes, sir.

Senator DOMENICI. I take it then you are willing to confront the problem of how you would go about selling to utility companies or users outside of your equity owners and do that in an equitable manner in terms of the price to be paid for the coal. Have you thought that through?

Mr. SCHREIBER. Yes; we thought it through. As I say, the production of coal by Peabody down the road should be greater than that necessary for our group itself and that coal will be made available to other utilities and to the spot market. We have made such representations to the FTC.

Senator DOMENICI. You have alluded in your statement, Mr. Schreiber, to the possibility that TVA might become one of the utility companies that formed a consortium to make the acquisition. I take it there is no discussion going on in that regard at this point. Is that right?

Mr. SCHREIBER. I think there has been a preliminary discussion, very preliminary discussion with representatives of our group and officials of TVA. Speaking for myself, I think our company would welcome TVA in the group.

Senator DOMENICI. I yield to the Chair. Thank you, Mr. Chairman.

Senator BAKER. Senator Domenici, thank you very much. I think you have given us a very thorough elaboration of the major points that Mr. Schreiber and his colleagues have made.

I have one or two other points. To turn that around, has there been any conversation about you taking over those parts of Peabody that TVA decides it doesn't want to keep or shouldn't keep?

Mr. SCHREIBER. Again, I would like to defer to Mr. Phillips who has had some discussion with TVA.

Mr. PHILLIPS. The discussions, Senator, really have not gone into any depth whatsoever. We have indicated to TVA that should they be willing and able to join our group we will entertain future discussions.

Senator BAKER. I really have no right to ask whether there had been any conversations or not. Let me ask you, would you consider doing it that way?

Mr. SCHREIBER. I think we would consider anything that would permit ourselves and TVA to own Peabody and keep it going.

Senator BAKER. As I understand the TVA position it is that they don't want to be in a position where they are as they conceive the captive purchaser of coal in a tight fuel market. They don't want to have to respond as they have been responding to these increases in coal prices. Therefore, they want coal reserves to protect themselves. That has sort of been the tradition of the energy consuming industries for a long time. I can think of other industries other than the electric power generating industries who have done that.

But they indicate in their testimony as I understand the testimony, they don't want to be an operating company, they don't want to operate in Australia and New Zealand, that they are going to keep those reserves as they need them and they are going to either sell, dispose of, or enter into partnerships with and I am not sure what that means. But they are going to do something with the balance of it I understand you to be saying now that you are willing to consider that or anything else

54-380 O - 75 - pt. 2 - 2

that would lead to agreement by your group and TVA to acquire the assets of Peabody Coal.

Mr. SCHREIBER. That is correct.

Senator BAKER. I am looking back in the audience to see TVA's reaction. So far I can ascertain none. I will have to stop depending on their facial expressions and start asking questions about it.

Mr. PHILLIPS. I would say this, Senator: Peabody has 9 billion tons of reserves plus 2 billion—quoted figures of 11 billion tons. If all of those reserves were chopped up and owned by particular utilities I don't see how Peabody can be a major competitor in the coal market. Something less than carving up all of the reserves for our 13 members and TVA would be necessary.

Senator BAKER. That raises another interesting point, Mr. Phillips. You mentioned the consequences that might flow from TVA's acquisition of all or part of Peabody, including the constructive nationalization as you put it on the part of the industry. But what happens if utility companies capture Peabody? That is a very substantial case of vertical integration. Peabody has 20 percent of the total coal produced in the United States?

Mr. PHILLIPS. Ten percent.

Senator BAKER. If you went to 100 million tons as you indicated, how much would that be?

Mr. PHILLIPS. Still about 10. They are predicted to remain about a 10-percent factor in the market.

Senator BAKER. What happens if the electric utility consortium that you represent acquires 10 percent of the total production? Before you answer, the phrase that caught my fancy is when you said we are going to use all we need and sell other surplus to other folks, that would be a terrible market to try to buy in, it seems to me, when the other fellow has gotten all he needs.

Mr. PHILLIPS. I don't think we said that. What we did say was that the coal that can be produced by Peabody is in the excess of the needs of our 13 utilities and that coal will be made available to other utilities.

Senator BAKER. These questions are imprecise and inexact, but they are for the purpose of trying to test the idea. In this particular case I am testing whether or not there is correct domination of a substantial part of the coal market by a particular group of users, that is, utility companies.

Mr. SCHREIBER. I think, Senator, what will really happen is that we in the utility group could stabilize our fuel costs. We would know what coal would cost us and could plan accordingly in generating electricity. At the present time, our fuel cost varies all over the map. Everybody is screaming about the widely fluctuating costs of fuels, including coal.

Mr. PHILLIPS. Perhaps it would be interesting, actually over 90 percent of Peabody's production today is sold to the utilities. Our group is a small fraction of that. Many of our members are present Peabody customers and a number of members are not Peabody customers. We would still be selling to the other large utilities in the United States. We would have to.

Senator BAKER. Let me put a very hypothetical and probably unfair question. If you had your druthers, would you druther that you bought it, TVA bought it, or that FTC change its mind and elect Kennecott keep it? It looks to me, I don't mean to prejudge this situation, but it looks to me like the greatest diversification in freedom from a captive market was before Kennecott was ordered to divest.

Mr. SCHREIBER. If I had my druthers, I would like to have the 220 million tons of coal in New Mexico.

Senator BAKER. Free and clear?

Mr. SCHREIBER. Yes, sir, for the generation of electricity.

Senator BAKER. That is what you ought to want.

Senator DOMENICI. I might comment, Mr. Chairman, that I don't want to put myself at odds with my good friend, Skip Schreiber, but I wholeheartedly agree with the statement of the Chairman, that the more we get into the hearings the more it seems obvious to me that the Federal Trade Commission ruling which stems from a state of facts valid in 1968 has probably created a situation that, if in fact we are to restore Peabody as a going concern and effective competitor in the mining, production, and sale of coal, it is probably best accomplished right where it is under Kennecott.

Kennecott seems capable of competing with other giants in the integrated energy field and it seems to be big enough to have utility companies in a position to sign long-term contracts and be in the short-term field, too.

If they are only 10 percent, it seems that they would be a viable competitor with the other 90. Whereas under any other option, we don't find anything but a move toward nationalization or the capture of the market by a group that collectively reduces competition.

On the other hand, if I had my druthers between TVA owning 240 million tons of coal in New Mexico and having this consortium, there is no doubt where this Senator lies. So in that respect I wholeheartedly agree with Mr. Schreiber.

Senator BAKER. The old saying is, if you ain't tried it, don't knock it. You might like it.

Mr. PHILLIPS. I think there is much truth in what you say, but let me explain what the FTC's order requires. Senator Baker, going back to your comment, that Peabody was best as a company before Kennecott acquired it, the FTC order is to put it back that way.

Our group is, as I indicated, not only a consortium of utilities, we are trying to have the utilities own less than 100 percent, say, in the area of 50 or 60 percent, bring in other companies with substantial resources, individual companies, perhaps a mining company, that can add to the expertise and the management of Peabody and put it back where it was in 1968.

That is our intent.

Senator BAKER. I think that is a good clarification. I fully understand what the Senator from New Mexico is driving for. It seems to me that that is a very legitimate area for inquiry. I am afraid it is the one thing that there is not much we can do about in this whole thing; that is. I am not sure we can do anything with the FTC except to inquire into that situation. Maybe I am wrong.

It is a paradox of sorts that in order to preserve competition the FTC ordered the divestiture of Peabody which was owned by a non-coal company, a nonutility company, and a nonenergy company. So what we have now is a choice between a foreign company, a national agency, the TVA, and a consortium of purchasers. It is sort of like the old man who said if I can't take it with me, I ain't going, but maybe we will find a solution.

Thank you very much. I appreciate your very excellent testimony.

Mr. SCHREIBER. Thank you very much.

Senator BAKER. The next group is a panel consisting of representatives of the American Public Power Association, the National Rural Electric Cooperative Association.

Gentlemen, welcome to the hearings this morning. If you will introduce yourselves for the record, we are ready to proceed.

STATEMENT OF ALEX RADIN, GENERAL MANAGER, AMERICAN PUBLIC POWER ASSOCIATION, ACCOMPANIED BY PAUL FRY, DIRECTOR OF ECONOMICS AND RESEARCH, AMERICAN PUBLIC POWER ASSOCIATION; AND BRADLEY KOCH, DIRECTOR OF THE ENERGY AND ENVIRONMENTAL POLICY DEPARTMENT OF THE NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION

Mr. RADIN. My name is Alex Radin, general manager of Public Power Association. I am accompanied by Paul Fry, director of economics and research of the American Public Power Association.

Mr. KOCH. My name is Bradley Koch, director of the Energy and Environmental Policy Department of the National Rural Electric Cooperative Association.

Senator BAKER. We are happy to have you with us. Now should we proceed? I have a statement from Mr. Radin and a statement from Mr. Koch. Which one would like to go first?

Mr. RADIN. I will proceed first, if it is all right.

Senator BAKER. I notice that the statement is how long?

Mr. RADIN. I think about nine pages. I will brief it, Senator, in about 10 minutes.

Mr. Chairman, the American Public Power Association is a national organization, established in 1940, that represents more than 1,400 municipal and other local publicly owned electric utilities in 48 States, Puerto Rico, the Virgin Islands, and Guam.

I might say, as a personal matter, that I was born in Chattanooga, Tenn., and spent the first 20 years of my life there.

Senator BAKER. I could tell right off by the healthy glow on your face you had a good upbringing.

Mr. RADIN. It lasted for about 30-some-odd years from the time I left. I was in the Tennessee Valley when TVA was created, and I saw at firsthand the benefits that TVA brought to the valley. So, I must confess at the outset that my comments may be colored somewhat by my own personal experience.

We have several reasons for an interest in these hearings. First, most of the municipal electric utilities in the Tennessee Valley are

members of our association and are concerned about the price TVA must pay for coal.

Second, the problems that TVA is facing in the purchase of coal are symptomatic of a national problem, shared by many of the member utilities of our association; and

Third, because TVA is the Nation's largest coal consumer, TVA's response to coal supply and price problems could influence the response of other coal purchasers as well as coal suppliers to this problem.

The basic reason we are so concerned about the price and availability of coal is that coal is, as you know, the principal source of primary energy used today to generate electric power; and the cost of fuel, including coal, in turn, is a principal reason for the sharp increase in electric rates that has occurred in recent years.

Coal accounts for about 45 percent of the fuel use by utilities, and as much as 70 to 90 percent of the cost of operation and maintenance of electric utilities is represented by fuel costs.

We are, therefore, deeply concerned and have been for some time about the skyrocketing coal costs. Just in the period from December 1973 to December 1974, the price of coal to utilities went up on the average 95 percent, but to some utilities the price increase was far in excess of that amount.

The price of other fuels also rose dramatically during this period. Oil was up 69 percent, and natural gas 15 percent. Although oil represents only about 19 percent of total fuel use by utilities, oil and oil prices influence utility costs to a far greater degree than the share that oil represents of total fuel use by utilities.

This is because oil prices are considered a bellwether for prices of other fuel, such as coal. Officials of coal companies have said that the price of coal should be equivalent on a Btu basis to the price of competing fuels, meaning oil at this time, because oil has the highest price of any of the competing fuels.

This is a philosophy that we reject. We believe that the price of fuel should be based on cost plus a reasonable return on investment.

Unfortunately, the electric utilities do not possess much bargaining power when negotiating purchase of fuels. They must have fuel if they are to meet their primary responsibility to provide reliable electric power supply, and they can negotiate over price only so long as the remaining fuel stocks permit.

Fuel sellers are well aware of this situation, and their negotiating posture is sometimes a little more than a take-it-or-leave-it attitude.

Attached to my statement is exhibit A, which gives, I think, a very good example of what has been happening to a typical municipal electric utility in its attempt to buy coal.

You will note from that exhibit and the correspondence that is embodied there, that within less than a year the price of coal quoted to this one utility went up from $31 per ton, f.o.b. mine, on April 1 of 1974, to $44.60 a ton as of December 31, 1974.

I think the real significance of that exchange of correspondence is in the fact that the sticking point in the negotiations between the

utility and the coal company was that the coal company flatly refused one provision of the contract which the utility felt was essential.

That was the utility's right to examine independently the costs of the company to be sure that the base price reflected costs plus a reasonable return. That was the principal sticking point and the reason why the negotiations ultimately were broken off.

My prepared statement also refers to another type of contract which was called to our attention by the Deputy Attorney General of the State of Pennsylvania which provided for the price of coal to be based on what is called comparative coal price, which is not tied to production costs but rather is a weighted average of the f.o.b. mine price per million Btu of all coal mined east of the Mississippi River by that particular coal company and sold to private companies, rural electric cooperatives, and municipally owned utilities.

I think my statement fails to point out that the price of coal to the purchaser is to be readjusted every 6 months on the basis of this comparative coal price.

I think these two situations clearly show the importance to all utilities of hard bargaining for fair cost-related coal contracts.

The utilities, we think, should be indebted to TVA for refusing to shirk its responsibilities to customers and for continuing to bargain aggressively for fair coal contracts.

TVA has continued to insist on fairness in coal pricing at a time when many other electric utilities were simply paying whatever price was asked and passing the cost on to their customer.

Our association has followed three avenues in attempting to get at the coal pricing problem. The first thing we have done is commission a study by two economists from George Washington University of what we think might be anticompetitive practices in the coal industry.

Senator BAKER. Before you go on to that, could I ask you a broad-based question?

Mr. RADIN. Yes.

Senator BAKER. It is stimulated by your statement, but probably doesn't relate directly to it. I, once again, don't want to prejudge this record or telegraph what our report is likely to be.

I have the growing feeling that both of these concepts are wrong, both the idea that the coal business ought to be a utility business, that you produce coal and get a 6-percent return or a "reasonable" profit and the idea that the pure free market ought to obtain or that coal prices ought to track the price of oil where you get a hundredfold increase in profit.

I wonder if you would care to comment on that, particularly if you have any ideas about it?

Mr. RADIN. I think the most supportable argument is one that says that coal prices ought to be based on cost plus a reasonable return. The reason I say that is because I think——

Senator BAKER. Technically, the marketplace determines what a fair return is, except in the monopoly industries which are regulated.

Mr. RADIN. We may ultimately have to come to that because coal is such a vital part of production of electric power and is so vital to the

consumer that I think you cannot allow the price to rise to whatever the market will bear, particularly if there is no active competition in the coal industry.

Senator BAKER. Let me interrupt one more time. The way we approached this problem before in the case of electricity was the creation of the TVA to have, among other functions, the yardstick effect, to demonstrate what it really reasonably costs to produce electricity.

Might that same function be assigned to TVA in the ownership of a coal company?

Mr. RADIN. I would certainly agree. In fact—getting ahead of myself in the testimony—one of the avenues that we have explored and one that we advocate, is the establishment of a Federal fuels corporation, which would provide the yardstick function that TVA has provided in the electric field. We don't think that this corporation should represent a nationalization of the coal industry.

Senator BAKER. How big do you think that Federal Corporation ought to be? Do you think it ought to take over the whole coal industry?

Mr. RADIN. No; I do not. I think it ought to be large enough to give some indication of the true price of producing coal. It ought to be large enough to be a viable competitor as TVA has been in the electric business, but we certainly don't believe that conditions warrant nationalization of the coal industry.

Senator BAKER. There is another alternative to this. I won't pursue the subject much further.

What TVA has proposed, as I understand what they propose, is that they buy the reserves and get other people to mine their coal. I assume that they are going to keep careful track of what it costs to mine the coal.

I also assume they are going to publish those figures. I would assume that would have an impact on the cost of coal in other markets.

Mr. RADIN. We would hope so, but I think it will only have an impact if there is more competition in the coal industry. The study that was made for us by the two economists from George Washington University raised a very serious question about whether or not there was adequate competition in the coal industry. Consequently, on the basis of their study, we went to the Justice Department and asked them to impanel a grand jury to see whether there really was viable competition within the coal industry.

Unfortunately, the Justice Department decided not to do that. They claimed that they were studying this problem, but did not choose to impanel a grand jury.

Senator BAKER. I certainly don't want to preempt the Justice Department. Don't you think we have a reverse Sherman or Clayton situation? Usually you have a monopoly condition when you have too few producers.

In this case we have got a monopoly condition because we have too few purchasers and they are captive. They have to have it. The stockpile is the restraining feature rather than competition.

Mr. RADIN. There are a multiplicity of purchasers when you look at the electric utility industry as a whole.

Senator BAKER. They are all one class of purchasers. There used to be a broad range. Now you sell to electric generating companies and to a few steel companies. Isn't that about it?

Mr. RADIN. Yes. I think the electric utilities dominate the field. There is no doubt about that.

Senator BAKER. Do you have any views about the idea of consortium utilities buying Peabody?

Mr. RADIN. We are in favor of electric utilities, more specifically our own, buying or somehow controlling the supply of coal for their own needs.

Senator BAKER. Do you have members of your association who are in the consortium?

Mr. RADIN. Yes. The Salt River project is a member of such a consortium.

Senator BAKER. Do you have members who are also contractees of TVA?

Mr. RADIN. Yes.

Senator BAKER. That makes you exquisitely independent, then?

Mr. RADIN. Yes. So the resolution which I appended to my statement—I think some of the copies failed to include it—indicates that we are in favor of utilities purchasing their own or controlling their own coal supply and the concept, such as TVA purchase of Peabody, is something that we accept.

Senator BAKER. Isn't that the very essence of the classical definition of restraint of trade, of monopoly, that you would have a vertical integration when the electric companies competing with the coal industry simply bought up enough coal companies to supply their whole need? Isn't that what got us in the whole antitrust concept to begin with?

Mr. RADIN. I think there is a problem, Senator Baker. In talking with our own members about this situation, I think they have arrived at the conclusion rather reluctantly that they should purchase coal, because this presents a very difficult problem for them. If they had their druthers, to use one of your words, why I believe that they would druther have a competitive situation and not have the headache of owning and producing coal from their own resources. But absent that sort of situation, they feel almost compelled to have control over the source of fuel themselves.

I would say this, also: Since our members are publicly-owned systems, there is no danger of the profits of any kind of artificial prices being set for coal, being used for private purposes.

Any gain that would be obtained in the use of the coal by publicly owned utilities would ultimately redound to the benefit of the public because the public owns these institutions.

Senator BAKER. I am sorry I interrupted.

Mr. RADIN. It is perfectly all right.

Senator DOMENICI. Could I ask one question? You are talking about the apparent lack of competition in the coal industry. I am again re-

minded of the record. We have Continental Oil Co. buying Consolidated Coal Co., combined assets of which are far greater than Peabody combined with Kennecott and nonenergy producing major American companies. We have a whole history since 1968 of Exxon, Gulf, and others, that are primarily oil and gas energy producing companies buying coal companies.

Based upon your experience in terms of creating competition in the coal industry, which would you choose as being the kind of relationship more apt to maintain competition, Kennecott's ownership of Peabody or Exxon's ownership of Peabody?

Mr. RADIN. I would say that Kennecott's ownership of Peabody would be the lesser of the evils, if I were to put some scale of values on it. The ownership of coal companies by oil companies is a very substantial problem; more so even than the question of Kennecott's ownership of Peabody.

In my own personal opinion, the acquisition of Consolidated Coal by Continental Oil never should have been permitted. One of the reasons that we feel that the price of coal has risen so much in recent years is because of the lack of interfuel competition.

I think there not only needs to be competition within the coal industry but also between the various fuels.

You would never be able to have a situation where the coal companies could say that the price of coal ought to be at a comparable level with the price of oil per Btu if there were real competition between coal and oil.

Senator DOMENICI. With you response the lesser of two evils, would you explain to me what is so evil about the lesser of the two evils? What is wrong with Kennecott owning Peabody from the the standpoint of the competition you seek in the coal industry?

Mr. RADIN. I have not read the record in its entirety or even in large part, Senator, so I could not comment in detail on that. I think the best situation would be to have coal companies that are independently owned rather than owned by companies that have other assets and other interests.

I believe that you would have the most viable and intense competition if coal companies were strictly coal companies and not encumbered with ownership by other corporations which might choose to manage their assets or resources in such a way as to divert resources from one to another.

Senator DOMENICI. Then I take it that it would strike you as being very peculiar reasoning on the part of the Federal Trade Commission that since Kennecott was basically a mining company, though it used no coal, and it had discussed for some 6 months that maybe it ought to get into the coal business, that the reason they shouldn't be permitted to buy Peabody is they have enough assets to go in the coal business themselves.

That is the particular theory that the Federal Trade Commission employed. If you fellow it through to its logical conclusion and Kennecott agreed in that wisdom, they would have formed a major coal company on their own.

So we would still have a situation you don't think is desirable, where you would have Kennecott in the coal business and you think the coal business should be a separate business all its own.

Mr. RADIN. Yes. I would prefer to see the coal business being run by independently run coal companies.

Senator DOMENICI. Thank you, Mr. Chairman.

Mr. RADIN. I think I have just about covered everything in my statement that I intended to. I did mention the fact that one of the avenues we have been following is the Federal Fuels Corporation.

Some of our members have taken steps to have control over their own coal resources. One of the most promising developments in this regard has been the organization of an entity called Western Fuels, which was organized by several rural electric generation and transmission cooperatives. Some of the municipality owned utilities, which are members of our association, are interested in joining that.

I would like to conclude by emphasizing one point. The success of TVA in providing a "yardstick" for the public to use in assessing electric utility operations and rates is beyond dispute.

TVA has been a boon not only to the citizens of the Tennessee Valley, but has served as a positive example of what an electric utility can be, and in so doing has benefited electric consumers throughout the United States.

The actions of TVA in attempting to secure coal under reasonable terms and conditions, despite the risks involved and despite a noticeable scarcity of company from investor-owned electric utilities, have been in the best TVA tradition of performing the yardstick function.

TVA has been a leader in attempting to carry out its responsibility to its customers to hold down costs so that the benefits of electric service may continue to be available to all, at a reasonable price. In spite of recent increases in electric rates in the valley, the region still has rates that are 45-percent lower than the national average.

Consumers have found relatively few champions to defend them against fuels price gouging. TVA deserves to be commended for standing up and being counted while so many others have found it convenient to get along by going along.

Senator BAKER. Thank you very much. I appreciate your statement.

The committee has to balance out the thoughts of your statement. You did nothing to deserve that except you are a good witness and it provides us an opportunity to discuss things from time to time.

You made reference in your statement, as I understand it, to an economic analysis of price increases?

Mr. RADIN. Yes.

Senator BAKER. Could you supply us a copy of that for the record?

Mr. RADIN. Yes; I would be glad to.

Senator BAKER. Thank you very much.

[Mr. Radin's prepared statement follows. The Economic Analysis of Price Increases appears at the end of today's proceedings, p. 1129.]

Statement by Alex Radin, General Manager,
American Public Power Association, Washington, D.C.
at TVA Oversight Hearings
Before Senate Committee on Public Works
May 8, 1975

My name is Alex Radin. I am General Manager of the American Public Power Association, 2600 Virginia Avenue, NW, Washington, D.C. The American Public Power Association is a national organization, established in 1940, that represents more than 1400 municipal and other local publicly owned electric utilities in 48 States, Puerto Rico, the Virgin Islands and Guam.

Our interest in these hearings--and especially the session today on fuel costs--stems primarily from these factors: (1) the price of coal is the single most important element influencing the price of electricity generated by TVA; (2) most of the municipally owned electric utilities in the Tennessee Valley are members of our organization, and are concerned about the price that TVA must pay for coal, its principal source of fuel; (3) the problems which TVA is facing with respect to its purchases of coal are shared by many of the member utilities of our Association outside of the Tennessee Valley, and (4) because TVA is the Nation's largest coal consumer, TVA's response to the coal supply and price problem could influence the response of other coal purchasers as well as coal suppliers to this problem.

High Fuel Costs Increase Electric Rates

The critical importance of fuel costs to electric rates was highlighted in a recent report made for a United States Senate Committee by the Congressional Research Service. The survey showed that fuel adjustment clause rate increases granted to electric and gas utilities cost American consumers an estimated $6.5 billion during 1974, more than the total rate increases approved in the previous quarter century.

Those utilities which generate their own power are, of course, directly affected by the price of fuel. Those utilities which purchase power are indirectly affected by the price of fuel, because it represents the largest single item of expense (about

70% to 90% of the cost of operation and maintenance), and is reflected in their wholesale power costs. It is important that the public understand that the price of fuel is the biggest single cause of rapidly rising electric rates.

Aubrey J. Wagner, chairman of the board of directors of the Tennessee Valley Authority, put his finger on the problem in a recent speech. Mr. Wagner said that if electric rates are ever to stabilize at reasonable levels, consumers must direct their attention to the price of fuel.

"For the most part," he said, "the power supplier is not the real source of increased rates. We must pass on costs that we cannot avoid, that we cannot absorb, and over which we have no control. If electric rates are ever to stabilize at reasonable levels -- and I agree they must -- consumers must know where the real trouble lies. Then their complaints can begin to have a telling effect."

After detailing the coal price increases TVA has had to pay in recent years, Mr. Wagner declared:

"If the honest cost of producing coal justified these high prices, then perhaps there would be nothing to do but accept them. But I do not believe they do. Since 1970, the consumer's price index has gone up about 35%. During that same period, the prices paid for power plant coal have increased about 300% to 400%. The cost of producing coal may have increased faster than consumer items generally, but certainly not 12 times as fast!...

"We are forced to stand as buffers between those who are pocketing these millions and the hard pressed consumers who must dig up the dollars. And we are taking unshirted hell for it while the real culprits, sheltered from criticism, rake in the windfall profits. It seems to me it is time for us to make it clear to consumers where their dollars are going and where their efforts and energies aimed at controlling electric rates should really be directed."

Because of the impact of fuel prices on electric rates, our Association has directed a major share of its efforts in recent years to the fuel problem. We have been joined in many of our efforts by the Tennessee Valley Public Power Association, a regional organization of distributors of TVA power which is affiliated with APPA.

Unfortunately, our efforts thus far have not been successful, but I believe that public power utilities deserve some credit for making vigorous efforts to solve a problem that is of monumental proportions.

Although coal is the principal source of primary energy used to generate electric power, the price of other fuels also, of course, affect the price of electricity.

In one year alone -- in the period from December 1973 to December 1974 -- the price of coal to utilities went up 95%, oil was up 69%, and natural gas rose 51%. The importance of oil prices is out of proportion to the share that oil comprises of total consumption of fuel by utilities. Oil represents about 19% of total fuel use by utilities, while coal represents 45%. However, oil prices tend to be a bellwether for prices of other fuel. Coal company officials have openly stated, for example, that the price of coal ultimately should rise to the same level, per Btu, as the price for competing fuels -- meaning oil, at this time.

Although the OPEC countries have been blamed for the rapid rise in oil prices (and they certainly bear an important responsibility), we should not overlook the fact that the domestic oil producers have not been pikers in this regard, either.

Although U.S. used slightly less oil, natural gas and coal in 1974 than in 1973, the total value of our payments for these fuels approximately doubled from $30.7 billion in 1973 to $62.1 billion in 1974, according to the Bureau of Mines. Of the $31.4 billion increase, only $16.8 billion was caused by the increase in the price which we pay for imported oil. The major portion of the 1974 increase in our payments for fossil fuels, $14.6 billion, was caused by an increase in our payments for domestic oil,

gas and coal from $22.9 billion in 1973 to $37.5 billion in 1974. In contrast, payments for domestic oil, gas and coal increased by only $2.4 billion in the preceding year. It should be noted that the price of fuel would have risen even higher in 1974 were it not for the fact that domestic "old" oil prices were controlled.

Utilities Often At Mercy of Fuel Sellers

Electric utilities very often do not possess a large amount of bargaining power when negotiating the purchase of fuels. They must have fuel if they are to meet their primary responsibility to provide reliable electric power supply, and they can negotiate over price only so long as their remaining fuel stocks permit. Fuel sellers are aware of this situation, and their negotiating posture is sometimes little more than "take it or leave it."

Attached to my statement (Exhibit A) is recent correspondence between Lansing (Michigan) Board of Water and Light, a member of APPA, and a major coal company, which illustrates the nature of the problem. (The name of the coal company has been blocked out of the attached copies, at the request of the Board of Water and Light.) Lansing purchases approximately one million tons of coal per year, and their delivered cost of fuel has increased almost 100% over the past two years.

In an effort to gain some control over the price they must pay for coal, Lansing has been trying to negotiate a new long-term contract (20 years) with one of the larger coal companies. The negotiations have extended over the better part of a year. Due to Lansing's insistence that base production costs and subsequent price escalators be fully documented, the coal company abruptly terminated negotiations, but only after the company had upped its base price from $31 per ton net f.o.b. mine effective April 1, 1974 (subject to escalation thereafter) to $40 per ton effective October 1, 1974.

After Lansing protested the termination of negotiations, the company indicated its willingness to reopen them, but with a base price of $44.60 per ton effective December 31, 1974. The company again refused to permit Lansing Board of Water and Light to make an engineering appraisal of the economics of the company's operation, with respect to this contract.

Mr. Al Brandon, deputy attorney general of the Commonwealth of Pennsylvania, recently called my attention to another interesting contract provision in a coal contract between a major coal company and a privately-owned electric utility in Pennsylvania. This provision ties the price of coal to the power company to something called the "comparative coal price." The "comparative coal price" is not in any way tied to production costs but rather is the weighted average f.o.b. mine price per million Btu of all coal mined east of the Mississippi River by the coal company and sold to private power companies, cooperatives or municipalities for use in generating electricity.

This clause, and the marketing strategy which it epitomizes, clearly show the importance to all utilities of hard bargaining for fair, cost-related, coal contracts. It is clear that any electric utility which has coal contracts with this type of clause owes a debt of gratitude to those of its sister electric utilities, such as TVA, that have refused to shirk their responsibility to their customers and have continued to bargain aggressively for fair coal contracts. It is important to note that TVA has distinguished itself by continuing to insist on fairness in coal pricing at a time when many other electric utilities were simply paying whatever price was asked and passing the cost on to their customers.

APPA Asks For Probe Of Possible Monopoly Practices

The problem of concentration of ownership control is one of the root problems in connection with coal pricing. For several years, APPA has been attempting to tackle this problem by asking the Department of Justice to empanel a grand jury to investigate possible anti-competitive practices in the coal industry. We formally renewed our request to the Justice Department last October.

When we made such a request last year, we submitted to the Department an economic analysis of price increases in the U. S. coal industry that was prepared for APPA, the National Rural Electric Cooperative Association, the Emergency Committee for the Tennessee Valley, and the Tennessee Valley Public Power Association. The study was prepared by Dr. James R. Barth and Dr. James T. Bennett, both of whom are assistant professors of economics at George Washington University, Washington, D.C.

Drs. Barth and Bennett concluded that the enormous coal price increases that occurred since 1968 "cannot be fully explained by increases in the cost of production, for unit labor cost increases are of much smaller magnitude than price increases. Nor do available data indicate that the coal operators were attempting to rapidly expand output," they reported, "for the evidence indicates that in recent years the industry has operated substantially below normal capacity."

Employment and output in the coal industry have remained relatively constant, the economists stated. Average weekly earnings have increased, but prices have risen far more dramatically. At the same time, output in 1971, 1972 and 1973 was below the level of 1970.

"It, therefore, cannot be argued that these price increases can be explained entirely by shortages of coal or by excess demand," Drs. Barth and Bennett declared. "A review of the available data on profits of coal companies and coal operating companies reveal tremendous increases in profits. Thus, price increases have been translated into profits."

Drs. Barth and Bennett concluded that their findings "are not consistent with competitive behavior in the market for coal. If the coal industry were competitive, one would expect price increases to be accompanied by substantial increases in output and an attempt to satisfy demand by full utilization of available capacity. Although

it is virtually impossible to prove conclusively that coal companies have entered into a conspiracy to raise prices and limit output, it should be noted that the findings of this report are entirely consistent with such behavior.

"There is no doubt whatsoever that control of the coal output in the U.S. is concentrated to a great extent in the hands of very few companies. Furthermore, many of these companies are also engaged in the production of oil and natural gas. Thus, the market for the substitutes for coal are controlled by many of the same companies which control the market for coal," Drs. Barth and Bennett declared.

The economists also pointed out that the concentration figures do not indicate the true extent of economic power wielded by coal companies, because long-term contracts tie up much of the coal produced, and because of prohibitive transportation costs, the number of sources available to an individual buyer is extremely limited.

"Whereas the market for coal is tightly controlled on the seller's side, the reverse is true of the purchasers who deal with coal companies individually," they added. "Even though there are a larger number of small operators, much of the coal produced by these small companies is sold by brokers or even other large companies. Thus, the marketing of coal is more concentrated than production itself. Because of these findings,one can conclude that an environment exists in the market for coal which makes collusion possible and desirable in order to increase profits."

Because of the serious nature of the findings of these reputable economists, we felt that an investigation by the Justice Department was warranted. Although this matter had been pending before the Department since last October, we were not informed until late last month that the Department had decided not to order the empaneling of a grand jury.

In view of the unresponsive attitude we have encountered at Justice Department for several years on the question of possible anticompetitive activity in the coal industry, we also have been pursuing other courses of action in order to attempt to hold down fuels prices.

Joint Fuel Purchases, Federal Fuels Corporation Advocated

For example, we have been encouraging our members to join together in pooling their purchases of fuel, or to purchase their own mines or other sources of fuel so that they can have more control over the cost of fuel. Some of our members have jointly purchased an oil supply or are providing for jointly owned storage facilities.

With regard to coal, one of the most promising developments has been the organization of Western Fuels Association, Inc., a non-profit corporation which was formed initially by several rural electric generation and transmission cooperatives, but which is also opening its membership to municipally owned electric utilities. Western Fuels Association has already obtained significant leases for coal to supply a large steam generating plant being built by a group of cooperatives and public agencies in Wyoming. Recently, several municipal systems have indicated an interest in joining Western Fuels Association. I believe that this type of joint action -- which is consistent with TVA's interest in purchasing Peabody Coal Co. -- offers considerable promise for holding the line or even reducing the cost of fuel to public agencies. (Attached as Exhibit B is a resolution adopted by the APPA Legislative and Resolutions Committee on the subject of proposals to purchase Peabody Coal Co.)

Another aspect of the fuels problem that is of special interest to APPA is the desirability of establishing a Federal corporation which would produce fuel on Federal land.

Over half of our Nation's remaining oil and gas resources, about 40% of our coal and uranium, 80% of our oil shale and some 60% of our geothermal energy are located on Federal lands. These fuels belong to all citizens of the United States, and should be developed to benefit the public interest in adequate supply and reasonable price. We therefore support the creation of a Federal fuels corporation to aid in carrying out this task through exploration, production and marketing.

Such an approach would supplement existing private development, stimulate competition, encourage price reductions, and provide a yardstick by which we could judge the performance of private parties.

In conclusion, I would like to emphasize one point. The success of TVA in providing a "yardstick" for the public to use in assessing electric utility operations and rates is beyond dispute. TVA has been a boon not only to the citizens of the Tennessee Valley, but has served as a positive example of what an electric utility can be, and in so doing has benefited electric consumers throughout the United States. The actions of TVA in attempting to secure coal under reasonable terms and conditions, despite the risks involved and despite a noticeable scarcity of company from investor owned electric utilities, have been in the best TVA tradition of performing the yardstick function. TVA has been a leader in attempting to carry out its responsibility to its customers to hold down costs so that the benefits of electric service may continue to be available to all, at a reasonable price. In spite of recent increases in electric rates in the Valley, the region still has rates that are 45% lower than the national average.

Consumers have found relatively few champions to defend them against fuels price gouging. TVA deserves to be commended for standing up and being counted while so many others have found it convenient to get along by going along.

Exhibit A, Page 1

May 14, 1974

Mr. E. F. Brush
General Manager
Board of Water and Light
P. O. Box 570
Lansing, Michigan 48903

Dear Mr. Brush:

Confirming our recent discussion, is pleased to propose to negotiate a contract on coal from the mine in unit train lots for 5,000 to 10,000 tons to be shipped to your various plants.

We enclose herewith a mine data sheet with analysis on the Pond Creek and Thacker Seams blended and would propose the following:

Tonnage: Approximately 50,000 tons per month starting June 1, 1976.

Term: 20 years, with 5 year reopeners.

Price: $31.00 per net ton F.O.B. mine effective April 1, 1974, and subject to escalation thereafter.

If this proposal to negotiate a contract is acceptable to the City of Lansing, it shall be subject to the following:

1) Notification to within 15 days of your desire to negotiate a contract.

2) A final contract must be negotiated by a date fixed by mutual agreement of the parties, such date to be decided on acceptance of proposal.

3) All price adjustments provided for herein, and in the escalation provisions of the contract, shall be effective from and after April 1, 1974.

4) The final contract is subject to Board of Directors' approval.

We would be pleased to furnish any additional information required and hope this proposal is favorably received.

Very truly yours,

May 30, 1974

Mr. E. F. Brush
General Manager
Board of Water and Light
P. O. Box 570
Lansing, Michigan 48903

Dear Mr. Brush:

We are in receipt of your telegram dated May 29th confirming our telephone conversation that you are definitely interested in negotiating a contract on our coal, per my letter dated May 14th.

We are in the process of drafting a proposed contract for Lansing Board of Water and Light and this will be submitted to you at the earliest time possible.

If you have any further questions please do not hesitate to give me a call.

October 28, 1974

Mr. E. F. Brush
General Manager
Board of Water and Light
P. O. Box 570
Lansing, Michigan 48903

Dear Mr. Brush:

As per our conversation this morning, you indicated very strongly that you were still very interested in negotiating a contract on our new coal.

I am enclosing the draft of a proposed contract; however there have been some changes, as you can see, in the contract, as follows:

1. The price effective October 1, 1974 will be $40.00 and (subject to change without documentation.) ← REQUEST DELETE

2. The product now is 100% washed, which will change the quality, and this will be discussed with you on my visit.

3. We are offering this contract in other directions and would like you to indicate your interest again after you have reviewed the draft with your legal personnel.

Please indicate your interest as soon as possible so we can reserve this tonnage for your new plant before someone else signs.

If you have any questions please do not hesitate to give me a call.

I am looking forward to going over this contract with you and your personnel as soon as possible.

November 15, 1974

This is to confirm our telephone conversation of Thursday, November 14, and to reaffirm our previous communication regarding the Board's interest in negotiating a long-term contract for approximately 50,000 tons per month in unit train shipments from your proposed County, Kentucky.

Recognizing that a contract contains many articles and subsections, I will not attempt to set forth our thoughts in that much detail, but the most important ingredients in the contract that are acceptable to us are as follows:

1. Base Price. The initial base price shall be expressed in cents per million Btu's on an as-received basis on your projected cost of production including a fair and reasonable rate of return on the investment. We would ask that you submit to us documentation on your projected initial cost of production, investment required, and rate of return. This information will be held in the strictest confidence, but such information is necessary so that our mining consultants can advise us of the appropriateness of the initial base price.

2. Escalation. The contract will provide for escalation of the base price for actual cost increase in production. Any and all requests for escalation increase shall be documented; likewise, escalation in the initial price shall be in a cents per million Btu's on as as-received basis.

3. Term of contract. We would prefer a ten-year contract with options to renew for two five-year extensions.

As I am sure you are aware, we are presently purchasing a substantial portion of our coal requirements under long-term contracts. One of those contracts was for a new mine to be opened, similar to your The same

November 15, 1974

information we are requesting of you was provided to the Board on that proposed new mine which ultimately resulted in the signing of a contract. The information we received was, and still is, held in the strictest confidence, and I wish to assure you that we will treat the information you furnish us in the same manner.

Very truly yours,

EFB:js

cc: Mr. Everett Myers

February 12, 1975

Mr. E. F. Brush, General Manager
Lansing Board of Water & Light
P. O. Box 570
Lansing, Michigan 48903

Dear Mr. Brush:

I apologize for not getting back to you before this, but it appears we are going ahead with our construction of the Plant at our on the N&W, and we presently have negotiations going on with three customers. My understanding is they have gone along with our price and our contract proposals; so at the present time, unless something changes, we are withdrawing our offer to supply coal off the N&W.

If there should be any change I will definitely be in contact with you.

Thank you for your time and consideration, and if we of can be of any assistance on spot coal off the N&W please do not hesitate to give us a call.

Very truly yours,

March 20, 1975

This is to acknowledge receipt of your letter of February 12, 1975, and to express our displeasure with this sudden turn of events.

It is difficult to understand why negotiations that have been going on between and the Board since early spring 1974 are being so abruptly terminated, particularly in view of correspondence to you expressing our interest in negotiating a long-term contract and supplemented with a telegram to that effect followed by my letter of November 15, 1974, outlining in broad terms our thoughts regarding the pertinent parts of a contract.

As you will recall, on November 26, 1974, we met in my office with you and officials of . for a detailed discussion of a contract. In that meeting we furnished you a copy of one of our present long-term contracts to assist you in understanding our philosophy in this matter.

This letter is to once again advise you of our interest of entering into a contract with from your proposed mine on a "cost related plus a reasonable rate of return basis" subject to escalation to reflect actual increased cost of production over the base price set forth in the contract at date of contract. We believe that this philosophy is fair and equitable to both parties. We are not mining engineers and would utilize our mining consultants, Paul Weir Company, Chicago, Illinois, to advise us of the reasonableness of the initial cost. This can be readily determined based on your proposed mining plan, type of equipment to be used, etc.

We cannot agree to entering into a contract with a base price which, in effect, is the current spot market price plus undocumented cost increases as you have proposed and are appalled to think that the utility industry regardless of ownership—public or investor owned—would agree to concept of a contract.

The papers, trade magazines, and news media are replete with public outcry regarding escalating energy costs. The concept which your company apparently

subscribes to regarding the cost of coal is going to do nothing but foster greater public outcry. I am concerned that unless the coal industry adopts a philosophy of a fair price for their product, they will reap the harvest of federal regulation.

I believe it is obvious to you, after having read this letter, we are very disturbed over being advised of your cancelling negotiations for a long-term contract with the Board and request that your company reconsider its position in this mateer. Again, let me re-emphasize that we are interested in negotiating a contract with your company along the lines outlined in our letter of November 15, 1974, and in our discussion of November 26, 1974.

Very truly yours,

EFB:ja

March 26, 1975

Mr. E. F. Brush, General Manager
Lansing Board of Water & Light
P. O. Box 570
Lansing, Michigan 48903

Dear Mr. Brush:

This will acknowledge receipt of your letter dated March 20, 1975 regarding the withdrawal of our proposal to enter into a contract with the Board of Water & Light.

In my letter of February 12, 1975 I explained that our preparation facilities at the were now being designed to fully wash the coal. As a result of this change in preparation, I was aware that it would be necessary to substantially increase the price of the product to the Board of Water & Light.

In our negotiations to that point, the Board of Water & Light had maintained that our price was too high, that our contract form was unacceptable, and that prior to finalizing a contract Paul Weir and Company would be required to make an engineering appraisal of the economics of our operation relating to the contract.

Since it seemed that we were so far apart in our negotiations, decided it best to withdraw the offer. In the event the Board of Water & Light would be interested in contracting for this coal at the price of $44.60 effective December 31, 1974, under a contract document similar to the one left with you on November 26, 1974, and without an engineering review by Paul Weir and Company, we would be pleased to reopen negotiations.

In your letter of March 20, 1975 you commented quite appropriately about the public awareness of escalating costs of energy. I would add to that expression that in order to expand and develop the coal resources of this country our industry needs to generate the necessary funds to finance new mines. As recently as the late 1960's, the cost per annual

ton to develop a mine of the quality and quantity planned in the area would be between $5 and $7 per annual ton of production. Present capital costs, which include environmental costs, compliance with safety legislation, inflation and other factors, have increased that relationship to the point where $20 to $25 per annual ton is commonplace. While the profit margin proposed by may seem high in relation to the late 60's and early 70's, let me assure you that these margins are necessary.

I would be pleased to discuss this matter with you in the future and reopen negotiations if you feel they would be advantageous to both our companies.

Mr. KOCH. NRECA is the national trade association of nearly 1,000 the same healthy glow as Mr. Radin, but I didn't have the advantage of a Tennessee upbringing.

Senator BAKER. You are a young man. You can still gain it.

STATEMENT OF BRADLEY R. KOCH, DIRECTOR, ENERGY AND ENVIRONMENTAL POLICY DEPARTMENT, NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION

Mr. KOCH. NRECA is the national trade association of nearly 1,000 nonprofit rural electric cooperatives which deliver central station electricity to over 20-million people primarily in the rural areas of 46 States. As you may know, these rural electric cooperatives are generally small distribution systems and consequently do not generate much of their own electricity.

In order to secure an adequate supply of bulk power our systems either purchase from investor-owned utilities, participate in owning their own generation and transmission facilities, or purchase power from Federal sources such as those built and operated by the Corps of Engineers, Bureau of Reclamation, and TVA.

We have some 50 REC's being served by TVA and for that reason we are vitally concerned with any proposed action legislative, regulatory, or operational that will impact on a source of electrical supply and ripple through to our consumer members.

TVA generates electricity in a number of ways, but by far the greatest source of power for TVA is steam generated, coal converted. Name plate capacity for all coal fired TVA units is roughly 18,000 megawatts. Last year TVA sold in excess of 100 billion kilowatt hours of electric energy making it the largest power system in the United States.

Obviously, with a service area dependent on TVA of well over 100 municipal and county systems, 50 REC's, and numerous industrial sale consumers, the need for a reliable fuel source is all too apparent.

Moreover, the recent emphasis that has been given to the development of our native resources so that this Nation can once again achieve energy independence has given coal a new degree of prominence. The President has set a very worthy goal of energy independence by this Nation. We feel that it is a necessary one, but will not be easily or quickly achieved. The short-term path toward that goal, most responsible energy experts agree, is to develop our rather abundant nuclear and coal resources. Since nuclear power is dependent on the development of a breeder reactor to extend its fuel supply beyond the next century, coal looms as the most favorable short-term remedial resource. Unfortunately the sudden swing toward the development of future coal supplies has resulted in an irregular reaction of the total supply market which in our opinion has worked and continues to work to the detriment of the American consuming public.

It has effectively resulted in a sellers market. No longer, it appears, are coal prices related to production costs.

As demand for coal is forecast to double by 1985, prices soar and it appears abuses may have crept in.

With our G. & T. systems frustrated in the recent past by what we believe to be the anomalous behavior of the coal martyrs, and faced with what appears to be an unresponsive, unstable, and unrealiable coal market, we participated in an investigative survey and study of the coal industry which Mr. Radin has referred to in his statement.

Supportively, the study states:

There are numerous reports stemming from the survey of the failure to deliver coal under contract, retroactive price increases, cancellation of coal contracts and price increases.

The report goes on to show a number of aberrant responses to certain economic stimuli in the coal industry. For example, with rapid price increases one would expect a firm in a competitive environment to expand output by utilizing facilities to their fullest. When this doesn't happen the evidence may suggest an explicit or implicit agreement to limit output, further driving up prices, and thereby profits.

The report incidentally attempts to establish a relationship between the recent astronomical rise in coal costs and such economic factors as wage increases, the cost of implementing the Federal Mine Health and Safety Act of 1969, the productivity of the labor force, effects of strikes, surface mine and environmental regulations to justify recent burgeoning coal costs. The report states, however, that:

Taken together, productivity, wages, health and safety regulations, and environmental factors do not account for all of the price increases. Furthermore, these price increases have occurred in spite of the fact that the coal mining industry has been operating at a level substantially below normal capacity. Had the coal operators been willing to produce at full capacity, these enormous price increases would have been accompanied by substantial increases in ouput. The fact that this did not happen, suggests that coal producers restricted output to further drive up prices and profits.

Senator BAKER. This is included in the same report?

Mr. KOCH. Yes, Mr. Chairman, it certainly is.

The report states in its conclusion that:

The findings outlined above are not consistent with competitive behavior in the market for coal. Although it is virtually impossible to prove conclusively that coal companies have entered into a conspiracy to raise prices and limit output, it should be noted that the findings of this report are entirely consistent with such behavior.

Finally—

Because of these findings, one can conclude that an environment exists in the market for coal which makes collusion possible and desirable to increase profits. We believe that an investigation of the coal industry with respect to pricing and supply policy is not only warranted in the light of the findings presented in this paper, but is also in the national interest.

That is the end of the quote and the conclusion of the report.

The purpose of mentioning the report is not to accuse the coal industry of wrongdoing, but to emphasize the fact that coal procurement has become a very serious problem and whether the coal producers actually consorted to raise prices or not, the opportunity to do so is

well documented. And where the opportunity exists, the incentive for greater profits can easily become overpowering.

We feel the very unhealthy, noncompetitive coal market is aggravating an already seriously depressed electric utility industry and an inflated economy. And through the expedient of the fuel cost adjustment, no check or regulatory challenge, is being made of the coal industry in a very suspect market situation.

Possible resolution to the problem we feel is the action taken by a number of our G. & T. systems who literally had their backs to the wall. Faced with the need of expanding future generating facilities these systems were unable to secure a loan from the Rural Electrification Administration without an assured long-range coal supply contract. The difficulties in securing such a contract have already been described.

As I said, without the coal contract no loan could be made. With no loan, no facilities could be built to meet the future demand. So those G. & T.'s with the immediate need formed a fuels cooperative corporation called Western Fuels. The cooperative fuel corporation was established to obtain an assured coal supply for the specific fuel requirements of its class A members through whatever legal options are open to them.

In yet, another situation, certain G. & T. members with less immediate needs are contemplating the formulation of a similar fuels cooperative with similar objectives. And if it should turn out that the only way to obtain an assured supply of coal is to purchase outright a coal producing company and such action is held not to be in conflict with existing statutes, you can be assured they will attempt to acquire such an operating company.

Furthermore, it is my judgment that they are not only morally justified to do so but have an explicit obligation to the consumer members they serve to pursue such avenues. It is my further judgment that TVA as a Government created body has not only a public trust, but a mandate to make available an adequate and reliable supply of electric energy, not only for its current needs but to insure a future healthy economy and environment for its consumers at reasonable costs.

TVA is known to have incurred many of the same problems in obtaining assured coal supplies as have our G. & T.'s. Thus, if TVA must purchase a coal company to assure its consumers of continued service, then I believe it is to their credit for having the foresight to find a way out of the current coal dilemma and see no reason why such a move should be opposed. Furthermore, the incursion of new market forces such as Western Fuels or TVA entering what, in our opinion, is a seller's market, seems like an effective way not only to foster competition and pave the way toward a return to normal market pressures but to move effectively toward the removal of opportunities for collusive practices.

The return to a normal market atmosphere would deter other neophytes from attempting to enter major marketing ventures, it seems to us. Quite seriously, I know of no G. & T. manager who wants to get into the coal producing business; those contemplating such action are compelled to do so much against their will.

In closing I would like to emphasize that public utilities render an invaluable service in a delicate, monopolistic market situation, regardless of whether regulated by a State, Federal agency, or a board of directors representing their consumer members.

By prohibiting these power suppliers from securing the essential future fuel resources you effectively remove the citizen safeguard inherent in regulation; self or governmental regulation.

In that situation, the coal marketeers—in the present seller's market—operate in the utilities monopoly market without, however, the restraints of regulatory oversight.

Accelerating fuel costs merely pass through present rate structures in the utilities fuel adjustment clause.

For these reasons we strongly favor TVA or any utility having the right to enter the fuels market in any legal manner that will insure their continued operation and their capability to serve now and in the future.

Thank you, Mr. Chairman, for the opportunity to present our views.

Senator BAKER. Mr. Koch, thank you very much. I notice that you skipped certain parts of your excellent statement. Without objection, the entire statement will be included in the record.

[The statement follows:]

54-380 O - 75 - pt. 2 - 4

Statement of the

National Rural Electric Cooperative Association

before the

Senate Public Works Committee

May 8, 1975

Mr. Chairman, my name is Bradley R. Koch. I am the Director of the Energy and Environmental Policy Department of the National Rural Electric Cooperative Association (NRECA). NRECA is the national trade association of nearly 1,000 non-profit rural electric cooperatives which deliver central station electricity to over 20 million people primarily in the rural areas of forty-six states. Since most rural electric cooperatives (REC's) are small distribution systems, they do not generate their own electricity. In order to avail themselves of an adequate and assured supply of bulk electric power these systems have had to contract with investor-owned utilities (IOU's), where practicable; share in joint ownership of their own generation and transmission (G&T) facilities where IOU service has proved unreliable; or purchase their power requirements from federally funded sources such as those built and operated by the Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration, and others including the Tennessee Valley Authority (TVA).

There are some fifty REC's which are currently being served by TVA. For this reason, we are vitally concerned with any proposed action legislative, regulatory, or operational that will impact on this source of electrical supply and ripple through to our consumer members. We are grateful to this Committee, therefore, to be given the opportunity to present our views on coal procurement for electric generating plants and how they might relate to the TVA.

As you may know, TVA generates electricity in a number of ways--nuclear, hydroelectric, combustion turbines--but by far the greatest source of bulk power for TVA is steam generated, coal converted. Name plate capacity for all coal

fired TVA units is roughly 8,000 megawatts which accounts for approximately 35% of the system's total capability. Last year, TVA sold in excess of 100 billion kilowatt hours of electric energy making it the largest power system in the United States.

Obviously, with a service area dependent on TVA of well over 100 municipal and county systems, 50 REC's, and numerous industrial sale consumers, the need for a reliable fuel source is all too apparent.

Moreover, the recent emphasis that has been given to the development of our native resources so that this nation can once again achieve energy independence has given coal a new degree of prominence. The Arab petroleum embargo last year, if nothing more, served to alert the American people to the inherent dangers of being dependent on foreign countries for any of life's necessities. The "hammerlock" these foreign states potentially hold in terms of blackmail and complete control of the petroleum market has seriously affected our economy, adversely impacted on our balance of trade and, had our dependence on mid-east oil been greater, our foreign policy could well have been set in the mid-east, our military strength dangerously weakened, and our financial base substantially eroded. In a way, we should probably be grateful to the Arab nations for alerting us to the perilous pathway we were treading to satisfy our insatiable and wasteful demand for ever-increasing supplies of petroleum products.

Nonetheless, the President has set a very worthy goal of energy independence for this nation. We feel it is one that will not be easily or quickly achieved. The short term path toward that goal, most responsible energy experts agree, is to develop our rather abundant nuclear and coal resources. And since nuclear power is dependent on the development of the breeder reactor to extend its fuel supply beyond the next century, coal looms as the most favorable short term remedial resource.

Unfortunately, the sudden swing toward the development of future coal supplies has resulted in an irregular reaction of the total coal supply market which, in our opinion, has worked and continues to work to the detriment of the American consuming public. Because demand for coal supplies has increased so dramatically in a relatively short period of time, and because there no longer exists viable alternative fuels, a seller's market has been created. No longer, it appears, are coal prices related to production costs. As demand for coal is forecast to double by 1985, prices soar and it appears abuses have crept in.

Our member G&T systems have been frustrated in the recent past by the apparently anomalous behavior of the coal marketeers. These behavioral abnormalities include: no response whatsoever from major area coal producers to a request for proposal solicitation; forced re-negotiation of existing contracts; inordinate price increases; and reluctance in serving follow on contracts.

Faced with what appeared to be an unresponsive, unstable, and unreliable coal market, NRECA jointly with the American Public Power Association, the Emergency Committee for the Tennessee Valley and the Tennessee Valley Public Power Association sponsored an investigative survey and study of the coal industry. The project was entitled "An Economic Analysis of Price Increases in the U.S. Coal Industry". Principal research for the study was carried out by two Economics Professors at the George Washington University in Washington, D.C.--Dr. James R. Barth and Dr. James T. Bennett. Interestingly, the study states "There are numerous reports stemming from the survey of failure to deliver coal under contract, retroactive price increases, cancellation of coal contracts and price increases" and then cites several typical cases.

The report goes on to show a number of aberrant responses to certain economic stimuli in the coal industry. For example, "With rapid price increases one would expect a firm in a competitive environment to expand output by

utilizing facilities to their fullest. When this doesn't happen...", and the report presents data to show the coal industry's capacity utilization rate to be substantially below peak "...the evidence may suggest an explicit or implicit agreement to limit output, further driving up prices, and thereby profits." Other irregularities in the price, demand, production picture are evidenced in the report. And a relationship between the recent astronomical rise in coal costs and such economic factors as wage increases, the cost of implementing the Federal Mine Health and Safety Act of 1969, the productivity of the labor force, effects of strikes, surface mine and environmental requlations was attempted in order to justify burgeoning coal costs. However, the report goes on, "Taken together, productivity, wages, health and safety regulations and environmental factors do not account for all of the price increases. Furthermore, these price increases have occurred in spite of the fact that the coal mining industry has been operating at a level substantially below normal capacity. Had the coal operators been willing to produce at full capacity, these enormous price increases could have been accompanied by substantial increases in output. The fact that this did not happen, suggests that coal producers restricted output to further drive up prices and profits."

The report states in its conclusion that, "The findings outlined above are not consistent with competitive behavior in the market for coal. Although it is virtually impossible to prove conclusively that coal companies have entered into a conspiracy to raise prices and limit output, it should be noted that the findings of this report are entirely consistent with such behavior." The report concludes that, "Because of these findings, one can conclude that an environment exists in the market for coal which makes collusion possible and desirable to increase profits. We believe that an investigation of the coal industry with respect to pricing and supply policy is not only warranted in the light of the findings presented in this paper, but is also in the national interest."

The purpose of mentioning the report to this Committee is not to accuse the coal industry of wrongdoing, but to emphasize the fact that coal procurement has become a very serious problem and whether the coal producers actually consorted to raise prices or not, the opportunity to do so is well documented. And where the opportunity exists, the incentive for greater profits can easily become owerpowering.

Regardless of who is guilty of what, the very unhealthy, non-competitive coal market is aggravating an already seriously depressed electric utility industry and an inflated economy. And through the expedient of fuel cost adjustment, (necessary to the electric utility industry) no check or regulatory challenge is being made of the business practices of a very essential industry in a very suspect market situation. Furthermore, the report gives substance to the argument for some positive action that will result in the return of the coal industry to a normal marketing structure. If that can be accomplished, it should have the added positive feature of removing the mantle of suspicion that is now so prevalent in the energy supply industry.

A possible resolution is the action taken by a number of our G&T systems who literally had their backs to the wall. Faced with the need of expanding future generating facilities, these systems were unable to secure a loan from the Rural Electrification Administration (their principal financial supplier) without an assured long range coal supply contract. The difficulties in securing such a contract have already been described, and as I said, without the coal contract, no loan could be made. With no loan, no facilities could be built to meet future demand. So, those G&T's with the immediate need formed a fuels cooperative corporation called Western Fuels. The cooperative fuel corporation was established to obtain an assured coal supply for the specific fuel requirements of its class A members, through whatever legal options may be open to them, i.e., leasing, purchase contracts, joint ownerships to secure reserves,

and if necessary, to mine and deliver the coal. In yet another situation certain G&T members with less immediate needs are contemplating the formulation of a similar fuels cooperative with similar objectives. And if it should turn out that the only way to obtain an assured supply of fuel is to purchase outright a coal producing company and such action is held not to be in conflict with existing statutes, you can be assured these pioneers will attempt to acquire such an operating company. Furthermore, it is my judgement that they are not only morally justified to do so, but have an explicit obligation to the consumer members they serve to pursue such avenues. Obviously, it is no longer a luxury to have available an assured, reliable supply of electricity, but an absolute necessity. Our society, economy, and our everyday environment is largely dependent in one way or another on electric energy. Because of the indispensability of the commodity provided by public utilities and the monopolistic market within which they operate, they are generally well regulated, unless they are publicly or consumer owned. Thus, in theory at least, the public needs are served at fair and equitable rates and the opportunity for an operating utility to extort from its consumers inordinate profits in the absence of a competitive atmosphere is materially reduced, if not made impossible.

We fully recognize that TVA is not an investor owned utility and is thereby not motivated by profit or a return on investment. One might argue also that as an electric utility, they have no business in the production of coal. In my opinion, however, TVA as a government created body has not only a public trust but a mandate to make available an adequate and reliable supply of electric energy not only for its current needs, but to ensure a future healthy economy and environment for its consumers at lowest possible costs. TVA is known to have incurred many of the same problems in obtaining assured coal supplies as have our G&T's. Thus, if TVA must purchase a coal company

to assure its consumers of continued service, then I believe it is to their credit for having the foresight to find a way out of the current coal dilemma and see no reason why such a move should be opposed. Furthermore, the incursion of new market forces such as Western Fuels of TVA entering what, in our opinion, is a seller's market, seems like an effective way not only to foster competition and pave the way toward a return to normal market pressures, but to move effectively toward the removal of opportunities for collusive practices. The return to a normal market atmosphere would deter other neophytes from attempting to enter major marketing ventures, it seems to us. Quite seriously, I know of no G&T manager who wants to get into the coal producing business; those contemplating such action are compelled to do so much against their will.

One thing more, as stated earlier, public utilities render an invaluable service in a delicate monopolistic market situation. And whether they are regulated by a state, federal agency or a Board of Directors representing their consumer members, by prohibiting these power suppliers from securing essential future fuel resources, you have effectively removed the citizen safeguard inherent in regulation (self or governmental). In that situation, the coal marketeers (in the present seller's market) operate in the utility's monopoly market without, however, the restraints of regulatory oversight. Accelerating fuel costs merely pass through present rate structures in the utility's fuel adjustment clause.

For these reasons we strongly favor operating utilities having the right to enter the fuels market in any legal manner that will assure their continued operation and their capability to serve now and in the future.

Thank you once again, Mr. Chairman, for the opportunity to present our views on this important energy matter.

Senator BAKER. I noticed one or two points that are minor, but you speak of TVA having 8,000 megawatts.

Mr. KOCH. That is coal-fired.

Senator BAKER. I believe it should be 18,000 megawatts. I think that is about right.

Mr. KOCH. It is possible that a digit was dropped in the copy. I thought I had current data on TVA.

Senator BAKER. I looked at the latest figures and I believe they show 17,749 megawatts installed.

Mr. KOCH, you have carefully and effectively outlined a concept that has proved to be fairly elusive in these hearings, especially for those members who don't come from the TVA area, that is the concept of self-regulation. I think you have done us a service by elaborating on that and by extending it beyond to the concept that the co-op, and the TVA, a publicly owned corporation, has the responsibility not only to regulate but the obligation to continue to serve and serve adequately.

Your summary of that analogy and your statement of that obligation is very well stated. We will especially take account of that recitation.

I thank you very much for your testimony. It has been very helpful.

Mr. KOCH. Thank you for those very kind words, Senator.

Senator BAKER. Bangert & Co., Investment Bankers, Mr. Kurland and Mr. Kelso.

STATEMENT OF NORMAN KURLAND, WASHINGTON COUNSEL, BANGERT & CO., INVESTMENT BANKERS

Mr. KURLAND. Thank you, Senator.

Senator BAKER. Do we have a copy of your statement?

Mr. KURLAND. Yes; I left 50 copies with the committee's staff.

Mr. Chairman, my name is Norman Kurland. I am Washington counsel of Bangert & Co., an investment firm that specializes in some innovative approaches to corporate finance, which include new ways of handling divestitures, similar to the one that you are considering in the case of the divestiture of the Peabody Coal Co. by the Kennecott Copper Corp.

I would like to express Mr. Kelso's apologies that because of a board meeting today at Bangert & Co. in San Francisco, he is unable to appear before you. But as a close associate of Mr. Kelso's for the last 10 years, I am sure that the views expressed here reflect his views.

If I may, I would like my entire statement to be inserted in the record and simply read excerpts from that statement.

Senator BAKER. We will be very happy to do that. Without objection, there entire statement together with the appendices or attachments, will be included in the record. We would be pleased for you to summarize it. (See p. 1051.)

Mr. KURLAND. Thank you, Mr. Chairman.

Mr. Chairman, the question before you is whether Congress should permit the Tennessee Valley Authority, a public monopoly, wholly owned by the U.S. Government, to acquire ownership of the Peabody Coal Co., the Nation's leading coal producer, from the Kennecott Copper Corp., one of the world's largest corporations, which has been ordered by the Federal Trade Commission to restore Peabody to a more

competitive position in the coal industry, or, in the alternative, whether Congress should propose a more appropriate remedy for assuring the utility customers at Peabody, including TVA, of a long-range and reliable source of coal at reasonable prices while protecting against further concentrations of economic power and control in U.S. energy production.

Mr. Chairman, our Nation is rapidly approaching the 200th anniversary of our extrication from a class-oriented, State-dominated old world, to a revolutionary experiment based on a rather radical assumption about the nature of man.

The American Revolution, in contrast to other revolutions before and since, has long inspired individuals who truly believe that if our institutions were designed to spread broadly, both economic power and political power and placed the opportunity and means to become self-sufficient in the hands of each citizen rather than in the State or in any small group of power wielders, then, out of enlightened self-interest, we could work together to build a better society than those from which our ancestors escaped, a society in which personal freedom and opportunity would flourish, one that the oppressed peoples of other nations would eagerly seek to emulate.

Since 1776, we have had our share of successes and we have had our share of failures in trying to adhere to our principles.

Hopefully, by rededicating ourselves to our founding principles, we can discover faster and more efficient ways of charting the next century, testing whether the founding fathers were right in placing their confidence in the ability of free individuals to govern themselves, favoring free and competitive associations of men over Government monopolies.

Mr. Kelso and I consider it a great irony of history that today this committee is even considering the question of whether the U.S. Government should permit the TVA to acquire, or more accurately, to nationalize the Peabody Coal Co., the Nation's largest, best managed, most productive supplier of coal in the U.S. economy. Not only does Peabody produce about 11.6 percent of the U.S. coal production but in the years ahead the demand for Peabody's coal reserves will grow at an exponential rate as we try to decrease our dependency on foreign oil and gas, and attempt to move toward energy self-sufficiency.

We think that there is a better way to satisfy the FTC divestiture decree and still assure the customers of Peabody and, ultimately, the power users of a continuing and reliable source of coal at reasonable costs.

Properly designed, Congress could help solve several problems with a single stroke. First, it would facilitate the financing of increased competition in the energy industry.

It would avoid new violations of our antitrust laws, possible foreign takeovers of valuable U.S. assets and resources, and the adverse political reactions associated with nationalization of Peabody.

It would restrain inflationary price hikes in Peabody's future operation through new incentives for maximizing coal production and minimizing labor costs.

It would reverse the tendency in the U.S. economy toward nationalization of basic industries, Government bailouts, subsidies, interferences with market mechanisms, wage and price controls, and so forth,

and it would spread the base of equity participation to include persons who own little or no capital in today's enterprise system.

To achieve these results we have proposed that this committee seek passage by the Congress of a special resolution or laws to prohibit the TVA or any other governmental agency from acquiring equity ownership of the Peabody Coal Co., and to encourage the sale at current fair market value by the Kennecott Copper Corp., of its present holdings of Peabody stock to all employees of Peabody, union and nonunion alike, through an employee stock ownership plan, known in the investment banking field as ESOP—E–S–O–P—to the extent financing can be arranged through such a plan.

Mr. Chairman, on page 14 I have included a chart showing how such a financing could take place.

Although Kennecott, for unknown reasons, is reluctant to take the initiative in satisfying the FTC divestiture decree through a sale to Peabody's present management and other employees, we have reason to believe that present Peabody management would be extremely sympathetic to the ESOP alternative.

Senator BAKER. Would you stop there for a minute?

What is the source of your information?

Mr. KURLAND. The source of my information is two trips to St. Louis to meet with the top executives of Peabody—first myself alone, and the second trip with Mr. Kelso.

We have reason to believe that present Peabody management would be extremely sympathetic to the Peabody alternative and that financing for an employee buyout—possibly with partial equity participation spread among a consortium of private utility companies and even cooperatives—could be arranged from a number of conventional financing sources which we will proceed to describe.

Working for a wholly owned subsidiary of Kennecott of course, it should be emphasized, Peabody management realistically is in no position to step forward to compete with other bidders without Kennecott's prior approval.

Senator BAKER. Are you saying here that the Peabody management would like to do this and Kennecott would not? Is that what you are telling us?

Mr. KURLAND. Yes, sir. In December, Mr. Kelso and I met with Mr. Gordon Fisher, vice president of Kennecott, who is in charge of handling the divestment of the Peabody Coal Co.

We indicated that we were not representing anyone, but that we felt that a technique of finance was available to Kennecott which would allow them to receive a fair price for their company and still satisfy the FTC divestiture decree. We had checked with the FTC to see that this approach would be acceptable as far as they are concerned.

Senator BAKER. We had Mr. Dean, the counsel for Kennecott testify, and he brought with him the statement of Mr. Milliken, president and chairman of Kennecott.

He listed a number of other potential purchasers. I don't recall this was included in the list. Was an offer ever made?

Mr. KURLAND. No; an offer was not made for these reasons. First, we represented no client. We were offering Kennecott an idea. Second, in order to make an offer, we would need certain financial information which Kennecott was not making available to us. We did request that information, and we have on file with the FTC the cor-

respondance that we have had with Kennecott. They never supplied us the kind of information that would be necessary to actually structure a financing through an employee stock ownership plan.

Before describing the nature of the employee stock ownership and how it would be structured to accomplish an employee buyout of Peabody, we think it is appropriate first to relate how the ESOP was introduced to head off an earlier nationalization thrust in another U.S. industry under circumstances far less favorable to implementing an ESOP than in the case of such an inherently financeable buyout as the Peabody Coal Co.

On February 28, 1973, Mr. Kelso and I testified before the Senate Surface Transportation Subcommittee. In its deliberations over whether the Penn Central Railroad and six other bankrupt Northeast railroads should be nationalized, we testified that the fundamental structural flaw underlying the demise of our railroads as well as the central cause of the general deterioration of our free enterprise system could be traced to the fact that too few Americans own a piece of the action.

Despite the fact that productive capital is the main source of U.S. productivity, the key to our Nation's economic power and standard of living, the key to our future, only about 5 percent of our consumer units have a direct, personal ownership stake in private capital, private enterprise, and private profits.

The top 1 percent, in fact, own over 50 percent of all corporation stock, according to a recent report commissioned by the Department of Commerce.

Ownership concentration, of course, results from conventional methods of financing corporate growth and transfers of corporate ownership.

To save the railroads, we proposed a new alternative which Bangert Co. has pioneered in the field of investment banking and has implemented successfully in about 100 corporations.

We proposed a new technique of corporate finance, the employee stock ownership plan, which would finance the new stripped-down "core system" for the Northeast as a private enterprise with significant equity participation built into each and every railway employee.

As you know, despite the general lack of enthusiasm and support for our sharp departure from conventional solutions to the rail problem and from the game plan that had been so carefully negotiated by representatives of the rail industry and rail labor, by finance institutions, and creditors hungry for a Federal bailout and by experts from academia and within Government bureaucracies, our proposals were incorporated in the Regional Rail Reorganization Act that was signed by the President on January 1, 1974.

Although there is some serious question whether the U.S. Railway Association has complied with the congressional mandate to study the ESOP alternative for structuring the Northeast rail system, within the last 18 months the ESOP has made even more significant advances, receiving Congress stamp of approval in three additional major pieces of legislation that have been signed into law.

It was given special legal recognition as a financing tool under the pension reform laws.

Companies with ESOP's can also receive preferences for loans under the trade reform laws, and an additional tax credit bonus is

provided to companies which finance their expansion capital through ESOP's under the investment tax provisions of last month's Tax Reduction Act.

Furthermore, the ESOP is now the focal point of a major restructuring of the tax laws in the form of the Accelerated Capital Formation Act of 1975, or H.R. 462, a bill which is expected to be considered soon by the House Ways and Means Committee and actively supported by the leadership of that committee and of the Senate Finance Committee.

Perhaps the Senate's most enthusiastic supporter of the ESOP is Senator Russell Long, who has described the ESOP as "the most important innovation in investment finance developed in recent years."

In the light of TVA's bid for ownership of Peabody, we should remind ourselves also that Senator Long has called the ESOP "the only logical alternative to nationalizing our railroads."

If I may, I would like to call your attention again to pages 11 through 16 of our written testimony, particularly page 14 for the diagram outlining how the ESOP would achieve an employee buyout of Peabody Coal, using corporate credit repayable with before-tax corporate earnings.

In conclusion, Mr. Chairman, whether the Peabody Coal Co. remains in the hands of a small ownership class, or whether it becomes another major victory in Karl Marx's nearly completed strategy for abolishing private ownership of capital completely, or whether you, the Members of Congress, will seize this opportunity to provide a creative alternative for getting this Nation back on its original track, toward a uniquely American, not socialist, vision of the economically free society, toward a more hopeful future where every person is afforded a genuinely, equal opportunity to own capital is, of course, a decision you will have to make and the world will have to live with.

Nevertheless, we urge you to bear in mind the claim of philosopher Mortimer J. Adler that the radically advanced conception of capitalism we are advocating here today not only "supports political democracy to preserve the institutions of a free society," but is, in his mind, "the most revolutionary idea of the century."

Because of the many warning signals around the world that creeping statism will eagerly fill the vacuum created by this Nation's abdication of the revolutionary ideas from which it sprang, I hope that this committee will not miss this opportunity to demonstrate that the spark of the original American dream is still alive.

Thank you, Mr. Chairman.

Senator BAKER. Mr. Kurland, thank you very much. The proposals you make are indeed unique, or at least unique to me. I know of the general field of employee stockownership plans. I am familiar with the general techniques.

I wonder if you would assist us by describing briefly how an ESOP differs from conventional financing?

I think I understand how TVA would finance a Peabody purchase or maybe even have a utility consortium do it. But how would the employees do it?

Mr. KURLAND. Yes, sir. The first point to make is that the ESOP uses the conventional logic of corporate finance; that is, to invest in something that is going to pay for itself.

Senator BAKER. Is the ESOP a corporation?

Mr. KURLAND. No. Technically, the ESOP is a tax-exempt employee deferred compensation trust qualified under section 401(a); in fact, given special recognition under section 401(a), of the Internal Revenue Code.

Senator BAKER. I have just drowned in a sea of numbers.

Mr. KURLAND. That is the section dealing with pension plans, profit-sharing plans, stock-bonus plans, thrift plans, and now under the new pension reform laws something called an employee stockownership plan.

Senator BAKER. But it is a nonprofit trust?

Mr. KURLAND. It is a tax-exempt trust, representing all employees of the company. How it differs from conventional finance is, if you would first look at——

Senator BAKER. Before we get to how it differs, and that is the question I put, you have got this trust and it has——

Mr. KURLAND. It has a borrowing capacity.

Senator BAKER. The trust is the legal entity that would arrange the financing?

Mr. KURLAND. That is correct. The trust has a trust committee that is generally appointed by management.

Senator BAKER. The corporation would remain intact—Peabody would still be a corporate entity?

Mr. KURLAND. Peabody would not change as a corporate entity. It would simply be a means by which Peabody would be able to acquire 100 percent of the common stock from Kennecott.

Senator BAKER. The trust would sell 100 percent of that stock to the employees?

Mr. KURLAND. No. Actually, using borrowed funds secured by the company's future earnings, the trust would buy the stock for the employees, without taking a penny out of their paychecks or savings. The stock would be allocated to their accounts in the trust as the trust's debt is repaid. The trust goes out and gets its loans for the buyout from either private lenders or by holding a public offering of secured debt securities out of the trust, or the trust could in fact itself sell part of the shares that it acquires from the Kennecott Corp., to the public or to a consortium of public utilities.

Senator BAKER. So they don't have to sell to the employees or distribute to the employees. They could sell it on a public underwriting or to an individual?

Mr. KURLAND. No; such sales would only be incidental to the primary use of ESOP. The trust, in order to qualify by the Internal Revenue, has to be set up so that the exclusive benefit, the sole benefit of this entire financing must be for the employees—without requiring any contribution of cash by employees—or it wouldn't get its tax-exempt status. The way it works, Senator, the best way to understand how it works is to compare it with conventional debt financing.

In normal debt financing, a company will go out, let's say, Peabody or Kennecott will go out and borrow money, let's say to buy a new company, as Kennecott did with Peabody. The purchaser would apply the standard rules of feasibility, which is to buy something that is

going to pay for itself. The general rule of thumb in the world of finance is repayment within 3 to 5 years. Investment feasibility is a self-justifying process. The logic of corporate finance, the logic within which any well-managed business uses to make an investment, is generally known as self-liquidating credit.

In conventional uses of debt financing when the debt is repaid and the underlying capital is paid for entirely, the incremental growth of the corporation, or the newly acquired assets of the corporation has been built into its former owners. Conventional finance, of course, doesn't add a single new owner to the picture. If you have a highly concentrated corporation, the new acquisition simply increases the already concentrated ownership holdings of that corporation.

Under an employee stockownership plan—I think it is best to look at the diagram on page 14—the ESOP would be able to go out to lenders just as the corporation would. Through either private placements or public underwritings, the trust would borrow money and give back its notes to the lenders.

These notes would be guaranteed notes because it isn't the general credit of the trust which attracts the money into the trust, rather, it is the general credit and assets of the corporation, just as in conventional debt financing, that supports a bank's loan to the ESOP.

So that in an ESOP financing just as in any standard debt financing, the corporation itself will pledge its general credit and future earnings behind that note.

The interesting thing about ESOP debt financing versus conventional debt financing is that ESOP is the only method in the whole world of investment finance in which a company can go out and borrow money and repay its debt in pretax dollars, rather than at double the cost in after-tax dollars. You see, the debt service arrangement here synchronizes the company's annual contributions to its trust with the debt service schedule that the trust has made with its lenders.

By so doing, the company is able to acquire new capital and tools, using pretax dollars, but spreads the ownership of that capital, in the form of new stock allocations, among all its employees. So we are saying, in effect, this is the lowest cost way for a company to finance its capital. Yet it does so uniquely in ways that spread capital ownership and provides a significant and growing piece of the action to productive workers. As the debt is repaid, stocks once paid for, then becomes allocated to the accounts of the individual employees and it is generally allocated under a formula based on relative compensation in the company.

Senator BAKER. Is it fair to say that someplace down the road the employees would own it if they wanted to, but they own it only as the debt is paid off?

Mr. KURLAND. Exactly. During the repayment period, the trust may hold the stock in an unallocated account or, if it is a private company whose stock is not traded in regulated exchanges, you can pledge the stock to private banks or other private lenders.

Senator BAKER. Would the trust have the authority to sell that stock in advance to somebody if they wanted to?

Mr. KURLAND. No; they could not sell the stock that was pledged against the trust's note. What the lenders are really looking at, however, is not the stock. They would be looking at the general credit

of Peabody, its future earnings and the assets of Peabody, some of which could be mortgaged as added security on the trust's debts.

Senator BAKER. They are looking at that tax-free transfer?

Mr. KURLAND. They are looking at a way the debt can be repaid in a way that gets behind the corporation income tax—and we go into this at some length in the proposed accelerated Capital Formation Act.

Senator BAKER. The ESOP, if you adopted it in this particular situation, I suppose it would have to raise one way or the other something over $1 billion to buy Peabody?

Mr. KURLAND. Whatever the fair market price plus working capital would amount to. They would have to pay Kennecott whatever Kennecott would get from another arm's length bidder. The trust could not pay over what the IRS considers fair market value.

Senator BAKER. What I was going to ask you, as I understand it, Kennecott is going to sell for cash. If that is so, do you think an ESOP could raise $1 billion-plus to buy it?

Mr. KURLAND. I would like to outline how we think the ESOP could do so. Yes, sir. I think it is doable, and from a number of different sources.

Let me outline the various sources of financing that I think are available in this situation, both through the ESOP and outside of it, to achieve an employee buy out.

First, there is, I am sure, a little bit of cash from the employees and management, not a great deal, but a little bit of cash. You are dealing with 13,000 employees.

Seantor BAKER. The first thing you would do is write the employees and say: We have set up an ESOP trust and do you want to buy the stock?

Mr. KURLAND. No, that wouldn't be necessary.

Senator BAKER. "Send your money to so-and-so?"

Mr. KURLAND. No. The ESOP is a noncontributory plan.

Senator BAKER. How do you get the money?

Mr. KURLAND. The money comes from lenders.

Senator BAKER. You spoke of money from employees and management.

Mr. KURLAND. That would be a supplement to ESOP sources of funding. I want to look at about 10 to 15 different sources of money for effecting an employee buyout, some through the ESOP, some not.

Senator BAKER. You are dealing with a man who is going to have a hard time following you. How does the money from the employee or from management of Peabody get into the trust?

Mr. KURLAND. It would not. That would be a direct purchase, not involving the ESOP method of financing. That would be just as you would purchase stock from your own employer in a conventional way. I don't want to emphasize that approach. I am just trying to list the various ways in which cash could be raised to effect a transfer of the equity of the Peabody Co.

Another source of cash would be the pension assets of the employees, management, and possibly even union employees. Again, that could be done outside of the ESOP.

Senator BAKER. How would you do that?

Mr. KURLAND. We have done this in a number of 100-percent divestiture situations where you can convert a portion of pension assets. You

can invest up to 10 percent of any pension plan in company securities. So you convert, say up to 10 percent, into cash and thereby have cash for making that kind of an investment in Peabody stock, if there was no opposition.

Senator BAKER. Don't the trustees of that pension fund have to agree?

Mr. KURLAND. That is right; exactly. They would have to agree that this is a sound investment of pension assets. Frankly, looking at the potential of Peabody, compared to many other enterprises in our enterprise system, I think a good case can be made out that Peabody stock is a reasonable investment.

A third source would be—this is the key—borrowing by the ESOP from banks, from insurance companies, and from general private lending sources for private placements of secured notes of the trust.

Another would be the public offering of debt securities directly out of the ESOP. You would have to have a SEC-registered public offering in this case.

Another source would be direct borrowings or loan guarantees from domestic or foreign customers.

Another source of cash would be borrowing of petrodollars, rather than absorbing them in the form of equity investments.

Senator BAKER. What about those foreign purchasers?

Mr. KURLAND. I am suggesting they would either guarantee or make loans to the ESOP rather than taking an equity position in the company.

Senator BAKER. What if Congress decided, as a matter of policy, or somebody else, and said we didn't want any foreign purchasers?

Mr. KURLAND. I would think that that should be Congress' first order of priority as far as any U.S. company should be concerned. I think that Congress could impose such limitations on foreign investors. On the other hand, it is a complicated issue.

Next, there could be an installment sale for all or part of Peabody's purchase price. There is no reason that Kennecott being a cash rich company could not take back part of the purchase price in the form of an installment contract rather than wholly in cash.

You may recall that Kennecott, when it first bought Peabody, arranged through a production payments contract to pay, I think, something like $300 million of the original purchase price.

At that time, there were some tax advantages in using the production payments route which I understand are not available under present law. But of course that law could easily be modified.

Next, the Government could make a loan guaranty to attract private loans to the ESOP.

Senator BAKER. Under existing law?

Mr. KURLAND. No, I think that would require special legislation.

Another source of financing might involve the exchange of Peabody stock to owners of coal mining lands in lieu of the present lease arrangements, thus increasing Peabody's cash flow for the buyout. These arrangements might be renegotiated for example, on some of the coal leases on Indian lands. Another source of cash would be a partial public stock offering directly from Peabody, instead of from the trust.

Or you could have outside the ESOP, as I mentioned, a traditional employee stock purchase program under a payroll reduction plan; ESOP-financed stock, this would involve an SEC registration.

A most important source that has not been considered—Mr. Kelso and I did testify before the Senate Financial Markets Subcommittee on a particular proposal that we hope Congress will be considering in the years ahead—involves an approach to generate expanded credit and lowered interest rates in basic areas of the economy, such as the industry Peabody is in; particularly the energy industry in general.

We think that the interest rates can be brought down by allowing lenders to ESOP's to discount their note paper directly with the Federal Reserve System.

We think that when the actual cost of money is taken into account, including the risk involved in terms of the ability of companies like Peabody to liquidate ESOP loans, the interest rates should never exceed 3 percent for well-managed companies.

Senator BAKER. Do you mean taking commercial paper in effect for a straight discounting by the Federal Reserve System?

Mr. KURLAND. Exactly.

Senator BAKER. What other alternatives are there?

Mr. KURLAND. The only analogy is to compare it with the horrible examples of the way we pump new money supply into the system under today's monetary policy.

Senator BAKER. The Fed isn't taking "commercial paper" at the rediscount rate presently. I know of no case like that.

Mr. KURLAND. I understand that. What I am trying to say is we are suggesting that if low interest rates are important for facilitating new capital formation, and we think they are, and if new capital formation is going to be the key to this country's ability to compete in the world markets then we are going to have to take another look at why interest rates are so high.

Mr. Kelso, in several of his books and in his presentation to the financial minisummit that was held last year, advocated the direct discounting in basic industries of ESOP loan paper with the Federal Reserve.

We would add one other little feature there, something that we would call the capital diffusion insurance corporation, which would be an industrial counterpart of the FHA. Like the premium charged borrowers for FHA home mortgage loans, a premium would be charged to offset the risk to lenders to ESOP's, which would, of course, be included in the interest rates paid by the ESOP to its lenders.

The analogy, of course, is to look at what we are doing now, pumping new money through the Federal Reserve System to purchase Treasury bonds, not for generating added production, but for paying for wars, paying for welfare, not tied to the production of marketable goods and services.

Senator BAKER. We are not doing that. We are just paying our debts.

Mr. KURLAND. We are not even paying our debts. They are increasing year after year. In other words, we are not putting new money and credit into self-liquidating capital formation. We are using the money supply in ways that either directly or indirectly bring about inflation. When we begin to use the money supply in ways that will add to the productivity of the Nation, then in fact we will find that instead of inflation, we will have a gradual hardening of the value of the dollar.

Senator BAKER. I think we ought to stop here long enough for me to say for this record that I think you and Mr. Kelso and I have vastly different conceptions of the functions of the Fed.

The Fed is not a commercial banker. The Fed is a central banker. The Fed's primary responsibility is to manage the debt of the United States and to regulate the money and credit supply of the Government of the United States.

It would take a terrible lot to convince me that we ought to deviate from that and put the Fed in the commercial banking business for any purpose.

Mr. KURLAND. I am not saying the Fed should be in the commercial banker business at all.

Senator BAKER. That is what you would be doing if you rediscount ESOP paper directly to the Fed, you would be undertaking a commercial banking function with the Federal Reserve bank.

Mr. KURLAND. We are saying that ESOP loans made by private banks that go into the new capital formation and basic industries ought to be at the lowest possible interest rates.

Senator BAKER. I have no quarrel with that, but I understood you to say—I apologize if I am wrong—that you propose that the paper of the ESOP's be discounted directly with the Fed.

Mr. KURLAND. That is, from the banking system.

Senator BAKER. I didn't understand that.

Mr. KURLAND. I am sorry. No, I don't think the Fed should be in commercial banking, not at all. I am sorry I misled you on that. In any event, it was not my basic intention here today to talk about Federal discounting of ESOP note paper, although we would like to get 3-percent loans for the transfer of ownership of Peabody to its employees and as an innovative way of restoring competition.

Senator BAKER. How would you do that? How do you think you could get a 3-percent loan? What is the prime rate. what is the Government rate, short-term rate now? What is the day paper rate at the Treasury?

Mr. KURLAND. I don't recall exactly. Let's say it is 6 or 7 percent. But don't forget we have increased interest rates today to 6 or 7 percent by including factors beyond the pure cost of money. Today's high interest rates reflect an inflation premium that has been built in, to some extent by the Fed's control over the money supply.

Second, the lenders are lending their depositors' money, and naturally when they make loans out of accumulated savings in the system, lenders have to get the highest interest rate that they can. What we are talking about, in contrast to using accumulated savings, is the use of pure credit. Pure credit, when used to monetize basic new capital formation, merely involves a means, whereby certain individuals or legal entities can accumulate claims against others or against the economy as a whole, under a system in which the claims can in fact, be enforced. It is a way of using the banking system to create new credit—that is, to increase the money supply—in order to increase the rate of new capital formation and ownership diffusion within productive private enterprises, perhaps limited initially to certain basic industries.

Senator BAKER. I don't mean to be unnecessarily adversary, but is there a single transaction, government or private. in the United States that you know of where money has been borrowed at 3 percent?

Mr. KURLAND. Interestingly enough, there is one that I am working on right now. It involves a demonstration 25-year, 3-percent loan that is being made by the EDA to an ESOP of the South Bend Lathe Co. to enable the South Bend Lathe Co., in behalf of its 500 employees, to acquire 100 percent of the equity from Amsted Industries, the present owners, who would have otherwise have sold out to liquidators.

Senator BAKER. Under the IRS regulations, if somebody attempts to make an interest-free loan and the Internal Revenue Service attributes interest to that loan as income to the lender, what rate would they apply to that? That is the lowest rate I know of. Is that still 6 percent?

Mr. KURLAND. That is right. They will attribute 6 percent, but we are going to try to make a case, if they are going to attribute——

Senator BAKER. If you are going to get 3-percent money, you are going to have the busiest shop in town.

Mr. KURLAND. No. This is a prototype that has been developed by the EDA as a way of demonstrating that there is a better approach to economic development. EDA is incorporating a model ESOP in their economic adjustment programs both for saving jobs in the private sector and for signaling a new direction for revitalizing and expanding industrial development in areas of high unemployment. As a precedent that may eventually lead to Federal Reserve actions to promote low-interest credit from private commercial sources for ESOP financings of basic new capital formation, EDA funds would make 3-percent—a 25-year, 3-percent loan available to this company.

Here is how the EDA project will work: EDA will make a grant to the city of South Bend. The city of South Bend will set up an industrial revolving loan fund for ESOP financing purposes. This fund, in turn, will loan the money to South Bend Lathe's ESOP trust at a 3-percent, 25-year rate.

Senator BAKER. So in effect what we have is an effective 3-percent rate which is the combination of the commercial rate plus the grant?

Mr. KURLAND. This is a straight 3-percent loan from that revolving loan fund to the ESOP of the South Bend Lathe Co. The EDA grant created the city's revolving fund from which the employee trust borrowed at 3 percent. That won't meet the entire purchase price. It will make about half of it. We are going to have to raise additional money from commercial sources at commercial rates for the balance of the purchase price and for working capital.

Senator BAKER. I didn't mean to divert you because that is sort of a collateral point.

Let me say, Mr. Kurland, that obviously you pique my curiosity and interest. Otherwise, I wouldn't have these questions. It is unique and new and a different approach to this problem, if it is a problem. I am especially grateful for your insights. I have a number of questions that the staff had prepared for me which are fairly exact and deal with the details of your proposal.

The hour is approaching noon. I have another commitment at 12 o'clock. Would you be agreeable to my submitting those questions to you and you answering them for the record?

Mr. KURLAND. Absolutely, sir. I would be happy to.

[Mr. Kurland's prepared statement and responses to additional questions from Senator Baker follow:]

TESTIMONY OF
LOUIS O. KELSO* AND NORMAN G. KURLAND**
FOR
BANGERT & COMPANY, INVESTMENT BANKERS
TO
SENATE PUBLIC WORKS COMMITTEE
HEARINGS ON
PROPOSED PURCHASE BY TENNESSEE VALLEY AUTHORITY OF
THE PEABODY COAL COMPANY FROM THE KENNECOTT COPPER CORP.
TO SATISFY F.T.C. DIVESTITURE DECREE
MAY 8, 1975

Mr. Chairman and Members of this distinguished Committee, Mr. Kelso and I are grateful for the opportunity to appear before you on the question of whether the Congress should permit the Tennessee Valley Authority, a Depression-inspired public monopoly wholly owned by the U.S. Government, to acquire ownership of the Peabody Coal Company, the Nation's leading coal producer, from its present owners, the Kennecott Copper Corporation, one of the world's largest corporations, which has been ordered by the Federal Trade Commission to restore Peabody to a more competitive position in the coal industry, or whether Congress should propose a more appropriate alternative for assuring the utility customers of Peabody, including TVA and the ultimate power users of a long-range and reliable source of coal and related energy derivatives at reasonable prices, while protecting against further concentrations of economic power and control in the U.S. energy production.

---

* Chief Economist and General Counsel, Bangert & Co., Investment Bankers, San Francisco; author of TWO-FACTOR THEORY: THE ECONOMICS OF REALITY (with Patricia Hetter) and THE CAPITALIST MANIFESTO and THE NEW CAPITALISTS (with Mortimer J. Adler) and many articles on economics and corporate finance.

** Washington Counsel, Bangert & Co., Inc.

Mr. Chairman, our Nation is rapidly approaching the two hundredth anniversary of our extrication from a class-oriented, feudalistic, State-dominated Old World to a revolutionary experiment based on a rather radical assumption about the nature of man. The American Revolution, in contrast to other revolutions before and since, was launched by individuals who truly believed that if our institutions were designed to spread broadly both economic power and political power, and placed the opportunity and means to become self-sufficient in the hands of each citizen, rather than the State or in a small group of power-wielders, then, out of enlightened self-interest, we would work together to build a better society than those from which our ancestors escaped, a society that would be internally strong, one in which personal freedom and opportunity would flourish, one that the oppressed peoples of other nations would eagerly seek to emulate. Since 1776, we have had our share of successes and we have had our share of failures in trying to adhere to our founding principles. Hopefully, by re-dedicating ourselves to our founding principles, we can discover wiser and more effective ways to chart the next century of testing whether the Founding Fathers were right in placing their confidence in the ability of free individuals to govern themselves, with competing voluntary private associations favored over the inherently coercive and monopolistic instruments of government as the basic social building blocks for organizing group action and group problem-solving.

Mr. Kelso and I consider it a great irony of history that today this committee of the Congress is even considering the question of whether the U.S. Government should permit the Tennessee Valley Authority, a wholly-owned government corporation to acquire, or, more accurately, to nationalize the Peabody Coal Company, the Nation's largest, best-managed, most productive

and most profitable supplier of coal in the U.S. economy. Not only does Peabody produce about 12 percent of all U.S. coal production, but in the years ahead, demand for Peabody's coal reserves will grow at an exponential rate as we try to decrease our dependency on foreign oil and gas, and attempt to move toward energy self-sufficiency. On the other hand, we think Congress has a unique opportunity to set a new precedent for the American economy by accepting the challenge that has been thrust upon this Committee by the divestiture decree of the Federal Trade Commission, which requires that the Kennecott Copper Corporation, having violated our anti-monopoly laws, "restore the Peabody Coal Company as a going concern and effective competitor in the mining, production and sale of coal."

We think that there is a better way to satisfy the F.T.C. divestiture decree and still assure the customers of Peabody and, ultimately, the power users, of a continuing source of coal at reasonable costs, even at lower prices than Peabody Coal would sell for if the company were sold to other outside bidders, public or private. Properly designed, Congress could help solve several problems with a single stroke: (1) facilitating the financing of increased competition in the private sector; (2) avoiding new violations of our anti-trust laws, and possible foreign takeovers, and adverse political reactions associated with present options for enforcing the Peabody Coal divestiture order; (3) restraining inflationary price hikes in Peabody's future operation through new incentives for maximizing coal production and minimizing labor costs; (4) reversing the tendency in the U.S. economy toward nationalization of basic industries, government bailouts, subsidies, interference with market mechanisms, wage and price controls, etc., and (5) spreading the base of equity participation to include persons who own little or no capital in today's enterprise system.

RECOMMENDATION.

To achieve these results, we propose that this Committee seek passage by the Congress of a resolution or special legislation to prohibit the Tennessee Valley Authority or any other governmental agency from acquiring equity ownership of the Peabody Coal Company and to encourage the sale at current fair market value by the Kennecott Copper Corporation of its present holdings of Peabody stock to all employees of Peabody, union and non-union alike, through an Employee Stock Ownership Plan or "ESOP," to the maximum extent financing can be arranged through such a plan.

Although Kennecott, for unknown reasons, is reluctant to take the initiative in satisfying the F.T.C. divestiture decree through a sale to Peabody's present management and other employees, despite the many economic and political advantages of an ESOP financing strategy for all parties affected by this transaction, we have reason to believe that present Peabody management would be extremely sympathetic to the ESOP alternative, and that financing for an employee buyout, possibly with partial equity participation spread among a consortium of private utility companies, could be arranged from a number of conventional financing sources, which we will describe below. Working for a wholly-owned subsidiary of Kennecott, Peabody management realistically is in no position to step forward to compete with other bidders, without Kennecott's prior approval.

A PRECEDENT: CONGRESS HEADS OFF NATIONALIZATION OF NORTHEAST RAILROADS

Before describing the nature of an Employee Stock Ownership Plan or "ESOP" and how it would be structured to accomplish an employee buyout of Peabody, we think it appropriate first to relate how the ESOP was introduced to head off an earlier nationalization thrust in another basic

U.S. industry under circumstances far less favorable to implementing an ESOP than in the case of such an inherently financeable buyout as the Peabody Coal Company.

On February 28, 1973, Louis O. Kelso and I enjoyed the great privilege of testifying before the Senate Surface Transportation Subcommittee in its deliberation over whether the Penn Central Railroad and six other bankrupt Northeast railroads should be nationalized. We proposed a new alternative, based on our analysis that the fundamental structural flaw underlying the demise of our railroads, as well as the central cause of the general deterioration of our free enterprise system as a whole, could be traced to the fact that too few Americans own a piece of the action. Despite the fact that productive capital is the main source of U.S. productivity, the key to our Nation's economic power and standard-of-living, only about 5 percent of our consumer units have a direct, personal ownership stake in private capital, private enterprise, and private profits. The top 1 percent, in fact, own over 50 percent of all corporate stock, according to a recent report commissioned by the Department of Commerce.

To save our railroads, we proposed the new alternative which Bangert & Company has pioneered within the field of investment banking and has implemented successfully in about 100 corporations: We proposed a new technique of corporate finance, the Employee Stock Ownership Plan, which would finance the new stripped-down "core system" for the Northeast, now known as "CONRAIL", as a private enterprise capable of competing with alternate forms of transportation, but re-structured so that significant equity participation would be built into each and every railway employee, as well as maintenance-of-way employees and perhaps employees of rail shippers.

As you know--despite the general lack of enthusiasm and support for our sharp departure from conventional solutions to the rail problem and from the "game plan" that had been so carefully negotiated by representatives of the rail industry and rail labor, by financial institutions and creditors hungry for a Federal bailout, and by establishment-certified "experts" from academia and within government bureaucracies--our proposals were incorporated in the Regional Rail Reorganization Act that was signed by the President on January 1, 1974.

LATEST CAPITOL HILL INITIATIVES TO BROADEN U.S. CAPITAL OWNERSHIP.

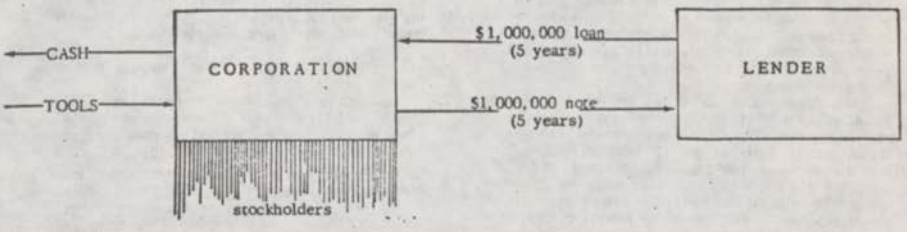
Although there is some serious question whether the U.S. Railway Association has complied with the Congressional mandate to study the ESOP alternative for structuring the Northeast rail system, within the last eight months, the "ESOP" made even more significant advances, receiving Congress' "stamp of approval" in three additional major pieces of legislation that have been signed into law. It was given special recognition as a financing tool and new tax incentives under the pension reform laws. Companies with ESOP's can also receive preferences for loans under the trade reform laws. And an additional tax credit is provided to companies which finance their expansion capital through ESOP's under the investment credit provisions of last month's Tax Reduction Act. Furthermore, the ESOP is now the focal point of a major restructuring of the tax laws, in the form of the "Accelerated Capital Formation Act of 1975" or H.R. 462, a bill which is expected to be considered soon by the House Ways and Means Committee and actively supported by the leadership of that committee and of the Senate Finance Committee.

WHAT IS AN EMPLOYEE STOCK OWNERSHIP PLAN?

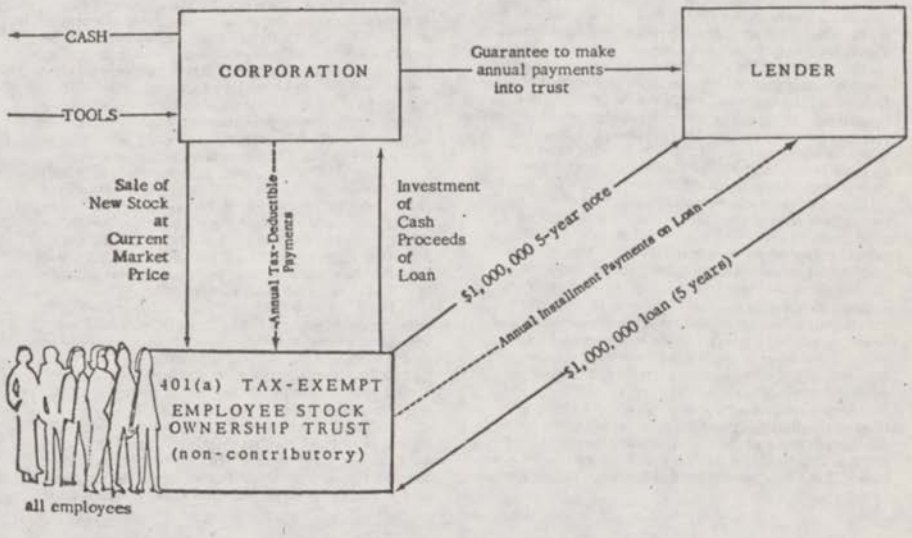
Perhaps the Senate's most enthusiastic proponent of the ESOP is

Senator Russell B. Long, who speaks for a highly diverse, bi-partisan, and growing base of members of Congress in describing the ESOP as "the most important innovation in investment finance developed in recent years." The following diagram contrasts the ESOP with conventional corporate finance.

MODEL I
CONVENTIONAL CORPORATE FINANCE



MODEL II
EMPLOYEE STOCK OWNERSHIP FINANCING



In the light of TVA's bid for ownership of Peabody, we would be hard-pressed to improve upon Senator Long's eloquent floor statement of December 11, 1973, in describing the mechanics of an ESOP and its political and economic implications for our Nation's future, when he advocated the ESOP as "the only logical alternative to nationalizing our railroads." In the words of Senator Long:

The ESOP is a remarkable innovation in corporate finance designed to reverse the heretofore universal tendency of all widely accepted techniques of corporate finance to concentrate ad infinitum the ownership of capital. It has enormously important social, economic, and political ramifications for strengthening our free enterprise economy.

Mr. President, I submit that the use of the ESOP financing technique to the maximum extent--ideally to the extent of 100 percent--in connection with solving the current railroad crisis, is the only logical alternative to nationalization of the railroads, for it is not just a way to efficiently finance economic growth, but also to build market power, and to motivate, in the most powerful way, the entire labor force to perform as never before in order to solve this problem.

The ESOP would enable the entire work force of the reorganized rail system to purchase, without deductions from their paychecks or savings up to 100 percent of the newly issued common stock of the proposed United Rail Corporation on credit tied to the new capital requirements of the United Rail Corporation and secured by its future profits. Shares of stock, when paid for, would be allocated to the individual accounts of each employee in a tax example deferred compensation ESOP trust, without reduction of the take home pay or other benefits of the worker. Unions and management would retain their normal bargaining prerogatives and responsibilities, but subject to a broader range of bargaining possibilities. Given these incentives, if the new system cannot be run at a profit, without subsidies, the workers will have no one to blame but themselves.

Each worker will be put in a position where his own efforts toward cost minimization and increased production will directly influence the value of the capital estate which he acquires during his working lifetime. I would anticipate that strikes and slowdowns, antiquated work rules, featherbedding, resistance to automation, and unreasonable wage demands--all seemingly unsolvable problems up to now --will eventually disappear once workers come to realize how these activities not only work against the interests of consumers as a whole, but also against their individual self-interests.

Before describing the mechanics and implications of the ESOP, I think it fitting to acknowledge the contributions of those responsible for launching ESOP as a solution to the labor and capitalization problems of the new Northeast and Midwest rail system. This concept was first proposed by our distinguished colleague from Oregon (Mr. Hatfield) in his "Dear Colleague" letter of November 5, 1973. Cosponsoring Mr. Hatfield's proposal were Mr. Curtis, Mr. Hansen, Mr. Humphrey, and Mr. Metcalf.

Description of the Basic ESOP Financing Technique

Let me briefly describe the basic logic of Employee Stock Ownership Plan financing and how it would work in the contemplated railroad reorganization. In my opinion, the ESOP financing technique is the most important innovation in investment finance developed in recent years. The ESOP addresses itself to three of the most fundamental barriers to broadening the private ownership of equity capital in connection with the financing of economic growth or the financing of changes in the ownership of business assets.

First. The logic of corporate finance is built around the idea of investing under conditions where the investment is expected to pay for itself. This can be most easily accomplished if the investor can get to the pretax--income produced by the newly acquired capital. To accomplish this objective, the ESOP involves using, in an innovative way, either or both of two traditionally recognized deferred compensation trusts designed to be qualified under section 401(a) of the Internal Revenue Code. These are the stock bonus trust and the money purchase pension trust designed to be invested, at least initially, either wholly or primarily in the stock of the sponsoring corporation.

Second. The employee must be shielded from income tax during his period of capital accumulation to the extent that his capital-derived income is used to defray the purchase price for his stock. Any "second income" or income from his newly acquired capital investment, thereafter used for consumption purposes would be subject to normal personal income taxation by Federal and State governments.

Third. The mechanism must not be capable of being abused by anyone for the purpose of building concentrated ownership rather than broad-based capital ownership. The present statutory law and regulations of the Treasury Department are admirably designed to prevent this abuse, and to assure building broad ownership into the employer.

Fourth. The financing technique must be so designed as to build significant capital ownership in the worker over a reasonable working lifetime. It often happens that where ownership of capital is insignificant in terms of its income-producing power it does

not arouse the natural acquisitive instinct of the worker to protect and preserve his investment.

Fifth. Any technique suitable for building capital ownership into the workingman must be capable of doing so without making deductions from his paycheck or calling upon him for the investment of his generally nonexistent savings, or his invariably inadequate personal savings. The ESOP technique thus fully harnesses the logic of corporate investment, namely, that investment should be made upon terms where it can reasonably be expected to pay for itself within a reasonable period of years.

The ESOP is not a plan to redistribute the profits or dilute the equity of existing shareholders. It is not a stock option plan. It is not an antiunion technique, but rather is designed to broaden the outlook of both union officials and union members to comprehend both factors of production: not just the employment of labor, but the acquisition of privately owned capital by employees. And ESOP financing is not a handout or tax loophole scheme in any sense of the word.

The ESOP is merely the most logical and most economical vehicle devised to date for ownership planning and for the creation of vast amounts of new capital formation which we so desperately need within our corporate sector. The key to corporate ownership, as bankers and businessmen know so well, is having access to corporate credit. Under conventional financing techniques corporate credit is used to make the rich richer; to build capital ownership into the top 5 percent of U.S. wealthholders, who today own all the productive capital.

The ESOP makes some of that corporate credit available to employees while simultaneously financing the growth or normal operations of the corporation itself. It is a practical means for providing access to corporate credit and the normal self-liquidating logic of corporate finance to the new employee owners. It does no more than to place corporate employees in the same position that has enabled America's wealthiest families to become rich, but does so without depriving anyone of his existing property rights. As applied to the reorganized rail system, it would spread ownership of up to 100 percent of the newly issued common stock into all employees. It should be noted here that the fact of bankruptcy itself indicates that the present common stock of the bankrupt rail corporations has been made substantially valueless. The ESOP financing technique can be used in such manner as to protect, and indeed to greatly enhance the likelihood of full recovery of their claims by existing creditors, while providing them, to the extent of their legally recognized claims, with either readjusted debt securities, or with preferred stock, or with a combination of the two. The important aspect of the ESOP financing technique in this instance is that, once the claims of creditors have been paid off through their preferential claims on the income of the reorganized corporation, the growing equity of the corporation, to the extent that the ESOP is used, will be built into employees. Thus, prior to paying off existing creditors and newly acquired creditors, the employees are motivated by the prospect of building their own capital holdings to do everything possible to run the system profitably. When and as creditors are paid off, the employees are equally motivated to build the value of their own equity holdings through diligent and cost-conscious efforts on their part.

Over 40 highly successful U.S. corporations have adopted, or are in the process of adopting ESOP's since the first application of this financing technique in 1957. Not only does the ESOP provide lost-cost capital for the employer, but it provides the most important form of job enrichment known to man: Enrichment for each employee in the form of a reasonable capital holding. It is ideally designed to generate labor-management harmony, expanded corporate profits, and to avoid the structurally inevitable inflation that arises in modern economies so long as employees are put in a position where, in order to keep up with rising living costs, rising taxes, and rising expectations, they must demand progressively more pay for progressively less work.

Financing loans, which under conventional techniques would be made directly to United Rail Corporation, would, under ESOP financing be made to a specially designed ESOP. While the details of the design of the ESOP would, under the Rail Services Act of 1973, be ultimately determined by the Government National Railway Association, it would seem that the trust in this case, as in most other ESOP financing instances, would cover all employees of the corporation, and their relative interests would be proportional to their relative annual compensation--however defined--over the period of years that they are employed. The voting power of the stock in the trust would normally be vested in a trust committee appointed by management and the membership on the committee would undoubtedly include representatives of the employees. Voting power on stock held in the trust to employees as the stock is paid for, or it may remain with the trust committee.

The trust committee invests the proceeds of loan financing and other trust income into newly issued stock of the United Rail Corporation at its current fair market value at the time of investment.

The trust gives its note to a lender, which note may or may not be secured by a pledge of the stock. If it is so secured, the pledge is designed for release of proportionate amounts of the stock to the trust each year as installment payments are made on the trust's note to the lender and the released stock is allocated to the participants' accounts.

United Rail Corporation would issue its guarantee to each credit source making a loan to the trust, insuring the lender that United Rail Corporation will make periodic payments into the trust sufficient to enable the trust to amortize its debt to the lender. Within limits specified by the Internal Revenue Code --15 percent of covered payroll for a stock bonus trust and an additional 10 percent of covered payroll if a money purchase pension trust of ESOP design is added--and such payments are deductible by the Corporation as payments to a qualified deferred compensation trust. Thus the lender would have the general credit of United Rail Corporation to support repayment of the loan, plus the added security resulting from the fact that the loan is repayable in pretax dollars. In contrast, it should be noted under conventional financing the repayment of principal on any loans is always in after-tax dollars.

Periodically, as payment is made by the Corporation into the ESOP, there is allocated proportionately among the accounts of the participants in the trust a number of shares of stock proportionate to each participant's relative compensation from the Corporation. Special formulas have been designed to counteract the relatively high proportion of early amortization payments used to pay interest and the relatively high proportion of latter payments used to pay principal.

As each particular financing is completed and the loan paid off, the beneficial ownership of the stock representing that financing accrues to the employees and is allocated proportionately to the individual account of each in the ESOP.

Most ESOP trusts are designed to permit the withdrawal of the portfolio in kind, subject to vesting provisions, either at termination of employment or at retirement. Special provisions concerning the portability of accounts of employees in the trust should be developed for the United Rail Corporation ESOP. It is desirable to so design the ESOP that any dividend income on shares of stock that have been paid for by the financing process and are thus allocated to the employees' accounts be distributed by the ESOP trust currently to the employee-participants, thus giving such employees a second source of income--"the eye of the owner."

Diversification of the portfolio of the ESOP can, if desired, be achieved after a particular block of stock has been paid for by exchanging this stock, at fair market value, for shares in other corporations at equal market value. Some modifications of present Treasury rules and regulations with respect to this aspect of the ESOP would probably be desirable. Since the trust is a tax exempt entity, such diversification is without tax impact to the employee owning the account that is diversified.

Through the use of ESOP financing, the corporation can obtain low cost capital and save the additional expenses of conventional public stock offerings. Once installed, the ESOP becomes a permanent part of the corporation's financial machinery, combining within a single package a mechanism for comprehensive long-range planning and the resolving of basic corporate problems: Financing, employee motivation, compensation, and retirement benefits, which in the past have been handled on a piecemeal, generally unplanned, and quite often self-defeating and mutually disruptive basis. Although there will be a temporary earnings dilution from the issuance of new stock in future financings through the ESOP, that dilution is soon restored by the inherent financing advantages of the ESOP technique: The use of pretax dollars to finance growth, the simultaneous building of property-supported retirement benefits as corporate growth is financed, the harnessing of the natural tendency of the employee under such circumstances to minimize costs and thus maximize profitability in order to benefit his own investment, and the normal savings in corporate retirement costs that occur when retirement funds are invested in the recycling of secondhand securities purchased in the market place.

Mr. President, U.S. business corporations, including railroad corporations, have always needed but heretofore have never had, a way to raise the incomes of employees, without raising corporate costs. Most approaches for liberlizing the railroad retirement systems, particularly measures calling for earlier vesting, have the same effect as wage salary increases, namely, they are inflationary. Most retirement programs are so designed that contributions become costs of doing business and enter into the costs of goods and services produced. Where retirement income payments are not made directly by business to the retirees, they are in general invested in outstanding securities--secondhand securities--purchased from speculators in the public markets. The funds thus invested do not, with rare exceptions, go into new capital formation to increase the productive power of business. Rather, the $15 to $20 billion annually contributed to private retirement systems, as recent testimony before the Financial Markets Subcommittee of the Senate Finance Committee has shown, are used to inflat the prices of outstanding stocks of "glamour corporations." Such securities are normally purchased by retirement trusts on a yield basis that is presently more than offset by the inflationary loss of purchasing power of the underlying funds. The very process that deprives the corporate sector of a major source of financing growth is thus devoted to the financing of stock market speculation and inflation. It should be remembered, that most private retirement funds contain recycled outstanding securities acquired in this irrational process.

This bill is designed to overcome these basic structural defects of present private retirement systems, while permitting earlier vesting without raising corporate costs--indeed while greatly reducing corporate costs. It is not designed, however, to adversely affect contributions to the existing Railroad Retirement System, which are mandated under present laws on a pay-as-you-go basis similar to social security. Contributions to the ESOP go directly into new capital formation, or, in certain cases can be used to acquire assets purchased on a self-liquidating basis.

Contributions to the United Rail Corporation ESOP would go directly into capital formation, using the funds to be provided under S. 2767 for that purpose. Eventually, such contributions may also be used to finance the acquisition of other operating assets. The important point to remember here, however, is that the pretax yield of productive capital is harnessed directly to the repayment of financing while building ownership into employees.

Mr. President, I know of no more efficient and effective way to build into railroad employees beneficial ownership of a private, viable capital holding, capable of supplementing their wage and salry incomes during their working lives, providing retirement security thereafter, and estates to pass on to their heirs. I know of no more practical way of enabling corporate management to raise the incomes of employees without raising corporate costs and with a long-term deflationary impact on the economy as a whole. Because the ESOP financing technique

can both accelerate the growth and lower the costs of railroad transportation, it can open up the opportunity for greatly increased employment in the enormously more important railroad system of tomorrow.

Management's search for a way out of the class-conflict era of labor-management relations would take a new and brigher turn through the use of ESOP financing, be united with that of employees in revitalizing the private enterprise system generally, while building economic security into all employees. Employee stock ownership financing accomplishes the ultimate synthesis of interests defined by economist John Bates Clark almost 90 years ago as:

> Productive property owned in undivided shares by laboring men, contention over the division of products replaced by general fraternity...

Thus, Mr. President, the potential benefits of providing every worker the chance to participate in the ownership of capital are enormous.

Some of my colleagues who favor the ESOP approach have expressed concerns that over-zealous tax reformers might level unfounded charges that this bill is a "tax loophole." If it is, and I deny that it is, then it is the first such "loophole" ever provided to working Americans. To the extent that existing ESOP tax incentives are taken advantage of by United Rail Corporation under S.2767, to that extent we will have achieved truly structural reform of the U.S. tax system. It represents a new thrust for cutting the costs of welfare, eliminating future consumer subsidies of dozens of different kinds for the purposes of "creating" jobs, and other nonproductive forms of government spending, as redundant workers among the unemployed are absorbed into a healthier and more dynamic private sector.

ESOP financing techniques are designed to build market power into the American people as they finance the growth of the American economy. I can imagine no better method for making common sense of the double-entry bookkeeping logic that is the very basis of any market economy.

This technique systematically broadens the personal income tax base for State and Federal Governments as more Americans begin drawing paychecks and dividend checks directly from enterprises that produce most of our goods and services. It is clearly a move in the direction of simplicity, fairness, and common sense, and that is what genuine tax reform is all about. Any reform that increases our dependency on government should be suspect. Conversely, the ESOP provision in S.2767 is designed to increase the self-sufficiency and productive potential of America's railway workers and to encourage them to demonstrate the value of broadened corporate ownership as a catalyst and motivating force for updating and revitalizing today's undercapitalized rail and mass transit systems.

Only when workers can become owners of new and more efficient means of production can we overcome the enormous alienation and resistance to technological advancements that have become commonplace within modern corporations, despite all the palliatives and psychological manipulations we have invented to mask the root cause of employee alienation and industrial disorder. That cause, for a certainty, lies in the inability of the worker to increase his productive power.

Without having legitimate access to the ownership of productive capital acquired on self-liquidating terms, one cannot be expected to use moral restraint against the tendency to demand progressively more pay in return for progressively less work when one must compete with the enormous productive power of modern capital. If a modern worker cannot acquire his share of the ownership of the machine, it must be a feared and hated enemy for it threatens his power to earn a living. Dignity can, however, come from acquiring legitimately, over a reasonable working lifetime, an ownership stake in the employer corporation and sharing in the "wages of capital"--the profits of the corporation in which the capital is employed.

STEPS IN FINANCING THE SALE OF PEABODY COAL TO ITS EMPLOYEES THROUGH AN EMPLOYEE STOCK OWNERSHIP TRUST

1. Kennecott Copper Corporation authorizes the present management of the Peabody Coal Company, its wholly-owned subsidiary, to take whatever

steps are necessary in order to negotiate an arms' length acquisition from Kennecott of 100 percent of Peabody's outstanding stock at fair market value and concurrently authorizes Peabody management to name to Peabody's board of directors substitutes acceptable to potential financing sources, for any present directors who directly or indirectly represent Kennecott interests on the board.

2. Peabody hires investment banking firm to prepare a divestiture plan and design; to determine a fair and reasonable appraisal of the value of Peabody; to design and obtain necessary legal approvals for establishing and implementing an ESOP; to coordinate financing strategy; and to assist in the buyout negotiations with Kennecott.

3. Peabody establishes ESOP trust covering all Peabody employees and agrees to make future tax-deductible contributions to trust in amounts sufficient to amortize any debts of the trust.

4. Peabody appoints an ESOP trust committee to control trust assets and to direct bank trustee on how to vote stock held by the trust; the issue of voting power is negotiable and may be passed through to employee beneficiaries once stock is paid for and allocated to their individual ESOP accounts.

5. Peabody negotiates with Kennecott on a buyout price and on terms and conditions of the transfer of ownership.

6. Peabody arranges for financing for buyout and for working capital and other requirements for continuing as a going concern from four main sources:

(a) Cash derived from private placements with commercial banks, insurance companies, other private lenders, and public lending sources in exchange for ESOP trust notes secured by Peabody guarantees, mortgages, pledges, etc., and repayable with future tax-deductible Peabody contributions to the trust.

(b) Cash from public underwritings of secured ESOP debentures, through investment banking consortium, with securities repayable with future tax-deductible contributions of Peabody to the trust.

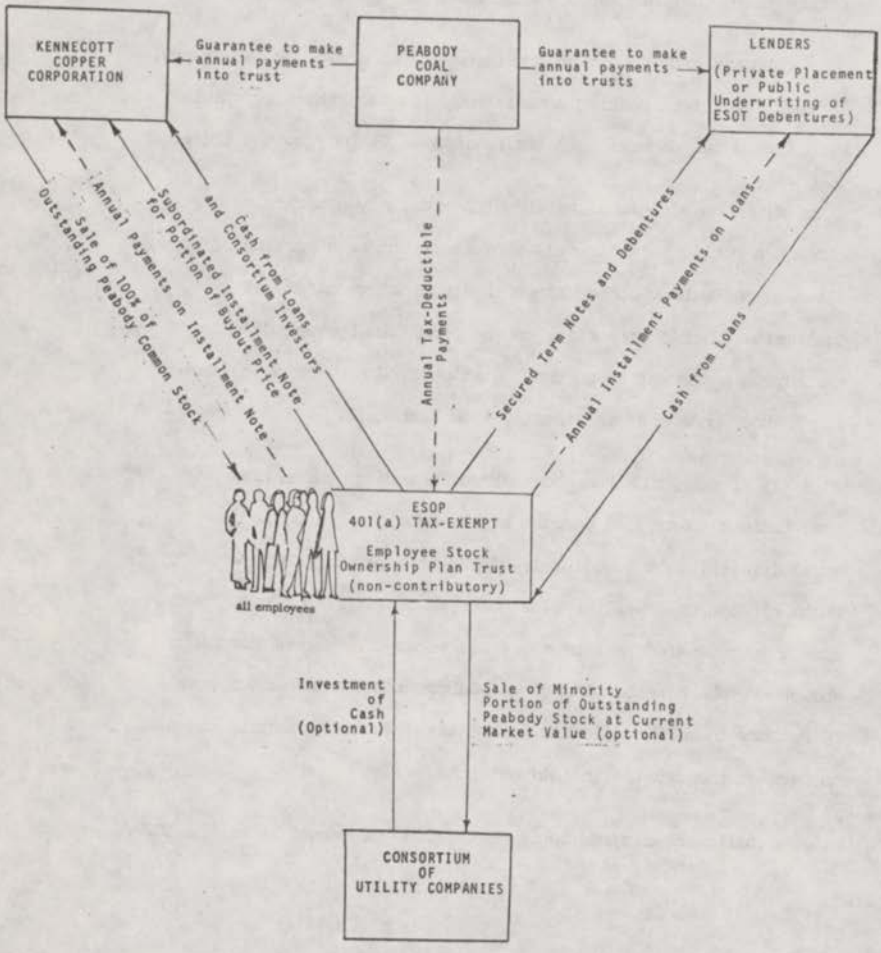
(c) As an additional action, the trust may generate cash through a public sale directly from the trust of a portion of outstanding Peabody common stock to a consortium of utility customers, or this consortium can be permitted by Peabody under the buyout agreement to purchase a stipulated portion of outstanding Peabody common stock directly from Kennecott.

(d) If cash from the above three financing sources is insufficient to pay 100 percent of the purchase price, Kennecott would divest itself immediately of the remaining shares of Peabody stock through an installment sale agreement with the trust, taking back a subordinated note of the trust secured by second mortgages and other subordinated pledges on Peabody assets and a guarantee by Peabody to make sufficient future tax-deductible contributions to service the trust's installment note.

7. The following diagram outlines the flow of events under the ESOP.

54-380 O - 75 - pt. 2 - 6

SALE OF 100 PERCENT OF OUTSTANDING PEABODY COAL COMMON STOCK BY KENNECOTT COPPER CORPORATION TO PEABODY EMPLOYEE STOCK OWNERSHIP PLAN TRUST



(a) Peabody activates its ESOP trust and commits itself to making tax-deductible contributions annually up to 15 percent of covered payroll to cover all debts of the trust.

(b) Trust issues secured notes through private placements with banks, insurance companies, etc., and sells guaranteed debentures through public underwritings.

(c) Peabody guarantees loan repayments and secures trust debt with mortgages, pledges of assets, etc.

(d) Lenders deliver cash to trust, supplemented by cash from optional sale of a portion of Peabody stock to consortium of utility customers.

(e) Trust pays Kennecott cash for 100 percent of outstanding Peabody stock; trust signs a subordinated installment note for any cash deficit, with the loans guaranteed by Peabody and repayable with Peabody's tax-deductible contributions to the trust. (As an option, the utility consortium may purchase a portion of the stock directly from Kennecott.)

(f) All outstanding Peabody common stock delivered to ESOP trust is held for the sole benefit of ESOP participants; stock may be pledged as collateral on notes issued by the trust and are then released as the debt is repaid.

(g) The loans are repaid using before-tax employer contributions, and supplemented by dividends; as loans are repaid, stock is allocated directly to individual accounts for all ESOP participants.

(h) For Peabody's expansion and working capital requirements, the trust goes through steps b, c, d, and g above, in exchange for which Peabody sells the trust new common stock at fair market value.

(i) Stock continues to accumulate tax-free in employees' accounts during their employment; dividends are passed through trust as second incomes; upon retirement, termination, total disability or death, Peabody stock is distributed; beneficiaries receive "put option" to require trust to re-purchase stock at new fair market value.

CONCLUSION: THE FUTURE LIES IN THE HANDS OF CONGRESS

Whether the Peabody Coal Company remains in the hands of a small ownership class, or whether it becomes another major victory in Karl Marx' nearly completed global strategy for abolishing private ownership of capital completely, or whether you, the members of Congress, will seize this opportunity to provide a creative alternative for getting this Nation back on its original track, toward a uniquely American, not Socialist, vision of the economically free and classless society, toward a more hopeful future where every person is afforded a genuinely equal opportunity to own capital, is, of course, a decision you will have to make and the world will have to live with. Nevertheless, we urge you to bear in mind the claim of the philosopher Mortimer J. Adler, that the radically advanced conception of capitalism we are advocating here today, not only "supports political democracy and. . . helps political democracy to preserve the institutions of a free society [but] is, in my mind, the most revolutionary idea of the century."

Because of the many warning signals around the world that creeping Statism will eagerly fill the vacuum created by this Nation's abdication of

the revolutionary ideas from which it sprang, I think it fitting to close with Senator Long's final comments when de detected that our railroads were fumbling towards nationalization:

Mr. President, there are but three political-economic roads from which we can choose.

We can take the course to the right, advocated by laissez-faire philosophers and economic anarchists, which would allow pinnacle ownership to remain and would indeed add enormously to its concentrated holdings. Under this approach, each advance in technology, and each added investment, would heighten the confrontation between the "haves" and the "have-nots", and would perpetuate economic class conflict.

We can take the road to the left, making everyone a "have-not" under the banners of "nationalization" and "equality." This would force an equal sharing of misery and scarcities, using the State or a collective to impose a new form of monopoly ownership, substituting robber-bureaucrat for robber-baron, perpetuating effective ownership by a small but different elite. This "new class" would, by such a step, be placed in a position where it could control the society not only through its stomachs, but also through the guns and nightsticks which it possesses, making corruption and tyranny even more inevitable than under pinnacle private ownership. Preventing workers from enjoying the power and distribution rights that flow from the personal ownership of productive capital, this second road invites a continuing class struggle and relentless inflation.

Or, Mr. President, we can steer a middle course, getting back to the original road that was opened by Jefferson, Adams, Madison, and other Founding Fathers, and expanded by Lincoln under the then revolutionary homestead programs. This was the essence of the American dream that sparked the hopes of the propertyless everywhere and worked so well before our land frontier closed. The third road opened by our pioneer ancestors was intended to make everyone a "have", an owner of income-producing property: it was intended to provide each person a stake to help him become independent of others for his subsistence and thus providing the economic foundation for a free and just political democracy. This road ended when our geographic frontiers ran out and our industrial frontier began.

We could take the first course and further exacerbate the already intensely concentrated ownership of productive capital in the American economy.

Or we could join the rest of the world by taking the second path, that of nationalization.

Or we can take the third road, establishing policies to diffuse capital ownership broadly, so that many many individuals, particularly productive workers, can participate as owners of industrial capital.

Mr. President, the choice is ours. There is no way to avoid this decision. Non-action is a political decision in favor of continued, and indeed increased, concentrated ownership of productive capital.

Which of these three ownership alternatives makes the most common sense, the most political sense, the most social sense, the most economic sense, indeed, the most moral sense?

The eyes of the world are upon this chamber as we deliberate this fundamental question at this moment of truth of our Nation's history.

Mr. President, are we ready to begin anew where our revolutionary forebearers ended, constructing a modern extension of the third road, the road of expanded ownership of productive capital, so that everyone will have the right to own the corporations that will, regardless of our decision, propel us further into the uncertain age of automation.

The have-nots of the world, including the 95 percent of the American people who own no capital, await our answer.

* * * * * * * * *

QUESTIONS SUBMITTED BY SENATOR BAKER TO NORMAN G. KURLAND

How does the ESOP differ from conventional techniques of corporate finance?

Where all conventional methods of financing new capital formation (i.e., expansion) or transfers in the ownership of existing corporate assets tend to concentrate capital ownership within a relatively small ownership class (the top 1 percent own over 50 percent of all outstanding corporate stock, according to a recent Wharton School study published in the November 1974 issue of the SURVEY OF CURRENT BUSINESS, U.S. Department of Commerce), ESOP financing insures, to the extent that corporations use it, that the ownership of new stock representing corporate growth and transfers in the ownership of existing stock are spread broadly and systematically among all the employees of such enterprises, without any reductions in their paychecks or savings.

To illustrate, each year the U.S. economy creates new capital pies, or new capital formation, amounting in recent years to over $110 billion in the corporate sector alone. In the last 15 years or so, roughly 2 percent of net new capital formation came from the sale of new stock for cash, in general to the relatively few Americans who could afford such a cash outlay, normally those already within the affluent ownership class. But the overwhelming bulk of our new capital pies (98 percent), representing new and more efficient industrial tools and structures, are financed either out of cash flow (i.e. profits retained by management and not distributed to stockholders) or out of borrowings repaid with cash flow. The common denominator

of the two primary methods of financing the expansion of U.S. productive capacity is that they use after-tax corporate dollars to buy new capital and will not create a single new capital owner once the financing process is completed. Not a single new constituent is added to the corporation's stockholder base and to the enterprise system as a whole, leaving the 95 percent of consumer units that have no direct ownership stake in corporate profits solely dependent on their technologically-vulnerable jobs, or direct or indirect governmental intervention, or charity, to meet their spending needs. This is the Achilles' heel of capitalism to date. This is why economic power and the distribution of capital ownership is so highly concentrated today, creating such social and economic imbalances that the only countervailing response to date has been to increase the powers and functions of the State to the point where government itself has finally become functionally overloaded.

In sharp contrast, the ESOP uses before-tax corporate dollars to purchase the same new plant and equipment, acquired with funds from the same lenders the corporation would borrow from in a conventional debt financing but after the ESOP financing process is completed and the ESOP trust's debt is repaid, the new capital (represented by newly issued stock purchased by the trust) is owned by a broad group of new capital owners who will share in the future profits of the company they work for. Since profit-ploughbacks from existing capital assets are no longer needed for financing growth where there is an ESOP alternative, dividends to former owners can be increased during the ESOP financing process. Equally

important, the ESOP broadens the base of Americans who have a proprietary stake in the enterprises for which they work and in market-oriented, private property, free enterprise solutions to our economic problems. Moreover, because of the tax savings available to companies financing their capital through ESOP's compared to conventional methods of corporate finance, companies in the 50 percent-plus tax brackets can buy their new tools at less than half price, enabling them to expand more rapidly and become more competitive in world markets. And since dividends may be passed through to workers once their stock is paid for, it offers a way to supplement the paychecks and retirement checks of participants without raising production costs. A more detailed explanation of the mechanics of ESOP financing and other implications of this innovative financing tool to corporations and the economy can be found in various books and articles by Mr. Kelso (see especially chapter 16 of TWO-FACTOR THEORY: THE ECONOMICS OF REALITY by Mr. Kelso and Patricia Hetter, Random House, Vintage paperback, 1967) and on pages 8 to 11 of my prepared statement.

How does the ESOP differ from profit sharing and ordinary employee stock purchase programs?

Under the Employee Retirement Income Security Act of 1974, profit sharing plans may not be used as corporate financing mechanisms, since they are not primarily designed to create proprietary stakes in the employer corporation among all the employees, as in the case of ESOP's. A "party in interest", such as the corporation may not guarantee debts of a profit

sharing plan, as is standard for ESOP financings, for many reasons, but primarily because, by definition, employer contributions to profit sharing plans are made only out of profits or retained earnings, which is a contingency no lender is willing to accept. In contrast, employer contributions to ESOP trusts are linked to the trust's debt service schedule, without regard to whether the company shows a profit on its books during any year. From the employees' standpoint, they receive benefits even during no-profit years, as the debt is being repaid and their share of the capital becomes channeled into their trust accounts. In addition, although in the past a few profit sharing plans, like Sears, invested in employer stock (but never for financing their new plant and equipment with outside borrowings), most profit sharing plan contributions, like any other kind of pay or fringe benefit increase, are pure costs to the company and are therefore inflationary; these contributions pass through the hands of intermediaries to buy outstanding, second-hand, recycled securities in the Wall Street gambling casino, not into the direct financing of the economy's new capital requirements. ESOP contributions go directly into the employer's own growth requirements, combining the cost of financing the company's capital needs with the same pre-tax dollar that provides for some of the retirement needs of its employees. There are also some philosophical, political and legal distinctions between the concept of sharing profits from capital owned by others and sharing profits from your personal ownership stake in productive capital; one violates an essential element of the institution of private property

(which is that an owner is entitled to the full fruits or profits derived from the land, structures, or machines that he or she owns, undiminished by management or any non-owner) and the other, the ESOP, rests on ownership sharing without violating any property rights of existing owners.

In contrast to ordinary employee stock purchase programs, the ESOP does not require employees to tighten their already tight belts to become owners of capital; instead they are given merely the same access to the logic and sources of corporate investment that has been always available to today's pinnacle class of corporate owners: that is, using the corporation to insulate themselves from personal investment risk, while availing themselves of the use of corporate credit for investing in things under conditions where they will pay for themselves, and, once paid for, will add to their wealth accumulations. Ordinary stock purchase programs never work for ordinary workers, because they require already income-deficient people to invest their own after-personal income tax dollars; ESOP's build ownership stakes on pre-tax corporate dollars. The first keeps the poor poor; ESOP's make the poor richer. There is no resemblance between the ESOP and ordinary employee stock purchase programs, stock option plans (which frequently have the same defects and are generally limited to executives), and payroll deduction plans to buy stock from the market or directly from the company.

Where would the money come from for an ESOP financing in this case?

The various sources for financing an employee-initiated buyout of the Peabody Coal Company from its parent, Kennecott Copper Corporation, were listed in my oral testimony, including sources available for direct financing through the ESOP trust, as well as sources that would be external and supplemental to ESOP financing. Assuming that the necessary financial data was available to undertake an investment banking analysis that concluded that an employee buyout, using ESOP financing to the maximum extent allowable under present tax laws, was feasible, the cash required (to the extent that Kennecott would be unwilling to accept partial payment in the form of an installment note, which seems particularly appropriate in cases of violations of our anti-trust laws and, in fact, was how Kennecott acquired Peabody in the first place) could come from: loans to the ESOP from conventional private lending sources; public offering by the ESOP of its secured debentures; ESOP borrowings from its domestic and foreign customers; ESOP borrowing of foreign petrodollars; government direct loans or guarantees under new legislation similar to ESOP loan provisions under section 273(d) of the Trade Reform Act of 1974 and under the U.S. Economic Development Administration's demonstration ESOP project (South Bend Lathe Company) under its economic adjustment program, title IX of the Public Works and Economic Development Act; special legislation authorizing private banks and insurance companies that make loans to Peabody's ESOP trust to discount such loan paper directly with the Federal Reserve System in order to facilitate the implementation of the anti-

trust decree and restore competition in the energy industry; the sale of a minority interest of Peabody shares by the trust for cash directly with Peabody utility customers and cooperatives; the sale to the same investors of a minority equity position directly from Kennecott or directly from Peabody, rather than through the ESOP trust; the swapping of some Peabody stock for lease obligations with tribal councils and other coal land owners to increase Peabody's cash flow position; the sale of a portion of Peabody stock to employees and the public through a conventional equity underwriting or employee stock purchase scheme tied to payroll deductions; loans to the Peabody ESOP from union and non-union pension funds; equity investments in a portion of Peabody stock by United Mine Worker and other union and non-union pension funds; etc.

Specifically, what would be the steps in using the ESOP to accomplish this divestiture?

This was covered in pages 11 through 16 of my written statement.

What do the employees have to put up or risk to implement an ESOP?

Peabody employees would not be required to make any cash outlay in any financing through the ESOP, which generally is designed as a non-contributory plan. Where there is no other pension plan involved, the law now allows an employer to contribute up to 25 percent of covered compensation tax-free to an ESOP and the benefits accumulate tax-free in each worker's ESOP account until they are distributed (generally upon retirement; termination of employment; death; total disabilty) and even then there are additional tax benefits for

ESOP distributions not available to other employee benefit plans. Where a pension plan remains in effect, the maximum tax-deductible employer contribution to an ESOP is 15 percent of total payroll. Once the shares are paid for, and not before, they are allocated to each participant's ESOP account under a formula based upon his relative compensation compared to other workers.

As indicated in the question above regarding profit sharing and conventional stock purchase plans, there is no personal liability on the part of any employees for the debts of their ESOP trust. These debts are repaid wholly out of future employer contributions and are secured by the general credit, assets, and sometimes the unpaid for stock until they are paid for. ESOP-held stock and other assets in the trust that have already been allocated to employee accounts are also exempt from liability on debts of the trust.

If Congress gave its full support to an ESOP buyout strategy, how would this affect the future price and supply of coal to Peabody customers?

We are confident that the production of coal would greatly increase and the price of coal would be substantially lower compared to levels that might be expected if an ESOP strategy is not adopted. The kinds of accelerated ownership possibilities under an all-out ESOP exceeds any form of economic benefit ever bargained for by any labor union in the past; beyond full participation in capital ownership there is no higher form of economic justice. Conventional wage increases and fringe benefits go directly into the cost of coal and therefore are self-

cancelling. Getting higher pay for no added production is one of the prime sources of the inflationary spiral in the economy, which rob not only working people generally but people on fixed incomes, including union retirees, of their spending power. It also makes the employer less competitive, the industry less competitive, and the national economy less competitive than competitors where income is directly tied to production of marketable goods and services. Since capital is accountable for the bulk of our productive output, particularly in such a capital-intensive industry as the one that Peabody is in, and workers have no access to participation in capital ownership and the "wages of capital", they are left with no choice but to make inflationary economic demands; they are left with no choice but to fear the machine and be repulsed by the profits that go to faceless outside investors. In all cases that I have been personally involved, including some with heavy union participation, worker motivation increases and alienation decreases by providing all workers a fair opportunity to own capital through an ESOP; I know of no situation where it has been otherwise.

The key to the ESOP's success is that it uniquely puts each employee in the position where the quality of his performance and the quality of the performance of his fellow-workers will directly affect the quality of his investment, his rate of capital accumulation, and his second income from dividends. He has a direct stake in maximum production and cost-minimization. A better motivator is hard to conceive. Why go out on strike?

Senator BAKER. I thank you once again for your testimony. With that, the committee will stand in recess until 2 o'clock.

[Whereupon, at 11:55 a.m., the committee recessed, to reconvene at 2 p.m., the same day.]

AFTER RECESS

[The committee reconvened at 2 p.m., Senator Howard H. Baker, Jr., presiding.]

Senator BAKER. The committee will resume.

This afternoon our first witnesses are once again a TVA panel, headed by Mr. Lynn Seeber, general manager. Mr. Seeber, if you and your associates will come to the table, we will be glad to hear from you. I might announce now that if the schedule on the Senate floor holds up, there will be a vote at 2:30 p.m. and another rollcall vote at 2:45 p.m.

If that in fact occurs, we will plan to recess at 2:30 p.m. or until about 3 o'clock. We will hold then beyond our usual adjournment hour, if necessary, in order to complete today's witness schedule.

This afternoon's witnesses consist of, in addition to Mr. Seeber and his panel, the Tennessee Construction Industry, Mr. W. R. Carter, chairman, TVA Relationship Committee; Associated General Contractors; Tennessee Valley Trades and Labor Council.

Mr. Seeber, we are pleased to have you back again as our most regular witness. We will be happy to hear from you.

STATEMENT OF LYNN SEEBER, GENERAL MANAGER, TVA; ROBERT BETTS, DIRECTOR OF PERSONNEL; GEORGE KIMMONS, MANAGER OF ENGINEERING DESIGN AND CONSTRUCTION; ROBERT MARQUIS, GENERAL COUNSEL, AND HERBERT SANGER, DEPUTY GENERAL COUNSEL

Mr. SEEBER. Thank you, Mr. Chairman. I would first like to introduce the other members of the panel. On the far left is Robert Betts, Director of Personnel for TVA; then George Kimmons, head of our Office of Engineering Design and Construction; Robert Marquis, General Counsel; Herbert Sanger, Deputy General Counsel.

Senator BAKER. Gentlemen, welcome. We have a statement. Do you want go forward with that at this time?

Mr. SEEBER. Yes, please.

We are pleased to have the opportunity to report to the committee on TVA employment and construction practices. We would like in this opening statement to give you a general insight into the subject areas, and focus specifically on two areas in which the committee has indicated particular interest: First, wage rates, and then TVA's use of the force account method of construction as opposed to construction by contract.

LABOR-MANAGEMENT RELATIONSHIPS IN TVA

The philosophy behind TVA's labor-management relationships is that management and employees should be cooperators working toward a mutual goal, rather than adversaries. We have found that this kind of atmosphere produces better productivity and efficiency, and we are very proud of the excellent relationships that TVA has enjoyed with the unions through the years.

The TVA Board first recognized the right of employees to organize and bargain collectively in 1934. Since 1937, TVA's trades and labor employees have been represented by the Tennessee Valley Trades and Labor Council, which is made up of 16 national and international unions.

The salary policy employees panel, composed of three AFL–CIO unions and two independent unions, has represented TVA nonmanagement white collar workers since 1943. In fact, TVA's experience in union-management relations has long been regarded as a model for public agencies.

All jobs with TVA fall within two major classifications: Salary policy and trades and labor. In the salary policy group are positions in professional and related technical fields, and in administrative, clerical, security, and custodial fields.

In the trades and labor group are operating and maintenance positions, and all construction workers.

WAGE RATES

The TVA Act states that its trades and labor force shall be paid "the prevailing rate * * * prevailing in the vicinity." And the act further states that in determining and prevailing rate, "due regard shall be given to those rates which have been secured through collective agreement by representatives of employers and employees." Contractors on TVA construction sites also are required under the act to meet the prevailing wage provision.

DEFINITION OF VICINITY

The term "vicinity," which is defined and written into TVA collective bargaining agreements, includes the Tennessee River watershed area, the TVA power service area, and certain adjacent urban centers. Large cities near the TVA area like Louisville and Atlanta are included in the vicinity because they represent major labor markets from which TVA would logically draw some of its work force. TVA rates of pay must be somewhat comparable with those paid in cities like these if we are to have an adequate number of employees with the various technical skills required for TVA's complex construction and operations program.

TVA employees in a given classification are paid at the same rate, no matter where in the region they work for TVA, and this has proved to

be operationally efficient. It has served to virtually eliminate problems for both labor and management which likely would be present under any other system.

I think the committee could envision the difficulties if TVA and employee bargaining units conducting separate wage surveys and negotiations, for example, at the Raccoon Mountain pumped-storage project near Chattanooga, at the Sequoyah nuclear plant a few miles up the river, and at the Watts Bar nuclear plant a few more miles up the river. It could hardly contribute to progressive and mutually cooperative labor-management relations.

DETERMINING THE PREVAILING WAGE

Both labor and management participate in determining exactly what constitutes the prevailing wage. This is done each year through negotiations based on a wage survey. A joint TVA-union wage data committee decides the cities and companies within the vicinity which are to be surveyed.

The committee later validates and verifies the wage facts produced by the survey, and these facts become the basis for negotiations. To give you an example, in 1974, construction craft wage and fringe benefit data were obtained in a survey of 14 cities.

Operating and maintenance wage and fringe data were obtained in a survey of 70 companies. I might point out here that from management's standpoint, we must be sure our comparison is made with those situations that provide or demand the same high degree of skill and experience in employees which is necessary in the work TVA does.

For example, it would not be proper for us to compare wages paid to people to build barns with wages paid for people to build nuclear powerplants when the degree of skill is different.

Nuclear plants require a high degree of skill and workmanship, and we must be able to compete for these workers with other employers building nuclear plants.

I would like now to take a look at the most recent trades and labor negotiations to show you how we came out in terms of wage rates and fringe benefits. Since we went into this area somewhat yesterday, you will recall that Senator Brock raised a question which caused us in effect to go through this next chart, I think perhaps we can eliminate that in the interest of time.

Senator BAKER. I think that is a good idea. The chart, of course, will be made a part of the record.

Mr. SEEBER. We also have in my statement yet another chart on electricians. I don't think any explanation is necessary there. It shows the same sort of thing. As we agreed yesterday, we are going to file for the record copies of each craft giving this same type of information.

Senator BAKER. By areas?

Mr. SEEBER. Yes.

Senator BAKER. Thank you.

[The charts follow:]

HOURLY WAGE RATES - CARPENTER

LOCATION BY RANK ORDER	EFFECTIVE DATE	RATE CONSIDERED IN DECEMBER 1974 NEGOTIATIONS
LOUISVILLE	6-74	9.350
ATLANTA	1-75	8.950
MEMPHIS	6-74	8.550
SHOALS AREA	1-75	8.140
CHATTANOOGA	1-75	7.980
NASHVILLE	11-74	7.900
BIRMINGHAM	9-74	7.900
→ TVA	1-75	7.725
HUNTSVILLE	1-75	7.490
KNOXVILLE	1-75	7.340
PADUCAH	7-74	7.200
JACKSON	1-75	6.850
GADSDEN	6-74	6.850
ASHEVILLE	5-74	6.750
TRI-CITIES	1-75	5.500

HOURLY WAGE RATES - ELECTRICIAN

LOCATION BY RANK ORDER	EFFECTIVE DATE	RATE CONSIDERED IN DECEMBER 1974 NEGOTIATIONS
LOUISVILLE	3-75	11.170
ATLANTA	8-74	10.887
MEMPHIS	3-75	9.523
PADUCAH	6-74	9.138
PADUCAH (OUTSIDE)	6-74	9.138
CHATTANOOGA	3-75	9.130
BIRMINGHAM	6-74	8.885
GADSDEN	6-74	8.885
→ TVA	1-75	8.759
HUNTSVILLE	12-74	8.734
SHOALS AREA	12-74	8.734
KNOXVILLE	10-74	8.229
JACKSON	12-74	8.179
NASHVILLE	6-74	8.173
BIRMINGHAM (LINE)	6-74	8.057
GADSDEN (LINE)	6-74	8.057
TRI-CITIES	6-74	7.067
ASHEVILLE	12-74	6.310

Mr. SEEBER. In summary, we believe our employees are compensated in accordance with the TVA Act, neither overpaid nor underpaid. These charts show the pattern which demonstrates this.

FORCE ACCOUNT CONSTRUCTION

The next topic I would like to address is force account construction. I would like to talk for a moment now about TVA construction practices. TVA's policy is to get its work done in the most efficient way possible and this has proved to be—primarily with its own employees. This is known as the force account method of construction, as opposed to construction by contract.

I would not, however, want the committee to get the mistaken impression that we do it all. TVA uses contract construction where we think that this would be more efficient. As a matter of fact, at the end of February of this year, TVA had nearly $312 million in work performance contract awards outstanding for projects currently under construction.

They range from a $216 million contract for glass and glazing at Browns Ferry nuclear plant to two contracts totaling $92 million for the purchase and installation of gas turbines on the site of TVA's Johnsonville steamplant.

TVA believes there are several distinct advantages to force account construction, and perhaps most significant is that of cost. I would like to give you an example of this. As you might imagine, with all the varying factors that go into a construction project as complicated as a major electric generating station, it is only once in a great while you come upon a case which permits a direct comparison of force account and contract work to be made. Such a case is provided by TVA's Shawnee steamplant, built under force account supplemented by contract work, when compared with the Joppa, Ill., steamplant, which was constructed by private utilities under contract with one of the largest private engineering-construction organizations in the country.

I might mention that at the time this was billed as a horse race to see who could do the best in building plants more efficiently. These two plants are located within 10 miles of each other on the opposite sides of the Ohio River. Both plants were built at the same time for the purpose of supplying power to the Atomic Energy Commission's plant at Paducah, Ky. Both plants are coal fired and have rail and barge facilities for the delivery of coal. The plants are designed to operate under essentially the same steam pressure and temperature. Other operating facilities are comparable and the thermal efficiency of both plants is about the same. The Joppa plant is a "full outdoor" type, while Shawnee is fully enclosed, which makes it more expensive as a capital expenditure but has certain advantages in savings in operating costs.

Although the Joppa plant had a higher priority on delivery of major equipment than the Shawnee plant, the first two units of the Shawnee plant were placed into commercial operation before the first unit of the Joppa plant came on line in the summer of 1953. TVA

had two more Shawnee units in operation within the following 6 months, before the second Joppa unit went into service.

The Federal Power Commission reports that the cost per kilowatt of installed capacity was $177 for the Joppa plant and $152 for the Shawnee plant. If the Shawnee plant had been built under a contract at the Joppa price per kilowatt, the Shawnee plant would have cost the Federal Government approximately $34 million more than it did under force account.

As I mentioned, the Joppa-Shawnee case occurred during the 1950's, and there may never again be a situation in which the factors are so similar for two virtually identical plants. Others may make other comparisons. I will mention, in departing from my statement, a couple of cautions. If people want to make these cost comparisons of what it takes to build plants, make sure that they are talking about the same kind of a plant. For example, it is not proper to compare a coal-fired plant with a gas- or oil-fired plant.

A coal-fired plant because of the coal handling facilities is more expensive. Another is, make them tell you the dates upon which the plants were built because that can make quite a considerable difference.

We can also, looking to the future and the present, get some strong indications of how things are going today if we compare how TVA force account construction compares with contract construction, looking at the data for nuclear plants.

We have a chart here on the easel. It is also in my statement.

This chart is taken from the AEC report entitled, "The Nuclear Industry, 1974." Across the bottom you have years when plants are supposed to be in commercial operation. Vertically, you have the dollars in kilowatts of installed capacity. All of the white dots on that are actual plants that have been built or are being built by utilities. This is the entire list.

We haven't been selective. This is all there is. Incidentally, I would like to file for the use of the committee an index showing the identity of each of these plants. If you have some curiosity about which one was No. 42, this list will enable you to determine that.

Senator BAKER. Thank you, sir. We will be glad to have it. Which one is dot No. 46?

Mr. SEEBER. No. 42?

Senator BAKER. No. 46. That is the one at the top, just out of curiosity.

Mr. SEEBER. No. 46. Barron?

Mr. BARRON. It is the Long Island Lighting Co. plant, the Shoreham plant.

Senator BAKER. Do you have any idea why it cost more than anybody else?

Mr. SEEBER. I haven't spotted No. 46, Mr. Chairman.

No. We really don't have specific information like that. They may have been built in a pretty high construction cost area.

Senator BAKER. High-class neighborhood.

We will receive the charts and the index.

[The material referred to follows:]

ESTIMATED CAPITAL COST PER KILOWATT FOR U.S. NUCLEAR PLANTS [1]—INDEX

Operating utility and plant	Size (MWe, net)	Estimated cost (millions) [1]	Cost per kilowatt, net	C.O. date
1. Connecticut Yankee A. P. Co., Haddam 1	575	$99	$172	January 1968.
2. Jersey Central P. & L. Co., Oyster Creek 1	640	91	142	December 1969.
3. Niagara Mohawk Power Corp., Nine Mile Point	625	162	259	Do.
4. Southern California Edison Co., San Onofre 1	430	97	226	January 1968.
5. Gulf States Utilities Co., River Bend 1	934	541	579	1980.
6. Boston Edison Co., Pilgrim 1	664	232	349	December 1972.
7. Commonwealth Edison Co., Dresden 2	809	100	124	1970.
8. Consolidated Edison Co., Indian Point 2	873	206	236	August 1973.
9. Florida P. & L. Co., Turkey Point 3	693	110	159	December 1972.
10. Northeast Nuclear Energy Co., Millstone 1	652	97	149	March 1971.
11. Public Service Co. of Colorado, Ft. St. Vrain	330	229	694	1974.[3]
12. Rochester G. & E. Corp., Robert E. Ginna	490	83	169	March 1970.
13. Carolina P. & L. Co., Robinson 2	700	81	116	March 1971.
14. Commonwealth Edison Co., Dresden 3	809	130	161	November 1971.
15. Commonwealth Edison Co., Quad Cities 1	800	150	188	February 1973.
16. Commonwealth Edison Co., Quad Cities 2	800	100	125	1972.
17. Consumers Power Co., Palisades	700	147	210	December 1971.
18. Duke Power Co., Oconee 1	886	156	176	July 1973.
19. Duke Power Co., Oconee 2	886	160	181	September 197 .
20. Metropolitan Edison Co., Three Mile Island 1	819	408	499	Do.
21. Northern States Power Co., Monticello	545	105	193	July 1971.
22. Omaha Public Power District, Ft. Calhoun	457	175	383	June 1974.
23. Pacific G. & E. Co., Diablo Canyon 1	1,084	397	366	1975.
24. Philadelphia Electric Co., Peach Bottom 2	1,065	527	495	May 1974.
25. Philadelphia Electric Co., Peach Bottom 3	1,065	226	212	December 1974.
26. Public Ser. E. & G. Co., Salem 1	1,090	496	455	1977.
27. Vermont Yankee N. P. Corp., Vermont Yankee	514	184	358	November 1972.
28. Virginia E. & P. Co., Surry 1	788	251	319	December 1972.
29. Virginia E. & P. Co., Surry 2	788	149	189	May 1973.
30. Wisconsin Michigan Power Co., Point Beach 1	497	74	149	December 1970.
31. Arkansas P. & L. Co., Nuclear One 1	850	228	268	December 1974.
32. Baltimore G. & E., Calvert Cliffs 1	845	338	400	Do.
33. Baltimore G. & E., Calvert Cliffs 2	845	258	305	1977.
34. Commonwealth Edison Co., Zion 1	1,050	276	263	December 1973.
35. Commonwealth Edison Co., Zion 2	1,050	271	258	September 1974.
36. Consolidated Edison Co., Indian Point 3	965	400	415	1975.
37. Duke Power Co., Oconee 3	886	166	187	December 1974.
38. Duquesne Light Co., Beaver Valley 1	852	451	529	1975.
39. Florida P. & L. Co., Turkey Point 4	693	121	175	September 1973.
40. Florida P. & L. Co., St. Lucie 1	810	366	452	1975.
41. Florida Power Corp., Crystal River 3	825	335	406	1975.
42. Georgia Power Co., Hatch 1	786	366	466	1974.[3]
43. Indiana & Michigan Power Co., D. C. Cook 1	1,060	800	{377	September 1975.[3]
44. Indiana & Michigan Power Co., D. C. Cook 2	1,060		{377	1976.
45. Jersey Central P. & L. Co., Three Mile Island 2	905	521	578	1978.
46. Long Island Lighting Co., Shoreham	819	695	849	1978.
47. Maine Yankee A. P. Co., Maine Yankee	790	219	277	December 1972.
48. Nebraska Public Power District, Cooper	778	316	406	July 1974.
49. Northern Indiana Public Service Co., Bailly	660	244	370	1980.
50. Northern States Power Co., Prairie Island 1	530	400	{377	December 1973.
51. Northern States Power Co., Prairie Island 2	530		{377	December 1974.[3]
52. Northeast Nuclear Energy Co., Millstone 2	828	380	459	1975.
53. Washington Public Power Supply System, Project 3	1,242	745	600	1981.
54. Philadelphia Electric Co., Limerick 2	1,065	539	506	1981.
55. Public Service E. & G. Co., Salem 2	1,115	496	445	1979.
56. Sacramento Municipal Utilities District, Rancho Seco	913	335	367	March 1975.[3]
57. Virginia E. & P. Co., North Anna 1	898	446	497	1976.
58. Wisconsin Electric Power Co., Point Beach 2	497	88	177	1972.
59. Wisconsin Public Service Corp., Kewaunee	541	202	373	June 1974.
60. Carolina P. & L. Co., Brunswick 1	821	269	328	1975.
61. Carolina P. & L. Co., Brunswick 2	821	339	413	September 1975.[3]
62. Consumers Power Co., Midland 1	492	940	{718	1980.
63. Consumers Power Co., Midland 2	818		{718	1979.
64. Detroit Edison Co., Fermi 2	1,093	501	458	1979.
65. Iowa Electric L. & P. Co., D. Arnold	569	211	371	December 1974.[3]
66. Pacific G. & E. Co., Diablo Canyon 2	1,106	282	255	1976.
67. Pennsylvania P. & L. Co., Susquehanna 1	1,050	692	660	1980.
68. Wisconsin Electric Power Co., Koshkonong 1	900	515	572	1981.
69. Portland General Electricity Co., Trojan	1,130	334	296	1976.
70. Power Authority of S. New York, Fitzpatrick	821	301	367	June 1975.[3]
71. Toledo Edison Co., Davis Besse 1	906	409	451	1976.
72. Alabama Power Co., Farley 1	829	455	549	1976.
73. Cincinnati G. & E. Co., Zimmer 1	810	434	536	1979.
74. Duke Power Co., McGuire 1	1,180	729	{309	1978.
75. Duke Power Co., McGuire 2	1,180		{309	1979.
76. Duke Power Co., Catawba 1	1,153	498	432	1981.
77. Pub. Ser. E. & G. Co., Hope Creek 1	1,067	565	530	1981.
78. Puget Sound P. & L. Co., Skagit 1	1,277	900	705	1981.
79. Alabama Power Co., Farley 2	829	362	437	1977.
80. Arkansas P. & L. Co., Nuclear One 2	912	318	349	1977.
81. Commonwealth Edison Co., LaSalle 1	1,078	770	{357	1979.
82. Commonwealth Edison Co., LaSalle 2	1,078		{357	1981.
83. Florida Power & Light Co., St. Lucie 2	810	360	444	1979.

See footnotes at end of table.

ESTIMATED CAPITAL COST PER KILOWATT FOR U.S. NUCLEAR PLANTS [1]—INDEX—Continued

Operating utility and plant	Size (MWe, net)	Estimated cost (millions) [1]	Cost per kilowatt, net	C.O. date
84. Georgia Power Co., Hatch 2	795	$513	$645	1978.
85. Louisiana P. & L. Co., Waterford 3	1,113	445	400	1980.
86. Mississippi P. & L. Co., Grand Gulf 1	1,250	656	525	1979.
87. Southern California Edison Co., San Onofre 2	1,140	1,311	575	1980.
88. Southern California Edison Co., San Onofre 3	1,140		575	1981.
89. Virginia E. & P. Co., North Anna 2	898	240	267	1977.
90. Carolina P. & L. Co., Harris 1	900	502	557	1981.
91. Portland General Electric Co., Pebble Springs	1,260	644	511	1981.
92. Northeast Nuclear Energy Co., Millstone 3	1,156	648	561	1979.
93. Long Island Light Co., Jamesport 1	1,150	803	698	1981.
94. Commonwealth Edison Co., Byron Station 1	1,120	496	443	1981.
95. Arizona Public Service Co., Palo Verde 1	1,270	602	474	1981.
96. Delmarva P. & L. Co., Summit 1	770	399	518	1981.
97. Illinois Power Co., Clinton 1	955	435	455	1980.
98. Duquesne Light Co., Beaver Valley 2	852	685	804	1981.
99. Niagra Mohawk Power Corp., Nine Mile Pt. 2	1,080	609	564	1981.
100. Pacific G. & E. Co., GE No. 1	1,128	647	574	1981.
101. Houston Lighting & Power Co., Allen's Creek 1	1,150	608	528	1980.
102. Washington Public Power Supply System, Nuclear Pro. 1	1,206	645	535	1980.
103. Texas Power & Light Co., Comanche Peak 1	1,150	355	309	1980.
104. South Carolina E. & G. Co., Summer	900	355	394	1978.
105. Virginia E. & P. Co., North Anna 3	907	396	437	1979.
106. Virginia E. & P. Co., North Anna 4	907	281	310	1980.
107. Washington Public Power Supply System, Hanford 2	1,103	472	428	1978.
108. Union Electric Co., Callaway 1	1,150	839	730	1981.
109. Public Service of New Hampshire, Seabrook 2	1,200	567	472	1981.
110. Boston Edison Co., Pilgrim 2	1,180	561	475	1980.
111. Cleveland Electric Illum. Co., Perry 1	1,205	1,234	512	1979.
112. Cleveland Electric Illum. Co., Perry 2	1,205		512	1980.
113. Commonwealth Edison Co., Braidwood 1	1,120	999	446	1980.
114. Commonwealth Edison Co., Braidwood 2	1,120		446	1981.
115. Public Service of New Hampshire, Seabrook 1	1,200	608	507	1979.
116. Mississippi P. & L. Co., Grand Gulf 2	1,250	571	457	1981.

[1] Cost and schedule information for non-TVA plants is taken from NRC report WASH 1174-74, "The Nuclear Industry, 1974." A footnote in the report states that "(Estimated cost) figures are taken from various sources and are not necessarily on comparable bases. Cost of the nuclear fuel core and transmission station are not included."
[2] Not commercial.

Mr. SEEBER. The TVA plants are shown in black dots on that chart. Browns Ferry is the first, Sequoyah Watts Bar, Bellefonte and Hartsville shown as the little black dots across there. However, I would like to point out, although we look pretty good on that chart, we disadvantaged ourselves in making this chart because all the white dots are data that were earlier than ours.

These are our current and up-to-date figures, the ones that we submitted to Congress as a part of our report on our appropriations proceeding. If we had put our dots on there using the same time frame as theirs, we would have another one to show you that indicates we are lower than anybody as of the same time.

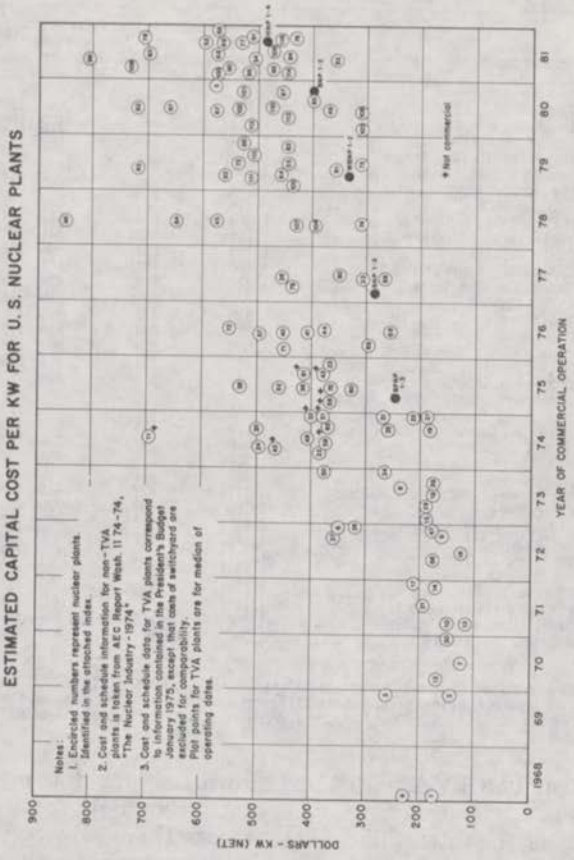
Another chart that Mr. Barron will put up will show, hopefully, red dots across the bottom. That may be difficult for you to see, Mr. Chairman. But the small red dots across the bottom indicate our estimates as of the time these other figures were taken.

Another way of looking at it is what we have found out since about the cost of other plants to bring them in time up to our black dots. We have yet a third chart. We do not have data on what has been happening in the entire industry, but you will see there in each case you have a red dot and a line leading back to where the estimate was at another time.

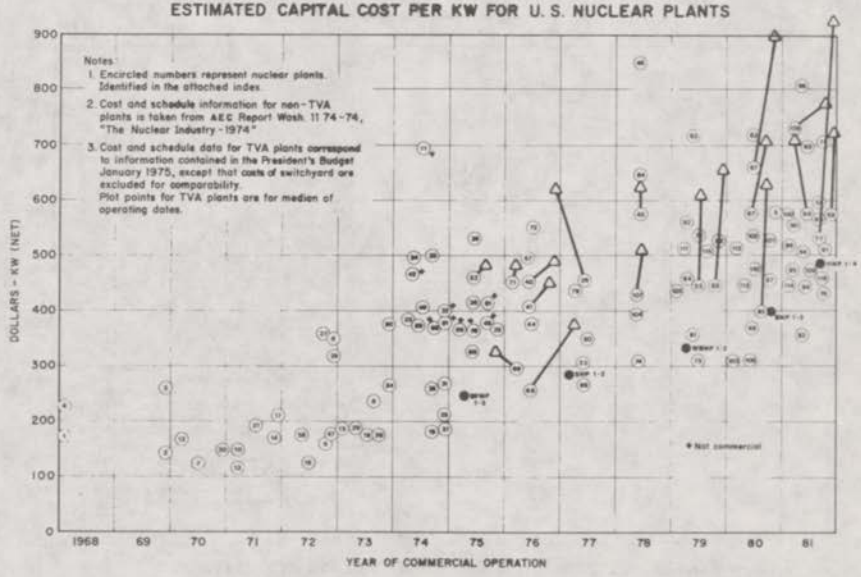
Senator BAKER. Could you supply us with copies of these charts so we can put them in the record?

Mr. SEEBER. Yes; we will be happy to supply them and we have small copies that we can supply for the record.

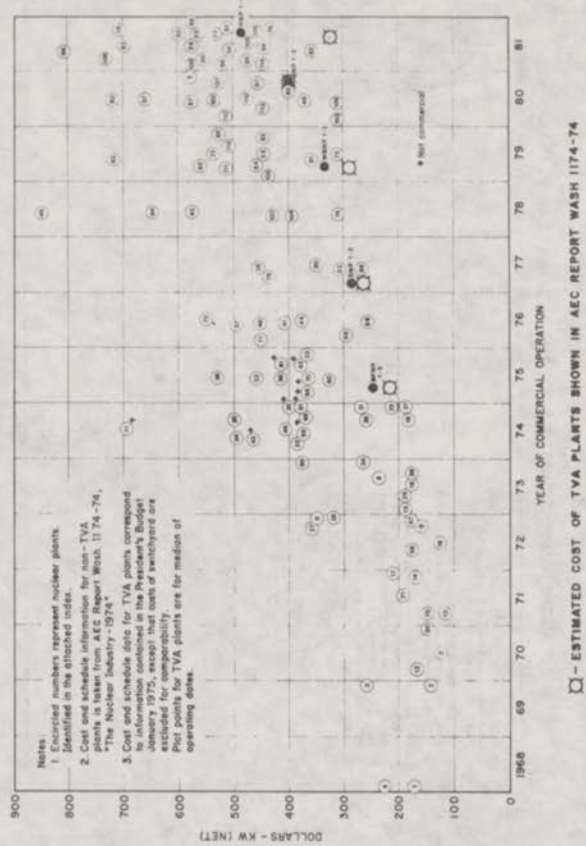
[The charts follow:]

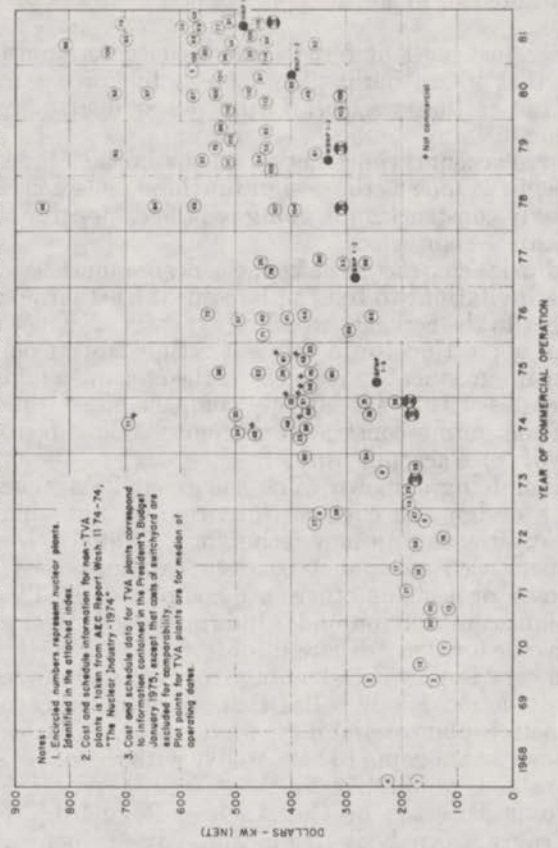

ESTIMATED CAPITAL COST PER KW FOR U. S. NUCLEAR PLANTS
Notes:
1. Encircled numbers represent nuclear plants identified in the attached index.
2. Cost and schedule information for non-TVA plants is taken from AEC Report WASH. 1174-74, "The Nuclear Industry - 1974."
3. Cost and schedule data for TVA plants correspond to information contained in the President's Budget January 1975, except that costs of switchyard are excluded for comparability.
Plot points for TVA plants are for median of operating dates.
DOLLARS - KW (NET)
900
800
700
600
500
400
300
200
100
0
1968
69
70
71
72
73
74
75
76
77
78
79
80
81
YEAR OF COMMERCIAL OPERATION
Not commercial

ESTIMATED CAPITAL COST PER KW FOR U. S. NUCLEAR PLANTS



△ - REVISED ESTIMATES FROM AEC QUARTERLY REPORTS FOR JAN 1, 1975


ESTIMATED CAPITAL COST PER KW FOR U.S. NUCLEAR PLANTS
Notes:
1. Encircled numbers represent nuclear plants identified in the attached index.
2. Cost and schedule information for non-TVA plants is taken from AEC Report Wash. 1174-74, "The Nuclear Industry - 1974"
3. Cost and schedule data for TVA plants correspond to information contained in the President's Budget January 1975, except that costs of switchyard are excluded for comparability.
Plot points for TVA plants are for median of operating dates.
DOLLARS - KW (NET)
900
800
700
600
500
400
300
200
100
0
1968
69
70
71
72
73
74
75
76
77
78
79
80
81
YEAR OF COMMERCIAL OPERATION
* Not commercial
□ - ESTIMATED COST OF TVA PLANTS SHOWN IN AEC REPORT WASH 1174-74


ESTIMATED CAPITAL COST PER KW FOR U.S. NUCLEAR PLANTS
Notes:
1. Encircled numbers represent nuclear plants identified in the attached index.
2. Cost and schedule information for non-TVA plants is taken from AEC Report Wash. 1174-74, "The Nuclear Industry - 1974"
3. Cost and schedule data for TVA plants correspond to information contained in the President's Budget January 1975, except that costs of switchyard are excluded for comparability.
Plot points for TVA plants are for median of operating dates.
DOLLARS - KW (NET)
900
800
700
600
500
400
300
200
100
0
1968
69
70
71
72
73
74
75
76
77
78
79
80
81
YEAR OF COMMERCIAL OPERATION
* Not commercial
● — DUKE POWER COMPANY PLANTS

Mr. SEEBER. Although the chart filed with my statement looks good enough, I wanted to make the point that it really is better than that chart shows.

There are advantages of force account construction other than cost. TVA feels that it can build plants faster by force account, thereby helping to insure that we meet future power demands when the demand is there.

Under force account, construction on the initial phases of a powerplant can begin as soon as the design for those phases is complete. And while the early construction is going on, the design for the remainder of the plan can be completed.

In a fixed price contract situation, the design must be virtually complete before invitations to bid can be issued. Furthermore, any subsequent charges to the contract woud be expensive because only the contractor is in a position to do the work. Substantial delays could be expected until agreement is reached on the cost of each major change.

TVA operates within a relatively compact geographical area, and TVA has a continuing construction program. Both factors are favorable for use of force account work.

In addition, doing our own work has given TVA the advantage of developing a design and construction organization which gets better as it gains experience in a new technology. It offers the flexibility of moving experienced personnel between existing construction projects, or to new projects as others are completed. If TVA contracted for powerplant construction under bidding procedures, we could have a new contractor for every different job.

Finally, a very important advantage to TVA and the region of force account construction is our belief that we obtain a better quality of work and better plant reliability when we design them and build them—because we are going to have to live with them.

To illustrate, I would like to quote from a report by Edwin G. Triner, who is Director of the Nuclear Regulatory Commission's Office of Program Analysis-Regulation. Mr. Triner says this with respect to nuclear plants built by contract:

> The AE's (architect-engineers) who are largely responsible for powerplant design have little incentive to consider increased reliability during the design process.
>
> Their interest is primarily short term. Once a plant is constructed, the AE fades out of the picture. Except for a few utilities, like Duke Power, who not only design and build the plant as well as operate it, the organization responsible for design does not usually have to live with the results.
>
> Parenthetically, our very limited investigation into this area seems to indicate that Duke Power, because of the all inclusiveness of its responsibility for design, construction, and operation, is more concerned wth the question of reliability than most other utilities. They have production engineers assigned as an integral part of the design group.

You can just as well substitute TVA for Duke Power Co., in that quote, because TVA and Duke do their own design work and use the same method of construction—force account.

Senator BAKER. Very good, Mr. Seeber. I thank you for that additional statement. Do any of your panel members have any further remarks to make in that respect? I have a few questions. The force account concept, of course, creates employment and is in competition

with private contractors obviously and some of the contractors are here to appear immediately after you.

Give us some idea how many people you employ in your force account presently for construction?

Mr. SEEBER. Mr. Kimmons will be the best person to give you those numbers.

Mr. KIMMONS. We have approximately 16,000 in our construction program now.

Senator BAKER. Is that a fairly stable figure?

Mr. KIMMONS. As we see it for the next few years; yes, sir. That will be a fairly stable figure.

Senator BAKER. Is the stability of it primarily on account of objective need for that level of work force for your nuclear program?

Mr. KIMMONS. That is correct, sir.

Senator BAKER. About how many people will you have on a single project like the Browns Ferry project?

Mr. KIMMONS. We have about 3,300 at Browns Ferry, I believe, at the peak, sir. That is a little bit high. We had three units going at one time. Normally, we will figure about 2,400 peak employees.

Senator BAKER. The cost per kilowatt-hour installed or kilowatt installed that you refer to in the FPC report, showing the Joppa plant at $177, the Shawnee plant at $152—can you give any idea how much of that represents a normal or reasonable or all profit to the contractor which, of course, TVA did not take? How much of it represents taxes? How much of that difference can we identify and isolate as the difference between the governmental agency conducting the job and private enterprise conducting the job?

Mr. SEEBER. I am personally not aware of what sort of profit they make on something like that. If anyone on the panel has any idea, please feel free to speak up. I just simply do not know.

Senator BAKER. Profit and taxes would account for part of the difference, I assume, between the $152 for Shawnee and the $177 for Joppa.

Mr. SEEBER. Yes; let's be quite frank about it. One of the advantages of force account construction work is that you eliminate the profit that would otherwise be taken by any contractor.

Senator BAKER. That is right. If there is a convenient way to give me an approximation of that in case of the Joppa-Shawnee illustration, I would be happy to have it; that is, some approximation or estimate of the amount of the difference between $152 and $177, which would represent, say, taxes and profit. That would give us a more direct comparison.

Mr. SEEBER. We are perhaps not the best witness on what profits and taxes that the contractors pay, but we will try to do what we can.

Senator BAKER. It shows you what confidence I have in you.

The first section of your statement dealing with the setting of wage rates as required by the act states that you include the cities of Louisville and Atlanta in the vicinity.

Excluding Memphis, which is about the same size, how do Louisville and Atlanta rates compare with other rates in the area? What I am driving at is does the inclusion of Louisville and Atlanta, neither of which is in the service area or the Tennessee River watershed have a particular distorting effect or does it make much difference?

Mr. SEEBER. Why not let Bob Betts, our director of personnel, who can say it better than I, take that?

Mr. BETTS. Mr. Chairman, as a general rule the Louisville and Atlanta rates are higher than the rates we find in the valley area proper.

Senator BAKER. How do they compare with Memphis?

Mr. BETTS. I have got indications here on 16 different crafts. I can give you each one individually.

Senator BAKER. Are they generally higher than Memphis?

Mr. BETTS. Let me take one or two just to make sure. Regarding the carpenters, the Louisville rate is higher than Memphis, the Atlanta rate is higher than Memphis; electricians, Louisville, Atlanta, Memphis come in that order.

I think we will find that generally true. However, you should also recognize that within the 14 cities of these surveyed, we also take in some cities that have typically traditionally lower rates than everything else that we look at.

For example, Asheville, N.C., Tri-Cities, Tenn., they tend to counterbalance each other. In fact, we have done some limited studies to see historically what would have been the effect if we had taken out this city or taken out that city or shuffled them around.

Our tentative conclusion is that it would have made very little effect.

Senator BAKER. I take it you fully subscribe to Lynn Seeber's statement that the reason for their inclusion is because they are on either side of the Tennessee Valley area and logically you would draw labor from it?

Mr. BETTS. Yes, sir. There is no possible way that TVA could get its work done relying exclusively on the labor available within our valley region proper—no possible way.

[A chart relative to number of employees follows:]

NUMBER OF EMPLOYEES AS OF OCT. 15, 1974

Location by rank order	Effective date	Rate considered in December 1974 negotiations
Group A operating engineers (Total 678):		
Paducah	January 1975	$9.188
Louisville	do	9.188
Shoals area	do	8.949
Huntsville	do	8.949
Jackson	do	8.725
Memphis	do	8.725
Atlanta	April 1975	8.722
TVA	January 1975	8.700
Birmingham	September 1974	8.414
Gadsden	do	8.414
Asheville	May 1974	7.648
Chattanooga	January 1975	7.500
Knoxville	May 1974	7.254
Tricities	do	7.254
Nashville	do	7.249
Laborer (unclassified) (Total 529):		
Louisville	June 1974	6.900
Atlanta	January 1975	5.750
Paducah	June 1974	5.680
Birmingham	September 1974	5.600
Chattanooga	May 1974	5.400
Shoals area	January 1975	5.375
Memphis	October 1974	5.350
Nashville	November 1974	5.200
TVA	January 1975	5.150
Tricities	May 1974	5.080
Knoxville	do	5.080
Huntsville	January 1975	4.780
Asheville	November 1974	4.125
Jackson	February 1975	3.900
Gadsden	June 1974	3.900

NUMBER OF EMPLOYEES AS OF OCT. 15, 1974—Continued

Location by rank order	Effective date	Rate considered in December 1974 negotiations
Steamfitters (Total 582):		
Louisville	April 1975	$11.640
Birmingham	March 1975	10.200
Atlanta	February 1975	10.050
Paducah	July 1974	10.050
Memphis	May 1974	10.020
Gadsden	April 1975	9.650
Huntsville	do	9.250
TVA	January 1975	9.250
Shoals area	do	9.000
Chattanooga	do	8.950
Knoxville	May 1974	8.800
Jackson	June 1974	8.300
Nashville	May 1974	8.140
Tricities	July 1974	7.700
Asheville	do	7.100
Structural ironworker (Total 250):		
Louisville	June 1974	10.700
Gadsden	September 1974	9.395
Birmingham	do	9.395
Memphis	June 1974	9.250
Jackson	do	9.250
Atlanta	January 1975	8.970
TVA	do	8.800
Huntsville	do	8.705
Shoals area	do	8.705
Nashville	February 1975	8.650
Paducah	October 1974	8.500
Chattanooga	November 1974	8.410
Tricities	May 1974	7.770
Asheville	do	7.770
Knoxville	do	7.770
Truck driver (Total 163):		
Louisville	July 1974	7.158
Paducah	April 1975	6.038
Shoals area	January 1975	5.955
Huntsville	do	5.955
Atlanta	do	5.900
Chattanooga	May 1974	5.890
Gadsden	September 1974	5.750
Birmingham	do	5.750
TVA	January 1975	5.675
Jackson	June 1974	5.450
Memphis	do	5.450
Nashville	May 1974	5.350
Knoxville	do	5.330
Painters (Total 92):		
Atlanta	February 1975	9.737
Gadsden	March 1975	8.540
Memphis	November 1974	8.451
Birmingham	April 1975	8.351
Louisville	March 1974	8.284
Paducah	May 1974	7.963
Huntsville	April 1975	7.951
Shoals area	do	7.951
TVA	January 1975	7.750
Tricities	July 1974	7.400
Knoxville	do	7.400
Nashville	May 1974	7.319
Chattanooga	do	7.006
Jackson	July 1974	5.814
Asheville	April 1971	4.791
Sheet metal worker (Total 73):		
Louisville	February 1975	11.300
Paducah	do	11.300
Shoals area	December 1974	9.950
Huntsville	do	9.950
Gadsden	do	9.950
Birmingham	do	9.950
Jackson	February 1975	9.750
Memphis	do	9.750
Atlanta	do	9.600
TVA	January 1975	9.425
Chattanooga	February 1975	9.170
Knoxville	do	9.170
Tricities	do	9.170
Nashville	May 1974	7.750
Asheville	November 1974	7.100

NUMBER OF EMPLOYEES AS OF OCT. 15, 1974—Continued

Location by rank order	Effective date	Rate considered in December 1974 negotiations
Boilermaker (Total 70):		
Louisville	October 1974	$10.950
Paducah	do	10.950
TVA	January 1975	9.950
Nashville	November 1974	9.700
Memphis	do	9.700
Shoals area	do	9.700
Tricities	do	9.700
Knoxville	do	9.700
Jackson	do	9.700
Huntsville	do	9.700
Gadsden	do	9.700
Chattanooga	do	9.700
Birmingham	do	9.700
Atlanta	do	9.700
Asheville	do	9.700
Machinist (Total 36):		
Louisville	June 1974	10.000
Atlanta	August 1974	8.520
Shoals area	June 1974	8.450
Chattanooga	January 1974	8.150
Nashville	July 1974	8.000
TVA	January 1975	7.800
Memphis	January 1974	7.700
Paducah	do	7.620
Birmingham	January 1972	5.800
Roofer—composition (Total 2):		
Memphis	April 1975	8.150
Jackson	do	8.150
Chattanooga	May 1974	7.050
Louisville	January 1974	7.050
Atlanta	January 1975	6.900
Paducah	do	6.800
TVA	do	6.775
Shoals area	December 1974	6.650
Birmingham	do	6.650
Huntsville	do	6.650
Gadsden	do	6.650
Knoxville	May 1974	6.550
Tricities	do	6.550
Nashville	do	6.450
Asbestos worker (None)		
Louisville	October 1974	10.460
Paducah	April 975	10.450
Memphis	October 1974	9.950
Jackson	do	9.950
Nashville	January 1975	9.250
TVA	do	9.050
Tricities	do	8.890
knoxville	do	8.890
Chattanooga	do	8.890
Atlanta	do	8.800
Huntsville	September 1973	8.310
Gadsden	do	8.310
Birmingham	do	8.310
Shoals area	do	8.310
Asheville	August 1974	7.650
Bricklayer (None)		
Memphis	January 1975	9.800
Louisville	June 1974	9.680
Atlanta	January 1975	9.250
Chattanooga	November 1974	8.900
Birmingham	September 1974	8.750
Huntsville	January 1975	8.500
Knoxville	May 1974	8.410
Shoals area	January 1975	8.345
Nashville	October 1974	8.000
Gadsden	January 1974	8.000
TVA	January 1975	7.950
Paducah	do	7.650
Tricities	June 1974	7.150
Jackson	January 1975	7.050
Asheville	May 1974	6.350

NUMBER OF EMPLOYEES AS OF OCT. 15, 1974—Continued

Location by rank order	Effective date	Rate considered in December 1974 negotiations
Lathers (None)		
Atlanta	January 1975	$9.100
Louisville	June 1974	9.040
Memphis	January 1975	8.550
Shoals area	do	8.550
Jackson	do	8.550
Knoxville	do	8.110
Tricities	do	8.110
TVA	do	7.650
Nashville	April 1974	7.500
Birmingham	March 1975	7.480
Paducah	May 1974	7.360
Huntsville	January 1975	7.320
Gadsden	do	7.320
Chattanooga	June 1974	7,150
Asheville	January 1974	5.750
Plasterer (None)		
Atlanta	January 1974	8.870
Louisville	July 1974	8.650
Memphis	January 1975	8.600
Paducah	November 1974	8.260
Birmingham	March 1975	7.770
Knoxville	November 1974	7.750
Nashville	April 1974	7.500
Chattanooga	November 1974	7.450
TVA	January 1975	7.350
Shoals area	do	7.250
Huntsville	July 1973	6.975
Gadsden	January 1975	6.930
Asheville	January 1974	5.650
Jackson	do	5.500

Senator BAKER. Gentlemen, I have two or three more questions, but the signal you hear now is the vote that was scheduled for 2:30. If I may, I will submit these questions for you to answer for the record later.

[The questions and responses follow:]

Senator BAKER. In your statement you point out that TVA had $312 million in construction contracts in effect in February of this year. Is there any reliable statistical basis for comparing that to TVA's total construction program as of February?

Can you provide a comparison of the magnitude of TVA's force account construction versus their contract construction for the past five years?

Mr. SEEBER. The $312 million in construction contracts represents a dollar value of work performance contracts entered into through February 1974 on major projects now under construction. The total obligations for direct construction costs for these projects for the same period amounts to $2,291 million. Thus work performance construction contracts are about 14 percent of the total direct construction obligations to date.

Dollar amounts paid by years on work performance contracts are not immediately available. However, a measure of the contract construction effort over the past several years is available from TVA's overall experience in the construction of coal-fired plants. In the construction of ten coal-fired steam plants by TVA, beginning with the Johnsonville plant which was started in 1949 and ending with the Cumberland plant which was placed in operation in 1973, about 9 percent of the total onsite craft labor man-hours were by contractors' forces.

Senator BAKER. In your written statement you include a graph comparing the per kilowatt cost of TVA's nuclear construction to that of other plants constructed presumably under private contract.

Only one of the TVA plants on that chart, however, is near completion—Brown's Ferry. For a better comparison can you furnish the Committee similar data on major TVA power facilities completed over the past twenty years and, if you will, a comparison of cost per kilowatt based upon FPC data of non-TVA plants for the same period.

Mr. SEEBER. In response to your question, I think a comparison of TVA's experience in construction with that of private utilities, for major power facilities, can best be done by using data published by the Federal Power Commission. FPC report S–237, "Steam-Electric Plant Construction Cost and Annual Production Expenses—Twenty-Fifth Annual Supplement—1972," is the latest available report. From that report we have tabulated the cost per kW for 192 coal-fired generating plants for which the initial year of operation was 1950 or later. These data include 12 TVA plants. The average cost for 180 non-TVA plants was $146 per kW, while the average cost for 12 TVA plants was $122 per kW. The costs are based on maximum generator nameplate rating, and exclude the cost of switchyard and transmission facilities.

Senator BAKER. The GAO report of April 29, 1975, reports that in 1975 TVA established a task force to study among other things the efficiency and economy of "force account" construction and that the task force reported:

1. TVA had not developed detailed comparisons to support its claim that construction by force account was competitive with private industry.

2. Because of limited cost data available for comparison purposes, no judgment could be made on the merits of force account versus contract construction.

It was the recommendation of that task force that TVA "let a substantial project on a contract basis from time to time for the purpose of obtaining a better measure of its own performance."

Has TVA let any "substantial contracts" to develop that information?

If so, would you furnish the Committee a detailed description of those projects and for comparison "force account" work of a similar nature in the same period?

Mr. SEEBER. TVA has not let any substantial contracts solely for the purpose of developing comparative data on the cost of contract versus force account work. We feel that we can obtain this information by comparing TVA's construction costs with the construction costs of other utilities, such as the comparison chart which we submitted for the record concerning nuclear plants. In the case of power plant construction work, we are opposed to cost-plus type contracts—the only alternative which would permit construction to proceed along with design and thus adhere to schedules already established for plant completion. In order to obtain a fixed price bid on an entire project such as a nuclear plant, or even major elements of such a plant, it would be necessary to have available perhaps 75 percent or more of the completed construction drawings and specifications. Thus construction would be delayed perhaps two years while the designs and specifications were being prepared for contract bids.

Numerous construction contracts have been awarded for specialized types of construction and some substantial contracts have been awarded for reasons other than to obtain contract versus force account work cost comparison data. For example, the design and installation electrostatic precipitators and two new 1,00-foot chimneys at Kingston Steam Plant is being performed under two contracts—one for the chimneys and one for the precipitator installation. This job is estimated at $65 million.

Another example is the installation of combustion turbines. In 1970, when TVA first began to install combustion turbines, a substantial portion of the work was done by contract. Since that time, we have used contractors to an even greater extent. Our last two installations were turn-key jobs totaling $115 million.

Senator BAKER. We will recess now until I can come back from that second vote, which I estimate will be about 20 minutes.

[Brief recess.]

Senator BAKER. The committee will come to order.

I thank the witnesses for bearing with me while I answered the two rollcall votes just completed in the Senate. I understand now that the Tennessee Construction Industry representative and the Associated General Contractors representative will appear together. Is that correct? We will be happy to have you.

Mr. Carter, we are happy to have you with us and to have this opportunity to hear your testimony. Why don't we consider you the chairman of this panel and you can introduce your colleagues.

STATEMENT OF W. R. CARTER, CHAIRMAN, TVA RELATIONSHIP COMMITTEE, TENNESSEE CONSTRUCTION INDUSTRY; KIRK FORDICE, CHAIRMAN, HEAVY INDUSTRIES DIVISION, ASSOCIATED GENERAL CONTRACTORS; ACCOMPANIED BY DON POWELSON, TENNESSEE ROAD BUILDERS ASSOCIATION; HUGH HAMMILL, PRESIDENT, ROAD BUILDERS, INC.; AND BOB MELTON, STATE EXECUTIVE DIRECTOR, ASSOCIATED BUILDERS AND CONTRACTORS

Mr. CARTER. Thank you. It is a pleasure to be here. We appreciate your listening to us. On my left is Mr. Don Powelson, for the Tennessee Road Builders Association of Nashville; next to him is Mr. Hugh Hammill, president of Road Builders, Inc., Nashville, Tenn., representing the Asphalt Paving Association of Tennessee; to my right is Mr. Kirk Fordice, of Fordice Construction Co.. Delta, La., representing AGC; to his right, Mr. Bob Melton of Nashville. He is State executive director of the ABC, the Associated Builders and Contractors.

Senator BAKER. Gentlemen, welcome. We are happy to have you as well. We have a copy of Mr. Carter's statement, the statement by Mr. Fordice and, I believe, those are the only statements we have. How would you like to proceed?

Mr. CARTER. As you wish, sir. We can paraphrase this in the interest of time.

Senator BAKER. The statement isn't very long. It is only four pages long with the exhibits on yours, Mr. Carter. You proceed as you prefer. We will do it either way. If you would rather read it, that would be great.

Mr. CARTER. All right, sir.

My name is William R. Carter. I am chairman of the board of CFW Construction Co., Inc., which is a medium-sized general contracting firm based in Fayetteville, Tenn. CFW does highway, heavy utility building, and housing construction over a geographic area of about 12 Southeastern States in addition to Tennessee.

I am officially representing the Tennessee Construction Industry comprising over 600 construction firms. Some of these contractors work union shop, some open shop, some merit shop and some a mixture. This testimony also mirrors the concern of the construction industry nationwide, along with AGC's.

We have a twofold purpose in meeting before you here to hopefully persuade or help TVA (1) To let more of its construction work, and we are thinking more of the field type construction work, to the construction industry, (2) to use a more realistic process of evaluating its prevailing wage rates.

Addressing ourselves first to the construction by contract, for the past 40 years to your knowledge and mine, the Tennessee Valley Authority has been in the forefront of the economic progress in the southeastern area of the United States.

We appear representing all segments of the construction industry in a continuing effort to benefit TVA and the Nation, as well as our own construction industry, by demonstrating, if we can, that contractors from the private sector should do more of the Tennessee Valley Authority's construction work.

We do acknowledge that TVA now lets considerable work to contractors, but we think more field type construction should be let. A great deal of the amount of over $300 million that TVA has let under contract now to contractors is for turbines and turbine installations and switch gear and things of that nature.

We are addressing ourselves more to field work, like grading.

Senator BAKER. Field work, meaning what? Describe what you mean.

Mr. CARTER. Grading, concrete, carpentry, just field construction, building construction and that type of thing.

We believe that the benefits of TVA using our industry more than it does will let them realize benefits of reoriented and improved regional impact and very importantly, better community relations.

We are sure that the competitive bid process is far superior and more economical than the "force account" method using "in-house forces" as is the current practice of TVA. Exhibit No. 1—even though there be discussion of how books are kept—gives an idea of ultimate construction cost comparisons.

There is quite a lot of discussion about the way TVA's books are kept versus private enterprise and there is a difference in cost of the coal-fired steamplant versus a gas-fired one. But this exhibit No. 1 we think gives a good indication of TVA's comparative cost.

TVA in some instances can let their work by contract by the competitive bid process in that they can complete their plans and specifications and then receive bids and let the low and best bidder do the work.

In other cases we also realize that time and technology and technique mandate that TVA construction be started simultaneously with its plans and specifications. This is not an ideal situation. just simply a necessary one. It is the reason most commonly used by TVA to justify its "in-house force" construction program.

We submit that this part of TVA's construction work also can be done by private contractors on a cost-plus or fixed fee or some other flexible basis that allows the work to be done simultaneously with plans and specifications being completed.

A large part of TVA's construction is complex and it is large in magnitude and TVA in the past has voiced concern as to whether the construction industry has the capacity to complete this large complex work satisfactorily.

The construction industry prides itself in its ability to build a quality product in a predictable time frame at a reasonable cost. Construction is high-risk and low-profit industry. We had a survey made in 1972 by Midwest Research Institute covering the prior 10 years. The survey showed that the construction industry earns the lowest margin of profit and has the highest percentage of failure of any industry comprising our gross national product.

We submit, however, that the construction industry historically survives by its ability to cope with the myriad problems of construction and is more qualified and capable of completing projects on time and within the budget than is TVA, as is annually illuminated by budget hearings in the Congress.

The construction industry is the largest single segment of our gross national product, about 12 percent. We obviously have access to manpower, engineers, ecologists, and all sorts of personnel and services to do the TVA's work.

The construction industry historically has successfully completed almost all of the significant construction in the United States as well as in the Southeastern United States, including the atomic energy works at Oak Ridge, the Arnold Engineering Development Center, and many other complex projects in the Tennessee Valley area.

The State highway departments throughout the Nation, the Soil Conservation Service, the Bureau of Reclamation, the Corps of Engineers, private and public utilities, and others similar to TVA have obviously used the construction industry successfully.

We are now in a time of rapid change. We feel it is especially important that TVA avail itself of the construction industry's flexibility and strength. We are confident that we are uniquely qualified to cope with all of the seemingly insurmountable problems of inflation, low productivity, and questionable quality that plague all construction.

We are taught by history that any enterprise and especially any public enterprise, tends to lose efficiency and to increase in comparative cost as time goes on. We in the construction industry, of course, are affected by this phenomena also, but our survival is predicated on our ability to minimize it.

The construction industry, we feel, is one of the few remaining bulwarks of free enterprise in our Nation, and can help sustain our Nation.

We offer our industry to serve TVA as one of its tools of progress. We realize the change in TVA's procedure must be gradual. In the best interest of TVA and the best national interest, we urge TVA to proceed with all possible haste to use the construction industry. The hour is late.

Addressing ourselves secondly to prevailing wages, TVA was created during the depression in 1933. Construction wages in the Tennessee Valley area were extremely low. Obviously, one of TVA's intended, or at least accomplished, goals was to raise the construction wage levels in the area.

Also, an initial problem encountered was that the construction projects of TVA did require skills somewhat different from those known in the valley in the early years and the resulting short supply of qualified workmen forced TVA to look to adjacent areas for certain skills and to pay sufficiently high wages to attract people from these other areas.

Senator BAKER. Do you think that is not the case now?

Mr. CARTER. No, sir. We don't feel that is the case now.

Senator BAKER. You heard the testimony earlier about the inclusion of Louisville and Atlanta and the determination of the prevailing wage.

Does that have any bearing in your view on the appropriateness of the wage?

Mr. CARTER. Yes, sir. We don't feel that they should be included. We think prevailing wage is prevailing as the word states, and it also is minimum as applied to TVA. This is the minimum wage they can pay. So you don't need to go all over the place looking for high wages to establish a minimum wage. We don't argue with the point that TVA may need in some instances, to pay higher wages than what really is prevailing. We have no argument with that.

But the fact they establish an artificially high wage as a minimum wage has hurt our industry.

Senator BAKER. Go ahead.

Mr. CARTER. From TVA's inception, it has used section 3 of the Tennessee Valley Authority Act to predetermine just one prevailing wage for each craft in the whole area of operation. Section 3 contains these specific words, "not less than the prevailing rate of wages for work of a similar nature prevailing in the vicinity shall be paid to laborers and mechanics."

It also says, "Due regard shall be given to those rates which have been secured through collective agreement."

In our opinion, TVA historically misinterprets these keywords in that language; "prevailing," "vicinity," "due regard," and "not less than."

Their interpretation of "prevailing" is "union" wages. They interpret "vicinity" to encompass 80,000 square miles, whereas the State of Tennessee, which TVA encompasses, covers 42,000 square miles, and it establishes nine different vicinities or zones for prevailing wages at this time. The Davis-Bacon arrangement with the U.S. Government establishes even smaller areas. "Due regard" is interpreted by TVA to mean "total regard." In other words, they give regard to nothing else but the union wage scale.

We understand that TVA may need to pay more, as I previously stated, than the prevailing wages as might properly be established and as are really prevailing. The original act in article 3 recognized this fact in the outset by stating that "not less than" the prevailing wage will be paid. TVA can pay more than, but just not less than.

We feel it is not fair or reasonable to base prevailing wage determination on the highest union wages to be found in the area and nearby, and then require either TVA or the contractors who work for TVA to pay "not less than" these artificially high wages.

We have two more exhibits, one showing the nine areas of Tennessee and the average wage rate for the crafts in each one of them. It shows that the average TVA rate for all crafts is about 35 percent higher than the average of the prevailing rate of the nine zones of Tennessee shown in exhibit 3.

TVA now takes the position that its previous action of using only union wage rates and only one areawide rate, and going out of the vicinity to obtain rates to compare with has by precedent locked TVA in the position of having to continue this method of determining prevailing wages.

To assist TVA in overcoming this obstacle, we required Congress to consider amending the TVA Act or at least urging TVA to be more flexible in order that prevailing wages may be more representative of the rates actually paid in the area.

The construction industry and I personally can assure you that varying minimum wages or prevailing wages in small areas can be coped with successfully. We in the construction industry do this all the time.

A change in the TVA method of wage determination would assist the Tennessee Valley by lowering cost of power or at least minimizing the high rate of power cost escalation and also by curtailing the bad effect that the present policy is having on the construction industry and consequently on the whole economy.

An example is the contractor in Knoxville, Tenn., who recently made a study—a time and motion study—of mechanism sent from a Knoxville equipment dealer to his jobs located some 50 miles from Knoxville.

He found that the cost per hour pulling wrenches—in other words, actually at work—was from $45 to $65, travel and lost time included.

We feel that TVA's inadvertent input into this situation has been significant.

Senator BAKER. What do you mean by "TVA's inadvertent input"?

Mr. CARTER. TVA's work practices in addition to its high wage rates breeds high cost and low production.

Mr. Chairman, we think that times have changed. I did work with TVA in the early 1940's and am grateful for the opportunity to work and learn. I admire TVA greatly, and others in our industry, and in our area, do also.

But we feel TVA should recognize that times have changed, and we feel that the free enterprise system should be used by TVA.

We think it is the system that will best get the job done. Free enterprise is the most difficult or demanding boss that anyone ever had because it doesn't accept excuses. It gets the best results.

We think that TVA could greatly profit by using our free enterprise construction industry. I thank you, sir.

Senator BAKER. Mr. Carter, thank you very much. I have to say that the most graphic description of hard work I have ever read is in your written statement—"We did work, however, and many was the morning our survey party drove 50 miles, walked to the survey line, set up our instruments, and waited for enough light to go to work."

How do you assess the relative impact of Davis-Bacon with respect to other Federal agencies and the TVA practices on the prevailing wage field?

Mr. CARTER. I personally think, and our industry feels, that need for a prevailing wage as established by Davis-Bacon has long since passed. It is just costing us millions of tax dollars and our economy dollars by having Davis-Bacon.

We feel like there is no slave labor any more. The market can seek its own level by supply and demand just like we expect other segments of our economy to seek its own level.

We see no need for prevailing wages. We know that TVA should have some policy for paying their own wages, but not if they were subcontracting or contracting with the free enterprise construction industry. I just don't think we need any prevailing wages, period.

If we are going to have them, then they should be just that, prevailing wages in the vicinity.

Senator BAKER. Not a minimum wage.

I understand that the areas are not the same, so a direct comparison may not be possible, but is there a substantial disparity between the Davis-Bacon prevailing wage as determined from time to time by the Secretary and the TVA prevailing wage?

Can you give me some idea of how much difference there is?

Mr. CARTER. It varies from place to place. Of course, TVA has one rate. Davis-Bacon will have a number of varying rates for different areas throughout the TVA area. It would be a very significant difference up to Davis-Bacon being lower than 50 percent of the TVA prevailing rate.

Senator BAKER. Would you say on the average it would be 50 percent?

Mr. CARTER. No. I would say on the average it would be somewhat over 50 percent, say 60 to 65 percent, something like that.

Senator BAKER. So you think on the average, it is a rough estimate only, that the Davis-Bacon prevailing rate would be about 65 percent of the TVA prevailing rate under section 3 of the TVA Act?

Mr. CARTER. Yes, sir.

Senator BAKER. Do you have any idea how much work TVA has under force account and how much work they have out on contract?

I believe we may have asked TVA to submit that later for us. Do you know offhand how much work TVA has awarded in whatever time frame you want to pick for the private contractors?

Mr. CARTER. I know from the testimony here today and from talking with TVA recently, that it is over $300 million.

Senator BAKER. How much?

Mr. CARTER. $300 million that they have let by contract or let to the construction industry, but a large segment of that we understand is for manufacturing and installing things like turbines and without these the amount of field construction would be much less.

Senator BAKER. Here is a piece of information that was just handed me on that subject. It is from page 31 of the April 29, 1975, report from the Comptroller General. It is not very long. I think I will read it into the record. It says:

> At December 31st, 1974, TVA's estimated present and future construction costs associated with power generating facilities was $12.4 billion. TVA could not readily determine how much of the $12.4 billion involves force account in contract because most of this amount represents future effort.
>
> TVA does not contract for work until it is needed. However, TVA performs the vast majority of this work by force account. For example, $727 million of TVA's actual expenditures for the Browns Ferry nuclear plant which was 92 percent complete as of December 31st, 1974, was for field labor, materials and equipment, land costs, general expenses and interests, and $27 million was for contractor effort.

Browns Ferry isn't very far from where you have your headquarters. I don't mean to get you into a debate with TVA. But let's use that as a frame of reference.

Is it your opinion, is it the burden of your testimony, that in that particular project that TVA could or ought to have awarded more of that job to private contractors?

Mr. CARTER. Yes, sir. That is my testimony.

Senator BAKER. How far is Browns Ferry from Lincoln County?

Mr. CARTER. From Fayetteville, Tenn.? I would say 40 miles.

Senator BAKER. Are you familiar with that project?

Mr. CARTER. Yes, sir. We built a sewerplant right nearby during the early days of Browns Ferry construction.

Senator BAKER. Much of that work down there as TVA testifies, of course, is highly specialized work. It requires an extremely high degree of skill and supervision.

Do you have some doubt with the construction industry's ability to cope with that or would you like or are you suggesting to us that the nuclear part of it should be excluded from the consideration?

Mr. CARTER. I would say personally that in the early stages, maybe as models were being built or the initial plants were being built, it might lend itself somewhat to being done by force account, either by private contractor or the TVA method, but now we don't see any reason why the private construction industry can't do it better than TVA. We believe we can.

Senator BAKER. TVA gave us an example this morning of comparative costs between Joppa steamplant and the Shawnee steamplant.

I asked them to submit a further cost analysis to isolate if they could, the amount of the, or the portion of that difference which might be attributable to costs such as taxes and profit.

Do you have any observations in that respect? Can you give us any idea about how much difference there would be in the actual cost of the TVA for construction by force account versus construction by private contractors?

Mr. CARTER. Senator, I would have to say in a general way that we, the contractors paying income tax alone have a 54 to 96 percent partnership with the Federal Government. If we do make any profit then that much of it would be included in the difference in costs.

TVA has an abnormally low interest rate which we don't have. We can't compete with that interest rate. Mr. Kimmons assures me and he makes a good case that TVA does keep the total cost of their projects. There has been a lot of discussion of TVA bookkeeping down through the years and all I can tell you is Mr. Kimmons' word, and he states it very eloquently, that they do properly keep costs.

Senator BAKER. Very good. Mr. Carter, I think that is an excellent contribution to our record. We are pleased to have your testimony.

I am ready to hear now from Mr. Fordice unless one of the gentlemen accompanying Mr. Carter has some additional remark they would like to make.

Mr. Fordice?

STATEMENT OF KIRK FORDICE, ASSOCIATED GENERAL CONTRACTORS OF AMERICA

Mr. FORDICE. Mr. Chairman, with your concurrence we certainly don't intend to read our statement. But I would like to attempt to summarize it, highlight it for you, if I may.

Senator BAKER. Your statement will be received, in its entirety, for the record. (See p. 1107.)

Mr. FORDICE. I am a medium-sized general contractor. My company is Fordice Construction Co., in Louisiana. We work in about five Southeastern States and do several different types of general construction.

However, today I am here to represent the Associated General Contractors of America of which I am the current chairman of the heavy industrial division.

I am accompanied today by Mr. John C. Ellis, who is the assistant executive director; and Mr. John Sroka, who is the director of the heavy industrial division of the AGC.

Therefore, my testimony is keyed more or less to the broad national interest of our association although we are in complete agreement with Mr. Bill Carter's statement.

I think in all respects I will try not to duplicate on that.

We believe that in addition to being in our own self interest as a contractor's organization that the competitive bidding system for public works construction is also in the public interest.

I feel somewhat presumptuous even mentioning that before a committee such as yours because of the Federal Government's traditional preference for competitively bid construction contracts in Federal work.

It is an old tradition. Apparently 98 percent of the Federal work is done by private contractors.

The principal advantages to the contract method of construction in Federal work are the fact that it establishes a definite cost for the project before the construction ever begins. It establishes a definite date for completion of the project. It insures the quality of the project that is produced and provides a central responsibility for getting all of the work done.

A private contractor's bid price is, of course, guaranteed by an owner approved surety. So everything is pretty well sewed up before the job ever starts as far as costs, completion, quality assurance, and so forth.

A contractor devotes considerable thought to the preparation of a bid before he ever submits it and what he does in essence is to mentally build this job and dope out as best he can, to see to the most economical and efficient manner for doing the work before he ever submits his price; and the Government benefits certainly from that process in getting the work done in the cheapest possible way.

His very survival depends on the manner in which he does this estimation of what the job is going to cost before he actually enters into it.

The fact also that his economic survival depends on finishing this job and getting on to another one within the time limits allowed by the owner assures the public that the job is going to be completed on time.

He has central responsibility for completion of the whole project; for scheduling, organizing the work force, purchasing the materials, arranging for delivery of them, operating the equipment, hiring the coordinating subcontractors, and assuring the responsibility for the work overall.

As I mentioned before, the Federal Government apparently endorses the method in that 98 percent of the Federal Government's work is

performed by contract. Summing up, the contract method assures maximum efficiency, greater economy, and construction according to detailed plans and specifications.

Despite all of these historically demonstrated advantages of private contract construction the overwhelming majority of TVA construction as has been mentioned several times is done by its own forces or what we call the force account method.

The AGC in 1970 advised the TVA that possibly 10 percent of project costs could be saved by shifting its construction projects from force account labor to contracting out the work.

We believe that that figure is still valid today. Obviously, there are pitfalls in accounting methods when you attempt to compare the cost of a job done by public agency as to a contract cost.

The contract cost is an absolute known figure, obviously it is a bid figure and that is what the job is going to cost. But the cost of construction done by TVA we submit costs what TVA says it costs, plus some. They have got tremendous administrative costs obviously in managing a 10,000-man construction force; handling the construction equipment costs provided for and so forth.

So I only point out here that there is a danger in trying to compare costs of construction by TVA's own forces as opposed to contract construction.

We think that the magnitude of the prospective savings in TVA's outlays for all the construction work that they are doing warrants a careful study of comparative costs of doing the work by TVA force account and private, competitively bid construction by contractors.

The fact is that TVA has never, as far as we know, made such a detailed comparison. In 1971, a TVA task force reviewed force account construction versus contract construction and that report stated that TVA had not developed detailed comparisons to support its claim that construction by force account was competitive with private industry.

Tuesday a week ago the GAO published a report which seems to demand such a comparison. This is GAO's report No. B–114850 which refers to an OMB circular, A76, of 1967. That circular provides guidelines for implementing the Government's general policy of relying on private enterprise to supply its needs.

Among other things, the circular indentifies the circumstances in which the Government may provide on its own products or services that are available from the private sector. It provides principles for making comparative cost analyses that are required when an agency decides to provide a product or service on its own.

It sets forth the guidelines for administering the policy. The circular requires each agency to not initiate any activities identified as new starts until commercial sources have been explored and until approved by the agency on the basis of factual justification.

After receiving the circular in 1967, TVA defined its entire program as an existing Government activity and thereby exempted itself from this comparison procedure.

According to the GAO report an OMB official responsible for interpreting the circular pointed out that each powerplant constructed by TVA should be considered as a new start. The OMB official indicated that in the future TVA should make evaluations for each con-

struction project in order to determine whether such projects should be constructed by force account or by contract.

We believe as apparently OMB believes, that in the public interest as well as in the interest of fostering the Government's policy of utilization of private enterprise, that TVA should meet the requirements of OMB Circular A76.

With regard to section 3 of the TVA Act, the wage policies which as has been pointed out are similar to the Davis-Bacon provsions, we feel that in times of rampant inflation such as we are living in now that we would be remiss if we didn't point out that section 3 of the TVA Act as well as the similar Davis-Bacon provisions we feel do nothing but inflate the cost of public construction with no redeeming productive results whatsoever.

One point, Senator, that is not often mentioned in this Davis-Bacon controversy, is the fact that smaller communities in the United States, I have particularly run into it in the southeast, really don't get their money's worth from the dollars because of the imposition of rates which are not in fact prevailing in the community but are much higher.

The community could get more for its public works dollar if it weren't forced to pay wages completely beyond the realm of those prevailing in the area.

The Comptroller General of the United States made a study with regard to Davis-Bacon rates and concluded that that law resulted in excess labor costs from 5 to 15 percent. This was over a 10-year period.

Further compounding the excessive costs that result from section 3 of the TVA Act is the fact that the TVA uses union rates for its 14 cities in the valley region and calls these prevaling when in fact we submit that that is not actually the prevailing rate or these are not the prevailing rates in the area.

For example, a city such as Knoxville has about 25 percent of its construction put in place by union labor.

This percentage decreases to nearly zero when you get outside of the Knox County area. Yet, TVA starts with the union rates and apparently applies even higher rates in some cases.

It is significant, I think, too, that the prevailing wage rates determined by the State of Tennessee are consistently and substantially less than the TVA prevailing wage rates. Someone has to pay for these unnecessary wage rates. Someone has to pay for these unnecessary costs.

In this case that someone is the TVA consuming public. Our only question is why? We thank you for the opportunity to present this, Mr. Chairman, and hope it is a help in some way.

Senator BAKER. Thank you very much, Mr. Fordice. It is, indeed.

The report you are referring to in your statement having to do with the analysis of relative costs of force account versus contractor construction and the expiration of private sources is the same report that we have been referring to throughout these hearings.

It is a report by the Comptroller General dated April 29, 1975, which is in the record.

I refer you to page 35 which is apparently the section you had reference to. Can you give us any comparison of costs? I know it is not easy to establish someone else's costs, maybe even particularly TVA's. But

can you give us some estimate of what the cost difference would be on a particular project between TVA force account construction and private contracting construction?

Mr. FORDICE. Senator, I would have to fall back again, I think, on the Comptroller General's report. He used a figure of 5 to 15 percent excess. I think it has been pointed out in some cases TVA rates are even higher than Davis-Bacon rates.

Senator BAKER. What I am looking for is a general answer from you as an expert witness, so to speak.

Are you telling me that you think private contractors can do the typical field work cheaper or would it be more expensive than TVA force account?

Mr. FORDICE. Senator, I think I can give you an unequivocal answer. We think it would be cheaper if the costs are properly prepared.

Senator BAKER. Have you ever negotiated with the TVA Board or representatives or officials of TVA on that issue?

Mr. FORDICE. Let me ask John Ellis what the Association has done.

Mr. ELLIS. Yes, sir. Without much success we have tried to meet with TVA and have on a few occasions in the past. They have not been very receptive to this viewpoint.

Senator BAKER. As I understand the testimony of TVA, they feel it is necessary to keep ongoing force account capability in some cases because of specialization, in others because they are in constantly a construction program.

Do you have any quarrel with the concept that there ought to be some force account work by TVA?

Mr. ELLIS. Some, probably not, Senator, but the fact that it has been implied that TVA has a corner on certain construction skills and on design skills due to the complexity of a project just won't hold up. They have no corner on such skills. They are freely available.

The private contractors of this country could build everything the TVA is building. There is no question about that.

Senator BAKER. Mr. Melton, do you have anything you would like to add?

Mr. MELTON. Senator, I have a comparison figure here of the 1974 prevailing wage rates paid on State of Tennessee projects and also the 1975 union scale minus the fringe benefits. This is Knox County alone.

The difference is 28 percent on labor costs; strictly on labor costs.

Senator BAKER. What are you referring to? Is that something we already have in the record?

Mr. MELTON. No, sir. I would be happy to furnish it to you. It gives a complete breakdown on all 95 counties and the 9 zones that Mr. Carter mentioned in our earlier testimony.

Senator BAKER. Would you supply that for the record?

Mr. MELTON. Yes, sir. I will be glad to.

[Mr. Fordice's statement and the information referred to by Mr. Melton follows:]

STATEMENT OF THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA, PRESENTED BY KIRK FORDICE

My name is Kirk Fordice. I am a partner in the Fordice Construction Company located in Delta, Louisiana. I appear before you today as Chairman of the Heavy Industrial Division of the Associated General Contractors of America.

The Associated General Contractors of America is a national business association representing more than 8,400 general construction firms. These firms perform about 80 percent of the annual contract construction volume of the United States. Our membership represents the full range of the construction industry, including the construction of highways, buildings, municipal-utilities projects and heavy and industrial facilities.

We are most pleased that this committee has afforded us the opportunity to present our views. We hope that the committee will find our comments useful. Today's economic conditions mandate critical reappraisal of old laws, regulations, policies and procedures; lest they become counterproductive, and yet routinely accepted through sheer habit. It is our hope that our comments may provoke some thought as to possible counterproductive areas in the TVA Program.

Our Association has a long history of sharp disagreement with certain aspects of TVA's construction programs. Admittedly our criticism emanates from a devout industry self-interest—we very bluntly feel that private enterprise can construct better and more economically and should not be subject to government competition created by legislation or regulation. However, we feel just as strongly, particularly in light of these critical economic times, that our industry self-interest is also in the public interest.

There are two areas in TVA's construction program that we believe need serious re-examination in the public interest: TVA construction using its own forces; and TVA's wage rates for construction projects.

TVA CONSTRUCTION USING ITS OWN FORCES

It is apparent that I need not advise a Committee such as this one, steeped as it is in the economies of competitively bid public works, as to the Federal Government's traditional preference for competitively bid construction contracts. The Federal Government has historically preferred formal advertising and open competition in the award of contracts. As early as 1809, Congress required that "All purchases and contracts for supplies or services * * * shall be made either by open purchase or by previously advertising for proposals." This preference for the competitive bid contract system is rooted in the reasoning that sealed bids, independently submitted, result in the lowest cost to the owner and best protect the public.

The contract method of construction has numerous advantages. It establishes definite costs before construction begins; it prescribes a date for completion of the work; it ensures quality workmanship and material; it provides centralized responsibility for the work.

To explain further, the contractor undertakes to carry out the work at his bid price. His bid is guaranteed by owner-approved sureties. Thus, the cost of a project is known with certainty before construction starts, and the public can be assured that the bid figures represent the real cost of the job.

Through long experience, contractors become specialists in one or more particular fields of construction. They know their sources of supply; they know the capacity of their machines and the capability of their men.

When preparing a bid, a contractor devotes considerable thought to the problem of devising the best and most economical manner of doing the work. His specialized knowledge and experience have been sharpened in the marketplace and are instrumental in saving money on the job.

The contract provides that the project be completed on a prescribed date. The contractor cannot receive final payment or the release of money that is retained while the work is progressing until the job has been completed to the satisfaction of the owner. This factor, plus his own economic need to finish up and get on to his next job, gives assurances to the public that the job will be completed on time.

The quality of workmanship and materials is guaranteed by the contract system. The materials which go into the project are prescribed in detail in the specifications and are subject to the approval of the owner. If, in the owner's opinion, the workmanship or the materials are not as specified, he can reject the work and order it redone at the contractor's expense.

It is also a practice of many owners to require that the contractor maintain the project in good condition for a period of time after completion. It is therefore to the contractor's economic interest—and to the maintenance of his reputation—that the quality of his work measure up to the prescribed standards.

The general contractor provides centralized responsility for the job. He alone is responsible to the owner for devising construction schedules, organizing the

work force, purchasing materials and arranging for delivery, operating equipment, hiring and coordinating subcontractors, and ensuring responsibility for the work, the men, and third parties against all insurable risks arising from the work.

An extra benefit of the contract system is the incentive a contractor has for doing a good job. His financial interests are at stake. Since his profit is directly dependent on the degree of efficiency which he can bring to the job, a loss is a personal penalty. He is spurred by the knowledge that, under the competitive conditions of the construction industry, the alternative to maintaining a high degree of efficiency is being forced out of business.

The superiority of the contract method is demonstrated by the fact that about 98 percent of the Federal Government's construction work is by contract. Summed up, contract construction offers maximum efficiency, greater economy, and construction according to detailed plans and specifications.

Despite these historically demonstrated advantages of private contract construction, the overwhelming majority of TVA construction is done by its own forces; done without the multitude of benefits and economies afforded by the competitive bid contract system; done, essentially, by civil servants. Private contractors have demonstrated their capacity to do public works construction better, more efficiently, and at less cost. Instead of competing, government should encourage the businessman; by doing so, government will be benefiting not only the contractor, but the tax paying public as well. In 1970 our Association advised TVA of possible 10 percent cost reductions achievable by shifting its construction projects from force account labor to contracting out. We believe that cost saving estimate to still be valid.

We must, in this area of cost comparison, point out the pitfalls of different accounting methods. Construction by contract costs exactly what the owner pays the general contractor. The cost of TVA construction, done by TVA, costs what TVA says it costs, *plus*. The plus factor of overhead administrative costs is not easy to quantify, but is very real and very considerable. For example, office supervision, costs of maintaining construction equipment and men while not actively employed on construction work, costs of computer time and personnel for construction activity, and many other real costs, must be added to come up with totals comparable to the general contractor's price for work.

Our Association believes that in the public interest, and particularly in light of current economic conditions, the magnitude of prospective savings in TVA's outlays for construction warrants a careful study of the comparative costs of TVA force account construction and private competitively bid construction by contract. TVA has never made such detailed cost comparisons. In 1971, a TVA task force, made up of three consultants and two former TVA officials, studied various aspects of TVA's Office of Engineering Design and Construction operations. One area reviewed was force account versus contract construction. In its report, the task force concluded that:

"TVA had not developed detailed comparisons to support its claim that construction by force account was competitive with private industry; and,

"Because of the limited cost data available for comparison purposes, no judgment could be made on the merits of force account versus contract construction."

A report issued by the General Accounting Office (B–114850) less than two weeks ago (April 29, 1975) reveals that TVA may be *obligated* to conduct such cost comparison studies. According to the GAO report an Office of Management and Budget (OMB) Circular A–76, dated August 1967, provides guidelines for implementing the Government's general policy of relying on private enterprise to supply its needs. Among other things, Circular A–76 identifies the circumstances in which the government may provide on its own products or services available from the private sector, provides principles for making a comparative cost analysis required when an agency decides to provide a product or service on its own, and sets forth guidelines for administering the policy. The circular requires each agency to:

(1) Not initiate any activities identified as "new starts" until commercial sources have been explored and until approved by the agency on the basis of factual justification.

(2) Perform systematic reviews of commercial or industrial activities identified as "existing Government activities" at least once by June 30, 1968, and at least once every 3 years afterwards, unless the agency exempts the activity from the initial review and waives the requirements from subsequent reviews.

After receiving this Circular in 1967, TVA defined its *entire construction program* as an "existing Government activity", and waived the requirement for

further review. As a result, TVA has exempted itself from the requirement to cost justify its force account construction.

According to the GAO report, an OMB official, responsible for interpreting Circular A–76, pointed out that each powerplant constructed by TVA should be considered as a new start. The OBM official also indicated that, in the future, TVA should make evaluations for each construction project in order to determine whether such projects should be constructed by force account or by contract.

We believe, as apparently does OMB, that in the public interest as well as in the interest of fostering the Government's policy of utilization of private enterprise, TVA should meet the requirements of OMB Circular A–76.

TVA WAGE POLICIES

AGC has called TVA's attention several times to the fact that its labor policies tend to inflate regional labor costs. Section 3 of the TVA Act provides that TVA shall pay laborers and mechanics the prevailing rates of wages for similar work in the vicinity. Committee members may recognize this provision as similar to Davis-Bacon provisions provided in public works construction. While we realize that the main purpose of this hearing is to examine TVA programs and policies and not to question enabling legislation, we would be remiss if we did not point out that Section 3 of the TVA Act, as well as the similar Davis-Bacon provisions, are archaic laws which do nothing but inflate the cost of public construction with no redeeming productive results whatsoever. Very simply, the TVA Act was enacted in 1933 during the depths of the great depression when manual construction workers were then among the lowest paid in the nation. It is apparent that Section 3 was added to the TVA Act to protect those construction workers by ruling out bids by any contractor paying less than the prevailing wages. However, it is now obvious that construction workers no longer need the Federal Government to protect them from sub-standard wages; construction workers are now among the highest paid manual employees in the nation.

While we are not aware of any statistical studies which have been conducted on the inflationary effects of Section 3 of the TVA Act, we think an analogous study may give some insight as to these costs. As noted previously, Section 3 is very similar to Davis-Bacon provisions. The Comptroller General of the United States made a 10-year study for the Congress, and concluded that the Davis-Bacon Laws result in excess labor costs from 5 percent to 15 percent, depending on particular situations, over and above what they would have been on comparable private construction. We think it ironic, especially in these economic times, that a provision such as Section 3—which does not now achieve the end for which it was created—is continued at such a high price to the public.

Further compounding the excessive costs inherent in Section 3 is TVA's administrative implementation of that section. TVA, in determining prevailing wage rates, uses union rates for 14 cities in the Valley Region. This is done despite the fact that the majority of Tennessee construction is built with open shop labor. For example, a city such as Knoxville has only about 25 percent of its construction put in place by union labor; this percentage decreases to nearly zero when one leaves the Knox County area. In addition, only about 15 percent of the construction completed in the 48 East Tennessee counties is done with union labor. While Section 3 of the TVA Act requires TVA to give "due regard" to union rates, it also requires that the approved wages be the "prevailing" rate in the vicinity, not merely the prevailing *union* rate. It is significant that the prevailing wage rates determined by the State of Tennessee are consistently and substantially less than the TVA "prevailing" wage rates.

This type of TVA determination of prevailing rates results only in excessive costs. As a recent example, a private contractor working for the TVA was not allowed to pay his men the wage rates his company had negotiated with the labor union, but instead was required to pay the higher TVA negotiated rates. The additional labor costs the first week amounted to a 23 percent increase in the rates his company had been paying. Someone has to pay for those unnecessary costs, and that someone is the TVA consuming public.

Our only question is, why?

As noted earlier, we hope that our comments may provoke thought as to some possible counterproductive areas in TVA programs and policies.

Thank you.

GROUP 1.—SHELBY COUNTY

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, vibrator	5.25	5.10	
Asbestos workers	8.00	8.20	2
Boilermakers	7.34	8.20	11
Boilermakers' helpers	5.25		
Bricklayers	8.00	9.15	14
Carpenters	7.08	8.05	13
Cement finishers	6.33	7.90	24
Electricians	7.42	8.68	16
Elevator constructors	7.08	8.29	17
Elevator constructors' helpers	5.25		
Glaziers	6.83	8.50	25
Iron workers:			
Structural	7.18	8.45	17
Ornamental	7.18	8.45	17
Reinforcing	7.52	8.45	12
Laborers			
Lathers	6.16	8.60	39
Marble setters	6.31	9.15	45
Marble setters' helpers			
Air compressors	3.75	6.57	75
Blade graders	5.91	7.67	29
Bulldozers	5.91	8.10	37
Cranes, derricks, draglines	5.91	8.10	37
Distributors	5.91	7.67	29
Finishing machine	5.91		
Firemen, oilers	3.75	6.97	85
Hoists:			
1 drum	5.91	7.67	29
2 drum	5.91	7.67	29
Mizers:			
11's and larger	3.75	7.67	104
Smaller than 11's			
Mason tenders	5.25	5.90	12
Mortar mixers	5.25	6.00	14
Painters:			
Brush	7.15	7.90	10
Structural steel			
Piledrivermen	7.08	8.05	13
Pipelayers (concrete and clay)	3.06	5.05	65
Plasterers		8.60	
Plasterers' tenders	5.25	5.90	6
Plumbers	8.57	9.42	9
Roofers	6.60	7.90	19
Sheet metal workers	6.15	8.40	36
Soft floor layers	7.08	8.05	13
Steamfitters	8.19	9.42	15
Stone masons	8.00	9.15	14
Terrazzo workers	6.31	9.15	45
Terrazzo workers' helpers			
Tile setters	6.31	9.15	45
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	2.30	5.35	75
Motor graders	5.91	7.67	29
Piledrivers	5.91	8.10	37
Pumps	3.75	7.67	104
Rollers	5.91	7.67	29
Scrapers	5.91	8.10	37
Shovels	5.91	8.10	37
Tractors:			
40 hp and larger	5.91	6.97	17
Less than 40 hp			
Trenching machines	5.91	7.67	29
Total Statewide (47 percent)			31

GROUP 2.—CROCKETT, POLK, FAYETTE, GIBSON, HARDEMAN, HAYWOOD, LAKE, LAUDERDALE, OBION, TIPTON, AND WEAKLEY COUNTIES

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, vibrator	3.20	3.10	59
Asbestos workers		9.10	
Boilermakers	7.00	8.20	17
Boilermakers' helpers			
Bricklayers	5.30	9.15	72
Carpenters	4.59	8.05	75
Cement finishers	3.99	7.90	97
Electricians	6.39	8.68	35
Elevator constructors			
Elevator constructors' helpers			
Glaziers	2.83	8.50	200
Iron workers:			
Structural	4.18	8.45	102
Ornamental	4.18	8.45	102
Reinforcing	4.07	8.45	107
Laborers	2.48	4.95	99
Lathers	6.80	8.60	26
Marble setters	4.22	9.15	116
Marble setters' helpers	3.20		
Air compressors	3.50	6.57	87
Blade graders	3.70	7.67	107
Bulldozers	3.70	8.10	118
Cranes, derricks, draglines	3.70	8.10	118
Distributors	3.70	7.67	107
Finishing machine	3.70		
Firemen, oilers	3.50	6.97	99
Hoists:			
1 drum	3.70	7.67	107
2 drum			
Mixers:			
11's and larger	3.70	7.67	107
Smaller than 11's			
Mason tenders	3.20	5.90	84
Mortar mixers	3.20	6.00	87
Painters:			
Brush	5.50	7.90	43
Structural steel	5.50		
Piledrivermen	4.59	8.05	75
Pipelayers (concrete and clay)	2.48	5.05	103
Plasterers	5.00	8.60	72
Plasterers' tenders	3.20	5.90	84
Plumbers	3.97	9.42	137
Roofers	3.00	7.90	163
Sheet metal workers	4.42	8.40	90
Soft floor layers	4.59	8.05	75
Steamfitters	4.01	9.42	134
Stone masons	5.30	9.15	72
Terrazzo workers	4.22	9.15	116
Terrazzo workers' helpers			
Tile setters	4.22	9.15	116
Tile setters' helpers	3.20	9.15	185
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	2.76	5.35	93
Motor graders	3.70	7.67	107
Piledrivers	3.70	8.10	118
Pumps	3.50	7.67	119
Rollers	3.70	7.67	107
Scrapers	3.70	8.10	118
Shovels	3.70	8.10	118
Tractors:			
40 hp and larger	3.70	6.97	88
Less than 40 hp			
Trenching machines	3.70	7.67	107
Total			99

GROUP 3.—BENTON, CARROLL, CHESTER, DECATUR, HARDIN, HENDERSON, HENRY, HOUSTON, HUMPHREYS, MADISON, PERRY, STEWART, AND WAYNE COUNTIES

Crafts	Hourly wage 1974	Hourly wage 1975	Percent
Air tool operator, jackhammer, vibrator	3.29	3.95	20
Asbestos workers	8.27	9.10	10
Boilermakers	7.12	8.20	15
Boilermakers' helpers			
Bricklayers	5.87	6.75	14
Carpenters	5.57	6.85	22
Cement finishers	5.30	5.50	3
Electricians	3.84	7.85	104
Elevator constructors	6.29	6.60	4
Elevator constructors' helpers	3.29	4.62	40
Glaziers	4.50	8.50	88
Iron workers:			
Structural	7.00	8.50	21
Ornamental	7.00	8.50	21
Reinforcing	4.07	8.50	108
Laborers	3.11	3.75	20
Lathers	6.58	5.50	
Marble setters	5.10	6.75	32
Marble setters' helpers			
Air compressors	3.34	6.57	96
Blade graders	5.35	7.67	43
Bulldozers	5.35	8.10	51
Cranes, derricks, draglines	5.35	8.10	51
Distributors	5.35	7.65	43
Finishing machine	5.35		
Firemen, oilers	3.34	6.57	99
Hoists:			
1 drum	5.35	7.67	43
2 drum	5.35	7.67	43
Mixers:			
11's and larger	5.35	8.10	51
Smaller than 11's			
Mason tenders	3.29	3.85	17
Mortar mixers	3.29	3.95	20
Painters:			
Brush	6.46	5.60	
Structural steel			
Piledrivermen	5.57	6.85	22
Pipelayers (concrete and clay)	3.11	4.00	29
Plasterers	5.14	5.50	7
Plasterers' tenders	3.29	3.85	17
Plumbers	7.18	7.80	8
Roofers	5.00	7.90	58
Sheet metal workers	6.06	8.40	38
Soft floor layers	5.57	6.85	23
Steamfitters	6.78	7.80	15
Stone masons	5.87	6.75	14
Terrazzo workers	5.10	6.75	32
Terrazzo workers' helpers			
Tile setters	5.10	5.65	10
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	2.50	5.35	114
Motor graders	5.35	7.67	43
Pile drivers	5.35	8.10	51
Pumps	3.34	6.97	108
Rollers	5.35	7.67	43
Scrapers	5.35	8.10	51
Shovels	5.35	8.10	51
Tractors:			
40 hp and larger	3.34	6.97	108
Less than 40 hp	5.35		
Trenching machines	5.35	7.67	43
Total			42

GROUP 4.—CHEATHAM, DE KALB, DICKSON, MACON, MONTGOMERY, ROBERTSON, SMITH, SUMNER, TROUSDALE WILLIAMSON, AND WILSON COUNTIES

Crafts	Hourly wage 1974	Hourly wage 1975	Percent
Air tool operator, jackhammer, vibrator	3.95	4.95	25
Asbestos workers	5.98	8.65	44
Boilermakers	7.22	8.20	13
Boilermakers' helpers			
Bricklayers	5.79	8.00	38
Carpenters	5.91	7.65	29
Cement finishers	4.12	6.04	46
Electricians	4.07	7.62	85
Elevator constructors	6.31	6.92	10
Elevator constructors' helpers	3.95	4.84	23
Glaziers	6.28	7.70	23
Iron workers:			
Structural	6.66	7.85	18
Ornamental	6.66	7.85	18
Reinforcing	6.92	7.85	13
Laborers	2.84	4.80	69
Lathers	4.18	6.30	51
Marble setters	4.62	8.00	73
Marble setters' helpers			
Air compressors	4.06	5.88	45
Blade graders	4.83	6.34	31
Bulldozers	4.83	6.80	41
Cranes, derricks, draglines	4.83	6.80	41
Distributors	4.83	6.34	31
Finishing machine	4.83	6.80	41
Firemen, oilers	4.06	5.88	45
Hoists:			
1 drum	4.83	6.34	31
2 drum	4.83	6.34	31
Mixers:			
11's and larger	4.83	6.34	31
Smaller than 11's	4.06	5.88	45
Mason tenders	3.95	5.00	27
Mortar mixers	3.95	5.00	27
Painters:			
Brush	5.20	6.50	25
Structural steel	5.20	6.75	29
Piledrivermen	5.91	6.80	15
Pipelayers (concrete & clay)	2.84	5.10	79
Plasterers	3.95	7.00	77
Plasterers' tenders			
Plumbers	5.29	7.34	39
Roofers	5.82	6.00	3
Sheet metal workers	4.56	7.20	58
Soft floor layers	5.91	7.65	29
Steamfitters	5.25	7.34	40
Stone masons	5.79	8.00	38
Terrazzo workers	4.62	6.04	31
Terrazzo workers' helpers			
Tile setters	4.62	7.65	65
Tile setters' helpers			
Welders—receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	2.78	5.55	99
Motor graders	4.83	6.34	31
Piledrivers	4.83	6.80	40
Pumps	4.06	6.34	56
Rollers	4.83	6.34	31
Scrapers	4.83	6.80	40
Shovels	4.83	6.80	40
Tractors:			
40 hp and larger	4.83	6.34	31
Less than 40 hp			
Trenching machines	4.83	6.34	31
Total			38

GROUP 5.—BEDFORD, CANNON, COFFEE, FRANKLIN, GILES, GRUNDY, HICKMAN, LAWRENCE, LEWIS, LINCOLN, MARION, MARSHALL, MAURY, MOORE, RUTHERFORD, AND WARREN COUNTIES

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, vibrator	4.08	4.95	21
Asbestos workers	5.98	8.65	45
Boilermakers		8.20	
Boilermakers' helpers			
Bricklayers	5.82	8.00	37
Carpenters	5.34	7.65	43
Cement finishers	4.79	6.04	29
Electricians	4.20	7.62	81
Elevator constructors	6.31	6.92	10
Elevator constructors' helpers	4.08	4.84	19
Glaziers	6.60	7.70	17
Iron workers:			
Structural	6.41	7.85	22
Ornamental	6.41	7.85	22
Reinforcing	3.02	7.85	159
Laborers	3.01	4.95	64
Lathers	4.60	6.30	37
Marble setters	4.57	8.00	75
Marble setters' helpers			
Air compressors	3.34	5.88	76
Blade graders	4.19	6.34	51
Bulldozers	4.19	6.80	62
Cranes, derricks, draglines	4.19	6.80	62
Distributors	4.19	6.34	51
Finishing machine	4.19	6.80	62
Firemen, oilers	3.34	5.88	76
Hoists:			
1 drum	4.19	6.34	51
2 drum	4.19	6.34	51
Mixers:			
11's and larger	4.19	6.34	51
Smaller than 11's	3.34	5.88	76
Mason tenders	4.08	5.00	23
Mortar mixers	4.08	5.00	23
Painters:			
Brush	5.39	6.50	21
Structural steel	5.39	6.75	25
Piledrivermen	5.34	6.80	27
Pipelayers (concrete and clay)	3.01	5.10	69
Plasterers	4.08	7.00	72
Plasterers' tenders			
Plumbers	4.64	7.34	58
Roofers	6.05	6.00	
Sheet metal workers	5.48	7.20	31
Soft floor layers	5.34	7.65	43
Steamfitters	5.65	7.34	30
Stone masons	5.82	8.00	37
Terrazzo workers	4.57	6.04	32
Terrazzo workers' helpers			
Tile setters	4.57	7.65	67
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck drivers	4.64	5.55	20
Motor graders	4.19	6.34	51
Piledrivers	4.19	6.80	62
Pumps	3.34	6.34	89
Rollers	4.19	6.34	51
Scrapers	4.19	6.80	62
Shovels	4.19	6.80	62
Tractors:			
40 hp and larger	4.19	6.34	51
Less than 40 hp			
Trenching machines	4.19	6.34	51
Total			49

GROUP 6.—ANDERSON, CAMPBELL, CLAY, CUMBERLAND, FENTRESS, JACKSON, MORGAN, OVERTON, PICKETT, PUTNAM, ROANE, SCOTT, AND WHITE COUNTIES

Crafts	Hourly wage 1974	3975	Percent
Air tool operator, jackhammer, vibrator	2.96	5.08	72
Asbestos workers	7.43	8.39	12
Boilermakers	7.25	8.20	13
Boilermakers' helpers			
Bricklayers	5.57	8.41	50
Carpenters	4.81	7.04	46
Cement finishers	4.97	6.56	31
Electricians	6.54	7.85	20
Elevator constructors	6.29	7.45	18
Elevator constructors' helpers	2.96	5.22	76
Glaziers	4.58	6.55	43
Iron workers:			
Structural	5.38	7.27	35
Ornamental	5.38	7.27	35
Reinforcing	3.25	7.14	119
Laborers	2.96	4.78	61
Lathers	5.40	6.56	21
Marble setters	4.38	8.41	92
Marble setters' helpers	2.00		
Air compressors	2.96	4.92	66
Blade graders	3.58	6.40	78
Bulldozers	3.58	6.89	92
Cranes, derricks, draglines	3.58	6.89	92
Distributors	3.58		
Finishing machine	3.58	6.89	92
Firemen, oilers	2.96	4.92	66
Hoists:			
1 drum	3.58	6.40	78
2 drum			
Mixers:			
11's and larger	3.58	5.36	49
smaller than 11's			
Mason tenders	2.96	4.93	66
Mortar mixers	2.96	4.93	66
Painters:			
Brush	4.93	6.75	36
Structural steel	4.93	6.75	36
Piledrivermen	4.81	7.04	46
Pipelayers (concrete & clay)	2.96	4.93	66
Plasterers	3.84	6.56	70
Plasterers' tenders	2.96	4.93	66
Plumbers	7.38	7.65	3
Roofers	6.07	6.30	3
Sheet metal workers	7.29	8.35	14
Soft floor layers	4.81	7.04	46
Steamfitters	3.40	7.65	125
Stone masons	5.57	8.41	50
Terrazzo workers	4.38	8.41	92
Terrazzo workers' helpers			
Tile setters	4.38	8.30	89
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	3.24	5.19	54
Motor graders	3.58	6.40	78
Piledrivers	3.58	6.89	92
Pumps	2.96	6.40	116
Rollers	3.58	6.40	78
Scrapers	3.58	6.89	92
Shovels	3.58	6.89	92
Tractors:			
40 hp and larger	3.58	6.40	78
Less than 40 hp	2.96	5.36	81
Trenching machines	3.58	6.40	78
Total			61

GROUP 7.—HAMILTON COUNTY

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, vibrator	4.84	5.05	4
Asbestos workers	7.45	8.39	12
Boilermakers		8.20	
Boilermakers' helpers	4.84		
Bricklayers	7.05	8.30	17
Carpenters	6.67	7.33	9
Cement finishers	6.00	7.15	19
Electricians	7.29	8.45	13
Elevator constructors	6.85	7.53	9
Elevator constructors' helpers	4.84	5.27	8
Glaziers	5.85	6.83	16
Iron workers:			
Structural	6.79	7.51	10
Ornamental	6.79	7.51	10
Reinforcing	6.67	7.51	12
Laborers	4.46	5.05	13
Lathers	5.59	4.92	
Marble setters			
Marble setters' helpers			
Air compressors	5.59	4.92	
Blade graders	6.02	6.89	14
Bulldozers	6.02	6.89	14
Cranes, derricks, draglines	6.02	6.89	14
Distributors	6.02	6.89	14
Finishing machine	6.02	6.89	14
Firemen, oilers	5.59	4.92	
Hoists:			
1 drum	6.02	6.89	14
2 drum			
Mixers:			
11's and larger	6.02	6.40	6
Smaller than 11's			
Mason tenders	4.84	5.25	8
Mortar mixers	4.84	5.25	8
Painters:			
Brush	4.84	6.50	34
Structural steel	6.41	7.46	11
Piledrivermen	6.67	7.46	11
Pipelayers (concrete and clay)	4.46	5.25	17
Plasterers	6.60	7.45	12
Plasterers' tenders	4.84	5.25	8
Plumbers	7.38	8.20	11
Roofers	6.08	6.95	14
Sheet metal workers	7.41	8.35	12
Soft floor layers	6.67	7.33	9
Steamfitters	8.03	8.20	2
Stone masons	7.05	8.30	17
Terrazzo workers			
Terrazzo workers' helpers			
Tile setters			
Tilesetters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	4.07	5.69	39
Motor graders	6.02	6.89	14
Piledrivers	6.02	6.89	14
Pumps	5.59	6.40	6
Rollers	6.02	6.40	14
Scrapers	6.02	6.89	14
Shovels	6.02	6.89	14
Tractors:			
40 hp and larger	6.02	6.40	6
Less than 40 hp			
Trenching machines	6.02	6.40	6
Total			27

GROUP 8.—BLEDSOE, BLOUNT, BRADLEY, LOUDON, MCMINN, MEIGS, MONROE, POLK, RHEA, SEQUATCHIE, SEVIER, AND VAN BUREN COUNTIES

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, vibrator	3.54	5.00	43
Asbestos workers	7.47	8.39	12
Boilermakers	6.26	8.20	30
Boilermakers' helpers			
Bricklayers	6.26	8.41	34
Carpenters	4.35	7.04	61
Cement finishers	3.26	6.56	101
Electricians	5.63	7.85	39
Elevator constructors	6.29	7.45	18
Elevator constructors' helpers	3.54	5.22	57
Glaziers	5.80	6.55	12
Iron workers:			
Structural	6.90	7.27	5
Ornamental	6.90	7.27	5
Reinforcing	5.12	7.14	39
Laborers	2.80	4.78	70
Lathers		6.56	
Marble setters	5.10	8.41	64
Marble setters' helpers			
Air compressors	2.84	4.92	73
Blade graders	3.92	6.40	63
Bulldozers	3.92	6.89	75
Cranes, derricks, draglines	3.92	6.89	75
Distributors	3.92		
Finishing machine	3.92	6.98	75
Firemen, oilers	2.84	6.40	125
Hoists:			
1 drum	3.92	6.40	63
2 drum	3.92	6.40	63
Mixers:			
11's and larger	3.92	6.40	63
Smaller than 11's			
Mason tenders	3.44	4.93	39
Mortar mixers	3.44	4.93	39
Painters:			
Brush	6.04	6.75	11
Structural steel			
Piledrivermen	4.35	7.04	61
Pipelayers (concrete and clay)	2.80	4.93	76
Plasterers	6.85	6.56	
Plasterers' tenders	3.54	4.93	39
Plumbers	7.11	6.65	7
Roofers	3.40	6.30	85
Sheet metal workers	7.15	8.35	16
Soft floor layers	4.35	7.04	61
Steamfitters	3.13	7.65	144
Stone masons	6.26	8.41	34
Terrazzo workers	5.10	8.41	64
Terrazzo workers' helpers			
Tile setters	5.10	8.41	64
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	3.00	5.00	66
Motor graders	3.92	6.40	63
Piledrivers	3.92	6.89	75
Pumps	2.84	6.40	125
Rollers	3.92	6.40	63
Scrapers	3.92	6.89	75
Shovels	3.92	6.89	75
Tractors:			
40 hp and larger	3.92	6.40	63
Less than 40 hp	2.84	5.36	88
Trenching machines	3.92	6.40	63
Total			56

GROUP 9.—KNOX COUNTY

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, vibrator	3.42	4.93	44
Asbestos workers	7.46	8.39	12
Boilermakers	7.06	8.20	16
Boilermakers' helpers			
Bricklayers	5.57	8.41	50
Carpenters	4.78	7.04	47
Cement finishers	4.29	6.56	52
Electricians	6.95	7.85	12
Elevator constructors	6.82	7.45	9
Elevator constructors' helpers	3.42	5.22	52
Glaziers	6.00	6.55	9
Iron workers:			
Structural	5.97	7.27	21
Ornamental	5.97	7.27	21
Reinforcing	3.21	7.14	122
Laborers	3.42	4.78	39
Lathers	6.68	6.56	
Marble setters		8.41	
Marble setters' helpers			
Air compressors	4.15	4.92	18
Blade graders	5.98	6.40	7
Bulldozers	5.98	6.89	14
Cranes, derricks, draglines	5.98	6.89	15
Distributors	5.98		
Finishing machine	5.98	6.89	15
Firemen, oilers	4.15	4.92	18
Hoists:			
1 drum	5.98	6.40	7
2 drum			
Mixers:			
11's and larger	5.98	6.40	7
Smaller than 11's			
Mason tenders	3.42	4.93	44
Mortar mixers	3.42	4.93	44
Painters:			
Brush	5.77	4.93	16
Structural steel	5.77	7.45	29
Piledrivermen	4.78	7.04	47
Pipelayers (concrete and clay)	3.42	4.93	44
Plasterers	6.00	6.56	9
Plasterers' tenders	3.42	4.93	44
Plumbers	7.25	7.65	5
Roofers			
Sheet metal workers	7.09	8.35	17
Soft floor layers	4.78	7.04	73
Steamfitters	4.73	7.65	61
Stone masons	5.57	8.41	50
Terrazzo workers			
Terrazzo workers' helpers			
Tile setters			
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	3.50	4.78	36
Motor graders	5.98	6.40	7
Piledrivers	5.98	6.89	15
Pumps	4.15	6.40	54
Rollers	5.98	6.40	7
Scrapers	5.98	6.89	15
Shovels	5.98	6.89	15
Tractors:			
40 hp and larger	5.98	6.40	7
Less than 40 hp	4.15	5.36	29
Trenching machines	5.98	6.40	7
Total			28

GROUP 10.—CARTER, CLAIBORNE, HANCOCK, COCKE, GRAINGER, GREENE, HAMBLEN, HAWKINS, JEFFERSON, JOHNSON, SULLIVAN, UNICOI, UNION, AND WASHINGTON COUNTIES

Crafts	Hourly wage 1974	1975	Percent
Air tool operator, jackhammer, virbrator	2.75	4.98	81
Asbestos workers	6.90	8.39	22
Boilermakers	7.02	8.20	17
Boilermakers' helpers			
Bricklayers	5.89	8.41	42
Carpenters	4.14	5.50	32
Cement finishers	3.29	6.56	99
Electricians	6.70	6.70	9
Elevator constructors	6.29	7.45	18
Elevator constructors' helpers	2.75	5.22	89
Glaziers	2.98	6.55	119
Iron workers:			
Structural	5.14	7.27	44
Ornamental	5.14	7.27	44
Reinforcing	3.98	7.14	79
Laborers	2.46	4.78	94
Lathers	4.81	6.56	36
Marble setters	3.23	8.41	160
Marble setters' helpers			
Air compressors	3.50	4.92	41
Blade graders	4.60	6.40	39
Bulldozers	4.60	6.89	49
Cranes, derricks, draglines	4.60	6.89	49
Distributors			
Finishing machine	4.60	5.36	17
Firemen, oilers	3.50	4.92	14
Hoists:			
1 drum	4.60	6.40	39
2 drum			
Mixers:			
11's and larger	4.60	5.36	17
Smaller than 11's			
Mason tenders	2.75	4.93	79
Mortar mixers	2.75	4.93	79
Painters:			
Brush	2.86	4.78	67
Structural steel	2.86	4.78	67
Piledrivermen	4.14	5.50	33
Pipelayers (concrete and clay)	2.46	5.08	106
Plasterers	4.50	6.56	45
Plasterers' tenders	2.75	4.93	79
Plumbers	5.25	7.00	31
Roofers	3.14	6.30	101
Sheet metal workers	4.15	8.85	113
Soft floor layers	4.14	5.50	35
Steamfitters	3.99	7.95	99
Stone masons	5.09	8.41	43
Terrazzo workers	3.23	8.41	160
Terrazzo workers' helpers			
Tile setters	3.23	8.41	160
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	2.58	3.56	107
Motor graders	4.60	6.89	49
Piledrivers	4.60	6.89	49
Pumps	3.50	5.36	53
Rollers	4.60	6.40	39
Scrapers	4.60	6.89	49
Shovels	4.60	6.89	49
Tractors:			
40 hp and larger	4.60	6.89	49
Less than 40 hp	3.50	6.40	82
Trenching machines	4.60	6.40	39
Total			62

GROUP 11.—DAVIDSON COUNTY

Crafts	Hourly wage 1974	1975	Percent
Air tool operator jackhammer, vibrator	3.46	4.80	38
Asbestos workers	7.63	8.65	13
Boilermakers	7.13	8.20	15
Boilermakers' helpers			
Bricklayers	6.65	8.00	20
Carpenters	5.91	7.65	29
Cement finishers	5.05	6.04	19
Electricians	5.02	7.62	51
Elevator constructors	6.31	6.92	9
Elevator constructors' helpers	3.46	4.84	39
Glaziers	5.55	7.70	38
Iron workers:			
Structural	6.56	7.85	19
Ornamental	6.56	7.85	19
Reinforcing	4.27	7.85	83
Laborers	3.42	4.95	44
Lathers	4.90	6.30	28
Marble setters	4.58	8.00	74
Marble setters' helpers			
Air compressors	4.88	5.88	20
Blade graders	5.49	6.34	15
Bulldozers	5.49	6.80	23
Cranes, derricks', draglines	5.49	6.80	23
Distributors	5.49	6.34	15
Finishing machine	5.49	6.80	23
Firemen, oilers	4.88	5.88	20
Hoists:			
1 drum	5.49	6.34	23
2 drum			
Mixers:			
11's and larger	5.49	6.34	23
Smaller than 11's	4.88	5.88	20
Mason tenders	3.46	5.00	44
Mortar mixers	3.46	5.00	44
Painters:			
Brush	4.83	6.50	34
Structural steel	4.83	6.75	39
Pile drivermen	5.91	6.80	15
Pipelayers (concrete and clay)	3.46	5.10	47
Plasterers	6.47	7.00	8
Plasterers' tenders			
Plumbers	5.66	7.34	29
Roofers	5.82	6.00	3
Sheet metal workers	5.91	7.20	21
Soft floor layers	5.91	7.65	29
Steamfitters	6.51	7.34	12
Stone masons	6.65	8.00	20
Terrazzo workers	4.58	6.04	31
Terrazzo workers' helpers			
Tile setters	4.58	7.65	67
Tile setters' helpers			
Welders—Receive rate prescribed for craft performing operation to which welding is incidental			
Truck driver	3.10	5.55	79
Motor graders	4.69	5.55	18
Pile drivers	5.49	6.34	15
Pumps	5.49	6.80	23
Rollers	4.88	6.34	29
Scrapers	5.49	6.34	15
Shovels	5.49	6.80	23
Tractors:			
40 hp and larger	5.49	6.34	15
Less than 40 hp			
Trenching machines	5.49	6.34	15
Total			28

Senator BAKER. Gentlemen, is there anything else? If not, we thank you very much for being here and for being patient.

The next and last witness for the day is Mr. J. W. Merritt, president, Tennessee Valley Trades and Labor Council, Mr. Merritt? Welcome to the hearings. We have a copy of your statement which you may read or summarize as you prefer. In any event, the entire statement will be included in the record.

STATEMENT OF J. W. MERRITT, PRESIDENT, TENNESSEE VALLEY TRADES AND LABOR COUNCIL

Mr. MERRITT. Mr. Chairman, I was honored to receive your invitation to participate in the oversight hearings. I have filed the council's position with your committee. With your permission, I will forgo the full report and go into a brief summary.

Senator BAKER. That would be entirely satisfactory. Your statement will, of course, be received and spread on the record. (See p. 1119.)

Mr. MERRITT. Of course, with appropriate comments.

Senator BAKER. We look forward to that.

Mr. MERRITT. The Tennessee Valley Trade and Labor Council has successfully dealt with TVA on a formal basis for 38 years. The success of our experience is a matter of record evidenced by the very favorable economic condition existing in the Tennessee Valley area at present.

From the depression era of the 1930's, through the strain of World War II, and continuing to the nuclear age of today, TVA with its engineering know-how, progressive labor relations policies, and dedicated labor force is second to none.

We of labor, representing some 12,000 trades and labor employees, strongly support TVA's method of force account construction, projects such as Shawnee and Paradise were built by the TVA wage rates.

I would like to bring to your attention the local union wage rates where the people were furnished on that job in many instances were $1 per hour above the TVA established wage rate. Through the good faith on the contract our people supplied TVA with the necessary amount of people to do these jobs.

I think that the record will clearly reveal that TVA's force account construction is more economical than contract construction and therefore enhances the economy of the people of the valley as well as the commercial community.

I couldn't help but hear a few minutes ago about the $45 or $60 an hour that firms are charging to go out to do a job. The man only made $4.50 an hour. So it doesn't add up to the $45 or $60 charge the people are making, are because of the mechanic.

Senator BAKER. It gets back to the question of whether you pay the man while he is traveling to and from work?

Mr. MERRITT. That is only an hour, an hour going and coming. So I count those, too, Senator.

Mr. Chairman, I have sat through these hearings today and listened with interest to all of the witnesses. I have listened to them with great interest, but I have yet to find anyone in here today to testify that they had superior engineering knowledge or superior construction skills than TVA. I have only sat here today and heard these people gripe about the exorbitant wage rates that are being paid to these mechanics, the great savings that they are going to save the taxpayers of this country by their contracting TVA construction work.

But I hasten to point out that the great savings that they are going to save is only the difference between the wage rates that they indicate that they want to pay and the wage rate that TVA is paying which is not substantial.

Therefore, I could only conclude that the savings they are going to make for the taxpayers is going to be at the expense of the taxpayers in the Tennessee Valley.

It is a point I would like to make. I haven't heard one of them say they could purchase turbines any cheaper than TVA.

I have to hear the first one say they could buy a pound of welding rods cheaper than TVA could buy it. I have only heard them say they can get men to work cheaper than TVA can get them to work. I would like to close with that, sir.

Senator BAKER. I think that is a very excellent point, Mr. Merritt. The TVA, of course, is dedicated to more than just the construction of powerplants. It is dedicated, I believe, to the whole general welfare of the people of not only the Tennessee Valley, but the entire United States.

I believe that over the years this board and other boards have had to take account of what is best for the general area in whatever undertakings they engage in. That no doubt has some bearing on how they approach the negotiations they had with your group as contradistinguished from another group whose other aspirations might be to maximize their proper potential. Both are right. They just happen to be different.

I think you have added a dimension to the record today and you have given us some insight into the perception of TVA by a significant number of the citizens of the area served by it. We are grateful both for your full statement and for your additional elaboration in that respect.

Mr. MERRITT. Senator, I would like to point out from my trade, the wage rates established on TVA, is negotiated with the AGC. My local unions in the Tennessee Valley negotiate with the AGC. They set the wage rate. Then we take that average on TVA.

Senator BAKER. Just as a matter of curiosity, you do negotiate both with the AGC and members of the AGC and with TVA.

Are you actively engaged in trying to set both of those rates?

Mr. MERRITT. Senator, the local union negotiates wage rates, once, twice, or every 3 years. The prevailing practice in these areas and in Knoxville, Tenn., is used in the TVA evaluation for my people and the AGC set it as a fair wage in Knoxville.

Senator BAKER. Are you actively engaged in your official capacity in helping negotiate these arrangments with TVA?

Mr. MERRITT. Senator, I am president of the Tennessee Valley Trades and Labor Council, which I am particularly head of 16 of the affiliated organizations.

I do not negotiate anyone's individual wage rate. My wage rate on TVA is negotiated based on the 14 areas which we survey which I just stated most of them are covered by the AGC contract in the first place.

Senator BAKER. Mr. Merritt, we thank you very much for coming here today and giving us the benefit of this important testimony.

[Mr. Merritt's statement and a statement from the National Electrical Contractors Association follow:]

TVA Employment and Contracting Practices
Statement by J. W. Merritt, President
Tennessee Valley Trades and Labor Council
Before the Senate Committee on
Public Works--May 8, 1975

I am pleased to report to the committee the position of the Tennessee Valley Trades and Labor Council regarding TVA's employment and contracting practices as they affect the Valley economy and commercial community. I am J. W. Merritt, General Vice President of the International Association of Bridge, Structural and Ornamental Iron Workers and President of the Tennessee Valley Trades and Labor Council. The Council is composed of 16 national and international unions. Each Council member is appointed by his general president to represent his craft on the Council. The Council represents approximately 12,000 trades and labor employees engaged in operating and maintenance and construction work throughout the TVA system. The laborers and mechanics of the Tennessee Valley are proud of the TVA system they have built. They are now proud to be a part of the most heavily committed utility in the world.

While labor shares a joint interest in all TVA programs, we will limit our remarks here to the two areas of most concern to the committee and certainly of grave concern to us.

TVA was established in 1933 to promote development of all the resources of the Tennessee Valley. The Act was vetoed twice, and when finally passed it was probably one of the most thought-through pieces of legislation that has ever come out of Congress. It was not a depression piece of legislation but a depression was needed to get it passed.

From the outset, the TVA Board of Directors decided to build its dams and other projects with its own forces rather than contract the work as

many Government agencies do. We are confident that this significant decision has aided efficiency and economy, and incidentally has resulted in the most unique pattern of labor relations in the world. In fact, TVA's labor-management relations policy has been studied by governments in many parts of the world.

While TVA was started in an era of labor strife throughout the country, we (TVA and labor) had a definite advantage, we started without conflict over union recognition. The members of the TVA Board believed in organized labor, an almost unheard of management philosophy in 1933, especially in the Federal service. But, there was mutual concern--labor recognized, in the aims of regional development, a parallel to the aims of labor--a better living for the people of the Tennessee Valley. We welcomed the coming of TVA.

Since 1937 the Tennessee Valley Trades and Labor Council has been recognized as the exclusive bargaining agent for TVA's trades and labor employees. We negotiate on rates of pay, fringe benefits, hours of work, and other working conditions. We recognize that TVA is an agency of, and accountable to, the Government of the United States and that TVA must operate within the limits of its legally delegated authority and responsibility; therefore, we have set up procedures to determine the rates of pay in accordance with Section 3 of the TVA Act with which I am sure the committee is familiar.

Since TVA is a Government agency and is excluded from coverage under the Taft-Hartley Act, union membership is not a condition of employment. Our local unions are not exclusive hiring halls; laborers and mechanics are

recruited with union assistance and are hired at the project after submission of an application for employment if they are qualified for the position they seek. To qualify for a journeyman position, a candidate must show at least as much experience in the trade as that required to complete an apprenticeship, four years in some trades, less in others. In accordance with the Veterans' Preference Act of 1944, veterans are given preference in employment.

In order to ensure a supply of skilled manpower, "labor's stock-in-trade," for TVA and other industry as well, TVA and the Council jointly administer apprenticeship programs in all apprenticeable trades. Presently, we have over 1,000 apprentices in 14 trades in addition to 250 trainees in special joint training programs. Our Equal Employment Opportunity goal, as stated in our affirmative action plan, is to maintain 20 percent minorities in each craft apprenticeship program until the number of minorities in each craft is equal to the population ratio of minorities to whites in the TVA area. This goal is presently being exceeded in many craft programs.

Our ability to build dams, fossil-fired steam plants, nuclear plants, and other projects for TVA is a matter of record. Never has a TVA project been delayed because of labor problems; that is a "fact" not true of any other utility I am sorry to say.

There are several reasons for our good construction record, three of which should be given consideration here: wage rates, no-strike obligation, and dedication. Our wage rates are based on rates prevailing in the TVA vicinity, not as high as the highest rate but above the lowest,

a negotiated prevailing rate. Naturally we always desire more, but in the course of negotiations there comes a time when we must recognize our obligation to our agreement and the TVA Act.

Our agreement provides that the Council and its member organizations will not permit their members to engage in work stoppages or refuse to perform work as assigned nor sanction their leaving the service pending settlement of issues and disputes. A no-strike provision is not unique in labor agreements, what is unique is the way in which we handle such problems. The Council and TVA strongly enforce the provision, and agree that there is no problem which cannot be handled under the terms of our agreement. Therefore, when a work stoppage occurs, each individual involved is interviewed individually by a joint committee composed of Council members and TVA management and discipline is recommended for those responsible by the joint committee. All recommendations are unanimous. In other words, we help discipline our members. To my knowledge there is no parallel to this method for handling work stoppages in the construction industry. The result of this method is shorter downtime and a discouragement of further work stoppages.

Time will not permit me to explain to you the dedication of our members who work for TVA. Again, we will stand on the record of accomplishments, such as the building of Douglas Dam, Fontana Dam, Shawnee Steam Plant, and others. We hear much from private interest groups about TVA's construction work, but no other organization has been able to beat the cost per kilowatt-hour and meet the schedules in order to fulfill obligations.

By being in daily contact with the commercial community of the Valley and the people of the Valley, as well as having knowledge of other areas of the Nation, we can only point you to published facts to prove a point. Construction unemployment in the Valley is far below that reported for the Nation as a whole--by the way, the same is true for unemployment in other industry as well, and since our people spend money when they are working, it only follows that the commercial community in the Valley is fairing better than the national average.

The two factors which appear to contribute most to this are TVA's force-account construction and the vicinity prevailing rate condition. By nature, construction work is intermittent. By hiring its own forces in the building of large projects, TVA schedules its work so there is virtually no lost worktime. Because TVA negotiates rates based on the vicinity concept rather than on the economic conditions of the immediate area in which work is being performed at a given time, the results of the process has a stabilizing effect on the economy throughout the vicinity.

We of labor in the Valley want this committee to clearly understand our position; we strongly favor the continuation of TVA's force-account method of construction work. It has withstood the test of time and has proven to be a continuing asset to the economy of the Valley while serving the Nation as a whole.

Tennessee Council of
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

PRESIDENT
JOE FRANZ

1509 Laurel Street Phone 615/242-4942
NASHVILLE, TENNESSEE 37203

MAY 23 1975

May 19, 1975

Senator Howard Baker
Senate Office Building
Washington, D.C.

Dear Senator Baker:

Apparently the contracting industry in the Tennessee Valley Watershed Area is not to be given the opportunity to discuss their problems with TVA before the Senate Investigating Committee, therefore we would like to bring to you, our representative on the committee, a few pertinent facts.

The first general agreement between the Tennessee Valley Trades and Labor Council and TVA was negotiated August 6, 1940, and that was the last time the Department of Labor considered TVA's interpretation of "Vicinity"-with regard to hourly rates to be paid employees.

In all probability at that time TVA was attracting workers from such cities as Louisville, Kentucky; Atlanta, Georgia; and Birmingham, Alabama; and therefore it would be considered in the "Vicinity."

This situation hardly applies today as much has changed since 1940. TVA is no longer the largest employer of contruction labor, we, therefore, contend that TVA should join the major employers of construction labor in negotiating agreements which could be very beneficial to TVA as well as the contractors and eleminate costly, inflationary competition for workers.

TVA's attitude toward "we the people" has in the past, left much to be desired. A few examples are:

Senator Howard Baker
Senate Office Building
Wahington, D. C.
Page 2

1. Contractors support financially and by direct participation apprentice training programs with the hope that they will get well trained journeymen. However, TVA gets the lions share of these journeymen because TVA rates generally exceed the local labor rates.

2. TVA also raids our apprentice programs and attract apprentices because their apprentice rates are much higher than those recommended in national standards which all of our programs adhere to. Just recently TVA took five apprentices from our Knoxville program including minorities apprentices which are so hard to find. This, of course, looks good for TVA's "recruiting" program.

3. Contractors have attempted to enlist the cooperation of TVA when strikes have occured. TVA has always hired more when these strikers are available resulting in support for the strike and eventually local contractors are forced to pay higher wages.

There have been area minimum rates (Davis-Bacon or Bureau of Labor Stastistics) on many jobs in the TVA area such as Volunteer Ordinance, Holston Ordinance, Milan Ordinance, Oak Ridge, Tullahoma, Corps of Engineer, Cumberland River Projects, and nearby Redstone Arsenal at Huntsville, Alabama.

If these projects can be and were built economically and timely under Davis-Bacon decision - we see no reason why TVA cannot join the other federal agencies and do likewise.

There are many practicies which are allowed as TVA work which is detrimental to the economy and moral of workers in general.

After a worker has worked for TVA so long he is usually no good to a contractor who is doing hard money contracts.

Featherbedding, high time, travel pay, foremen premium pay and apprentice rates which far exceed recommended national standards are a few examples.

In our opinion TVA exceeds the intent of Congress and of the Davis-Bacon act when it requires payment of "current" TVA rates on construction contracts that span more than the one wage rate period

for which rates were published with the bid documents and are in effect at the time the contract is signed.

On "Davis-Bacon" jobs contracted by other governmental agencies the published rates are the ones determined for the area where the work is performed and are usually the AFL-CIO rates negotiated in the local Metropolitan Statistical Area or rates lower than the Union rates where substantial amounts of open shop work is being done.

On multi-year contract area rate changes that occur subsequent to the signing of the contract are the product of negotiations (between employer organizations and contractors in the area) to which the contractor, performing the government contract, has the opportunity to be a party. The contractor on a TVA construction contract is permitted no part in the determination of the rates which TVA negotiates.

This is grossly unfair to the contractor and we feel that the requirement exceeds the constitutional authority of TVA in the case of the contract with CRM for the Knoxville Office Building Complex. Started under 1974 rates it will be completed under 1976 rates. Two raises our contractors must pay, which we have no control over or no say in their determination.

During the past five years especially, both under wage controls and out, the Tennessee Construction Employers Council and its members have made repeated attempts to communicate with TVA concerning these problems.

To date, no meaningful dialogue has been established. The mighty bureaucracy has all but ignored us.

Apparently we are again being ignored and these problems will not even be discussed.

We therefore feel we must appeal to you direct as our representative in the Senate and as a member of the TVA Investigating Committee, to look at these problems squarely in the interest of economy and more efficient operation of one of the large bureaus of our government. Coal cost is one of the more visible items effecting the TVA Power Rates - however, the high cost of TVA construction is

Senator Howard Baker
Senate Office Building
Washington, D.C.
Page 4

also a big factor and will become a bigger one as we move further into the nuclear age of power generation. We sincerely believe that this aspect of cost of production of power should also be brought to the attention of the committee.

Sincerely,

Joe Franz
President, Tennessee Association
of Chapters of the National Electrical
Contractors Association

mlf

Senator BAKER. The hearings will stand in adjournment until 10 o'clock Monday morning.

[Whereupon, at 4 p.m., the committee recessed, to reconvene at 10 a.m., Monday, May 12, 1975.]

[The publication, "An Economic Analysis of Price Increases in the U.S. Coal Industry," previously referred to by Mr. Radin follows:]

AN ECONOMIC ANALYSIS OF PRICE INCREASES IN THE U. S. COAL INDUSTRY

Prepared for:

American Public Power Association
Emergency Committee for the Tennessee Valley
National Rural Electric Cooperative Association
Tennessee Valley Public Power Association

By:

Dr. James R. Barth, Assistant Professor of Economics,
George Washington University

Dr. James T. Bennett, Assistant Professor of Economics,
George Washington University

October 1, 1974

AN ECONOMIC ANALYSIS OF PRICE INCREASES IN THE U. S. COAL INDUSTRY

I. Introduction

The purpose of this report is to document the rapid increases in the price of all types of coal produced in the U. S. and to investigate possible causes of these increases. Coal is a primary fuel used to drive the nation's economy and to provide a source of power for the generation of electricity. Due to shortages in oil and natural gas, the traditional substitutes, the nation will become increasingly dependent upon coal, which is relatively abundant. Increases in the price of coal, therefore, have and will continue to have far-reaching effects into every segment of the U. S. economy, particularly on the cost of generation of electric power, for utilities typically consume more than 65 percent of the Bituminous coal produced in the U. S.

In the second section of this paper, increases in coal prices are reviewed and trends in production in coal mining are surveyed. Although some of the price increases can be explained by increased costs of production, it appears that the supply response of the coal industry to a rapid rate of price increase cannot be justified on the basis of cost increases alone. In a competitive environment, one would typically expect a rapid rate of price increase to lead to substantial increases in

industry output. This has not occurred. Rather, output has remained virtually constant over time and operating profits from coal have increased tremendously. The third section contains a study of profits from coal operations which indicates that price increases have been accompanied by substantial increases in profits. Section IV provides an overview of increasing economic concentration of U. S. coal production and resources. Coal companies have, since 1967, been the target of acquisitions and mergers. Oil companies, which are also involved in the production of natural gas, have been particularly active in obtaining ownership or operating control of coal firms. Thus, there has been increasing concentration in the energy sector, not just in coal production alone. The last section contains a summary of the major findings and the conclusions.

II. Coal Prices, Production, and Consumption, 1955-1974

The price indices compiled by the Bureau of Labor Statistics of the United States Department of Labor are an important source of information on the average price movements of coal. These indices are available for various types of coal, including Metallurgical coal (both High and Low Volatile) which is used principally in the production of coke, Bituminous coals which are used by electric utilities and other industry for the generation of steam, and Anthracite. The price indices are derived from actual prices charged in the spot market (f. o. b. cars at mine) by coal producers throughout the country to coal consumers. Indices, unfortunately, are not available on a regional basis. In any case, data on prices for the years 1955 through the first six months of 1974 are reported in Table II. 1.

TABLE II. 1

II-2

Price Indices for Various Types of Coal
by Year, 1955-1974
(1967 = 100)

Year	Bituminous Coal		Anthracite	Metallurgical High Volatile	Metallurgical Low Volatile	All Coal
	All	Industrial Screenings				
1955	80.9	80.0	94.6	N.A.	N.A.	82.3
1956	89.4	89.7	97.0	N.A.	N.A.	89.8
1957	96.8	98.1	107.2	N.A.	N.A.	97.6
1958	95.5	95.9	107.0	97.2	97.8	96.5
1959	95.0	93.1	108.7	96.2	95.2	96.2
1960	94.4	92.1	107.5	96.3	94.2	95.6
1961	93.8	91.2	103.0	95.7	94.1	94.6
1962	93.0	90.8	101.4	95.6	93.9	93.7
1963	92.9	90.9	103.3	95.6	92.2	93.8
1964	92.7	91.9	105.7	96.4	91.7	93.8
1965	92.7	91.8	100.9	96.8	92.3	93.4
1966	95.1	94.8	99.6	98.4	97.0	95.5
1967	100.0	100.0	100.0	100.0	100.0	100.0
1968	103.4	103.6	107.2	101.8	103.4	103.7
1969	112.3	112.8	117.0	110.2	111.0	112.6
1970	151.9	152.9	131.5	150.9	149.9	150.3
1971	184.9	187.2	145.0	185.3	184.2	181.8
1972	197.4	199.2	151.1	198.4	204.8	193.8
1973	222.5	226.0	166.9	216.5	227.9	218.1
1974 [a]	289.5	- [b]	198.1	330.8	347.8	282.4

Source: Bureau of Labor Statistics

[a] Six-Month Average

[b] Discontinued December, 1973

On the basis of this table, it is evident that the price indices were quite stable during the 1958-1967 decade. The price of Bituminous coal (All) increased by only 4.5 percentage points during this period and the price index for Industrial Screenings increased by only 4.1 percentage points. Metallurgical coal--both High and Low Volatile--experienced even smaller increases in price during the 1958-1967 period, while the price of Anthracite declined by seven percentage points. Rapid increases in the price of coal did not occur until sometime in 1969. But when prices did begin to rise, they rose phenomenally and rapidly. By 1972, prices for every type of coal except Anthracite had increased approximately 100 percent since the base year of 1967. Even Anthracite had increased in price by 51 percent in the same five-year period. And by 1974, only two years later, the average price of all coal except Anthracite was approximately three times what it had been in 1967. The year-to-year changes in prices further highlight the recent upsurge in coal prices and are, therefore, reported in Table II. 2.

TABLE II. 2

Year-to-Year Changes in the BLS Coal Price Indices by Type of Coal, 1969-1974

Year	Bituminous Coal		Anthracite	Metallurgical Coal		All Coal
	All	Industrial Screenings		High Volatile	Low Volatile	
1958-1967	4.5	4.1	7.0	2.8	2.2	3.5
1969-1970	39.6	40.1	14.5	40.7	38.9	37.7
1970-1971	33.0	34.3	13.5	34.4	34.3	31.5
1971-1972	12.5	12.0	5.9	13.1	20.6	12.0
1972-1973	25.1	26.8	15.8	18.1	23.1	24.3
1973-1974[a]	67.0	----	31.2	114.3	119.9	64.3

Source: Computed from Table II. 1

[a] First 6-months of 1974.

The year-to-year changes in the price indices give ample evidence of the enormous increases in coal prices in recent years in comparison with the relative stability of prices which prevailed during the decade 1958-1967. As an example, the price change between 1969 and 1970 for Bituminous Coal-Industrial Screenings is about ten times as large as the entire change which occurred during the ten years 1958-1967. Prices for all types of coal increased by between 30 and 40 percentage points between 1969 and 1970 as well as between 1970 and 1971. Once again, Anthracite was an exception, for the rate of increase in price for this type of coal was about one-half that for all other types, though still a substantial increase.

Between 1971 and 1972, the rate of price increase diminished to approximately one-third the rate in the previous years, most likely due to the impact of wage and price controls imposed by the government in August of 1971. Moreover, in the 1972-1973 period, the rate of increase was higher than in the previous year, but also below that experienced between 1970 and 1971. With the expiration of wage and price controls in late 1973 and early 1974, the price indices of all types of coal indicate an extraordinary rate of price increase. This is particularly evident when one recalls that the data for 1974 are only for the first six months of the year. Thus, if the rate of increase for the first six months continues during the last six months, the year-to-year change figures shown in the last line of Table II. 2 must be doubled to be comparable with the other figures reported in the table.

Under the reasonable assumption that the rate of price rise during the first six months of 1974 persists through the last six months, the indices for December, 1974 will be as follows:

		Metallurgical Coal		
All Bituminous Coal	Anthracite	High Volatile	Low Volatile	All Coal
356.5	229.3	445.1	467.7	347.6

According to these figures, in general, the coal that cost $100 in 1967 will cost at least 3.5 times as much at the end of 1974. Particularly severe price increases have plagued the metallurgical coals, for coking coal on a per ton basis has increased about 4.5 times since 1967. Since coal is basic to the functioning of the U. S. economy as a source of prime energy and also in the generation of electric power, it is obvious that these recent and rapid price increases will further complicate attempts to deal with inflation.

Because electric power plays such an important role in the economy, it is important to explore in greater detail the price increases in the coal supplied to electric utilities, that is, price increases in steam coal. The relevant price index for this purpose is the Bituminous Coal-Industrial Screenings index. This composite index was discontinued at the end of 1973 and instead broken into two indices: Bituminous Coal-Manufacturers and Steam Coal-Electric Utilities. These latter two price indices (using December, 1973 as the base month) are shown in Table II.3.

TABLE II.3

Price Indices for Bituminous Coal - Manufacturers and Electric Utilities by Month: January-June, 1974 (December, 1973=100)

Month	Manufacturers	Utilities
January	102.4	104.2
February	103.3	105.7
March	104.4	107.4
April	149.5	109.4
May	155.1	110.1
June	157.7	116.7

Source: Bureau of Labor Statistics

As may be seen, in the six months since December, 1973, the price of Bituminous Coal used by Manufacturers increased by 57.7, whereas the price of steam coal increased by only 16.7 percent. Because these two types of coal are very similar (often identical), the differences in the rates of price increase are difficult to explain--even to the Bureau of Labor Statistics. According to the Bureau of Labor Statistics, the two indices should move together very closely. The fact that they do not is attributed to bad sampling. In any event, the procedure followed when constructing the indices is to be revised, as is the index for steam coal itself. In light of this problem, recent data on the prices paid by electric utilities for coal was obtained from the Federal Power Commission which, since July 1972, has required utility companies to report prices and quantities of fuels purchased for the generation of electric power (on Form 423). Monthly data taken from these forms are shown for July, 1972 through March, 1974 - the latest month for which data are available.

TABLE II.4 II-7

Average Price Per Ton of Coal Purchased
By Electric Utilities By Month
July, 1972 to March, 1974

Month, Year	$/Ton	Index
July, 1972	8.187	100.0
August	8.250	100.8
September	8.366	102.2
October	8.388	102.5
November	8.373	102.3
December	8.310	101.5
January, 1973	8.419	102.8
February	8.593	104.5
March	8.716	106.5
April	8.800	107.5
May	8.804	107.5
June	8.941	109.2
July	8.822	107.8
August	8.843	108.0
September	9.096	111.1
October	9.350	114.2
November	9.744	119.0
December	9.996	122.1
January, 1974	11.317	138.2
February	12.527	153.0
March	13.365	163.2

Source: Federal Power Commission, Form 423

In July, 1972, the average price per ton paid by utilities was $8.19, which by July, 1973, had risen to $8.82, representing a 7.8 percent increase. But by March, 1974, the average price per ton was already 63.2 percent higher than the July, 1972, price. In contrast to the BLS Steam Coal Index, the FPC report indicates that prices were 33.7 percent higher in March, 1974 than the previous December. Care must be employed in interpreting all of these data, however, for they do not represent spot prices paid in the open market. Large quantitites of coal are purchased by utilities under long term contracts, the result of which is that in many cases, contract prices have not increased as much as spot prices.[1/] Furthermore, about 4 percent of coal consumed by utilities is obtained from captive mines. These points are emphasized in the following statement by the Federal Power Commission:

> In March [1974], the Industrial Commodities Wholesale Price Index rose 2.9 percent to 146.6. The average price paid for coal and gas rose at twice the rate of the index. . .
> The average price of coal jumped 6.9 percent in March to 60.8 cents per million Btu. The average March price of $13.37 per ton is 56.3 percent higher than a year ago. The average price of spot coal, $22.54 per ton, was a $1.97 per ton increase from February, and a $9.20 per ton climb from December. [2/]

Thus, coal available to utilities in the spot market in March, 1974, sold

---

1/ "Of the 31.1 million tons of coal delivered [to utilities] in June [1973], 25.6 million tons (82.3%) were received under contract." A Staff Report of Cost and Quality of Fuels for Steam Electric Plant (FPC Form 423 data for June 1973), Federal Power Commission, Washington, D.C., April, 1974, p. 3.

2/ Federal Power Commission, News Release No. 20445, June 28, 1974, p. 3.

for 69 percent more than the average price of coal. Also, while the average price index increased by 33.7 percent from last December, the spot price increased by 69.2 percent. And, while the average price of coal increased by 6.9 percent during the month of March, the spot price increased by 9.6 percent. The importance of the differences in these figures is that the spot market price of coal is generally used as the basis for price determination on long term contracts. This means that as contracts expire and are renegotiated or new contracts are drawn, the average price paid for coal by utilities will continue to rise. All of this is in addition to the problem of the small utility that purchases coal in the spot market and does not enter into long terms contracts: the price of coal is increasing at a rapid rate - much more rapidly than the national indices covering all utilities indicate.

In 1974 the National Rural Electric Cooperative Association and the American Public Power Association surveyed their membership in order to obtain information on coal prices and deliveries. The survey is too detailed to discuss comprehensively here, but selected excerpts typical of the responses will be cited to illustrate the magnitude of the problems facing utilities. For example, an excellent overview of the problems reported in the survey is provided in a letter written by Mr. Robert R. Pawleski, Utility Manager of the Marshfield Electric and Water Department of Marshfield, Wisconsin to Senator William Proxmire on April 19, 1974:

> In March of this year the Peabody Coal Company of St. Louis, Missouri, (local branch office in Madison, Wisconsin) informed the Marshfield Electric and Water Departments that after the

expiration of their contract in June, 1975, there would be no more coal available to them. The Peabody Coal Company stated that signing a new contract could not be considered and that no more coal would be available at any price, or under any terms, after the expiration of the present contract.

When asked the reason for this, the Peabody Coal Company's representative replied that the coal from the mine that is normally supplied to the Marshfield Electric and Water Departments has been sold to Southern Utilities Service Corporation under a long term contract.

Investigations have shown that there are many other industries and utilities, both in Wisconsin and other states, that have been or will be effected.

We are presently buying coal from the Peabody Coal Company at $9.00 per ton. They have stated that our contract is marginal and their profit small or non-existent. After May 1, 1974, we will be paying $15.50 per ton for all coal from Peabody. Even at this increased rate, Peabody has restated that there will be no more coal available after June, 1975.

There are numerous reports stemming from the survey of failure to deliver coal under contract, retroactive price increases, cancellation of coal contracts and price increases. As an example of price increases, consider the experience of the Wallingford Electric Division of the Town of Wallingford, Connecticut relating to the price per ton paid for the same quality and size of coal:

April - June 1973	$14.75/ton
July - September 1973.	15.11/ton
October - December 1973.	15.90/ton
January - March 1974	21.15/ton
April 1974	29.50/ton

The utility not only experienced 4 increases in the price of coal in a single year, but also increases which resulted in a doubling of price in that one year.

On the basis of the information provided above, there can be no doubt that coal prices have risen dramatically since 1969, and that the rate of increase has accelerated in recent months. The size of the price increases can perhaps be interpreted more meaningfully when compared with prices predicted by Professor William Nordhaus of Yale University.[3/] After developing a model of energy sources in the U. S., Nordhaus uses the model to predict average prices per ton (f. o. b. mine) for Bituminous coal and Lignite in the U. S. for 1970 and each decade thereafter through 2010. These prices are as follows:

Year	Predicted $/ton
1970	$11.91
1980	12.07
1990	12.42
2000	13.34
2010	15.77

In 1970 dollars.

As reported earlier, prices paid by utilities already reached $13.37 per ton in March, 1974. Nordhaus also predicted that the rate of price increase over the 1970-2010 period would be on the order of 2.3 percentage points per year. But coal has been increasing in price in multiples of this amount each month. Clearly, the model developed by this noted economist fails to explain recent increases in prices of coal.

3/ William D. Nordhaus, "The Allocation of Energy Resources," in Brookings Papers on Economic Activity No. 3, Arthur M. Okun and George L. Perry (eds.), The Brookings Institution, 1973, pp. 529-576. In particular, see Table 7, p. 555.

The issue is whether or not these price increases are the result of the competitive functioning of the market for coal. That is to say, can the price increases be completely explained in terms of competitive factors. The answer involves an investigation of the factors which influence the cost of coal production. Also, one must consider the overall production and consumption of coal.

Table II.5 contains data on the annual production and consumption of Bituminous coal in the U. S. for the period 1955-1973. The 591 million tons produced in 1973 almost reached the same output tonnage in 1948. During the entire nineteen-year period, the peak production year was 1970, when slightly more than 600 million tons of coal were produced. Output then fell by about 8 percent in 1971, increasing again in 1972 to about the level of 1970.

The consumption of Bituminous Coal by utilities has increased steadily in both absolute amounts and in share of total production. In 1955 utilities consumed only 30 percent of the Bituminous coal produced, but by 1973 utilities consumed almost two-thirds of Bituminous production. For just the two-year period 1972-1973, utilities consumed 58.5 percent and 65.6 percent of this type of coal, respectively, representing an increase of 7.0 percentage points. An important reason for this recent and significant increase in the utilities' share of coal output is that the utilities are more dependent upon coal as a fuel because of shortages of natural gas and oil. Meanwhile, coal consumption by mining and manufacturing industries has decreased in both absolute terms and relative shares, the

latter falling to 27.2 percent in 1973 from 45.8 percent in 1955. At the same time, coal exports have removed about 10 percent of the production from the domestic market. It should be noted, however, that exported coal is generally metallurgical coal which is not used for steam generation.

TABLE II. 5

II-14

Bituminous Coal Production and Consumption
By Category By Year
1955-1973

Year	Total Production	Electric Power Utilities		Manufacturing & Mining		Exports	
		Consumption	% of Total	Consumption	% of Total	(Tons)	% of Total
1955	464,633	140,550	30.2%	212,870	45.8%	51,227	11.0%
1956	500,874	154,983	30.9	215,430	43.0	68,553	13.6
1957	492,704	157,398	31.9	210,793	42.7	76,446	15.5
1958	410,446	152,928	37.2	173,476	42.2	50,293	12.2
1959	412,028	165,788	40.2	167,761	40.7	37,253	9.0
1960	415,512	173,882	41.8	173,096	41.6	36,541	8.7
1961	402,977	179,629	44.5	166,271	41.2	34,790	8.6
1962	422,149	190,883	45.2	168,066	39.8	38,413	9.0
1963	458,928	209,038	45.5	175,969	38.3	47,078	10.2
1964	486,998	223,032	45.7	187,758	38.5	47,969	9.8
1965	512,088	242,729	47.3	196,732	38.4	50,181	9.7
1966	533,881	264,202	49.4	201,490	37.7	49,302	9.2
1967	552,626	271,784	49.1	191,066	34.5	49,510	8.9
1968	545,245	294,739	54.0	188,450	34.5	50,637	9.2
1969	560,506	308,461	55.0	183,835	32.7	56,234	10.0
1970	602,932	318,921	52.8	184,328	30.5	70,908	11.7
1971	552,192	326,280	59.0	157,024	28.4	56,633	10.2
1972	595,386	348,525	58.5	159,253	26.7	55,960	9.4
1973	591,000	386,879	65.5	160,827	27.2	52,870	8.9

Source: Survey of Current Business, Various Issues.

Could the price increases which have occurred since 1969 be the competitive result of a demand for coal greater than the available supply? In testimony on July 14, 1971, before the Subcommittee on Special Small Business Problems of the House Committee on Small Business, Walker B. Comegys, Acting Assistant Attorney General of the Antitrust Division of the Department of Justice stated that he regarded the increases in late 1970 to be the result of the "depletion of utility inventories and the unusually severe buying pressures on coal prices from April 1970 through the last half of the year in a scramble to replenish stocks. . . it was concluded that the 1970 price rises could be attributed to this interaction of supply and demand. . ." As shown in Table II. 6, Bituminous coal inventories were lower in 1969 than in 1968 which implies an inventory depletion which was remedied by the end of 1970. Indeed, it is obvious that stocks at electric utilities were higher by 20 percentage points at the end of 1970 than at the end of 1969. And the size of electric utility inventories increased steadily through 1972. As the figures show, the buildup of inventories between 1969 and 1970 was approximately 10. 7 million tons. Note, however, that even though an inventory buildup of 17 million tons occurred between 1966 and the end of 1967, prices for Industrial Screenings rose by only 5. 2 percentage points. But during the 1969-1970 period, the Industrial Screenings index increased by 40. 1 percentage points. Clearly, the supply response of the coal industry to inventory adjustments in the two periods was remarkably different.

TABLE II.6

End of Period Inventories of Bituminous Coal by Year, 1965-1973 (000s of short tons)[a]

Year	Total Stocks		Electric Utility Stocks	
	Tons	Index	Tons	Index
1965	77,393	100.0	53,437	100.0
1966	74,466	96.2	52,895	99.0
1967	93,128	120.3	69,737	130.5
1968	85,525	110.5	64,168	120.1
1969	80,482	104.0	60,597	113.4
1970	92,275	119.2	71,295	133.4
1971	89,985	116.2	76,987	181.5
1972	115,313	149.0	98,450	184.2
1973	99,022	128.0	85,512	160.0

Source: Survey of Current Business, Biennial Supplement 1973.

[a] End of period figures.

A principal tenent of the economic theory of the competitive firm is that as output prices increase, other things equal, the quantity offered for sale will increase. Stated another way, the law of supply states that output is directed related to price, other things remaining unchanged. In view of the large price increases levied by coal firms in recent years, one would, therefore, expect that the quantity of coal offered for sale would have also increased substantially. This is not, in fact, the case, for production in 1971, 1972, and 1973 was lower than production in 1970. In spite of the large price increases between 1972 and 1973, for example, Bituminous production fell by 4.4 million tons. And this decline does not appear to be due to any incapacity to produce more coal. This is evident when one looks at the potential of the coal industry to produce coal. One measure of this potential to produce is capacity utilization. "Full capacity should be defined as an attainable level of output that can be reached under normal input conditions - without lengthening accepted working weeks, and allowing for usual vacations and for normal maintenance."[4/] Using this definition, Klein and Long have estimated quarterly capacity utilization rates by industry. Their estimates for the coal industry are reported in Table II.7.

4/ Lawrence R. Klein and Virginia Long "Capacity Utilization Concept, Measurement, and Recent Estimates" in Brookings Papers on Economic Activity No. 3, Arthur M. Okun and George L. Perry (eds.). The Brookings Institution, Washington, D. C., 1973, p. 744.

TABLE II.7

Coal Industry Capacity Utilization Rates
Quarterly, 1969-I through 1973-III

Year & Quarter	Capacity Utilization Rate
1969-I	92.6
1969-II	92.0
1969-III	91.5
1969-IV	94.2
1970-I	94.2
1970-II	94.0
1970-III	95.0
1970-IV	94.1
1971-I	100.0
1971-II	98.1
1971-III	95.6
1971-IV	56.7
1972-I	90.1
1972-II	92.0
1972-III	87.9
1972-IV	84.6
1973-I	85.9
1973-II	85.4
1973-III	89.0

Source: Klein and Long, Op. Cit., p. 756

Between the first quarter of 1969 and the third quarter of 1973, coal mining was at full or 100.0 percent of capacity in only one quarter, the first quarter of 1971. During every other quarter, the industry was operating at a level which did not utilize fully its productive capacity. On the basis of the capacity utilization rates estimated by Klein and Long, the industry could have achieved an output between the third quarter of 1972 and the third quarter of 1973 about 15 percent above what was produced without taking extraordinary measures. With rapid price increases, one would expect a firm in a competitive environment to expand output by utilizing facilities to their fullest. When this doesn't happen, the evidence may suggest an explicit or implicit agreement to limit output, further driving up prices, and thereby profits.

Admittedly, in the short run, it is difficult to achieve rapid expansion of physical facilities and bring new equipment into operation. It is common in industry under such circumstances, however, to increase the working hours of the labor force by operating on an overtime basis. In this way, existing facilities can be used to the maximum extent possible so that output can be increased to satisfy demand, thereby moderating the price increases. Yet, as shown in Table II.8, there is no evidence that in recent years the coal companies have significantly increased the average length of the work week. In spite of rapid price increases, the average number of hours worked weekly in 1973 was less than the average in 1972. The average number of hours worked during 1966 and 1967 when prices of coal were relatively stable is actually

larger than for the years 1969, 1970, 1971, and 1973. This is not the response one would expect from firms in an industry with excess capacity while prices are rising rapidly. As is also evident from the same table, little has been done to increase rapidly the number of employees in the industry. As a result, employment in 1972 was less than in 1961. It is true that there was an increase of 15.6 thousand men between 1969 and 1970 - 12.5 percent - but this rate of increase has not been sustained. Between 1970 and 1971, the Bituminous coal workforce increased by 3.9 percent, whereas between 1971 and 1972 the increase was only 2.5 percent. Thus, although the rate of price increase was greater in the 1972-1973 period than the 1969-1970 period, the rate of employment increase diminished. This evidence does not support the contention that the coal industry was increasing supply in response to price increases.

If the demand for coal is price inelastic, that is to say, if the quantity of coal demanded by the market is not sensitive to price increases, then coal producers can pass cost increases on to coal consumers directly. During the so-called energy crisis, the substitutes for coal (oil and natural gas) have been in very short supply, so that the argument that the demand for coal is price inelastic appears reasonable. The important issue here, thus, is the extent to which increases in coal prices can be explained by increases in the cost of production.

TABLE II.8

Average Employment, Hourly Wages, and Hours Worked Weekly in Bituminous Coal Mining By Year, 1955-1973

Year	Average Employment	Average Hourly Wages	Average Hours[a] Worked Weekly
1955	225,093	$2.47	37.3
1956	228,163	2.72	37.5
1957	228,635	2.92	36.3
1958	197,402	2.93	33.3
1959	179,636	3.11	35.8
1960	169,400	3.14	35.8
1961	150,474	3.12	35.9
1962	143,822	3.12	37.0
1963	141,646	3.15	38.9
1964	128,698	3.30	39.2
1965	133,732	3.49	40.2
1966	131,752	3.66	40.8
1967	131,523	3.75	40.7
1968	127,894	3.86	40.2
1969	124,532	4.24	40.1
1970	140,140	4.58	40.7
1971	145,644	4.86	40.5
1972	149,265	5.34	41.0
1973	-	5.73	39.8

Source: Bituminous Coal Data, National Coal Association

[a] Eleven month average; July is excluded because of vacation.

An important element of the total cost of producing coal is wages paid to coal miners. Average hourly wages paid are reported by year in Table II. 8. As may be seen, average hourly wages increased from $3. 75 to $5. 73, or by 52. 8 percent, between 1967 and 1973. It is perhaps more interesting to consider the year-to-year percentage changes which are reported in Table II. 9.

TABLE II.9

Year-to-Year Percentage Changes in Average Hourly Wages in Bituminous Coal Mining, 1965-1975

Year	% Change
1965 - 1966	4.9
1966 - 1967	2.5
1967 - 1968	2.9
1968 - 1969	9.8
1969 - 1970	8.0
1970 - 1971	6.1
1971 - 1972	9.9
1972 - 1973	7.3

Source: Computed from Table II.8

Between 1965 and 1966, the average hourly wages increased by 4. 9 percent, even though the price index of All Bituminous coal increased by only 3. 6 percentage points (see Table II. 1). Clearly, the rate of price increase was less than the rate of wage increase. The rate of wage increases then decreased to 2. 5 percent between 1966 and 1967 and to 2. 9 percent between 1967 and 1968. Between 1968 and 1969, the average hourly

wage increased by 9.8 percent and was accompanied by an 8.9 percentage point increase in the All Bituminous coal price index. In sharp contrast, an 8.0 percent rise in wages between 1970 and 1971 was associated with a 33.0 percentage change in prices. Even a casual review of these data indicates that the relationship between wage and price increases is substantially different in the post-1969 years. Although one can assert that increasing wage rates are a factor in increasing the price of coal, it is clearly not possible to justify the substantial increases in recent years on the basis of wage increases alone. For it is obvious that in recent years price increases have outstripped wage rate changes many times over.

A second factor which has led to increased costs in mining of Bituminous coal is the Federal Mine Health and Safety Act of 1969. After the passage of the Act, labor productivity in underground mines diminished. This is seen by consulting Table II. 10, which provides recent information on the output (in tons) per man/day in underground mines, strip mines, and auger mines. As may be seen, output per man/day for underground mines increased throughout the period 1967-1969, though decreasing thereafter. Output reached a maximum of 15.61 tons per man/day in 1970, decreasing to about 12 tons per man/day two years later. Regarding 1971, it should be recalled that this was a strike year for the coal industry and also a year of economic slow-down; both factors may have exerted a downward push on productivity. This represents a decline in

labor productivity of approximately twenty percent. Productivity in strip mines, however, has not been affected at all by the Act. Indeed, productivity in 1972 remained at an all time high of about 36 tons per man/day. Output per man/day at auger mines has fluctuated over this period. Bituminous coal produced by auger mines, however, is an insignificant proportion of total production - between 2 and 3 percent of total Bituminous output (see Table II. 11). Thus, one can conclude that the health and safety regulations have only increased the cost of the extraction of coal from underground mines.

TABLE II. 10

National Average Output Per Man Per Day (Tons)
at Bituminous Coal Mines
By Year and By Mining Method
1967-1972

Year	Underground		Strip Mines		Auger Mines	
	Tons	Index	Tons	Index	Tons	Index
1967	15.07	100.0	35.17	100.0	46.48	100.0
1968	15.40	102.2	34.24	97.4	40.46	87.0
1969	15.61	103.6	35.71	101.5	39.88	85.8
1970	13.76	91.3	35.96	102.2	34.26	73.7
1971	12.03	79.8	35.69	101.5	39.00	83.9
1972	11.91	79.0	35.95	102.2	43.00	92.5

Source: Bituminous Coal Data 1972, 1973. National Coal Association.

TABLE II.11

Production of Bituminous Coal
By Method of Mining and Year
1955-1972*

Year	Total Production	Strip Mining		Underground Mining		Auger Mining	
		Output	% of Total	Output	% of Total	Output	% of Total
1955	464,633	115,093	24.7%	343,465	73.9%	6,075	1.3%
1956	500,874	127,055	25.3	365,774	73.0	8,045	1.6
1957	492,704	124,109	25.1	360,649	73.1	7,946	1.6
1958	410,446	116,242	28.3	286,884	69.8	7,320	1.7
1959	412,028	120,953	29.3	283,434	68.7	7,641	1.8
1960	415,512	122,630	29.5	284,888	68.5	7,994	1.9
1961	402,977	121,979	30.2	272,766	67.6	8,232	2.0
1962	422,149	130,300	30.8	281,266	66.6	10,583	2.5
1963	458,928	144,141	31.4	302,256	65.8	12,531	2.7
1964	486,998	151,859	31.1	321,808	66.0	13,331	2.7
1965	512,088	165,241	32.2	332,661	58.1	14,186	2.4
1966	533,881	180,058	33.7	338,524	63.4	15,299	2.8
1967	552,626	187,134	33.8	349,133	63.1	16,360	2.9
1968	545,245	185,836	34.0	344,142	63.1	15,267	2.8
1969	560,505	197,023	35.1	347,132	61.9	16,350	2.9
1970	602,932	244,117	40.4	338,788	56.1	20,027	3.3
1971	552,192	258,972	46.8	275,888	49.9	17,332	3.1
1972	595,386	275,730	46.3	304,103	51.1	15,554	2.6

* All Production Figures Are in Thousands of Tons

Source: Bituminous Coal Data, 1973; National Coal Association

It is difficult to determine the additional per ton cost resulting from this legislation. The limited information which is available was provided in a statement made before the Subcommittee on Special Small Business Problems of the House Select Committee on Small Business on July 13, 1971. The testimony which was given indicates that the costs are on the order of 20 to 40 cents per ton. If this estimate is reasonably accurate, then health and safety regulations explain only a small fraction of the price increases. In any event, the cost increase would be a one-time increase and would, therefore, not explain the continuing increases in the price of coal. Moreover, Table II. 11 shows that the output of underground mines decreased between 1966 and 1971. In fact, the proportion of total output taken from underground mines has declined over the longer period 1955 to 1971. Whereas almost three-fourths of Bituminous coal production came from underground mines in 1955, only half came from these mines in 1972. Certainly, health and safety of the worker is much less of an issue in strip mining than in underground mining. It should also be pointed out that even though all Anthracite coal is taken from underground mines, the price index for Anthracite has not increased nearly as rapidly as that for Bituminous coal.

Even though there has been little data on the economic impact of the mine health and safety legislation, the U. S. Bureau of Mines

reported that some marginal mines have been closed, but that overall productivity has remained constant due to the opening of new, more efficient mines.[1/]

With regard to proposed regulations regarding surface mining and environmental issues on coal, Dr. David B. Brooks, a highly qualified coal economist who was formerly employed by the Bureau of Mines and is now Head of the Economic Research Section of the Department of Energy, Mines and Resources of the Canadian Government, stated that the major environmental consideration with respect to coal is sulphur dioxide emissions, but he pointed out that this should be regarded as a utility cost and not a coal cost.[2/] Moreover, he observed that the nature of increased production cost for strip mining (such as site restoration) is on the order of only $.05 to $.10 per ton.

All the evidence presented in this section on prices, production, and consumption of coal leads to the conclusion that phenomenal increases in the price of all types of coal have occurred in the past five years. Moreover, the rate of price increase has been accelerating in recent months, and there is no prospect for immediate relief. Particularly hard-hit by these huge price increases are the nation's electric utilities which

---

1/ U. S. Bureau of Mines, Restrictions on the Uses of Coal (June, 1971), p. 53.

2/ To the extent that coal companies have had to incur additional costs to obtain low-sulfur coal (for example by opening new mines), pollution regulations do affect coal companies. However, no data are available on such costs.

consume about two-thirds of the Bituminous coal produced. Taken together, productivity, wages, health and safety regulations, and environmental factors do not account for all of the price increases. Furthermore, these price increases have occurred in spite of the fact that the coal mining industry has been operating at a level substantially below normal capacity. Had the coal operators been willing to produce at full capacity, these enormous price increases could have been accompanied by substantial increases in output. The fact that this did not happen, suggests that coal producers restricted output to further drive up prices and profits. In the next section, consideration is given to recent profits reported by coal companies.

III. Coal Company Profits

In view of the substantial increases in the price of coal which have not been matched by similar increases in costs of production in recent years, one would expect profits of coal operators to have increased. To determine whether in fact this has been the case, an attempt was made to obtain data from annual reports and other sources for the fifteen largest coal producers in 1973. Unfortunately, this effort was largely unsuccessful for at least three reasons. First, captive coal is not sold in the open market but is instead used as an intermediate product (for example, metallurgical coal is an imput in steel processing). As a result, profit data are not available as companies do not report profit figures for intermediate products. Second, as will be discussed in detail in section IV of this report, a large proportion of U. S. coal operations have been acquired by other firms--particularly oil companies. Although a company is required to report profit data by major product to the Securities and Exchange Commission on Form 10-K when sales of the product account for fifteen percent or more of the total revenues, some of the coal operations that are under control of large corporations (Gulf Oil, Kennecott Copper, Occidental Petroleum, and General Dynamics) do not account for the required percentage. Coal profits for these companies, therefore, are not available. Third, corporations with three hundred or fewer shareholders are also not required to report to the SEC. This, too, precludes any attempt at obtaining profit figures for all companies.

As a result of these difficulties, profit data are, at best, sketchy and hence do not permit a comprehensive analysis. In any case, data from SEC sources for three companies are presented in Table III. 1.

TABLE III. 1

Annual Profits of Three Major Coal Producers, 1971-1974
(thousands of dollars)

Company	1971	1972	1973	1974[a]
North American Coal	1, 248	2, 629	4, 452	6, 228
Eastern Associates	11, 438	4, 864	(315)	9, 229
Westmoreland Coal	4, 433	4, 386	4, 702	10, 128

Source: Securities and Exchange Commission Reports

[a]Based on first quarter 1974

As may be seen, North American Coal and Westmoreland Coal have experienced substantial gains in profits since 1971. If the profit rate in the first quarter of 1974 continues throughout 1974, North American's profit in 1974 will be about 5 times as large as in 1971 and Westmoreland Coal's 1974 profit will be about 2. 2 times as large as the 1971 figure. Eastern has had a less even profit record over the past 4 years. Despite this slight volatility in profits, 1974 profits will be about 1. 9 times that of 1972, although they are slightly less than 1971 profits.

The financial condition of a larger sample of companies can be considered by using Internal Revenue Service data. The net income figures covering a sample of companies that receive the largest percentage

of their revenue from coal operations are reported in Table III. 2.

TABLE III. 2

Net Income of Companies Reporting the Largest Percentage of Total Receipts from Coal Operations, 1966-1971 (thousands of dollars)

Year	Number of Companies	Net Income Less Deficit	Average Net Income Per Firm
1966	2,336	$ 96,120	41.1
1967	2,304	65,687	28.5
1968	1,581	56,724	35.9
1969	1,676	13,699	8.1
1970	2,228	283,365	127.2
1971	1,664	159,201	95.7

Source: Bituminous Coal Data, 1973. National Coal Association.

Unfortunately, the date are not available from this source for 1972 and 1973. In any event, it is noteworthy that net income of all firms in 1970 exceed the sum of the preceeding four years by more than $51.1 million. Net income in 1971 was greater than the sum of the reported net income in 1967, 1968, and 1969. These comparisons, of course, are influenced to some degree by the number of companies reporting. To correct for this, the average net income per firm has been computed. On the basis of these calculations, it is found that the average net income per firm in 1970 is greater than the sum of the average net incomes for the years

1966-1969. Average net income per firm in 1966 was one third that of 1970 and about 43 percent of the 1971 figure. Average net income per firm fell by about 25 percent between 1970 and 1971 when price controls were placed on coal and the rate of price increase was cut by half. Even though these data are not as complete as would be desirable, they are indicative of the substantial increases in profits earned by coal producers.

Oil companies have a large stake in coal operations, and the recent profits of oil companies are now legend. Although it is not always possible to determine the increase in profits due to coal operations per se for these companies, it is reasonable to assume that part of the increase in profits can be attributed to coal. For purposes of comparison, Table III.3 contains profit figures for oil firms engaged in coal operations during 1972 and 1973.

As may be seen, profits for these companies during the last two years have been sizeable. Profits range from a high of roughly $1.5 billions to a low of $19.7 millions in 1972. The profit highs and lows in 1973 are substantially greater, ranging from $2.4 billions to $74.1 millions. In terms of the percentage change in profits over this two year period, not one company recorded a decrease. Indeed, even the smallest percentage increase in profits represented a 28 percent gain. And Occidental reported a whopping 305 percent increase in profits. Surely, the coal operations of these companies contributed to this bright profit picture.

TABLE III. 3

Profits for Oil Companies Engaged in Coal Operations
for 1972 and 1973 (dollars in thousands)

Company	1972 Profits	1973 Profits	% increase
Exxon	$1,534,600	$2,440,000	59
Mobil	573,300	842,800	47
Texaco	891,300	1,292,400	45
Gulf	446,900	800,000	79
Standard (Cal.)	547,800	843,600	54
Standard (Ind.)	375,900	511,200	36
Shell	259,900	332,700	28
Continental	169,700	242,700	43
Atlantic Richfield	193,200	270,500	40
Standard (Ohio)	59,800	74,100	24
Occidental	19,700	79,800	305

Source: United Mine Workers Journal, April 1-15, 1974, p. 18.

Some other profit figures which were available are reported in Table III. 4. As is quite clear from the information contained in this table, this group of coal companies and some of the larger parent companies of coal companies has recorded extremely large profits in recent years. Not one of these companies incurred losses in 1971, 1972,

or the first quarter of 1973. Among the independent companies, Utah International led the others with $39.8 millions in profits in 1972. Pittston was not far behind with $28.5 millions. Consolidation Coal, which is owned by Continental Oil, contributed $16.6 millions in profits to its parent company, an increase of 118 percent over the $7.6 millions in 1971. The two steel companies with captive mines also showed substantial profits. Other companies turned in sizeable profits, too.

TABLE III.4

Profits of Selected Companies Engaged in Coal Operations

Company	1971 Profits	1972 Profits	Jan.-March 1972	Jan.-March 1973	Percent Change
Kennecott Copper	$103,119,000	$107,097,000	$18,400,000	$28,600,000	+55
Peabody Coal	8,513,000	15,668,000	N.A.	N.A.	+83
Pittston	43,437,000	28,585,000	9,900,000	7,400,000	-25
U. S. Steel	154,516,000	156,987,000	19,000,000	49,000,000	+160
American Metal Climax	51,310,000	66,190,000	13,700,000	20,200,000	+48
Amax Coal	15,000,000	23,000,000	N.A.	N.A.	+53
Bethlehem Steel	139,239,000	134,585,000	25,000,000	40,500,000	+61
Old Ben Coal	12,200,000	10,900,000	N.A.	N.A.	N.A.
Consolidation Coal	7,600,000	16,600,000	N.A.	N.A.	+118
Utah International	35,500,000	39,800,000	17,398,000	21,712,000	+24

Source: United Mine Workers Journal, July 15-31, 1973, p. 9.

The percentage change in profits from the first quarter of 1972 to the same period in 1973 is also reported in Table III. 4. As may be seen, every company but one increased its profits during this period. Even the company which sustained a decrease earned $7. 4 million in profits in the first quarter of 1973. The other companies saw their profits increase by at least 24 percent and in one case by 160 percent. Such increases in profits are exceptionally large, to say the least.

All of the available information on profits in the coal industry suggests that the recent and rapid increases in coal prices have been accompanied by similar increases in coal profits. As the next section will document, the structure of the coal industry is conducive to non-competitive activities which may well explain both the price and profit increases.

IV. Economic Structure of the Coal Industry

The discussion in Section II suggests that there is no satisfactory explanation for the full extent of the exceptionally large price increases in coal during recent years in terms of higher production costs resulting from lower productivity, increased wages and recent health and safety legislation. It is important, therefore, that an examination be made of the economic structure of the coal industry to determine whether any substantial changes may have occurred in recent years which could have made it possible for the dominant members of the industry to establish artifically higher prices by noncompetitive methods.

Even though there were approximately 4,000 coal mining concerns in 1972, the great majority of these were very small independent operators. For instance, as Table IV.1 shows, there were 3,413 firms producing less than 100,000 tons per year. To put these figures in perspective, it should be pointed out that all of these firms accounted for only about 5 percent of total coal production. In contrast, the 76 operating groups[1/] consisting of 139 firms producing over one million tons accounted for over 74 percent of the total coal produced.

1/ A company group consists of a number of firms tied together through "common ownership, investment, production or sales management, or a combination of such factors." Keystone Coal Industry Manual, 1970 Coal Mine Directory, (New York: McGraw-Hill, Inc., 1970) p. 148.

TABLE IV. 1

SIZE DISTRIBUTION OF BITUMINOUS COAL AND LIGNITE

COMPANIES AND OPERATING GROUPS IN 1972

Size Class (Coal Output Per Year)	Number of Groups	Number of Companies	Production In Thousands of Tons	Production as Percent of Total
Over 1,000,000 Tons	76	139	440,204	74.6
100,000--1,000,000 Tons	441	448	119,745	20.3
Under 100,000 Tons		3,413	30,051	5.1

Source: Keystone News Bulletin, 1972, p. 6.

Thus, even though the coal industry is populated by a large number of sellers, output is still controlled by a relatively small number of firms. The economic significance of this situation lies in the fact that economic theory clearly suggests that the greater the concentration of an industry's production in a relatively few firms the less intense the competitive rivalry. As a result, it is more likely that the price in such a situation will be higher than the price which would prevail in a perfectly competitive market.

For purposes of historical comparison, Table IV. 2 contains the percentages produced by various tonnage groups for selected years. As may be seen, firms producing over one million tons have enlarged their share of total coal production to 74. 6 percent in 1972 from 50. 5 percent

in 1949, roughly a 48 percent increase in only 25 years. In sharp contrast, the smaller firms have seen their share of total coal production slip to 5.1 percent from 17.9 percent during the same period. The trend is clearly towards increasing control over coal production by a small minority of firms.

TABLE IV.2

Percentages Produced
By Various Tonnage Groups

Tonnage Range	1949	1960	1965	1970	1971	1972
1,000,000 Tons and Over	50.5	64.9	68.1	72.3	70.3	74.6
100,000 to 999,999 Tons	31.7	22.1	22.5	21.5	24.2	20.3
Under 100,000 Tons	17.9	13.0	9.4	6.2	5.5	5.1

Source: Keystone Coal Industry Manual, 1973

To obtain a more detailed view of the coal industry's output distribution, Table IV.3 reports the annual production and industry share figures of the 50 largest coal operating groups for the years 1943 through 1973. The overall trend in the share of total coal production by these groups has clearly been upwards. Starting with 45.5 percent of total coal production in 1943, the next thirty years saw this percentage climb to 66.4 percent in 1973. Although the share of the top 50 groups has risen substantially during this period, total industry tonnage was about the same in 1973 as in 1943. This suggests that the average size of the larger firms is increasing relative to the average size of the smaller firms.

TABLE IV.3

Annual Production and Industry Share of the Top 50
Bituminous Coal Operating Groups

Year	Top 50 Tonnages	Industry Tonnages	% Top 50
1943	268,399,422	590,177,069	45.5
1944	277,902,542	619,576,240	44.8
1945	254,680,178	577,617,327	44.1
1946	230,346,662	533,922,068	43.1
1947	263,477,220	630,623,722	41.8
1948	256,567,797	599,518,229	42.8
1949	190,321,125	437,868,036	43.5
1950	233,393,064	516,311,053	45.2
1951	254,156,803	533,664,732	47.6
1952	232,333,768	466,840,782	50.0
1953	242,677,400	457,290,449	53.2
1954	211,812,342	391,706,300	54.0
1955	254,503,011	464,633,408	54.7
1956	279,844,275	500,874,077	55.9
1957	288,681,591	492,703,916	58.5
1958	241,067,718	410,445,547	58.7
1959	244,222,585	412,027,502	59.2
1960	248,936,537	415,512,347	59.9
1961	239,652,075	402,976,802	59.4
1962	254,393,843	422,149,325	60.2
1963	273,550,751	458,928,175	59.6
1964	302,213,579	486,997,952	62.0
1965	319,354,805	512,088,263	62.3
1966	341,129,969	533,881,210	63.8
1967	365,403,669	552,626,000	66.1
1968	374,221,189	545,245,000	68.6
1969	381,697,923	560,505,000	68.1
1970	402,782,490	602,932,000	66.8
1971	357,492,567	552,192,000	64.7
1972	399,448,778	595,386,000	67.0
1973	392,124,322	590,000,000	66.4

Source: Keystone News Bulletin, March 1974, p. 20.

Information regarding the extent of control over coal production by the 15 largest coal companies in the United States in 1973 is reported in Table IV. 4. The combined market shares of the 15 largest companies was 49. 7 percent in 1973, compared to 40. 9 percent in 1962. The top 15 companies now control, therefore, about half of the nation's coal output. The largest coal company, Peabody Coal Company, accounted for 11. 8 percent of total coal output in 1973. This means that Peabody alone produces more than twice as much coal as the smallest 3, 400 companies combined.

TABLE IV. 4

TOTAL BITUMINOUS COAL PRODUCTION AND MARKET SHARES OF THE FIFTEEN LARGEST PRODUCERS IN 1973

Rank	Parent	Coal Subsidiary (and date acquired)	Bituminous Coal Production (Tons)	Market Share
1	Kennecott Copper Corp.	Peabody Coal Co. (1967)	69,918,787	11.8
2	Continental Oil Co.	Consolidation Coal Co. (1966)	60,477,363	10.3
3	Occidental Petroleum Corp.	Island Creek Coal Co. (1968)	22,879,320	3.9
4	Pittston Coal Co.	-----	18,796,305	3.2
5	American Metal Climax Inc.	Amax Coal (1969)	16,657,552	2.8
6	United States Steel Corp.	-----	16,222,038	2.8
7	Bethlehem Steel Corp.	Bethlehem Mines	14,129,000	2.4
8	North American Coal Corp.	-----	12,501,316	2.1
9	Standard Oil Co. (Ohio)	Old Ben Coal Corp. (1968)	10,846,684	1.8
10	Eastern Gas and Fuel Assoc.	Eastern Associates Coal Corp.	10,640,063	1.8
11	Westmoreland Coal Co.	-----	8,808,651	1.5
12.	General Dynamics Corp.	Freeman Coal Mining Corp.	8,669,921	1.5
13	Gulf Oil Corp.	Pittsburgh & Midway Coal Mining Co.	8,064,089	1.4
14	Utah International Inc.	-----	7,389,321	1.3
15	American Electric Power Co.	Central Ohio Coal Co.	6,563,194	1.1

Source: Keystone News Bulletin, March 1974, p. 20.

"Troubled Coal Industry," National Journal Reports, Government Research Corporation, June 29, 1974, p. 954.

Information is also available regarding the name of the parent company of the fifteen largest coal producers in 1973, and Table IV.5 has been constructed to determine the share of output by industry affiliation.[1/] As the figures in this table show, four of the top fifteen companies are owned by large oil companies. Of the remaining companies, six are owned by other large industrial concerns well known for their activities outside the coal business. Only three of the companies among the top fifteen are still independent coal companies. Only eleven years earlier, however, there were eleven such companies. It can also be seen that the three independent coal companies account for only 13.7 percent of the coal output of the top fifteen companies and only 6.8 percent of the total coal output. In contrast, the four-oil affiliated companies account for 35.0 percent of the coal output of the top 15 producers and 17.4 percent of the total coal output. Excluding the independent coal producers, the remaining top fifteen producers accounted for 42.9 percent of the nation's coal output in 1973. Just eleven years earlier, however, the situation was reversed. For in 1962 the independent coal companies accounted for 31.5 percent of industry production, while the remaining large industrial companies accounted for only 9.4 percent of total coal output. The two

---

1/ The industry affiliation of all coal companies producing one million or more tons annually is provided in the Appendix.

steel companies (which are both captive coal producers) accounted for 5.3 percent of total output in 1962 versus 5.2 percent of total output in 1973--hardly any change at all.

TABLE IV.5

Industry Affiliations of the 15 Largest Coal Producers in 1973

Primary Industry	Number of Firms	Percentage of Top 15 Production	Percentage of Total Coal Production
Coal	3	13.7	6.8
Petroleum	4	35.0	17.4
Captive Producers	2	10.4	5.2
Other Non-Coal Firms	6	41.0	20.3

Source: Keystone News Bulletin, March, 1974, p. 20

"Troubled Coal Industry," National Journal Reports, Government Research Corporation, June 29, 1974, p. 954

It is apparent, then, that there has been an exceptionally rapid shift in the control of the coal mining industry between 1962 and 1973. Large industrial concerns in other businesses, particularly oil and gas companies, are now in a strong position to exercise considerable control over the coal industry. Specifically, this increased concentration of ownership in the supply of not only coal but all energy is likely to result in reduced competition among the four major fuels (oil, gas, coal, and

uranium) with a consequent rise in all fuel prices. Furthermore, now that the large petroleum firms have acquired significant interests in the coal industry, they have less incentive to pursue any technological advances in coal which represent a threat to their oil and gas operations. Any attempt to retard technological advance, however, is in essence a reduction in competition. This point is clearly expressed in a staff report by Joseph P. Mulholland and Douglas W. Webbink for the Federal Trade Commission as follows:

> Efforts by fuel producers to adapt their products to the needs of energy consumers represent an important form of competition that eventually influences the intensity of interfuel competition as well as fuel price levels. An important example is the on-going research into processes for transforming coal into oil and natural gas. Owing to the vast amounts of coal available for such developments, the potential for synthetic petroleum products derived from coal can be a significant threat to the petroleum industry. 2/

As impressive as the data discussed above may be in pointing toward the continued growth of large enterprise in the coal industry, it does not detail sufficiently the extent of economic concentration. For such detailed information one turns to concentration ratios. These ratios typically refer to the share of output accounted for by the four, eight,

---

2/ Joseph P. Mulholland and Douglas W. Webbink, "Concentration Levels and Trends in the Energy Sector of the U. S. Economy," Federal Trade Commission, March 1974, p. 31.

or fifteen largest firms in an industry. The economic importance of these measures is that where a relatively few firms possess a sufficiently large share of the market, none can or will remain indifferent to the actions of the others. Stated another way, the greater the level of concentration the more likely one is to find attempts to coordinate price and output policy to achieve monopoly profits.

Data on concentration ratios for the coal industry for 1973 are reported in Table IV. 6. For purposes of comparison, the concentration ratios or calculated shares of total output accounted for by the top four, top eight, and top fifteen firms with and without captive production are presented. The reason for even listing concentration ratios after excluding captive production is that coal taken from captive mines is used only by the parent firm and is, therefore, not sold in the open market. As may be seen, when captive production is excluded the degree of concentration increases to 30. 7 from 29. 2 at the 4 firm level. This represents the largest increase in concentration since the two largest captive producers (U. S. Steel and Bethlehem) ranked sixth and seventh in the overall top 15 list. In any event, given that there were more than 4,000 coal producing firms in 1973, the figures in Table IV. 6 indicate a substantial degree of concentration in the coal industry. Only four firms account for almost one-third of the total output. Including just another eleven firms and the share jumps to nearly one-half.

TABLE IV.6

Bituminous Coal and Lignite Production Concentration Ratios, Inclusive and Exclusive of Captive Production, 1973

Concentration Level	Including Captive Production	Excluding Captive Production
4 Firm	29.2	30.7%
8 Firm	39.3	39.8
15 Firm	49.6	46.9[a]

Source: Keystone News Bulletin, March 1974, p. 20.

[a]13 rather than 15 firms

It is also important to recognize that some of the largest coal companies that sell in the commercial market are also engaged in the marketing of coal produced by other companies, in addition to selling the coal produced from their own mines or the mines of their affiliates. These companies either buy coal from the other producers for resale or act as brokers for other companies in the sale of their coal. This effectively increases the control of the large companies that engage in such purchasing and brokerage activities, since the coal that is involved is produced by smaller companies. The actual control over the commercial market by the largest coal companies is even greater, therefore, than the figures reported in Table III.6 indicated. It

is estimated that these 15 companies control close to two-thirds of the sales in the commercial market. Thus, a relatively small number of very large and economically powerful corporations appear to be in a position to exercise a considerable degree of control over the marketing of coal.

The concentration ratios are more meaningful when it is realized that the relevant market for measuring concentration may be a regional rather than national market. A major reason is that transportation costs for coal are substantial, even for coal transported a few hundred miles. As a case in point, Table IV.7 shows that concentration in the Midwest region is significantly greater than that found on the national level. Moreover, concentration has been increasing at a rapid rate in the Midwest just as it has been increasing at the national level. Indeed, the 4 firm and 8 firm concentration ratios have more than doubled since 1955.

TABLE IV.7

Concentration Ratios for Coal Production
in the Midwest and at the National Level in 1970

Concentration Ratios	Midwest	National
4 Firm	65.6	30.2
8 Firm	85.6	40.7
20 Firm	97.0	51.7

Source: Keystone Coal Industry Manual, U. S. Coal Production by Company. . . 1970.

Various issues of Keystone News Bulletin.

Staff Report to the Federal Trade Commission, p. 311.

Data on trends in concentration of economic power in the coal industry at the national level during the post-1955 period are shown in Table IV. 8. At the 4 firm level, concentration has nearly doubled since 1955. Somewhat smaller but still significant increases have taken place in the 8 firm and 15 firm concentration ratios. Taken together, these ratios indicate that concentration in the coal industry has increased significantly during the past twenty years. Since 1970 the concentration ratios do display a slight variability both upwards and downwards, but certainly do not indicate a reversal of their longer run tendency to increase.

TABLE IV. 8

BITUMINOUS AND LIGNITE PRODUCTION CONCENTRATION RATIOS, 1955, 1960, 1965, 1970, 1971, 1972, 1973
(Percent)

Concentration Level	1955	1960	1965	1970	1971	1972	1973
4 Firm	17.8	21.4	26.6	30.2	27.8	30.2	29.2
8 Firm	25.4	30.5	36.3	40.7	37.6	40.0	39.3
15 Firm	39.5[a]	44.5[a]	45.0	51.7	48.1	50.6	49.6

Source: Joseph P. Mulholland and Douglas W. Webbink, "Concentration Levels and Trends in the Energy Sector of the U. S. Economy," Staff Report to the Federal Trade Commission, March 1974, p. 138.

Various issues of Keystone News Bulletin.

[a]20 Firm Concentration Level

The rising concentration in coal production reflects a number of factors. As already noted, production by large companies has become increasingly important in the post-war years. Companies with an output of over one-half million tons per year have increased their share of total production, while all of the smaller size companies have experienced declines in relative production shares. The economic reason for this structural shift appears to be that there are economies of scale in strip mining, a method of producing an ever-increasing percentage of all coal since 1955 (see Table II. 11). Assuming that the use of strip mining continues to grow in the future, this could lead to further increases in concentration because of the advantages of larger size mines. What is bothersome is that there is no evidence that economies of scale have been reflected in lower prices.

TABLE IV.9

Chronological List of Coal Company Acquisitions, 1959-1974

Year	Acquired Coal Company	Acquiring Company
1959	Freeman Coal	General Dynamics Corp.
1963	Midland Electric Coal	Peabody Coal
1964	Pittsburgh & Midway Coal	*Gulf Oil Corporation
1966	Consolidation Coal Co.	*Continental Oil Co.
1966	United Electric Coal Co.	General Dynamics Corp.
1968	Old Ben Coal Corp.	*Standard Oil (Ohio)
1968	Enos Coal	*Standard Oil (Ohio)
1968	Island Creek Coal Co.	*Occidental Petroleum Corp.
1968	Peabody Coal Co.	Kennecott Copper
1968	Omar Mining	Wheeling-Pittsburgh Steel
1968	Winding Gulf	Westmoreland Coal
1968	Hawley Fuel Corp.	*Belco Petroleum Corp.
1968	Colombine Coal Co.	Bartep Industries
1968	United Pocahontas Coal Co.	National Bulk Carriers
1969	Joanne Coal	Eastern Gas & Fuel
1969	Amax Coal Co.	American Metal Climax
1969	Eastern Coal	Pittston Co.
1969	Imperial Smokeless	Westmoreland Coal
1969	Maust Properties	*Occidental Petroleum Corp.
1969	Virginia Iron, Coal & Coke	Bates Manufacturing Co.
1969	Canterbury Coal Co.	*Westrans Industries, Inc.
1969	Monterey Coal Co.	*Humble Oil and Refining
1969	Thompson Creek Coal & Coke	North American Resources & Chemical

TABLE IV. 9 (cont'd) IV-16
-2-

1970	Ranger Fuel (30% Interest)	Eastern Gas & Fuel
1970	Sterling Smokeless	Eastern Gas & Fuel
1970	C & K Coal Co.	Gulf Resources & Chemical
1970	Barnes & Tucker Co.	Alco Standard Corp.
1970	Breathitt County Coal Corp.	*Falcon Seaboard, Inc.
1970	Black Eagle Coal Co.	*Falcon Seaboard, Inc.
1970	Mt. Top Stripping	*Falcon Seaboard, Inc.
1970	Pine Bluff Auger Co.	*Falcon Seaboard, Inc.
1970	Boone County Coal Corp.	*Zapata Corp.
1970	Marietta Coal Co.	*McCulloch Oil Corp.
1970	Kingdom Come Coal Co.	*McCulloch Oil Corp.
1970	No. 7 Corp.	*McCulloch Oil Corp.
1970	Big Four	*McCulloch Oil Corp.
1970	Aloe Coal Co.	Pullman, Inc.
1970	Oak Leaf Coal Co.	Sherwood Leasing Corp.
1970	Call & Ramsey Coal Co.	Universal Acceptance Corp.
1970	Tenn-Ky. Coal Co.	U. S. Plywood-Champion Papers
1970	Twilight Industries, Inc.	*U. S. Natural Resources
1970	Path Fork Harlan Coal Co.	U. S. Plywood-Champion Papers
1970	Gauley Coal Land Co.	Westvaco Corp.
1971	Black Lode Coal Co.	*Crestmont Oil & Gas Co.
1971	Dusky Diamond Coal Co.	*Dal Petroleum
1971	Pratt Mining Co.	Federal Resources Corp.
1971	Webster County Coal Corp.	*Mapco, Inc.
1971	Carbon Fuel	*McCulloch Oil Corp.
1971	River Processing, Inc.	Pargas, Inc.
1972	Upshur Coals, Ltd.	Alco Standard Corp.
1972	Sigmon Construction Co.	*Ray Resources Corp.
1972	Kristianson & Johnson Coal	*Westrans Industries, Inc.

TABLE IV.9 (cont'd) IV-17
-3-

1973	Alumbaugh Coal Corp.	Donovan Construction Co.
1973	Elk Horn Coal Co.	*Ethyl Corp.
1973	Fresno Coal Co.	General Exploration Co.
1973	Blue Diamond Coal	W. R. Grace Co.
1973	Zeigler Coal Co.	Houston Natural Gas Corp.
1973	Interstate Coal Co., Inc.	Kaneb Services, Inc.
1973	Lelco, Inc.	Kaneb Services, Inc.
1973	Mountain Clay, Inc.	Kaneb Services, Inc.
1973	Pickands Mather & Co.	Moore & McCormack Co.
1973	Call & Ramsey Coal Co.	National Industries, Inc.
1973	Rapoca Resources	Rapoca Energy Corp.
1974	Buckhorn Hazard Coal	General Energy Corp.
1974	Brilliant Coal Co.	Great Northern Nekoosa Corp.
1974	Belva Coal Co.	*International Mining & Petroleum

Source: Joseph P. Mulholland and Douglas W. Webbink, "Concentration Levels and Trends in the Energy Sector of the U. S. Economy," Staff Report to the Federal Trade Commission, March 1974, p. 202.

S. Robert Mitchell, "Preliminary Economic Report on the Bituminous Coal Price Increase During 1970," March 1971, Exhibit 3.

Keystone News Bulletin, May 1974.

*Oil producer or company with oil producing interests

Another factor weakening competition has been the large number of mergers in the coal industry. Table IV.9 chronologically lists coal company acquisitions during the period 1959 through the first half of 1974. As may be seen, there have been a large number of acquisitions of coal companies during this period. Clearly, these acquisitions have caused concentration levels to be higher than they would have been had the acquisitions not taken place. Moreover, many of the acquisitions of coal companies have been consummated by oil producers or companies with oil producing interests. In fact, of the 65 acquisitions during this fifteen year period, oil firms accounted for 27, representing about 41 percent. Considering just the 1970's, the oil firms were responsible for about 42 percent of the total number of acquisitions of coal companies. Since two-thirds of all the acquisitions occurred in the past five years, it is significant that nearly half of these were accounted for by oil firms. On the basis of such figures, Joseph P. Mulholland and Douglas W. Webbink concluded that ". . . because petroleum company acquisitions of coal and uranium companies can be viewed as horizontal acquisitions, they definitely should be subject to antitrust review for possible anticompetitive effects."[3/]

At this point, it should be noted that it would also be desirable to provide data on coal reserves ownership and concentration similar to that available for coal production ownership and concentration. Unfor-

---

3/ Joseph P. Mulholland and Douglas W. Webbink, "Concentration Levels and Trends in the Energy Sector of the U. S. Economy," Federal Trade Commission, March 1974, p. 263.

tunately, detailed information is not available from public sources. Even the limited data which are available appear ". . . to include only a small fraction of the reserves actually owned by coal companies and a much smaller fraction of potentially available reserves."[4/] There are, however, rough estimates of reserves owned by the top 17 companies. These estimates are reported in Table IV. 10. Obviously, outside control is substantial on coal's future reserves, as 16 of the top 17 holders are companies representing oil, railroad, steel, and metal interests.

4/ Ibid., p. 136.

TABLE IV. 10

Estimated Reserves of the Top 17 Companies

Company	Total Estimated Reserves (Billions of Tons)
Burlington Northern RR	11.0
Union Pacific RR	10.0
Kennecott Copper (Peabody Coal)	8.7
Continental Oil (Consolidation Coal)	8.1
Exxon (Monterey Coal)	7.0
American Metal Climax (Amax Coal)	4.0
Occidental Petroleum (Island Creek Coal)	3.3
United States Steel	3.0
Gulf Oil (Pitts. & Midway Coal)	2.6
North American Coal	2.5
Reynolds Metals	2.1
Bethlehem Steel	1.8
Pacific Power & Light	1.6
American Electric Pwr.	1.5
Eastern Gas & Fuel Assoc. (Eastern Assoc. Coal)	1.5
Kerr-McGee	1.5
Norfolk & Western RR	1.4
Utah International	1.3
Westmoreland Coal	1.2
Pittston Co.	1.0
Montana Power (Western Energy)	1.0
Standard Oil of Ohio (Old Ben Coal)	0.8
Ziegler Coal	0.8
General Dynamics (Freeman/United Elec.)	0.6
Rochester & Pitts. Coal	0.3
Carbon Fuel	0.1
Amer. Smelting & Refin. (Midland Coal)	0.1

Source: United Mine Workers Journal, July 15-31, 1973, p. 5.

Numerous firms have also initiated significant exploration efforts on Government owned coal lands administered by the Bureau of Land Management and the U. S. Geological Survey. At the time the Interior Department began freezing new leases for coal rights to federal lands in 1971, a total of 773,000 acres was under lease in the Great Plains states and the Southwest, and some of the biggest leaseholders to get in before the cutoff date were oil companies.

According to a recent study by the Council on Economic Priorities, a New York-based nonprofit research group, the top 15 of 144 leaseholders out of the 474 leases outstanding in seven western states controlled 70 percent of all the land under lease. Moreover, five oil companies--Continental Oil Co., Shell Oil Co., Sun Oil Co., Gulf Oil Corp., and Atlantic Richfield Co. --were in the top 15. Other leaders included five of the nation's 15 leading coal producers and three electrical utilities.5/

The large corporate lease-holders, the report said, "speculate the most," holding public coal unmined until prices go up. Only 11 percent of the 474 leases examined by the study group were under active production, and 321 leases "have never produced a single ton of coal."6/

All of the evidence presented thus far indicates that concentration in coal production is not only already substantial but will continue to increase

---

5/ James G. Phillips, "Coal II: East-West Dispute," National Journal Reports, July 6, 1974, p. 1019.

6/ The Washington Post, May 1974.

in the future. In addition, many of the largest coal companies are now owned by other fuel companies or are captive producers owned by steel companies. But unlike the other fossil fuels, coal is not subject to production or pricing regulations, although it is being subject to anti-pollution and ecological regulations. As a result, the increasing degree of economic concentration taking place in the coal industry may be the missing factor which explains the recent perverse price behavior.

V. Summary and Conclusions

It is well-known that coal is relatively abundant in the United States. It is also well-known that coal, as a source of energy, is vital to the functioning of the economy, particularly in view of the scarcity of oil and natural gas. The price of coal is, therefore, extremely important, especially since electric utilities consume the majority of the coal output and increases in fuel costs to utilities are passed on to industry and consumers. Thus, rapid price increases in coal only worsen domestic inflation. Coal prices remained relatively stable during the period 1958-1968, but since that time enormous price increases have occurred. These price increases cannot be fully explained by increases in the cost of production, for unit labor cost increases are of much smaller magnitude than price increases. Nor do available data indicate that the coal operators were attempting to rapidly expand output, for the evidence indicates that in recent years the industry has operated substantially below normal capacity. These findings are summarized in Chart V. 1.

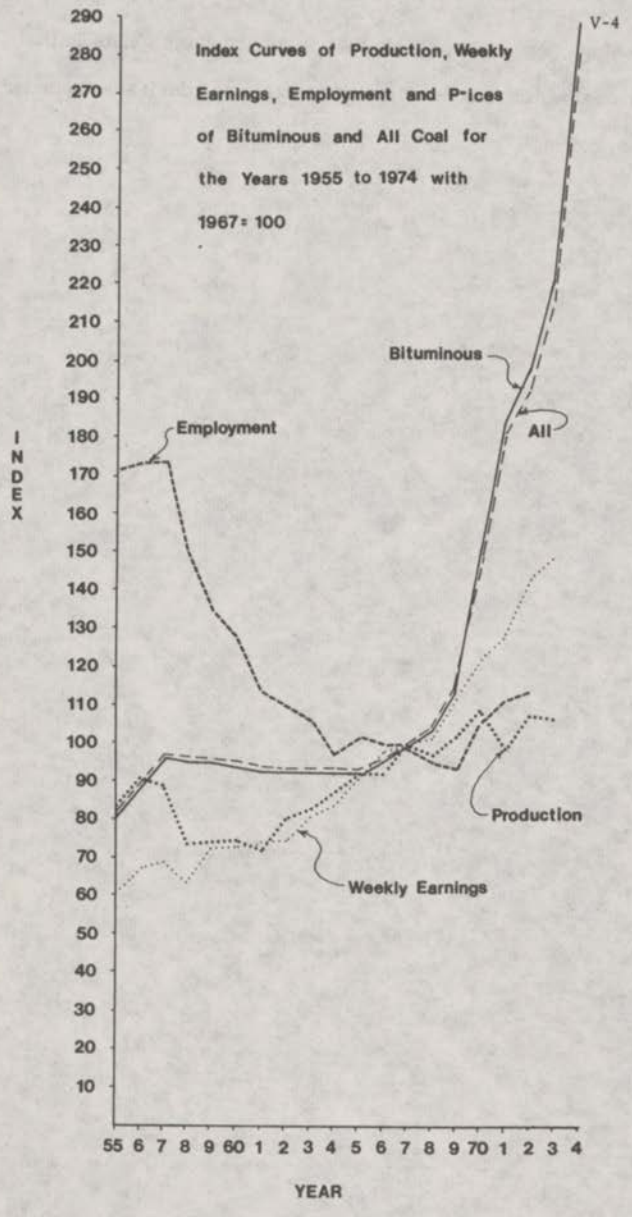
From the chart, it is evident that employment and output since 1967 have remained relatively constant. Admittedly, average weekly earnings have increased, but prices have risen far more dramatically. On the basis of Chart V. 1, one finds that output in 1971, 1972, and 1973 was below the level of 1970. It, therefore, cannot be argued that these price increases can be explained entirely by shortages of coal or by excess demand. A review of the available data on profits of coal companies and coal operating companies reveal tremendous increases in profits. Thus, price increases have been translated into profits.

The findings outlined above are not consistent with competitive behavior in the market for coal. If the coal industry were competitive, one would expect price increases to be accompanied by substantial increases in output and an attempt to satisfy demand by full utilization of available capacity. Although it is virtually impossible to prove conclusively that coal companies have entered into a conspiracy to raise prices and limit output, it should be noted that the findings of this report are entirely consistent with such behavior.

There is no doubt whatsoever that control of the coal output in the U. S. is concentrated to a great extent in the hands of very few companies. Furthermore, many of these companies are also engaged in the production of oil and natural gas. Thus, the markets for the substitutes for coal are controlled by many of the same companies which control the market for coal. As discussed earlier, the concentration figures do not indicate the true extent of economic power wielded by coal companies, for long-term contracts tie up much of the coal produced and, because of prohibitive transportation costs, the number of sources available to an individual buyer is extremely limited. Whereas the market for coal is tightly controlled on the seller's side, the reverse is true of the purchasers who deal with coal companies individually. Even though there are a larger number of small operators, much of the coal produced by these small companies is sold by brokers or even other large companies. Thus, the marketing of coal is more concentrated than production itself. Because

of these findings, one can conclude that an environment exists in the market for coal which makes collusion possible and desirable in order to increase profits.

CHART V. 1



*Source Computed From Earlier Tables

We believe that an investigation of the coal industry with respect to pricing and supply policy is not only warranted in the light of the findings presented in this paper, but is also in the national interest.

James R. Barth

James T. Bennett

APPENDIX

Ownership of Coal Companies Producing
One Million or More Tons Annually

Coal Operating Company	Parent or Controlling Company	Primary Field or Parent or Controlling Co.
Affinity Mining Co.	Eastern Gas & Fuel Assoc.	Other
Alabama By-Products Corp.	Alabama By-Products Corp.	Other
Aloe Coal Co., Inc.	Pullman, Inc.	Other
Alumbaugh Coal Co., Inc.	Donovan Companies, Inc.	Other
Amax Coal Co.	American Metal Climax, Inc.	Metal
American Coal Co.	Utah Power & Light Co.	Utility
Amherst Coal Co.	Amherst Coal Co.	Coal
Amigo Smokeless Coal Co.	Pittston Co.	Other
Arch Coal Co.	Ashland Oil Co.	Oil
Arch Mineral Corp.	Ashland Oil Co.	Oil
Armco Steel Corp.	Armco Steel Corp.	Steel
Ashland Mining Corp.	Sovereign Pocahontas Coal Co.	Coal
Badger Coal Co.	Pittston Co.	Other
Barbour Coal Co.	Barbour Coal Co.	Coal
Barnes & Tucker Co.	Alco Standard Corp.	Chemical
Baukol-Noonan, Inc.	Baukol-Noonan, Inc.	Coal
Beatrice Pocahontas Co.	Occidental Petroleum and Republic Steel	Oil, Steel
Belva Coal Co.	International Mining & Petroleum	Oil
Benjamin Coal Co.	Benjamin Coal Co.	Coal
Beth-Elkhorn Coal Corp.	Bethlehem Steel Co.	Steel
Bethlehem Mines Corp.	Bethlehem Steel Co.	Steel
Big Horn Coal Co.	Peter Kiewit Sons Co.	Other
Big Mountain Coal, Inc.	Armco Steel Corp.	Steel
Bishop Coal Co.	Continental Oil Co.	Oil
Black Creek Coal Sales Div.	The Drummond Co.	Coal
Blackwood Fuel Co., Inc.	Belco Petroleum Corp.	Oil
Blair Fork Coal Co.	W. R. Grace Co.	Other
Blue Diamond Coal Co.	W. R. Grace Co.	Other
Bradford Coal Co., Inc.	Bradford Coal Co., Inc.	Coal
Buckeye Coal Co.	Youngstown Sheet & Tube Co.	Steel
Buckeye Coal Mining Co.	Keller Steel Co.	Steel
Buckhorn Hazard Coal Corp.	General Energy Corp.	Other
Buffalo Mining Co.	Pittston Co.	Other
Burgess Mining & Construction	Burgess Mining & Construction	Other
CF&I Steel Corp.	CF&I Steel Corp.	Steel
C & K Coal Co.	Gulf Resources & Chemical Co.	Chemical
Cannelton Coal Co.	Cannelton Industries, Inc.	Steel
Canterbury Coal Co.	Westrans Industries	Other
Carbon Fuel Co.	Carbon Fuel Co.	Coal
Cedar Coal Co.	American Electric Power Service Corp.	Utility
Central Appalachian Coal Co.	American Electric Power Service Corp.	Utility
Central Coal Co.	American Electric Power Service Corp.	Utility
Central Ohio Coal Co.	American Electric Power Service Corp.	Utility

A-2

Coal Operating Company	Parent or Controlling Company	Primary Field or Parent or Controlling Co.
Charter Coal Corp.	Gulf Resources & Chemical Corp.	Chemical
Cimarron Coal Corp.	Cimarron Coal Corp.	Coal
Clinchfield Coal Div.	Pittston Co.	Other
Clintwood Mining Co.	Sovereign Pocahontas Coal Corp.	Coal
Colowyo Coal Co.	W. R. Grace Co.	Other
Consolidation Coal Co.	Continental Oil Co.	Oil
Cravat Coal Co.	Cravat Coal Co.	Coal
Cumberland Collieries	Jewell Coal & Coke Co.	Coal
Decker Coal Co.	Peter Kiewit Sons Co.	Other
H. E. Drummond Coal Div.	The Drummond Co.	Other
Duquesne Light Co.	Duquesne Light Co.	Utility
Eads Coal Co.	Ashland Oil Co.	Oil
Eastern Associated Coal Corp.	Eastern Gas & Fuel Assoc.	Other
Eastern Coal Corp.	Pittston Co.	Other
Eastover Mining Co.	Duke Power Co.	Utility
Elkay Mining Co.	Pittston Co.	Other
Falcon Coal Co., Inc.	Falcon Coal Co., Inc.	Coal
Florence Mining Co.	North American Coal Corp.	Coal
Freeman Coal Mining Corp.	General Dynamics Corp.	Other
Fresno Coal Corp.	General Exploration Co.	Other
Gabriel Valley Enterprises	General Energy Corp.	Other
Gateway Coal Co.	Jones & Laughlin Steel Corp.	Steel
Gibraltar Coal Corp.	Kennecote Copper; American Metal Climax	Metal
Greenwich Collieries Co.	Pennsylvania Power & Light Co.	Utility
Harman Mining Corp.	Sovereign Pocahontas Coal Co.	Coal
Harmar Coal Co.	Continental Oil Co.	Oil
Hawley Coal Mining Corp.	Belco Petroleum Corp.	Oil
Helen Mining Co.	North American Coal Corp.	Coal
Helvetia Coal Co.	Rochester & Pittsburgh Coal Co.	Coal
Industrial Mining Co.	Keller Steel Co.	Steel
Inland Steel Co.	Inland Steel Co.	Steel
International Harvester Co.	International Harvester	Other
Island Creek Coal Co.	Occidental Petroleum Corp.	Oil
Itmann Coal Co.	Continental Oil Co.	Oil
Jewell Coal & Coke Co.	Jewell Coal & Coke Co.	Coal
Jewell Ridge Coal Corp.	Pittston Co.	Other
Johns Creek Elkhorn Coal	General Energy Corp.	Other
Johns & Laughlin Steel Corp.	Jones & Laughlin Steel Corp.	Steel
Kaiser Steel Corp.	Kaiser Steel Corp.	Steel
Kellerman Mining Div.	The Drummond Co.	Coal
Kemmerer Coal Co.	Kemmerer Coal Co.	Coal
Kentland-Elkhorn Coal Corp.	Pittston Co.	Other
Kentucky Carbon Corp.	Carbon Fuel Co.	Coal
Kerr-McGee Coal Corp.	Kerr-McGee Corp.	Other
King Knob Coal Co.	King Knob Coal Co.	Coal
Knife River Coal Mining Co.	Montana Dakota Utilities	Utility
Kristianson & Johnson Coal Co.	Westrans Industries	Other
Majestic Collieries Co.	Sovereign Pocahontas Coal Co.	Coal
Maple Meadow Mining Co.	Cannelton Industries, Inc.	Steel
Marty Corporation	Marty Corporation	Coal
Mathies Coal Co.	Continental Oil Co.	Oil

A-3

Coal Operating Company	Parent or Controlling Company	Primary Field or Parent or Controlling Co.
Mead Corporation	Mead Corporation	Other
Midland Coal Co.	American Smelting & Refining	Metal
Midway Coal Co.	Pullman, Inc.	Other
Monterey Coal Co.	Exxon Corp.	Oil
Mountain Drive Coal Co.	Mountain Drive Coal Co.	Coal
Nacco Mining Co.	North American Coal Corp.	Other
National Coal Mining Co.	Occidental Petroleum Corp.	Oil
National Mines Corp.	National Steel Corp.	Steel
Natural Bridge Coal Div.	The Drummond Co.	Coal
New River Coal Co.	Chessie System	RR
North American Coal Corp.	North American Coal Corp.	Coal
Ogleboy Norton Co.	Oglebay Norton Co.	Other
Ohio Coal & Construction Co.	Ohio Coal & Construction	Coal
Ohio Edison Co.	Ohio Edison Co.	Utility
Old Ben Coal Co.	Standard Oil Co. (Ohio)	Oil
Olga Coal Co.	Youngstown Sheet & Tube Co.	Steel
Oneida Mining Co.	North American Coal Corp.	Coal
Pacific Power & Light Co.	Pacific Power & Light Co.	Utility
Peabody Coal Co.	Kennecott Copper Corp.	Metal
Peter White Coal Mining Corp.	Belco Petroleum Corp.	Oil
Pikeville Coal Co.	Steel Co. of Canada	Steel
Pocahontas Red Ash Mining Corp.	Belco Petroleum Corp.	Oil
Pittsburg & Midway Coal Mining	Gulf Oil Co.	Oil
Princess Susan Coal Co.	Central Penn Industries	Other
Quarto Mining Co.	North American Coal	Coal
R&F Coal Co.	Gulf Resources & Chem. Corp.	Coal
Race Fork Coal Corp.	W. R. Grace Co.	Coal
Ranger Fuel Corp.	Pittston Co.	Other
Republic Steel Corp.	Republic Steel Corp.	Steel
Rochester & Pittsburgh Coal	Rochester & Pittsburgh Coal	Coal
Rocky Mountain Energy Co.	Union Pacific; Ideal Basic Ind.	Other
Rosebud Coal Sales	Peter Kiewit Sons Co.	Other
Rushton Mining Co.	Pennsylvania Power & Light	Utility
Sahara Coal Co.	Sahara Coal Co.	Coal
Scotia Coal Co.	W. R. Grace Co.	Other
Semet Solvay Div.	Allied Chemical Corp.	Chemical
Sewell Coal Co.	Pittston Co.	Other
Shamrock Coal Co.	Jewell Coal & Coke Co.	Coal
Slab Fork Coal Co.	Slab Fork Co.	Coal
Snap Creek Coal Co.	Pittston Co.	Other
Southern Appalachian Coal	American Electric Power Service	Utility
Southern Electric Generating	Southern Electric Generating Co.	Utility
Southern Ohio Coal Co.	American Electric Power Service	Utility
Southern Utah Fuel Co.	Coastal States Energy Co.	Other
Southwestern Illinois Coal	Ashland Oil Co.	Oil
Sovereign Coal Corp.	Sovereign Pocahontas Coal Co.	Coal
Tunnelton Mining Co.	Pennsylvania Power & Light	Utility
Twilight Industries, Inc.	U. S. Natural Resources Co.	Other
Union Carbide, Ferroalloys Div.	Union Carbide Corp.	Chemical
United Electric Coal Co.	General Dynamics Corp.	Other
United States Fuel Co.	U. S. Smelting & Refining Co.	Metal
United States Pipe & Foundry	Jim Walter Corp.	Other

A-4

Coal Operating Company	Parent or Controlling Company	Primary Field or Parent or Controlling Co.
United States Steel Corp.	United States Steel Corp.	Steel
Upshur Coals Inc.	Alco Standard, Inc.	Chemical
Utah International Inc.	Utah International Inc.	Metal
Valley Camp Coal Co.	Valley Camp Coal Co.	Coal
Virginia Iron Coal & Coke Co.	Virginia Iron Coal & Coke Co.	Coal
Virginia Pocahontas Co.	Occidental Petroleum Co.	Oil
Walker-Fayette Coal Co.	Ashland Oil Co.	Oil
Washington Irrig. & Denlop. Co.	Pacific Power & Lt; Washington Water Power	Utility
Webster County Coal Corp.	Mapco Inc.	Other
Western Energy Co.	Montana Power Co.	Utility
Westmoreland Coal Co.	Westmoreland Coal Co.	Coal
Westmoreland Resources	Westmoreland Coal' Penna-Va Corp; Morrison-Knudsen; Kewanee Oil	Other
Wheeling-Pittsburgh Steel Corp.	Wheeling-Pittsburgh Steel Corp.	Steel
Windsor Power House Coal Co.	American Electric Power Service	Utility
Wyodak Resources Devel. Co.	Black Hills Power & Light Co.	Utility
Youghiogheny & Ohio Coal Co.	Youghiogheny & Ohio Coal Co.	Coal
Youngstown Mines Corp.	Youngstown Sheet & Tube Co.	Steel
Zapata Coal Corp.	Zapata Corp.	Other
Zeigler Coal Co.	Houston Natural Gas Corp.	Other

Source: Keystone News Bulletin, May 1974, pp. 5 - 6.

TENNESSEE VALLEY AUTHORITY OVERSIGHT HEARINGS

MONDAY, MAY 12, 1975

U.S. SENATE,
COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The committee met at 10 a.m., pursuant to recess, in room 4200, Dirksen Senate Office Building, Hon. Howard H. Baker, Jr., presiding.

Present: Senators Randolph (chairman of the full committee), Baker, Gravel, Stafford, and Domenici.

Also present: Senator Brock.

OPENING STATEMENT OF HON. HOWARD H. BAKER, U.S. SENATOR FROM THE STATE OF TENNESSEE

Senator BAKER. The committee will come to order.

Gentlemen, welcome. Many of you have become familiar faces in the course of the last 5 days of testimony on oversight. We are preparing today to hear from the TVA Board, Mr. Aubrey Wagner, Mr. Don McBride, and Mr. Bill Jenkins, as our concluding witnesses.

Today's hearing is the last in the series of six that began 2 weeks ago. The hearings have covered a wide range of issues and will, I believe, furnish a broad background for the committee's scheduled consideration of the appointment of a new director to fill the vacancy which will be created by the retirement of Mr. McBride on May 18, and the solid foundation for our review of TVA's bond selling.

These hearings will serve an even broader purpose, I believe. As the first hearing since the thirties directed toward providing a comprehensive overview of the programs and policies of TVA without the limitation of a specific legislative focus, these hearings have provided the committee and Congress a basis for evaluation of the TVA program 40 years later.

That is extremely important for this committee and Congress will have a great role in directing the TVA on its course into the future.

Many specific points and issues have been raised over the past 2 weeks by witnesses in these hearings. I know that TVA's representatives will want, and they certainly deserve, an opportunity to respond on many of these points.

It is my hope that the presentation of the Board today will not be limited to rebuttal, but will be a statement of policies which are directed and will direct TVA in its endeavors.

Therefore, without objection and if it is acceptable to the members of the TVA Board, I will ask the staff to review the transcripts of the hearings when they are received and prepare a list of issues and questions raised during the hearings so that TVA may have an opportunity to respond to them on a more detailed basis if they care to.

I understand the direct statements and testimony have been requested to be submitted on or before May 15. However, the record will be kept open for statements in response to issues raised at the hearings for an additional period until June 15, 1975.

With that, gentlemen, we are most pleased to have you and to give account to the Board of Directors that your staff has made excellent presentations on the hearing issues. They have sat here patiently and heard some fairly critical testimony. I think that we have been through a process, a learning process, and one that I know has been useful to me, I suspect may be useful to TVA, and in the long term I hope and think will argue in favor of an even greater future for TVA in the years to come.

With that, gentlemen, I will be happy to hear your further remarks today.

STATEMENTS OF AUBREY J. WAGNER, CHAIRMAN; DON McBRIDE, DIRECTOR; WILLIAM L. JENKINS, DIRECTOR; AND LYNN SEEBER, GENERAL MANAGER, TENNESSEE VALLEY AUTHORITY BOARD OF DIRECTORS

Mr. WAGNER. Thank you very much, Mr. Chairman. I am glad to hear the TVA staff acquitted itself well. I wouldn't do my job if I didn't say we sent them to do that. We are always glad to hear comments that people have about TVA and its activities.

Before I begin, Mr. Chairman, I would like to repeat as you indicated earlier that this is probably Mr. McBride's last appearance before a congressional committee as a member of the TVA Board.

I wouldn't want him to leave without saying he has contributed greatly to the success of its operations, to many activities and endeavors, and we will be sorry to see him gone.

Senator BAKER. I might interrupt and say that I, too, as a Tennesseean, familiar with the daily operations of TVA, have come to know Mr. McBride and his contributions not only to the agency but to our area.

I know that he has been a very, very respected and revered citizen in our community. We are, too, sorry to see him leave his position and hope he will continue to stay with us as a resident.

Mr. McBRIDE. Thank you, Mr. Chairman. Thank you, Mr. Wagner.

Mr. WAGNER. Mr. Chairman, from the newspaper and television that I have seen, and the reports I have received from the TVA staff as

these hearings have progressed, I believe congratulations are in order for the members and staff of your committee.

Your oversight inquiry into the operations of TVA has been an enlightening and constructive one—thorough in its scope, and exacting in its quest for information. This is as it should be.

To borrow a phrase used from time to time over the past 12 days, if we had had our druthers, I don't believe we would "druther" have had it any other way.

As a public agency charged by Congress with the responsibility of helping the people in the Tennessee Valley carry out a unified resource development program and as a continuing national demonstration, TVA has an obligation to respond fully and frankly to the inquiries of members of the committee and members of the public who have testified here.

Indeed, those two concepts I just mentioned, responsibility and responsiveness, have been common threads running through much of the testimony you have heard. Some of your witnesses have come rather softly. Some have come loudly. Some, I am told, came with yardsticks.

But I am convinced that virtually all have come to you with legitimate, honest views and concerns about TVA programs. We bear the responsibility to be responsive to these views and concerns.

We accept that responsibility gladly, Mr. Chairman.

It seems to me, then, that the central issue facing TVA today, and the central question facing this committee, is this: How has TVA met, and how will it continue to meet its statutory obligations as a multiple-purpose regional development agency and remain responsive to the people, the Congress, and the Nation it serves?

There isn't an easy answer, and the question has been with us for nearly 42 years.

During these hearings you have heard from a wide variety of groups and individuals expressing a sometimes equally wide variety of honest views. And we have seen that there is no agreement on the problems we face, much less on the solutions.

We have heard from some that TVA electric rates are too high, and thereby detrimental to the economic and social health of the region.

By the same token, other witnesses have maintained that rates are too low, at least for some classes of customers, or in relation to other regions. Or they have stated by inference that rates are too low by advocating far stricter environmental controls on the production of power.

We have heard from those who opposed the building of dams, and also from those who described the flood control, industrial, recreational, and other benefits that have flowed from such projects.

Still others suggest that TVA should not burn strip-mined coal, while some witnesses have said that nuclear power is not the answer for the region's electric supply either.

TVA has responsibility in all these areas, but to whom shall we be responsive?

All the concerns which have been expressed are real and honest to us, and to the witnesses who have expressed them. But they are in many cases competing, conflicting, or mutually exclusive.

So we come back to the question, to whom shall TVA be responsive? Total responsiveness to one viewpoint may be total rejection of all the others.

May I again suggest, as I did in my statement on the day which opened these hearings, that the TVA approach, and we believe it is the correct one, is one of balance. This is not to say that we always find the right balance; but the course we seek is the one that will provide the greatest good for the greatest number of people over the longest time.

This must be our constant goal for responsiveness, and I must add that in the broad overview, I believe TVA has discharged that responsibility with good effect.

In my years with the agency, it has always seemed that because of the multipurpose role assigned to TVA by the Congress, our way has been a narrow path in a wide spectrum—many times more difficult and less popular than if we had been given a single task, or a narrowly limited assignment.

Many of the issues and questions before the committee during these hearings—indeed, many of the questions the committee has had for TVA, relate directly or indirectly to the TVA power system.

Questions such as how we produce power and what that does to the environment and consumer pocketbooks; how we charge for electricity and how much we charge for electricity; why, how, and with whom we build the power system; and how, where, and from whom we obtain the fuel to keep it running, and the lights burning.

Each of these questions and issues is complex and interrelated, as is the total resource development job which TVA has been given. But I feel it is extremely important to point out to the committee and to the people from whom you have received testimony the following fact: As all of us weigh the alternatives which are open and as we seek to find the balanced answers to difficult questions, we must remember that an electric system operates in the harshest kind of real world. And power failures or prolonged shortages can make it much, much more harsh.

If electric power supply is not continuously and instantaneously equal to the total demand, things begin to come apart in a hurry. In our homes, our schools, our offices, our factories, our people would be in trouble. Indeed, almost nothing I can think of can put a region—or the Nation—into deeper trouble quicker than failure of its electric power supply.

Similarly, if any set of circumstances work together to price so valuable a commodity as electric energy above the people's ability to pay, the entire way of life we have now, is in trouble.

Mr. Chairman, conservation is an extremely important word and an important activity today.

We subscribe to it wholly and totally. We must avoid waste of energy particularly in these days and we recognize that.

But as we look to the future and contemplate the ultimate, complete use of our oil and natural gas supplies and as we look at a population which, even though we attain a stable birth rate, will grow for some decades into the future, I think it is clear we are going to need more electricity in spite of our very best conservation efforts. This is a point we must never forget.

Finding the appropriate balance point when the issues are so complex and the stakes are so high is almost unbelievably critical, and it is my understanding the TVA staff has described to you some of our activities in attempting to find that balance, particularly the balance between power supply and power costs, with respect to the electric power system.

TVA and other electric power suppliers across the country are faced with a somewhat similar situation in these inflationary times of rising costs and rising rates: consumers want to know why. It is a pocketbook issue like groceries and taxes, so it is easy to understand why they want answers, but not so easy to respond.

This is particularly true given the complex nature of the subject and today's prevalent skepticism—even distrust—in Government and institutions in general.

That makes our job of being responsive more difficult, but not impossible. And rather than telling you we are doing all we can, TVA is telling you we realize we must do more, and do it better. As the direct contact with consumers of electric power in the Tennessee Valley region, our 160 local distributors have done an excellent job in this respect. Distributor managements and boards of directors are respected leaders in each of their communities, and come from all walks of life.

In addition to TVA's own direct contacts with the public, these distributors and their staffs provide us with a valuable pipeline for the two-way flow of information, and have indicated their willingness to do more.

You have had described for you a few of our efforts to receive input from the public. And just as we have listened and learned at these hearings, we intend to do more listening and learning from the people we serve.

Since TVA's conditional offer to purchase the Peabody Coal Co. was the initial stimulus for these hearings, let me reiterate this morning what has been said before: TVA's interest is only in obtaining coal reserves to meet the future needs of the TVA power system.

We are not interested in acquiring a coal company and operating it, nor in selling coal to others. We appreciate the concerns expressed by committee members and others with respect to the possible purchase of Peabody by TVA.

The TVA Board will closely examine, and we will ask the staff to examine, all the alternatives available, including our possible mem-

bership in a consortium, which I believe FTC itself has indicated that it may favor.

We pledge to you our best effort to find the best possible means of obtaining the coal reserves we feel we need, and at the same time meet the concerns expressed by this committee and others.

Thank you, Mr. Chairman.

Senator BAKER. Mr. Chairman, thank you very much. I think that is a very excellent statement. At a later point I would like to discuss these aspects of it with you in more detail.

I would particularly like to discuss with you and the other board members your statement with respect to Peabody and if possible, a further delineation of how that would operate, particularly in view of the testimony we have heard so far. But why don't we defer these questions until Mr. McBride and Mr. Jenkins have an opportunity to make their presentations for the record.

Mr. McBride?

Mr. MCBRIDE. Thank you, Mr. Chairman, and members of the committee. The last time that I was officially before this committee was 9 years ago when this committee voted for my confirmation to the directorship of the TVA.

That tenure expires on May 18. It has been a pleasing 9 years. I concur in the testimony that our board chairman has given you.

Our general manager and the staff I believe have been forthright in their testimony and in answering your questions. I do not care to make a lengthy statement because it would be repetitious.

I do want to do a little reminiscing and indicate that a few years before I went to the TVA I used to occupy that desk up there when the late Senator Robert S. Kerr was the chairman of the Rivers and Harbors and Flood Control Subcommittee.

Senator BAKER. He was at least the chairman.

Mr. MCBRIDE. Yes. Thank you.

I would like, Mr. Chairman, to file for the record without reading it, a statement that I previously made entitled "The Tennessee Valley and the Energy Future: An Overview."

I know that this is good because I wrote it.

Senator BAKER. We are delighted to have it. It will be received for the record.

[The document follows:]

THE TENNESSEE VALLEY AND THE ENERGY FUTURE: AN OVERVIEW

By

Don McBride

Director

Tennessee Valley Authority

February 1975

More than 30 years ago when America was anticipating the economic adjustments that would come with the end of World War II, the Twentieth Century Fund issued a report which began with these words:

> "Electricity is the chief activating force of the modern industrial world. Its importance, both in our economic and social life, is beyond all measurement. And, because its currents reach into the intimate corners of our homes as well as into our factories and farms, few of us indeed are free of their effects. As electric power is an essential industry in winning the war so also will it be in the achievement of the kind of postwar world that can make our sacrifices worth their cost."

This assessment is still valid today, except that the fabric of America is even more tightly enmeshed with electric energy. To list but a few of the revolutionary changes which have increased public dependence on electricity in postwar decades:

--Rural electrification has put an end to the era symbolized by the scrub board and the kerosene lamp. Electric power is an integral part of farm production as well as rural comfort.

--Television has revolutionized communications and entertainment.

--Climate control, represented by air conditioning, is essential to nearly every business, but indispensable in modern medicine and other technological and health situations.

--Computers do the bookkeeping for the Nation's immense credit and banking establishments and perform even more vital tasks in science and engineering.

--Factories run on electricity, and stop without it. The job of nearly every man and woman is dependent in some way upon it, whether it is the train or elevator that takes them to work, or the assembly line or metal reduction plant that would be quiet and cold without it.

Whatever affects the adequacy, reliability, and price of the Nation's electric power supply affects far more deeply the human values of the total American society.

FUTURE NEEDS

The United States will require increasing amounts of electricity in the coming years. The national rate of increase for all forms of energy use has averaged 4.3 percent a year--a rate which doubles total consumption in 17 years--while electrical power generation has been increasing at about 7 percent per year, doubling every 10 years.

To illustrate the kind of growth in the use of electricity that we face in the years immediately ahead, TVA has projected that the electricity needs of the Tennessee Valley will approach 200 billion kilowatthours by 1984--almost double TVA's total sales of electricity for fiscal year 1974 and about three times the region's requirement in 1964.

A study on U.S. Energy Prospects by a task force of the National Academy of Engineering completed late in 1974 states: ". . . the demand for energy in the United States could surge to the equivalent of 58 million barrels of oil per day (MBPD) by 1985--more than 55 percent greater than the 1973 consumption of 37.2 MBPD. However, if major initiatives are undertaken to conserve energy, the demand by 1985 could possibly be reduced to some 49 or 50 MBPD. . . ." Most similar studies come to the same conclusion: Despite our best efforts to reduce energy consumption, it is unrealistic to assume that such efforts will prevent substantial increases in future energy use.

One of the major reasons for increasing energy usage in the United States is population growth. For many decades it has been an exponential growth, working like compound interest, so that the increase in population each decade is successively larger than the year before.

Although the U.S. birth rate has slowed, population growth is not expected to end for some years to come, if ever. The 1972 report of the U.S. Commission on Population Growth and the American Future stated that even if immigration from abroad ceased and couples had only two children on the average--just enough to replace themselves--U.S. population would continue to grow for about 70 years.

It has also been projected on the basis of children already born that by around 1985 the number of households will be 34 percent greater, the labor force will be 25 percent larger, and the number of young consumers in the 25-34 age bracket will be 61 percent greater than today. In 10 short years TVA has projected it will be supplying electric energy to 7 million people--about 1 million more than today and 1½ million more than 10 years ago. Certainly it is realistic to assume that these people will require a great deal of energy, if a broader proportion of society is to gain better living standards.

The consequences of not being ready to meet those needs are almost too drastic to contemplate. Our whole industrial economy runs on electricity. We have only to look at what happened during the coal miners strike in Great Britain in 1972 for a preview of what could happen in this country with any substantial curtailment of electric supply.

The strike, which lasted about six weeks, resulted in power cuts of up to 30 percent and blacked out some areas of the country for as much as 12 hours a day. Nearly three million workers were idled at the height of the strike and millions of others were placed on 3-day workweeks. The British government estimated that had the strike lasted two more weeks, up to 20 million workers would have been laid off and every home in the country would have been without power.

Thus, the future progress, growth, and well-being of the people of the Tennessee Valley region and the Nation depend to a great extent on how well we plan now to provide a continuous adequate supply of electricity at a price they can afford.

The importance of an adequate supply of electric power to our total national well-being--indeed to our very survival--cannot be overemphasized.

ENERGY SUPPLY AND DEMAND

If we are to maintain a sound economy, it seems clear that the Nation must reorient its present energy policies and practices to achieve some semblance of energy self-sufficiency in the years ahead.

At the present time the Nation's energy resources are not being allocated in the most effective and efficient way. Only about 17 percent of our energy needs are being met by coal; coal comprises about 80 percent of our identified energy reserves. On the other hand, oil and natural gas meet about 78 percent of the Nation's energy needs, while domestic reserves comprise only about 17 percent of the Nation's total.

Petroleum Products

Today 35 percent of our petroleum and petroleum products is imported and by 1985 there have been estimates that this will increase to 50 percent, unless domestic oil exploration is dramatically accelerated. The recent embargo on oil exports by the Middle East oil-producing nations, and the resulting escalation in price, demonstrates the impracticality of relying solely on foreign sources for fuels with which to meet the future energy requirements of the United States.

In looking at the history of the world petroleum market, the dominant event of the past decades has been the discovery of enormous quantities of very low-cost oil in the Middle East. Much of this oil can be recovered at costs far below that of domestic production, and until recently was delivered in the United States at a cost less than half that of U.S. crude oil. This has inevitably acted as a deterrent to exploration and development in the United States.

Unquestionably, the net effect of all the factors acting on petroleum exploration and production in the United States has not provided the impetus to develop a continuing domestic reserve and productivity. It is estimated that less than one-half of the oil in place has been discovered in the United States and its territorial waters. Although some new oil will be discovered inland, it is anticipated that most new oil will be found offshore and in Alaska. Estimates of the total vary from 100 billion to 400 billion barrels.

However, the two most promising areas for U.S. development, the Alaskan North Slope and our outer Continental Shelf, have been retarded by environmental objections. Construction of additional refineries and of the deep water port complexes necessary to receive and process super tanker cargos also has been delayed and in many cases cancelled because of economic conditions and other factors. Based on the best evidence to date, there appears little probability that within the next 10 years the U.S. can produce enough crude oil to meet its needs.

Coal

Considering our abundant reserves, increased coal production should be a major factor in reducing our dependence on foreign sources of energy. However, due to a number of factors, coal production has not expanded sufficiently to keep pace with requirements and America is currently experiencing a critical coal shortage.

In 1973 the Nation burned about 10 million tons more coal than was mined. Preliminary figures for 1974 indicate that the recent coal miners strike caused a loss in annual production estimated at 32 million tons and that total production will show no appreciable increase over 1973. Thus, the gap between supply and demand will be even greater. The shortfall in national coal production has been met by drawing from existing stockpiles. Obviously, the Nation cannot continue to have this kind of imbalance in supply and demand, particularly if coal is expected to help meet an increasing proportion of our total energy use.

Although there are undoubtedly many complex factors involved, legislation which has restricted coal mining has played a major role in creating the current shortage. The 1969 Federal Coal Mine Health and Safety Act was badly needed, but its enforcement has resulted in a serious drop in productivity in underground mines and has contributed to a reduction of the quality of coal. The 1970 Clean Air Act, if enforced, could render much of the coal produced in the eastern portion of the United States unacceptable for utility use after 1975 because of its high sulfur content.

As a result of the uncertainty of a continued return on investment in new mines, coal operators in the East have been reluctant to expand production and there now exists a coal shortage. This shortage has been compounded by a shortage of transportation equipment. The railroads and barge lines have been affected by the same uncertainty in regard to future markets as the coal industry and have not placed orders for sufficient equipment.

With the demand outstripping supply, coal users have been forced to bid against each other, causing coal prices to increase as much as five to six times what they were two years ago. The average delivered cost of coal to TVA doubled from around $4.50 per ton 5 years ago to about $9 per ton last year, but in recent months TVA has been forced to pay as much as $35 per ton--and some utilities made spot purchases in the $50 to $60 per ton range. TVA fuel costs for the fiscal year ending next June 30 are expected to approach $476 million, up about $144 million from the previous fiscal year and the largest single item in the agency's power system costs. These increased costs must ultimately be passed along to the consumer in the form of higher electric rates. In TVA's case, each $1 per ton increase in the average cost of coal burned adds $40 million to the agency's fuel bill.

The problems associated with supply and cost and the mining and burning of coal were important factors in TVA's decision that nuclear power offered the best means of meeting the region's power growth needs in the decades just ahead.

NUCLEAR POWER - OUR BEST ALTERNATIVE

After more than 30 years of research, development, and large-scale demonstrations, nuclear power plants are now being utilized on a rapidly increasing scale by electric utilities in the United States. Over 50 percent of new power plant orders since 1970 have been going nuclear. Today, some 53 licensed nuclear generating units with about 35.8 million kilowatts of generating capacity are on line--representing some 8 percent of total U.S. electric generating capacity.

In the Tennessee Valley region, TVA has undertaken the largest commitment by a single utility in the entire Nation to nuclear power generation. This commitment, taken only after a thorough examination of the safety, environmental and economic factors involved, is made to assure the region a dependable supply of electricity during the coming decade.

In total, TVA's nuclear commitment between now and 1984 involves 17 reactor units at seven plants. These units will have a combined generating capacity of more than 21 million kilowatts--the equivalent of the capacity of all the dams, steam plants, and gas turbines operating on the TVA system as late as June 1973.

These nuclear units, plus planned hydro pumped-storage capacity, will virtually double the TVA electric power system--from some 24 million kilowatts to some 47 million kilowatts--between now and 1984. Almost half of TVA's total capacity in 1984 will be nuclear.

The first of TVA's nuclear units went into commercial operation in August 1974 at the Browns Ferry plant in northern Alabama, and the second Browns Ferry unit is expected in commercial operation at any time. The third unit of the three-unit plant is scheduled for operation in early 1976. Six additional units are under construction, two each at the Sequoyah and Watts Bar plants in east Tennessee and at Bellefonte in north Alabama. Four units have been proposed for a site near Hartsville in middle Tennessee. Orders have been placed for equipment and fuel for the last four units, and detailed siting and environmental studies are under way concerning proposed plant locations.

Any assessment of nuclear power, to be useful, must be comparative; the question is, compared to what? Until perhaps A.D. 2000, the major choices are nuclear power, fossil fuels, or nothing, in varying proportions. At this time there are no other alternatives to light water nuclear reactors such as TVA is building to supplement fossil fuels in meeting our short- and mid-term electric energy needs. There are other alternatives on the horizon such as nuclear fusion and possibly solar power that may be available in the long-term future. But the technology for utilizing both these potential power sources on a large scale is simply not available today, and at this point there is no way of knowing when they will be ready.

It must be emphasized that coal, as our Nation's most abundant fossil fuel resource, will continue to generate a large portion of this country's electric energy for many years to come. The Federal Energy Administration's Project Independence Report estimates the Nation's known coal reserves at about 434 billion tons--enough coal to last over 800 years at 1973 consumption levels. Even with its massive commitment to nuclear power, TVA expects to burn between 35 and 40 million tons of coal yearly at least until 1985.

However, as technology for producing synthetic liquid and gas fuels from coal develops, coal will be increasingly used as a substitute for our dwindling supplies of oil and natural gas in the vital petrochemical industries and other critical areas. As such, it will probably become too valuable a fuel for electric power generation.

On January 16, 1975, 32 of the country's most eminent scientists, 11 of them Nobel Prize winners, issued a statement on energy problems. As a part of that statement, they assessed the roles of coal and nuclear power in meeting this country's energy needs. That portion of their statement is reproduced below:

"The U.S. choice is not coal or uranium; we need both. Coal is irreplaceable as the basis of new synthetic fuels to replace oil and natural gas.

"However, we see the primary use of solid fuels, especially of uranium, as a source of electricity. Uranium power, the culmination of basic discoveries in physics, is an engineered reality generating electricity today. Nuclear power has its critics, but we believe they lack perspective as to the feasibility of non-nuclear power sources and the gravity of the fuel crisis.

"All energy release involves risks and nuclear power is certainly no exception. The safety of civilian nuclear power has been under public surveillance without parallel in the history of technology. As in any new technology there is a learning period. Contrary to the scare publicity given to some mistakes that have occurred, no appreciable amount of radioactive material has escaped from any commercial U.S. power reactor. We have confidence that technical ingenuity and care in operation can continue to improve the safety in all phases of the nuclear power program, including the difficult areas of transportation and nuclear waste disposal.

"The separation of the Atomic Energy Commission into the Energy Research and Development Administration and the Nuclear Regulatory Commission provides added reassurance for realistic management of potential risks and benefits. On any scale the benefits of a clean, inexpensive, and inexhaustible domestic fuel far outweigh the possible risks.

"We can see no reasonable alternative to an increased use of nuclear power to satisfy our energy needs.

"Many of us have worked for a long time on energy problems and therefore we feel the responsibility to speak out. The energy famine that threatens will require many sacrifices on the part of the American people, but these will be reduced if we marshal the huge scientific and technical resources of our country to improve the use of known energy sources."

Reliability of Technology

After initial shakedown, experience to date indicates that today's nuclear plants are an extremely reliable source of power, in many instances outperforming comparable coal-fired plants. Experience with Browns Ferry Unit 1 indicates that it will be one of the most trouble-free units in the TVA power system. Since July 1, 1974, Unit 1 has been available for service about 85 percent of the time, an unusually

high level of reliability for a large steam-electric unit. The average availability of TVA's larger coal-burning units has been about 72 percent.

Cost

When TVA began building nuclear power plants in the late 1960's, one reason was the projected cost advantage over continuing to build power plants that burn coal. This advantage for nuclear power appears even stronger today because of the tremendous increase that has taken place in coal prices, plus the costly environmental support equipment required on coal-burning steam plants.

Unit 1 at Browns Ferry will generate about 7 billion kilowatthours a year in normal operation at a total cost of about $43 million. The cost in 1973-74 for an equal amount of power from TVA's coal-burning plants was nearly $50 million, and that amount is much larger today due to recent coal price increases. Nuclear fuel at Browns Ferry is currently running the equivalent of about $3 per ton for coal as contrasted with average coal costs at TVA steam plants of around $12 per ton. The latter figure (up from $7.46 in 1973 and $8.61 in 1974) is expected to continue to increase substantially as more and more high cost coal is purchased and burned.

The nuclear power plants that will follow Browns Ferry on the TVA system will have successively higher construction costs because of the rising trend that is taking place each year in construction costs nationally. But even with today's inflation and the anticipated higher cost for future nuclear plants, the gap between nuclear and coal-fired power plants is expected to grow much wider. In fact, TVA's present estimates are that coal-burning power plants built to produce power in the 1980's would be nearly twice as expensive, in cost per kilowatthours of power produced, as the nuclear plants TVA is now planning for that period.

Safety

As with any new technology, especially a technology as complex and as difficult to understand as nuclear energy, thoughtful people have raised the legitimate question: Are nuclear power plants safe? Experience and the overwhelming weight of scientific evidence indicates that the answer is "yes."

In an accumulation of more than 200 reactor years of operation, no licensed nuclear power plant in the United States has ever caused property damage or injury to the public or operating personnel from any nuclear-related accident. However, for those who want absolute and final assurance that any activity of man, including nuclear power, carries no risk, such assurance is not available.

Preliminary results of a two-year reactor safety study sponsored by the Atomic Energy Commission and directed by Dr. Norman Rasmussen of the Massachusetts Institute of Technology compares the risks from nuclear power with the risks from other non-nuclear activities. Two basic findings from the study are:

--The likelihood of reactor accidents is much smaller than many non-nuclear accidents having similar consequences.

--The consequences of potential reactor accidents are no larger, and in many cases, are much smaller than those of non-nuclear accidents.

SOME OBSTACLES TO DEVELOPMENT

Of increasing concern to the nuclear industry in the United States is the possibility that without an acceleration in this country's capacity to produce nuclear fuels, production capability will not be able to meet uranium fuel requirements in the 1980's. Areas of particular concern to the industry are uranium exploration, mining and milling, uranium enrichment, and spent fuel reprocessing.

Delays in plant licensing and construction are additional deterrents to the full utilization and development of nuclear power in this country.

Exploration, Mining and Milling

The source of nuclear electric generating plant fuel is uranium ore. Uranium ores, like all minable natural resources, are depletable and of finite size. Atomic Energy Commission estimates show that the United States has 520,000 tons of uranium reserves producible at a cost of $15/lb. or less and an additional 1,000,000 tons of potential resources producible at this cost. Without an acceleration in the rate of exploration for new uranium reserves, these identified reserves will be depleted by A.D. 2000. In addition, the Project Independence Report of the Federal Energy Administration concluded in late 1974 that existing uranium mining and milling capacity of 18,000 short tons per year does not meet the 1980 requirements.

Forewarned by problems with its coal supply, TVA has for some time been securing uranium supplies under long-term contracts to meet its projected nuclear fuel requirements. Of a total requirement through 1980 of 31.5 million pounds of uranium, TVA had acquired all but 2.5 million pounds by September 1974; unfilled requirements for the period from 1981 through 1990 were 49 million pounds.

In addition, three years ago TVA entered into a program of acquisition of uranium reserves and of actively exploring for uranium in the United States as an additional means of supplying the fuel to its reactors. This program is presently being pursued in several western states.

As previously stated, the Nation's domestic uranium reserves are finite; some day they will be exhausted if we continue using our present type of reactors. It is for this reason that TVA, along with Commonwealth Edison of Chicago and the Atomic Energy Commission (now the Energy Research and Development Administration), and with the support of the entire electric utility industry, is planning to build the Nation's first large-scale demonstration nuclear breeder reactor at Oak Ridge, Tennessee.

With the breeder, there is substantial increase in fuel utilization efficiency--the prospect of utilizing perhaps 60 percent of the potential energy in uranium instead of 1 or 2 percent as in present light water reactors. With this efficiency, the life of U.S. uranium supplies would be stretched from decades to centuries. The project cost is high--$1.736 billion for the total program through 1987--but the dividends could be much higher. If commercial breeders can be introduced by the late 1980's, the Atomic Energy Commission estimates a savings in power costs of $50 billion by the year 2020--in addition to the energy insurance and independence the breeder could provide.

Uranium Enrichment

Naturally occurring uranium is composed of two types of uranium atoms or isotopes--U-235 and U-238. Only 0.7 percent of natural uranium is the U-235 isotope. The other 99.3 percent is U-238. A concentration of fissionable U-235 in the range of 1.5 to 3.5 percent is normally required for today's reactors. The enrichment process boosts the U-235 concentration to the desired level.

Existing enrichment capacity in the United States is confined to three Government-owned plants. Based on present projections for nuclear power growth, about 30 times the present capacity will be needed by A.D. 2000. This would represent a very large commitment by the private sector, or possibly the Government, with a long-term payback of investment. Total enrichment investment could approach $20 billion.

Spent Fuel Reprocessing

Unlike conventional fuels, the energy source in a nuclear power plant can be recycled in part--used again and again. Somewhere between one-fourth and one-third of the uranium-235 which was in the reactor fuel originally is still usable at the time the fuel bundles are removed. In addition, some of the original uranium has been transformed by that time into another element--plutonium--which is also a fissionable material. Reprocessing salvages these residual fuel materials for reuse.

The Project Independence Report estimates that recovering usable uranium by reprocessing spent nuclear fuel could reduce new uranium requirements by about 15 percent and enrichment service requirements by about 20 percent. However, while over 2,000 metric tons per year of reprocessing capacity is scheduled to be in service by 1977-78, this capacity is only adequate through 1980 and meets only half the 1985 requirements. Each new 1,500 metric ton per year reprocessing plant is estimated to cost about $200 million.

Licensing and Construction Delays

A significant contributing factor to the current energy crunch has been the licensing and construction delays which have kept nuclear power from carrying the load it would have been able to carry by this time.

Until about two years ago, Atomic Energy Commission and industry projections were about 150 million kilowatts of nuclear generating capacity by 1980 and about 300 million kilowatts by 1985. As a result of these delays, which have stretched out nuclear plant completion schedules from five or six years to nine or ten years, new forecasts project that under most likely conditions only about 100 million kilowatts of nuclear power will be in operation by 1980, and only about 250 million kilowatts by 1985.

In terms of relative fossil fuel displacement, the 50 million kilowatt forecast difference in 1980 is equivalent to about 1.4 million barrels of oil per day or about 127 million tons of coal per year. Thus, this nuclear plant slippage is quite serious indeed.

SOME COURSES OF ACTION

While there are many conflicting opinions over how we are to go about it, there is a consensus that the Nation must begin taking positive action today if we are to meet the energy requirements of the future. Some of the fundamental steps which can be taken now are relatively simple to state, but much more difficult to accomplish.

First, the importance of adopting energy conservation as a way of life--the so-called "conservation ethic"--must continue to be emphasized and will play a role in reducing unnecessary energy consumption. However, much larger opportunities for reducing waste and improving energy efficiency lie in the reduction of oil and gas usage through substituting electricity, using our more abundant resources of coal and uranium as fuel. While such substitution for oil and gas resources does not reduce demand, it does serve the objective of energy self-sufficiency and a cleaner environment. Further savings can be achieved by the utilization of more efficient energy-conserving technology in the construction of industrial, commercial, residential, and transportation facilities.

Second, steps must be taken immediately to increase domestic natural gas and oil production and thereby reduce U.S. dependence on foreign sources, although we must continue to utilize these sources to an extent whenever it is economically and politically feasible to do so. One key to accelerating domestic oil exploration using known technology is the establishment of a better economic climate that would lead the producer to expect to recover higher costs where it is necessary to take greater risks or to operate in a more expensive manner or area.

Third, far greater use must be made of U.S. coal reserves than has been done in the past. Some method must be found to guarantee investment in new coal mining and coal transportation equipment in order to increase coal production and provide for its transportation. This might be accomplished by changing the implementation of the Clean Air Act to permit the use of alternate control measures to ensure meeting ambient air quality standards, thus allowing use of higher sulfur coal, or possibly a Federal action which would guarantee an investment by a coal producer. At the same time, standards for thermal discharges should be reexamined to determine if the benefits to the environment resulting from these requirements will be substantial enough to justify the additional costs to the Nation's consumers.

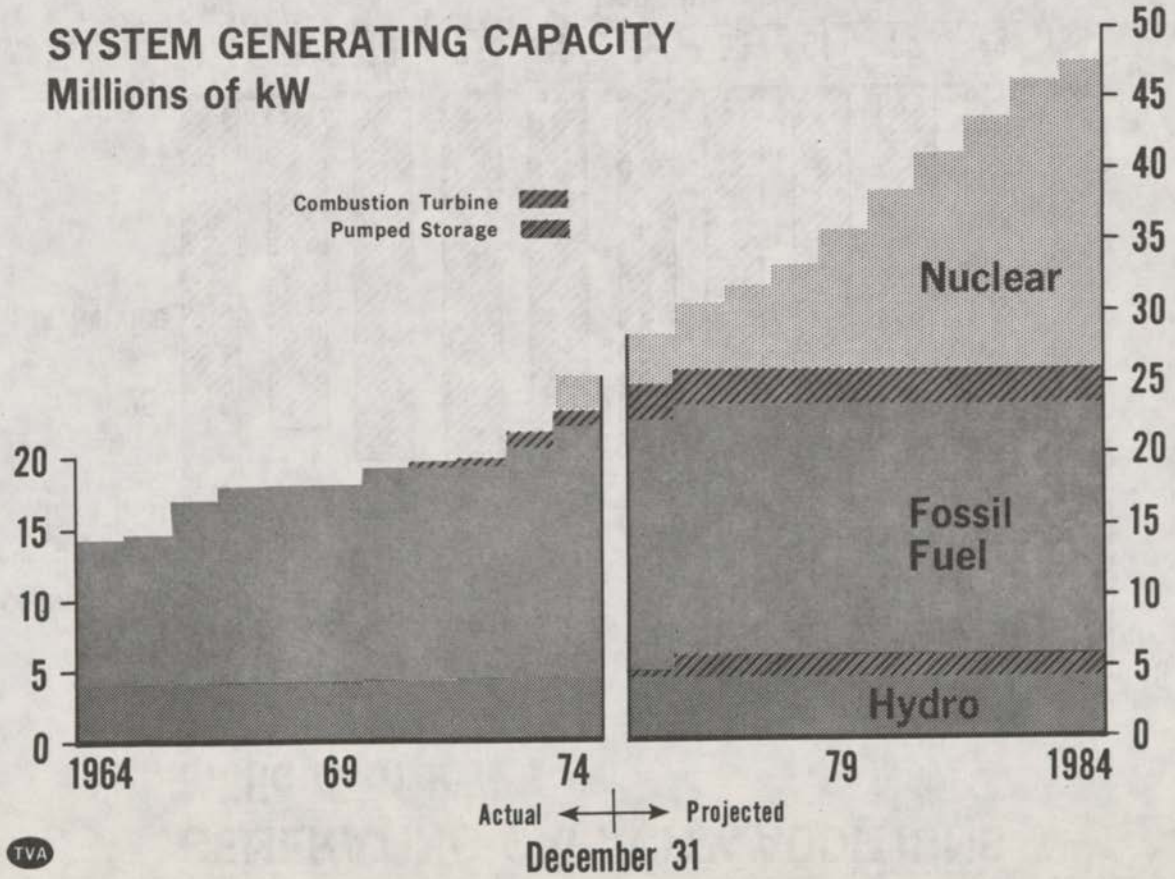
Fourth, policies concerning land use, economic incentives, regulatory standards and imports should encourage exploration efforts for uranium. Prompt action should be taken to ensure that enrichment and reprocessing capacity in the United States will be sufficient to meet projected needs.

Finally, procedures should be explored to reduce the delays currently encountered in the planning and construction of nuclear power plants. A recent study by a National Academy of Engineering task force concludes that the present lead time of 9 or 10 years could be cut to 6 or 7 years without sacrificing safety. The nuclear industry, including manufacturers, architect-engineers, and utilities, must persist in the effort to standardize designs, and increase reliability and quality.

Inherent in any plan for meeting this Nation's energy needs must be the realization that we can overcome the problems we are presently facing through decisive

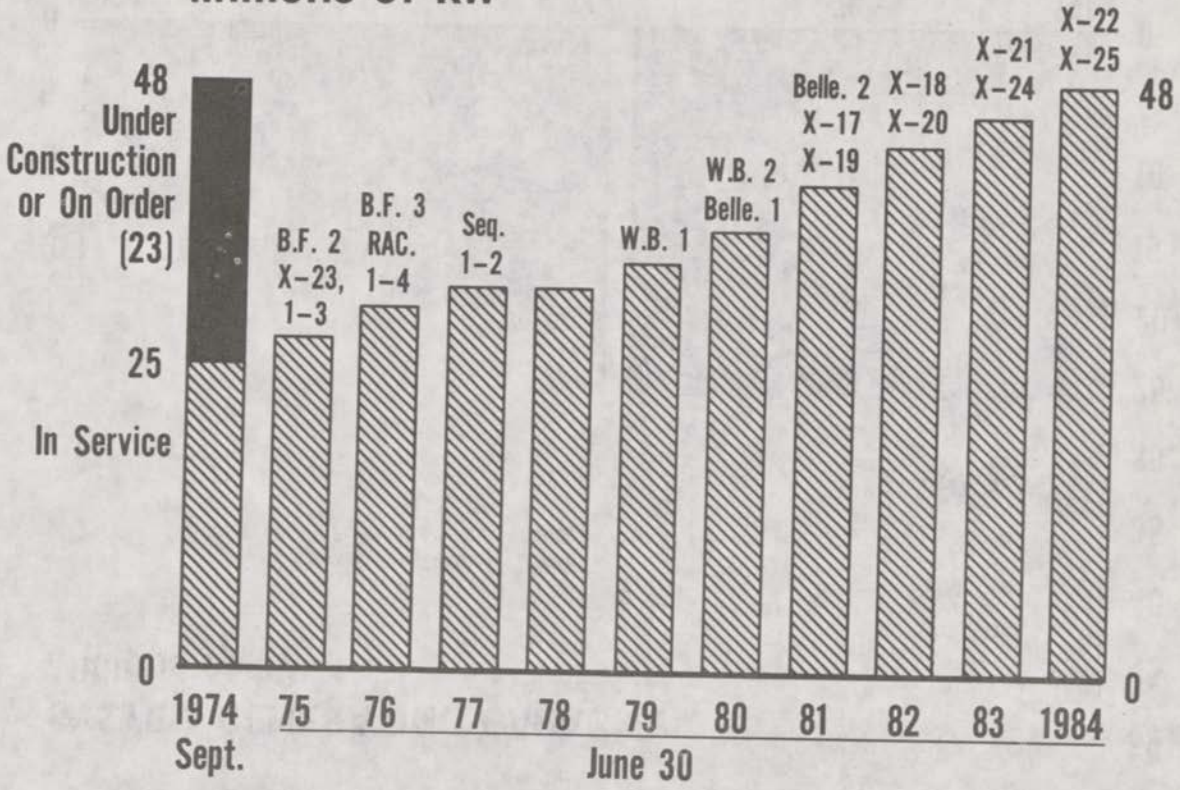
action. Our coal and uranium reserves ensure us of adequate energy resources for many hundreds of years, and we have the technology and the means to develop these resources with proper concern for the environment, for conservation of resources, and for public health and safety. The energy requirements of the future should provide us with the stimulus for making decisions today which will enable us to maintain the trajectory toward an even better standard of living tomorrow.

#


SYSTEM GENERATING CAPACITY
Millions of kW
Combustion Turbine
Pumped Storage
Nuclear
Fossil Fuel
Hydro
50
45
40
35
30
25
20
15
10
5
0
20
15
10
5
0
1964
69
74
79
1984
Actual
Projected
December 31
TVA

1217

GENERATING CAPACITY ADDITIONS
Millions of kW



Mr. McBRIDE. That concludes my statement.

Senator BAKER. Mr. McBride, we are happy to have you here. As I indicated earlier, we commend you on the distinguished service to the Agency and to the region. We are happy to have you on this panel and participating in these hearings today.

Our next director, of course, is Mr. Jenkins, Mr. Bill Jenkins. Bill is the youngest member of the Board in terms of service.

Mr. WAGNER. Otherwise, too.

Senator BAKER. We look forward to your testimony.

Mr. JENKINS. Mr. Chairman, I feel like I am aging fast.

Senator BAKER. You don't look it.

STATEMENT OF WILLIAM L. JENKINS, DIRECTOR, TVA

Mr. JENKINS. Mr. Chairman and members of the committee: I do not have a prepared statement. But I am very happy to be here. I would like to echo at least one of the points that was made by the chairman in his opening statement and that is that for my part and I am sure for the part of this entire Board, we do want to be responsive to the people in the Tennessee Valley.

Sometimes in being responsive, as the chairman pointed out, there are conflicts. There are all sorts of conflicts. They are hard to resolve.

I am very appreciative that in resolving those conflicts, the ones that are before us today and the ones that will arise in the future, that we are benefited by the guidance of the Senate of the United States and this committee of the Senate.

As I said, I do not have a prepared statement, but I would be very happy to answer any questions that any member of this committee might have relative to any votes that I have cast or relative to what has transpired since I have been on the Board, or what we might face for the future.

Thank you very much.

Senator BAKER. Thank you, Mr. Jenkins.

Mr. Seeber, you have been with us this past week. Is there anything you would like to add to the record at this point?

Mr. SEEBER. No, Mr. Chairman.

Senator BAKER. If my colleagues will permit, I would like to ask one or two questions and then yield to Senator Stafford and Senator Brock.

Senator STAFFORD. Mr. Chairman, I will yield all of my time to you and Senator Brock.

Senator BAKER. No. Don't do that. We are delighted that you are here as a distinguished member of this committee and we look forward to your participation.

Senator Brock, of course, is not a member of the committee but he has sat with us for most of these hearings in the obvious interest of the people of the Tennessee Valley and the people of the State of Tennessee.

Senator STAFFORD. Mr. Chairman, as a disciple in some respects of Calvin Coolidge, I want to commend the last two gentlemen for the brevity of their statements.

Senator BAKER. Mr. Chairman, I suppose these hearings probably did come about because of the Peabody situation. I recall the first statement I made on it was I guess to a newspaper reporter when I said that proposal to acquire Peabody was certainly not an ordinary and routine thing and it ought to be carefully looked into and that I expected we would have hearings on it.

I sometimes find it necessary to remind witnesses and even myself that these hearings are not for a legislative purpose. They are in the nature of oversight hearings, meaning the periodic congressional review of the conduct of Federal agencies. I think that is one of the most worthwhile functions of the Congress. My colleagues will agree, I think, that sometimes we are tempted to believe that we already have enough laws and maybe we do a little better if we devoted more time and attention to oversight and a little less to leigslation.

In any event, you are right. TVA has embarked on a proposal to acquire the country's largest coal company.

TVA, of course, is in a unique situation. President Roosevelt described it when he sent the TVA bill up here as possessing, I believe, the flexibility of private enterprise and the authority and public purpose of a governmental agency.

I think by and large over the years TVA has done a remarkable job of bringing realism to that difficult emphasis. But this is another milestone. How do we go about justifying or providing for the acquisition by a Federal corporation of a private corporation, in this case a very large one, the largest coal company in the country?

So we have listened with great interest as you set forth your intentions, as they are described on page 4 of your statement. TVA's interest is only in obtaining some of the coal reserves of Peabody and to meet the future needs of TVA's power system. I am paraphrasing some, but this is what I understand it to mean.

We are not interested in acquiring the coal company and operating it, or in selling coal to others. That is a considerably different impression than was originally conveyed, I believe, when many of us heard the TVA proposed by Peabody.

We have heard that testimony from TVA witnesses and others with similar elaboration. From time to time, I put the question: Do you think that TVA's proposal, as you describe it, complies with the requirement of the FTC order which says we want Peabody sold so that it will end up as an independent operating coal company?

That is not the language of the FTC order, but that is about what it says. You don't intend to do that. Do you have any doubt about that? I assume that you agree that your proposal when it is finally submitted would have to be approved by FTC under that guideline?

Mr. WAGNER. Yes, Mr. Chairman. We recognize our final proposal would have to be approved by FTC and whether it would meet their requirements, their criteria, I think they would have to decide. I am not sure what the answer would be.

Senator BAKER. But you are going to make no effort to comply with the terms of the FTC order other than as it serves the immediate purposes and needs and the objectives of TVA?

Mr. WAGNER. That is correct.

Senator BAKER. TVA's objective is not to buy and operate a coal company?

Mr. WAGNER. That is correct.

Senator BAKER. You are going to buy the reserves and I take it you are going to sell off the operating assets, you are going to sell off maybe the assets in Australia and New Zealand; is that right?

Mr. WAGNER. That is correct.

Senator BAKER. And keep the land with the coal under it. Is that right?

Mr. WAGNER. Some of the land with the coal under it; yes. Let me say that negotiations are now underway with possible partners in this, with prospective buyers of part of the company, with Kennecott itself, and I don't know just where we would come out.

I think, again, if we could have our druthers, Mr. Chairman, where we would like to end up is perhaps as a member of a partnership or a consortium in which we would take only the coal reserves that we feel we need and somebody else would own the balance of it.

Senator BAKER. The partnership consortium language has shown up in other testimony, I believe in yours initially, and the testimony of Mr. Seeber, the general manager, previously. Let's talk for just a second about that. You are not talking about partnership in an operating coal company.

Mr. WAGNER. No.

Senator BAKER. You are talking about partnership and consortium of owners of coal reserves?

Mr. WAGNER. Let me say I am not sure what the final results will be because we don't know until we work it out but we hope in the acquisition we would actually acquire only the reserves that we need and someone else would acquire the balance of it.

Whether that kind of an arrangement would be satisfactory to Kennecott or the Federal Trade Commission, we don't know. But this is our objective. To give you a little background, if I may, Mr. Chairman, TVA like many other electric utilities recognized years ago we ought to have some coal reserves of our own, both for short supply situations and to assure we get a reasonable shake on the price.

We bought some coal reserves. We found out in recent years that we didn't have enough. So our staff, at the Board's direction, had been looking for opportunities to buy additional coal reserves. In the middle of that search, Peabody was thrust onto the market by the Federal Trade Commission.

Under the circumstances, which I am sure have been described to you in more detail than I want to take now, we felt we simply must submit a bid. So we did. But our intention is still to get reserves and we have no intention of operating a coal company.

Senator BAKER. What are you going to do about the purchase price? Are you going to recover part of that from your partners or fellow members of the consortium?

Mr. WAGNER. We would hope we would have to put up only as much of the purchase price as is needed to cover the reserves that we would get.

Senator BAKER. If we are talking about the necessity for providing borrowing authority to TVA to increase your bond savings, so in

part you can acquire Peabody, we are not necessarily talking about $1.2 billion?

Mr. WAGNER. Not necessarily; that is correct. We won't know just what it is until we get the best arrangement that we can work out.

Senator BAKER. The $1-billion-plus figure that we hear is the popular assesment of the value of the Peabody Coal Co., not just the coal. Is that correct?

Mr. WAGNER. That is correct.

Senator BAKER. Do you have any idea what that figure is likely to be? Before you answer, I understand your difficulty here, I believe. You have not yet worked out the final details of the proposal to Kennecott. You have made a general proposal, as I understand it.

Mr. WAGNER. That is correct.

Senator BAKER. But even so, can you give us some estimate of how much it might cost, how much TVA might have to put out to buy those coal reserves, not the operating facilities, not other assets of Peabody?

Mr. WAGNER. As I have indicated in my testimony on the opening day of these hearings, I believe the figure of $1 billion has been quoted as our bid in the newspapers. I said that is a ball park figure.

Senator BAKER. Is that for your part of it or the whole thing?

Mr. WAGNER. We submitted a bid for the whole thing. That was the only way it was offered.

Senator BAKER. You don't have any idea what your part of it would be?

Mr. WAGNER. We don't, at this point, no, sir. I can say, however, that we would propose to dispose of as much of Peabody as we possibly could and still retain the reserves that we needed; that is, if we should have to buy the whole company.

Senator BAKER. You might get it all back.

Mr. WAGNER. We have some east Tennesseeans, Senator, on our staff and you know their reputation as east Tennesseeans for trading. It is a good one.

Senator BAKER. They are pretty good. Bill Jenkins practices law over there. He is a hard man to trade with. I would put him in charge of the spinoff.

The whole situation, of course, comes down to a philosophical consideration, I suppose; that is, whether or not you ought to buy Peabody. When you hear this testimony it is pretty clear that you are not doing what we thought you were doing or what our first impression would indicate. You are not buying a coal company nor going into the coal business. You are buying coal reserves or proposing to, selling off the other assets and operating for Peabody for whatever you can realize on it; doing what you have been doing all along; that is, trying to buy up coal reserves as a hedge against the unavailability of coal or against price gouging in the future. Is that a fair summation?

Mr. WAGNER. That is correct.

Senator BAKER. How many acres of coal reserves or how many tons of coal reserves do you now have?

Mr. WAGNER. We have about 360 million tons, as I recall the figure, Senator; 166,495 acres, 360 million tons.

Senator BAKER. 360 million tons of coal reserves and 160,000-plus acres of land, that you already have dedicated to these purposes?

Mr. WAGNER. That is correct.

Senator BAKER. Would you say that what you keep out of Peabody would be about that much more or more than that?

Mr. WAGNER. I don't know. My feeling would probably be it should be more than that.

Senator BAKER. Do you know yet whether all of it or most of it would be in the TVA service area or in the area where the TVA currently buys most of its coal?

Mr. WAGNER. We don't know, but naturally we would buy it where it would give us power at the minimum costs and where it could be used in our existing plants.

Senator BAKER. You don't intend to go out to Wyoming and start a big strip mine and sell that coal to Pacific Gas & Electric or something?

Mr. WAGNER. No, sir.

Senator BAKER. I have a lot of other questions. I have used up my initial 10 minutes. I will yield to Senator Stafford.

Senator STAFFORD. Thank you, Mr. Chairman, I just have one or two questions at this time. Mr. Wagner, your colleagues, in terms of your mandate, as a natural resources agency, is the TVA committed to be an example in such areas of environmental concern as protection of air and water quality, reclamation of the strip mine lands, emphasis on deep mined coal and consideration of all environmental effects in the construction and operation of your facilities?

Mr. WAGNER. Senator Stafford, yes, we are committed to that. As you heard, I am sure during these hearings there is disagreement as to how well we carry out that responsibility. We have the responsibility under the TVA Act, as passed by this Congress, to help develop the region, to provide power at the lowest possible cost consistent with, of course, good conservation approaches.

I think my concept has always been that TVA is primarily a conservation agency. The conservation to us means the use of our natural resources for the good of mankind, not just sitting on them.

For this reason, as we approached the question of strip mining, beginning in the 1940's, we recognized that something needed to be done to reclaim strip-mined land. That was before we even bought strip-mined coal in any quantity. At that time we undertook reclamation demonstrations. We urged legislation by the States first and then by the Federal Congress.

We said we think that good reclamation should be that work that is honestly needed to restore the land to a condition that is at least as useful as it was before strip mining and would prevent offsite damages. We have resisted some provisions that have been proposed because we felt they would be more expensive than was required to achieve good reclamation or because they would in fact deny coal that we thought could be strip mined satisfactorily.

The same is true on the question of air and water quality control. The quality of the Tennessee River is better today than it was in 1933. Not many river basins can claim that.

The air quality is still good in the Tennessee Valley.

54-380 O - 75 - pt. 2 - 16

Senator BAKER. Could I interrupt just for a second? I am sorry. Is there any other river system in the country that can claim it has a higher quality of water than it had in 1930?

Mr. WAGNER. There is none that I know of, Senator; no, sir.

On air quality, we have followed pretty much the same approach. We have recognized that the air must be kept clean, but we have resisted expenditures which would impinge heavily on the consumers and which we feel would not purchase benefits equal to the cost.

We have said repeatedly that we think the consumers ought to understand what costs some of these clean air requirements and clean water requirements would impose on them and they ought to determine whether they want them.

We have felt that as a national demonstration we have a responsibility to hold up both sides of the question and seek the balance point we have been talking about.

Senator STAFFORD. Correct me if I am wrong, but it seems to me on the basis of Mr. Seeber's testimony last week that you burn about 40 million tons of coal a year in the production of electricity.

Mr. WAGNER. That is an approximate figure. Yes.

Senator STAFFORD. Am I also correct that that produces about 80 percent of your coal and electrical generation?

Mr. WAGNER. It has produced about 80 percent of our generation. It would be a lessening amount as years go on.

Senator STAFFORD. So coal is a very important part of the generation picture in the TVA?

Mr. WAGNER. Coal is a tremendously important part. It is the largest single cost element that we have.

Senator STAFFORD. With relation to the use of sulfur dioxide emission limitation, SDEL, which I understand TVA has proposed, which is what other electric utility companies call intermittent or supplemental control systems, there were witnesses before the current Clean Air Act hearings who indicated that such systems will degrade the air quality, are unreliable, unenforceable, and in practice.

One of the witnesses from the Montana agency called such a system with its need to move monitors constantly to detect the plume as plume-chasing and says it will never work. Would you care to comment on that?

Mr. WAGNER. The best comment I can make is we have had it in operation now for about 5 years at one of our plants. We have operated SDEL at that plant with an extremely high degree of reliability.

If the question is: Must you have monitors everywhere? I don't know how you escape that with any kind of a system. We place monitors in critical points and where we get an accurate reflection of air quality.

Senator STAFFORD. Let me ask you one more question and then I will be done. On the other hand, David Klipstein, of Research Cotrell, on behalf of the Industrial Cleaning Institute, says scrubbers are reliable, cost-effective, and efficient, that the problems of caking, scaling, and sludge fixation have been corrected and that the industry using them can meet all anticipated demand by 1980.

Do you have any comment on that?

Mr. WAGNER. In the first place, this gentleman is apparently selling scrubbers. I am sure he feels they would work as he ought to. We believe they can be made to work on the basis of our experience and we have been researching scrubbers since the 1950's.

We think that they are not yet fully workable. You are going to have trouble with them. When they are not working you have no control over SO_2.

The beauty about our SDEL system is you can maintain continuous control. We think there is some work still to be done on scrubbers. I think there is a question that when we finally get scrubbers developed whether we may not have some better method for cleaning our coal up.

I think there is no question if we are going to continue to burn coal in increasing quantities we have to find ways to control the amount of sulfur that goes into the atmosphere. Whether it is going to be scrubbers or something else, I don't know. Scrubbers appear to our people to be the best bet so far.

Senator STAFFORD. Thank you very much, Mr. Chairman.

Just a final question to educate this Senator: How many nuclear powerplants do you have in operation at TVA?

Mr. WAGNER. We have one which has been in commercial operation. It is down now from a fire we had. There are two units there that were operating commercially.

Senator STAFFORD. Do you have some units that are under construction?

Mr. WAGNER. Yes; we have a total of 17 units either operating, planned, or under construction.

Senator STAFFORD. How many of them are actually under construction.

Mr. WAGNER. All but six, I believe. I can add them up. Nine are under construction now.

Senator STAFFORD. What percent of your electrical generation will be produced by the nuclear powerplants when the nine you say are under construction are completed?

Mr. WAGNER. I have a figure for the complete program. It is nearly half, about 46 percent. But for the nine it would be probably in the neighborhood of 30-some percent.

Senator STAFFORD. Some of your electrical generation is still hydro generating, is it not?

Mr. WAGNER. That is correct.

Senator STAFFORD. How much comes from that source?

Mr. WAGNER. About 3.5 to 4 million kilowatts of capacity. It has been about 15 percent of our generation. The net percentage would diminish as the system grows. We don't have any substantial amounts of hydroelectric potential left to develop.

Senator STAFFORD. So to sum it all up in a matter of a few years, about half of your generation will be either hydro or nuclear. Am I correct in that assumption?

Mr. WAGNER. That is correct. Probably a little more than half.

Senator STAFFORD. The rest will come from fossil fuels?

Mr. WAGNER. That is correct.

Senator STAFFORD. Thank you, Mr. Chairman.

Senator BAKER. Thank you, Senator Stafford.

Gentlemen, we are pleased now to have our chairman of this committee with us. Senator Randolph, would you like to proceed at this point?

Senator RANDOLPH. Yes. Thank you, Mr. Chairman.

I have been intensely interested in what Mr. Wagner has said. Mr. Wagner, in reference to scrubbers, do you speak yourself alone, or is that the considered opinion of those of you who form the directorship?

Mr. WAGNER. I believe my colleagues agree with me. I would be glad to——

Senator RANDOLPH. You don't mind my asking?

Mr. WAGNER. No; go ahead.

Senator RANDOLPH. They can answer as they would like.

Mr. Jenkins?

Mr. JENKINS. Yes, sir. I am sorry.

Senator RANDOLPH. Senator Stafford had a colloquy with Mr. Wagner on scrubbers within the last 5 minutes. That is what I asked about.

Mr. JENKINS. I concur with the chairman on scrubbers; yes, sir, insofar as he reaches a conclusion that some day they will be workable, but at the present time we do not believe that they are completely perfected.

Senator RANDOLPH. Mr. McBride, what do you think?

Mr. MCBRIDE. Chairman Randolph, I think that our opinion is unanimous in connection with the scrubber problem. We do not believe that the scrubbers that are now in operation have indicated that they would be successful or not successful, and if installed on TVA plants, which are bigger than any on which they have been installed, they would be less efficient.

We believe also that there are environmental problems that they create in connection with the sludge that would be produced from these scrubbers. There are many, many questions, both environmental, technical, and economic that haven't been answered. We have not found an indication that at present they could be successful in the TVA program.

Senator RANDOLPH. Thank you. Mr. Seeber, would you comment as the manager? You are back again. You were here for a long while last week.

Mr. SEEBER. Yes, sir. The views expressed by the TVA Board were of course not arrived at in a vacuum. A staff had to recommend something. We are very fortunate in that we are in the chemical business, through our fertilizer program, as well as being in the power business.

Senator RANDOLPH. You mean you went from the yardstick to a walking stick?

Mr. SEEBER. No, sir. Right in the original TVA Act, which you recall, and you were one of those who passed it, it has in there the responsibility for fertilizer research. In so doing, we are involved in chemical processes. This knowledge and expertise that we have in that area has been invaluable in addressing ourselves to the scrubber problem.

Our experts provide the scientific base upon which my recommendation and the Board's views are based. We recommended this position in the first place.

Senator RANDOLPH. I thank you very much.

Mr. WAGNER. Mr. Chairman, may I comment further?

Senator RANDOLPH. Yes, Mr. Wagner.

Mr. WAGNER. I would want to emphasize the point I believe I made earlier that we do believe scrubbers can be made to work and will be made to work. We think this is important because we recognize that for a good many decades the electric utility business is going to depend quite heavily on coal. For that reason, we are interested in finding ways that it can be burned compatibly with maintaining a good environment.

We are supporting research into coal gasification and coal synthesis of various kinds to see what might ultimately prove to be the best method for utilizing coal.

We think coal is important also as an important chemical source for the Nation. If coal is going to be used in those ways, it would make research into coal synthesis more important. We are saying that while we don't think scrubbers will work now it doesn't mean that we think coal is not going to be needed or that it cannot be burned.

Senator RANDOLPH. Chairman Wagner, Mr. Chairman, I will be brief. I asked this rather abrupt question of all four of the gentlemen so that I might follow with questions that I think bear on this subject.

You mentioned, Chairman Wagner, about the coal being with us for a long while. We have tried to think in terms of coal being used in the place of natural gas, which is certainly in much shorter supply and in the place of oil, from the standpoint of our own oil being in much shorter supply, not dealing at the moment with the imports in any degree.

But the Federal Energy Administration, as it moved last week to institute a program for conversion from gas and oil to coal, and set as its goal 70 generating powerplants to make the conversion, found very quickly that there was a buzz saw into the operation. Are you familiar with that?

Mr. WAGNER. I knew that the Federal Energy Administration proposed the conversion of many plants to coal. Yes, sir. I didn't hear the buzz saw buzz.

Senator RANDOLPH. It came within hours. So we will see where we go, but that is another story.

But constantly when we have attempted to move coal into the markets and to use scrubbers or other facilities to make coal acceptable, we find exactly the same thing is happening in the latest of the 70 conversions to coal from oil and gas.

Incidentally, many of these would use the coal from the West as Senator Domenici well knows.

Mr. WAGNER. Mr. Chairman, I would surely fully agree that we must use more coal. We must find ways to burn it. We must find ways to mine it satisfactorily because for several decades we are going to continue to depend heavily on coal for our electric power supply.

Senator RANDOLPH. Our research program on coal and its uses has been minuscule in comparison to the research in the other types of energy. Is that correct?

Mr. WAGNER. More research is certainly needed in the field of coal use; yes, sir.

Senator RANDOLPH. TVA emissions account for more than half of the sulfur dioxide in the Southeast region. That is what I am told. Recently a joint TVA–EPA task force studied this problem. It was a study of the effort to control SO_2 on the plants of TVA. Is that correct?

Mr. WAGNER. Yes, sir. That is correct. I don't know about the half. I don't know that TVA produces half of the sulfur dioxide in the area. But I have no basis for disputing that figure.

Senator RANDOLPH. I did qualify it by saying that is what I had been told.

Chairman Wagner, how many plants did that study include and also how many scrubbers would be needed to comply with the present provisions of the Clean Air Act?

Mr. WAGNER. Mr. Chairman, that included all of our coal-burning plants. There are 12 of them. There have been discussions as to how many scrubbers would be required. At the present time we are putting an experimental scrubber, a demonstration scrubber on one unit.

Senator RANDOLPH. Where is that unit?

Mr. WAGNER. It is at the Widows Creek plant, northern Alabama, on a 500-megawatt unit. This is a wet limestone scrubber that we are putting about $50 million of our own money in to see if it will work and to advance the technology. The question of how many scrubbers would be required in total is one we are still discussing with EPA and we will have further discussions with them on the basis of the task force report that you mentioned.

Senator RANDOLPH. Thank you. That installation in Alabama, is that in process of completion?

Mr. WAGNER. It is under construction now. It is scheduled for completion in 1977.

Senator RANDOLPH. I commend you, Mr. Chairman, and you, Mr. Seeber, and the directors for moving in this direction.

The final question: Does TVA believe that stack gas scrubbers can be made reliable? That doesn't mean as of a certain date, but do you believe that it can be done? We ask that question because there has been satisfactory performance of scrubbers at the Louisville Gas and Electric Co., and that scrubber is located in the TVA region.

Mr. WAGNER. We believe they can be made to work. Yes, sir. I should say at this point that there may be places where the air quality is already so bad that if a new plant is going to be built it would have to include scrubbers or maybe an existing plant would have to have scrubbers put on it.

We think that is not the situation in our area. The criteria that we go by is that the ambient standards must be met.

The plant in Louisville, as I understand it, is rather a unique situation that is not typical of our plants. In the first place, it is a 70-megawatt plant. We have plants up to 1,300 megawatts. The one we are installing the scrubber on is a 500-megawatt plant.

In addition, this is a peaking plant. It is not in service much of the time. There is opportunity to maintain it. It is not like a baseload plant. Another factor is they have a calcium carbide waste available to them that they can use as a liming agent which solves the problem in a way that we couldn't solve it.

Another factor is they have natural gas available for heating. That might not be a good use for natural gas. But they are using it.

We don't have natural gas available for that. There may be other factors. But the point is there may be special circumstances in which scrubbers will work now.

There may be special circumstances in which the quality of air might require that they be installed now even though they would not work well. But we don't think that our area is in that situation.

At the same time, as I indicated and you indicated approval of, we are researching scrubber technology to help advance the science.

Senator RANDOLPH. Mr. Chairman, I think that is a reasoned statement. But I do want to add, Mr. Chairman, as I close this colloquy, that when I mentioned the Louisville Gas and Electric Co., that the scrubber, which is at Paddy's Run plant, was found to be successful. They are moving forward with other scrubbers.

So, I think, you can, as you research a situation which has its variables, check very carefully, as I am sure you are, on what was done at the Paddy's Run plant in Kentucky.

Has that been done, Mr. Seeber?

Mr. WAGNER. Yes, sir. Not only there, Mr. Chairman. We have checked installations all around the world. We have followed this technology very closely and reached our conclusions on the basis of the best information that is available to us; not only at other plants in this country but around the world.

We certainly would be remiss if we had not done what you suggested.

Senator RANDOLPH. Thank you, Mr. Chairman, and also you, Mr. Wagner, Mr. McBride, and the man who is with us very often, the manager, Mr. Seeber.

Senator BAKER. Mr. Chairman, thank you for your usual good questioning of the witness. I might comment as a panel, someone on the panel may have commented a minute ago, you are the only one on this committee who was privileged to be here to vote for the TVA Act.

You have watched it evolve and develop over several years. It is a great pleasure to me to hear a man with knowledge and expertise you have—not only with TVA but in the whole field of fuels policy engaged in this colloquy.

I can remember when I first came to the Senate in 1967 that I was inspired to make a speech on the energy crisis based on your questioning of witnesses here. I went down to Knoxville, Tenn., and spoke to the Engineers Club about the energy shortages in the years to come. Everybody just sat there with a glazed look in their eye. But you have been in this for a long, long time. You have come to foresee and understand the problems that we have not only in terms of energy conservation and resources, but in terms of our related environmental concerns, and more particularly the extraordinarily valuable assets we have in our coal reserves and the absolute necessity for their effective utilization in this country.

So it is a great pleasure for me personally to have sat on this committee now for over 8 years and to learn from you much about this particular field.

Senator RANDOLPH. Mr. Chairman, it is my privilege to work with all the members who are on this committee in these matters that come before us as well as my colleagues in the Senate.

Thank you.

Senator BAKER. Thank you very much, sir.

Senator Domenici?

Senator DOMENICI. Thank you, Mr. Chairman. I might just comment. I haven't been here since 1967, but I think we still have a glazed look in our eyes about the energy problem.

Let me first state, Mr. Wagner, that my first impressions about your proposition as one member of this committee are to look with disfavor on your proposal to purchase Peabody.

I wish I could come up with a Tennessee expression to explain how this seems to be inconsistent, but I can't. I can't even come up with a New Mexican expression.

But I am going to tell you how I feel about it at this point. We started these hearings with a Federal Trade Commission ruling in front of us. It stemmed from a 1968 FTC hearing. They found that Peabody Coal Co. was a much-needed competitor in the coal business.

They also indicated that they thought Kennecott Copper had a very good chance of going into the coal business on their own. So they ended up telling Kennecott, "You get rid of Peabody and you get rid of it as a going concern so it will remain a competitor in the coal business in the United States." I then noted that TVA was interested in apparently making an acquisition.

I have attended about five of the hearings and heard TVA explain what they really had in mind. It appears to me they don't have it in mind at all complying with the Federal Trade Commission order because all they really want to do is buy some coal reserves.

If you were here when I asked earlier just how much you needed, I extrapolated it out and concluded, you might be talking about 2 billion tons of reserves out of Peabody's 10.

I think that is probably comparable to what you were telling me when you talked about a 50-year supply. Each day we proceed TVA says it doesn't really want to buy Peabody. They just want to take a big chunk of their reserves, get rid of the rest and let somebody else operate it.

Still I don't understand how that is compliance with the Federal Trade Commission's desire to keep a company like Peabody in the competitive coal market.

In fact, I think it is less in compliance and less reasonable than to let Peabody remain in the ownership of Kennecott and compete with other major coal companies in America. So we start with that basis.

Let me ask you: You stated in some responses to Senator Baker that you were busy about trying to acquire reserves when you apparently got notice that Kennecott had to divest and was looking for a buyer.

Where were you looking for the reserves that you might acquire if Peabody hadn't come along?

Mr. WAGNER. What I thought I said or intended to say was that we had asked our staff to look for reserves, wherever they might find them at reasonable prices, in a location where they would be reasonably placed as a normal supply for us.

I have assumed that they were looking in the areas where we now buy coal, in southern Illinois and western and eastern Kentucky, Tennessee, possibly southwest Virginia; our normal coal supply area. We were not looking for western reserves.

Senator DOMENICI. That wasn't my question. I assume if Peabody wasn't on the market you would be exploring this desire on your part to acquire increased reserves for the future; is that correct?

Mr. WAGNER. That is correct. We still are doing that.

Senator DOMENICI. I would assume you are still doing that?

Mr. WAGNER. That is correct.

Senator DOMENICI. I would assume from the little that I know that there are substantial reserves available in TVA's natural region of acquisition and transportation other than Peabody; is that correct?

Mr. WAGNER. I am afraid it is not correct. There are substantial reserves there. We haven't been able to find enough reserves that would be available to us.

Senator DOMENICI. Are there substantial suppliers of coal in the region within your normal market area that are willing to supply you with coal under long-term contracts?

Mr. WAGNER. We have had standing invitations out for long-term contracts for some time. We haven't had the coal offered to us that we needed. There are substantial suppliers in the area. There are people who own substantial reserves. But this is one of our problems. We can't get the coal that we want, particularly at the prices that we think make sense.

Senator DOMENICI. What has been your experience in purchasing low-sulfur, high-Btu eastern coal? The Bureau of Mines and others indicate that there are vast deposits of that coal in West Virginia and the southern fields, Kentucky and Virginia. They say there is enough to meet power company and metallurgical needs for many years until a better technology comes along.

Mr. WAGNER. We haven't had too good luck in buying low-sulfur coal. Some of it may be out of the reach of our normal purchasing area; that is, that would make transportation costs prohibitive. But we have tried to buy it in the general area that serves us without too good success. It might be Mr. Seeber or some of our coal-buying people could comment further on that. Would you like a further discussion?

Senator DOMENICI. I would like to know why you haven't when we are told there is plenty there. Is it that it is too expensive or you don't want to sign long-term contracts to buy it?

Mr. WAGNER. We have entered into long-term contracts without hesitation. We prefer them, in fact. A considerable part of our coal does come from long-term contracts. We would want it. I think perhaps the kind of luck that we have had getting long term, getting low-sulfur coal, could be described best by Mr. Wilkerson.

Senator DOMENICI. Would you do that briefly for me?

Mr. WAGNER. Mr. Williams. Let's ask him. He is director of purchasing.

Mr. WILLIAMS. Yes; we have two contracts that total about 5 million tons a year for low-sulfur coal, one from east Kentucky, and one from Alabama. In about 1972, the summer of 1972, we issued an invi-

tation to bid for low-sulfur coal specifically. The results were very disappointing. We made one contract at the time. We have an announcement out right now for another set of bids that we will open about mid-July where on the schedule we specifically asked coal suppliers to bid low-sulfur coal.

Senator DOMENICI. When is that invitation supposed to be responded to?

Mr. WILLIAMS. About July 15 will be the opening date. The announcement went out about 2 weeks ago, that we were advertising for coal.

Senator DOMENICI. By way of the contents of your advertisement for bid, what are you asking people to bid on?

Mr. WILLIAMS. This invitation will have two or three schedules, one of the schedules will specify less than 1 percent sulfur. The next schedule will be a little greater percentage.

Senator DOMENICI. What kind of commitments are you asking them to make—short-term, long-term, small-quantity or large-quantity?

Mr. WILLIAMS. Senator, the nature of our advertisements are such that we leave that up to the supplier. He tells us what term, what quality, what schedule, what amount of coal that he would offer. So these are in effect blanks that are filled in on the invitation by him. We have no hesitation to enter into long-term contracts.

Senator DOMENICI. Thank you very much.

Does someone have an estimate of how much TVA spends on research and development for environmental programs in some relative cost terms that we can understand?

Mr. WAGNER. I don't think we have one on research and development. We can provide it. It will go into several million dollars a year.

Senator DOMENICI. Would you supply us with that in terms that we can compare with some other operating companies that spend a given amount on R. & D. that we are aware of because of changing technology?

Don't compare it with an overall TVA budget that is unrelated to the production of energy. Instead relate it to the operational costs and receipts as related to energy production.

Mr. WAGNER. We will be glad to do that.

[The information requested follows:]

TVA'S ELECTRIC POWER RESEARCH AND DEVELOPMENT ACTIVITIES

	Fiscal year—	
	1974	1975
Internal TVA research and development:		
Resource extraction	$787,300	$1,238,700
Energy conversion	164,400	148,500
System operation and control	106,100	21,300
Transmission	295,500	137,500
Environmental control technology	1,505,800	1,846,800
Energy utilization	24,900	29,100
Miscellaneous	40,200	8,000
Subtotal	2,924,200	3,429,900
Payments in support of liquid metal fast breeder reactor project	2,400,000	2,400,000
TVA's pro rata payment in support of the Electric Power Research Institute	3,881,000	6,300,000
Total	9,205,200	12,129,900

Senator DOMENICI. I understand that the Fifth Circuit Court of Appeals in 1974 in the case of *Natural Resources* v. *EPA* held that tall stacks and intermittent controls could not be substituted for emission limitations. That fifth circuit does encompass jurisdictionally a portion of the area you serve. I might ask this question: Does TVA believe that that decision is binding on them especially since, as I indicated, two of your plants are in Alabama and the fifth circuit covers Alabama.

Mr. WAGNER. Senator Domenici, that question is still in litigation, I believe. I think I had better have our General Counsel respond to your question rather than do it myself.

Mr. MARQUIS. Senator Domenici, that fifth circuit decision which you mentioned had to do specifically with the validity of an implementation plan in the State of Georgia. We have no plants in the State of Georgia.

Second, I would say that a part of that decision was appealed to the Supreme Court and has just been reversed. As I read the Supreme Court decision, it has not only reversed the portion of the fifth circuit decision that actually went up, but it has at the very least cast doubt on the reasoning of the fifth circuit in the balance of the decision it handed down.

I would also say that this question is now being directly litigated first in the State of Kentucky, where two suits are pending, and another one, which I understand is to be heard next week, growing out of a Nevada regulation where the ninth circuit is about to hear argument.

That suit, incidentally, involves Kennecott Copper Co.

Senator DOMENICI. Let me press you just a little bit harder, although I don't want to get involved in the detail of your bidding. Senator Baker has alluded to what percentage of Peabody you would get rid of, what percentage you would keep. I think it is relevant in two ways, relevant to my objection that you don't leave an ongoing competitive company, although you could do that, if it is handled in a certain way.

So it becomes important what you keep and what you hope will be taken over and run as an operating company. If the reserves are the only thing you want, do you have any better estimate of what TVA would really want to keep of the assets and ongoing value versus what it would like some consortium or entity to take over?

Mr. WAGNER. We don't have at this time, Senator Domenici, because as far as I am concerned, the Board has not looked at this. It is still in staff study. We asked the staff to come up with a proposal, if they can, that would involve the smallest dollar commitment to us but would still get the reserves that we need. This will depend on where the reserves are and I don't know that at this moment. There are just a number of factors involved. I would think it would not be a major part of the value of the company.

I don't know about that. It would depend also on how good a deal we could make with the people who might join with us.

Senator DOMENICI. I guess that is what bothers me. If it isn't a major portion why should you be the principal in the acquisition?

Mr. WAGNER. We had the opportunity under the Federal Trade Commission order to submit an offer for the whole company or for

nothing. So we submitted an offer for the whole thing. What we can work out we don't know. This will be subject to a number of approvals, I suppose.

It would have to suit Kennecott; it would have to suit the Federal Trade Commission; it would have to suit others that we could work it out with. As we said repeatedly, it was a conditional offer. Where we finally come out, I don't think I can tell you at this point.

Senator DOMENICI. Do you have good contracts with Peabody at this point?

Mr. WAGNER. We have contracts with Peabody, yes, sir. I think we have four of them.

Senator DOMENICI. I am aware of that. My question is are they not a good supplier and have they not entered into long-term contracts which give you good reliability and good control on price escalations?

Mr. WAGNER. Peabody has been a good supplier of ours. In the past we have had good prices. Some of those contracts expire soon, one in February 1977, another one in March 1978, and another one will be subject to cancellation by them this summer.

The contract has a provision that is tied in with the general price of coal. When the general coal market reaches a certain point, the contract has to be renegotiated. Another one runs to 1984 or 1986. That is a long-term contract.

Senator DOMENICI. Have you or your staff evaluated whether or not Peabody is a money-making company and has been for the past 3, 4, or 5 years?

Mr. WAGNER. That is being evaluated now, I think.

Senator DOMENICI. Do you have any present evaluation of whether or not it has?

Mr. WAGNER. My general understanding has been that Peabody was not particularly profitable for a couple of years. I think they did better this last year but that is hearsay with me. I am not sure.

Senator DOMENICI. I have no further questions.

Senator BAKER. Thank you.

Senator Gravel?

Senator GRAVEL. Thank you very much.

I have read recently that you may be coming back to Congress, Mr. Wagner, with the thought of increasing the existing TVA debt limit. I understand you are limited to $5 billion and that you are going to ask that it be raised. How much more do you project that you will need?

Mr. WAGNER. We are not certain. We haven't made up our minds about that yet, Senator. It will be several billion dollars more. The President's budget shows $5 billion, but that will not be enough. Inflation, escalating the price of everything we buy and use has increased our costs. As I recall, the figure, it would take something like eight and a fraction billion dollars to complete the plants that are now under construction or ordered.

Normally, in the past, the Congress has by its actions indicated that we ought to have perhaps 5 years running time between coming back for the ceiling to be changed.

So you can see the figure would have to be more than the additional $8.7 billion by some margin. I am not sure just what.

Senator GRAVEL. So you are going to need about $8 billion-plus and you will be probably coming in for another $10 billion in addition to the $5 billion that you already have?

Mr. WAGNER. I should think at least that.

Senator GRAVEL. You say most of that is because of the construction you have underway. That is primarily your nuclear expansion. Is that correct?

Mr. WAGNER. Yes, sir. We have one pump storage hydro project underway, but primarily it is nuclear power.

Senator GRAVEL. With respect to your Hartsville nuclear plant, which is going to be the largest in the world, what was the original projection you had forecast on that plant? Is $660 million about what was originally projected?

Mr. WAGNER. I would think it was more than that. It is large.

Senator GRAVEL. I am talking about the original projection.

Mr. WAGNER. Just a minute. I think we can get it.

Senator GRAVEL. The figures that I have indicate that what you originally estimated was $660 million and now the cost is up to $1.6 billion. That is last year's estimate and this year's estimate is $2.5 billion. That is an escalation from $660 million to $2.5 billion in 3 years. Is that reasonable?

Mr. WAGNER. The figure we have here is that the original estimate for the Hartsville plant was $1,425 million; the current estimate for it is $2.5 billion. So you are correct on the final figure. The original was $1,425 million.

Senator GRAVEL. Last year's figure?

Mr. WAGNER. That was the original estimate, when the plans were reported to Congress in 1972.

Senator GRAVEL. Originally in Congress in 1972 it was $1.6 billion?

Mr. WAGNER. Originally, $1.4 billion, revised to $1.6 billion for fiscal 1974, and $2.5 billion now.

Senator GRAVEL. Now it is up to $2.5 billion?

Mr. WAGNER. That is right.

Senator GRAVEL. So that is a $1 billion increase?

Mr. WAGNER. That is correct.

Senator GRAVEL. How about other increases in our projected nuclear developments? Is Hartsville unrepresentative of what is happening in the marketplace?

Mr. WAGNER. Construction costs of all kinds, whether we are talking about nuclear plants or whatever, are escalating very rapidly. Hartsville was perhaps typical. I should point out, however, that at the same time our estimated costs are still among the lowest in the industry, for comparable sized plants.

Senator GRAVEL. From your consumers' point of view, they don't take much solace from a comparative track record. You could only deal in positive terms. I know that construction has increased all over the country and we have inflation in this country. But certainly a $1 billion increase in a year's time is considerably above the average of inflation. Why have the costs increased so much at this Hartsville plant?

Mr. WAGNER. It is projecting in the future. The projection assumes generally about a 10-percent-per-year inflation rate which is the same

as we are using on our other plants, too. I think you will find the projections of increased costs among the industry generally follow about that same pattern or are even greater.

Senator GRAVEL. Are you telling me that the nuclear plant price increase here is the same as what you have experienced on a recent coal-fired plant or do you have a recent coal-fired plant?

Mr. WAGNER. We don't have a recent coal-fired plant.

Senator GRAVEL. What is the last nonnuclear plant that you built?

Mr. WAGNER. The Cumberland plant was completed about 3 years ago.

Senator GRAVEL. What kind of cost overrun did you experience there?

Mr. WAGNER. I don't have the figure. I am sure it was less than we are experiencing now.

Senator GRAVEL. A lot less?

Mr. WAGNER. Substantially; yes, because the inflation rate we calculated for it is less than it is now.

Senator GRAVEL. This $1 billion that you calculate here is all inflation? The $1 billion increase here, is that all inflation?

Mr. WAGNER. Changes in requirements for the plant design. Is that correct?

Senator GRAVEL. How much of this inflation, how much is changed design or other cost factors?

Mr. WAGNER. I don't have that figure in mind.

Senator GRAVEL. Could you supply it for the record?

Mr. WAGNER. Yes.

Senator GRAVEL. I think it is important to pin this down and not just lay it all off on inflation. That is a good way of covering it all up, if we don't want to see the guts of what is happening.

[The information requested follows:]

The previous estimate of $1.575 billion had included allowances for inflation and interest at rates which were judged to be reasonable and prudent at the time that estimate was prepared in July 1972.

The revised estimate of $2.5 billion was prepared in July 1974 using higher allowances for inflation and interest. The increase in total estimated cost of $925 million is comprised of $775 million attributable to higher assumptions for inflation and interest, and $150 million attributable to other factors.

The tabulation below compares the assumptions for escalation and interest used in the two estimates:

	$1,575,000 estimate	$2,500,000 estimate
Assumed annual increase in salaries and wages	5.5	[1] 10
Assumed annual increase in price of materials and equipment	3.0	[1] 10
Interest rate, per annum	7.0	8.5

[1] Approximately.

Senator GRAVEL. What happens if you go into something like this that has such an unbelievable cost overrun? The increase is built right into the rate base the consumer pays. Is that correct?

Mr. WAGNER. That is correct. It is like everything else in the inflationary spiral. Coal-burning plants are going up the same way.

Senator GRAVEL. But I think we have generally agreed that you don't know of any coal plants that have had this kind of cost overrun.

Mr. WAGNER. No; but we take a look at what is happening to the coal-burning plants that others are planning in the future. One of the things that you have to remember there is if we were to plan a coal-burning plant now we would have to include scrubbers or some other constant emission limitation. So the cost of the coal-fired plant per kilowatt of capacity would get very close to the cost of nuclear plants.

Senator GRAVEL. What you are saying there is that if you had to put in scrubbers, it would make the cost almost that of a nuclear plant, meaning the nuclear plant is more expensive?

Mr. WAGNER. The nuclear plant of the same installed capacity would be slightly more expensive than the coal-burning plant. The fuel cost is so much lower that the cost of power to the consumer comes out less.

Senator GRAVEL. Will the Hartsville plant be a water-cooled reactor?

Mr. WAGNER. Light-water reactor, boiling-water reactor.

Senator GRAVEL. Where are you going to get your fuel?

Mr. WAGNER. Does somebody know where we are going to get the fuel for that plant?

Senator GRAVEL. Do you know?

Mr. WAGNER. Yes. We have fuel bought or initial orders in for most of our plants for some years into the future.

Senator GRAVEL. For how long?

Mr. WAGNER. Mr. Seeber will comment on that. We have some figures.

Senator GRAVEL. Please. Mr. Chairman, you can put the question to any one among the group. Certainly we are not limited to one source in this colloquy.

Mr. SEEBER. The information that I am going to talk about is contained in a GAO report that has been filed as part of the record of this proceeding on April 29, 1975. There is quite a long section in there detailing the uranium that we have purchased, the enrichment contracts that we have purchased, and so on.

That is a long dissertation.

Senator GRAVEL. I will just take a summary of it. Maybe you can summarize it by responding in this fashion. How many years' supply do you think you have tied up to meet nuclear plants that you have under construction?

Mr. SEEBER. We don't state it in terms of years supply. For example, for 1975 through 1978 on, uranium concentrates, on page 18 here, it shows 100 percent. Then that figure, each year, drops and gets smaller and smaller until 1985. We had 15 percent.

Senator GRAVEL. So by 1985 you would essentially be out of fuel as you presently project it from an economic point of view?

Mr. SEEBER. No, sir. This is merely what we have committed right now. We will continue to purchase requirements as time goes by.

Senator GRAVEL. But are you aware that there is going to be a scarcity of uranium by about the same time you are down to 15 percent? When you start buying it, will the product be considerably scarce so that the price would rise?

Mr. SEEBER. That is exactly the reason we have taken the precaution

of buying uranium reserves in the ground and are engaged in an exploration plan so we will not get caught in such a bind. This same portion of the GAO report details the various arrangements that we have made. We are in the uranium exploration business. In the same manner that we do not wish to get caught short on coal reserves, we do not wish to get caught short on uranium reserves and are taking measures to prevent that.

Senator GRAVEL. Are the uranium reserves projected in these percentages calculated only until 1985 or is that reserves beyond 1985?

Mr. SEEBER. A lot of the property which we have is under exploration and we don't know what those reserves are yet. It must be in addition to some of this.

Senator GRAVEL. How much of it, though? That is pretty important.

Mr. SEEBER. Let me get someone on the staff.

Senator GRAVEL. Have them join in the colloquy.

Mr. SEEBER. Mr. Hughes?

Mr. HUGHES. We have a program of exploration with a number of companies out in the West. We have no indication now exactly how many tons or pounds or uranium we will have available to us. But we have a confidence that we will have a great amount of uranium that will come from these exploration ventures.

Senator GRAVEL. Are those projected amounts of which we are not sure included in the percentages going from 1975 to 1985 on fuel? These figures must come from some place.

Mr. HUGHES. The figures in the GAO report are firm contract figures. What I am talking about is additional reserves and additional supplies that we will have from these exploration ventures. The firm figures are just what we have our finger on right now.

Senator GRAVEL. Under these ventures, do you have a firm price if they find something?

Mr. HUGHES. It is a firm—it is related to the cost of the recovery of the uranium. Yes, sir.

Senator GRAVEL. Would the market have any effect on those prices?

Mr. HUGHES. It depends on the type of contract involved. We have some contracts that give us a 50-percent interest in the material that would be mined. Whatever it costs to get it out—half belongs to us.

Then we have an opportunity in some of the contracts to have right of first refusal on the other 50 percent. That would be related to the market price.

Senator GRAVEL. What calculations have you made for anything beyond 1985 as to what costs you might face, including that of the exploration, which of course is very tenuous? You are assuming you are going to find something?

There is also the question of what the cost will be for a combination of what you have tied down in contracts and that in which you have right of first refusal. Suppose the price goes up 400 or 500 percent. What kind of economic projections have you made in that regard?

Mr. HUGHES. Of course, as to the uranium that may be recovered from our current explorations we can make a pretty good projection of the cost to bring it out of the ground. We have a fair degree of confidence on that portion of it.

The portion that is geared to the open market of course relates to the amount of uranium that is available for sale and the amount of uranium in demand by the industry at that time. Of course, that is a very nebulous figure. But the projections of our costs of uranium relate heavily to what we have and what we have under contract, and what we have available from our own sources.

Mr. WAGNER. Mr. Watson, I think, had a comment.

Mr. WATSON. I just wanted to point out, Senator, that the basic price of uranium amounts to about a third of the price of the fuel.

If you are going to compare the cost of generating electricity with their fossil fuels or uranium, then you have to take into account that you have got a bigger difference between the cost of coal at the present time and the cost of uranium.

So that the cost of uranium itself could go up two or three times before coal got to be really competitive with it.

Senator GRAVEL. We saw fossil fuel climb four times in the space of 3 months. Certainly, it would not be unusual to see uranium do that in a 3-month period, not necessarily pushing it all the way to 1985.

But I think what I am really trying to probe for is how much consideration is being given to this and what will really be the total cost of bringing nuclear power on line. When you have an overrun like you have here and you don't have a guaranteed fuel supply source for the full period in which you are going to amortize the equipment, then the consumer could end up getting stuck with quite a white elephant.

Mr. WAGNER. I think the price we have to pay for uranium in the future and for other costs of the system would follow the general economy.

Senator GRAVEL. Why would that be the case?

Mr. WAGNER. That is the way things happen.

Senator GRAVEL. It hasn't happened that way with oil. I don't know why it would have to happen with uranium.

Mr. WAGNER. Oil has followed the general trend.

Senator GRAVEL. It hasn't.

Mr. WAGNER. I agree. So has coal, faster.

Senator GRAVEL. Not only faster but it has led it by a quantum lead of 4.

Mr. WAGNER. I understand that.

Senator GRAVEL. If we are to accept that in uranium, then you have lost your economic base, haven't you?

Mr. WAGNER. There is one reason I said a little earlier that we are trying to acquire uranium reserves of our own so we can have control over that factor. It is the same reason we went for the Peabody reserves.

There is no way in the world that I know that you can operate a power system, whether public or private, that is risk free. You build plants. You make reasonable investigation into the costs of various sources of energy available to you at the time and make the best selection you can.

If we build a coal-burning plant, we try to assure a supply of coal at the time we buy the plant. The same thing for the nuclear plants for its initial operation. But there is no way in the world I know that you could insure a supply of fuel for any powerplant for 35 years into the future, which is a normal life at the time you build it.

54-380 O - 75 - pt. 2 - 17

Senator GRAVEL. Why is the State of Tennessee opposed to the Hartsville plant?

Senator BAKER. I might ask the Senator if he would yield, I believe we have testimony from the Governor recently that the State of Tennessee was not opposed to the Hartsville plant, meaning the State government, that the Governor had instructed the attorney general to intervene for purpose of joining the issue.

But I believe the Governor's testimony was that neither he nor the State government had a position of opposition.

Senator GRAVEL. That responds to the question. What are you going to do with the wastes from the nuclear plants?

Mr. WAGNER. I should let one of our nuclear experts handle that question for you. Bob Davidson?

Mr. DAVIDSON. Senator, you are speaking of high level wastes from the fuel assemblies, I assume?

Senator GRAVEL. Either that or the wastes from the plant itself.

Mr. DAVIDSON. Perhaps if we can deal with these in two parts, the fuel assemblies themselves would be stored in fuel pools, either at the site or at a reprocessing plant. Following a short period of storage, the fuel material would be chemically processed, the wastes would be extracted and concentrated and probably stored in liquid form at the site for a period of about 5 years.

After that period of time, it would be under the authority of the Energy Research and Development Administration. Right now they have engineered storage facilities that are in the process of being evaluated. Three types of facilities for storage of this waste, for a period of about 20 to possibly 50 years.

This material would be shipped to these storage facilities in a solid form, ceramic, perhaps, and stored until such time as a permanent storage could be established.

This permanent storage could be in salt mines or other places. There are good reasons for holding this waste in a retrievable form. There may be material in this waste that is commercially usable, commercially valuable and we also may find methods of extracting some of the materials, such as plutonium for further use in reactors.

Senator RANDOLPH. Mr. Jenkins, there was a difference of opinion within the three directors on the matter of the purchase—to put it in broad terms—of Peabody Coal. You made a brief statement here earlier in reference to your feelings about this purchase. The vote was 2 to 1.

You were in the minority. Would you care to express to us whether that was a philosophical decision on your part or whether it was other reasons that motivated your vote? I will couple with that the question whether your opposition to the purchase of nuclear power plants was a philosophical decision or whether there were other reasons?

Mr. JENKINS. Yes, sir. I would be glad to comment on both, Senator. First of all, if I might take them in reverse order, when I went to TVA a little over 2 years ago there were five nuclear plants that were in some stages of planning. Three of those had already been finally authorized and two were authorized shortly after I went to TVA making the total of five nuclear plants that were authorized. I have supported those and voted for those five plants with every vote.

At the time I went there it was estimated that these five plants could be completed and we could stay within the $5 billion debt limitation.

About a year after going there it was made known to me that the $5 billion estimate for completion of the five plants was low, that it would take about $8.5 billion to complete the five plants.

Shortly thereafter the matter of authorizing two additional plants came before the Board. As Senator Gravel pointed out, there were cost overruns in connection with what had been done so far. Browns Ferry nuclear plant had originally been estimated at about $250 million.

Midway during that construction that was revised upward to about $500 million. Browns Ferry is going to cost better than $800 million, I am told, when all three units are finally completed.

So we had some cost overruns. On the day we voted for the two additional plants, it was made known to me that perhaps we would have to ask the Congress of the United States to raise the debt ceiling to as much as $15 billion. There was no question in my mind, but that the authorization of these two additional plants would exceed our debt limitation of $5 billion.

So I felt that since we had budget hearings coming up, since we had oversight hearings coming up, that it would perhaps be wiser to wait and determine the feeling of the Congress relative to how much the debt ceiling would be raised.

In line with that I made a motion on the day we voted for those parts of the plants to defer action on the purchase of those plants for a period of 90 days. That motion failed for lack of a second.

But that is basically my reasoning with respect to that vote. In connection with the Peabody purchase, without having crossed the philosophical bridge which I would be glad to comment on briefly, there was some mechanics, some details of the transaction that I felt were important.

To begin with, the first time I ever knew that this was going to be a matter of consideration was approximately September 27 or 28 of 1974.

We discussed this very briefly in Mr. Wagner's office on the afternoon of that day. It was brought to the Board for a final vote on October 2, 1974, a few short days after. There was a weekend that intervened.

On one of those days I was in Chattanooga entertaining guests that we had from the World Energy Conference and on another day I was at Muscle Shoals with visitors to the Fertilizer Demonstration Center. There was very little time, I felt, to ponder a transaction of this magnitude.

There was some question in my mind—there was no question but that the offer was conditional, but the conditions of that offer were not in my opinion to the substance of the offer. They dealt with the mechanics.

If we, as I saw it, were given accurate information by the people with whom we were negotiating then we had what amounted to, in my mind, an offer to purchase that coal company. There was some consideration about the price. The price that we offered exceeded

what I felt we should have offered because the unaudited assets were considerably lower based upon the reports that we had on that day.

The price that I understood that the company had paid for it was much, much less than our offer.

In addition to that, there were complications relative to where the coal reserves were located. There were out-of-country reserves as has been pointed out. With those reserves there were what I considered to be international complications.

There were partnerships with third countries and corporations in third countries. There were complications relative to the purchase that would be allowed by the host country. I think those reserves were the Australian reserves.

In addition to that, some of the reserves of Peabody were committed, it was pointed out, to other utilities. We didn't have a complete breakdown on the percentages. But they were committed in long-term contracts to other utilities.

In addition to that, about 2 billion tons of the 9 billion tons of coal in reserves were committed to research projects, gasification projects and other research projects.

There were, as has been pointed out by other witnesses, some opportunities to buy other coal reserves, located near to where we operate in the Tennessee Valley.

I do not have the names of those companies. I know at the time I can recall the Tennessee Land and Mine Co., was for sale. I can't recall other offers that we had at approximately the same time, but I can supply those for the record.

We had, as has been pointed out, about 360 million tons of coal in our ownership at the time. We were only realizing about 5 million tons a year from those reserves.

We have since stepped up production and taken steps to step up production in reserves to about 7 million tons per year. But I felt that we had reserves that were not utilized at all and in addition to that we had reserves that were underutilized. That was a factor that weighed in my decision.

In addition to that, of course, the only way that we could make the purchase was with borrowed money, interest rates are high. If we borrowed the money, if we paid the interest rates, then we were very definitely going to lose some of the advantage that we would derive from having coal under our ownership and mining it ourselves.

I felt that companies that were in the business of digging coal and supplying coal in this country could perhaps do it more economically in the final analysis because of that factor.

As far as the philosophical bridge is concerned, I never really had to cross that, in my mind. I perhaps have crossed it in other areas.

I proposed purchase of uranium reserves in the West. We do own coal reserves. I would not be opposed to purchasing a portion of these reserves of this company or other coal reserves if I felt that it was, as Senator Baker earlier classified it, a good Tennessee horse-trading deal.

Senator RANDOLPH. We also horse-trade in West Virginia.

Mr. Jenkins, this is helpful for the record. I wonder, about a second question, and then I shall be through because of the necessity to leave—and I thank my colleague.

I want to place it on the table for us without asking someone to comment particularly. The Federal Trade Commission in essence, as I understand it, said to Kennecott Copper that you cannot as a producer of copper move into the production of coal. Is that correct?

Senator DOMENICI. Not necessarily so. They indicated in their ruling that they thought Peabody was a coal company and in and of itself was a major competitor. They said if you want to go in the coal business, you do it another way, form your own coal company, but don't buy up an existing one. I think that is basically the premise of the FTC ruling that Kennecott was thinking about going in the coal business.

Therefore, they were a primary potential entrant, simply because their board had been discussing it. So the FTC said since you have been thinking about going into it, don't go into it by buying up Peabody. Go into it some other way. That is basically the heart of their decision. Is that correct, Senator Baker?

Senator BAKER. To be honest with you, I don't know what they meant. They indicated that the Peabody acquisition by Kennecott was inappropriate, I suppose, because Kennecott was in the mining business, though not in the coal mining business.

There was another aspect of the decision called deep pocket theory, which says if you buy Peabody, you have so much money floating around nobody else would want to compete with you. Therefore, that might depress competition in the coal industry. That is not a very good description of the theory, but that is the best I can do. I don't quite know what the FTC did except hand us a hot potato.

Mr. Chairman.

Senator RANDOLPH. I have been concerned. That is why I approached the question. I am appreciative of the clarity with which the Senator from New Mexico speaks, and the equal clarity, with the question mark, with which our chairman speaks.

Senator BAKER. I am clear on the point that I am confused.

Senator RANDOLPH. It is like the person who thanked someone for their enthusiastic criticism.

This further question is part of the other. Island Creek Coal Co. is owned by Occidental Oil. Consolidation Coal Co. is owned by Continental Oil.

I am trying to rationalize the fact that Kennecott is told in essence you cannot own and operate a coal company.

Does anyone want to comment on it, since you are thinking of Peabody, Kennecott, and other subject matter?

Mr. JENKINS. Mr. Chairman, our chairman has been to Solomon's Tomb. I would like to defer to him on that.

Mr. WAGNER. I certainly can't comment on what the Federal Trade Commission had in mind. All we know is we got an offer, an invitation from Kennecott Copper Co. to bid on the Peabody Coal Co. as a unit. The majority of us at least felt that we had an obligation to our consumers to do that.

I would say that we are concerned by this question of ownership of the basic energy reserves in this country in a relatively small number of hands, and all of the forms of energy in the same hands.

We have pointed that out on numerous occasions to congressional committees, to Members of Congress, talks we have made in the area, to the public.

It seems to me that the question of availability of energy in this Nation in the future is so vital to our total well-being that it is a subject for investigation as to just how those energy resources should be controlled. From TVA's standpoint we saw the price of coal going way beyond what we felt to be the reasonable cost of producing it. Yet, we had to have coal. This is why we moved to our own reserves to begin with and sought to acquire additional reserves if we could. This is also why we moved to acquire uranium in the ground and explored for uranium.

We can't handle the problem nationally but we have been doing our best to protect our own consumers in that regard. As I may have said earlier, we are satisfied that for a good number of decades at least we are going to have to use both coal and uranium to meet the region's electric power supplies and use them both in increasing quantities.

This is why we have been doing our best to acquire the reserves that would enable us to do that at prices to the consumer which bear some relationship to the cost of producing the mineral. Our people have said earlier that if we should acquire Peabody reserves we would first move to have the mining done by others because we don't want to go into the mining business even for ourselves.

Some board in the future might determine they were being gouged by the companies that could mine the coal. That board might determine they want TVA to mine coal for itself. I hope that will be a question a future board will not have to face.

I don't want to tackle that one myself. I don't know whether that is a comment on your statement, Senator Randolph, but it is the best I can do for you.

Senator RANDOLPH. I won't go so far as to say you are a Solomon.

Mr. WAGNER. Thank you.

Senator RANDOLPH. Because that would be a comparison that you would not desire. But this is vexing me. It is very, very troublesome.

I am sure the members of our committee will continue the thrust of trying to put together the pieces here. It has been a long time, Mr. Chairman, since we have thought about TVA and its growth and spread. I don't know how many years—I don't know that we ever had a review of TVA. Did we? If so, it was a long time ago.

Senator BAKER. I don't believe we ever had. We have had any number of TVA hearings, as TVA general counsel pointed out the other day, both in the earlier years with the disputes between Franklin Roosevelt and Director A. E. Morgan and later with the TVA bond financing act.

But I believe this is the first general oversight hearings that we have had since the passage of the act.

Senator RANDOLPH. We will check that out for the record. Of course the board matter was discussed in considerable depth at hearings. I thank you, Mr. Chairman, and I thank my colleague.

Senator BAKER. Thank you.

Senator GRAVEL. Perhaps we could have the gentleman who was responding on the nuclear—would you give your name for the record?

Mr. DAVIDSON. My name is Robert Davidson.

Senator GRAVEL. What about the chemical treatment of the waste? Is that going to take place on TVA property or will you have to send the material to another plant?

Mr. DAVIDSON. Senator, the fuel assemblies would be shipped in shipping casks, very highly engineered shipping casks, shielded so that the radioactive level on the outside of those casks is minimal. They would be shipped in such casks to a processing plant. There is one such plant that is about a year away from operation now. The chemical processing would be done there; not on TVA's facilities.

Senator GRAVEL. Supposing for some reason or other the chemical processing plant doesn't become operational. What are you going to do to your wastes then?

Mr. DAVIDSON. There are other possibilities. There are other plants that are being studied, that could be built. If that plant didn't become operational——

Senator GRAVEL. Is there any plant operational today?

Mr. DAVIDSON. No.

Senator GRAVEL. Do you happen to know what they did in New England when there was no plant operational to handle their wastes?

Mr. DAVIDSON. I am not positive of what you are referring to. I assume they held it in storage.

Senator GRAVEL. They had to build additional storage capacity right at the plant.

Mr. DAVIDSON. That is correct.

Senator GRAVEL. Of course at considerable cost.

Have you assessed what it might cost you to build facilities needed to store your wastes?

Mr. DAVIDSON. I don't have a figure. But that is being assessed assuming that the plant might be delayed or that some other plant might have to be built before we have that facility available. We are considering the possibility of storing fuel as fuel asemblies either on a TVA reactor site or elsewhere.

Senator GRAVEL. So in terms of the cost and rate base, the economies in question, the eventuality has not yet been assessed?

Mr. DAVIDSON. That specific eventually, but I do not think the cost would be an extremely high addition to the rate base: I guess I am using judgment perhaps that I shouldn't. I don't think that cost is that significant.

Senator GRAVEL. I would ask you to contact New England Electric people who testified right where you are sitting now. They felt it was a substantial cost. It was not an insignificant sum of money. In fact, it was considerable and one not included in the overrun that you have already experienced. But that may occur.

Mr. DAVIDSON. We have facilities onsite for storage of several cores of fuel.

Senator GRAVEL. How long would that last you?

Mr. DAVIDSON. It depends on which plant we are talking about. If we consider the Browns Ferry plant, there are three fuel storage pools at Browns Ferry. Each of those pools, as I recall, will hold about 1⅓ cores. We discharge about one-third of the core at a time at each refueling once a year.

Senator GRAVEL. I understand ERDA has abandoned the engineered storage that you spoke of and they are now looking to Mexico as the site. They haven't been greeted with any——

Senator DOMENICI. Just barely looking.

Senator GRAVEL. That is the political attitude we are hearing there. But they have abandoned that. What costs have you projected for your waste disposal plant? Is ERDA going to charge you anything for taking your wastes from you and if so, how much? Does anybody know the answer to that?

Mr. DAVIDSON. Senator, I am reminded that as far as our Browns Ferry plant is concerned we have a comprehensive contract with the fuel supplier—that is, General Electric—that lasts for the first 7 years or so of the fuel use within those 3 units.

With our second plant, the Sequozh plant, we have a similar comprehensive contract with Westinghouse Corp. for the first core of that fuel. So at least for, say, 7 to 10 years from now this item is already contracted. The cost is considered in the cost of fuel and the cost of operating those facilities.

Senator GRAVEL. I am not familiar with this—who carries the cost of this? Is it ERDA or is the cost transmitted through GE and is there a resulting escalation in the contract? Is it open ended so they can reassess you if they are met with some exorbitant costs?

Mr. DAVIDSON. The cost of the reprocessing itself is borne by GE paying the reprocessing facilities. The cost of storage of the fuel, I am not certain, but I think that is by ERDA.

Senator GRAVEL. Suppose, as we outlined before, the plant doesn't get operational and you are stuck with storing the materials. Do you sue GE because they don't take your materials? Is that what happens?

Mr. DAVIDSON. I would have to speculate, but they do have the obligation to take care of the spent fuel. A contractual obligation to take care of the spent fuel.

Senator GRAVEL. If they don't meet that, then you are in litigation, but until litigation is solved your consumers are going to have to carry that cost? You can respond directly.

Mr. DAVIDSON. Again, we only pay for that fuel as we use it.

Senator GRAVEL. I am talking about the wastes.

Mr. DAVIDSON. But we are buying kilowatt-hours for that 7-year period that I spoke of.

Senator GRAVEL. I don't think you understood me. What I am saying is that within that 7-year period, if they can't handle the waste, reprocess it and get you back new fuel, you are out in the marketplace looking for uranium. Maybe GE will supply it. I don't know. If they can't operate their plant, and we have a track record of that happening in the country where there was a 5-year delay in reprocessing, who eats the cost of this?

It would surprise me very much if GE did. I think it is far more likely the consumer would absorb it.

Mr. DAVIDSON. I feel GE would contract with it. We are buying under those contracts.

Senator GRAVEL. Would you supply for the record the contract and mark the section where if their plant doesn't get up on time——

Mr. WATSON. We just will never pay them. So it isn't a question of their suing us.

Senator GRAVEL. I submit you can't do that, because if you don't pay them, they will not give you any fuel. They have got you. You don't have them because your plant is going to be idle without fuel.

So I don't think I would accept as a prudent businessman that I am not going to pay you and you are not going to give me the goods and, therefore, I go broke. I am going to keep paying you and litigate.

Mr. WATSON. I thought you were talking about reprocessing and on the reprocessing, they have to take care of it.

Senator GRAVEL. If you don't pay them for reprocessing, then they don't reprocess. If they don't come on line they will not charge you anything. You are going to suffer the damage because you don't have anywhere to ship the wastes, the spent fuel. If you can't do that, then you have to pay the cost of additional storage. They are not getting hurt at all. They have their own problems.

Mr. WATSON. We don't have any obligation to reship this to them. It is their waste product. They have an obligation to supply us with new fuel. If they don't supply it, we, of course, have the claim against them.

Senator GRAVEL. You mean they come and collect the wastes?

Mr. DAVIDSON. Yes, sir.

Senator GRAVEL. Supposing they don't have a plant and they don't come and collect it? What happens? Then you have to provide some storage. Is that correct?

Mr. WATSON. It has to be taken care of.

Senator GRAVEL. So, as happened in New England, you build an additional building at great cost and start storing. At the same time you start suing GE. In the meantime, who is going to pay? Obviously you will. Right? When you pay, your consumers pay. Maybe you would have a different answer for that.

Mr. WAGNER. May I comment briefly, Senator Gravel? I think if I did the arithmetic correctly on Bob Davidson's figures with our storage of three pools at one and a quarter loading on each one, we have a storage of about 15 years. It seems to me the basic assumption that there will not be processing facilities available over a reasonable period of time is one that I don't believe in a valid assumption.

We are not the only ones building the nuclear plants. Others are building them, too. This will be a business proposition for someone. The technology for it is reasonably understood at least.

It seems to me that just to assume that we can't get fuels reprocessed is the wrong assumption. We may run into delays with it. But we have facilities to carry us for about 15 years in the Browns Ferry plant.

So I think it is not as large a problem as the questioning might indicate. As I understand it, also the cost of this fuel reprocessing is a very, very small figure in relation to the total cost of supplying the electricity.

Senator GRAVEL. Were you aware that the plant which GE was building has been abandoned?

Mr. WAGNER. Yes.

Senator GRAVEL. Are they going to build another plant?

Mr. DAVIDSON. Probably not GE, but others are.

Senator GRAVEL. But the contract you have, on which you are basing your waste disposal plans, is with GE.

Mr. DAVIDSON. GE has the obligation to contract with others.

Senator GRAVEL. If they don't do it, then they have to get somebody else to do it?

Mr. DAVIDSON. Yes.

Senator GRAVEL. But you were aware of the fact they abandoned their plant?

Mr. DAVIDSON. Yes.

Senator GRAVEL. You are aware of other delays around the country?

Mr. DAVIDSON. Yes.

Senator GRAVEL. So you are aware that this is a fairly serious problem. I wouldn't want to comment one way or the other on whether it is reasonable to expect that it will happen when we are already confronted with the possibility.

Are you aware that the agency regulating nuclear activity has just stated that they want a moratorium on the recycling of plutonium?

Mr. DAVIDSON. Yes, sir.

Senator BAKER. I think that is not quite right. Senator Gravel, I think the regulatory authority has published inquiry on whether or not plutonium lends itself to utilization as a primary fuel. I am not aware that they have indicated a moratorium on the reprocessing of plutonium or of the extraction of plutonium from other materials.

Senator GRAVEL. The information I have is, of course, that they deferred, put off the decision. But they raised the question and since the regulatory agency raised the question, then I would question the efficacy——

Senator BAKER. They have done that. They have raised the question much as I framed it, I believe. But I respectfully suggest that they have not done what the Senator stated.

Senator GRAVEL. I take back the statement that there is a moratorium. We have legislation that we hope will do that. It has a long way to go before passage.

But the question has been raised within the regulatory agency and there is a great deal of discussion within the Congress on this point. It therefore seems obvious that your decision saying that there will be a solution to the problem may place your consumers in jeopardy since apparently 50 percent of your rate base, your baseload rather, is going to be nuclear.

Mr. WAGNER. There is nothing we can do that doesn't involve some risks when you plan for the future power supply.

The question you are pursuing now is as the cost of having the fuel processed.

As I recall, someone may want to amplify it or correct it, this is a very small part of the cost of providing power to the nuclear plant.

Senator GRAVEL. You had a fire at Browns Ferry. What happened?

Mr. WAGNER. The plant is shut down at the present time. I think we have someone around here who is expert on that. Is that Mr. Davidson again? Let me ask him to explain it.

Mr. DAVIDSON. Would you like for me to go through my understanding of what happened at Browns Ferry that produced the fire?

Senator BAKER. Let me interrupt just for a moment. Before Senator Gravel arrived it had been indicated that we would try to limit our questions on the first round to about 10 minutes so that we could get through the entire committee.

I have no desire to cut off the Senator from Alaska. But Senator Brock has sat with us during most of these hearings. If it is possible before we break today, I would like to get down to his questions as well.

With that, I would ask that we try to move along as fast as we can, but I have no desire to——

Senator GRAVEL. This is the first opportunity I have had to address these questions to TVA. They are the biggest nuclear people in the country, with respect to utilities. I think these are pretty important questions. We haven't had much of a hearing at the joint committee on the subject. So this is the best opportunity I have.

Senator BAKER. I really don't think that is so. I think that is wrong. I think the joint committee has done an extraordinarily good job with it. And there are hearings yet to come. I think the NRC has done a good job with it. I have been down here for the joint committee myself as a member of the joint committee. I really think that that statement is not correct.

I have no desire to terminate the Senator's questions. But I see no necessity for putting things in a framework and attitude that I think are not accurate. With that, your 10 minutes has expired. You are free to go forward. But I respectfully request that you conclude before 12:15 so that we can move on to Senator Brock.

Senator GRAVEL. I would like to defer to Senator Brock to ask the questions that he might have. I would like to come back to the nuclear questions because, with all deference to the joint committee and I know of your long-term services on it, I have had legislation before that committee since 1971 and I haven't had a hearing.

I happen to be on the Public Works Committee. Since I am here, I will pursue some of the questions I would have raised if I had been allowed a hearing since 1971 on what I think is very important legislation.

Senator BAKER. Very good.

Senator GRAVEL. I will be happy to defer to my colleague here.

Senator BAKER. Senator Brock.

Senator BROCK. May I express my appreciation to both Senator Gravel and Senators Baker and Randolph for letting me participate in the hearings. I know it is a little bit unusual. I thank you for your gracious attitude.

Mr. Chairman, may I say before asking any qestions that I personally would like to compliment your manager. He has been here day in and day out. He continued in answering his questions to exhibit a most accommodating and forthright and gracious response.

I appreciate the attitude of the manager of the facility, Mr. Seeber.

Mr. WAGNER. Thank you, Senator.

Senator BROCK. I would like to go back a little bit. I am interested in the nuclear, too. I think I have some answers. But I won't get into that debate at the moment. There is some more pressing matters before the committee.

Let's talk about the FTC's report. I have before me a study by the staff of the Federal Trade Commission called Concentration Levels in the Energy Sector of the U.S. Economy.

One of the decisions they had to make when they were studying concentration was whether or not to include what they called captive mine

production. They concluded that captive mines did have a competitive effect; and a negative one on occasion.

The question I have is whether or not this in fact would constitute in addition to the captive mine segment of the market the purchase of Peabody or the purchase of a certain portion of reserves.

I raise that question for a couple of reasons. One is that it bothers me that Peabody itself is a major factor in the marketplace to the extent that you buy even a portion thereof that will no longer be a part of the marketplace.

Peabody, as a major producer of coal, is a major competitive factor. The chairman of the committee, Mr. Randolph, mentioned the ownership of Island Creek by Occidental, the ownership of Consolidated by Continental.

It seems to me that TVA in its purchases, because it is so large, does have the effect of holding down the price of coal and if TVA were to own 100 percent of its needs and production, consumption, rather, that that competitive factor would be removed from the marketplace and the objectives of the FTC would be thwarted specifically by the purchase.

Would it not be in TVA's interest if it bought any new reserves to buy a considerably less amount than that which is required to supply 100 percent of its needs so that it remain a market factor in holding down the price of coal?

Mr. WAGNER. We are talking futures now, Senator. But it would be my idea that even if we owned enough reserves to exploit them quickly and met our total needs we would probably continue to buy in the marketplace as long as we got decent prices.

We have no intention of just putting people out of the business for the sake of doing so. But we have seen in past months the price of coal go to double and then quadruple. We felt we simply had to do something in the interest of our consumers.

I think as to whether these mines should become captive mines, it is a matter of semantics, perhaps.

But it is true that they would be dedicated to us, if we opened them.

At the same time it would not have an adverse effect on the consumer's point of view on the market, because I presume we would publish our costs on mining coal just as we do on costs of producing electricity.

They would be there for people to see and know whether the other utilities are being price gouged on coal.

Senator BROCK. You buy today on long-term contracts. You have three or four contracts with Peabody itself which run into a couple or 3 million tons a year. More than that?

Mr. WAGNER. Yes, sir.

Senator BROCK. If you were producing say 30 million tons a year on your own facility, I am a little concerned as to whether or not there would be a motivation to hold down the costs quite so much there.

Let's say that you in your present contracts have an escalator clause with the producer, relate to his costs and perhaps marketing factors other than his cost, I don't know. But I do know you have escalator clauses which allow for an upward adjustment in the prices.

If you were contracted out to someone else to operate the mines for you and he doesn't own the coal, but he has a good, clear, long-term

contract, it seems to me like you are on sort of the same sort of a bid that a Defense contractor gets into once in a while, a cost-plus bid where his motivation is not to hold down cost, but to increase it because he gets a percentage of the total.

Mr. WAGNER. If we were going to contract mining this coal by others, I think we would devise measures to be sure he had an incentive to hold costs down and we would get it at reasonable costs.

Senator BROCK. I think Senator Domenici asked you, and maybe I can ask you in a different fashion, what do you think is essential to TVA's protection in this? How much additional reserves would be appropriate? Is it 1 billion tons, 2 billion tons, 3 billion tons?

Mr. WAGNER. I think we would rather take the more complete look at where the reserves are and which ones might be suitable for our use, Senator. I don't have a figure in mind now. It is dependent on what we would work out. We want no more than we would need for our own purposes and I think we have to recognize in that connection that in the future we may perfect MHD or some other method of burning coal cleanly. We would want to be sure we didn't cut ourselves too short.

Senator BROCK. Let me go to a question that I am sure Mr. Seeber has related to you. I asked him last week if you would be willing to consider making an offer or deciding what properties are essential to your own future that are contiguous for nearby and making an offer to Kennecott if the FTC would allow it.

In other words, making an offer to buy just the reserves or the properties rather than making the offer to buy the whole property. You have to go through the process of forming a conglomerate, partnership, or buying it outright and reselling it.

Would it not be in your interest to make a tentative offer just for those properties you need, assuming FTC would allow it:

Mr. WAGNER. We have an offer that has already been made. It is before Kennecott. They have laid it before FTC. Let me say that if, as the negotiations proceed, we can find the way to give us only the reserves we need, I would favor it.

Senator BROCK. Have you explored since last week, or is there any interest in exploring with FC the possibility of doing this?

Mr. WAGNER. We have not explored it with them.

Mr. SEEBER. I just wanted to mention, you will recall that I said we would look into that. We have been somewhat occupied with the hearing and simply have not had an opportunity to do so yet.

Senator BROCK. I understand that, Mr. Seeber. I just wanted a similar statement from the Chairman of the Board that he would not find that process objectionable, at least as an alternative.

Mr. WAGNER. No, sir. Anything that will give us the reserves we need at minimum cost, I am for it.

Senator BROCK. Let me go very quickly to the scrubber question. What is the total investment you have in your 12 coal-fired plants today? Do you have any idea, approximately within $100 million or so?

Mr. WAGNER. We can get it.

Senator BROCK. While you are trying to get it, let me ask you a different question. What is the estimated cost of installing scrubbers as EPA would have you install across the board? What is your estimated total cost of that?

Mr. WAGNER. The proposal EPA has worked out involving minimum standards which might be acceptable to them for sulfur dioxide control would include scrubbers at three plants, plus coal washing and other measures.

The capital cost of that EPA proposal is $340 million. The annual cost is estimated at $150 to $200 million a year, depending on whether you take their estimate or ours.

Senator BROCK. Let's take yours: $340 million and that is now reduced from what was originally a much higher estimate.

Mr. WAGNER. Originally, we produced a figure of about $1 billion for scrubbers at all plants. But EPA concluded that we would not have to put scrubbers at all plants, but at three of them.

Senator BROCK. $340 million at 8 percent interest would run about $27 million a year. So you are talking at a minimum of about $200 million and you would say about $225 million in operation costs. Is that right?

Mr. WAGNER That $150 to $200 million would include the interest, I believe, Senator.

Senator BROCK. Let's just take the $200 million, then. That is about 25 percent of your current revenues, isn't it?

Mr. WAGNER. About 20 percent.

Senator BROCK. So, the people of Tennessee would be required to pay a 20-percent increase in their electric bill with no increase in power?

Mr. WAGNER. That is correct. In fact, with a decrease in power because it takes power to run these scrubbers.

Senator BROCK. Tell me alternative costs on the technology you are trying to develop on your own.

Mr. WAGNER. We had developed a system of our own which we would describe as the SDEL system.

The capital cost of the SDEL program is $70 million as against $340 million.

Senator BROCK. What is the operating cost?

Mr. WAGNER. This table says $14 million, Senator. I had in mind the figure of $17 million. I don't know whether it has been revised since I looked at it or what.

Senator BROCK. Let's say it is 10 percent of operating costs of what you would have to pay. What is the difference between ground level emission?

Mr. WAGNER. The ground level concentration would be the same in either case.

Senator BROCK. The same under your approach as it is under EPA?

Mr. WAGNER. Yes.

Senator BROCK. Ambient air standards?

Mr. WAGNER. Ambient air standards would be met and with our system they would be continuously met. With scrubbers, if the scrubber doesn't work, you shut it off and bypass it until you get it fixed. That would give you problems.

Senator BROCK. One last question, and again I thank my colleague from Alaska for his allowing me to participate.

I have just read a study from two individuals who did an economic analysis of this explosion in nuclear costs.

The Senator from Alaska referred to the Hartsville cost. I think it is a little bit erroneous to call it an overrun, Mr. Chairman.

Mr. WAGNER. I agree with you. I am glad you said that. It is not an overrun. It is a reestimate based on inflation rates.

Senator BROCK. The economist found that the greatest single increase in cost was not inflation, but rather it was the delay in application of the licensing—what that did to you in terms of taking longer to build it—new standards that might be applied and the attendant costs and the regular increase in the construction costs. But the point they raised is that we are now approaching the point where the two curves are now between coal and nuclear again. The lower cost of nuclear fuel is a major factor, but the capital costs have gone up so fast on nuclear that it is raising the end product, kilowatt-hour cost, to where they are beginning to come back together again.

I don't know what your Btu costs are on coal, but if coal were to hold at $20-plus a ton, and if you are required by EPA, whether it is right or wrong, I happen to think they are in error on this matter, but if you are required to install limestone scrubbers, which markedly increase your capital investments, where is this curve now? Where do you see it from now to 1980?

I think Mr. Jenkins' point is valid. All I can think of when you talk about $10 billion in new borrowing authority, Mr. Chairman, that is $800 million a year interest payments not counting principal in today's market. That is the total revenue of the system.

Mr. WAGNER. Of course, the revenue of the system would be quite different in the future. If these costs go up, as they are indicated, the value of the power that is produced would be greater. My own personal feeling is that we could not survive a 10-percent annual inflation rate for very many years.

Senator BROCK. I couldn't agree more with that. I want to be very sure that the board is looking at not just what we think is the case now, but the pattern of change in the nuclear construction costs. I have reference not just to Hartsville, but to the facility, the AEC or now ERDA, was developing with TVA to build a breeder facility. That will be, by the way, to address some of your nuclear, uranium supply problems, I hope. That is why I think it is essential to continue.

But that has had a cost explosion, not overrun, because it is R. & D. It has an explosion in costs that ultimately have to be transferred to the consumer of power in the value.

I hope that you are considering maybe not just nuclear but maybe some more coal plants.

Senator BAKER. Let me interrupt just for a moment, if I may. Senator Brock's time has expired. I would like to reserve the balance of that line of questioning for a little later.

I would like to return now to Senator Gravel.

Senator GRAVEL. I wouldn't mind if they responded to the last question Senator Brock had.

Mr. WAGNER. Every time we have to add new capacity to the system we take a look at all of the forms of energy that are available to us. This means you have got to predict 10 years into the future.

But we are not committed to just add nuclear plants from now on or not to add nuclear plants. Each time we need to add an increment of

capacity, we examine the alternatives available and select the one that is environmentally satisfactory, acceptable, and that gives us the lowest cost when added to the power system.

Senator GRAVEL. At this point, what plants do you have under construction other than the nuclear plants?

Mr. WAGNER. We have one pump storage plant, a hydroelectric plant with about 1.5 million kilowatts.

Senator GRAVEL. Other than that?

Mr. WAGNER. That is all. Well, there is a dam that is being built on the Little Tennessee River, the Tellico project that will provide some additional energy for us. We do from time to time add oil-fired gas turbines to handle the peaking.

Senator GRAVEL. But essentially the lion's share of your power budget is nuclear right now?

Mr. WAGNER. That is correct, because each time we made an addition the nuclear power figures would be the cheapest for us and environmentally the best.

Senator GRAVEL. What about conservation with respect to an alternative? What kind of effort is TVA making with respect to end-use conservation?

Mr. WAGNER. We are making a very considerable effort in that direction. We have been for some time. We have worked through our distributors with consumers in the valley, to help them find ways to use less energy.

We have proposed through the use of ordinances and building code revisions to require better insulation. We recognize conservation is very important. We must not waste energy. At the same time, as I believe I indicated earlier, we feel that conservation will help, but it can't do the job alone.

Senator GRAVEL. What percentage of your budget do you spend on advertising or public relations?

Mr. WAGNER. We don't spend any money on advertising.

Senator GRAVEL. Public relations?

Mr. WAGNER. We will supply it for the record, Senator. The figure is perhaps a little confused because in our Public Information Office, in that budget, we also include figures for operating the technical library, and a number of other items like that. It just happened to be budgeted in that category.

Senator GRAVEL. It would be valuable to have for the record.

[The information requested follows:]

TVA has no public relations budget per se, but expenditures of this nature would be made principally through our Information Office, which has the responsibility for technical library and information services. The overall Information Office function includes the providing of library services at Chattanooga and Knoxville, Tennessee; the supervision of library services at the TVA National Fertilizer Development Center at Muscle Shoals, Alabama; the arranging of orientation programs and training schedules for official visitors; and the supplying of information about TVA and its activities to requests received from outside TVA. The budget for fiscal year 1975 includes $1,250,000 for this purpose. Of that total, approximately $594,000 would be spent on programs to keep the public, members of Congress, and other audiences informed of TVA activities.

It is difficult to arrive at precise amounts TVA spends on energy conservation since our activities in this area take place throughout the organization. A conservative estimate based only on those activities clearly related to energy conservation suggests that in fiscal year 1975 TVA will spend approximately $1,546,000

on energy conservation. This includes the development and circulation of materials promoting energy conservation and the involvement of TVA personnel in active promotion of conservation through contacts with local power distributor groups, speeches to civic clubs, home demonstration clubs, and similar activities.

In addition to energy conservation activities by TVA, attention should be directed to those related efforts conducted by the 160 distributors of TVA power. Activities similar to those described for TVA are conducted throughout the TVA power service area by TVA distributors, generally under the guidance and direction of TVA employees assigned primary responsibility for energy conservation. We estimate that in fiscal year 1975 the distributors will expend in excess of $8,500,000 in this effort.

Senator GRAVEL. What amount of money do you spend on end-use conservation? What amount of money on your whole conservation program? I am trying to make a comparison from the policy point of view of how much is spent on public relations and how much is spent on conservation?

Mr. WAGNER. A rough figure is $500,000 a year.

Senator GRAVEL. On end conservation?

Mr. WAGNER. End use conservation.

Senator GRAVEL. Do you think your PR budget is at least $500,000?

Mr. WAGNER. It is perhaps in that neighborhood. Of course, let me say again that part of what the PR budget is used to promote energy conservation.

Senator GRAVEL. Do you still sell electric power on an escalating basis, in a reverse situation, the more power you use, the less you pay?

Mr. WAGNER. The rates that we have in effect now are based on the assumption that each user of electricity should pay for each kilowatt hour of electricity that he uses at about the cost of providing it. That results in a lower cost per kilowatt hour for larger users than it does for small users.

Senator GRAVEL. How do you make that distinction? If I own a house and I use electricity, why is it that a unit of electricity costs me more than it does a plant that consumes a great deal of power?

Mr. WAGNER. The cost of providing the service to them is reflected in the rate they pay. It cost less to provide them with electricity than residential because more of it goes to the same facilities. It is a complex situation, Senator, but as far as our board is concerned, we asked the staff to devise rate structures that would recover our costs.

One change that has taken place in recent years is that the increases that we have had to put in are largely energy increases. As a consequence—they have been passed uniformly. Regardless of how many kilowatt hours a person uses, the energy increment is the same.

So if you are speaking about residential users, the small users have had an increase of maybe 45 percent, the figure I saw recently, while the larger users have had an increase of over 100 percent.

Senator GRAVEL. From a philosophical point of view, doesn't it strike you that you are violating your effort at conservation, when you say the more you use, whether it is residential or commercial, the less you pay? If you really wanted to conserve, wouldn't it be more worthwhile to flatten the rate out?

Mr. WAGNER. It has been flattened to an extent. I think the way you put it is not quite right. The more you use, the more you pay. You pay less per kilowatt hour. As the price of electricity goes up, this in itself is a deterrent to use anyway.

Senator GRAVEL. I am confused. The more you use you pay less per unit of kilowatt?

Mr. WAGNER. That is right.

Senator GRAVEL. So you are buying power cheaper?

Mr. WAGNER. But your electric bill is much larger and you pay it not in cents per kilowatt hour, but you pay in total dollars.

Senator GRAVEL. From a conservation point of view, the practical effect is the more you use, the less it costs you. True, you have to pay more because you are buying more, but you are getting it at a better price the more you use.

Mr. WAGNER. That is correct.

Senator GRAVEL. If you want to bring about conservation, maybe it would help to have a uniform pricing system that said, regardless of what you use, it is going to cost you x amount per unit. That way, if you want to use a lot you pay a lot.

Mr. WAGNER. Let me take a look at that with you for a minute. The largest users, residential users of electricity in the Tennessee Valley are those who have electric heat in their homes. We are promoting the use of heat pumps as a conservation measure.

If a man has an electrically heated home, you tell him he will have to pay a premium for this, you are either telling him he has to live in a home colder than 65 or 68 degrees, or you are telling him to get gas, oil or coal to heat with. What we are trying to do is avoid waste of electricity, but conserve the dwindling supplies we have of oil and gas. Coal for heating individual homes is no good from the environmental standpont. It is too dirty.

It puts the smoke and gases right down where the people live. I don't think by penalizing a person for having electric heat helps you help anything. We believe everybody ought to pay his fair share of the costs of serving him.

Suppose in the Tennessee Valley we should tell industry because you are using a lot of electricity we are going to charge you more for it. The first thing you would do is drive the industries to other areas where this was not done.

Suppose you do it as a national policy. What we would do is drive the energy using industries out of this country. This from my standpoint is not good, because it deprives people of jobs.

It seems to me that something as vital to our well-being as energy is ought to be priced as near as you can accomplish it at the cost of producing it, plus a reasonable profit. I think it is like water. It is like food. It is like the air we breathe.

The country cannot live without energy. In fact, it could not live without electric energy.

Senator GRAVEL. I am very mindful of that. I just commend for your consideration the thought that if you price electricity on a uniform basis, it won't be discriminatory. It might act as a greater discipline.

Mr. WAGNER. I should say we are looking at the environmental effects of our electric rate structure at the present time. The Board has not had a look at this. But the staff is working on it. We are trying to find out if there are ways we can accomplish better utilization of the energy by the way the rate structure is set.

We haven't completed that study. But we are aware of your problem. We would like to do it. But we want to keep the economy in the country moving at the same time.

Senator GRAVEL. I would like to ask that you provide for the record a written explanation of the reasons for the fires at Browns Ferry, how long you expect the plant to be shut down and what impact this shutdown will have in terms of cost.

Mr. WAGNER. We would be glad to do that.

[The information follows:]

The following preliminary report of a TVA investigating committee provides details on the recent fire at Browns Ferry Nuclear Plant. At this time our estimates are only tentative, but we anticipate having the plant back in service by January 1976. Preliminary cost estimates for repairs are in the order of $3 million.

PRELIMINARY REPORT ON FIRE AT BROWNS FERRY NUCLEAR PLANT

The preliminary investigating committee met at Browns Ferry Nuclear Plant on March 24, 1975, to initiate its investigation of the fire which occurred there on March 22, 1975. Numerous interviews, inspections, and studies have been conducted and are continuing. Following is a preliminary report of the committee's tentative findings:

A. GENERAL DESCRIPTION AND CAUSE OF FIRE

The fire started in a cable penetration through the wall between the units 1 and 2 cable spreading room and the unit 1 reactor building. Construction workers were checking for airleaks in the penetration, which was filled with polyurethane foam, preformed spongy polyurethane material, and RTV compound around the cables. A lighted candle was being used to detect airleakage through the penetration when the spongy polyurethane material ignited and the fire spread through the penetration and into the reactor building cable trays.

B. DESIGN FEATURES OF PENETRATIONS

The control bay which includes the spreading room is designed to maintain a positive air pressure with respect to the reactor building. Cable penetrations in the wall between the spreading room and reactor building are filled with polyurethane foam to provide an airtight seal and are made fire resistant by spraying Flamemastic coating over both outside surfaces of the polyurethane foam seal.

C. CONSTRUCTION ACTIVITIES

On March 22, 1975, TVA Division of Construction personnel in the cable spreading room was engaged in checking for airleaks and sealing airleaks at cable tray and conduit penetrations through the wall between the units 1 and 2 spreading room and unit 1 reactor building. Work was being performed under approved Work Plan No. 2892. Information obtained thus far indicates the following events occurred.

1. Leak detection and sealing operations were being performed by an electrician and an engineering aide at a penetration window where cables from ten trays penetrate the wall.
2. The engineering aide was checking for airleaks in the penetration seal by placing a lighted candle in the vicinity of a suspected airleak and observing the movement or direction of the flame.
3. At one of the penetrations an airleak was detected in the penetration seal.
4. The electrician was unable to reach the airleak and the engineering aide inserted two pieces of preformed spongy polyurethane material (approximately two inches by four inches) in the area of the leak.
5. The engineering aide then placed a lighted candle near the preformed spongy polyurethane material to determine whether the airleak had been sealed.
6. The candle flame ignited the preformed spongy polyurethane.
7. The engineering aide quicky attempted to extinguish the fire by striking at

it with a flashlight, then attempted to smother the fire with rags but was unsuccessful.

8. The differential pressure between the spreading room and the reactor building provided a draft in the area of the fire in the penetration and apparently enhanced the fire which spread into the reactor building where it ignited the cable insulation.

9. With the aid of other workers in the spreading room area, the engineering aide attempted to extinguish the fire by applying the contents of two CO_2 and two dry chemical fire extinguishers but was unsuccessful.

10. Workmen became aware that the fire was now in the cable trays on the opposite side of the wall (in the reactor building) and several left the spreading room and proceeded to that area.

11. Workmen gathered fire extinguishers on their way and proceeded to the reactor building side of the penetration where the fire was observed a distance of approximately 20 feet high from the floor.

12. One of these workmen on his way to the reactor building notified the public safety officer at post 8D (construction portal between units 2 and 3) who notified the shift engineer's office by telephone.

13. Construction workmen arriving at the scene of the fire in the reactor building positioned a ladder in the area of the fire and began discharging fire extinguishers on the blaze.

14. Smoke and fumes made it difficult to stay in the immediate area of the fire. From this point, fire fighting activities were conducted by plant personnel using airbreathing apparatus.

Observations

Thus far, the committee has interviewed most of the construction personnel directly involved in the fire and has surveyed the fire-damaged area and submits the following preliminary observations.

(*a*) Formal procedures were not provided to construction workers for performing the work described by the work plan.

(*b*) Two reported fires occurred elsewhere in cable penetrations on March 20, 1975, under similar circumstances and were successfully extinguished before causing damage.

(*c*) At least some of the construction personnel involved in this task were aware that some of the penetration sealing materials are flammable.

(*d*) A random examination of cable tray penetrations revealed that a number of the penetrations were not coated with Flamemastic.

(*e*) Cables have been added to or removed from penetrations which would have damaged the fire barrier without procedures for assuring its replacement.

(*f*) A random inspection of cable trays in the reactor buildings revealed the presence of flammable debris in the trays adjacent to the penetrations.

(*g*) It has been a "common" practice to use a lighted candle to detect airleaks.

D. OPERATIONS ACTIVITIES RELATED TO THE FIRE

According to information received thus far from operating personnel, the following events were established.

1. The shift engineer's office was notified of the fire at approximately 1235 hours. The fire alarm apparently was sounded immediately.

2. Operating personnel located the fire on the second floor of the reactor building at the spreading room wall and initiated the fire fighting activities.

3. The CO_2 system in the spreading room was activated manually two or three times in the course of the fire.

4. Off-shift plant personnel was notified of the emergency and reported promptly to the plant. The plant superintendent arrived at approximately 1310 hours.

5. Public Safety Headquarters was informed of the fire between 1245 and 1250 hours and proceeded to the plant. A class of 14 off-duty public safety officers were in a fire-training drill and proceeded to the plant.

6. At approximately 1330 hours, lighting in the area of the fire was lost which hampered efforts of personnel fighting the fire. Operations functions requiring manual operation of controls were also made more difficult due to the loss of lighting.

7. Personnel fighting the fire used breathing apparatus to enable them to gain access to the fire. At least one person was apparently partially overcome by smoke inhalation.

8. Lifelines were improvised to enable fire fighters to find their way to and from the fire in the darkness and dense smoke.

9. At times, some of the operating personnel in the unit 1 control room who had to remain there found it necessary to use breathing apparatus because of smoke and fumes in the control room.

10. At least one of the plant fire water pumps remained operative during the fire.

11. The Athens Fire Department was notified at approximately 1310 hours and promptly arrived at the scene.

12. Operations personnel used only chemical extinguishers on the electrical cable fire until approximately 1830 hours. Then the decision was made to use water, and the fire was extinguished at approximately 1930 hours.

Observations

Based on interviews with operations personnel involved in extinguishing the fire, the following preliminary observations are made:

(*a*) Fire extinguishing equipment used in the spreading room and reactor building appears to have performed adequately. In the reactor building, the fire extinguishing equipment readily accessible was capable of controlling the fire. Chemical extinguishing equipment did not extinguish the fire due to the type and location of the fire and accumulation of smoke and fumes. The potential electrical shock hazard and location of the fire contributed to the hesitancy to use water during the early stages of the fire.

(*b*) The types, quantity, and recharging of emergency breathing apparatus appears to have limited the ability of personnel to extinguish the fire experienced.

E. ADMINISTRATIVE CONTROLS

A review of Work Plan No. 2892 and applicable administrative procedures indicates that the work being performed was categorized as non-safety-related. The work plan was requested by Division of Construction project construction personnel and was authorized by the plant modification coordinator. It is noted that drawings showing the installation of the penetration sealant and flame retardant materials were not identified on the work plan. A further review of the administrative aspects of work control will be made.

F. PRELIMINARY DAMAGE ASSESSMENT

Following is a list of the most evident damages resulting from the fire. This preliminary assessment was developed from a visual inspection and from information developed by personnel now evaluating the extent of damages to electrical cables.

1. Inside the spreading room approximately 6 to 10 feet of all cables in the 10 trays penetrating the units 1 and 2 spreading room—reactor building wall were destroyed.

2. On the unit 1 reactor building side of the penetration and parallel to the north wall, all cables in the trays were destroyed over a distance of 35 to 40 feet; all cables in the trays running south for a distance of about 30 feet were destroyed; and contents of four vertical cable trays were destroyed over a distance of 5 to 10 feet.

3. Approximately 110 conduits were destroyed or damaged in the area of the unit 1 reactor building fire.

4. A total of about 1,580 cables were involved in the fire, including power, telephone, signal, coaxial, control, thermocouple, and special control cables.

5. Preliminary information indicates that both division 1 and division 2 circuits were affected by the fire in the unit 1 reactor building.

6. Damages to equipment caused by smoke, soot, etc., are being assessed by plant operations personnel. Specialized assistance for this effort is being requested from other divisions as required.

A detailed evaluation of electrical damages is being prepared by DED with inputs from DEC and DPP and a formal report will be prepared.

G. PERSONNEL INJURIES

As far as can be determined at this time, there were no significant injuries to personnel. At least one employee was partially overcome by smoke inhalation.

H. RADIATION RELEASES

Apparently there were no personnel exposures or radioactive concentrations in the reactor building in excess of established limits as a result of this event.

I. PLANT OPERATIONS AND EQUIPMENT RESPONSE

1. Unit 1

As a result of the fire, conditions occurring on unit 1 placed it in a position making safe operation questionable. It was subsequently placed in a safety shutdown condition by the following operator actions.

The unit 1 reactor was manually scrammed at 1251 hours, and the main turbine was tripped. Equipment malfunctions caused the normal high pressure water input systems and the condenser heat sink to become unavailable. Four main steam line relief valves were opened and the reactor depressurized to a point at which the available condensate booster pumps began to admit water into the vessel. The control rod drive pump continued to function during this time and the observed reactor water level remained above the core at all times. The reactor water level was restored to normal and pressure and level maintained by the relief valve blowdown and control rod drive pump and condensate booster pump input as required. Containment suppression pool cooling was achieved at 2200 hours on March 22, 1975.

Normal reactor shutdown cooling was achieved at 0410 hours on March 23, 1975, and the unit taken to cold shutdown condition.

2. Unit 2

The unit 2 reactor was scrammed at 1300 hours, and the main turbine was tripped. The main steam isolation valves closed and water level makeup to the unit was supplied by the reactor core isolation coolant pump. The reactor pressure was controlled by opening of the main steam relief valves and initiation of the high pressure coolant injection pump in the condensate recycle mode. The unit was held in this mode of operation for approximately one hour and fifteen minutes.

It was determined at this time to bring the unit to the cold shutdown condition and reactor depressurizing began by opening the main steam relief valves, with water inventory continuing to be supplied by the reactor core isolation coolant pump and control rod drive pump input.

Suppression pool cooling was achieved at 1500 hours, and normal reactor shutdown cooling was placed in service at 2240 hours.

The areas covered in this preliminary report will be expanded in the final report as additional information is developed and evaluated. One source of information that will be available is from a fire consultant who is being retained by Division of Engineering Design to advise in the aspect of fire propagation.

Further work by the committee includes, but is not limited to, the following:

Further examination into administrative controls related to this incident to ascertain if adequate procedures, controls, and instructions exist for activities involving the interface between construction and operation for performing construction work on an operating unit at Browns Ferry Nuclear Plant.

Development as accurately as possible of the response and non-response of plant systems during the incident, alternative measures taken, and the status of these systems when the conditions stabilized. The committee intends to do this primarily by examining, in group session, the key operating personnel involved in controlling and shutting down the units during the incident. In this session the committee will use advisors, expert in unit operation, from the Division of Power Production staff but not assigned to Browns Ferry. Unit logs and instrument charts that exist will be used to document the sequence of events.

The committee is requesting the Division of Engineering Design, with assistance from the Division of Power Production, to identify each damaged cable and ascribe its function.

Further examine radiation exposures and release of radioactivity.

Assure a means of preservation of adequate incident documentation.

Senator BAKER. Thank you, Senator Gravel.

Let me inquire at this point of Senator Gravel, Senator Domenici

and the panel about our plans. Originally these hearings had been scheduled for the morning only: This afternoon the full Public Works Committee has a makeup session on the highway bill, as you know, Senator, at 2.

It is 12:35 now. I understand Senator Domenici has a few more questions. I wonder if the panel would be agreeable and Senator Gravel would be agreeable to trying to finish before we adjourn.

Would that be satisfactory?

Senator DOMENICI. That is fine.

Senator BAKER. Would the panel be agreeable to continuing for another 10 or 15 minutes? Then we will avoid an afternoon session.

Senator Domenici?

Senator DOMENICI. Mr. Jenkins, I am delighted that the chairman of the full committee asked you for your views. I had just discovered that you had cast a negative vote and had he not, I would have asked you for your reasons.

Might I pursue with you just a little bit further your reasoning? We have been told over and over again that TVA doesn't want an operating coal company known as Peabody, that your offer was made for the purpose of acquiring future reserves for TVA so that they would be rid of what they had called extreme fluctuations in the price of coal.

Where did the discussions about the TVA conditional bid occur?

Mr. JENKINS. They occurred on the first meeting.

Senator DOMENICI. Was this a closed meeting?

Mr. JENKINS. The first discussion on September 28 or 27 was, yes, Senator. At that time I suppose that was before we had gone to the policy of open board meetings. I suppose at both meetings I spoke of were closed session meetings.

Let me say at the initial meeting, at the October 2 meeting, I remember very vividly that there were discussions about whether TVA would want, of course, to buy the stock or could buy the stock or whether they would own just reserves, coal reserves, the coal in the ground.

There was considerable discussion about TVA's plans to divest itself first of all of the reserves located outside of the country and, second, the Western reserves.

Senator DOMENICI. How about the operating company that operates in the East?

Mr. JENKINS. There was discussion about whether TVA could own the stock and the company or whether immediately upon acquisition the corporation would have to be completely liquidated.

I think in all fairness that the overwhelming consensus even at that meeting was to the effect that TVA was only interested in some portion of the company, certainly not the overseas part and certainly as I recall it, not the Western part of it.

I don't remember how much discussion there was about where these reserves are located.

As I pointed out, we had scant information at that time exactly on where these reserves were located, what States they were located in and how near to our plants they were and what kinds of transportation costs we were going to have to incur in order to get that coal to our plants.

Senator DOMENICI. Mr. Chairman, there is indication now that TVA presently owns approximately 360 million tons of reserves.

Is that a correct statement?

Mr. WAGNER. Yes, sir.

Senator DOMENICI. There is a further indication that at the time you were burdened with these extreme fluctuations in the price of coal you were at the same time causing to be mined from your own reserves 5 to 7 million tons.

Mr. WAGNER. I think less than that then. We were getting between 4 and 5 million tons, as I recall it. We had plans underway or have them underway now, at least, to expand that to perhaps 6 or 7 million tons a year.

Senator DOMENICI. So under your present plans you will be able to realize about 7 million tons out of a 360-million-ton reserve?

Mr. WAGNER. That is correct.

Senator DOMENICI. Are these reserves good reserves?

Mr. WAGNER. Yes, sir.

Senator DOMENICI. Is that a reasonable proportion for TVA to be getting from its own reserves?

Mr. WAGNER. It is as much as we have been able to get out so far. There is one reserve, I believe in southern Illinois, which we have not mined yet. It is a deep mine. We are looking into the possibilities of getting some of that coal out of the ground.

At the present time we are told that as deep as this coal lies it would take us maybe 5 years to get production from it. We have some other coal reserves in east Kentucky. This is the so-called Red Bird properties. We bought just the coal and mineral rights, but we did not buy the surface rights after we had purchased the mineral. So now there is a question of how much coal we can get out of there because it has become a national forest.

Senator DOMENICI. Mr. Chairman, why would we assume that your record of 7 million tons of production versus 360 million tons of reserves would be any better if you only acquired Peabody reserves?

Mr. WAGNER. There is a limit to how fast you can mine a reserve. For instance, we began mining one seam of the reserves that we bought at Camp Breckinridge which is due to provide a substantial amount of our tonnage. There are two seams available.

We are now proposing to open the second seam. But you can't take the reserves that you have and decide you are going to mine them all in 3 years. It is not feasible. We are mining on these about as fast as we can with the exception that we would hope to open up the reserves in southern Illinois. We are still talking to the Forest Service about what we might do in the Red Bird area.

Senator DOMENICI. Is it safe for us to then assume if you do not acquire Peabody reserves you will continue looking for additional reserves and that you are looking for ways to increase your supply percentage from your own reserves?

Mr. WAGNER. Yes, sir.

Senator DOMENICI. That will remain your policy, I assume?

Mr. WAGNER. Yes.

Senator DOMENICI. You answered a question from Senator Brock with reference to mining contractors where he indicated that perhaps

you would be captive to them and you said if you were going to rely upon an operating company under a contract to mine your coal.

You didn't mean if you were, did you? Your manager has told us you do not intend to get into the operating business yourself. You meant to say you would try to control their costs, but you are not going to get in the mining business, are you?

Mr. WAGNER. We have no intention of doing it at the present time. I wouldn't want to try to forecast what a future board might do.

Suppose, for example, among the people who were qualified to mine there should arise an arrangement where they decided they wanted a profit from mining that appeared excessive.

I would think that a future board would want to be free to move in any direction it could to protect its consumers. If this meant mining the coal with their own forces or by other arrangements in contracting to have it mined, I think they ought to be free to do it.

What I am saying is that all that we have had mined so far we have been able to get satisfactory contract arrangements to have it mined.

I assume we could do that in the future. We have no plans to do otherwise. But forever is a long time, Senator.

Senator DOMENICI. So it was in that context that you were using "if you were." Is that correct?

Mr. WAGNER. Yes, sir. That is correct.

Senator DOMENICI. Let me ask you: It appears to me that your entire program with reference to coal burning is calculated to move in the direction of as much low sulfur coal as you can get and moving as slowly in the direction of permanent scrubber cleanup technology. I am not being critical, but it just appears to me that that seems to be the direction you are going. Am I correct or not?

Mr. WAGNER. We would certainly get as much low sulfur coal as we could because that is part of our program. The existing plants we would hope we could operate with this alternate control strategy that we have and the experimental scrubber we are building in one plant.

I think we would have to recognize that if we propose to build additional coal burning plants in the future, we would probably have to put on scrubbers or else have devised some method for controlling sulfur dioxide emissions.

This is something we have to again size up each time we propose a plant. But I think it is not realistic for anyone to assume that you can continue to have one coal burning plant after another without doing something about sulfur dioxide.

This is one of the reasons that we have gone nuclear because we figure we didn't know how to handle sulfur dioxide adequately.

Senator DOMENICI. You had a bad experience with low Btu Montana coal, did you not?

Mr. WAGNER. Yes.

Senator DOMENICI. Could you supply for the record that costs are involved for a higher sulfur, a higher Btu eastern coal as a comparison of, operational comparison, for us, please?

Mr. WAGNER. We may want to supplement it. But briefly, by the time we got it delivered it was about $19 a ton which was in the range of what we were buying coal for then. Because we were burning it in plants that were designed for higher heat content coal, we suffered a 20- to 30-percent reduction in output.

Just as a conservation measure it does not seem to me that it makes sense when we are short of oil to buy coal way out West, spend $15 a ton in transportation costs, or $14, whatever it is, and use up all that diesel fuel oil to haul it to the East where we have coal.

I think we need arrangements where we can burn our eastern coal to meet eastern needs.

Senator DOMENICI. So it is fair to assume that you have no serious motivation in terms of your conditional offer to Peabody to use low sulfur, low Btu Southwestern Plains Coal in the Tennessee Valley?

Mr. WAGNER. No, sir. If for no other reason than I don't think it makes good conservation sense. As I said earlier, we are primarily a conservation agency. I can't see burning up millions of barrels of scarce diesel oil to haul coal to New Castle.

Senator DOMENICI. Thank you.

Senator BAKER. Thank you very much, Senator. I think that brings us close to the ending of this 6 days of hearings. I have just a few questions. Before I ask them, I am going to ask unanimous consent that other questions may be submitted to clarify the points we have covered or other points for inclusions in the record. I take it you have no objection to that.

Very good. On the question of scrubbers or other control technology, is it fair to say that one of the principal problems from a cost standpoint is retrofit?

Would it be considerably cheaper if you were setting out initially to build these control systems in the new plants?

Mr. WAGNER. Yes, sir, it would. This has been one of the complaints that I have personally had about the efforts to control pollution. There is no grandfather clause. There may be situations where you have to go back even though retrofit is expensive.

Going back to old plants that have been operating for years, particularly if they have been operating without any evidence of difficulty, seems to me expensive and unreasonable.

Senator BAKER. On the question of mining your own coal reserves. Either those you have now or those you plan to acquire or would like to acquire from Peabody, just to make sure I fully understand the exchange between you and Senator Domenici, what you are telling us, as I understand it, is that you have no desire to go into the coal mining business. TVA doesn't want to become a coal company. But you don't want to give up that theoretical possibility, in case everybody mining coal suddenly gangs up and said we are not going to mine it, except at an exorbitant profit. Is that what you are saying?

Mr. WAGNER. That is correct.

Senator BAKER. But it is your present intention, and, as far as you can see your future intention, not to go into the coal business?

Mr. WAGNER. Correct.

Senator BAKER. On the question of nuclear reactors, we have had testimony about the so-called cost overrun. Is it fair to say, as I believe you have already said, that that is not really an accurate characterization of it, but rather it is a reappraisal of the cost of a nuclear powerplant because of delays, because of inflation, because of design changes that may be built into the Government's requirements?

Mr. WAGNER. That is correct. It is not an overrun on expenditures. It is a reestimate of the cost in light of what we think is a realistic assessment of the future.

Senator BAKER. But even so, it is the judgment of the majority of the directors of the Tennessee Valley Authority that considering the increased capital costs, considering the operating costs for a kilowatt-hour of electricity to the consumer in the Tennessee Valley and probably to the Nation as a whole, nuclear power is still cheaper and probably will remain cheaper than fossil fuel plants?

Mr. WAGNER. That is correct as far as I am concerned.

Senator BAKER. Do you see any insuperable problems in the construction and operation of nuclear facilities?

Mr. WAGNER. No insuperable problems. I think there is a problem of persuading the public that these plants are safe, and also helping the public to arrive at an understanding of what their alternatives are. We are either going to use more coal and nuclear power in the years immediately ahead of us and for the next several decades, or we are going to run out of energy.

Senator BAKER. I am not trying to be a salesman of nuclear power, although I am an advocate of nuclear power and make no bones about it.

Is it also fair to say that nuclear power makes the best mix in terms of environmental improvement, in the terms of air, water, in terms of fuel costs, in terms of minimum damage for the recovery of fuels to drive our energy machines as far as we can see into the future?

Mr. WAGNER. That is correct. With that final qualification, it is correct.

Senator BAKER. Is that essentially why TVA has chosen to go all nuclear in the years ahead?

Mr. WAGNER. Yes, sir. That is why we decided to build the nuclear plants now under construction.

Mr. JENKINS. Mr. Chairman, let me add to the chairman's answer. They have also come to the conclusion that the time of operation—in other words, the nuclear plants, the percentage of time of operation will be much more than it is with coal-fired plants. In other words, coal-fired plants go down because of boiler tube failings, and so forth.

Nuclear plants operate at a greater percentage of time than coal-fired plants, which adds to its efficiency.

Senator BAKER. Which is an important point.

Mr. Jenkins, just to set your testimony in perspective for the rest of the record, I have a question or two.

I was pleased to recommend Mr. Jenkins' appointment to President Nixon with Senator Brock, and others. I am delighted he is there. I don't mean to unnecessarily paraphrase your position. If I am wrong, I want you to correct me. I understand your position with respect to the proposed Peabody acquisition to be this: The letter offering to buy Peabody, addressed to Kennecott, in response to the invitation to bid, in your judgment, constituted a commitment under circum-

stances that were beyond what you thought proper prior to review of this project by the Congress and full authorization.

Mr. JENKINS. In my opinion, in the event that they supplied us with factual information which we could have the opportunity to check out and if it was properly verified and as they represented it to be, then it did amount to at least—well, an offer; that was capable of acceptance.

Senator BAKER. We are both lawyers. Let me resist the temptation to shovel a little smoke and get down to fundamental concern here; that is, whether or not you are opposed to the purchase of Peabody in principle, or just on the basis of those informational requirements?

If you were satisfied with the form of a letter and if you were satisfied that all the other switches were set, including bond authority to buy, would you agree with the position expressed by Chairman Wagner and Mr. McBride?

What would you say if all switches were set and you had a chance and you could go forward?

Mr. JENKINS. I pointed out some of the factors that were taken into consideration in my decision. Since that time, I have more information than I had at the time the offer was made. One consideration was the amount of the offer that we made.

Since that time, it is my understanding that there are other purchasers who have at least approached the same amount of money as an offer. So that is not as great a concern as it was at that time. I was very much concerned that the offer that we made was so much higher than what was reported to me that they had paid for the company in about 1967 or 1968 and it was so much higher than the unaudited assets as reported to us, that we were making what constituted and amounted to an offer that would allow a windfall situation.

Senator BAKER. Your East Tennesseean instinct said they offered to pay too much for it.

Mr. JENKINS. That is right.

Senator BAKER. Do you still think that or not?

Mr. JENKINS. That is not as great a concern as it was on October 2.

Senator BAKER. On the theory that something is worth whatever other folks will pay for it?

Mr. JENKINS. Yes, sir.

Senator BAKER. I understand that all of you reserve final judgment on the question of total price in this, on the arrangements that may be made for the acquisition of reserves, the spinoff of the assets you choose not to keep, what you get for them and what that leaves you. The transaction also depends on dealing with the Congress satisfactorily in terms of the bonding authority to buy.

But I think I understand your position and the Board's position, and I am going to state it one more time; that is, assuming everybody agrees that you have arrived at the right amount of money, assuming that you have agreed on what you are going to do with those assets you don't want; assuming you have gotten rid of the complications such as a coal mine in Australia, assuming you have done all of those things and you have the full authority, do any one of the three of you express to me now, or for this

record, a reservation on a philosophical basis as to the purchase of these reserves in this manner by TVA?

Bill, this is primarily directed to you, but if somebody does, now is the time to say so.

Mr. JENKINS. You have placed many assumptions before us. I believe if all of those assumptions were met, and, as I said, if we were able to purchase some of those reserves—we own reserves at the present time—then I would vote to purchase reserves if I felt it was a good deal for the rate payers in the Tennessee Valley.

Senator BAKER. That, after all, is one of the primary considerations: What is good for the people you serve?

Mr. JENKINS. That is the primary consideration in this instance.

Senator BAKER. I am not trying to corner any of you. I fully understand that any of the three of you, or Mr. McBride's successor might come along later and find a defect in it. But I want to identify the current status of the concern and to relate to it to the questions before the Congress.

On the nuclear question, gentlemen——

Senator DOMENICI. Would the chairman yield before he goes to nuclear?

Senator BAKER. I would be happy to.

Senator DOMENICI. Mr. Jenkins, assume all the assumptions made by Senator Baker in terms of conditions, assume Tennessee Valley has to buy it and take the responsibility of seeing all those conditions are met; would your answer be different?

Mr. JENKINS. I would be very hesitant. There is one point that I failed to cover that I didn't point out that I think is important in that connection, Senator. That is, there were some discussions about the people who operate the Peabody Coal Co., the management of Peabody Coal Co.

I don't know how accurate the salary ranges that were reported to us were, but there were salary ranges that were exceeded many times the top salary that we could pay as a governmental agency to the president or the general manager of that company.

There is a serious question in my mind as to whether or not we could recruit people to perform the day-to-day operations of that coal company when in a competitive market they could go with a coal company for a much greater salary.

There were salaries, as I recall, that were perhaps five times greater than we could pay under the governmental salary range that were paid to people who are in the active participation of operating that company.

Senator DOMENICI. Let me put it another way. Assume the only way TVA could buy Peabody Coal Co., is to buy the whole package lock, stock, and barrel. You get that precondition before you even have a right price. But if you were left with untangling all the other arrangements that have been discussed, so as to keep the reserves for yourself, would your answer be yes or no as to whether you would be for that?

Mr. JENKINS. Lock, stock, and barrel and operating as an operating company?

Senator DOMENICI. You had to buy it that way and your staff had approaches to divesting that were not yet contracted for. You were told, however, that is what TVA is going to do over the long haul, would you be for buying it lock, stock, and barrel?

Mr. JENKINS. As I understand your question, sir, the only element that you have changed is whether or not I considered the price to be fair. If that were the only consideration at this point, I would say vote exactly as I did because I think it is important that these details be known, that we do know exactly what we are going to do, that we know if a foreign government is going to allow a purchaser other than a native of that country to be the purchaser of these interests in that country.

It is my understanding that in one instance there is a partnership in which a third country is involved and that they are the prevailing interest in the coal reserves. This is one of the better parts of the company.

As far as divestiture is concerned, there have to be practical problems about whether or not we can work out something to sell and then the host government has to be cooperative.

Senator DOMENICI. You have answered my question. Thank you, Mr. Chairman.

Mr. WAGNER. Mr. Chairman, may I comment on that just briefly? I think none of us knows what kind of a proposition will come back to us. I always am hesitant to answer iffy questions or comment on iffy questions.

I think all of us want to see what comes in. This was a conditional offer to begin with, conditional not only on our having the bonding authority we needed to make the purchase, but on many other things.

Senator DOMENICI. That is why Mr. Jenkins referred to you as Solomon and then in Senator Baker's hypothetical, he didn't play Solomon himself.

Senator BAKER. I don't think we ought to be quite that biblical. If we were going to be, I would say we are all striving over Bill Jenkins' soul over here. There is always one nice thing about being on the Board of Directors. It is sort of like being in Congress. We can speculate all day long. But if we live long enough we will find out how he is going to vote.

I am trying to identify for this record elements that are involved and anticipate in advance how the Board will react under certain circumstances.

I have not concluded that TVA ought to buy Peabody. But I haven't ruled out that possibility. You are the experts.

Mr. JENKINS. I think it is a very legitimate question. I don't want to evade the issue. If we could draw it into something like—we know where we buy coal and where we can transport it economically, in the States of Kentucky, Tennessee, Virginia, Illinois, and Alabama.

If we come down to the proposition of purchasing reserves in those States and we can purchase them at a fair price and we can work out some arrangements for somebody to mine them, and get them to our plants with a good transportation factor involved, then I would say it comes back to what is good for the ratepayers.

Senator BAKER. That gets back to the nuclear question, too. You get to the whole question of how much it costs and whether you have the money to pay for it.

Mr. JENKINS. That is correct.

There was one factor in connection with the nuclear plants or the expansion of capacity that needs to be looked at. In 1959, when the Senate, when the Congress of the United States passed the Self-Financing Act, in that year I am told—I have asked and been told for the purpose of making speeches—that TVA's interest payments were zero in 1959. Gross receipts from the sale of electricity were about $237 million.

For fiscal year 1975 ending June 30, our interest payments are about $289 million; gross receipts, $1.2 billion; approximately 25 percent of the gross receipts.

If you project our indebtedness and you project as has been pointed out, the doubling of our capability with the seven nuclear plants—of course it is unrealistic to only double because we know there will be other price increases coming along. But you would have a $2.4 billion gross receipts and your interest even on the 11.5—I think $15 billion indebtedness when all seven plants are completed is more realistic—would be in the neighborhood of $1.5 billion.

That relationship, the relationship of interest to gross receipts needs to be, in my opinion, looked at very closely.

Senator BAKER. I think it does, too. I have no quarrel with your point of view. You are in effect the voice of the consumer. You are saying if this costs me too much, we can't afford it, it doesn't make any difference how good it is. We can go broke on good business. But that is a question we will always have before us.

I think just one brief observation might be appropriate to these remarks. My father was involved with many others in the writing of the 1959 Self-Financing Act, along with Senator Sparkman in the Senate and a number of others.

I have an idea that they, the authors of the bill and those who supported it in 1959, understood, as I believe it now, that the fundamental nature, the basic design of the Tennessee Valley Authority changed at that point. At least the power system did, because we stopped being an agency of the Government where all of its money came from the Treasury of appropriated funds, almost all of it for capital expansions, and we shifted the whole burden to the ratepayers, to the people of the Tennessee Valley.

We are having to pay now not only the cost of the capital improvement, but the interest on the money. There is nothing wrong with that. But it is different. It is different than TVA used to be in 1959. It will be different in the future as capital costs are greater and interest costs are higher.

So we ought to relate some of the problems that we have now and some of the differences we have now to that fundamental change that occurred when we shifted the burden of capital improvements away from the Federal Treasury, directly to the ratepayer in the Tennessee Valley area.

That is one reason I have tried, so far unsucessfully, to get the Congress and the President to agree that with environmental controls

that we ought to get some credit for it. One hundred percent gets charged to the ratepayer. I have a hard time of convincing people of that.

Gentlemen, this has been a long and helpful series of hearings. It is now 5 after 1. I understand Chairman Wagner has a closing statement to make. We would be glad to hear it.

Mr. WAGNER. I will be very brief.

Before I leave the witness stand I should like to take a brief moment to acknowledge and recognize the continuing dedication of the entire TVA staff, from the general manager and department heads who you met in these hearings, on to the thousands you have not met, but who are at their posts each day doing their level best to serve the people of our region and of the entire Nation, and their level best is considerable.

It has been my privilege through the years to work with representatives of many other large organizations, both public and private, and I can say without reservation that nowhere have I found an abler, harder working group, more devoted to the task at hand or with a greater passion for finding and accomplishing right solutions rather than the popular one.

It is not easy, as they often must, to stand against expediency and the immediate pressures of both sides in conflict as we seek the answers that will serve the greatest good for the greatest number over the longest time.

But this is what our people have come to understand the TVA requires of them. In the long run, it brings solid accomplishment and a rewarding sense of fulfillment.

The act of Congress creating TVA is a masterpiece in providing the outlines and framework within which men and women can give their best to help solve the problems of resource use for better living, problems that press upon us increasingly each day.

I know the entire TVA organization would want me on this occasion to express to you and your committee, to the Congress and the President, our appreciation for the opportunity that you have given us to serve. They would want me to pledge our continuing best to carry out the task given to us as efficiently and effectively as God gives us the wisdom and the strength to do.

Thank you, Mr. Chairman.

Senator BAKER. Thank you, Mr. Chairman.

Gentlemen, the record will be open for further questions and for your replies. We thank you very much for your diligent attention.

The hearings are adjourned.

[Whereupon, at 1:07 p.m., the committee recessed, to reconvene subject to the call of the Chair.]

APPENDIX A

RESPONSES TO ADDITIONAL QUESTIONS

54-380 O - 75 - pt. 2 - 19

Question 1. Has TVA experienced any increase in availability of low-sulfur eastern coal in its coal purchase efforts? Does TVA have any program or purchasing policy to encourage development of eastern low-sulfur coal reserves? If so, elaborate.

Answer. TVA has been actively seeking low-sulfur coal for the past several years. Although we have recently received some short-term offers for low-sulfur coal, the quantity offered would not be considered a significant increase. TVA recognizes that low-sulfur coal commands a higher price and is now evaluating such coal separately from higher-sulfur coal on our weekly spot purchase program. In addition, we recently issued invitations to bid on long-term coal supply contracts. The invitation provides for a separate evaluation of low-sulfur coal, consequently the higher priced low-sulfur coal will not have to compete directly with higher sulfur coal. If successful, this invitation should encourage producers to further develop eastern low-sulfur coal reserves.

Question 2A (supplemental questions). Has TVA participated in research and development efforts relative to fluidized-bed combustion, coal liquefaction, and coal gasification?

Answer. TVA has participated in all these areas at varying levels of effort through in-house explorations and national programs beginning on some as early as the mid-1960's. Its participation has included serving on advisory and planning committees formulating Federal and utility programs in these technologies.

TVA, in cooperation with the Energy Research and Development Administration, is participating in a program to develop the technology of large fixed-bed coal gasification. The program consists of an economic assessment of various commercial applications of the gasifier system and the design, construction, and operation of a test facility incorporating one or more fixed-bed gasifiers and associated desulfurization units.

TVA has completed conceptual design and cost studies for the Electric Power Research Institute on both atmospheric and pressurized low-Btu gasification systems. Final reports have been released on these studies. Since about the mid-1960's, TVA has followed the progress of R&D efforts in fluid-bed combustion (FBC) and since about 1970 has followed these efforts on coal liquefaction. More recently TVA has actively participated in industrial advisory committees seeking to establish national development programs for both ERDA and Electric Power Research Institute (EPRI).

TVA has offered to provide a site and to cooperate with ERDA in other ways in the design, construction, and testing of a 20 to 60-MW pressurized fluid-bed combustion pilot plant for which proposals are now being evaluated by ERDA. TVA is also considering the possibility of offering a site, financial assistance, and active staff participation for an ERDA-sponsored 200-MW atmospheric fluid-bed demonstration plant. TVA's role will be established by ERDA within the next few months.

In addition to the ERDA efforts, EPA is considering the design and construction of a flexible pressurized fluid-bed combustion environmental test facility. TVA would provide a site and would engineer, construct, operate, maintain, develop, and evaluate results of this test facility.

TVA is also studying the feasibility of developing a coal gasification process designed to produce a gas optimized for ammonia production. Such a development would provide a substitute for the natural gas presently used to produce ammonia-based fertilizers.

TVA has no projects in coal liquefaction, but is presently evaluating the merits of participating in several promising areas of liquefaction research.

Question 2B (supplemental questions). What have been the results of these efforts?

Answer. The conceptual design and cost studies on gasification for EPRI are now receiving rather wide circulation and are apparently being accepted as a significant document in the gasification program planning. TVA's internal comparison of these technologies has permitted TVA to participate more effectively in the national programs and has perhaps influenced their direction to some extent. As an example, the national programs on fluid-bed combustion plan's have undoubtedly been stimulated by TVA's evaluations of the advantages of fluid-bed combustion as compared to other technologies which utilize coal.

Question 2C. What are the environmental and energy advantages and disadvantages of these processes?

Answer. A major motivation for the development of coal conversion processes for application to coal-burning utilities is to enable plants to comply with sulfur dioxide (SO_2) emission standards. For utili'ies burning gas or oil, conversion can provide an acceptable alternate fuel for the more limited supplies of oil and gas. Although some conversion processes can meet SO_2 standards, problems may arise through the production of environmentally objectionable byproducts such as nitrogen oxides, phenols, sulfa'e sludge, etc. Discharge of these compounds from the plant must also be controlled to minimize the environmental impact.

From an energy standpoint, coal conversion processes waste much of the heat in the coal. For example, such processes may involve a 15 to 30 percent loss of energy in conversion. A major research goal is to reduce the process heat losses and to enable the use of the product fuel in more efficient combined cycle gas turbine/steam turbine power plants. Such application may offset the process heat losses or perhaps may even provide an overall energy gain over conventional coal-fired power plants.

Question 2D. When will these processes be available for commercial application?

Answer. Some development programs are now entering pilot plant operational phase while others are still in the design or planning stage. Construction and operation of a demonstration plant will be the next likely step with plant design based on the results of the pilot plant test data. This would be followed by the design, construction, and operation of the first commercial scale units.

For coal gasification and fluid-bed systems, the earliest commercial scale operation is expected in the early or mid-1980's, with general availability some five years later.

For coal liquefaction the development to commercial availability appears to be later than other coal conversion processes. We estimate availability of a clean power plant fuel from a commercial coal liquefaction plant to occur no earlier than the mid-1980's but, more likely, by 1990.

Question 3. Does TVA have any present or future plans for construction of major impoundments within the watershed of the Tennessee River?

Answer. TVA has no plans for construction of additional major impoundments and has no planning under way for such projects. Preliminary investigations for various ways of meeting future power needs do include consideration of (1) additional potential pumped-storage hydroelectric sites and (2) thermal power plants which might involve a cooling pond. No decision has been made, however, to pursue detailed planning for a particular project and such potential impoundments would be small as compared with existing major TVA reservoirs.

Question 4. Would TVA furnish the Committee a list of research and impact studies regarding the effects of air emissions from steam electric plants which it has undertaken or participated in?

Answer. A list of some research and impact studies which TVA has undertaken or participated in is attached.

Title: Bench-Scale Studies of Advanced Concepts for SO_2 Removal Process Improvements.

Research institution: Tennessee Valley Authority.

Sponsor: TVA and EPA.

Estimated expenditure: Fiscal year 1974, $100,000; fiscal year 1975, $125,000.

Duration: Ongoing—October 1978.

Project description: To study at the laboratory and bench-scale level absorption and regeneration in scrubber systems. Also laboratory and bench-scale studies of oxidation in both solution and slurry scrubbing systems.

Title: Comparative Economics of Major Processes Being Developed For Removal of SO_2 From Power Plant Stack Gases.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1974, $132,000; fiscal year 1975, $50,000.
Duration: Fiscal year 1976.
Project description: To select processes for evaluation, define study objectives and economic premises, prepare flowsheets, material balances and layouts, estimate equipment costs, capital investments, operating costs and evaluate cost sensitivities.

Title: Intersystem Transfer and Effects of SO_2 and NO_x Emissions on Vegetation (Crops and Forests) and Soils.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $100,000; fiscal year 1976, $275,000.
Duration: Fiscal year 1976.
Project description: The objective is to quantify for coal-fired power plants, (1) the principal mechanism for transfer to the terrestrial environment SO_2 and NO_x, (2) the impacts of total atmospheric loading of pollutants on crops, forests, and soils around a large coal-fired steam plant.

Title: Full-Scale Atmospheric Interaction Studies.
Research institution: Tennessee Valley Authority.
Sponsor: EPA.
Estimated expenditure: Fiscal year 1975, $150,000; fiscal year 1976, $150,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: To provide a detailed understanding of the chemical reactions in coal-fired power plant emissions to allow prediction of the concentrations and fates of all significant pollutant species, for guidance on minimizing the impact of current operations and on control technology requirements.

Title: Effects of Moisture Emissions on Terrestrial Habitats.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $50,000; fiscal year 1976, $60,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: To determine whether moisture emissions from cooling systems cause modifications in terrestrial habitats.

Title: Energy Requirement Optimization Study of Selected Processes for Removing SO_2 From Power Plant Stack Gases (TVA).
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $50,000; fiscal year 1976, $50,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: The results of this study will be to summarize the current energy requirements of selected processes for removal of SO_2 from power plant gases with economic and feasibility analysis of process modification for reducing and optimizing the energy requirements for the processes.

Title: Remote Sensing of SO_2 Effects on Vegetation.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $100,000; fiscal year 1976, $100,000; fiscal year 1977, $100,000; fiscal year 1978, $100,000; fiscal year 1979, $100,000.
Duration: Fiscal year 1975 through fiscal year 1979.
Project description: The refinement of remote sensing techniques for monitoring the effects of SO_2 emissions from fossil-fueled electric generating plants on terrestrial vegetation.

Title: Air Quality Instrument Field Comparisons for Reliability, Accuracy, Precision and Robustness.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $35,000; fiscal year 1976, $35,000; fiscal year 1977, $25,000; fiscal year 1978, $25,000; fiscal year 1979, $25,000.

Duration: Fiscal year 1975 through fiscal year 1979.
Project description: To compare under field conditions the accuracy, precision and robustness and reliability of newly developed and standard automatic instruments for measuring SO_2, H_2SO_4 mist, NO, NO_2, hydrocarbons or particulates in regions affected by coal-fired power plant effluents.

Title: Controlled Fumigation Study of the Effects and Dosage Kinetics of Atmospheric Pollutants from Coal-Fired Steam Plants on Soybeans and Other Crop Species of Economic Importance in the Southeastern United States.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $35,000; fiscal year 1976, $80,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: The objective is to determine the combined effects on vegetation of SO_2, NO_2 and O_3 at concentrations and dosage rates typically occurring during surface fumigations from coal-fired power plants.

Title: Field and Filtered/Unfiltered Greenhouse Studies of Effects of Coal-Fired Steam Plant Effluents on Soybeans, Cotton, Hay, Forage and Other Crop Species of Economic Importance in Southeastern United States.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $140,000; fiscal year 1976, $166,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: The objective is to quantify the impact of atmospheric pollutants (primarily SO_2) on visible appearance, growth and yield of selected crops grown in the vicinity of coal-fired steam plants.

Title: Dual-Response Relationships for Effects of Fossil-Fueled Power Plant Pollutants on Economically, Esthetically, and Ecologically, Important Plant Species, Communities and Ecosystems.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $30,000; fiscal year 1976, $50,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: Existing data on dose-response relationships for effects of power plant pollutants and combinations of other pollutants on important plant species will be analyzed and summarized.

Title: Investigation of a Possible Beneficial Effect of SO_2 on Vegetation. Increased Density of Wood on SO_2 Resistant Pines.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Fiscal year 1975, $50,000; fiscal year 1976, $50,000.
Duration: Fiscal year 1975 through fiscal year 1976.
Project description: The objectives are to determine; (1) whether SO_2 is the cause of increased wood density in SO_2 resistant white pines, (2) whether a similar response occurs in other pine species and (3) the physio-biochemical mechanism of the response.

Title: TVA's Lime/Limestone and Advanced Concept—1–MW Pilot Plant.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA (EPRI possibly in future).
Estimated expenditure: Fiscal year 1974, $315,000; fiscal year 1975, $350,000.
Duration: January 1971—.
Project description: TVA's basic pilot plant which has been used to develop scrubber technology applicable to TVA's program of sulfur removal technology.

Title: Development of Flue Gas Desulfurization Technology Pilot Plant Study of Ammonia Absorption Ammonium Bisulfate Regeneration Process at TVA's 1–MW Pilot Plant.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1974, $530,000; fiscal year 1975, $350,000.
Duration: 1964 to December 1976.
Project description: This project consists of pilot plant testing of ammonia

scrubbing for recovery of sulfur in a useful form from fossil-fuel combustion gases, with special emphasis on the ammonium bisulfate process which yields elemental sulfur.

Title: Development of Flue Gas Desulfurization Technology Shawnee Lime/Limestone Scrubbing Program.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1974, $1,875,000; fiscal year 1975, $2,815,000.
Duration: Ongoing–December 1977.
Project description: To complete lime/limestone advanced concept short-term testing, advanced long-term reliability testing, lime/limestone economic evaluation computer study for base program, sludge disposal/fixation studies, parametric study with base computer programs.

Title: Characterization of Effluents from Coal-Fired Utility Boilers.
Research institution: Tennessee Valley Authority.
Sponsors: TVA and EPA.
Estimated expenditure: Fiscal year 1975, $16,000.
Duration: July 1974 to July 1979.
Project description: To complete characterization and assessment of coal pile drainage, pH adjustment of ash pond effluent, monitoring program for ash pond effluent, assessment of ash pond leachment on ground water and characterization of gaseous emissions from different boilers.

Title: Fly Ash Characterization and Disposal.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1975, $21,000.
Duration: July 1974 to July 1978.
Project description: To characterize coal, ash and ash effluent, to study disposal and utilization of fly ash and to compare dry and wet fly ash handling systems.

Title: Fluidized-Bed Coal Combustion—Environmental Test Facility.
Research institution: Tennessee Valley Authority; Westinghouse.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1975, $50,000.
Duration: July 1974—December 1980.
Project description: To complete conceptual design, preliminary design, detailed design, construction, operation and testing of a fluid-bed combustion and environmental test facility.

Title: Advanced Waste Heat Control.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1975, $490,000.
Duration: July 1974 to July 1978.
Project description: To assess feasibility of application of membrane technology to power plant water effluent; determine mechanism to reduce intake structure effects, and demonstrate wet/dry cooling tower technology and associated engineering and environmental consideration and economics.

Title: Waste Heat Utilization.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1974, $35,000; Fiscal year 1975, $100,000.
Duration: June 1974 to December 1977.
Project description: To complete design and construction of soil heating facility and complete field crop production studies; optimize biological recycling of nutrients in livestock wastes; design and construct a facility to evaluate a controlled environment for combined livestock operations.

Title: Byproduct Marketing.
Research institution: Tennessee Valley Authority.

Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1974, $50,000; fiscal year 1975—?
Duration: Ongoing–October 1979.
Project description: Market evaluation of sulfuric acid and sulfur byproducts produced from existing U.S. plants and ultimate products, such as sulfuric acid, sulfur, ammonium sulfate, sodium sulfate, and wallboard.

Title: Processing Sludges from Lime/Limestone Wet-Scrubbing Processes for Disposal or Recycle.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and EPA.
Estimated expenditure: Fiscal year 1974, $0; fiscal year 1975, $40,000.
Duration: July 1974 to March 1977.
Project description: To study the properties of various sludges and to study processes designed for their disposal and utilization. Also to study the production of fertilizer from scrubber sludges.
Title: Environmental Transport—Pilot and Demonstration-Scale Lime-Limestone Scrubbing and Ammonia Scrubbing Processes.
Research institution: Tennessee Valley Authority.
Sponsor: Tennessee Valley Authority.
Estimated expenditure: Fiscal year 1975, $100,000; fiscal year 1976, $100,000.
Duration: 1975–1976.
Project description: The work will be divided into two phases: (1) preliminary experimentation to develop sampling and measurement methods for studying plumes from ammonia and lime/limestone scrubber pilot plant and (2) screening-type atmospheric interaction studies at the steam plants to ascertain the more important chemical species for future full-scale scrubber plume studies at Widows Creek power plant.

Title: Electric Power System Operation and Expansion Environmental Residue Output Model.
Research institution: Tennessee Valley Authority, Office of Power.
Sponsor: U.S. Environmental Protection Agency.
Estimated expenditure: Fiscal year 1975, $60,000; fiscal year 1976, $66,000.
Duration: 1975–1980.
Project description: The objective will be to demonstrate by modeling how to manage and integrate research information on environmental controls and effects of energy technology systems.

Title: Development of Biological Indices for Evaluating and Predicting Short- and Long-Term Impacts of SO_2 on Crop and Forest Species of the Southeastern United States.
Research institution: Tennessee Valley Authority.
Sponsor: Tennessee Valley Authority.
Estimated expenditure: Fiscal year 1975, $135,000; fiscal year 1976, $100,000.
Duration: Fiscal year 1975 through fiscal year 1980.
Project description: The objective is to quantify the effects of SO_2 exposure levels on growth, yield mortality, quality, seed viability, and type and degree of visible effect on sensitive economically important forest and crop species indigenous to the Tennessee Valley.

Title: ASTM Air Quality Evaluation Methods.
Research institution: Tennessee Valley Authority.
Sponsor: TVA and ASTM.
Estimated expenditure: Unknown (TVA contributed to the overall project in 1972).
Duration: Fiscal year 1972 through fiscal year 1976.
Project description: Validation of 35 ASTM standard methods for sampling and analyzing ambient air and stationary source emissions.

Title: Cooling Tower Plume Behavior.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Unknown.
Duration: Completed.

Project description: A study to obtain data to relate hyperbolic natural-draft cooling tower plume configuration and environmental effects to accompanying meteorological and tower operating conditions.

Title: Development of New Processes for Recovering Sulfur.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Unknown.
Duration: Continuing.
Project description: A long range project with the objective of finding and developing economical processes for recovering useful products from stack gas sulfur dioxide.

Title: Peak to Mean Ratios of SO_2 Concentrations.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Unknown.
Duration: Completed.
Project description: Evaluations of relationships between SO_2 concentrations for various time periods and their dependence upon averaging time and plant stack height.

Title: Cumberland Atmospheric SO_2 Loading.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Unknown.
Duration: 1969——.
Project description: The objective of the study is to identify and characterize the impacts of SO_2 emissions from the Cumberland Steam Plant on the acidity of precipitation, and in turn the effects of acid precipitation on the terrestrial ecosystems.

Title: Two-Phase Flows in Sulfur Dioxide Scrubber.
Research institution: Tennessee Valley Authority.
Sponsor: TVA.
Estimated expenditure: Unknown.
Duration: Continuing.
Project description: Studies to ensure specified performance levels and the two-phone flows in a limestone scrubber.

Question 5. How many of TVA's fossil fuel power plants meet the standards of State implementation Plans for the state in which they are located with regard to particular emissions? . . . with regard to SO_2 emissions? Is TVA taking steps to bring plants which exceed those standards into compliance with state laws?

Answer. Particulates: Of TVA's 63 coal-fired electric generating units located at 12 plants, 36 units are now meeting the particulate emission standard of the state in which they are located. (Nineteen of these 36 units are in the process of being tested to demonstrate compliance.) Installation of additional equipment and design is progressing as rapidly as possible on the remaining 27 units. Eleven of these units will be completed within the next year, but some of the others will not be ready until 1978. Both EPA and the State of Tennessee have recognized the necessity of an extended schedule.

SO_2: Two plants, Bull Run and John Sevier, are meeting the state SO_2 emission standard and efforts are underway to bring a third plant. Watts Bar, into compliance with this standard through the use of low-sulfur coal. In addition, an SO_2 scrubber is being installed on a large 550-MW unit at the Widows Creek Steam Plant. For the other plants, TVA has requested the state air pollution control agencies to allow the use of an alternate control strategy under which the plants would meet variable emission limitations determined by an arrangement approved by the control agencies. Outstanding questions regarding the use of these controls are now being resolved by TVA, EPA, and the states.

Question 6. It has been reported that TVA will not achieve compliance with particulate emission regulations at all TVA plants until 1980—five years after the attainment date specified by the Clean Air Act. Since reliable technology was available at the time of this mandate, how does TVA justify its lack of compliance with this national goal?

Answer. Compliance with the particulate emission standards at 27 generating units will be delayed beyond July 1, 1975. Despite the delays, the national

goal—attainment of the national primary ambient air quality standards for the protection of public health—will be met on time as specified in the Clean Air Act at all but one plant consisting of eight units.

TVA has been installing electrostatic precipitators for the control of particulate emissions from its plants on an almost continuous basis since 1959. In 1966, the specifications to which we were designing this equipment were upgraded to meet the newly issued requirements for Federal facilities. In 1969—fully three years before the states adopted their present standards—TVA made the decision to again upgrade its design specifications so that all new precipitators were designed to remove 99 percent of the fly ash, a goal substantially more difficult to achieve than the standards existing at that time. Because of this voluntary decision, precipitators on 17 units which were begun between 1969 and 1972 now meet the present standards.

At this time precipitators on 19 additional units, begun since 1972 are being tested and are considered to be in compliance with current standards. The delay in the remaining 27 units is brought about by the scarcity of engineers experienced in this highly specialized area, and long delivery lead time and delays in the delivery of steel and other essential equipment.

One of the key factors affecting the schedule is the limited number of engineers who are skilled in this specialized area. This is a problem which affects the entire electric utility industry. We have tried to expedite precipitator work in several ways, including overtime work, efforts to hire additional experienced engineers and to train new engineers, and the use of outside engineering firms in "turnkey" projects wherever possible. These efforts have not been completely successful.

A second factor, frequently not understood by the layman, involves the timing of the construction schedule. Even if all engineering, material, and construction constraints were removed, precipitators would still have to be installed on a staggered schedule taking several years, since installation must be carefully coordinated with demands placed on the power system to generate electricity. These demands often preclude shutting down a unit for precipitator installation, especially during the summer and winter peak seasons. Obviously, this constraint compounds with the others to make the installation schedules extend longer than they otherwise might have. EPA and the State of Tennessee have formally recognized the existence of these scheduling problems.

Question 7. What changes have occurred in the debt to equity ratio of TVA since enactment of the self-financing authority in 1959? What is the projection of this ratio for the next 10 years? What will be the impact of this ratio upon the borrowing costs of TVA?

Answer. The tabulation below shows historical and projected debt to equity ratios for the TVA power system. This ratio is calculated by dividing total debt by the sum of debt and equity.

Fiscal year	Millions of dollars		Ratio (percent)
	Debt	Equity	
1960		1,771.6	0
1961	50.0	1,773.5	3
1962	145.0	1,783.5	7
1963	195.0	1,790.3	10
1964	265.0	1,798.7	13
1965	320.0	1,801.3	15
1966	385.0	1,790.7	17
1967	517.2	1,769.4	23
1968	625.0	1,762.2	26
1969	827.7	1,745.8	32
1970	1,096.0	1,749.2	38
1971	1,455.3	1,785.9	45
1972	1,955.0	1,825.8	52
1973	2,355.0	1,858.5	56
1974	2,795.0	1,881.6	60
1975	3,575.0	1,938.5	65
1976	4,325.0	2,093.7	67
1977	4,896.1	2,335.1	68
1978	5,676.1	2,620.9	68
1979	6,714.1	2,931.7	70
1980	8,004.8	3,244.3	71
1981	9,707.4	3,573.8	73
1982	11,833.6	3,937.1	75
1983	14,123.5	4,335.1	76
1984	16,488.8	4,782.2	77
1985	18,788.6	5,291.0	78

We do not believe the forecasted changes in TVA's debt to equity ratio will have an impact on borrowing costs. Bond rating agencies would normally include this ratio as a key factor in the several variables used to determine what they consider to be an appropriate rating. However, agencies rating TVA bonds have indicated that a principal factor in our AAA rating is the TVA Board's flexibility in setting rates to meet the financial tests imposed by the TVA Act. These tests in effect require the Board to set rates yielding sufficient revenues to cover debt service as well as operating expense, in lieu of tax payments to states and counties, Treasury payments as required by the Act, and sufficient additional net margin for investment in the power system and for other purposes connected with TVA's power business.

Question 8. What has been the ratio of debt to revenues of TVA since enactment of the 1959 Self-Financing Act? What are the projections for this ratio for the next ten years? What are the implications of these projections for TVA's rates and the attractiveness of TVA's bond issues?

Answer. The tabulation below shows historical and projected debt to revenue ratios for the TVA power system.

Fiscal year	Millions of dollars— Debt	Revenue	Ratio
1960		242.4	0
1961	50.0	248.3	.20
1962	145.0	252.1	.58
1963	195.0	268.8	.73
1964	265.0	286.4	.93
1965	320.0	296.0	1.08
1966	385.0	326.8	1.18
1967	517.2	351.1	1.47
1968	625.0	383.7	1.63
1969	827.7	403.3	2.05
1970	1,096.0	479.6	2.29
1971	1,455.3	598.0	2.43
1972	1,955.0	641.8	3.05
1973	2,355.0	749.3	3.14
1974	2,795.0	883.6	3.16
1975	3,575.0	1,212.5	2.95
1976	4,325.0	1,657.5	2.61
1977	4,896.1	2,008.3	2.44
1978	5,676.1	2,344.1	2.42
1979	6,714.1	2,535.0	2.65
1980	8,004.8	2,549.9	3.14
1981	9,707.4	2,678.8	3.62
1982	11,833.6	2,938.1	4.03
1983	14,123.5	3,203.4	4.41
1984	16,488.8	3,579.9	4.61
1985	18,788.6	4,052.2	4.64

The increase shown in the ratio of borrowings outstanding to annual revenues indicates the rising proportion of revenues and rates which has been and will be required to service debt. Such a situation results in a decline in revenue remaining after fixed charges are covered. TVA does not anticipate that these projected results will reduce the rating of its securities.

Question 9. How does TVA determine the amount of in-lieu-of-tax payments to the states and localities in which its facilities are located? Can you give specific examples of these calculations and the amounts paid for typical facilities?

Answer. Section 13 of the TVA Act provides for TVA to pay annually to states and counties 5 percent of its power revenues from sales of power in the preceding fiscal year, excluding revenue from power sold to Federal agencies. One-half of the annual payment is divided among the states in the same proportion that TVA's revenues from power sales in each state relate to TVA's total revenues from power sales; the remaining half is divided in the same proportion that the book value of TVA's power property in each state relates to the total book value of TVA's power property. The Act further provides that TVA's minimum payments to the respective states, including payments to counties, for any year shall not be less than the two-year average of the state and local property taxes that were levied against power property purchased and operated by TVA and against

that portion of TVA reservoir lands allocated to the power program. This average is based on the last two years such properties were in private ownership. Neither may the annual payment to any state, including payments to counties, be less than $10,000.

Amounts in lieu of the former county and district taxes paid on purchased power properties and on reservoir lands allocable to the power program are required to be paid directly to the respective counties. These payments are deducted from the amount otherwise payable to the state in which the counties are located. Coal reserves acquired by TVA are treated as purchased power properties for tax replacement purposes. TVA does not make payments directly to cities and towns, but former municipal taxes on purchased power properties and reservoir land allocated to power are included in the minimum amounts payable to the respective states based on the two-year average of state and local ad valorem taxes payable during the last two years of private ownership. It should be pointed out also that five of the eight states to which payments in lieu of taxes are made have enacted laws providing for redistribution of all or part of the TVA payment to local governmental units. It should be noted, further, that the state and local governments also receive payments of taxes or tax equivalents from the municipal and cooperative electric systems distributing TVA power, and therefore any comparisons with taxes paid to state and local governments by other utility systems should take into account the combined payments of TVA and the distributors.

The following four tables show data used in calculating TVA's payments in lieu of taxes for fiscal year 1974 and the computations of the payments for the respective states and counties. Because of the manner in which such payments must be calculated, it is not possible to give specific examples of the total amounts attributable to particular facilities. However, it has been estimated that approximately $15.2 million of TVA's annual payments in lieu of taxes will be attributable to the sale of power and energy from the proposed Hartsville Nuclear Plant. It is anticipated that the State of Tennessee and its local governmental units will receive about 60 percent, or $9.1 million, of that amount.

SCHEDULE 1

TENNESSEE VALLEY AUTHORITY

COMPUTATION OF TOTAL PAYMENTS TO STATES AND COUNTIES IN LIEU OF TAXES FOR YEAR ENDING JUNE 30, 1974

	Alabama	Georgia	Illinois	Kentucky	Mississippi	North Carolina	Tennessee	Virginia	Total
Ratios (percent):									
Power revenues within States to total power revenues (schedule 2)	17.5390	1.6053	0	8.5206	6.6760	0.3762	64.6616	0.6213	100.0000
Book value of power property within States to total book value of power property (schedule 3)	29.5299	.3794	.0036	13.1507	1.8616	1.1724	53.8560	.0464	100.0000
Average ratios	23.53445	.99235	.00180	10.83565	4.26880	0.77430	59.25880	0.33385	100.00000
Percentage payment: 5 percent of gross power proceeds as defined in TVA Act, allocated among States on basis of average ratios	$7,321,340.68	$308,710.52	$559.96	$3,370,866.33	$1,327,982.56	$240,877.27	$18,434,841.82	$103,857.52	$31,109,036.66
Minimum payment: Former ad valorem taxes paid on TVA-purchased properties allocated to power: [1]									
County and district	39,653.77	53,752.03	2,306.60	41,827.14	34,596.68	7,296.56	946,724.87	1,582.14	1,127,739.79
State and municipal	22,562.66	10,058.89		16,109.46	12,736.92	309.12	147,394.40	67.41	209,238.86
Total former taxes	62,216.43	63,810.92	2,306.60	57,936.60	47,333.60	7,605.68	1,094,119.27	1,649.55	1,336,978.65
Statutory minimum			10,000.00						1,344,672.05
Excess of percentage payment over minimum payment	7,259,124.25	244,899.60	0	3,312,929.73	1,280,648.96	233,271.59	17,340,722.55	102,207.97	29,773,804.65
Total amount payable	7,321,340.68	308,710.52	10,000.00	3,370,866.33	1,327,982.56	240,877.27	18,434,841.82	103,857.52	31,118,476.70
Payment distribution:									
To counties (former taxes)	39,653.77	53,752.03	2,306.60	41,827.14	34,596.68	7,296.56	946,724.87	1,582.14	1,127,739.79
To States (remainder)	7,281,686.91	254,958.49	[2] 7,693.40	3,329,039.19	1,293,385.88	233,580.71	17,488,116.95	102,275.38	29,990,736.91
Total	7,321,340.68	308,710.52	10,000.00	3,370,866.33	1,327,982.56	240,877.27	18,434,841.82	103,857.52	31,118,476.70

[1] 100 percent of average taxes on purchased power properties and on reservoir lands for single-use power dams, and 42 percent of average taxes on multiple-use reservoir lands (except 35 percent for Melton Hill, 12 percent for Nickajack, 10 percent for Tellico, and 6 percent for Tims Ford) for the 2 yr immediately preceding TVA acquisition.

[2] The payment to the State of Illinois is the difference between the county payment and the $10,000 statutory minimum.

SCHEDULE 2

GROSS PROCEEDS FROM SALE OF POWER AS DEFINED IN SECTION 13 OF THE TVA ACT FOR YEAR ENDED JUNE 30, 1973

Source of Revenue	Alabama	Georgia	Kentucky	Mississippi	North Carolina	Tennessee	Virginia	Total
Municipalities	$44,264,712	$372,102	$13,797,752	$13,446,446	$724,403	$275,419,287	$2,306,689	$350,331,391
Cooperatives	13,748,328	9,599,144	16,035,087	21,935,868	1,553,198	61,598,851	1,552,531	126,023,007
Total distributors	58,013,040	9,971,246	29,832,839	35,382,314	2,277,601	337,018,138	3,859,220	476,354,398
Electric utilities	96,309	16,552	49,530	58,744	3,780	559,520	6,406	790,841
Directly served industries	51,014,398		23,113,527	6,095,128	59,177	64,450,108		144,732,338
Customers' forfeited discounts	682		17,335	592	44	284,503		303,156
Gross proceeds from sale of power as defined in Section 13 of the TVA Act, as amended	109,124,429	9,987,798	53,013,231	41,536,778	2,340,602	402,312,269	3,865,626	622,180,733
Percentage	17.5390	1.6053	8.5206	6.6760	0.3762	64.6616	0.6213	100.0000

Note: There are no sales of TVA power in the State of Illinois.

SCHEDULE 3

BOOK VALUE OF POWER PROPERTY JUNE 30, 1973 [1]

Type of power property	Alabama	Georgia	Illinois	Kentucky	Mississippi	North Carolina	Tennessee	Virginia	Total
Hydroelectric dams:									
Multiple-use	$84,166,873	$3,829,427		$21,707,835	$317,705	$35,962,375	$185,959,822	$713,534	$332,657,571
Single-use		2,875,474				3,660,832	116,140,749		122,677,055
Total hydro	84,166,873	6,704,901		21,707,835	317,705	39,623,207	302,100,571	713,534	455,334,626
Steam plants	246,355,476			403,256,150	500,603		[3] 886,888,623		1,537,000,852
Nuclear powerplants	[2] 665,389,217						[4] 384,823,416		1,050,212,633
Other electric plant	221,530,025	8,935,836	$148,744	117,204,340	75,932,297	8,710,541	646,529,155	1,200,768	1,080,191,706
Total book value of power property	1,217,441,591	15,640,737	148,744	542,168,325	76,750,605	48,333,748	2,220,341,765	1,914,302	4,122,739,817
Percentage	29.5299	0.3794	0.0036	13.1507	1.8616	1.1724	53.8560	0.0464	100.0000

[1] Includes investigations for future projects and construction in progress.
[2] Includes nuclear fuel in the amount of $82,054,236.
[3] Includes $53,331,975 for Allen Steam Plant which is being operated under lease-purchase agreement.
[4] Includes nuclear fuel in the amount of $11,035,758, but excludes expenditures amounting to $940,934 for N5—liquid metal fast breeder reactor.

SCHEDULE 4

Payments to Individual Counties—Year Ending June 30, 1974

	Annual amount
Alabama:	
Cherokee	$312.85
Colbert	[1] 3,947.87
DeKalb	[1] 1,180.64
Franklin	684.54
Jackson	[1] 5,222.22
Lauderdale	[1] 5,584.29
Lawrence	[1] 2,889.41
Limestone	[1] 4,117.34
Madison	[1] 5,510.52
Marshall	[1] 6,651.82
Morgan	[1] 3,552.27
Total	39,653.77
Georgia:	
Fannin	53,074.74
Towns	[1] 440.06
Union	[1] 237.23
Total	53,752.03
Illinois: Franklin, total	2,306.60
Kentucky:	
Allen	24.79
Barren	556.95
Bell	139.11
Caldwell	152.76
Calloway	[1] 3,883.34
Christian	3,028.08
Clay	1,226.59
Edmonson	14.41
Fulton	1,675.99
Graves	4,704.11
Harlan	22.60
Henderson	167.85
Hickman	853.60
Leslie	1,428.54
Livingston	[1] 382.73
Logan	6,195.31
Lyon	[1] 523.30
Marshall	[1] 2,609.10
McCracken	640.26
Metcalfe	6.11
Simpson	402.06
Todd	3,797.77
Trigg	[1] 1,087.13
Union	3,427.71
Warren	4,268.75
Webster	608.19
Total	41,827.14
Mississippi:	
Alcorn	4,346.96
Chickasaw	1,408.72
Choctaw	777.88
Clay	5,160.04
Itawamba	158.40
Lee	5,189.83

Mississippi—Continued	*Annual amount*
Lowndes	$4,350.66
Monroe	2,304.19
Neshoba	1,171.58
Noxubee	497.24
Oktibbeha	2,605.67
Prentiss	1,333.91
Tippah	430.15
Tishomingo	[1] 2,476.37
Union	203.27
Webster	717.21
Winston	1,464.60
Total	34,596.68
North Carolina:	
Avery	297.30
Cherokee	[1] 1,728.47
Clay	[1] 985.51
Graham	[1] 493.56
Swain	[1] 3,791.72
Total	7,296.56
Tennessee:	
Anderson	[1] 18,380.32
Bedford	5,530.45
Benton	7,098.43
Bledsoe	15,984.89
Blount	[1] 12,045.60
Bradley	[1] 32,195.75
Campbell	[1] 20,283.67
Cannon	[1] 7,174.84
Carroll	[1] 11.78
Carter	[1] 34,189.13
Claiborne	[1] 1,975.60
Cocke	[1] 7,039.04
Coffee	2,698.92
Crockett	179.86
Cumberland	1,034.95
Davidson	10,175.07
Decatur	[1] 10,013.09
DeKalb	106.55
Dickson	1,356.60
Dyer	206.51
Franklin	[1] 10,083.38
Gibson	112.54
Giles	2,141.59
Grainger	[1] 5,623.68
Greene	20,586.36
Grundy	5,209.01
Hamblen	[1] 2,837.64
Hamilton	[1] 38,418.96
Hancock	142.86
Hardin	[1] 7,023.25
Hawkins	[1] 4,567.02
Haywood	1,250.49
Henderson	[1] 2,685.07
Henry	[1] 4,948.58
Hickman	13,062.19

See footnote at end of table.

Payments to Individual Counties—Year Ending June 30, 1974—Continued

Tennessee—Con.	*Annual amount*
Houston	[1] $1,046.21
Humphreys	[1] 11,264.68
Jefferson	[1] 16,707.51
Johnson	[1] 2,482.57
Knox	[1] 19,258.81
Lauderdale	1,045.86
Lawrence	2,300.74
Lewis	11,067.02
Lincoln	3,397.11
Loudon	[1] 21,319.67
Madison	1,902.24
Marion	[1] 83,432.27
Marshall	7,943.63
Maury	10,501.80
McMinn	[1] 40,970.76
McNairy	2,506.18
Meigs	[1] 3,710.66
Monroe	[1] 25,720.08
Montgomery	762.74
Moore	[1] 1,420.88
Morgan	[1] 3,801.75
Obion	400.94
Perry	[1] 3,562.20
Polk	[1] 111,342.61
Putnam	1,287.43
Rhea	[1] 6,340.85
Roane	[1] 20,781.47
Robertson	651.00
Rutherford	$15,188.38
Scott	90.28
Sequatchie	[1] 7,375.42
Sevier	8,962.67
Shelby	39,790.85
Smith	2,502.79
Stewart	[1] 1,746.62
Sullivan	[1] 15,842.86
Sumner	692.36
Tipton	1,486.06
Unicoi	493.35
Union	[1] 4,594.52
Van Buren	9,069.16
Warren	37,010.68
Washington	[1] 13,016.19
Wayne	[1] 19,196.87
Weakley	1,012.17
White	32,849.36
Williamson	5,410.04
Wilson	7,090.90
Total	946,724.87
Virginia: Washington, total	[1] 1,582.14
Grand total: 147 counties	1,127,739.79

[1] Includes reservoir land.

Question 10. The General Accounting Office, in their latest report on TVA, stated that because of the problem encountered with Middle Tennessee Electric Membership Corporation's implementation of the adjustment addendum, TVA was intensifying its review of the implementation of the adjustment addendum. What steps has TVA taken to do this? Does TVA plan to provide more formal guidelines to power distributors for determining billing cycles? Has TVA turned up any other problems similar to the one at Middle Tennessee? If so, what amounts are involved?

Answer. TVA has reviewed this situation very carefully, not only with the Middle Tennessee Electric Membership Corporation but also with all 160 distributors of TVA power. The General Accounting Office report of a misapplication of the adjustment addendums at Middle Tennessee EMC apparently was made because of some misunderstanding of the term "billing cycle." This term was defined in TVA's July 16, 1974, letter to all of the distributors.

Power distributors spread meter reading, billing and collecting over an entire working month. For statistical and other practical reasons, this working month usually does not coincide with a calendar month. The beginning date of the working month or "billing cycle" varies somewhat through the year because of nonworking weekends, holidays, inclement weather, etc. Therefore, although a given distributor may have established a particular day—say the 5th calendar day, as the beginning of its billing cycle, it may not be able each month to begin on the 5th for the reasons mentioned earlier. These are the kinds of variations the General Accounting Office found at Middle Tennessee EMC. Following a very thorough examination of the situation there, TVA has concluded that the Cooperative correctly applied the adjustment addendums of July 2, 1974, and January 2, 1975.

TVA field accountants have reviewed the application of rate adjustments with each of the 160 distributors. Four systems apparently misapplied charges under the adjustment addendums. Two of these have since modified their timing to

comply with TVA guidelines. TVA is discussing this with the other two systems. These two are in Kentucky, and because the state regulatory commission has already approved their procedures, adjustments in the timing of the application of the current adjustment addendum may not be made quickly.

In these four cases described above the amounts for affected consumers are relatively small, in the order of two to seven cents per month for the average residential customer. The cost of determining each amount and the processing of all the customers' bills to provide a credit would far exceed the total amount involved. This expense would be a burden on the systems' ratepayers which TVA believes would be unwarranted under the conditions.

TVA feels that the practicable corrective step in the instance of the two remaining Kentucky distributors is the attainment of proper timing of applications of the amounts under the adjustment addendums and is pursuing this course diligently.

Question 11. What documentation exists for the September 1968 review of TVA's construction activity?

Answer. No documentation of cost comparisons with private industry exists for the September 1968 review of TVA's construction activity. The review was based on extensive knowledge and years of past experience of persons associated with the TVA construction program. The findings of the 1968 review were as follows:

This review again verifies that the policy of performing construction by the use of TVA forces, supplemented in certain specialized instances by contract construction, is the most efficient and economical means of providing the physical plant necessary to the attainment of TVA's program objectives.

Application of this policy enables the realization of the following economies and efficiencies:

1. Earlier project completion and consequent realization of benefits. The beginning of construction is not delayed until complete designs and specifications are available as is required under contract construction. Concurrent design and construction permit a close coordination of these activities and more rapid execution of work.

2. The transfer of forces and equipment to new projects from those being completed within the relatively compact geographic area of TVA's activities.

3. Utilization of a team of trained and highly experienced construction supervisors and key workers which has been developed in the execution of TVA's past construction program.

4. Negotiation and application of trades and labor practices and rates common to all construction work.

5. Flexibility in adjusting activities and schedules to unforeseen factors encountered during construction, technological advances, improved construction methods developed on previous projects, or funding modifications.

6. Utilization of contract construction for those specialized types of construction where cost comparisons indicate contract construction to be more advantageous.

Question 11(a). For each of the last five years, please provide the number of salaried and hourly employees involved in TVA's construction program.

	Salaried employees	Hourly employees	Total employees
June 30:			
1970	826	7,118	7,944
1971	1,027	9,114	10,141
1972	1,084	8,362	9,446
1973	1,124	6,724	7,848
1974	1,294	7,607	8,901
May 31: 1975	1,681	9,437	11,118

Question 11(b). Please identify the skills and the number of employees possessing those skills which TVA feels necessary for carrying out its construction program economically.

	Current employment (May 31, 1975)	Estimate for June 30, 1976
Salaried employment:		
Construction management and craft supervision	332	390
Construction engineering, scheduling, and quality control	336	430
Construction inspection and surveying	524	500
Cost accounting and warehousing	82	100
Clerical	389	390
Custodial	18	20
Total salaried	1,681	1,830
Hourly employment:		
Boilermakers	330	350
Carpenters and millwrights	1,248	1,525
Electricians	1,231	1,300
Ironworkers	798	1,050
Steamfitters	1,276	1,400
Teamsters	624	650
Laborers	1,901	2,100
Operating engineers	1,294	1,250
Painters	164	250
Sheet metalworkers	255	300
Machinists and mechanics	195	200
Cement masons	115	125
Asbestos workers	6	----
Total hourly	9,437	10,500

Question 12. What are the guidelines which TVA uses for selection of construction work to let to contract without competitive bidding? What portion of TVA's construction program is under such contracts?

Answer. The bulk of TVA's construction is performed by TVA's own forces rather than by contract. When TVA does contract for construction work, such contracts are generally made after competitive bidding. In certain situations, such as an emergency or where the procurement of construction services supplemental to those already contracted dictates that the original contractor is the only only source, the TVA Act permits the awarding of contracts without advertising. Also, TVA has arranged for certain types of specialized work to be performed by utilities or other agencies; for example, TVA contracts for utility relocation with the utility owner and contracts with the Corps of Engineers under the Economy Act (31 U.S.C. Section 686) for the construction of mooring cells and similar navigation facilities.

Substantially less than one percent of TVA's construction work is accomplished under contracts made without competitive bidding.

Question 13. What safety features will be incorporated in the Hartsville and Rogersville nuclear plants so that the accident sequence that occurred at Browns Ferry will not be repeated?

Answer. Substantial advance have been made in the state-of-the-art technology in the time since the original design of Browns Ferry. These advances in design will be incorporated in the proposed Hartsville Nuclear Plants and the plant being considered for location on the Holston River. In regard to special features related to the Browns Ferry fire, the following improvements will be incorporated;

Use of electrical cables that are more fire retardant than those used at Browns Ferry;

Routing of control cables in two or more separate safety divisions for the emergency systems of each unit, so that the loss of cables in one division will not affect the safety equipment connected to cables in other divisions;

Cable trays in certain areas will have solid bottoms, and will be covered in some congested areas.

All wall and floor openings (penetrations) where electrical cables are routed will be fire stopped by use of highly fire retardant or nonflammable materials, with ventilation barriers where pressure differentials exist;

Exercise of tighter control on sources of ignition;

Grouping engineered safety features of like safety divisions together and providing maximum physical separation between these groupings.

Locating combustion fire detectors throughout the facility;

Providing detailed instruction and control of work on operating reactors that involve an interface between operating personnel and others such as construction workmen.

The use of open flames for testing has been banned, not only at Browns Ferry but for all other TVA nuclear plants. In addition, administrative procedures have been formulated for control of other ignition sources arising from site personnel activities in operating plants. Studies are underway on the advisability and feasibility of providing additional fire detection and extinguishing systems, including personnel training and means to recharge air tanks of portable breathing apparatus. Quality assurance procedures are being strengthened to prevent instances of this type. An especially constructed fire testing building has been provided at the Watts Bar Nuclear Plant. This will provide facilities in which various materials for use in cable penetrations can be tested. Data and experience gained will be used to design a more effective pressure seal and fire stop.

Question 14. What policies does TVA have with regard to assisting localities plan and develop facilities necessitated by the construction of major power plants?

Answer. TVA recognizes that the influx of large numbers of construction workers and their families may create problems for communities in the project area. Frequently the needs for additional facilities and services are of a temporary nature, lasting only during the period of construction employment. However, through joint planning with affected communities and agencies, TVA supplements existing facilities and service capabilities when needed during the construction period.

To the extent possible, TVA's assistance is planned and carried out so as to be complementary to local plans and programs. TVA's intention is to derive lasting contributions to community development from an otherwise temporary construction period impact.

TVA programs to help the project area are in the form of technical, equipment, or financial assistance. Their immediate goal is to maintain the quality of community services throughout the construction period at a level at least as high as the preconstruction level, without causing undue financial stress on the local governments. In some instances this enables communities to obtain needed facilities earlier than would otherwise be the case. The longer range goal is to help the project area attain the benefits of development to a higher level made possible by the increased economic activity during this period.

Question 15. Has the TVA undertaken to provide any assistance to the farmers who have experienced crop losses as the apparent result of emissions from the Shawnee Steam Plant? If so, what?

Answer. Crop losses due to power plant emissions have been rare and when they have occurred they have been very small. In fact, crop losses have happened around only two of the twelve TVA plants. At the Shawnee Plant we have received only two claims for payment of damages since the plant began operating in 1953. Both were from the 1974 growing season. One of these—injury to tobacco—has been settled on terms agreeable to the farmer. The other has been thoroughly investigated, but has not yet been settled.

TVA's concern about such losses and the extent of our efforts to settle them properly is illustrated by our handling of complaints about soybean injury in the Shawnee area during the 1971 and the 1974 growing seasons. In both years it was clear that sulfur dioxide had injured some of the leaves on soybean plants growing in the area, but it was not clear whether such leaf injury would, in fact, cause any reduction in crop yield of the soybeans at harvest time.

TVA joined with the Environmental Protection Agency, the University of Kentucky, county agents, and the farmers themselves to conduct a thorough scientific investigation of the results of the leaf injury. The acidity, fertility, and other parameters of soil quality, together with crop yields in the injured fields, were carefully measured. These were compared with measurements from uninjured fields. Analysis of these data revealed that the sulfur dioxide leaf injury had no effect on soybean yields. It was determined, however, that on some fields, in both areas affected and not affected by SO_2, reduced yields were being caused by low soil fertility, high acidity, pest infestations, and other agricultural practices. The results of this investigation were made available to all concerned, and no claims for payment of damages were made.

A similar investigation is now being made in response to the complaints of SO_2 leaf injury which were made during the 1974 growing season. As soon as all the

participants have submitted their data and it is analyzed, it too will be made available to interested parties.

Question 16. Are any of TVA's power plants exempted from federal regulations issued under the Federal Water Quality Control Act regarding thermal discharges? Are these plants, if any, required by State laws to install "closed cycle cooling?" Are any of TVA's plants covered by federal thermal pollution standards required by State laws to meet a stricter standard?

Answer. Under the FWPCA, TVA's power plants are subject to the same federal and State water pollution requirements as privately owned plants, including those relating to thermal discharges. These thermal requirements fall into two basic categories. First, the Environmental Protection Agency is required by the FWPCA to establish limitations on the specific types and amounts of pollutants (including heat) which can be discharged from a power plant. Generally, these effluent limitations and the dates by which they must be met take into account technological considerations, such as the availability of equipment and processes to limit such discharges, and the pollution abatement benefits to be obtained. Second, under FWPCA, the States can establish thermal water quality standards, which apply in the streams themselves and which must also be met by the operator of a power plant. These State standards are based upon establishing conditions in the stream which would restore and maintain desirable levels of water quality. Upon approval by EPA, these State stream standards become federally enforceable requirements. All of the States in which TVA operates power plants have adopted such thermal standards.

EPA has recently promulgated its effluent limitations for electric power plants. With respect to thermal discharges, these regulations establish closed cycle cooling as a basic requirement, but exempt certain older plans. Even these "exempt" plants, however, must comply with State thermal water quality standards if the discharges from the plants will cause the stream standards to be exceeded. Where an operator can show that either an EPA requirement or a State stream standard is more stringent than would be required to protect aquatic life, he may, under section 316(a) of the FWPCA request that EPA relax the State or federal requirements.

With respect to the EPA requirements alone, all of TVA's operating plants, except Paradise unit 3, Cumberland units 1 and 2, and Browns Ferry units 1 and 2, are exempt under the "old unit" categorization.

With respect to State water quality standards, all TVA power plants, regardless of age, are subject to stream standards. While none of TVA's plants are specifically required by State law to install closed cycle cooling, where a relatively large facility is located on a relatively small stream, thermal discharges can exceed the permitted temperatures. It is sometimes difficult to establish whether or not these standards are, in fact, being met and to date no final determination with respect to compliance with State standards has been made at TVA plants.

Based upon extensive biological and fish studies and years of plant operation without significant effect on aquatic life, TVA is convinced that less stringent State and federal thermal standards can be properly applied at all of our plants. Accordingly, in all cases where closed cycle cooling would otherwise be required, TVA has requested that EPA establish relaxed standards under section 316(a), for both "exempt" and "nonexempt" plants. These requests have not been finally acted on yet, however.

Whether any of TVA's three operating plants which are subject to the federal thermal requirements would be required to meet a stricter standard under State law cannot be determined until TVA's requests for establishment of less stringent standards under 316(a) have been acted on.

Question 17. Do any of TVA's steam electric plants experience problems of entrainment, entrapment, or impingement at water intake structures? If so, what steps is TVA taking to correct these problems and are these steps consistent with EPA's proposed standards issued pursuant to Section 316(b) of the Federal Water Quality Control Act?

Answer. TVA's 13 steam electric generating plants do entrain and impinge some aquatic organisms. Whether or not these occurrences represent a problem requires a determination of the number of organisms affected and then a detailed analysis of whether these losses constitute an adverse impact on the flora and fauna of the waterbody. In order to determine if a problem exists, TVA is currently conducting extensive impingement and entrainment studies at all commercial generating plants at a cost estimated to be approximately one million

dollars over the next two to three years. In addition, we have initiated a research program to investigate various techniques to mitigate impingement and entrainment problems if such problems are identified. One part of the research program includes continuing studies on an experimental fish pump designed by TVA and installed in the intake area at the Browns Ferry Nuclear Plant in northern Alabama. Studies are also being initiated to evaluate other techniques, such as electric barriers, light and sound barriers, diversion mechanisms, and intake structure modifications.

If TVA's studies indicate that any intake structure is causing adverse environmental impacts, we intend to take appropriate corrective action.

Question 18. TVA's analysis of the cost of air and water pollution control facilities supplied for the Record estimates the annual cost of scrubbers at the three TVA plants for which EPA now proposes emission controls at $150 to $200 million. In a letter from Chairman Wagner to Administrator Train dated January 23, 1974, TVA estimated the annual cost of scrubbers on the entire TVA coal-fired steam electric system consisting of 12 plants at $225 million. What is the explanation of this apparent discrepancy?

Answer. There is no discrepancy between the two estimates. The $225 million estimate referred to in the question was the annual cost of meeting the state SO_2 emission standards adopted in 1972. These standards would have required TVA to install over $1 billion worth of scrubbers on all of its generating units.

In 1974, new SO_2 emission standards applicable to some TVA plants were approved in Tennessee and Alabama and additional revisions were being considered. The new standards were less stringent than the original standards at eight of TVA's twelve plants. The annual cost of complying with the less stringent standards by the most optimum combination of control measures is estimated to be $150 to $200 million. This cost would include installing SO_2 scrubbers at three plants, coal washing and blending at five plants, and the use of low-sulfur coal at the remaining plants.

Question 19. Briefly discuss TVA's current and potential contributions to solving the energy related aspects of the food production problem.

POTENTIAL FOR IMPROVING FOOD PRODUCTION THROUGH INTEGRATION OF ENERGY AND AGRICULTURAL RESEARCH

Two of the most important elements of our way of life are food and energy, and they are interrelated because the agricultural industry is dependent on oil and gas both for raw materials and for fuels. Up until recent years, our country has had an abundant supply of both low-cost fuels and inexpensive agricultural products—enough to meet our own needs and to provide assistance to other countries. The availability of these materials has contributed in a major way to our very high standard of living compared to much of the rest of the world. However, the situation is changing rapidly and our domestic demands exceed our ability to produce oil and gas. This and price increases lead to concern about cost and availability of agricultural products. It has become obvious that research on alternatives to traditional uses of fuels and on improvements in the agricultural industry to increase food production is a high national priority.

TVA is in unique position to assist with the national research program in both the energy and agricultural fields.

TVA has the incentive, the professional disciplines, and many of the facilities necessary to carry out a variety of integrated, cost-effective program elements. The National Fertilizer Development Center operated by TVA is currently involved in several projects (funded by EPA pass-through funds, direct appropriation to TVA, and power revenues) that deal specifically with energy-agriculture integration. Subjects of these studies include:

Recovery and utilization of sulfur from power plant stack gas.
Production of ammonia synthesis gas from coal.
Recovery of uranium from phosphate ore.
Productive use of calcium-based sulfur removal products.
Energy conservation through improved fertilizer process technology.
Beneficial use of waste heat from power plants.

A summary description of the work in the more important areas is attached.

The overall objective of the program is to develop reliable methods for utilization of available resources (raw materials and byproducts) in promoting the required mix of agricultural products in sufficient volume and at minimum

cost without adverse environmental effects. The current effort will provide some of the answers needed to begin use of new technology. However, both the schedule and the scope are limited by the level of funding. Additional financial support would accelerate the approach to the overall objective and would provide for revising the technology as the mix of resources changes, as it surely will.

ENERGY RELATED AGRICULTURAL RESEARCH

Recovery and Utilization of Sulfur From Stack Gas

Utilities that have been required to use stack gas cleaning to meet environmental regulations have generally chosen lime or limestone scrubbing because these methods are more advanced than alternative methods. However, there are strong incentives to develop processes that recover sulfur in useful form rather than as a disposal product.

About 0.9 ton of sulfur is required as sulfuric acid per ton of phosphorus pentoxide (P_2O_5) produced as wet-process acid. (Production of wet-process acid in the United States is projected as about 9 million tons P_2O_5 by 1977.) Nearly 70 percent of U.S. sulfur production is by the Frasch (hot water) mining process. An average of about 8 million Btu's as natural gas (800 ft^3) is required per short ton sulfur, or about 7 million Btu's per short ton P_2O_5 is required to produce wet-process acid from Frasch sulfur. Recovery of sulfur from fuels would, therefore, conserve our natural sulfur reserves and reduce the energy requirement for mining.

Several recovery processes are being developed, some at the fullscale level. The major disadvantages are high energy requirement and the need for gas or oil to provide reducing gas for processes that recover sulfur oxides as elemental sulfur.

TVA has been involved in research and development of recovery of sulfur from stack gas for several years and work is continuing. One of these processes (the ammonium bisulfate process) has been developed to an advanced stage in a 1-MW pilot unit at Colbert Steam Plant. This system involves scrubbing stack gas with an ammoniacal solution to remove sulfur dioxide and then regenerating the SO_2 in a concentrated form suitable for directly producing sulfuric acid or elemental sulfur. The energy requirement for the regeneration step is significantly lower than for alternative methods. Also, studies on use of coal as the reductant are being carried out. A further advantage is that direct oxidation of the scrubbing solution produces ammonium sulfate, a traditional fertilizer material, without the need for a regeneration step. These studies are moving ahead, with about 2 to 3 more years required to complete the development at the pilot-plant level. Demonstration of the process in full-scale equipment will then be recommended.

Approximately $2 million has been budgeted for work in FY 1976 and 1977. Prior to 1976, expenditures have totaled $2.5 million.

Production of Ammonia Synthesis Gas From Coal

About 95% of the current U.S. agricultural nitrogen consumption is based on anhydrous ammonia produced by the reforming of natural gas, which is becoming critically short in supply. The production rate of natural gas is said to have peaked out at about 24 trillion cubic feet per year in 1973 and the rate is now declining at 8 to 10% per year.

The U.S. Geological Survey and the American Gas Association predict no significant change in the rate of decline of gas production. It therefore appears that all industries based on natural gas as fuel or feedstock face increasing curtailments and resulting production losses.

There are a number of alternatives for alleviating the effects of the current gas shortage on existing or new ammonia production capacity.

1. Deregulate interstate gas prices to provide an incentive for increased production.
2. Allocate the full requirement of gas to the fertilizer industry.
3. Convert existing capacity, at enormous costs, or build new capacity based on imported naphtha, residual fuel oil, or liquid natural gas.

The first two alternatives involve political judgments, and even if fully implemented, would not ensure adequate gas availability for future U.S. ammonia production. The last would simply perpetuate this country's debilitating dependence on foreign sources and its untenable balance-of-trade position.

One source of ammonia feedstock that does not suffer these serious drawbacks is the vast coal deposits of this country. Proved reserves of coal, minable by current technology, are reported to be sufficient for over 300 years at present rates of consumption. Some of these vast reserves are in close proximity to the heartlands of American agriculture, the Midwest States and the Northern Plains States.

A large number of coal gasification projects are planned or in progress in the United States. However, none of those reported are aimed specifically at optimization of the system for ammonia production.

Several large coal-based ammonia plants are either under construction or in various phases of early operation in South Africa and India. The technology exists, but it is inefficient and expensive relative to natural gas feedstock. Much improvement is needed. Also, the technology is controlled by German engineering firms, with only limited access for U.S. licensees.

The scope of a proposed long-term project to develop practical technology to produce ammonia from coal is given in outline form in Table I. The phases of work include (1) a review and evaluation of current technology, (2) formulation of plan for future work, (3) pilot-plant studies, and (4) prototype or demonstration-plant studies. The last phase might well be lengthened to include both a small prototype unit, say at NFDC, followed by a large, single-train gasifier at a strategic western location. Approximately $400,000 has been budgeted for work in FY 1976 and 1977. Additional funding is being actively pursued so that the project schedule can be accelerated.

TABLE I.—COAL GASIFICATION FOR AMMONIA FEEDSTOCK, PROPOSED PROJECT OUTLINE

Fiscal year	Project stage	Objectives
1976–77	Review and evaluate current and planned gasification research and development, including existing coal-based ammonia technology.	Identify potential improvements in existing or developmental processes: A. Minimize coal handling and preparation. B. Simplification of indirectly heated gasification processes to permit: 1. Elimination of expensive liquid air plant. 2. Reduction size of gas purification system. C. Increase size of gasifiers to permit single-train operation. D. Decrease energy consumption of present technology.
1977–78	Design and construct pilot plant, 1–5 tons/d capacity.	Confirm conclusions reached after completion of first phase.
1978–81	Operate and modify pilot plant.	Define effects of operating parameters.
1981–84	Design and construct alternate coal-gasification unit for an existing ammonia plant.	Demonstrate technical and economic viability of process.

Recovery of Uranium From Phosphate Ore

The U.S. economic phosphate reserves are estimated at 10 million tons, about half of which is considered minable by present technology. The uranium content of this phosphate rock is quite variable, ranging from a high of 399 mg U/kg rock in South Carolina, down to about 12 mg U/kg rock in Tennessee rock. The uranium content of Western and Florida rocks, which comprise the bulk of U.S. reserves, ranges from 115 mg U/kg rock to about 160 mg U/kg rock. Taking 125 mg U/kg rock as an estimated average, the potentially recoverable uranium from minable phosphate rock is about 625,000 tons. Only a portion of this rock is converted to wet-process acid, and is, therefore, available for uranium recovery with present solvent extraction technology.

Wet-process phosphoric acid produced from Florida phosphate rock contains 0.1–0.2 uranium/liter and represents a potential source of about 2000 tons of U_3O_8 per year. The potential for recovering much of this uranium is good. In the past, depressed prices were the major impediment to its recovery but increased price and demand for U_3O_8 (yellow cake) have led to renewed recovery efforts. It was anticipated that the use of plutonium recycle in boiling water and breeder reactions would moderate this yellow cake demand, but plutonium recycle is undergoing increased attack for safety, environmental, and economic reasons and will make no significant contribution to U.S. nuclear energy demand in the near future. Thus, escalating yellow cake prices will stimulate corporate interest in uranium recovery for wet-process acid.

Four companies are operating or planning to operate new recovery processes on pilot or prototype scale with wet-process acid in Florida. Details of these processes are not available, but they probably use solvent extraction methods.

TVA work has been limited to uranium recovery during wet-process acid laboratory purification. The acetone solvent extraction process, methanol precipitation process, and urea phosphate purification process have been extensively investigated at TVA and in all three processes, the uranium can be concentrated in the impure phase. This uranium concentration is a significant advantage because only a portion of the acid volume will require treatment.

TVA work has shown that it is feasible to recover uranium in high yield during methanol purification of wet-process acid. Work on extracting uranium from the mother liquor produced in the urea phosphate process and acetone process is getting started. This work will be continued to better describe and optimize these recovery operations. Approximately $100,000 has been budgeted for work in FY 1976 and 1977.

Production of Fertilizer From Calcium-Based Sludge

Scrubbing processes using lime or limestone slurries are currently the leading methods for removing pollutants from electric power generating plant stack gases. These processes produce sludge containing primarily calcium and sulfur salts along with a number of minerals and trace elements. Disposal of the large quantities produced (about 3500 tons per day for a 500-MW power plant) is both difficult and costly. The material is thixotropic with little or no bearing capacity and is unsuitable as a landfill. Pond containment, the usual method of disposal, is one of the major cost items in the scrubbing process.

Recent bench-scale work at the National Fertilizer Development Center has shown that the sludge can be incorporated in a granular fertilizer, offering an attractive means of sludge disposal. A typical grade of 5–20–0–5S (5% nitrogen, 20% P_2O_5, and 5% sulfur) has been produced. Crop responses in greenhouse pot tests indicate that the nutrients in the granulated sludge material compare favorably with conventional fertilizers. Preliminary cost estimates indicate that the value of the fertilizer material without any credit for the sulfur and trace elements or micronutrients will cover the cost of processing the sludge.

A 2-year, $250,000 pilot-plant study of the sludge-fertilizer process will begin in FY 1976 to obtain more definitive cost and process data. A sufficient quantity of material will be produced to permit TVA engineers, agronomists, and economists to fully evaluate and compare the material with conventional fertilizers and to determine the market impact of the large quantity (about 3000 tons per day for a 500-MW power plant) of fertilizer material from the new source.

Energy Conservation Through Improved Fertilizer Process Technology

Melt-Type Granulation: The TVA melt-granulation process is attractive because it avoids the drying operation in the processing sequence. In production of granular ammonium phosphates, the heat of ammoniation of the merchant-grade phosphoric acid is effectively utilized to drive off the water and produce the anhydrous melt. After granulation the product is simply cooled with ambient air. With conventional ammonium phosphate granulation technology now in use, both drying and cooling operations are required; the drying requires burning of 6 gallons of fuel oil equivalent to about 0.9 million Btu's per ton of P_2O_5.

Granular ammonium phosphates are the leading phosphate fertilizers with a current annual production of about 4 million tons of P_2O_5. The trend is to increasing proportions of ammonium phosphates in the United States, with about 5 million tons of P_2O_5 in this form projected for 1980. Therefore, the potential energy savings resulting from melt granulation is equivalent to about 700,000 barrels of oil or about 4.5 billion cubic feet of natural gas per year. Approximately $200,000 has been budgeted for this work in FY 1976 and 1977.

Hemihydrate Wet-Process Acid System: By 1977, about 87% of the U.S. phosphate fertilizer will be produced from wet-process acid intermediate totaling about 9 million tons P_2O_5. Wet-process acid is made by treating phosphate rock with sulfuric acid to form phosphoric acid and precipitate calcium sulfate, which is removed by filtration. Current U.S. practice involves precipitation of calcium sulfate as a dihydrate (gypsum) by cooling the sulfuric acid—phosphate rock reactors. The product phosphoric acid contains about 30% P_2O_5 and must be concentrated to merchant-grade (52–54% P_2O_5) by evaporation.

If the reaction slurry is not cooled, the calcium sulfate can be precipitated as hemihydride ($CaSO_4.1/2H_2O$), and the product acid concentration is as high as 54% P_2O_5. Therefore, use of this system can save the energy required to concentrate the acid. This is equivalent to about 2.5 million Btu's per ton of P_2O_5.

The hemihydrate system has been commercialized in Europe with some types of foreign phosphate rock. TVA will carry out extensive pilot studies of the system with U.S. rock. Approximately $1 million has been budgeted for this work and other wet process acid technology in FY 1976 and 1977.

Beneficial Uses of Waste Heat

The heat in power plant condenser water discharge provides the opportunity for developing a new energy source, fostering economic development, and reducing environmental control costs not only in the Tennessee Valley region, but also throughout the Nation and the world. Tremendous amounts of waste heat exist.

The annual quantity of waste heat available in the United States is equivalent to 1.6 billion barrels of fuel oil; an amount of energy slightly less than 20% of all the energy used in the U.S. annually. Research and development activities are being conducted to develop technological systems that can economically utilize this new energy source. Objectives of this work are to identify, quantify, and assess new technologies needed to recover heat energy from power plant condenser discharge water as a new energy source in food and fiber production. The waste heat will be utilized in (1) heating and cooling greenhouses for year-round horticultural production, (2) determining the influence of increasing soil temperature on extending the growing season and increasing crop yields, (3) controlling temperatures in confined livestock feeding facilities, (4) recycling livestock wastes to purify water and produce protein for livestock feed, and (5) production of cat fish in heated raceways. Both off-site and power plant sites will be utilized in the research and development activities.

Active off-site activities being conducted are greenhouse environmental control, soil heating to extend crop growing season, and biological recycling of nutrients from livestock waste. Results have been sufficiently encouraging that greenhouse and soil heating facilities using condenser discharge water will be constructed at Browns Ferry Nuclear Plant. Research will be started off-site in 1977 to evaluate the use of waste heat in providing environmental control for confined livestock facilities. Research activities conducted in a 10-raceway facility on the Cumberland River utilizing condenser discharge water from Gallatin power plant showed that an opportunity exists to produce, harvest, process, and market catfish on a year-round basis. Plans are to initiate an integrated multiagency aquaculture demonstration project at Browns Ferry Nuclear Plant in the near future. Approximately $1.8 million has been budgeted for this work in FY 1976 and 1977.

Question 20. In Mr. Seeber's statement on May 2, reference is made to a joint EPA–TVA task force review of potential emission strategies on TVA's coal-fired steam electric plants. That task force issued a preliminary assessment of alternatives in January 1975. Would TVA supply a copy of that report for the Record?

Answer. A copy of the report follows.

PRELIMINARY ASSESSMENT OF ALTERNATIVE SULFUR OXIDE CONTROL STRATEGIES FOR TVA STEAM PLANTS [1]

The present study seeks only to establish a firm point of departure for the resolution of present differences between EPA and TVA as to the implementation of the Clean Air Act. It is to be regarded as a working document, and is the product of discussions held in May, November, and December, 1974 by a joint task force made up of the following representatives of the two agencies:

TASK FORCE MEMBERS

EPA

Jack E. Ravan, Regional Administrator, Region IV; James T. Wilburn, Chief, Air Enforcement Branch, Region IV; G. T. Helms, Acting Director, Air Programs Office; Greer Tidwell, Chief, EPA Liaison Office for Tennessee/Kentucky.

[1] Prepared jointly by a task force composed of representatives of the Environmental Protection Agency and the Tennessee Valley Authority June 1974; Portions Revised January 1975.

TVA

T. L. Montgomery, Chief, Air Quality Branch, Division of Environmental Planning; H. W. Elder, Director, Stack Gas Emission Studies, Division of Chemical Development; C. L. Massey, Supervisor, Air Quality Task Force, Office of Power; James P. Darling, Chief, Power Supply Planning for Office of Power.

AUXILIARY MEMBERS

R. T. Walsh, Ofc. of Control Tech.; J. A. McCarthy, OAQPS; James M. Speyer, Ofc. of Planning & Evaluation; D. R. Mayfield, APO, Region IV; W. Ray Cunningham, Air Enf. Br., Region IV; W. H. Bishop, APO, Region IV; Natie Allen, Office of Power; Ray N. McCleskey, Office of Power; J. A. Hudson, Division of Design; W. B. Norris, Div. of Env. Planning; John W. Frey, Div. of Env. Planning.

I. INTRODUCTION

This document presents a compilation of facts regarding ambient air quality and sulfur oxide emissions at TVA's steam plants. Also presented are two alternative approaches to the problem posed by these emissions in relation to the requirements of the Clean Air Act. The cost of each is assessed, and comments are offered in support or in rebuttal.

The first approach, based on EPA's interpretation of the Act, develops strategies for complying with SO_2 emissions limiting regulations. The strategies elaborated for this approach are based on annual average emissions, but the task force acknowledges that some shorter averaging time must be settled upon for purposes of determining compliance. These compliance strategies involve the use of coal washing, low sulfur coal, coal blending and (for three plants) flue gas desulfurization. Two cases are presented. In the first case, strategies are selected for TVA plants based on present stack heights. In the second case, allowances are made for increased stack heights at some plants.

The second approach, based on TVA's interpretation of the Act, is intended to achieve direct compliance with ambient SO_2 standards. It involves the use of control strategies based on intermittent reduction of generating operations or use of low sulfur coal during brief periods when the need to reduce emissions is indicated by monitoring and on-site weather observations on the dispersive capability of tall stacks, and on the use of flue gas desulfurization at one generating unit.

This study resulted from the initiative of Messrs. Train and Wagner, and is offered as a briefing document for their use. The task force trusts that it has adequately fulfilled its immediate mission, and that its work will serve as the basis for policy-making activity at the upper levels of management.

This effort should not be construed as an attempt to bypass the legitimate involvement of the States affected—Alabama, Kentucky, and Tennessee. The air pollution control agencies of these three States were apprised of the joint deliberations of EPA and TVA at their outset.

Mr. AUBREY J. WAGNER,
Chairman, Tennessee Valley Authority,
Knoxville, Tenn.

DEAR RED: Our April 19 meeting in my office on TVA compliance with Clean Air Act requirements was very useful from our standpoint.

We recognize that there is a basic difference between us concerning constant emission limitations as applied to existing plants and the need to install scrubbers or use low-sulfur coal at such plants. As we made clear, it is not our view that scrubbers need to be installed on all of your plants or units, and we think it would be helpful to establish just how far we consider you should go in either installing them or converting to low-sulfur coal.

As we agreed, Jack Ravan, EPA's Regional Administrator for Region IV, and Lynn Seeber, TVA's General Manager, have designated EPA and TVA personnel who are now working together as a small task force to achieve agreement on the facts (including cost calculations, fuel switching possibilities, etc.) insofar as possible and, where this is not possible, specify areas of and the basis of disagreement. I appreciate your adhering to your policy of full disclosure of relevant TVA data.

I am hopeful that this task force's efforts will enable us to define more clearly the scope of the scrubber and low-sulfur fuel question on the TVA power system, and I look forward to our further reviewing the situation together, after Mr. Ravan's June 1 report to me, to ensure the necessary follow-up actions.

Sincerely,

RUSSELL E. TRAIN,
Administrator.

II. DESCRIPTION OF THE TVA SYSTEM

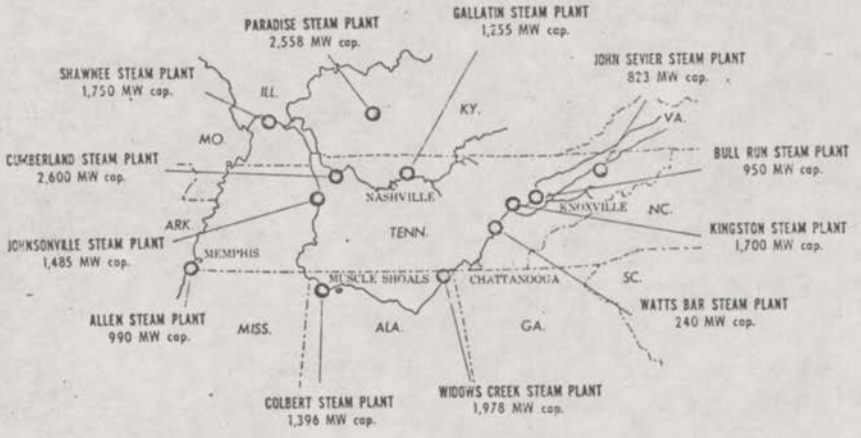
A. General Description

A map of the TVA coal-fired power plant system, which—together with hydroelectric, nuclear and gas turbine plants—serves an area of 80,000 square miles, is shown in figure II–1. The coal-fired system consists of 12 plants, 63 units, with a total generator nameplate capacity of 17,726 megawatts. In FY73, these plants burned 37.5 million tons of coal, about 6% of the total burned in the U.S. The oldest plant, Watts Bar, was placed in service in 1942. The newest, Cumberland, was completed in 1973. The size of the units ranges from 60 to 1300 megawatts.

B. Statistical Description of Individual Plants

The task force gathered pertinent statistical data on the individual plants of the TVA coal-fired system. This data is presented in tables II–1 through II–12 in the following order:

1. Allen
2. Bull Run
3. Colbert
4. Cumberland
5. Gallatin
6. John Sevier
7. Johnsonville
8. Kingston
9. Paradise
10. Shawnee
11. Watts Bar
12. Widows Creek



TVA COAL-FIRED POWER PLANTS

FIGURE II–1

DATA SHEET

Name of plant: Allen Steam Plant.
Location: Memphis, Tenn.
AQCR: 018—Metropolitan Memphis Interstate.

Priority classification:	
Particulates	I.
SO_2	III.
Maximum plant generator nameplate rating (MW)	99.[a]
Number of generating units	3.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	11,120.
Ash content (percent)	11.5.
Sulfur content (percent)	3.2.
Maximum plant heat input (10^6 Btu/hr)	8,794.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	1,554
At 100 percent capacity factor	3,600.
Source of coal (Bureau of Mines coal districts)	9, 10, 14.
Compliance with particulate emission standards	Yes.
EPA-approved compliance schedule	NA.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	
Total annual particulate emissions (fiscal year 1973) (tons)	447.[b]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None.[c]
Total annual SO_2 emissions (fiscal year 1973) (tons)	89,510.[d]

[a] The gas turbine plant at the site has an additional capacity of 621 MW.
[b] This value is based on 25-percent ash retention in the boiler.
[c] TVA proposes to meet ambient standards by using ICS.
[d] This value is based on 90 percent of the sulfur being emitted as SO_2.

NA. Not available.

ALLEN STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit			Plant total
	1	2	3	
Generator nameplant rating (MW)	330	330	330	
Boiler:				
Manufacturer	B & W	B & W	B & W	
Type of firing	CYCL	CYCL	CYCL	
Type of bottom	Wet	Wet	Wet	
Annual coal use (10^3 tons): [a]				
Fiscal year 1973	392	549	613	
At 100 percent capacity factor	1,200	1,200	1,200	
Maximum heat input (10^6 Btu/hr)	2,931	2,931	2,931	8,794
Year placed in service	1958	1959	1959	
Stack information:				
Existing:				
Number	1	2	3	
Height (feet)	400	400	400	
Planned:				
Number	NA	NA	NA	
Height (feet)	NA	NA	NA	
Particulate emissions:				
Ash content of coal, fiscal year 1973 (percent):				
Maximum weekly average	13.6	13.1	12.7	
Annual average	11.4	11.5	11.6	11.5
Emission rates (pounds/10^6 Btu):				
Fiscal year 1973 (using actual heat input)	0.03	0.03	0.03	
SIP emission standard [b]	0.10	0.10	0.10	
Control equipment:				
Mechanical collector	No	No	No	
Electrostatic precipitator	Yes	Yes	Yes	
Year ESP placed in service	1972	1972	1972	
Overall efficiency (percent) (with 2.5 percent sulfur or greater)	99	99	99	
Sulfur dioxide emissions:				
Sulfur content of coal (percent):				
Fiscal year 1973:				
Maximum weekly average	3.4	3.7	3.9	
Annual average	3.2	3.3	3.2	3.2
Allowable by emission standard: [b]				
Present	0.7	0.7	0.7	0.7
Revised	2.5	2.5	2.5	2.5
Proposed	2.5	2.5	2.5	2.5
Emission rates:				
Fiscal year 1973 (using actual heat input):				
Maximum 24-hr average (pound/second)	3.9	3.9	3.8	11.6
Total annual, fiscal year 1973 (tons)	22,579	32,611	35,309	89,510
Annual average (pound/10^6 Btu)	5.2	5.3	5.2	5.2
Allowable by emission standard: [b]				
Mass rate (pound/second):				
Present	1.0	1.0	1.0	2.9
Revised	3.3	3.3	3.3	9.7
Proposed	3.3	3.3	3.3	9.7
Process rate (pound/10^6 Btu):				
Present	1.2	1.2	1.2	1.2
Revised	4.0	4.0	4.0	4.0
Proposed	4.0	4.0	4.0	4.0

[a] Natural gas used—10,976 (10^9 ft^3).
[b] At maximum generator nameplate rating.

SO_2 AMBIENT INFORMATION

Name of plant: Allen Steam Plant.

Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.50
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.35
24-hr average (ppm)	0.08
Annual average (ppm)	0.011
Amount of record (instrument-yrs)	8
TVA calculations—present stack heights:	
3-hr average (ppm)	0.65
24-hr average (ppm)	0.15
Annual average (ppm)	0.007
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	2.5
24-hr-average standard:	
EPA	4.7
TVA	2.9
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	9.9
Process rate (lb/10^6 Btu): TVA	4.1
24-hr-average standard:	
Mass rate (lb/sec): TVA	11.6
Process rate (lb/10^6) Btu:	
EPA	8.1
TVA	4.8
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Bull Run Steam Plant.
Location: Clinton, Tenn.
AQCR: 207—Eastern Tennessee-Southwestern Virginia Interstate.

Priority classification:	
Particulates	I.
SO_2	I.
Maximum plant generator nameplate rating (MW)	950.
Number of generating units	1.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	11,140.
Ash content (percent)	15.2.
Sulfur content (percent)	1.0.
Maximum plant heat input (10^6 Btu/hr)	8,270.

DATA SHEET—continued

Annual coal consumption (10^3 tons):	
Fiscal year 1973	2,375.
At 100 percent capacity factor	3,248.
Source of coal (Bureau of Mines Coal Districts)	8.
Compliance with particulate emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	February 1977.
Total annual particulate emissions (fiscal year 1973) (tons)	54,863.[a]
Compliance with SO_2 emission standards	No.[c]
EPA-approved compliance schedule	
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	
Total annual SO_2 emissions (fiscal year 1973) (tons)	42,750.[b]

[a] This value is based on 20-percent ash retention in the boiler.
[b] This value is based on 90 percent of the sulfur being emitted as SO_2.
[c] If proposed revised standard is approved, the plant will be in compliance by burning low-sulfur coal.

BULL RUN STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit 1	Plant total
Generator nameplate rating (MW)	950	950
Boiler:		
Manufacturer	CE	
Type of firing	PCTA	
Type of bottom	Dry	
Annual coal use (10^3 tons):		
Fiscal year 1973	2,375	
At 100 percent capacity factor	3,248	
Maximum heat input (10^6 Btu/hr)	8,270	8,270
Year placed in service	1966	
Stack information:		
Existing:		
Number	1	
Height (feet)	800	
Planned:		
Number	NA	
Height (feet)	NA	
Particulate emissions:		
Ash content of coal, fiscal year 1973 (percent):		
Maximum weekly average	16.9	
Annual average	15.2	15.2
Emission rates (pounds/10^6 Btu):		
Fiscal year 1973 [using actual heat input]	2.07	
SIP emission standard*	0.10	
Control equipment:		
Mechanical collector	No	
Electrostatic precipitator	Yes	
Year ESP placed in service	1966	
Overall efficiency (percent) [with 2.25 percent sulfur or greater]	**99.0	
Sulfur dioxide emissions:		
Sulfur content of coal (percent):		
Fiscal year 1973:		
Maximum weekly average	1.5	1.0
Annual average	1.0	
Allowable by emission standard*:		
Present	0.7	0.7
Revised	2.5	2.5
Proposed	2.5	2.5
Emission rates:		
Fiscal year 1973 [using actual heat input]:		
Maximum 24-hr average (pound/second)	5.3	5.3
Total annual, fiscal year 1973 (tons)	42,750	42,750
Annual average (pound/10^6 Btu)	1.6	1.6
Allowable by emission standard *:		
Mass rate (pound/second):		
Present	2.8	2.8
Revised	9.2	9.2
Proposed	9.2	9.2
Process rate (pound/10^6 Btu):		
Present	1.2	
Revised	4.0	
Proposed	4.0	4.0

*At maximum generator nameplate rating.
**ESP efficiency is about 81 percent with the coal which is presently being burned. However, this is improved to about 95 percent with the use of SO_3 flue gas conditioning.

SO_2 AMBIENT INFORMATION

Name of plant: Bull Run Steam Plant.

Ambient standards:	
Secondary: 3-hr average[1] (ppm)	0.50
Primary:	
24-hr average[1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.21
24-hr average (ppm)	0.05
Annual average (ppm)	0.005
Amount of record (instrument-yrs)	31
TVA calculations—present stack heights:	
3-hr average (ppm)	0.14
24-hr average (ppm)	0.03
Annual average (ppm)	0.002
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	3.6
24-hr-average standard:	
EPA	1.8
TVA	5.0
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	13.3
Process rate (lb/10^6 Btu): TVA	5.8
24-hr-average standard:	
Mass rate (lb/sec): TVA	18.5
Process rate (lb/10^6 Btu):	
EPA	3.0
TVA	8.0
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Colbert Steam Plant.
Location: Tuscumbia, Ala.
AQCR: 007—Tennessee River Valley—Cumberland Mountains Interstate

Priority classification:	
Particulates	I.
SO_2	I.
Maximum plant generator nameplate rating (MW)	1,396.[a]
Number of generating units	5.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	11,160.
Ash content (1 percent)	15.3.
Sulfur content (1 percent)	4.0.
Maximum plant heat input (10^6 Btu/hr)	12,938.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	2,933.
At 100 percent capacity factor	5,110.

See footnotes at end of table.

DATA SHEET—continued

Source of coal (Bureau of Mines Coal Districts)	9, 10, 13.
Compliance with particulate emission standards	No.[b]
EPA-approved compliance schedule	
Final SIP compliance date	May 31, 1975.
TVA proposed final compliance date	October 1975.
Total annual particulate emissions (fiscal year 1973) (tons)	62,257.[c]
Compliance with SO_2 emission standards	No.[d]
EPA-approved compliance schedule	No.
Final SIP compliance date	May 31, 1975.
TVA proposed final compliance date	None.[e]
Total annual SO_2 emissions (fiscal year 1973) (tons)	211,200.[f]

[a] The gas turbine plant at the site has an additional capacity of 476 MW.
[b] Units 1–4 meet the standards; unit 5 does not.
[c] This value is based on 20-percent ash retention in the boiler.
[d] Pilot flue gas desulfurization is being performed at this plant.
[e] TVA proposes to meet ambient standards by using ICS.
[f] This value is based on 90 percent of the sulfur being emitted as SO_2.

COLBERT STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit					Plant total
	1	2	3	4	5	
Generator nameplate rating (MW)	200	200	223	223	550	1,396
Boiler:						
Manufacturer	B & W	B & W	B & W	B & W	B & W	
Type of firing	PCFR	PCFR	PCFR	PCFR	PCOP	
Type of bottom	Dry	Dry	Dry	Dry	Dry	
Annual coal use (10^3 tons):						
Fiscal year 1973	453	493	508	492	998	
At 100 percent capacity factor	771	771	771	771	2,033	
Maximum heat input (10^6 Btu/hr)	1,841	1,841	2,073	2,073	5,109	12,938
Year placed in service	1954	1955	1955	1955	1962	
Stack information:						
Existing:						
Number	1	2	3	4	5	
Height (feet)	300	300	300	300	500	
Planned:						
Number	NA	NA	NA	NA	NA	
Height (feet)	NA	NA	NA	NA	NA	
Particulate emissions:						
Ash content of coal, fiscal year 1973 (percent):						
Maximum weekly average	16.2	16.5	17.1	16.9	16.9	
Annual average	15.1	15.1	15.1	15.1	15.6	15.3
Emission rates (pounds/10^6 Btu):						
Fiscal year 1973 [using actual heat input]	0.08	0.08	0.08	0.08	5.5	
SIP emission standard*	0.12	0.12	0.12	0.12	0.12	
Control equipment:						
Mechanical collector	Yes	Yes	Yes	Yes	No	
Electrostatic precipitator	Yes	Yes	Yes	Yes	Yes	
Year ESP placed in service	1971	1972	1972	1972	1962	
Overall efficiency (percent) [with 3 percent sulfur or greater]	99.25	99.25	99.25	99.25	50	
Sulfur dioxide emissions:						
Sulfur content of coal (percent):						
Fiscal year 1973:						
Maximum weekly average	4.6	4.4	4.6	4.5	4.4	
Annual average	4.0	4.0	4.0	4.0	4.1	4.0
Allowable by emission standard:*						
Present	0.7	0.7	0.7	0.7	0.7	0.7
Revised	1.1	1.1	1.1	1.1	1.1	1.1
Proposed	2.5	2.5	2.5	2.5	2.5	2.5
Emission rates:						
Fiscal year 1973 [using actual heat input]:						
Maximum 24-hr average (pounds/second)	3.5	3.3	3.4	3.1	7.7	21.0
Total annual, fiscal year 1973 (tons)	32,616	35,496	36,576	35,424	73,652	211,200
Annual average (pounds/10^6 Btu)	6.5	6.5	6.5	6.5	6.6	6.5
Allowable by emission standard:*						
Mass rate (pounds/second):						
Present	0.6	0.6	0.7	0.7	1.7	4.3
Revised	0.9	0.9	1.0	1.0	2.6	6.5
Proposed	2.0	2.0	2.3	2.3	5.7	14.4
Process rate (pounds/10^6 Btu):						
Present	1.2	1.2	1.2	1.2	1.2	
Revised	1.8	1.8	1.8	1.8	1.8	
Proposed	4.0	4.0	4.0	4.0	4.0	4.0

*At maximum generator nameplate rating.

SO_2 AMBIENT INFORMATION

Name of plant: Colbert Steam Plant.	
Ambient standards:	
Secondary 3-hr average [1] (ppm)	0.50
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.79
24-hr average (ppm)	0.24
Annual average (ppm)	0.011
Amount of record (instrument-yrs)	7
TVA calculations—present stack heights:	
3-hr average (ppm)	1.9
24-hr average (ppm)	0.29
Annual average (ppm)	0.012
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr average standard: TVA	1.7
24-hr average standard:	
EPA	2.4
TVA	1.9
Emission rates—present stack heights:	
3-hr average standard:	
Mass rate (lb/sec): TVA	8.3
Process rate (lb/10^6 Btu): TVA	2.7
24-hr average standard:	
Mass rate (lb/sec): TVA	9.7
Process rate (lb/10^6 Btu):	
EPA	4.0
TVA	3.1
Emission rates—planned stack heights:	
3-hr average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Cumberland Steam Plant.	
Location: Cumberland City, Tenn.	
AQCR: 208—Middle Tennessee Intrastate.	
Priority classification:	
Particulates	I.
SO_2	II.
Maximum plant generator nameplate rating (MW)	2,600.
Number of generating units	2.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	10,510.
Ash content (percent)	15.8.
Sulfur content (percent)	3.6.

DATA SHEET—continued

Maximum plant heat input (10^6 Btu/hr)	23,475.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	2,743.
At 100 percent capacity factor	7,126.
Source of coal (Bureau of Mines coal districts)	9,10.
Compliance with particulate emission standards	Yes.
EPA-approved compliance schedule	
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	
Total annual particulate emissions (fiscal year 1973) (ton)	7,197.[a b]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None [c]
Total annual SO_2 emissions (fiscal year 1973) (tons)	461,600.[a d]

[a] This value is based on projected full-year plant operation.
[b] This value is based on 25-percent ash retention in the boiler.
[c] TVA proposes to meet ambient standards by using SCS.
[d] This value is based on 90 percent of the sulfur being emitted as SO_2.

CUMBERLAND STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit 1	Unit 2	Plant total
Generator nameplate rating (MW)	1,300	1,300	2,600
Boiler:			
Manufacturer	B&W	B&W	
Type of firing	PCOP	PCOP	
Type of bottom	Dry	Dry	
Annual coal use (10^3 tons):			
Fiscal year 1973	2,132	612	
At 100 percent capacity factor	3,563	3,562	
Maximum heat input (10^6 Btu/hr)	11,737	11,737	23,475
Year placed in service	1972	1973	
Stack Information:			
Existing:			
Number	1	2	
Height (feet)	1,000	1,000	
Planned:			
Number	NA	NA	
Height (feet)	NA	NA	
Particulate Emissions:			
Ash content of coal, fiscal year 1973 (percent):			
Maximum weekly average	17.1	16.7	
Annual average	15.8	15.6	15.8
Emission rates (pounds/10^6 Btu):			
Fiscal year 1973 [using actual heat input]	0.10	0.10	
SIP emission standard*	0.10	0.10	
Control equipment:			
Mechanical collector	No	No	
Electrostatic precipitator	Yes	Yes	
Year ESP placed in service	1972	1973	
Overall efficiency (percent) [with 2.5 percent sulfur or greater]	99.2	99.2	
Sulfur dioxide emissions:			
Sulfur content of coal (percent):			
Fiscal year 1973:			
Maximum weekly average	3.9	3.8	
Annual average	3.6	3.6	3.6
Allowable by emission standard:*			
Present	0.7	0.7	0.7
Revised	2.3	2.3	2.3
Proposed	2.3	2.3	2.3
Emission rates:			
Fiscal year 1973 [using actual heat input]:			
Maximum 24-hr. average (pounds/second)	17.3	15.7	33.1
Total annual, fiscal year 1973 (tons)	138,154	39,658	177,746
Annual average (pounds/10^6 Btu)	6.2	6.2	6.2
Allowable by emission standard* mass rate (pounds/second):			
Present	3.9	3.9	7.8
Revised	13.0	13.0	26.1
Proposed	13.0	13.0	26.1
Process rate (pound/10^6 Btu):			
Present	1.2	1.2	1.2
Revised	4.0	4.0	4.0
Proposed	4.0	4.0	4.0

* At maximum generator nameplate rating.

SO_2 AMBIENT INFORMATION

Name of plant: Cumberland Steam Plant.

Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.50
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.32
24-hr average (ppm)	0.08
Annual average (ppm)	0.005
Amount of record (instrument-yrs)	19
TVA calculations—present stack heights:	
3-hr average (ppm)	1.09
24-hr average (ppm)	0.22
Annual average (ppm)	0.011
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	1.7
24-hr-average standard:	
EPA	6.0
TVA	2.3
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	18.4
Process rate (lb/10^6 Btu): TVA	2.8
24-hr-average standard:	
Mass rate (lb/sec): TVA	25.6
Process rate (lb/10^6 Btu):	
EPA	10.3
TVA	3.9
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Gallatin Steam Plant.
Location: Gallatin, Tenn.
AQCR: 208—Middle Tennessee Intrastate.

Priority classification:	
Particulates	I.
SO_2	II.
Maximium plant generator nameplate rating (MW)	1,255.
Number of generating units	4.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	10,720.
Ash content (percent)	16.1.
Sulfur content (percent)	2.7.
Maximum plant heat input (10^6 Btu/hr)	11,103.

DATA SHEET—continued

Annual coal consumption (10^3 tons):	
Fiscal year 1973	3,050.
At 100 percent capacity factor	4,580.
Source of coal (Bureau of Mines coal districts)	8, 9, 11.
Compliance with particulate emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	October 1977.
Total annual particulate emissions (fiscal year 1973) (tons)	18,252.[a]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None.[b]
Total annual SO_2 emissions (fiscal year 1973) (tons)	148,200.[c]

[a] This value is based on 20-percent ash retention in the boiler.
[b] TVA proposes to meet ambient standards by using ICS.
[c] This value is based on 90 percent of the sulfur being emitted as SO_2.

GALLATIN STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit				Plant total
	1	2	3	4	
Generator nameplate rating (MW)	300	300	328	328	1,256
Boiler:					
Manufacturer	CE	CE	CE	CE	----
Type of firing	PCTA	PCTA	PCTA	PCTA	----
Type of bottom	Dry	Dry	Dry	Dry	----
Annual coal use (10^3 tons):					
Fiscal year 1973	714	761	770	805	----
At 100 percent capacity factor	1,118	1,118	1,174	1,174	----
Maximum heat input (10^6 Btu/hr)	2,669	2,669	2,883	2,883	11,103
Year placed in service	1956	1957	1959	1959	----
Stack information:					
Existing:					
Number	1	1	2	2	----
Height (feet)	500	500	500	500	----
Planned:					
Number	NA	NA	NA	NA	----
Height (feet)	NA	NA	NA	NA	----
Particulate emissions:					
Ash content of coal, fiscal year 1973 (percent):					
Maximum weekly average	19.5	18.6	19.2	20.5	----
Annual average	16.0	15.9	16.3	16.1	16.1
Emission rates (pound/10^6 Btu):					
Fiscal year 1973 [using actual heat input]	0.38	0.38	0.72	0.72	----
SIP emission standard*	0.10	0.10	0.10	0.10	----
Control equipment:					
Mechanical collector	Yes	Yes	Yes	Yes	----
Electrostatic precipitator	Yes	Yes	Yes	Yes	----
Year ESP placed in service	1699	1970	1970	1969	----
Overall efficiency (percent) [with 3.0 percent sulfur or greater]	92	92	90	90	----
Sulfur dioxide emissions:					
Sulfur content of coal (percent):					
Fiscal year 1973:					
Maximum weekly average	4.0	4.0	4.3	4.2	2.7
Annual average	2.7	2.6	2.7	2.8	----
Allowable by emission standard*:					
Present	0.7	0.7	0.7	0.7	0.7
Revised	2.4	2.4	2.4	2.4	2.4
Proposed	2.4	2.4	2.4	2.4	2.4
Emission rates:					
Fiscal year 1973 [using actual heat input]:					
Maximum 24-hr average (pounds/per second)	3.2	4.1	4.7	3.9	15.9
Total annual, fiscal year 1973 (tons)	34,700	35,615	37,422	40,572	148,200
Annual average (pounds/per 10^6 Btu)	4.5	4.3	4.6	4.7	4.5
Allowable by emission standard*					
Mass rate (pounds/per second):					
Present	0.9	0.9	1.0	1.0	3.7
Revised	3.0	3.0	3.2	3.2	12.3
Proposed	3.0	3.0	3.2	3.2	12.3
Process rate (pound/10^6 Btu):					
Present	1.2	1.2	1.2	1.2	1.2
Revised	4.0	4.0	4.0	4.0	4.0
Proposed	4.0	4.0	4.0	4.0	4.0

*At maximum generator nameplate rating.
NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: Gallatin Steam Plant.

Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.50
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.47
24-hr average (ppm)	0.14
Annual average (ppm)	0.005
Amount of record (instrument-yrs)	9
TVA calculations—present stack heights:	
3-hr average (ppm)	0.63
24-hr average (ppm)	0.14
Annual average (ppm)	0.006
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	2.2
24-hr-average standard:	
EPA	5.5
TVA	2.6
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	11.2
Process rate (lb/10^6 Btu): TVA	3.6
24-hr-average standard:	
Mass rate (lb/sec): TVA	13.7
Process rate (lb/10^6 Btu):	
EPA	9.8
TVA	4.4
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: John Sevier Steam Plant.
Location: Rogersville, Tenn.
AQCR: 207—Eastern Tennessee-Southwestern Virginia Interstate.

Priority classification:	
Particulates	I.
SO_2	I.
Maximum plant generator nameplate rating (MW)	823.[a]
Number of generating units	4.
Principal fuel	Coal.

DATA SHEET—continued

Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	11,630.
Ash content (percent)	14.9.
Sulfur content (percent)	1.8.
Maximum plant heat input (10^6 Btu/hr)	7,244.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	1,822.
At 100 percent capacity factor	2,773.
Source of coal (Bureau of Mines coal districts)	8, 11.
Compliance with particulate emission standards	No.
EPA-approved compliance schedule	Yes.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	Oct. 31, 1974.
Total annual particulate emissions (fiscal year 1973) (tons)	42,816.[b c]
Compliance with SO_2 emission standards	No.[d]
EPA-approved compliance schedule	NA.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None.
Total annual SO_2 emissions (fiscal year 1973) (tons)	59,000.[e]

[a] This is the total plant capacity as of June 30, 1973; on July 1, 1973, unit 2 was uprated 23 MW for a plant total of 846 MW.
[b] New precipitators are in service on units 1 and 2.
[c] This value is based on 20-percent ash retention in the boiler.
[d] If proposed revised standard is approved, the plant will be in compliance by burning low-sulfur coal. Some coal blending may be necessary, however.
[e] This value is based on 90 percent of the sulfur being emitted as SO_2.
NA. Not available.

JOHN SEVIER STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit				
	1	2	3	4	Plant total
Generator nameplate rating (MW)	223	200	200	200	823
Boiler:					
Manufacturer	CE	CE	CE	CE	----
Type of firing	PCTA	PCTA	PCTA	PCTA	----
Type of bottom	Dry	Dry	Dry	Dry	----
Annual coal use (10^3 tons):					
Fiscal year 1973	350	394	546	531	----
At 100 percent capacity factor	693	693	693	693	----
Maximum heat input (10^6 Btu/hr)	1,957	1,762	1,762	1,762	7,244
Year placed in service	1955	1956	1956	1957	----
Stack information:					
Existing:					
Number	1	1	2	2	----
Height (feet)	350	350	350	350	----
Planned:					
Number	NA	NA	NA	NA	----
Height (feet)	NA	NA	NA	NA	----
Particulate emissions:					
Ash content of coal, fiscal year 1973 (percent):					
Maximum weekly average	17.9	17.6	20.9	17.4	----
Annual average	14.8	14.8	14.9	14.8	14.9
Emission rates (pounds/10^6 Btu):					
Fiscal year 1973 [using actual heat input]	0.05	0.05	3.4	3.4	----
SIP emission standard*	0.11	0.11	0.11	0.11	----
Control equipment:					
Mechanical collector	Yes	Yes	Yes	Yes	----
Electrostatic precipitator	Yes	Yes	Yes	No	----
Year ESP placed in service	1973	1973	1974	NA	----
Overall efficiency (percent) [with 1 percent sulfur or greater]	99.5	99.5	99.5	67	----

See footnote at end of table.

JOHN SEVIER STEAMPLANT—PLANT AND EMISSIONS INFORMATION—Continued

	Unit				
	1	2	3	4	Plant total
Sulfur dioxide emissions:					
Sulfur content of coal (percent):					
Fiscal year 1973:					
Maximum weekly average	2.5	2.4	2.4	2.7	
Annual average	1.8	1.8	1.8	1.8	1.8
Allowable by emission standard:*					
Present	0.8	0.8	0.8	0.8	0.8
Revised	2.6	2.6	2.6	2.6	2.6
Proposed	2.6	2.6	2.6	2.6	2.6
Emission rates:					
Fiscal year 1973 [using actual heat input]:					
Maximum 24-hr average (pounds/second)	1.2	1.2	1.3	1.9	5.6
Total annual, fiscal year 1973 (tons)	11,340	12,766	17,690	17,204	59,000
Annual average (pounds/10^6 Btu)	2.8	2.8	2.8	2.8	2.8
Allowable by emission standard:*					
Mass rate (pounds/second):					
Present	0.7	0.6	0.6	0.6	2.4
Revised	2.2	2.0	2.0	2.0	8.0
Proposed	2.2	2.0	2.0	2.0	8.0
Process rate (pounds/10^6 Btu):					
Present	1.2	1.2	1.2	1.2	1.2
Revised	4.0	4.0	4.0	4.0	4.0
Proposed	4.0	4.0	4.0	4.0	4.0

*At maximum generator nameplate rating.
NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: John Sevier Steam Plant.	
Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.5
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.28
24-hr average (ppm)	0.06
Annual average (ppm)	(2)
Amount of record (instrument-yrs)	2
TVA calculations—present stack heights:	
3-hr average (ppm)	0.29
24-hr average (ppm)	0.07
Annual average (ppm)	0.003
TVA calculations—planned stack heights:	
3-hr average (ppm)	(2)
24-hr average (ppm)	(2)
Annual average (ppm)	(2)
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	3.1
24-hr-average standard:	
EPA	2.3
TVA	3.6

See footnotes at end of table.

SO_2 AMBIENT INFORMATION—continued

Specifications of techniques for meeting ambient standards—Continued	
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	9.7
Process rate (lb/10^6 Btu): TVA	4.8
24-hr-average standard:	
Mass rate (lb/sec): TVA	11.1
Process rate (lb/10^6 Btu):	
EPA	3.6
TVA	5.5
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Johnsonville Steam Plant.	
Location: New Johnsonville, Tenn.	
AQCR: 208—Middle Tennessee Intrastate.	
Priority classification:	
Particulates	I.
SO_2	II.
Maximum plant generator nameplate rating (MW)	1,485.
Number of generating units	10.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	10,960.
Ash content (percent)	14.3.
Sulfur content (percent)	3.7.
Maximum plant heat input (10^6 Btu/hr)	14,450.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	3,192.
At 100 percent capacity factor	5,803.
Source of coal (Bureau of Mines coal districts)	8, 9, 11.
Compliance with particulate emission standards	No.[a]
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	July 1976.
Total annual particulate emissions (fiscal year 1973) (tons)	130,221.[b]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None.[c]
Total annual SO_2 emissions (fiscal year 1973) (tons)	212,600.[d]

[a] Units 1–2 and 7–10 meet the standards; units 3–6 do not.
[b] This value is based on 20-percent ash retention in the boiler.
[c] TVA proposes to meet ambient standards by using ICS.
[d] This value is based on 90 percent of the sulfur being emitted as SO_2.

JOHNSONVILLE STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit										
	1	2	3	4	5	6	7	8	9	10	Plant total
Generator nameplate rating (MW)	125	125	125	125	147	147	173	173	173	173	1,486
Boiler:											
Manufacturer	CE	CE	CE	CE	CE	CE	FW	FW	FW	FW	
Type of firing	PCTA	PCTA	PCTA	PCTA	PCTA	PCTA	PCFR	PCFR	PCFR	PCFR	
Type of bottom	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	
Annual coal use (10^3 tons):											
Fiscal 1973	295	317	344	338	201	315	319	378	351	333	
At 100 percent capacity factor	544	544	544	544	544	544	636	636	636	636	
Maximum heat input (10^6 Btu/hr)	1,274	1,274	1,274	1,274	1,511	1,511	1,583	1,583	1,583	1,583	14,450
Year placed in service	1951	1951	1951	1952	1952	1952	1958	1959	1959	1959	
Stack information:											
Existing:											
Number	1	2	3	4	5	6	7	7	7	7	
Height (feet)	272	272	272	272	272	272	400	400	400	400	
Planned:											
Number	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Height (feet)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Particulate emissions:											
Ash content of coal, fiscal year 1973 (percent):											
Maximum weekly average	17.1	16.1	16.1	16.9	16.3	16.7	16.3	16.9	16.7	17.1	
Annual average	14.5	14.4	14.3	14.5	14.1	14.4	14.1	14.3	14.2	14.2	14.3
Emission rates (pounds/10^6 Btu):											
Fiscal year 1973 [using actual heat input]	4.2	4.2	4.2	4.2	4.2	4.2	3.1	3.1	0.04	0.04	
SIP emission standard [1]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	

Control equipment:											
Mechanical collector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	----------
Electrostatic precipitator	No	No	No	No	No	No	No	No	Yes	Yes	----------
Year ESP placed in service	NA	NA	NA	NA	NA	NA	NA	NA	1974	1974	----------
Overall efficiency (percent) (at 2 percent sulfur or greater (1–6), 3.6 percent sulfur or greater (7–10))	60	60	60	60	60	60	70	70	99.6	99.6	----------
Sulfur dioxide emissions:											
Sulfur content of coal (percent):											
Fiscal year 1973:											
Maximum weekly average	4.1	4.0	4.2	4.1	4.6	4.3	4.0	4.2	4.3	4.2	----------
Annual average	3.7	3.7	3.7	3.7	3.8	3.7	3.7	3.7	3.8	3.7	3.7
Allowable by emission standard: [1]											
Present	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Revised	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Proposed	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Emission rates:											
Fiscal year 1973 (using actual heat input):											
Maximum 24-hr. average (pounds/second)	2.1	2.1	1.9	2.0	1.9	2.0	2.3	2.4	2.3	2.2	21.2
Total annual, fiscal year 1973 (tons)	19,647	21,112	22,910	22,511	13,748	20,979	21,245	25,175	24,008	22,178	212,600
Annual average (pounds/10^6 Btu)	6.1	6.1	6.1	6.1	6.2	6.1	6.1	6.1	6.2	6.1	6.1
Allowable by emission standard: [1]											
Mass rate (pounds/second):											
Present	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	4.8
Revised	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.3	12.0
Proposed	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	4.8
Process rate (pounds/10^6 Btu):											
Present	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Revised	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Proposed	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

[1] At maximum generator nameplate rating.
NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: Johnsonville Steam Plant.

Ambient standards:	
Secondary: 3-hr average[1]: (ppm)	0.50
Primary:	
24-hr average[1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.61
24-hr average (ppm)	0.16
Annual average (ppm)	0.013
Amount of record (instrument-yrs)	12
TVA calculations—present stack heights:	
3-hr average (ppm)	1.31
24-hr average (ppm)	0.31
Annual average (ppm)	0.014
TVA calculations—planned stack heights:	
3-hr average (ppm)	(2)
24-hr average (ppm)	(2)
Annual average (ppm)	(2)
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	1.4
24-hr-average standard:	
EPA	<0.7
TVA	1.7
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	9.4
Process rate (lb/10^6 Btu): TVA	2.3
24-hr-average standard:	
Mass rate (lb/sec): TVA	11.1
Process rate (lb/10^6 Btu):	
EPA	<1.2
TVA	2.8
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	(2)
Process rate (lb/10^6 Btu): TVA	(2)
24-hr-average standard:	
Mass rate (lb/sec): TVA	(2)
Process rate (lb/10^6 Btu):	
EPA	(2)
TVA	(2)

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Kingston Steam Plant.
Location: Kingston, Tenn.
AQCR: 207—Eastern Tennessee-Southwestern Virginia Interstate.

Priority classification:	
Particulates	I.
SO_2	I.
Maximum plant generator nameplate rating (MW)	1,700.
Number of generating units	9.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	10,830.
Ash content (percent)	19.6.
Sulfur content (percent)	2.2.
Maximum plant heat input (10^6 Btu/hr)	15,314.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	4,282.
At 100 percent capacity factor	6,251.
Source of coal (Bureau of Mines coal districts)	8.
Compliance with particulate emission standards	No.
EPA-approved compliance schedule	No.[a]
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	July 1976.
Total annual particulate emissions (fiscal year 1973) (tons)	51,620.[b]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None.[c]
Total annual SO_2 emissions (fiscal year 1973) (tons)	169,600[d]

[a] Approval has been recommended for unit 1.
[b] This value is based on 20-percent ash retention in the boiler.
[c] TVA proposes to meet ambient standards by using ICS and taller stacks.
[d] This value is based on 90 percent of the sulfur being emitted as SO_2.

KINGSTON STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit									Plant total
	1	2	3	4	5	6	7	8	9	
Generator nameplate rating (MW)	175	175	175	175	200	200	200	200	200	1,700
Boiler:										
Manufacturer	CE	CE	CE	CE	CE	CE	CE	CE	CE	
Type of firing	PCTA	PCTA	PCTA	PCTA	PCTA	PCTA	PCTA	PCTA	PCTA	
Type of bottom	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	
Annual coal use (10^3 tones):										
Fiscal year 1973	375	406	421	418	550	507	529	538	538	
At 100 percent capacity factor	654	654	654	654	727	727	727	727	729	
Maximum heat input (10^6 Btu/hr)	1,617	1,617	1,617	1,617	1,769	1,679	1,769	1,769	1,769	15,314
Year placed in service	1954	1954	1954	1954	1955	1955	1955	1955	1955	
Stack information:										
Existing:										
Number	1	2	3	4	5	6	7	8	9	
Height (feet)	250	250	250	250	300	300	300	300	300	
Planned:										
Number	1	1	1	1	1	2	2	2	2	
Height (feet)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
Particulate emissions:										
Ash content of coal, fiscal year 1973 (percent):										
Maximum weekly average	21.7	23.0	23.0	21.9	23.1	22.6	22.0	22.5	23.1	
Annual average	19.6	19.6	19.2	19.2	19.8	19.7	19.9	19.5	20.1	19.6
Emission rates (pounds/10^6 Btu):										
Fiscal year 1973 [using actual heat input]	1.16	1.16	1.16	1.16	1.09	1.09	1.09	1.09	1.09	

SIP emission standard*	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	----
Control equipment:										
Mechanical collector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	----
Electrostatic precipitator	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	----
Year ESP placed in service	1960	1960	1960	1960	1959	1960	1960	1960	1960	----
Overall efficiency (percent) [with 1 percent sulfur or greater]	92	92	92	92	92.5	92.5	92.5	92.5	92.5	----
Sulfur dioxide emissions:										
Sulfur content of coal (percent):										
Fiscal year 1973:										
Maximum weekly average	2.7	2.7	2.9	2.7	2.6	2.6	2.8	2.8	2.6	----
Annual average	2.2	2.2	2.2	2.2	2.2	2.2	2.3	2.2	2.3	2.2
Allowable by emission standard*:										
Present	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	.7	0.7
Revised	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Proposed	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Emission rates:										
Fiscal year 1973 [using actual heat input]:										
Maximum 24-hr average (pound/second)	1.3	1.2	1.3	1.1	1.9	1.8	2.2	1.9	2.0	14.8
Total annual, fiscal year 1973 (tons)	14,850	16,078	16,672	16,553	21,780	20,077	21,901	21,305	22,273	169,600
Annual average (pound/10^6 Btu)	3.6	3.7	3.6	3.6	3.7	3.7	3.8	3.6	3.9	3.7
Allowable by emission standard*:										
Mass rate (pound/second):										
Present	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	5.1
Revised	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	6.8
Proposed	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	5.1
Process rate (pound/10^6 Btu):										
Present	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Revised	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Proposed	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

*At maximum generator nameplate rating.

SO_2 AMBIENT INFORMATION

Name of plant: Kingston Steam Plant.

Ambient standards:	
Secondary: 3-hr average[1] (ppm)	0.5
Primary:	
24-hr average[1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.83
24-hr average (ppm)	0.45
Annual average (ppm)	0.020
Amount of record (instrument-yrs)	55
TVA calculations—present stack heights:	
3-hr average (ppm)	1.01
24-hr average (ppm)	0.56
Annual average (ppm)	0.026
TVA calculations—planned stack heights:	
3-hr average (ppm)	0.46
24-hr average (ppm)	0.11
Annual average (ppm)	0.005
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	1.1
24-hr-average standard:	
EPA	<.7
TVA	0.6
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	7.7
Process rate (lb/10^6 Btu): TVA	1.8
24-hr-average standard:	
Mass rate (lb/sec): TVA	3.9
Process rate (lb/10^6 Btu):	
EPA	<1.2
TVA	0.9
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec). TVA	17.1
Process rate (lb/10^6 Btu): TVA	4.0
24-hr-average standard:	
Mass rate (lb/sec): TVA	20.2
Process rate (lb/10^6 Btu):	
EPA	(2)
TVA	4.8

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Paradise Steam Plant.
Location: Drakesboro, Ky.
AQCR: 072—Paducah-Cairo Interstate.

Priority classification:	
Particulates	I.
SO_2	II.

DATA SHEET—continued

Maximum plant generator nameplate rating (MW)	2,558.
Number of generating units	3.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	10,340.
Ash content (percent)	18.4.
Sulfur content (percent)	4.2.
Maximum plant heat input (10^9 Btu/hr)	23,246.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	6,668.
At 100 percent capacity factor	9,879.
Source of coal (Bureau of Mines coal districts)	9.
Compliance with particulate emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	Apr. 9, 1975.
TVA proposed final compliance date	July 1975.
Total annual particulate emissions (fiscal year 1973) (tons)	15,336.[a]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1978.
TVA proposed final compliance date	None.[b]
Total annual SO_2 emissions (fiscal year 1973) (tons)	504,100.[c]

[a] This value is based on 25-percent ash retention in the boiler.
[b] TVA proposes to meet ambient standards by using ICS.
[c] This value is based on 90 percent of the sulfur being emitted as SO_2.

PARADISE STEAM PLANT—PLANT AND EMISSIONS INFORMATION

	Unit 1	Unit 2	Unit 3	Plant total
Generator nameplate rating (MW)	704	704	1,150	2,558
Boiler:				
Manufacturer	B. & W.	B. & W.	B. & W.	----
Type of firing	CYCL	CYCL	CYCL	----
Type of bottom	Wet	Wet	Wet	----
Annual coal use (10^3 tons):				
Fiscal year 1973	1,944	1,856	2,869	----
At 100 percent capacity factor	2,707	2,707	4,462	----
Maximum heat input (10^6 Btu/hr)	6,454	6,454	10,338	23,246
Year placed in service	1963	1963	1964	----
Stack information:				
Existing:				
Number	1	2	3	----
Height (feet)	600	600	800	----
Planned:				
Number	NA	NA	NA	----
Height (feet)	NA	NA	NA	----
Particulate emissions:				
Ash content of coal, fiscal year 1973 (percent):				
Maximum weekly average	20.8	21.3	20.4	----
Annual average	18.3	18.5	18.4	18.4
Emission Rates (pound/10^6 Btu):				
Fiscal year 1973 [using actual heat input]	0.22	0.22	0.22	----
SIP emission standard [1]	0.11	0.11	0.11	----
Control equipment:				
Mechanical collector	No	No	No	----
Electrostatic precipitator	Yes	Yes	Yes	----
Year ESP placed in service	1967	1967	1969	----
Overall efficiency (percent) [with 2.5 percent sulfur or greater]	95	95	95	----

See footnote at end of table.

PARADISE STEAM PLANT—PLANT AND EMISSIONS INFORMATION—Continued

	Unit			Plant total
	1	2	3	
Sulfur dioxide emissions:				
Sulfur content of coal (percent):				
Fiscal year 1973:				
Maximum weekly average	4.8	4.6	4.5	4.2
Annual average	4.1	4.2	4.2	4.2
Allowable by emission standard: [1]				
Present	1.1	1.1	1.1	1.1
Revised	NA	NA	NA	NA
Proposed	2.3	2.3	2.3	2.3
Emission Rates:				
Fiscal year 1973 [using actual heat input]:				
Maximum 24-hr average (pounds per second)	14.0	13.6	21.8	49.4
Total annual, fiscal year 1973 (tons)	143,467	140,314	216,896	504,100
Annual average (pounds/10^6 Btu)	7.1	7.3	7.3	7.3
Allowable by emission standard: [1]				
Mass rate (pounds per second):				
Present	3.6	3.6	5.7	12.9
Revised	NA	NA	NA	NA
Proposed	7.2	7.2	11.5	25.8
Process rate (pound/10^6 Btu):				
Present	2.0	2.0	2.0	2.0
Revised	NA	NA	NA	NA
Proposed	4.0	4.0	4.0	4.0

[1] At maximum generator nameplate rating.
NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: Paradise Steam Plant.	
Ambient standards	
Secondary: 3-hr average [1] (ppm)	0.5
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.79
24-hr average (ppm)	0.17
Annual average (ppm)	0.011
Amount of record (instrument-yrs)	100
TVA calculations—present stack heights:	
3-hr average (ppm)	1.54
24-hr average (ppm)	0.32
Annual average (ppm)	0.016
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	1.4
24-hr-average standard:	
EPA	2.9
TVA	1.8
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	15.2
Process rate (lb/10^6 Btu): TVA	2.4

See footnotes at end of table.

SO_2 AMBIENT INFORMATION—continued

Specifications of techniques for meeting ambient standards—Continued	
Emission rates—present stack heights—Continued	
24-hr-average standard:	
Mass rate (lb/sec): TVA	20.4
Process rate (lb/10^6 Btu):	
EPA	5.5
TVA	3.1
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Shawnee Steam Plant.
Location: Paducah, Ky.
AQCR: 072—Paducah-Cairo Interstate.

Priority classification:	
Particulates	I.
SO_2	II.
Maximum plant generator nameplate rating (MW)	1,750.
Number of generating units	10.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	10,470.
Ash content (percent)	15.4.
Sulfur content (percent)	2.7.
Maximum plant heat input (10^6 Btu/hr)	16,170.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	4,703.
At 100 percent capacity factor	6,827.
Source of coal (Bureau of Mines coal districts)	9, 10.
Compliance with particulate emission standards:	
EPA-approved compliance schedule	No.
Final SIP compliance date	Apr. 9, 1975.
TVA proposed final compliance date	December 1977.
Total annual particulate emissions (fiscal year 1973) (tons)	12,466.[a]
Compliance with SO_2 emission standards	No.[b]
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1978.
TVA proposed final compliance date	None.[c]
Total annual SO_2 emissions (fiscal year 1973) (tons)	228,600.[d]

[a] This value is based on 20-percent ash retention in the boiler.
[b] Pilot flue gas desulfurization is being performed at this plant.
[c] TVA proposes to meet ambient standards by using ICS and taller stacks.
[d] This value is based on 90 percent of the sulfur being emitted as SO_2.

SHAWNEE STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit										Plant total
	1	2	3	4	5	6	7	8	9	10	
Generator nameplate rating (MW)	175	175	175	175	175	175	175	175	175	175	1,750
Boiler:											
Manufacturer	B & W	B & W	B & W	B & W	B & W	B & W	B & W	B & W	B & W	B & W	----
Type of firing	PCFR	PCFR	PCFR	PCFR	PCFR	PCFR	PCFR	PCFR	PCFR	PCFR	----
Type of bottom	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	----
Annual coal use (10^3 tons):											
Fiscal year 1973	512	499	504	499	443	454	527	454	416	446	----
At 100 percent capacity factor	683	683	683	683	683	683	683	683	683	683	----
Maximum heat input (10^6 Btu/hr)	1,617	1,617	1,617	1,617	1,617	1,617	1,617	1,617	1,617	1,617	16,170
Year placed in service	1953	1953	1953	1954	1954	1954	1954	1955	1955	1956	----
Stack information:											
Existing:											
Number	1	2	3	4	5	6	7	8	9	10	----
Height (feet)	250	250	250	250	250	250	250	250	250	250	----
Planned:											
Number	1	1		1	1	2	2	2	2	2	----
Height (feet)	800	800	800	800	800	800	800	800	800	800	----
Particulate emissions:											
Ash content of coal, fiscal year 1973 (percent):											
Maximum weekly average	18.8	19.2	19.3	18.1	17.8	17.9	17.2	18.8	18.1	18.6	----
Annual average	15.7	15.4	15.4	15.4	15.3	15.1	15.2	15.3	15.3	15.3	15.4
Emission rates (pounds/10^6 Btu):*											
Fiscal year 1973 [using actual heat input]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	----
SIP emission standard**	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	----

Control equipment:											
Mechanical collector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	----
Electrostatic precipitator	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	----
Year ESP placed in service	1970	1969	1969	1969	1970	1969	1970	1970	1969	1969	----
Overall efficiency (percent) [with 2.7 percent sulfur or greater]	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	----
Sulfur dioxide imissions:											
Sulfur content of coal (percent):											
Fiscal year 1973:											
Maximum weekly average	3.5	3.4	3.6	3.2	3.5	3.8	3.8	3.5	3.6	3.6	----
Annual average	2.6	2.7	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.9	2.7
Allowable by emission standard:*											
Present	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Revised	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Proposed	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Emission rates:											
Fiscal year 1973 [using actual heat input]:											
Maximum 24-hr average (pound section)	2.1	2.2	2.2	2.1	2.4	2.4	2.0	1.9	2.1	2.0	21.3
Total annual, fiscal year 1973 (tons)	23,962	24,251	23,587	24,251	21,530	22,064	25,612	22,064	20,218	23,281	228,660
Annual average (pound/10^6 Btu)	4.5	4.7	4.5	4.6	4.6	4.6	4.6	4.6	4.6	5.0	4.6
Allowable by emisson standard:*											
Mass rate (pounds/second):											
Present	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	9.0
Revised	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Proposed	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	9.0
Process rate (pounds/10^6 Btu):											
Present	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Revised	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Proposed	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

*At maximum generator nameplate rating.
**TVA contends that this standard should be 0.24 lb particulate/10^6 Btu.

NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: Shawnee Steam Plant.

Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.5
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.67
24-hr average (ppm)	0.24
Annual average (ppm)	0.020
Amount of record (instrument-yrs)	15
TVA calculations—present stack heights:	
3-hr average (ppm)	1.08
24-hr average (ppm)	0.24
Annual average (ppm)	0.011
TVA calculations—planned stack heights:	
3-hr average (ppm)	0.59
24-hr average (ppm)	0.14
Annual average (ppm)	0.006
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights	
3-hr-average standard: TVA	1.2
24-hr-average standard:	
EPA	1.0
TVA	1.4
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	9.6
Process rate (lb/10^6 Btu): TVA	2.1
24-hr-average standard:	
Mass rate (lb/sec): TVA	10.5
Process rate (lb/10^6 Btu):	
EPA	1.9
TVA	2.3
Emission rates—planned stack heights:	
3-hr-average standard	
Mass rate (lb/sec): TVA	17.6
Process rate (lb/10^6 Btu): TVA	3.9
24-hr-average standard:	
Mass rate (lb/sec): TVA	20.2
Process rate (lb/10^6 Btu):	
EPA	
TVA	4.5

[1] Not to be exceeded more than once per year.

DATA SHEET

Name of plant: Watts Bar Steam Plant.
Location: Spring City, Tenn.
AQCR: 207—Eastern Tennessee-Southwestern Virginia Interstate.

Priority classification:	
Particulates	I.
SO_2	I.
Maximum plant generator nameplate rating (MW)	240.
Number of generating units	4.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	11,130.
Ash content (percent)	15.5.
Sulfur content (percent)	3.8.
Maximum plant heat input (10^6 Btu/hr)	2,763.
Annual coal consumption (10^3 tons):	
Fiscal year 1973	518.
At 100 percent capacity factor	1,091.

DATA SHEET—continued

Source of coal (Bureau of Mines coal districts)	9, 13.
Compliance with particulate emission standards	No.
EPA-approved compliance schedule	Yes.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	June 1975.
Total annual particulate emissions (fiscal year 1973) (tons)	2,014.[a]
Compliance with SO_2 emission standards	No.
EPA-approved compliance schedule	No.
Final SIP compliance date	July 1, 1975.
TVA proposed final compliance date	None.
Total annual SO_2 emissions (fiscal year 1973) (tons)	35, 431.

[a] This value is based on 50-percent ash retention in the boiler.

WATTS BAR STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit				Plant total
	A	B	C	D	
Generator nameplate rating (MW)	60	60	60	60	240
Boiler:					
Manufacturer	B & W	B & W	B & W	B & W	
Type of firing	(†)	(†)	(†)	(†)	
Type of bottom	(‡)	(‡)	(‡)	(‡)	
Annual coal use (10^3 tons):					
Fiscal year 1973	134	135	113	137	
At 100 percent capacity factor	273	273	273	273	
Maximum heat input (10^6 Btu/hr)	691	691	691	691	
Year placed in service	1942	1942	1943	1945	
Stack information:					
Existing:					
Number	1	2	3	4	
Height (feet)	177	177	177	177	
Planned:					
Number	NA	NA	NA	NA	
Height (feet)	NA	NA	NA	NA	
Particulate emissions:					
Ash content of coal, fiscal year 1973 (percent):					
Maximum weekly average	17.5	17.6	17.3	17.6	
Annual average	15.7	15.6	15.5	15.3	15.5
Emission rates (pounds/10^6 Btu):					
Fiscal year 1973 [using actual heat input]	0.35	0.35	0.35	0.34	
SIP emission standard*	0.14	0.14	0.14	0.14	
Control equipment:					
Mechanical collector	No	No	No	No	
Electrostatic precipitator	Yes	Yes	Yes	Yes	
Year ESP placed in service	1969	1969	1969	1969	
Overall efficiency (percent) [with 1 percent sulfur or greater]	95	95	95	95	
Sulfur dioxide emissions:					
Sulfur content of coal (percent):					
Fiscal year 1973:					
Maximum weekly average	4.7	4.4	4.6	4.7	
Annual average	3.8	3.9	3.8	3.9	3.8
Allowable by emission standard*					
Present	0.7	0.7	0.7	0.7	0.7
Revised	2.5	2.5	2.5	2.5	2.5
Proposed	2.5	2.5	2.5	2.5	2.5
Emission rates:					
Fiscal year 1973 [using actual heat input]:					
Maximum 24-hr average (pounds/second)	1.3	1.4	1.3	1.4	5.3
Total annual, fiscal year 1973 (tons)	9,166	9,477	7,729	7,617	35,431
Annual average (pounds/10^6 Btu)	6.1	6.3	6.2	6.3	6.1
Allowable by emission standard:*					
Mass rate (pounds/second):					
Present	0.2	0.2	0.2	0.2	0.9
Revised	0.8	0.8	0.8	0.8	2.1
Proposed	0.8	0.8	0.8	0.8	2.1
Process rate (pounds/10^6 Btu):					
Present	1.2	1.2	1.2	1.2	1.2
Revised	4.0	4.0	4.0	4.0	4.0
Proposed	4.0	4.0	4.0	4.0	4.0

*At maximum generator nameplate rating.
†Pulverized coal, vertical.
‡Wet and dry.
NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: Watts Bar Steam Plant

Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.5
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	0.35
24-hr average (ppm)	0.08
Annual average (ppm)	[2]
Amount of record (instrument-yrs)	2
TVA calculations—present stack heights:	
3-hr average (ppm)	0.37
24-hr average (ppm)	0.08
Annual average (ppm)	0.004
TVA calculations—planned stack heights:	
3-hr average (ppm)	[2]
24-hr average (ppm)	[2]
Annual average (ppm)	[2]
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard: TVA	5.2
24-hr-average standard:	
EPA	1.4
TVA	6.5
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	6.5
Process rate (lb/10^6 Btu): TVA	8.4
24-hr-average standard:	
Mass rate (lb/sec): TVA	8.0
Process rate (lb/10^6 Btu):	
EPA	2.4
TVA	10.5
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu): TVA	[2]
24-hr-average standard:	
Mass rate (lb/sec): TVA	[2]
Process rate (lb/10^6 Btu):	
EPA	[2]
TVA	[2]

[1] Not to be exceeded more than once per year.
[2] Not available.

DATA SHEET

Name of plant: Widows Creek Steam Plant.
Location: Stevenson, Ala.
AQCR: 007—Tennessee River Valley—Cumberland Mountains Interstate.

Priority classification:	
Particulates	I.
SO_2	I.
Maximum plant generator nameplate rating (MW)	1,978.
Number of generating units	8.
Principal fuel	Coal.
Average coal quality (fiscal year 1973, as fired):	
Heat content (HHV) (Btu/lb)	11,250 (1–6).
	11,330 (7–8).
Ash content (percent)	16.8 (1–6).
	14.6 (7–8).
Sulfur content (percent)	2.7 (1–6).
	3.7 (7–8).
Maximum plant heat input (10^6 Btu/hr)	19,364.

DATA SHEET—continued

Annual coal consumption (10^3 tons):	
Fiscal year 1973	3,669.
At 100 percent capacity factor	7,427.
Source of coal (Bureau of Mines coal districts)	8, 9, 13.
Compliance with particulate emission standards	No.[a]
EPA—approved compliance schedule	No.
Final SIP compliance date	May 31, 1975.
TVA proposed final compliance date	July 1977.
Total annual particulate emission (fiscal year 1973) (tons)	149,247.[b]
Compliance with SO_2 emission standards	No.
EPA—approved compliance schedule	No.[c]
Final SIP compliance date	May 31, 1975.
TVA proposed final compliance date	No.[d e]
Total annual SO_2 emissions (fiscal year 1973) (tons)	204,700.[f]

[a] Unit 7 meets the standards; units 1–6 and 8 do not.
[b] This value is based on 20-percent ash retention in the boiler.
[c] Experimental flue gas desulfurization is planned for unit 8.
[d] November 1976 for unit 8.
[e] TVA proposes to meet ambient standards by using a combination of SCS, a taller stack, low-sulfur coal, and experimental flue gas desulfurization.
[f] This value is based on 90 percent of the sulfur being emitted as SO_2

WIDOWS CREEK STEAMPLANT—PLANT AND EMISSIONS INFORMATION

	Unit								Plant total
	1	2	3	4	5	6	7	8	
Generator nameplate rating (MW)	141	141	141	150	141	141	575	550	1,978
Boiler:									
Manufacturer	B & W	B & W	B & W	B & W	B & W	B & W	CE	CE	
Type of firing	PCFR	PCFR	PCFR	PCFR	PCFR	PCRF	PCTA	PCTA	
Type of bottom	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	
Annual coal use (10^3 tons):									
Fiscal year 1973	355	317	316	226	332	374	927	822	
At 100 percent capacity factor	572	572	572	572	538	538	2,131	1,890	
Maximum heat input (10^6 Btu/hr)	1,476	1,476	1,585	1,476	1,387	1,387	5,393	5,183	19,364
Year placed in service	1952	1952	1952	1953	1954	1954	1960	1964	
Stack information:									
Existing:									
Number	1	2	3	4	5	6	7	8	
Height (feet)	270	270	270	270	270	270	500	500	
Planned:									
Number	1	1	1	1	1	1	2	3	
Height (feet)	1,000	1,000	1,000	1,000	1,000	1,000	500	500	
Particulate emissions:									
Ash content of coal, fiscal year 1973 (percent):									
Maximum weekly average	20.8	21.4	20.0	22.6	20.3	20.1	17.1	19.6	
Annual average	17.2	17.1	16.8	17.0	16.3	16.2	14.6	14.6	15.7
Emission rates (pounds/10^6 Btu):									
Fiscal year 1973 [using actual heat input]	4.5	4.5	4.5	4.5	4.5	4.5	0.11	5.6	
SIP emission standard [1]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Control equipment:									
Mechanical collector	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
Electrostatic precipitator	No	No	No	No	No	No	Yes	Yes	
Year ESP placed in service	NA	NA	NA	NA	NA	NA	1960	1964	
Overall efficiency (percent) [with 3 percent sulfur or greater]	60	60	60	60	60	60	99	50	
Sulfur dioxide emissions:									
Sulfur content of coal (percent):									
Fiscal year 1973:									
Maximum weekly average	4.0	4.2	4.1	4.5	4.2	4.1	4.1	4.1	
Annual average	2.5	2.5	2.6	2.6	2.8	2.9	3.6	3.7	3.1
Allowable by emission standard: [1]									
Present	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Revised	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Proposed	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Emission rates:									
Fiscal year 1973 [using actual heat input]:									
Maximum 24-hr average (pounds/second)	1.8	2.0	2.0	2.1	1.9	1.8	7.2	7.4	26.2
Total annual, fiscal year 1973	15,975	14,265	14,789	10,577	16,733	19,523	60,070	54,745	204,700
Annual average (pound/10^6 Btu)	4.0	4.0	4.2	4.2	4.5	4.6	5.7	5.9	4.9
Allowable by emission standard:									
Mass rate (pounds/second):									
Present	0.5	0.5	0.5	0.5	0.5	0.5	1.8	1.7	6.5
Revised	0.7	0.7	0.8	0.7	0.7	0.7	2.7	2.6	9.7
Proposed	0.5	0.5	0.5	0.5	0.5	0.5	1.8	1.7	6.5
Process rate (pounds/10^6 Btu):									
Present	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Revised	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Proposed	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

[1] At maximum generator nameplate rating.
NA. Not available.

SO_2 AMBIENT INFORMATION

Name of plant: Widows Creek Steam Plant.

Ambient standards:	
Secondary: 3-hr average [1] (ppm)	0.5
Primary:	
24-hr average [1] (ppm)	0.14
Annual average (ppm)	0.03
Maximum concentrations:	
TVA measurements:	
3-hr average (ppm)	3.03
24-hr average (ppm)	0.52
Annual average (ppm)	0.019
Amount of record (instrument-yrs)	26
TVA calculations—present stack heights:	
3-hr average (ppm)	4.85
24-hr average (ppm)	1.31
Annual average (ppm)	0.018
TVA calculations—planned stack heights:	
3-hr average (ppm)	1.97
24-hr average (ppm)	0.49
Annual average (ppm)	0.011
Specifications of techniques for meeting ambient standards:	
Sulfur content of coal (percent)—present stack heights:	
3-hr-average standard:	
TVA	0.3
24-hr-average standard:	
EPA	<.7
TVA	0.3
Emission rates—present stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	2.5
Process rate (lb/10^6 Btu): TVA	[2] 0.7
24-hr-average standard:	
Mass rate (lb/sec): TVA	2.6
Process rate (lb/10^6 Btu):	
EPA	<1.2
TVO	[2] 0.8
Emission rates—planned stack heights:	
3-hr-average standard:	
Mass rate (lb/sec): TVA	8.6
Process rate (lb/10^6 Btu): TVA	[2] 3.7
24-hr-average standard:	
Mass rate (lb/sec): TVA	10.1
Process rate (lb/10^6 Btu):	
EPA	
TVA	[2] 4.4

[1] Not to be exceeded more than once per year.
[2] See following table.

SO_2 EMISSION RATES REQUIRED TO MEET AMBIENT STANDARDS, WIDOWS CREEK STEAMPLANT—TVA ESTIMATES

Stack configuration	Emission rate required to meet ambient standards (pound of SO_2/10^6 Btu)					
	3-hr-average standard			24-hr-average standard		
	1-6	7-8	1-8	1-6	7-8	1-8
Existing stacks	0.6	1.6	[1] 0.7	0.6	1.9	[2] 0.8
1,000-feet stack (1-6)	6.2	1.6	[3] 3.7	7.3	1.9	[4] 4.4

[1] Weighted average of 0.4 for units 1-6 and 0.9 for units 7-8.
[2] Weighted average of 0.4 for units 1-6 and 1.2 for units 7-8.
[3] Weighted average of 6.2 for units 1-6 and 1.6 for units 7-8.
[4] Weighted average of 7.3 for units 1-6 and 1.9 for units 7-8.

EPA ESTIMATES

Emission Rate Required to Meet Ambient Standards, (lb. of $SO_2/10^6$ Btu), 24 hour average standard.

Stack Configuration.—Existing stacks (valley model), less than 1.2; 1000-ft stack (1–6) (24-hour model), 500-ft stack (7), 500-ft stack (8), less than 1.2.

III. REGULATIONS AND STANDARDS

A. National Ambient Air Quality Standards

On April 30, 1971 (36 FR 8186), pursuant to section 109 of the Clean Air Act, as amended in 1970, the Administrator promulgated national ambient air quality standards for six air pollutants. These standards were based on the air quality criteria documents which the Agency had developed under section 108 of the Act. In the language of the Act, sec. 108(a)(2), "Air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities."

National primary ambient air quality standards are those which, based on the air quality criteria and allowing an adequate margin of safety, are necessary to protect the public health. The secondary standards are intended to protect the public welfare from any known or anticipated adverse effects associated with the presence of the pollutants in the ambient air.

The Clean Air Act also provides that both the air quality criteria and the standards derived from them may be revised from time to time as new information becomes available. Thus, on September 14, 1973, after reevaluating the available information on the effects of sulfur oxides in the ambient air, the Administrator revised the standards for this pollutant by deleting the annual secondary standard.

The national ambient air quality standards currently in effect are given in Table III–I at the end of this section.

Under section 110 of the Clean Air Act, each State was required to adopt and submit to the Administrator for his approval a plan providing for the implemenation, maintenance and enforcement of air quality standards within the State. The Administrator was directed by the Act to approve a State's plan if, among other things, "it includes emission limitations, schedules, and timetables for compliance with such limitations, and such other measures as may be necessary to insure attainment and maintenance of such primary or secondary standard . . ." (sec. 110 (a)(2)(B)).

In the regulations which the Administrator promulgated for the purpose of implementing section 110 of the Act (40 CFR Part 51, published originally as 42 CFR Part 420 in the Federal Register of August 14, 1971), States were directed to present in their plans a control strategy for attaining and maintaining the national standards in regions where these standards were being violated.

B. Emission Limiting Regulations

The original State implementation plans which Alabama, Kentucky, and Tennessee submitted to the Administrator for his approval contained sulfur dioxide emission limiting regulations. For large power generating plants, these regulations require a reduction in emission to a range of from 1.2 to 2.0 pounds of sulfur dioxide per million BTU of heat input. These plans were approved by the Administrator on May 31, 1972 (37 FR 10842).

The original State implementation plans which Kentucky and Tennessee submitted also provided that these emission limiting regulations would not apply to sources which could demonstrate that other techniques would permit the attainment and maintenance of the ambient standards. Of these provisions the Administrator said:

> Several State plans include regulations under which a source owner or operator could be exempt from compliance with an applicable emission limitation if he can show that emissions from the source will not interfere with attainment or maintenance of the national standards. The Administrator neither approves nor disapproves such optional control features. States are advised, however, that action taken to allow any such exemptions will constitute revision of a State plan and therefore will be subject at that time to the Administrator's approval (37 FR 10845, May 31, 1972).

As one phase of the clean fuels policy which the Agency developed in response to the energy crisis, the Administrator invited certain States to remove the overkill in their sulfur oxide regulations. Tennessee and Alabama subsequently adopted new emission limiting regulations for SO_2, which were proposed in the Federal Register on December 14, 1973 (38 FR 34477 & 34476).

EPA's evaluation of the Tennessee proposal suggested that it was inadequate with respect to the Johnsonville and Kingston plants, for which respective emission limits of 3.0 and 1.6 lbs. $SO_2/10^6$ BTU were provided. Accordingly, Region IV will recommend to the Administrator that these new limits not be approved that the original SIP limit of 1.2 lbs. SO_2BTU be retained in the case of Humphreys and Roane Counties.

With respect to Alabama's proposal, the Agency has determined that the emission limit of 1.8 lbs. $SO_2/10^6$ BTU adopted for the area of the Widows Creek Steam Plant is inadequate to assure attainment of the national standards. On the other hand, this limit, which applies throughout the Tennessee River Valley-Cumberland Mountains AQCR, appears too stringent with respect to the Colbert plant, located in the opposite extremity of the region. The Agency is now working with the State to resolve these problems. For these two plants, Region IV feels that respective limits of 1.2 and 4.0 lbs. $SO_2/10^6$ BTU are needed.

The Tennessee and Alabama implementation plans and regulations call for compliance with SO_2 standards by mid-1975.

The Administrator's original approval of the Kentucky implementation plan was vacated by a decision of the U.S. Circuit Court of Appeals. Accordingly, the plan has been proposed a second time for public comment (39 FR 10277, March 19, 1974), and it is anticipated that approval/disapproval action will shortly be forthcoming. The plan as originally approved calls for the Paradise and Shawnee plants to comply with SO_2 emission limits by July, 1978. The plan stipulates an emission limit for both plants of 2.0 lb. $SO_2/10^6$ BTU input.

Region IV feels that the current limit of 2.0 lbs. $SO_2/10^6$ BTU is needed to assure attainment of standards in the vicinity of the Shawnee plant, but regards a limit of 4.0 lbs. as adequate for the Paradise plant. Accordingly, Region IV will meet with Kentucky in the immediate future on possible means of implementing EPA's clean fuels policy in the State.

Summarized in the Table III–2 are current emission limits which apply to each TVA steam plant, the new limits proposed by the States and the limits which the task force has used as a basis for considering alternative emission control strategies.

TABLE III–I.—NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Primary	Secondary
Particulate matter:		
Annual geometric mean	75	60.[1]
Maximum 24-hour concentration [2]	260	150.
Sulfur oxides:		
Annual arithmetic mean	80 (0.03 p/m)	
Maximum 24-hour concentration [2]	365 (0.14 p/m)	260 (0.1 p/m).[1]
Maximum 3-hour concentration [2]		1,300 (0.5 p/m).
Carbon monoxide:		
Maximum 8-hour concentration [2]	10 (9 p/m)	10 (9 p/m).
Maximum 1-hour concentration [2]	40 (35 p/m)	40 (35 p/m).
Photochemical oxidants: Maximum 1-hour concentration	160 (0.08 p/m)	160 (0.08 p/m).
Hydrocarbons: Maximum 3-hour (6–9 am) concentration [2]	160 (0.24 p/m)[1]	160 (0.24 p/m).[1]
Nitrogen oxides: Annual arithmetic mean	100 (0.05 p/m)	100 (0.05 p/m).

[1] Guide for SIP development.
[2] Not to be exceeded more than once a year.

Note: All measurements are expressed in micrograms per cubic meter except those for CO, which are given in milligrams per cubic meter. Equivalent measurements in parts per million (p/m) are given for the gaseous pollutants.

TABLE III-2.—EMISSION LIMITS

[Lb SO_2/10^6 Btu]

Plant	State's current	State's proposed	Assumed for the study
Allen	1.2	4.0	4.0
Bull Run	1.2	4.0	4.0
Colbert	1.2	1.8	4.0
Cumberland	1.2	4.0	4.0
Gallatin	1.2	4.0	4.0
John Sevier	1.2	4.0	4.0
Johnsonville	1.2	3.0	1.2
Kingston	1.2	1.6	1.2
Paradise	2.0	----------	4.0
Shawnee	2.0	----------	2.0
Watts Bar	1.2	4.0	4.0
Widows Creek	1.2	1.8	1.2

IV. ALTERNATIVES TO MEET EMISSION STANDARDS AND REGULATIONS

A. Bases and Assumptions for Section IV

The strategy outlined in this section was designed with the following assumed bases. These assumptions may or may not be valid:

1. Coal washing facilities can be installed for TVA coal supplies.
2. Low sulfur coal is available.
3. Coal handling systems for blending coals can be developed.
4. Transportation and handling facilities are available for interchanging coal between selected TVA steam plants.
5. Reliable flue gas desulfurization facilities can be installed.
6. The assumed emission limitations will result in compliance with national primary and secondary ambient SO_2 standards.
7. The assumed emission limitations are based on maximum plant capability and adverse dispersion conditions.
8. The objective of this control strategy is to meet ambient standards by continuous emissions limitations.

B. Potential Control Strategies

EPA and TVA Task Force members agree that if emissions from TVA plants must be limited to the more relaxed levels now proposed, SO_2 scrubbers would not be necessary at all plants. Relaxation of the emission standards would permit the use of other control measures at some plants. In an effort to identify a system wide emission reduction control strategy, the Task Force considered several basic alternatives. Consideration of a strategy for a system as large as TVA's (12 plants, 63 units) involves many interrelated factors. Ideally such a strategy would represent the least cost solution while at the same time providing a high degree of confidence that applicable emission regulations will be complied with at all times. Because of the complexities and uncertainties that exist, no single approach can be considered as the best solution. However, it is possible to outline a general strategy that utilizes a blend of individual alternatives. The Task Force agreed that the control strategies to meet the proposed emission standards most applicable to the TVA system were:

1. *Use of Low Sulfur Coal.*—This alternative considers the use of both existing and new supplies of naturally occurring coal. In this consideration, the Task Force agreed to give primary consideration to only those supplies located east of the Mississippi River. This decision was predicated primarily on TVA's historic dependence on and utilization of Appalachian and midwestern coal supplies. It should be noted, however, that subsequent fine tuning of the control strategy may indicate that western or foreign coals could be used on a limited basis.

Use of existing coal supplies that would comply with the emission limitations was given highest priority by the Task Force. Since none of the TVA's present coal supply is sufficiently low in sulfur content to meet the 1.2 lb. standard and only 16 percent is low enough to meet the 4.0 lb. standard, the widespread application of this strategy would involve acquiring new sources of coal for the TVA system. Factors that impact on the use of existing acceptable coal supplies include length of the current contracts and the variability in sulfur content of the individual supplies. This latter factor is a particular problem where there is marginal compliance with the applicable limit. Of particular importance is that a significant portion of TVA's existing coal contracts will terminate by 1980 and will have to be renewed. Essentially all of the Kingston, John Sevier, and Allen Steam Plants' (9.1×10^6 tpy) will have to be renewed by July, 1977, and 18.6×10^6 tpy, or 58% of TVA's midwestern field coal contracts will have to be renewed by July, 1980. Much of the midwestern coal which TVA currently has under contract costs in the range of $5–$8 per ton at the mine. While the present coal market is very unstable, it is expected that renewal of existing coal contracts will involve a substantial increase in costs.

Additional factors that must be considered are the effect of burning such coals in the individual boilers and the effect on existing or proposed particulate control equipment. Slagging may present a problem in wet-bottom boilers, and electrostatic precipitators designed for high-sulfur coal may not comply with particulate limitations when low-sulfur coals are being burned. The latter factor would require the use of flue gas conditioning in marginal situations or the installation of additional particulate control equipment. Moreover, reduction in plant generating capacity has been observed when low-sulfur, low-BTU western coal was being burned.

Serious coal shortages are presently being experienced by TVA as well as by other utilities throughout the nation. Thus, the extent to which this strategy could successfully be applied is uncertain. Clearly, the application of the strategy at the present time is severely restricted. Therefore, the compliance strategies outlined below were selected in part to minimize reliance on new supplies of low sulfur coal.

2. *Use of Washed Coal.*—As an alternative to the development of new supplies of lower sulfur coals, the Task Force considered the use of coal washing. This is basically the technique of grinding, washing, and recovering various size fractions in an effort to mechanically remove ash and pyritic sulfur from coal and thus reduce its overall sulfur content. A portion of the heat content of the coal is also lost in this process. However, this is offset to some extent by reduced transportation and coal handling costs, reduced particulate loadings on control equipment, reduced ash handling, and improved boiler operation.

Technology for coal washing as defined in this study is well developed. More exotic and still undeveloped processes for cleaning raw coal were not considered. Coal washing appears to be most applicable to TVA's midwestern coal supply which represents 70 to 80 percent of its total supply.

3. *Use of Coal Blending.*—This strategy involves the mixing of high and low sulfur coal to obtain a product with sulfur content at some intermediate level. Coal blending on a large scale has not been attempted over long periods at TVA power plants. Although engineering design work would be needed to develop the "coal yard technology" needed to properly blend coal at specific power plants, blending could probably be accomplished.

4. *Use of Flue Gas Desulfurization.*—This strategy involves the installation of equipment at the power plant to remove SO_2 from the stack gases. The task force did not debate or attempt to resolve the differences between EPA and TVA on the present state of scrubbing technology. Basically, EPA believes that flue gas desulfurization technology is developed to a stage that scrubbers could be installed now on TVA plants. TVA believes that additional research, development, and demonstration is needed before properly designed scrubbers can be added at its plants. It was agreed that at such time as satisfactory operational efficiency has been established, the use of flue gas desulfurization for meeting constant emission limitations within the TVA system would offer a higher degree of flexibility for use of readily available coal supplies.

C. Applicability of Control Strategies to the TVA System

Using a limited amount of data available concerning TVA operations, EPA staff prepared a proposed compliance strategy for each TVA coal-fired plant. This proposal is shown in table IV–2. This proposal was reviewed by TVA staff to assess its feasibility, to make refinements where necessary, and to estimate costs.

The results of the TVA analysis are described below and are summarized in table IV–3. This analysis is a preliminary assessment and does not reflect EPA's or TVA's view of the optimum compliance strategy. The cost estimates are order of magnitude estimates only. The strategy is based on achieving the proposed emission limits on an annual basis. In practice, the averaging time for determining compliance is less than a year, so the cost of compliance could be higher than indicated. Table IV–1 shows the emission limits used as the basis for this study and the actual average emission rates at each plant in FY73.

1. *Allen, Colbert, Cumberland, Gallatin, Paradise.*—The proposed limit for these five plants is 4.0 lbs. $SO_2/10^6$ BTU. The plants are located in the western portion of the TVA system, and depend primarily on midwestern fields for their coal supply. These lie mainly in Kentucky; some are in Illinois and Indiana. Utilizing the best information currently available[1], an analysis was made of the washability of coals from the three major seams of midwestern coal—seams 9, 11, and 12. The analysis indicated that with well-designed coal washing plants, SO_2 emissions produced from burning seam 9 coal could be reduced to 4.4 lbs. $SO_2/10^6$ BTU, seam 11 coal to 4.7–4.9 lbs., and seam 12 coal to 4.0 lbs. Based on present long-term contracts for coal from these seams, the weighted average emissions from burning this coal could be reduced to 4.4 lbs./10^6 BTU, or by 37%. Further reductions in sulfur emissions could be attained by blending low sulfur coal with the higher-sulfur washed coal.

Coal consumption of these five plants is projected to be about 22 million tons per year (based on present coal quality) throughout the remainder of this decade. If 19 million tons of coal were washed to attain a sulfur content equivalent to 4.4 lbs. $SO_2/10^6$ BTU, and if this product were blended with about 3 million tons of low-sulfur coal ($\leq$1% S), the proposed emission rate could be attained.

According to TVA's estimates, the annual cost of this control strategy at the five steam plants is $99 million. This cost estimate is based on the following.

a. Coal washing cost at 18.4¢/10^6 BTU. Over half of this cost results from the fact that about 10% of the heating value of raw coal is lost during the washing operations. With the present price of raw west Kentucky coal in the order of $18 to $25 per ton, the cost of replacing this lost energy from new sources is greatly increased.

b. New low sulfur coal at an incremental cost of 30¢/10^6 BTU over raw west Kentucky coal.

c. Coal blending cost at 25¢ per ton of coal blended.

EPA's estimate of the annual cost of washing at the five plants is $73 million. The cost estimate is based on the following:

a. 10% of the tonnage and 3% of the heat value is lost during the washing operation.

b. Replacement cost of the lost BTU's would be $18/ton. While EPA used a cost of $18/ton, it was felt that a more realistic cost of a long-term contract for western Kentucky coal in early 1975 would be $12–$15/ton.

c. Overall washing cost (including the cost of replacing the lost BTU's) of 12¢/10^6 BTU.

d. New low sulfur coal at an incremental cost of 30¢/10^6 BTU over raw western Kentucky coal.

e. Coal blending at 25¢ per ton of coal blended.

2. *Kingston, Bull Run.*—The proposed standard for Kingston is 1.2 lbs. $SO_2/10^6$ BTU. TVA has low sulfur coal under long-term contract from the Falcon Coal Company in east Kentucky. While burning this coal, Kingston emissions would average 1.3 lbs. $SO_2/10^6$ BTU. Most of this coal is now being burned at Bull Run, located about 20 miles northeast of Kingston. Therefore, by interchanging the coal supplies of Kingston and Bull Run, Kingston emissions would be significantly reduced. Of course, Bull Run emissions would correspondingly increase. However, the proposed standard for Bull Run is 4.0 lbs., so the plant should be in compliance if Kingston coal is burned. Kingston coal requirements exceed the Falcon contract by about 1.1 million tons per year. Thus, a supply of 1.1 million tons of new low sulfur coal would have to be acquired to bring the Kingston plant into compliance. The plant would still not fully comply with the 1.2 lb. standard, however, because the sulfur content of the Bull Run coal is slightly higher than that amount.

---

[1] Bureau of Mines RI 7633, "Sulfur Reduction Potential of the Coals of the United States," 1972. MTR 4151, "The Physical Desulfurization of Coal," Mitre Corporation, 1970. EPA 650/2–74–025, "Applicability of the Meyers Process for Chemical Desulfurization of Coal: Initial Study of Fifteen Coals," 1974.

The estimated annual cost of this control strategy for Kingston is $10 million. Another $4 million annually would be needed to transport Kingston coal to Bull Run. These estimates are based on the following:

a. A detailed engineering study would be needed to determine the most economical and efficient method of interchanging coal supplies between Kingston and Bull Run. Primarily because the two plants are located on different railroads, transportation charges alone would increase about $5 million annually. In addition, modification to present coal handling facilities at each plant would be necessary. For example, since most coal is delivered to Kingston by truck, coal loading facilities, truck to rail, would have to be installed. For purposes of this study, it is estimated that the annual charges on new facilities plus operating and maintenance expense is $3 million.

b. New low sulfur coal at an incremental cost of 30¢/10^6 BTU over the present cost of coal delivered to Kingston.

It may be necessary to blend the Kingston coal at the Bull Run plant because the sulfur content of some of the Kingston coal exceeds the proposed standards. The cost of blending is not included in this estimate.

3. *John Sevier.*—On average, the John Sevier plant is in complance with the proposed standard of 4.0 lbs. $SO_2/10^6$ BTU. Like the Kingston plant, however, some of the coal delivered to John Sevier could cause emissions to exceed this amount for short periods. Therefore, coal blending may be necessary to achieve strict compliance. The feasibility and cost of blending John Sevier coal has not been determined.

4. *Watts Bar.*—The proposed standard for Watts Bar is 4.0 lbs. $SO_2/10^6$ BTU. Although the plant is located in East Tennessee, West Kentucky coal is being burned because of slagging problems experienced with East Tennessee coals. For purposes of this analysis, it is assumed that coal with proper burning characteristics can be found in coals presently supplied the Kingston plant. If so, this plant could be brought into compliance by switching to this coal. Some blending of coals may be necessary. No additional costs are included for switching coal at Watts Bar.

5. *Widows Creek, Johnsonville, Shawnee.*—The proposed standards for these three plants are 1.2 lbs. for Widows Creek and Johnsonville and 2.0 lbs. for Shawnee. For these three plants, average annual emissions range between 4.3 to 6.5 lbs/10^6 BTU. Thus, an overall 71% reduction in emissions is needed to meet the proposed standards. The two control strategies with potential for attaining this degree of reduction are low-sulfur coal and stack gas cleaning.

Estimates of the cost of adding scrubbers at these plants are shown in table IV–4. These estimates are based on TVA's detailed design and cost estimates for the Widows Creek Unit 8 scrubber now under construction. In estimating costs at the other plants, certain costs associated with the prototype nature of the Unit 8 scrubber were excluded, and the remaining costs were extrapolated based on an engineering assessment of the relative ease or difficulty of backfitting similar equipment at the other plants. The installation costs are stated in 1975 dollars in order to provide a more valid comparison with current estimates of the incremental cost of low-sulfur coal and with the cost of other alternate control strategies. If escalated to account for anticipated inflation between 1975 and the projected completion dates, installation costs would increase 30 to 60%.

The dates shown for completion of scrubber projects at each plant are based upon TVA's best estimate at this time. The dates assume that detailed design work would begin on Widows Creek unit 7 in July 1976 and would begin on the next priority plant six months later. In TVA's judgment, design could not begin before these dates because of the need for additional research, development, and demonstration of reliability in basic scrubber technology and because of the full commitment until that time of TVA's design engineering staff to air and water pollution control projects which are already under way.

Table IV–4 shows the estimated scrubber costs at each plant in terms of 1975 dollars and in terms of ¢/10^6 BTU's. These costs represent the break-even value in choosing between scrubbers and low-sulfur coal as the most economical control strategy for each plant. The following is a plant-by-plant assessment of the applicability of each of these strategies.

a. *Widows Creek 1–6.*—About 27,000 tons per week of low-sulfur coal is presently assigned to the Widows Creek plant. This coal is mined at Arch Coal Company's Fabius Mine on Sand Mountain, Alabama, near the Widows Creek plant.

This coal represents about two-thirds of the Widows Creek 1–6 contract requirement. With the acquisition of another 0.6 million tons per year of low-sulfur coal, units 1–6 would be in near compliance with the proposed standard. Such a strategy would be consistent with present pollution control plans for these units since new electrostatic precipitators are being designed to accommodate low-sulfur coal.

Based on the assumed incremental cost of low-sulfur coal of 30¢/10^6 BTU, the estimated cost of compliance with the proposed emission standard would be $4 million per year. The plant would not fully comply with the 1.2 lb. standard, however, because the sulfur content of the Arch coal slightly exceeds that amount. To achieve compliance, an additional supply of coal yielding less than 1.2 #/MM BTU would be needed for blending.

b. *Widows Creek 7 and 8.*—An experimental scrubber is already under construction at Widows Creek 8. Assuming the Fabius coal is dedicated to Widows Creek units 1–6, the installation of a scrubber on unit 7 would apparently be the most economical alternative for meeting the proposed emission standard on that unit since the cost of a scrubber is estimated to be less than the incremental cost of low sulfur coal.

c. *Johnsonville.*—Scrubber costs at Johnsonville would be among the highest of any plant on the TVA system because of expected difficulties in installing the equipment at the plant and because of the projected limited plant use for its remaining life after the scrubbers are installed. In spite of these high costs, scrubbers may still be preferred relative to low-sulfur coal. New precipitators are being installed which are not adequately sized to meet particulate emission standards if low-sulfur coal is burned. Furthermore, western low-sulfur, low BTU coal was burned at Johnsonville to test its burning characteristics. Plant generating capability was reduced by 15 percent to 30 percent during these tests. Therefore, substantial plant modifications would be necessary at Johnsonville if a low-sulfur coal strategy were selected. Consequently, this study assumes that scrubbers are preferred to low-sulfur coal for meeting the proposed standards at the Johnsonville plant.

d. *Shawnee.*—Estimated scrubber costs at Shawnee are 33¢ per million BTU. This is higher than the estimated 30¢ per million BTU for low-sulfur coal assumed elsewhere in this report. As in the case of Johnsonville, new precipitators would be required at Shawnee if low-sulfur coal were burned, and if low-BTU western coal were burned, some reduction in plant generating capability would be expected. Consequently, for purposes of this analysis, scrubbers are selected as the control strategy for meeting the proposed emission standard at Shawnee.

D. *Alternatives To Meet Emission Standards and Regulations With Allowances Made for Existing and TVA Proposed Tall Stacks (Supplementary Section—Prepared December 1974)*

Still another alternative considered by the EPA/TVA task force was the use of tall stacks to reduce SO_2 concentrations at ground level. Installation of taller stacks has been initiated at three of TVA's power plants (Kingston, Shawnee, and Widows Creek) and is being considered for a fourth (Johnsonville). In this section of the report, the stack heights being planned or considered for the four plants, which in at least three cases will be in operation in the late 1970's, have been included in the calculations establishing hypothetical constant emission limits consistent with the attainment and maintenance of National Ambient Air Quality Standards.

In recent months EPA has explored numerous alternative definitions of "Good Engineering Practice" (GEP) stack height. Two of these definitions (40 CFR 51.13(h) as proposed September 14, 1973, 38 FR 25701, and a draft revision of 40 CFR Part 51) yield heights fairly close to those now in existence at the four plants just mentioned, while a third [2] would sanction stacks as high as those being built or considered by TVA at these plants. For the sake of simplicity, this discussion of stack heights and their effect on control strategies previously elaborated will weigh two factors: (1) existing stacks and (2) future tall stacks (of unrestricted height).

1. *Constant Emission Standards and Control Strategies for Meeting Ambient Standards at TVA Plants with Tall Stacks.*—Table III–2 of this report lists each

[2] "National Strategy for Control of Sulfur Oxides from Electric Power Plants," Environmental Protection Agency, July 10, 1974.

TVA plant and the constant emission limits considered necessary for ensuring that ambient SO_2 standards are met. Limits of 4.0 lbs. $SO_2/10^6$ BTU are assumed for all plants except Johnsonville, Kingston, Widows Creek Steam Plants, where the assumed standard is 1.2 lbs./10^6 BTU, and Shawnee, where the assumed standard is 2.0 lbs/10^6 BTU. These limits are determined from dispersion calculations based on present plant size, layout, topography, and stack heights.

TVA's present program for SO_2 control includes modifications in stack heights at three of these four plants (Kingston, Shawnee, and Widows Creek) for the purpose of reducing the ground-level impact of SO_2 emissions. Stack height modifications are also being considered for the Johnsonville Steam Plant.

Table IV–5 shows the stack heights planned for Kingston, Shawnee, and Widows Creek units 1–6 and the stack heights presently being considered for Johnsonville. Given these stack heights, dispersion calculations have been made for each of these plants, and constant emission limits have been estimated for ensuring maintenance of ambient standards. These limits are shown in column 6 of table IV–5. The calculations show that when the stack height modifications are completed at these plants, emission rates could be increased above the limits assumed in section III of this report without undue risk of exceeding national ambient standards.

Section IV.B of this report describes four possible methods for meeting SO_2 emission standards at coal-fired power plants: (1) low-sulfur coal, (2) coal washing, (3) coal blending, and (4) flue gas desulfurization. An analysis was made of the applicability of each of these methods to the four plants in question for meeting standards of 1.2 and 2.0 lbs/10^6 BTU. Under the assumptions of the analysis, flue gas desulfurization was deemed most applicable at Johnsonville and Shawnee, and low-sulfur fuel was found most applicable at Kingston and Widows Creek 1–6. The cost of compliance at the four plants was estimated at $73 million per year. This analysis has been repeated assuming that these plants are required to meet emission standards of 4.0 lbs $SO_2/10^6$ BTU.

a. *Kingston Steam Plant.*—The SO_2 emission standard at Kingston proposed in section IV.B is 1.2 lbs $SO_2/10^6$ BTU. If allowance is made for tall 1,000-foot stacks it is estimated that ambient standards could be attained as long as Kingston emissions did not exceed 4.0 lbs. In FY 1973, Kingston Steam Plant emissions averaged 3.7 lbs $SO_2/10^6$ BTU and in FY 1974 emission average 3.6 lbs.[3] In order for the Kingston plant to comply with the 4.0 lbs $SO_2/10^6$ BTU emission limit by using its present coal supply, it would probably be necessary to develop methods for blending the coal because the sulfur content of some of it would cause emissions to exceed the 4.0 lbs. $SO_2/10^6$ BTU limit.[4]

b. *Johnsonville, Shawnee, and Widows Creek Units 1–6.*—The SO_2 emission standard assumed in section IV.B for Johnsonville and Widows Creek 1–6 is 1.2 lbs $SO_2/10^6$ BTU and 2.0 lbs for Shawnee. If credit is allowed for planned or proposed tall stacks, it is estimated that ambient standards could be attained by limiting emissions at these plants to 4.0 lbs $SO_2/10^6$ BTU. Table IV–1 shows that the average SO_2 emission rate for these three plants in 1973 was 6.1 lbs at Johnsonville, 4.6 lbs at Shawnee, and 4.3 lbs at Widows Creek 1–6. In section IV.C of this report, a control strategy was developed for five TVA plants which involved washing of coal from midwestern sources and blending this coal with new supplies of low-sulfur coal. A similar strategy could be applied to Johnsonville, Shawnee, and Widows Creek 1–6.

The coal burned at Johnsonville originates almost entirely from west Kentucky sources and thus is similar in quality to the coal burned at the five plants to which this strategy was applied in section IV.C. Consequently, based on the coal-washing data and cost assumptions used in section IV.C (as revised), emissions at Johnsonville during the latter part of the 1970's could be limited to 4.0

---

[3] Due to a critical coal supply situation in the TVA system, west Kentucky coal is being shipped to Kingston temporarily. This has resulted in an increase in Kingston emissions above levels experienced in the past. Kingston emissions averaged 4.7 lbs $SO_2/10^6$ BTU during the first 4 months of FY 1975.

[4] Although coal blending may be needed to continuously limit Kingston emissions to 4.0 lbs $SO_2/10^6$ BTU, it would probably not be needed for the purpose of meeting ambient standards. The limit of 4.0 lbs is derived from dispersion calculations assuming the plant is operating at full load (1,700,000 KW). With this degree of control, the allowable mass SO_2 emission rate at full load is about 17.0 lbs. SO_2/s or 734 tons/day. The Kingston plant rarely operates all nine generating units at full load simultaneously. In FY 1973, for example, plant gross generation averaged about 1,165,000 KW, and the average mass SO_2 emission rate was 10.8 lbs SO_2/s. Thus, on the average, the process rate could be as high as 6.3 lbs $SO_2/10^6$ BTU without exceeding the mass rate limit of 734 tons SO_2/day. It is likely that a detailed probability analysis of the Kingston coal sulfur distribution and generation distribution would show that, even without blending, the probability of exceeding 734 tons SO_2/day is low enough to ensure that ambient standards would not be exceeded.

lbs $SO_2/10^6$ BTU for an annual cost of about $17.3 million. This strategy would require washing about 4.0 million tons per year of raw west Kentucky coal and blending with about 0.5 million tons of new low-sulfur coal. In addition, the annual capital charges of $1.2 million for the tall (1,000-foot) stack would increase the overall total annual cost of this strategy to $18.5 million.

A significant fraction of the coal burned at Shawnee and Widows Creek 1–6 is mined from other sources, however, so that a more detailed analysis is needed to prepare a preliminary evaluation of the coal-washing strategy at these plants.

Shawnee coal requirements are projected to average about 4.9 million tons per year for the remainder of the 1970's. Historically, Shawnee's coal supply has come from several sources in west Kentucky and Illinois. The sulfur content of coal burned at Shawnee has ranged from as low as 1 percent to as high as 6 percent. A detailed analysis was made of Shawnee coal deliveries during 1971 and 1972 which indicated that about 25 percent of Shawnee coal contained 2 percent sulfur or less, another 25 percent contained more than 2 percent sulfur but less than 3.5 percent, and the remaining 50 percent of the coal contained 3.5 percent sulfur or more. There have been changes in Shawnee coal supply sources since that time which have affected this distribution somewhat, and additional short-term changes are foreseen in the near future. However, if it is assumed that in the long run the sulfur content of Shawnee coal will generally be maintained at quality levels experienced in the past, 25 percent of the coal could be burned without treatment, 25 percent would have to be washed, and 50 percent would have to be washed and blended with new supplies of low-sulfur coal. Based on coal-washing data and cost estimates used in section IV.C (as revised), emissions from Shawnee could be limited to 4.0 lbs/10^6 BTU for an annual cost of about $15.2 million. In addition, the annual capital charges of $3.0 million for the tall (800-foot) stacks would increase the total annual cost of this strategy to $18.2 million.

Widows Creek 1–6 coal requirements are estimated to be about 2.1 million tons per year for the remainder of the 1970's. A limited amount of low-sulfur coal is available in north Alabama which is presently being burned in the Widows Creek Plant. This coal amounts to about 1 million tons per year and is less than 1 percent in sulfur content. If this coal were restricted to units 1–6, the emissions from these units could be limited to about 4.2 lbs $SO_2/10^6$ BTU. This emission limit should be adequate for attaining ambient standards because dispersion calculations indicate that a 4.9 lbs $SO_2/10^6$ BTU limit is sufficient. However, another 100,000 tons per year of low-sulfur coal would be needed to reach a 4.0 lbs $SO_2/10^6$ BTU limit. Based on the cost estimates used in section IV.C (as revised), the cost of this strategy would be about $1.2 million per year. In addition, the annual capital charges of $1.1 million for the tall (1,000-foot) stacks would increase the total annual cost of this strategy to $2.3 million.

Since TVA presently has no plans for installing a tall stack on Widows Creek 7 or 8, but is installing a scrubber on Widows Creek 8, the compliance strategy considered in this section for units 7 and 8 of installing scrubbers is unchanged from that presented in section IV.C.

Table IV–6 summarizes the cost of meeting constant emission standards at TVA plants if allowances are made for proposed or planned tall stacks shown in table IV–7 for the four plants.

As shown in table IV–6, the annual cost for compliance with required emission standards if allowance is made for TVA's tall stacks would total $153.2 million. This represents a reduction of $18.8 million from the estimate of $172 million presented in section IV.C (table IV–3), where the tall stacks were not recognized. The annual cost of compliance for units where tall stacks are planned or proposed is reduced from $59.0 to $40.2 million.

2. *Constant Emission Standards and Control Strategies for Meeting Ambient Standards at TVA Plants With Existing Stacks.*—Table IV–7 summarizes the allowable SO_2 emissions for meeting ambient standards at the Johnsonville, Kingston, Shawnee, and Widows Creek plants based on the proposed GEP definition. The allowable emissions using this definition vary from a low of 1.2 lbs/10^6 BTU at Kingston to a high of 1.7 lbs/10^6 BTU at Johnsonville. Thus, these allowable emissions do not vary significantly from those calculated in section IV.B, on the basis of existing stacks. The allowable emissions preclude consideration of coal washing or alternatives other than those evaluated in section IV.B on the basis of existing stacks. Therefore, at these four plants, the compliance strategy and cost for meeting ambient standards based on the proposed GEP definition would be the same as those presented in section IV.B.

TABLE IV-1.—SO_2 EMISSION LIMITS ASSUMED FOR STUDY AND AVERAGE EMISSION RATES, 1973

[Lb $SO_2/10^6$ Btu]

Plant	Assumed emission limits	Present annual average emission rates
Allen	4.0	5.2
Bull Run	4.0	1.6
Colbert	4.0	6.5
Cumberland	4.0	6.2
Gallatin	4.0	4.5
John Sevier	4.0	2.8
Johnsonville	1.2	6.1
Kingston	1.2	3.7
Paradise	4.0	7.3
Shawnee	2.0	4.6
Watts Bar	4.0	6.1
Widows Creek	1.2	[1] 4.3, [2] 5.9

[1] Units 1 to 6. [2] Units 7 to 8.

TABLE IV-2.—COMPLIANCE ALTERNATIVE FOR TVA POWER SYSTEM AS PROPOSED BY EPA

Plant	Proposed action	Result
Allen	Wash coal	Compliance.
Bull Run	None	Do.
Colbert	Send present coal to Widows Creek. Receive equal amount from Widows Creek.	Do.
Cumberland	Wash coal	Do.
Gallatin	do	Do.
John Sevier	None	Do.
Johnsonville	Send present coal to Paradise. Receive equal amount from Paradise, Install scrubbers.	Do.
Kingston	Acquire low-sulfur coal	Do.
Paradise	Send present coal to Shawnee and Johnsonville. Receive Shawnee and Johnsonville coal, wash it.	Do.
Shawnee	Send present coal to Paradise. Receive equal amount from Paradise. Install scrubbers.	Do.
Watts Bar	Send present coal to Widows Creek. Receive equal amount from Widows Creek.	Do.
Widows Creek	Send present coal to Colbert and Watts Bar. Receive equal amounts from Colbert and Watts Bar. Install SO_2 scrubbers.	Do.

Note: Based on proposed SO_2 regulations and assuming Paradise and Colbert are allowed to meet 4 lb SO_2/mm Btu.

TABLE IV-3.—PRELIMINARY STRATEGY FOR COMPLIANCE WITH PROPOSED EMISSION STANDARDS AT 12 TVA STEAMPLANTS

Plant(s), strategies and resources required	Estimates annual cost (millions)	Estimated completion date	Estimated change in SO_2 emissions 1st year after completion (thousands of tons)
1. ALLEN, COLBERT, CUMBERLAND GALLATIN, PARADISE			
Coal washing, low-sulfur coal, coal blending:			
(a) Process 22, 4,000,000 tons of coal through coal preparation plants	*$74	1977	−425.8
(b) 3,000,000 tons of new low-sulfur coal (less than 1 percent)	20	1976	−155.1
(c) Blend 20,000,000 tons of washed coal and low-sulfur coal to achieve a mixture yielding 4 lb/10^6 Btu	5	1977	0
2. KINGSTON			
Low-sulfur coal:			
(a) Receive coal now shipped to Bull Run†	4	1975	−44.5
(b) 1,100,000 tons of new low-sulfur coal (less than 0.7 percent S)	6	1976	−29.7

TABLE IV-3.—PRELIMINARY STRATEGY FOR COMPLIANCE WITH PROPOSED EMISSION STANDARDS AT 12 TVA STEAMPLANTS—Continued

Plant(s), strategies and resources required	Estimates annual cost (millions)	Estimated completion date	Estimated change in SO_2 emissions 1st year after completion (thousands of tons)
3. BULL RUN			
Low-sulfur coal, coal blending:			
(a) Receive portion of coal shipped to Kingston	$4	1975	+44.5
(b) Blend if necessary		1975	
4. JOHN SEVIER			
Coal blending: (a) Blend present coal if necessary		1975	0
5. WATTS BAR			
Low-sulfur coal, coal blending:			
(a) Receive portion of coal now shipped to Kingston		1975	−5.3
(b) Blend if necessary		1975	0
6. WIDOWS CREEK 1 TO 6			
Low-sulfur coal:			
(a) Acquire 6,000,000 tons of new low-sulfur coal (less than 0.7 percent S)	4	1976	−20.1
(b) Use all coal presently produced at Fabius mine in units 1 to 6†		1975	0
7. WIDOWS CREEK 7 AND 8			
Scrubbers:‡ (a) Scrubbing equipment for 1,125 MW capacity lime or limestone, waste storage area, electric power, etc	14	1977 1979	−66.0 −66.8
8. JOHNSONVILLE, SHAWNEE			
Scrubbers (or low-sulfur coal):‡ (a) Scrubbing equipment for 3,235 MW capacity, lime or limestone, waste storage area, electric power, etc	41	1983	−100.6 −97.2
Total annual cost	172		

*EPA's estimate is $48,000,000.
†Bull Run and Fabius coal averages 1.3 lb $SO_2/10^6$ Btu, slightly above the proposed limit of 1.2 lb.
‡Scrubber installation and operating costs would be 30 to 60 percent higher if escalated to reflect costs at the date of completion. The costs are shown in 1975 dollars in order to compare with estimates of the cost of ambient control strategies which can be implemented in the 1975–77 period.

TABLE IV-4.—COST OF INSTALLING AND OPERATING SCRUBBERS AT 3 TVA STEAM PLANTS

Item	Johnsonville 1 to 10	Shawnee 1 to 10	Widows Creek 1 to 6	Widows Creek 7	Widows Creek 8
Total nameplate capacity (kilowatts)	1,485,200	1,750,000	852,975	575,010	550,000
Scrubber cost $/kW (1975) (per kilowatt, 1975)*	$79.95	$65.10	$79.80	$60.90	$76.00
Total scrubber cost (1975)*	$118,750,000	$113,925,000	$68,067,000	$35,018,000	$42,000,000
Earliest completion date†	1982	1981	1981	1979	1977
Average installation date	July 1981	July 1980	July 1980	July 1979	February 1977
Remaining life after installation date (years)	14	13	12	22	28
Capital charge rate (percent)—assumes 8 percent interest	12.130	12.652	13.270	9.803	9.049
Annual capital charge (thousands)	$14,404	$14,414	$9,032	$3,433	$3,800
Projected levelized capacity factor for remaining life (percent)	27.3	44.6	29.7	52.1	53.8
Levelized annual generation (million kilowatt-hours)	3,551.8	6,837.2	2,219.2	2,624.3	2,592.1
Levelized annual O. & M. cost (thousand)‡	$4,262	$8,205	$2,663	$3,149	$3,110
Total levelized annual cost:					
Amount (thousands)	$18,666	$22,619	$11,695	$6,582	$6,910
Mills per kilowatt-hours	5.26	3.31	5.27	2.51	2.67
Cents per 10^6 Btu	49.8	33.1	49.1	26.4	28.1

*Scrubber installation costs would be 30 to 60 percent higher if escalated to reflect costs at the date of completion. The costs are shown in 1975 dollars in order to compare with present estimates of the incremental cost of low sulfur coal.
† Assumes Widows Creek Unit 7 given No. 1 priority after Widows Creek Unit 8. For other plants, the date shown is the earliest if plant is assigned No. 2 priority. If scrubbers were added on all of these units except Widows Creek 1 to 6, installation could not be completed before 1983.
‡ Based on O. & M. of 1.2 mills per kilowatt-hours (1975 dollars).

TABLE IV-5.—CONTINUOUS SO_2 EMISSION LIMITATIONS FOR FOUR TVA STEAMPLANTS

Plant	Maximum heat input (10^6 Btu/ per hour)	With present stacks: Stack height (feet)	With present stacks: SO_2 emission limitations required by present State emission standards: Pounds SO_2 per Btu per 10^6 Btu	With present stacks: SO_2 emission limitations required by present State emission standards: Tons SO_2 per day	With planned or proposed stacks: Planned or proposed stack height (feet)	With planned or proposed stacks: SO_2 emission limitations needed to meet ambient standards: Pounds SO_2 per 10^6 Btu	With planned or proposed stacks: SO_2 emission limitations needed to meet ambient standards: Tons SO_2 per day
Kingston 1 to 4	6,468	250	1.2	93	1,000	4.0	310
Kingston 5 to 9	8,845	300	1.2	127	1,000	4.0	424
Johnsonville 1 to 6	8,818	270	1.2	127	1,000	*4.0	423
Johnsonville 7 to 10	6,332	400	1.2	91	400	*4.0	304
Shawnee 1 to 10	16,170	250	2.0	388	800	†4.0	776
Widows Creek 1 to 6	8,787	270	1.2	127	1,000	‡4.0	424
Widows Creek 7 to 8	10,576	500	1.2	152	500	1.2	152

*For purposes of standard setting, the precise dispersion estimate of 3.7 lb per 10^6 Btu is rounded to 4 lb SO_2 per 10^6 Btu.

†For purposes of standard setting, the precise dispersion estimate of 3.8 lb per 10^6 Btu is rounded to 4 lb SO_2 per 10^6 Btu.

‡For purposes of standard setting, the precise dispersion estimate of 4.9 lb per 10^6 Btu is rounded to 4 lb SO_2 per 10^6 Btu.

TABLE IV-6.—PRELIMINARY STRATEGY FOR COMPLIANCE WITH EMISSION STANDARDS AT 12 TVA STEAMPLANTS IF ALLOWANCE IS MADE FOR TVA'S PLANNED OR PROPOSED STACK HEIGHTS

Plant(s), strategies and resources required	Estimated annual cost during late 1970's (millions)
ALLEN, COLBERT, CUMBERLAND, GALLATIN, PARADISE	
Coal washing, low-sulfur coal, coal blending:	
(a) Wash 22,400,000 tons of raw coal annually	$74.0
(b) 3,000,000 tons of new low-sulfur coal (less than 1 percent sulfur)	20.0
(c) Blend 20,000,000 tons of washed coal and low-sulfur coal to achieve a mixture yielding 4 lb per 10^6 Btu	5.0
KINGSTON	
Tall stack, low-sulfur coal, coal blending:	
(a) Two 1,000-ft stacks	1.2
(b) Limited blending of present coal supplies may be necessary	
BULL RUN	
Low-sulfur coal: (a) None, plant is in compliance	
JOHN SEVIER	
Low-sulfur coal, coal blending: (a) Plant is in compliance but limited coal blending may be required	
WATTS BAR	
Low-sulfur coal, coal blending:	
(a) Develop coal sources in Appalachia area	
(b) Limited blending may be required	
JOHNSONVILLE	
Tall stack, coal washing, low-sulfur coal, coal blending:	
(a) One 1,000-ft stack	1.2
(b) Wash 4,000,000 tons of raw coal annually	13.1
(c) 5,000,000 tons of new low-sulfur coal	3.3
(d) Blend 3,600,000 tons of washed and low-sulfur coal to achieve a mixture yielding 4 lb per 10^6 Btu	.9
SHAWNEE	
Tall stack, coal washing, low-sulfur coal, coal blending:	
(a) Two 800-ft stacks	3.0
(b) Wash 3,800,000 tons of raw coal annually	12.6
(c) 1,200,000 tons of existing low-sulfur coal	
(d) 300,000 tons of new low-sulfur coal	2.0
(e) Blend 2,300,000 tons of washed and low-sulfur coal to achieve a mixture yielding 4 lb per 10^6 Btu	0.6
WIDOWS CREEK 1 TO 6	
Tall stack, low-sulfur coal, coal blending:	
(a) 1,000-ft stack	1.1
(b) 1,000,000 tons of existing low-sulfur coal	
(c) 100,000 tons of new low-sulfur coal	.7
(d) Blend 2,000,000 tons of high-sulfur and low-sulfur coal to achieve a mixture yielding 4 lb per 10^6 Btu	.5
WIDOWS CREEK 7 TO 8	
SO_2 scrubber: (a) Scrubbers on units 7 to 8	14.0
Total annual cost	153.2

TABLE IV-7.—ALLOWABLE PROCESS EMISSIONS FOR VARIOUS TVA AND GEP STACK HEIGHTS

Powerplant	Existing	GEP	TVA proposed	Plant process emissions (pounds per 10^6 Btu)		
				Assumed for existing stacks	GEP	TVA proposed*
Johnsonville:						
1 to 6	272	480	1,000	1.2	1.7	3.7
7 and 8	400	500	400			
9 and 10	400		400			
Kingston:						
1 to 4	250	280	1,000	1.2	1.2	4.0
5 to 9	300	300	1,000			
Shawnee:						
1 to 5	250	250	800	2.0	1.6	3.8
6 to 10	250	250	800			
Widows Creek:						
1 to 6	270	300	1,000	1.2	1.5	4.9
7 and 8	500	500	500	1.?	1.7	1.2

*TVA calculations of emission rates needed to meet both primary and secondary ambient SO_2 standards.

E. Comments of EPA Task Force Members—Section IV

1. In fiscal year 1973 TVA emitted into the atmosphere some 2.37 million tons of SO_2. This represents 14% of the national and 53% of Region IV emissions of SO_2 from electric power generation.

2. EPA's initial proposal of a compliance strategy for the TVA power system (Table IV–2, page 6) was based upon a limited amount of data available concerning TVA operations (FPC Forms 67, etc.) and was prepared to stimulate discussion only. It does not represent EPA's view of the optimum compliance strategy.

3. TVA should continue to exercise its emergency authority to negotiate coal contract without competitive bidding.

4. In negotiating new contracts for coal, TVA should give priority to purchasing those supplies that satisfy (or are capable of being washed to satisfy) applicable emission limitations.

5. For several reasons, EPA feels that TVA could sign long-term contracts for considerable amounts of eastern low-sulfur coal and that TVA should consider opening up their own low-sulfur coal mines. First, a recent study by the Environmental Policy Center (*An Inventory of Low Sulfur Coal Producers in the Appalachian States, June, 1974*) indicated that there are approximately 2,000 mines in the Appalachian States that are producing coal from seams having a mean sulfur content of less than 1.5%. The breakdown by sulfur content is given below:

Number of mines:	*Sulfur content (percent)*
815	0.7
580	0.7–1.0
605	1.01–1.5

It would be possible to sign long-term contracts with those mines that have sufficient reserves. Second, Charles River Associates has recently estimated that there are about 42 billion tons of coal reserves containing less than 1% sulfur in the states of Virginia, West Virginia, and Kentucky. These reserves are in seams more than 28 inches thick and at depths of less than 1,000 feet. Finally, at least 5 utility companies (Carolina Power, Alabama Power, American Electric Power, Duke Power, and Ontario Hydro) have already signed long-term contracts for about 17 million tons of new eastern low-sulfur coal for delivery in 1977.

6. TVA should develop a vigorous quality control program directed at reducing or minimizing the variability in the sulfur content of its coals. TVA's use of coal blending (at an estimated cost of 25¢ per ton) should tend to reduce or minimize the effect of variability in coal sulfur content and thus make the question of annual average emissions versus short-term average emissions a less significant issue. Other utilities in the region have not indicated that fuel variability presents a problem of the magnitude suggested by TVA.

7. TVA should consider installing and operating coal washing plants as may be required to obtain sufficient clean coal to meet emission limiting regulations.

8. TVA's estimate of the cost of coal washing is slightly more than double EPA's estimate (i.e., 26¢/10^6 BTU vs. 12¢/10^6 BTU, respectively). As shown in the following table, the differences stem from assumptions concerning the amount of energy lost during the washing operation:

	Percent
Weight loss:	
EPA	10
TVA	24
Heat loss:	
EPA	3
TVA	17

Additional analysis is needed to devise more accurate estimates of the cost of washing.

9. The switching of coal between Bull Run and Kingston has a total cost for compliance of $8 million with no reduction in total SO_2 emissions. This is TVA's first proposal to achieve compliance at least cost. While it would likely cost more to acquire new low-sulfur coal or to use flue gas desulfurization at the Kingston Plant to lower total SO_2 emissions, these alternatives would be preferable from an environmental viewpoint. This latter approach was proposed by EPA.

10. Last fall, EPA held a public hearing in Washington, D.C., to review the status of power plant compliance with sulfur oxide air pollution emission limitations. The hearing panel concluded that the reliability of stack gas cleaning systems has been sufficiently demonstrated on full scale units (e.g., Chemico Mitsui Miike lime scrubbers, Louisville Gas and Electric's Paddy's Run lime scrubber, and Japan's Synthetic Rubber's Chiba Wellman-Lord system) to warrant widespread commitments to scrubbers at coal and oil-fired power plants. Although some scrubbers in the U.S. have encountered reliability problems, the panel found that each of these problems can be solved through careful system design.

11. EPA believes that TVA's estimate of time required to install flue gas desulfurization equipment can be reduced by at least one to two years.

12. TVA contends that the task of installing particulate equipment will not be completed until 1977 or 1978, and that they cannot initiate design for scrubbers until July 1977 due to a shortage of manpower and resources. TVA's management should immediately acquire and/or commit the resources needed to proceed with design and installation of both particulate and flue gas desulfurization control equipment on a system-wide basis and in an expeditious manner.

13. Should constant emission controls not result in the attainment of ambient standards for a particular source, EPA could allow the use of a supplemental control system (SCS) to achieve the necessary further reduction in air quality levels until some substantially better procedure for emission reduction could be developed. The possibility for developing emission reduction procedures more efficient than flue gas desulfurization for application to power plants seems far in the future. Thus, by using reasonable available control technology with presently available removal efficiencies and by making provisions for increasing removal efficiency, the installation of flue gas desulfurization at this time would not in any way be a wasted investment.

14. While the constant emission reduction approach appears more costly than the intermittent reduction approach, the former approach will not significantly increase TVA's capital requirements. Specifically, TVA has estimated that the cost to install scrubbers at three plants would be $378 million, which EPA estimates as being only some 4–7% of their capital requirements between 1974 and 1982.

15. TVA's compliance with the emission limiting regulations assumed in this study will not significantly increase the residential consumer's electricity bill. EPA estimates that based on an annual cost of $150 million, the actual increase in cost to a residential customer in 1980 (on the basis of 1,300 kilowatt-hours/month) would be about 6% or $1.25 per month.

16. TVA has estimated that in fiscal year 1985 it will only use about 67% of its fiscal year 1974 coal usage. This assumed that its nuclear program will be on schedule. EPA views this as a very optimistic forecast.

17. Since TVA's consumption of coal at its coal-fired plants is projected to decrease 33% by 1985, the cost of complying with emission limitations will also decrease. EPA would like TVA to estimate the increase in annual costs (on a cash flow basis) needed to comply with emission limitations in 1977, 1980 and 1985.

18. In Section IV.D of the report, TVA has estimated that the annualized cost of complying with emission limits established through use of good engineering practice stack heights would be $18.8 million dollars more than the use of unrestricted stack heights. The use of unrestricted stack heights is contrary to the recent opinion of the 5th Circuit Court and EPA's interpretation of the requirements of the Clean Air Act.

19. TVA estimates that the annual cost of the GEP alternative would be $172 million or only some $18.8 million more than the unrestricted stack height alternative. Assuming an annual sales base of 100 billion kilowatt hours and an evenly distributed additional cost. This would amount to only 0.018 cents per kilowatt hour or 23.4 cents per month at a usage of 1300 kilowatt hours.

20. In Section IV.D TVA discussed the probability that Kingston would be able to achieve ambient air quality standards on a mass emission rate basis through use of existing supplies of low-sulfur coal. EPA must note that full compliance with applicable emission limiting regulations is a basic requirement of the Clean Air Act and TVA will be required to demonstrate through an appropriate testing and reporting program that such limits are complied with. The concept of allowing mass emission rates for a facility rather than for an individual unit is one that will have to be considered in greater depth by EPA and the States involved.

F. Comments of TVA Task Force Members—Section IV

1. Constant emission limitations can attain and maintain ambient SO_2 standards.

2. This constant emission control strategy cannot be fully implemented in time to attain ambient SO_2 standards by the deadlines established by the Clean Air Act.

3. For all but a small percentage of the time, constant emission limitations will result in more stringent emission control than is necessary to meet ambient standards because (1) the emission limitations are designed for the most adverse meteorological conditions, which normally occur less than 5 percent of the time, and (2) the emission limitations are based on maximum plant generating capability, which is rarely attained in actual power system operations.

4. If the proposed continuous emission limitations to meet ambient standards were successfully implemented on the TVA system, total emissions from TVA plants would be reduced by about 50 percent.

5. Based on present system planning projections, by 1985 TVA emissions from its existing power plants will be reduced to 67 percent of present levels even without continuous emission controls due to reduced operation of these plants.

6. There are no significant demonstrated or quantified benefits from the reduction of emissions from TVA's existing power plants below levels needed to meet ambient standards.

7. The cost of achieving the proposed continuous emission limitations at TVA plants is in the order of $180 million per year above what is needed to meet ambient standards.

8. Based on FY 1973 sales and assuming the annual cost increase of $200 million is distributed equally to all classes of customers on a per-kWh basis, the average monthly bill for the 2 million residential customers in the TVA service area would increase about $2.50. The average bill of TVA's 59 directly served industrial and Federal customers would increase over $100,000 per month. The remaining cost of approximately $5 million per month would be borne by the commercial, industrial, and municipal customers in the region. Industrial and commercial rate increases will eventually be passed on to consumers.

9. The availability of low-sulfur coal supplies to TVA are uncertain. The remaining available reserves of low-sulfur coal in the Nation could be used more effectively in other ways.

10. Coal washing is a major element in this strategy. Additional information is needed in order to determine the effectiveness of washing on sulfur reduction for coals that will be available to TVA.

11. Coal washing results in significant losses of coal reserves in discarded materials. TVA estimates of these losses are considered realistic; if anything, losses could be higher. The estimates are based in large part on studies by EPA consultants and on the quality of raw coal actually being received by TVA from midwestern mines. TVA's estimates of the cost of replacement coal are based on coal prices which are lower than the prices of most of the coal now being offered TVA from this area.

12. Flue gas desulfurization (FGD) technology has not been developed to the point that it can be used commercially at the present time.

13. Even when FGD is demonstrated, the reliability is likely to be less than that of the generating unit. Thus there could be extended periods when the control system is out of service and ambient standards could be jeopardized.

14. FGD based on lime-limestone technology involves significant environmental effects such as mining operations to supply raw materials, solid waste disposal, and potential water pollution problems.

15. FGD involves significant economic effects such as utilization of material and manpower resources for fabrication and installation and energy consumption for transportation of raw materials and operation.

16. The proposed emission limitations take into account present stack heights at TVA plants but do not reflect emission limits which would be needed when new tall stacks are completed. For example, the control strategy includes the interchange of coal between Kingston and Bull Run. This can be done because Bull Run, with 800-foot stacks, can burn higher sulfur coal than Kingston, with 250- to 300-foot stacks. By 1976, however, Kingston will have 1,000-foot stacks and the control strategy will result in the incurring of a cost of $8 million annually to burn the lower sulfur coal in the plant with taller stacks.

17. Coal sulfur variability has not been adequately considered in this strategy.

18. If this continuous emission control strategy does not result in the attainment of ambient standards, necessary adjustments would be difficult, costly, and time consuming and the capital investment in an inadequate strategy may be wasted.

19. TVA has already committed approximately $250 million for particulate control equipment at its plants and is proceeding as rapidly as possible with the design and installation of this equipment.

20. TVA believes there is a better alternative to constant emission limitations for meeting ambient SO_2 standards.

21. The tall stack is the most effective and economical means available for reducing ground-level concentrations of sulfur dioxide.

22. State implementation plans should recognize the effectiveness of tall stacks and permit their use in control strategies for attaining and maintaining ambient standards.

23. If tall stacks were permissible control strategies for attaining ambient standards on the TVA system, the annual cost of meeting constant emission standards at the four plants with tall stacks would be reduced to about 25 percent.

24. Acceptance of tall stacks would result in more cost-effective control measures but would not remove the substantial overkill inherent in constant emission control requirements.

25. Taking into account TVA's planned stack heights reduces the need for source supplies of low-sulfur coal. However, coal losses associated with coal washing are increased.

26. Basing constant emission standards on TVA's planned tall stacks would reduce the number of SO_2 scrubbers employed in the control strategy to two. Therefore, large quantities of limestone or lime used in scrubbers are conserved, as are power requirements (about 7 percent of plant capacity) to operate scrubbers.

V. ALTERNATIVES TO MEET AMBIENT STANDARDS

A. Bases and Assumptions of the Ambient Approach

The strategy outlined in this section was designed with the following assumed bases. These assumptions may or may not be valid.

1. Tall stacks can be used as a means of meeting ambient SO_2 standards in the vicinity of large power plants.

2. TVA Sulfur Dioxide Emission Limitation (SDEL) programs, comparable to Supplemental Control Systems (SCS), are techniques for meeting ambient SO_2 standards.

3. The objective of this control strategy is to achieve compliance with ambient SO_2 standards.

B. Exposition of Alternatives to Meet Ambient Standards

The purpose of this section is to present compliance alternatives for meeting ambient SO_2 standards for the TVA power system. The ambient standards and the dates by which they must be met are shown in table V–1. Table V–2 shows both the measured and calculated values of the maximum ambient SO_2 concentrations. Ambient SO_2 concentrations measured at one continuously recording monitor near the Kingston plant from 1968 through 1973 are shown in figures V–1 and V–2. From these figures it can be seen that concentrations in excess of the ambient standards occur less than 5% of the time at this monitoring station. At most other TVA monitoring stations, these high concentrations occur much less frequently. Between January 1, 1968, and December 31, 1973, TVA measured ambient SO_2 levels on 66,566 monitor days. 24-hour concentrations exceeded 0.14 ppm on 151 of these monitor days, or 0.2% of the time. 134 of these high measurements were made at Widows Creek and Kingston.

The alternatives considered in this section for meeting ambient SO_2 standards in the TVA power system are Sulfur Dioxide Emission Limitation (SDEL) programs, comparable to EPA's proposed supplemental control systems (SCS), tall stacks, and an SO_2 scrubber on Widows Creek Unit 8. SDEL programs reduce emissions during adverse dispersion conditions through a switch to low-sulfur coal or by a reduction in generation. Use of tall stacks alone is not feasible since at some plants it would be impractical to build stacks of sufficient height to ensure that ambient standards are met (see table V–3). Therefore, use of tall stacks was considered only in conjunction with the use of SDEL programs.

TVA has operated an SDEL programs for nearly five years at the Paradise Steam Plant, and has proved the reliability of this type of system in meeting ambient SO_2 standards (see figure V–3 and table V–4).

The use of SDEL at other plants in the TVA system is expected to result in the frequency and duration of emission reductions shown in tables V–5 and V–6. These tables also show the average expected magnitude of the reductions in equivalent megawatt-hours per year if emissions are reduced by generation reductions. The alternative to load curtailment for reduction of emissions during control periods is use of low-sulfur coal. Coal-handling facilities for quickly introducing the low-sulfur coal are being developed. Live-yard storage and divided bunkers are also being designed. Also, the effect of low-sulfur content of stack gas on precipitator performance will have to be determined. TVA's experience in temporarily switching to low-sulfur coal at the Widows Creek plant indicates that short-term (4–6 hours) use of low-sulfur coal does not adversely affect precipitator performance.

For some plants, use of SDEL without the addition of tall stacks could have an adverse impact on TVA power system reliability because of the high frequency, duration, and magnitude of the generation reductions. Therefore, it is considered that use of SDEL alone is not a satisfactory alternative for meeting ambient SO_2 standards. However, the combination of SDEL and tall stacks is considered a viable approach.

The proposed schedule for designing and implementing these programs is shown in figure V–4. This schedule should result in compliance with ambient standards by mid-1975. As seen in this figure, four plants—Allen, Cumberland,

Gallatin, and Paradise—already have operating SDEL programs. Also indicated on the figure is the planned date for the completion of tall stacks at Kingston, Widows Creek, and Shawnee. When these tall stacks go into service, the SDEL program will be modified appropriately. With tall stacks, the frequency of generation reductions will be diminished considerably and could possibly be eliminated at Kingston.

Estimated costs for SDEL programs for each plant are shown in table V–7. These cost estimates for the implementation of this ambient control strategy are based on annual average expected frequencies. The actual use may be higher, and thus costs might be higher than those shown—$2–$3 million more if the actual annual frequency were twice as high.

TVA's proposed compliance strategy for its power system using both SDEL and tall stacks is shown in table V–8. Potential maximum ambient SO_2 concentrations in the vicinity of TVA plants and the manner by which they may be limited through the use of this approach are shown in figure V–5. From this figure it can control other than a coal-sulfur-content limitation sufficient to maintain the ambient standards. This would permit continued use of present coal supplies. Two plants—Allen and Gallatin—require little control. Two other plants—Cumberland and Paradise—are already equipped with tall stacks, and will require control only during certain specific meteorological conditions. Finally, five other plants—Kingston, Johnsonville, Colbert, Shawnee, and Widows Creek—will require sophisticated SDEL systems.

Estimate costs for this compliance strategy for the entire system are shown in table V–9.

TABLE V–1.—AMBIENT SO_2 STANDARDS APPLICABLE TO TVA STEAMPLANTS

Plants	Secondary standard (parts per million)	Primary standard (parts per million)		Date standard required to be met
	3-hr average*	24-hr average*	Annual average	
Alabama plants: Colbert and Widows Creek	0.5	0.14	0.03	May 31, 1975
Kentucky plants: Paradise and Shawnee	.5	.14	.03	†July 1, 1978
Tennessee plants: Allen, Bull Run, Cumberland, Gallatin, John Sevier, Johnsonville, Kingston, and Watts Bar	.5	.14	.03	July 1, 1975

*Not to be exceeded more than once per year.
† Date for meeting secondary standard. Primary standards are to be in the Louisville AQCR by July 1, 1977. The State implementation plan indicates that primary standards are already being met in the Paducah-Cairo AQCR where both Paradise and Shawnee are located.

TABLE V–2.—AMBIENT SO_2 CONCENTRATIONS TVA STEAMPLANTS

[In parts per million]

Plant	Maximum measured SO_2 concentrations*			Maximum calculated SO_2 concentrations†		
	3-hr average	24-hr average	Annual average	3-hr average	24-hr average	Annual average
Allen	0.35	0.08	0.011	0.65	0.15	0.007
Bull Run	.21	.05	.005	.14	.03	.002
Colbert	.79	.24	.011	1.19	.29	.012
Cumberland	.32	.08	.005	1.09	.22	.011
Gallatin	.47	.14	.005	.63	.14	.006
John Sevier	.28	.06	(‡)	.29	.07	.003
Johnsonville	.61	.16	.013	1.31	.31	.014
Kingston	.83	.45	.020	1.01	.56	.026
Paradise	.79	.17	.011	1.54	.32	.016
Shawnee	.67	.24	.020	1.08	.28	.011
Watts Bar	.35	.08	(‡)	.37	.08	.004
Widows Creek	3.03	.52	.019	4.85	1.31	.018

*Actual measurements recorded during the history of each plant's monitoring system.
†Based on fiscal year 1973 average emissions.
‡Not available.

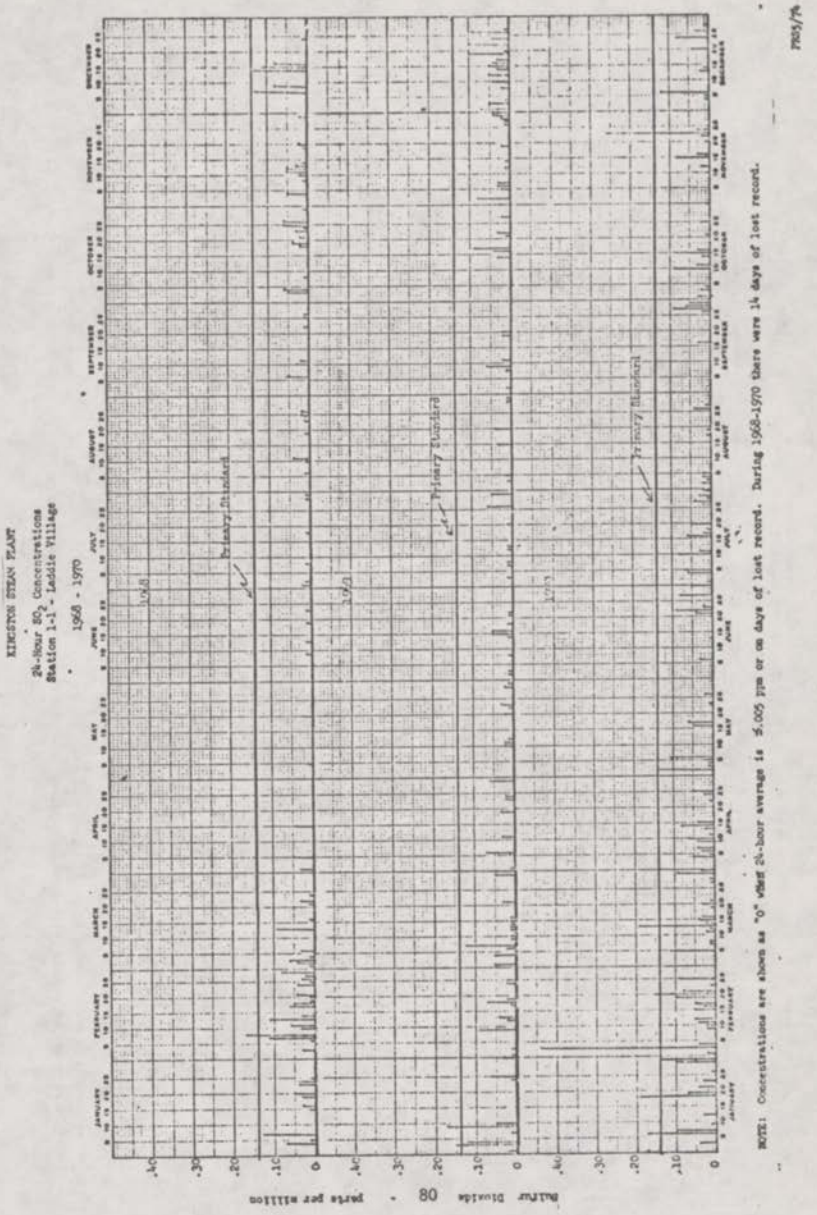
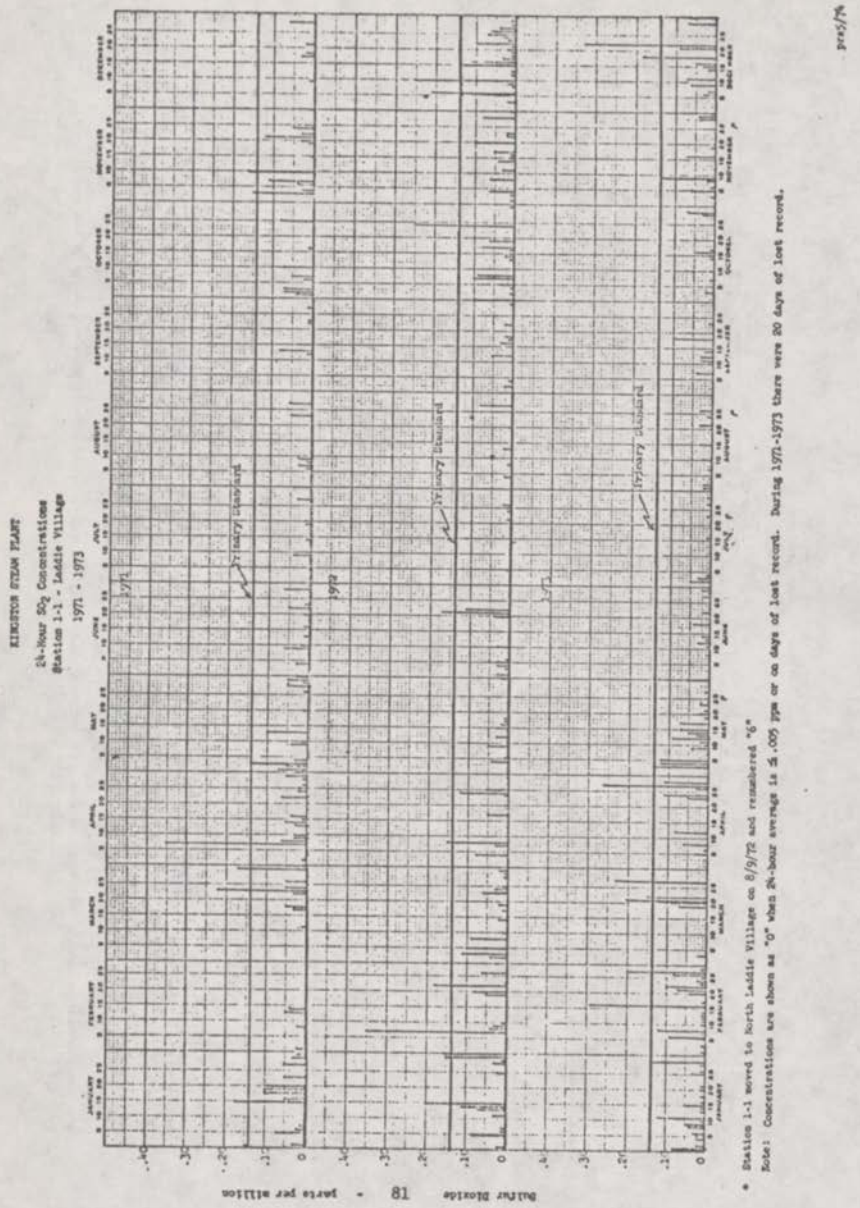

KINGSTON STEAM PLANT
24-Hour SO_2 Concentrations
Station 1-1 - Laddie Village
1968 - 1970
Primary Standard
Primary Standard
Primary Standard
Sulfur Dioxide - parts per million
NOTE: Concentrations are shown as "0" when 24-hour average is ≤.005 ppm or on days of lost record. During 1968-1970 there were 14 days of lost record.
7635/74

FIGURE V–1



* Station 1-1 moved to North Laddie Village on 8/9/72 and renumbered "6"

Note: Concentrations are shown as "0" when 24-hour average is ≤.005 ppm or on days of lost record. During 1971-1973 there were 20 days of lost record.

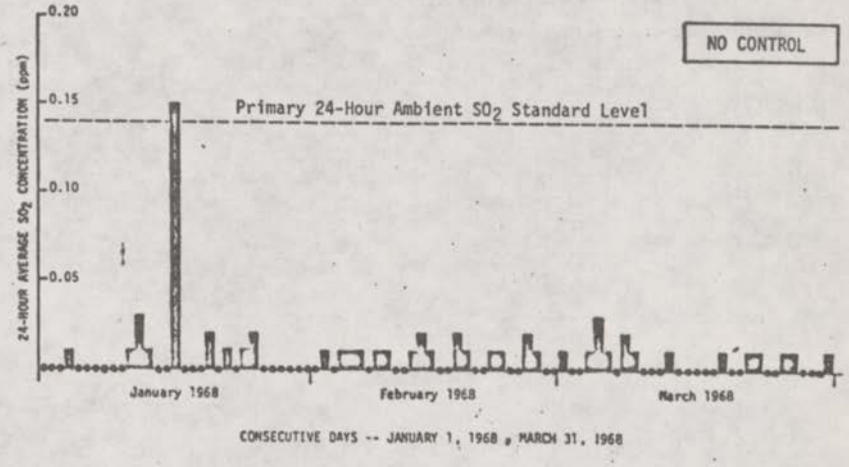
pro5/74

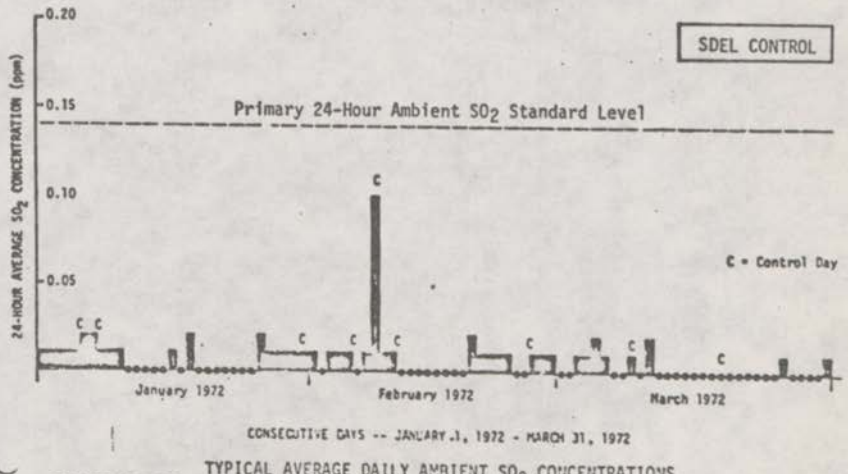
FIGURE V–2

TABLE V-3.—STACK HEIGHTS REQUIRED TO MEET AMBIENT SO_2 STANDARDS AT TVA STEAMPLANTS

[Based on fiscal year 1973 emission rates]

Plant	Stack height required to meet ambient standard (feet)	
	3-hr average standard	24-hr average standard
Allen	600	500
Bull Run	<800	<800
Colbert	>1,300	>1,300
Cumberland	>1,300	>1,300
Gallatin	600	500
Johnsonville	>1,300	>1,300
John Sevier	<350	<350
Kingston	1,000	1,000
Paradise	>1,300	>1,300
Shawnee	1,100	1,100
Watts Bar	<177	<177
Widows Creek	>1,300	>1,300





TYPICAL AVERAGE DAILY AMBIENT SO_2 CONCENTRATIONS
BEFORE AND AFTER IMPLEMENTATION OF AN SO_2 EMISSION LIMITATION (SDEL) PROGRAM

FIGURE V-3

TABLE V–4.—FERQUENCY DISTRIBUTION OF MEASURED SO_2 CONCENTRATIONS* BEFORE AND AFTER IMPLEMENTATION OF SO_2 EMISSION LIMITATION PROGRAM, PARADISE STEAMPLANT

	Frequency	
	Before (Jan. 1, 1968 to Sept. 19, 1969)	After (Sept. 19, 1969 to June 25, 1971)
3-HR AVERAGE SO_2 CONCENTRATION DISTRIBUTION		
3-hr average SO_2 concentration range (parts per million):		
0	51,097	55,961
0.01 to 0.10	10,574	9,363
0.11 to 0.20	443	275
0.21 to 0.30	102	59
0.31 to 0.40	37	28
0.41 to 0.50	16	10
0.51 to 0.60	7	2
0.61 to 0.70	2	0
0.71 to 0.80	1	0
24-HR AVERAGE SO_2 CONCENTRATION DISTRIBUTION		
24-hr average SO_2 concentration range (parts per million):		
0	3,064	3,752
0.001 to 0.02	4,248	4,043
0.021 to 0.04	400	305
0.41 to 0.06	92	73
0.061 to 0.08	24	19
0.081 to 0.10	14	9
0.101 to 0.12	6	3
0.121 to 0.14	4	2
0.141 to 0.16	7	0
0.161 to 0.18	1	0

*For 14 SO_2 monitoring stations in the north/northeast sector of the Paradise steamplant area.

TABLE V-5.—ESTIMATED FREQUENCY, DURATION, AND MAGNITUDE OF EMISSION REDUCTIONS NEEDED TO MEET AMBIENT SO_2 STANDARDS AT TVA STEAMPLANTS WITH EXISTING STACKS

[Based on simulation of actual conditions in 1970]

Plant	Stack height (feet)	Estimated frequency of emission reductions (days per year)	Estimated duration of emission reductions (hours per day)	Estimated magnitude of emission reductions		Maximum expected reduction		
				Equivalent replacement power (megawatt-hours per year)	Equivalent low-sulfur coal fired (10^3 tons per year)	Mass emission rate (pounds per second)	Generation (megawatts)	Fraction of plant capacity (percent)
Allen	400	1	6.0	1,400	2.4	3.0	230	23
		24	5.5	25,000	78.0	13.6	810	58
Colbert	300							
Units 1 to 4	500							
Unit 5	1,000	10	3.0	15,000	32.0	21.8	1,410	54
Cumberland	500	7	4.5	9,000	16.0	2.9	260	21
Gallatin		32	6.0	45,000	130.0	15.2	920	62
Johnsonville	273							
Units 1 to 6	400							
Units 7 to 10		55	7.0	100,000	270.0	7.9	860	50
Kingston	250							
Units 1 to 4	300							
Units 5 to 9		13	3.5	222,000	48.0	31.7	1,730	68
Paradise *	600							
Units 1 and 2	800							
Unit 3	250	42	6.0	87,000	190.0	11.2	940	54
Shawnee		25	6.0	75,000	130.0	24.6	1,770	90
Widows Creek †	270							
Units 1 to 6	500							
Units 7 and 8								

* Based on experience with implemented program.

†Based on ambient SO_2 data from Widows Creek monitoring network.

54-380 O - 75 - pt. 2 - 24

TABLE V-6.—ESTIMATED FREQUENCY, DURATION, AND MAGNITUDE OF EMISSION REDUCTIONS NEEDED TO MEET AMBIENT SO_2 STANDARDS AT TVA STEAMPLANTS WITH INSTALLATION OF TALL STACKS AT THREE ADDITIONAL PLANTS

[Based on simulation of actual conditions in 1970]

Plan	Proposed stack height (feet)	Estimated frequency of emission reductions (hours per day)	Estimated duration of emission reductions power mega-watt-hours per year	Estimated magnitude of emission reduction		Maximum expected reduction		
				Equivalent replacement power (watt-hours per year)	Equivalent low sulfur coal fired (10^3 tons per year	Mass emission rate (pounds per second	Generation (megawatts)	Fraction of capacity
Allen		1	6.0	1,400	2.4	3.0	230	23
Colbert		24	5.5	25,000	78.0	13.6	810	58
Cumberland		10	3.0	15.000	32.0	21.8	1,410	54
Gallatin		7	4.5	9,000	16.0	2.9	260	21
Johnsonville		32	6.0	45,000	130.0	15.2	920	62
Kingston (2 stacks)	1,000	0	0	0	0	0	0	0
Paradise*		13	3.5	22,000	49.0	31.7	1,730	68
Shawnee (2 stacks)	800	3	3.5	2,800	8.0	3.1	270	15
Widows Creek†		12	6.0	36,000	62.0	12.9	840	42
Units 1 to 6 (1 stack)	1 000							

* Based on experience with implementation program.
† Based on projections of ambient SO_2 data from Widows Creek monitoring network.

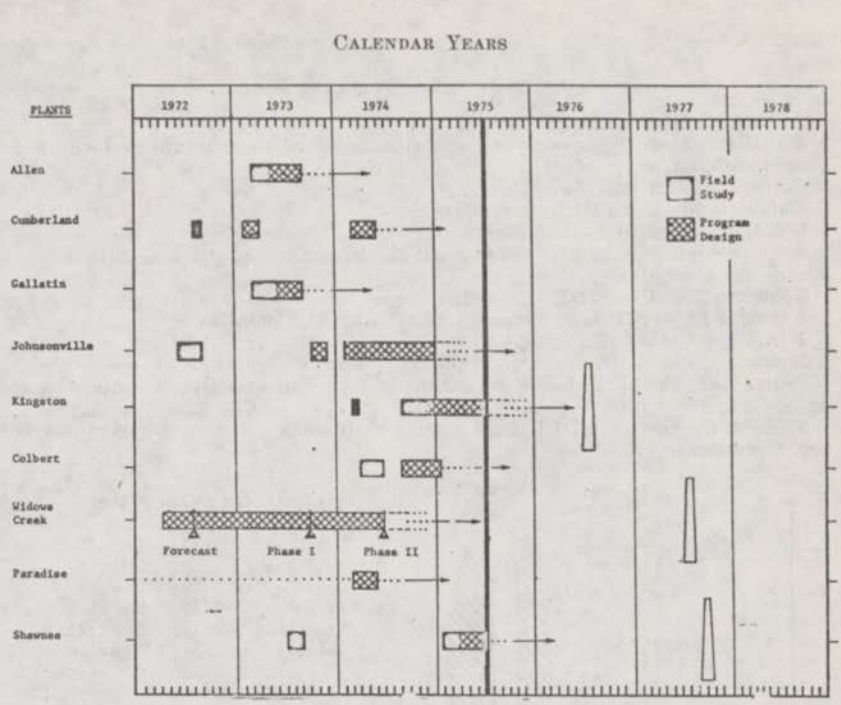


FIGURE V–4.—Development schedule—SO_2 emission limitation programs

TABLE V–7.—COST ESTIMATE * TVA SO_2 EMISSION LIMITATION PROGRAMS

[In thousands of dollars]

Plant	Capital cost (including 1st year development cost)				Annual operating cost
	Existing air monitors †	New air monitors	Development of SDEL programs	Total	
Allen	19	94	269	382	143
Colbert	19	170	269	458	188
Cumberland	170	227	352	749	329
Gallatin	0	94	270	364	132
Johnsonville	19	208	269	496	214
Kingston:					
Existing stacks	38	189	352	579	218
Tall stacks			21	21	(218)
Paradise	132	227	270	629	304
Shawnee:					
Existing stacks	57	245	269	571	252
Tall stacks			21	21	(252)
Widows Creek:					
Existing stacks	113	302	526	941	343
Tall stacks			21	21	(343)
Total, all plants	567	1,756	2,909	5,232	2,124
Average cost per plant	63	195	323	581	232

* Includes only program development and operating costs, exclusive of power replacement or increased fuel costs.
† Effective September 1973.

TABLE V-8.—ALTERNATIVE TO MEET AMBIENT STANDARDS TVA POWER SYSTEM

PLANT, PROPOSED ACTION AND RESULT

Allen: Use SDEL, Compliance.
Bull Run: Coal-sulfur-content limitation sufficient to maintain ambient standards, Compliance.
Colbert: Use SDEL, Compliance.
Cumberland: Use SDEL, Compliance.
Gallatin: Use SDEL, Compliance.
John Sevier: Coal-sulfur-content limitation sufficient to maintain ambient standards, Compliance.
Johnsonville: Use SDEL, Compliance.
Kingston: Use SDEL and construct tall stacks[1], Compliance.
Paradise: Use SDEL, Compliance.
Shawnee: Use SDEL and construct tall stacks, Compliance.
Watts Bar: Coal-sulfur-content limitation sufficient to maintain ambient standards, Compliance.
Widows Creek: Use SDEL and construct tall stack and an experimental scrubber, Compliance.

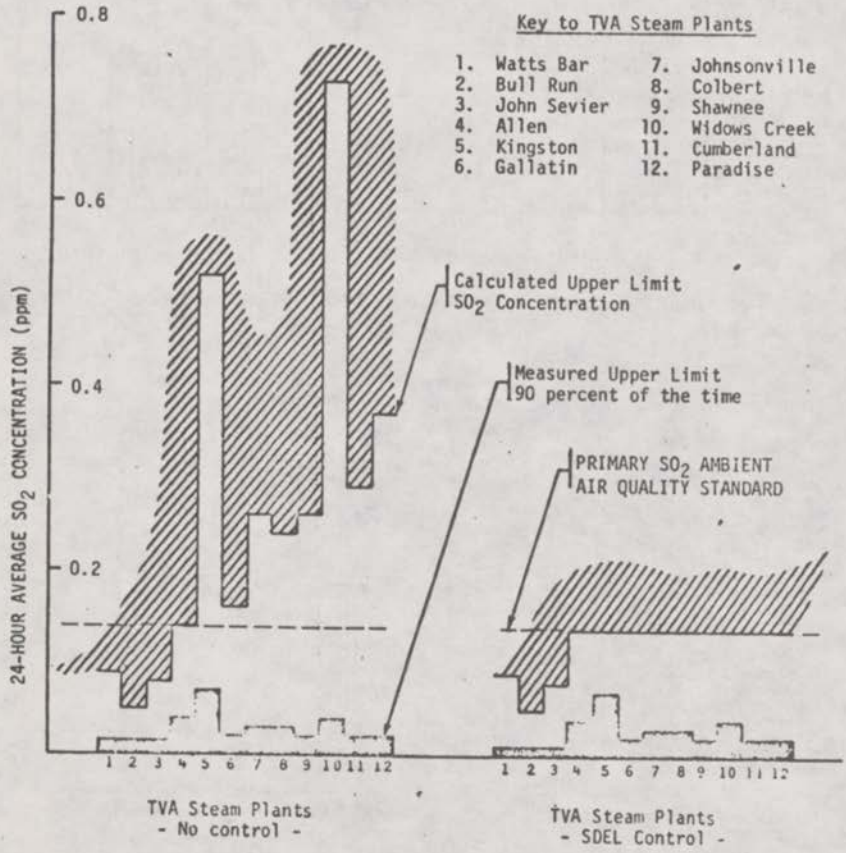


Figure V-5

[1] It may be possible to discontinue use of SDEL after tall stacks are in operation.

TABLE V–9. *Estimated Capital and Annual Costs for Meeting Ambient SO_2 Standards at TVA Coal-Fired Plants*

	Amount in millions
Capital costs:	
SDEL programs:	
Development and installation of SDEL programs and monitoring networks	$5
New tall stacks (Kingston, Shawnee, Widows Creek Steam Plants)	47
Coal switching capability (Colbert, Cumberland, Johnsonville Steam Plants)	8
Total capital costs of SDEL program	60
SO_2 removal system: SO_2 removal system—Widows Creek Unit 8	42
Total capital costs of proposed TVA program for SO_2 control	$102
Annual costs:	
SDEL Programs:	
Annualized capital charges on $60 million investment at 9.642 percent	5.8
Operation and maintenance of SDEL programs (including cost for replacement power), stacks, and monitoring equipment	3.6
Incremental cost of low-sulfur coal for coal switching, including added transportation and handling costs	1.6
Total annual costs of SDEL program	11.0
SO_2 Removal System	
Annualized capital charges on $42 million investment at 9.049 percent	3.8
Operation and maintenance of SO_2 scrubber at 1.2 mills/kwh Widows Creek unit	3.1
Total annual cost of SO_2 removal system	6.9
Total annual cost of proposed TVA program for SO_2 control	17.9

C. Comments of EPA Task Force Member—Section V

1. EPA maintains that the Clean Air Act mandates the use of continuous emission reduction techniques to achieve National Ambient Air Quality Standards (NAAQS). Further, the U.S. Fifth Circuit Decision of February 8, 1974 (*NRDC* v. *EPA*) ruled that dispersive techniques for meeting ambient air quality standards are not consistent with the Clean Air Act. Congress recently indicated its wish that continuous emission reduction techniques be used by placing strong emphasis on these techniques in the Energy Supply and Environmental Coordination Act of 1974.

2. The implementation of TVA's Sulfur Dioxide Emission Limitation (SDEL) program will not result in compliance with the continuous emission limits set forth in the applicable State implementation plans. Thus, this approach does not satisfy legal obligations imposed by State and Federal authority.

3. The question of sulfur dioxide removal technology was dealt with in EPA's National Public Hearings on Power Plant Compliance with Sulfur Oxide Air Pollution Regulations (from October 18 to November 2, 1973). The "Report of the Hearing Panel" (January 1974) indicated that flue gas desulfurization technology is currently available.

4. The reliability of the SDEL approach, at any one time, to more than one TVA power plant has not been demonstrated. It should be noted that the feasibility of a reliable supplemental control system (SCS) such as SDEL around the Paradise power plant has been shown by eliminating violations of NAAQS in only one downwind sector. However, an acceptable and reliable SCS which insures that NAAQS will be protected in all areas around this plant has not yet been developed.

5. TVA has not demonstrated that SDEL can meet ambient SO_2 standards without jeopardizing the system's ability to meet customer demand. The SDEL

approach is based on two assumptions that are open to question: (1) sufficient reserve generating capacity is available to permit the switching of load from one plant to another, and if not, (2) low-sulfur coal can be burned.

The problem of maintaining sufficient reserve generating capacity is a serious one for utilities throughout the country. In a recent draft environmental impact statement (*Gas Turbine Peaking Plant Addition, Johnsonville Steam Plant*) TVA indicated that their available reserves without the proposed gas turbines would be 16.9% for Summer 1975 and 21.5% for Winter 1975–76; with the proposed gas turbines (637 megawatts) their available reserves would be 19.8% for Summer 1975 and 24.2% for Winter 1975–76. In Table V–6, p. 86, TVA states that maximum expected reductions at eight of their plants would be from 15–68% of plant capacity for 1 to 32 days of the year. This might not cause problems if adverse dispersion conditions affected only one plant in the system at a given time. But in fact TVA's plants are in a limited geographical area subject to similar meteorological conditions, many facilities being clustered along the Tennessee River. TVA does not have sufficient information on simultaneous occurrence of episode conditions at its plants to assure that both load requirements and environmental requirements could always be met.

While it is true that both load requirements and environmental requirements can be met through the use of low-sulfur coal, burning this fuel could cause violations of particulate standards by degrading precipitator performance, for the dispersion conditions which cause a buildup of SO_2 in the atmosphere have the same effect on particulate concentrations. TVA claims that short-term use of low-sulfur coal would not have this effect on precipitators, but EPA feels that sufficient evidence to support their contention is lacking. The use of flue gas conditioning (injection of SO_3 to improve precipitator performance) has been demonstrated, but never on a quick-response, short-term basis. TVA would have to experiment with these conditioning techniques on a large scale before being able to depend on them as part of a compliance program. TVA has not indicated that they plan such experiments, nor have they included the cost of flue gas conditioning in their estimates of the cost of SDEL.

Therefore, it is necessary to face the possibility that at times load requirements cannot be met without violating ambient standards if SDEL alone is relied upon. In such a situation, according to Dr. F. E. Gartrell (former Environmental Affairs Director, TVA), power needs would take precedence over environmental needs (p. 2736, Transcript, Ohio Adjudication Hearings, Columbus, Ohio, April 2, 1974). This basic conflict between power needs and clean air needs is inherent in SDEL, and EPA feels this conflict can be best avoided by use of continuous emission controls.

6. TVA's cost estimates for full implementation of their SDEL programs (Table IV–9, p. 91) do not include any costs for additional generating capacity that may be needed if present generating capacity would not be sufficient to maintain load requirements during adverse meteorological conditions that would bring the SDEL program into operation.

TVA's SDEL program cost estimates therefore may grossly underestimate the total costs for implementing the program. It is interesting to note that TVA is presently proceeding to install ten gas turbines with a total capacity of 637 megawatts at their Johnsonville power plant.

7. There is a growing body of health effects data which links the acid-sulfate aerosols associated with sulfur oxide emissions to serious health problems. Acid-sulfate aerosols in the ambient air have been linked to adverse health effects at concentrations an order of magnitude less than those for sulfur dioxide, viz., 6–15 $\mu g/m^3$ of suspended sulfates as a 24 hour and/or annual average. Furthermore, there is evidence that the resulting harmful acid-sulfate aerosols may be transported considerable distance in the atmosphere.

8. Control of sulfur oxide emissions from powerplants is necessary to control acid-sulfate aerosol exposures. Both urban and non-urban acid-sulfate aerosol levels in the ambient air will increase if power plants remain uncontrolled or if they rely upon tall stacks during periods of good dispersion and upon fuel switching during periods of poor dispersion. (Finklea, J. F., D. B. Turner, G. G. Akland, R. I. Larsen, V. Hasselblad, and S. D. Shearer, *Briefing Notes—A Status Report on Sulfur Oxides*. EPA, ORD, NERC, RTP, NC, April, 1974).

9. Since sulfates are long-lived, can be transported over long distances, and have been linked to adverse health effects at much lower ambient concentrations than sulfur oxides, EPA feels that the health danger from sulfates appears to require that total emissions of sulfur oxides over large areas be reduced to an extent that can only be achieved by the use of permanent controls.

10. EPA's policy is that supplemental control systems should be relied upon only as an interim measure until more appropriate alternatives are available. EPA is currently conducting research on sulfates to fill in present knowledge gaps, particularly in the area of atmospheric chemistry, so that the national air quality standard setting mechanism for this pollutant can be initiated. It would be short-sighted to move in a contrary direction now by encouraging use of supplemental control systems other than on an interim basis for existing facilities.

D. Comments of TVA Task Force Members—Section V

1. This control strategy can attain and maintain ambient SO_2 standards at TVA steam plants.

2. Although full implementation of the strategy will not be completed until 1978, ambient SO_2 standards should be met by the applicable deadlines.

3. These control strategies do not result in environmental overkill. Emissions are regulated based on meteorological surveillance to determine the dispersive capability of atmosphere. Even at present emission rates at TVA plants, emissions are far below dispersive capacity most of the time.

4. Tall stacks are the most reliable of all pollution control measures for reducing ground-level concentrations. The reliability of SDEL has been demonstrated at TVA's Paradise Steam Plant. The reliability of such techniques has been recognized by EPA on September 14, 1973 (38 FR 25698 and 25700).

5. TVA data shows that without additional control measures, SDEL will have to be implemented relatively frequently at five plants. For this reason, tall stacks are planned for three of these plants and intermittent coal switching is being considered at the other two. In addition, an SO_2 scrubber is under construction on one generating unit at one of these plants.

6. There is insufficient evidence to conclude that long-term continued discharge of sulfur dioxide causes adverse health effects as long as primary ambient standards are met. This conclusion has also been reached by Mr. John Quarles, Deputy Administrator, and in several scientific reports. (EPA Hearing on SO_2 Emission Compliance by Power Plants, Transcript, p. 2116 [October 30, 1973]; "Synopsis of the Health Basis for Existing Air Quality Standard," EPA, p. 2 [September 1973]; "Health Consequences of Sulfur Oxides: Summary and Conclusions Based Upon CHESS Studies of 1970–1971," EPA, p. 21–22 [August 15, 1973]; "A Review of the Health Effects of Sulfur Oxides," National Institute of Environmental Health Sciences, p. 7 [October 9, 1973]; National Academy of Sciences Conference on Health Effects of Air Pollution of the Senate Public Works Committee [November 1973])

7. With the exception of the scrubber on Widows Creek unit 8, this control strategy does not significantly reduce total annual SO_2 emissions from TVA power plants. However, annual ambient standards are not exceeded at any TVA plant.

8. Based on present system planning projections, by 1985 the emissions from TVA's existing coal-fired power plants will be reduced to 67 percent of present levels due to reduced operation of these plants.

9. Ambient controls can be quickly fine tuned and adjusted to compensate for modeling errors.

10. This control strategy is the most cost-effective method for attaining ambient SO_2 standards in the vicinity of TVA power plants. The cost is in the order of $180 million per year less than constant emission controls.

11. The control strategy will utilize scarce supplies of low-sulfur coal only as they are needed to protect the environment. Also, large quantities of limestone or lime used in scrubbers are conserved, as are the power requirements (about 7 percent of plant capacity) to operate scrubbers. Coal losses associated with coal washing are also avoided.

12. With the exception of potential adverse impacts from the operation of the Widows Creek scrubber, there are no significant adverse environmental impacts associated with TVA proposed ambient control measures. Adverse environmental impacts associated with constant emission control measures are avoided by ambient control strategies. Adverse impacts avoided include scrubber and coal

washing plant waste disposal problems and impacts associated with increased limestone and coal mining.

13. TVA's SDEL programs are enforceable either as against the ambient standards or as plant emission limitations in the same manner as constant emission limitations. The fact that such techniques can be enforceable has been recognized by EPA on September 14, 1973 (38 FR 25698).

14. The use of TVA's SDEL programs is permitted under the Clean Air Act. Mr. William D. Ruckelshaus, EPA's first Administrator, took the position that states could adopt any measures or combination of measures, including intermittent or variable emission limitation techniques, and that the Administrator would have to approve them if they were reliable and enforceable. (Hearings on implementation of the Clean Air Act Amendments of 1970 Before the Senate Subcommittee on Air and Water Pollution, 91st Congress, 2nd Session pt. 1, at 238, 244, 245, and 251 [1972]; Clean Air Act Oversight Hearings Before the House Subcommittee on Public Health and Environment, January 1972, reported at Cong. Rec. S10955 [June 12, 1973]; 40 CFR §§ 51.1[n], 51.2 [b], [c], and [d] and 51.10[a]; 37 FR 10845–6 [May 31, 1972]; 37 FR 15095 [July 27, 1972].) In any case, the issues should be approached on their merits and their resolution should be based on reason and good judgment. If the present law stands in the way of a reasonable course of action, it surely must be changed.

15. Ambient control strategies should be usable alternatives as long as they provide sufficient protection of the environment.

VI. EXECUTIVE SUMMARY

The TVA power system has been analyzed by a task force of EPA and TVA staff to assess alternatives for controlling sulfur oxides. Two basic approaches for sulfur oxide control were considered—controls for meeting emission limiting regulations and controls for attaining ambient standards.

EPA and TVA dispersion calculations on a plant-by-plant basis indicate that, for many TVA plants, the original emission limitations required by state implementation plans are overly restrictive. An alternative set of emission limitations for TVA plants were suggested by Region IV EPA, and the applicability, feasibility, and cost of four alternatives for achieving these limitations were studied. The four alternatives are:

1. Low-sulfur coal.
2. Coal washing.
3. Coal blending.
4. Flue gas desulfurization.

A preliminary TVA system control strategy was developed which utilized each of these alternatives. Implementation of the strategy at the 12 TVA steam plants would involve the following action:

1. Purchase about 4.7 million tons of low-sulfur coal per year.
2. Wash 22.4 million tons of midwestern coal per year.
3. Blend at least 20 million tons of coal per year.
4. Interchange the coal supplies at two plants.
5. Switch from midwestern coal to low sulfur Appalachian coal at one plant.
6. Install SO_2 scrubbers at three plants on 22 generating units with a total capacity of 4,360,000 kW.

TVA estimates the cost of this strategy would be in the order of $170 million per year, even excluding some costs which were not estimated in the analysis. EPA contends the cost would be more in the order of $125–$150 million per year. The cost estimates differ primarily because of difference in estimate of the cost of coal washing. No attempt was made when developing the strategy to optimize cost or to determine the most cost-effective combination of alernatives.

In November and December 1974, the Task Force reconvened to explore more fully the environmental and cost implications of further relaxation of emission standards by making allowances for increased stack heights at certain TVA plants. An alternative strategy was developed for meeting the more relaxed emission standards which relied more heavily upon coal washing and less upon flue gas desulfurization. By TVA estimates, the annual cost of this strategy would be in the area of $150 million per year.

Controls for attaining ambient standards were also reviewed and analyzed. Alternative methods considered for meeting ambient standards at TVA plants include:

1. Tall stacks.

2. Sulfur Dioxide Emission Limitations (SDEL) programs which result in:
   a. Intermittent generation reductions, or
   b. Intermittent switching to low-sulfur coal
3. Flue gas desulfurization.

A preliminary TVA system control strategy was developed which utilized each of these alternatives. Implementation of the strategy at the 12 TVA steam plants would involve the following action:

1. Installation of new tall stacks (800–1,000 feet) at three plants.
2. SDEL programs at nine plants.
3. Installation of rapid coal switching capability at three plants.
4. Purchase about ¼ million tons of low-sulfur coal per year.
5. Installation of an SO_2 scrubber on one 550,000 kW generating unit.

TVA estimates the cost of this strategy would be in the order of $17.9 million per year. Portions of this control strategy are already being installed on the TVA system.

In summary the three alternative control strategies and cost as estimated by TVA are:

Emission control: Allowing for existing stacks, $172,000,000.

Emission control: Allowing for tall stacks, $153,200,000.

Ambient control: Use of SDEL programs and TVA proposed tall stacks, $17,900,000.

There are fundamental differences between EPA and TVA in the proper choice of strategies for controlling sulfur dioxide. The major differences are itemized in the comments following Sections IV and V of the report.

Other possible approaches to meeting constant emission limitations have been identified by the Task Force but have not been fully explored. One such approach involves the development of constant emission restrictions based on pounds of SO_2 per unit of time rather than pounds per million BTU of heat input. TVA estimates that with standards based on pounds per unit of time, compliance costs could be reduced by as much as one-half. The Task Force believes that exploration of such approaches may provide the best opportunity for developing a reasonable approach to resolving the SO_2 question.

Question 21. It has been suggested by some that TVA rates should be reviewed on a routine basis by an outside agency, perhaps the Federal Power Commission. Would this give increased opportunity for public participation as well as greater public confidence in the validity of the TVA rate structure? Would there be any objections to such a procedure?

Answer. We believe that rate review of the type indicated would not increase public participation in TVA's rate determinations in any meaningful way or contribute to greater public confidence in the validity of the TVA rate structure. We think such review would be undesirable.

Public participation in rate review by the Federal Power Commission would require appearances through attorneys before the Commission. In such case the public participation would be less direct, and involve far fewer people, than existing quarterly rate review arrangements whereby members of the public can communicate directly with TVA and the 160 municipal and cooperative distributors at the open, formal discussions between TVA and the distributors and in conjunction with the open TVA Board meetings. Moreover, public participation in review by FPC or another outside agency would be more time consuming and expensive for both the members of the public seeking representation of their interests through counsel, and for TVA.

TVA's power program is basically different from the operations of private utility companies. Private utilities normally operate for purposes of profit and have an incentive to maximize the return on stockholder's investments. TVA, on the other hand, has a statutory mandate as to how it shall develop and utilize the resources of the Valley Region for the benefit of the people, including the specific requirement that it keep power rates as low as feasible. What TVA pays to the United States Government—which is, in effect, TVA's sole stockholder—is prescribed by law.

FPC and other regulatory commissions exercise authority over private utilities to prevent excessive and unfair rates and accumulation of unreasonable profits. Since TVA's power program is not operated for profit, determination of TVA rates involves different concepts. In addition, TVA has duties and obligations under Section 15d of the TVA Act and its Basic Bond Resolution which are different from those of the federal agencies whose rates are reviewed by FPC.

TVA's rates must be structured and determined within the framework of its duty to keep rates as low as feasible and at the same time meet all of the financial tests under the Act and the Basic Bond Resolution, and still take into account the obligation to provide an ample supply of power for the area TVA serves. If TVA no longer had control over its rates, it is difficult to see how it could meet these diverse responsibilities.

The existing quarterly review procedure followed by TVA enables TVA to operate with lower margins than might otherwise be possible because it is assured of being able to put a rate adjustment into effect promptly at the end of any quarter should one be necessary. On the other hand, the time now required by FPC and other regulatory commissions for completion of review and approval of rates proposed by private utilities frequently extends over periods of many months and this time period is continuing to lengthen. Indeed, extended delays in obtaining sufficient revenues could force TVA to suspend needed construction programs for meeting future power supply needs.

Current rate regulation proceedings furnish no evidence that there is more public confidence in such traditional regulatory review processes than in TVA's rate review arrangement. Rate regulation proceedings appear to be evidencing large and ever-increasing numbers of intervenor actions by consumer and other groups who apparently feel that their interests have not been or are not being adequately represented by the regulatory bodies.

More importantly, from the standpoint of the rate-paying public, TVA rates have been and continue to be significantly less than those of private utilities subject to the regulatory process, in spite of recent rate adjustments which have received widespread attention. Since TVA rates have historically been lower than rates of private utilities subject to the regulatory process, we do not see how a changeover to the regulatory process could result in lower TVA rates. On the contrary, for the reasons mentioned above, the virtually inevitable result would be higher rates.

To summarize, TVA believes that the present procedure for establishment and review of its rates is adequate and altogether appropriate for maintaining the lowest possible rates, providing for public participation, and maintaining public confidence. We believe further, that a requirement for additional review of TVA's rates would unnecessarily encumber and frustrate the attainment of TVA's objective of providing an adequate supply of electricity at the lowest feasible rates for the benefit of the region as a whole, and would tend to increase, rather than decrease, power rates.

Question 22. The two nuclear units at Sequoyah are scheduled for operation in 1977. According to a GAO study dated March 1975, the Nuclear Regulatory Commission has raised 427 questions while reviewing TVA's safety analysis. What is the status of these questions? If any are significant, please outline them and indicate progress towards their resolution.

Answer. Responses have been submitted to all of the 427 questions that were raised by the Nuclear Regulatory Commission (NRC). Of these the NRC has outstanding concerns on 11. TVA and the NRC have reached tentative resolutions on all but four. The following is an overview and status of the four questions in contention.

1. The NRC has posed questions about the seismic and environmental qualification testing program for the plant instrumentation and controls. TVA and Westinghouse are presently working with the NRC toward a satisfactory testing program. The impact of such a testing program could be extensive or small depending upon NRC requirements. If an extensive testing and redesign program was required, it could significantly impact the Sequoyah schedule.

2. The NRC has stated its position that TVA must run a preoperational test on the Emergency Core Cooling System (ECCS) containment sump intake by flooding the sump. Since compliance with the NRC request to flow test the sump would require extensive temporary relocation of equipment, temporary piping, and temporary structures inside the containment and for which Sequoyah was not designed, it would place an undue hardship on plant testing for TVA to comply with this position. To demonstrate that such a test is not required, TVA has performed extensive engineering analysis to demonstrate that the systems which take suction from this sump will properly function under the worst operating conditions. This analysis has been submitted to NRC as a part of the response to the question. Further, in light of this analysis, it is TVA's judgment that the knowledge to be gained from such a test is not commensurate with the effort involved.

3. The NRC has stated their position that safety systems containing motor operated valves must be designed to withstand the active and passive failure of the valve operator. This would require some system redesign, including the ability to remove and restore electric power to the valve operators on certain ECCS valves from the control room. TVA and Westinghouse have submitted analyses to the NRC to indicate that spurious operation of these valves at a time when they are required to remain in the proper position for accident mitigation is an event of extremely low probability.

The Advisory Committee on Reactor Safeguard (ACRS) has requested NRC to study their position, and other utilities have appealed this position to NRC management. TVA is awaiting the outcome of these two items before taking further action.

4. The NRC has stated that it will require automatic action designed to backup manual switchover from injection to recirculation core cooling. TVA has taken the position that the plan would function automatically to mitigate the effect of an accident until low level in the Refueling Water Storage Tank is alarmed. At that point the operator must intervene and accomplish the switchover which will allow the ECCS pumps to take suction from the containment sump. This switchover must take place prior to reaching the low-low level alarm setpoint, and TVA has submitted both an engineering evaluation and a switchover timetable to the NRC to justify our position that Sequoyah is designed for manual switchover and that operator controlled switchover without automatic backup is a proper and safe accident sequence for Sequoyah.

While not the result of direct NRC questions, the following are open items on which the NRC could still require significant action, impacting Sequoyah.

1. ECCS—An analysis has been provided to satisfy the performance requirements for acceptance of the ECCS. The analysis has not been accepted as yet.

2. Anticipated Transient Without Scram (ATWS)—An analysis has been submitted for NRC review describing our position on ATWS. If this analysis is rejected, the NRC will require additional equipment and instrumentation be added to Sequoyah.

3. Standardized Technical Specifications (STS)—TVA has submitted a revised version of the STS to the NRC.

Question 23. What percentage of the lands stripped for TVA coal have been returned to satisfactory condition? What steps have been taken to ensure reclamation of those lands that have not yet been restored? What steps has TVA taken to make sure its suppliers comply in the future with the reclamation requirements of TVA contracts? Has TVA ever cut off a supplier for failure to perform on reclamation?

Answer. Since 1965, when TVA first included reclamation requirements in its contracts for procurement of surface mine coal, some 31,000 acres of land have been disturbed under TVA surface mine contracts. To date, about 14,200 acres or 46 percent of the disturbed areas have been reclaimed satisfactorily. The remaining 16,800 acres are in various stages of reclamation with some of this acreage merely awaiting final inspection at the appropriate time to confirm that adequate vegetation has been established.

TVA strictly enforces its contract reclamation requirements. This is done, whenever possible, by working with the contractor during both routine and specially scheduled inspections of the disturbed areas to resolve reclamation problems as they arise. However, as necessary, TVA takes appropriate enforcement action to achieve reclamation. This includes the suspension of contract deliveries until the deficient reclamation is performed. If unable to secure compliance with the reclamation requirement, TVA terminates the contract and starts appropriate legal proceedings to collect damages to be used to perform the deficient reclamation. To date, a total of 22 contracts have been affected by suspensions or terminations. Also, TVA has refused to enter into new contracts with suppliers having records of unsatisfactory reclamation performance on previous contracts.

TVA's current reclamation provisions for term contracts provide for a cash reclamation account to be established and maintained by TVA until all required reclamation under the contract has been performed satisfactorily. If the reclamation is not done, TVA uses the money in the reclamation account to do the required reclamation work.

Question 24. TVA has indicated that scrubbers are not generally proved reliable at this time. However, Louisville Gas and Electric has had satisfactory results with their Paddy's Run plant which is very near several large TVA plants. What prevents TVA from taking advantage of L, G, and E's experience and installing a large-scale scrubber on at least one plant in this area?

Answer. Since we are vitally interested in scrubber technology and are installing a very large full-scale scrubber on a 550-MW unit at our Widows Creek plant, we have followed very closely the operation of the scrubber at the Louisville Gas and Electric Company's Paddy's Run station and analyzed the results and factors involved in this particular installation. Paddy's Run is a small (65 MW) unit operated mainly for peaking purposes. Hence, the scrubber system has been operated only intermittently since its inception with longest continuous run being about 40 days. Reliability has not been established for long continuous runs. TVA units have a high capacity factor and must operate over extended periods.

During this limited operation at Paddy's Run, no solids deposition has occurred of the type which has plagued other scrubbers. The reason for this is thought to be "low oxidation" unique to Paddy's Run, but why this takes place in that scrubber is not well understood and may be related to use of carbide sludge as the absorbent. The sludge is a byproduct of acetylene manufacturing, is in very limited supply, and not available to the Tennessee Valley Authority power plants.

The scrubber system at Paddy's Run is made up of two small 35-MW scrubbers. Considerable uncertainty exists about performance of such scrubbers if they were scaled up in size to operate on TVA's much larger sized units—500 MW or more.

Paddy's Run uses natural gas to reheat the stack gases after scrubbing so they will disperse adequately in the atmosphere which avoids the use of steam in tube-type heaters. Nothing then has been learned about corrosion of tube-type heaters—a problem of major significance at other scrubber installations. Natural gas is a valuable fuel and, as a matter of national priority, its use for station service in a power plant has been restricted.

Basically, the satisfactory results at Paddy's Run are not extrapolatable to the TVA system requirements because they reflect unique circumstances which may not exist at any other plant in the country. However, lessons learned from this operation certainly will contribute to the development of large scrubber systems required for larger fossil-fueled units in the Nation.

Question 25. In 1974, the Fifth Circuit, United States Court of Appeals (in *Natural Resources Defense Council* v. *EPA*), held that tall stacks and intermittent controls could not legally be substituted for emission limitations in achieving national ambient air standards.

Does TVA believe that this decision is binding upon you, especially since your headquarters and two power plants are located in Alabama, which is part of the Fifth Circuit?

If not, what legal basis does TVA have for believing that constant emission controls are not required?

Answer. In a case reviewing Georgia air pollution regulations, the Fifth Circuit Court of Appeals in *Natural Resources Defense Council* v. *EPA* held that, under the Clean Air Act, a state cannot approve as an alternate control strategy the use of new taller stacks and their improved dispersion of SO_2 even where national ambient standards would be met by such a strategy. The Court also held that states cannot grant variances which would extend compliance dates for meeting emission limitations under state implementation plans, even where ambient standards would be met. (Other courts of appeal had ruled that such variances could be granted, but only under very limited circumstances.) The United States Supreme Court in the recent case of *Train* v. *Natural Resources Defense Council* reversed the Fifth Circuit insofar as variances are concerned, holding that state-granted variances from meeting emission limitations are permissible as long as the national ambient standards are met. The Supreme Court, however, did not rule directly on the question of whether tall stacks and other means and alternate controls to achieve ambient standards are permitted, since EPA had not sought review of this part of the lower court's decision. The language of the opinion, however, casts considerable doubt on EPA's present interpretation of the Clean Air Act, that tall stacks and alternate controls are not permitted on a permanent basis.

In any event, since TVA does not have any generating facilities in the State of Georgia and therefore was not subject to that State's implementation plan, the Fifth Circuit ruling does not directly affect TVA. There are, however, actions now pending in other courts of appeal involving the same or similar issues as the Fifth Circuit ruling with respect to alternate control methods. One such case has been brought by a number of parties in the Sixth Circuit seeking review

of EPA's disapproval of Kentucky's air pollution regulations permitting the use of alternate controls. Since TVA does have two major generating plants in Kentucky, it is participating in that case as a party. A similar case involving alternate controls is being challenged by other parties in the Ninth Circuit. Thus, the question of the use of alternate controls is still an open issue in the courts.

Until these legal issues as to the use of alternate controls are fully resolved, it would be irresponsible for TVA to financially commit itself to buying expensive low sulfur coal or scrubbers for all of its plants in order to meet emission limitations. Such a program eventually will cost $175 to $200 million *annually*. This expense, however, is entirely unnecessary for achieveing ambient SO_2 standards, set for the protection of public health and welfare. If TVA now made the financial commitments to buy low sulfur coal or install scrubbers, any right to challenge this unnecessary spending in the future would be largely meaningless.

The second reason that TVA has not been made the enormous financial commitments which would be required to meet constant sulfur dioxide emission limitations is that such a task would have been impossible for many years. That much low sulfur coal is not available for TVA's plants, and as far as scrubbers are concerned, our experts conclude that this equipment has not yet been perfected so that it would work satisfactorily at our plants. EPA itself has recognized this and the Administration's energy bill is a result of the fact that these controls cannot be implemented within the time frames originally laid down in the Clean Air Act.

Question 26. TVA is doubling its capacity by building 17 nuclear plants in the next 10 years. In view of the questions that exist on safety, waste disposal, nuclear fuel availability and safeguards, how do you justify complete reliance on nuclear power at your new stations?

Does TVA plan to build any more fossil steam plants?

Are your financial and staff resources sufficient to accomplish both new nuclear construction and cleanup of existing fossil steam plant emissions?

Answer. Questions on safety, waste disposal, nuclear fuel availability, and safeguards continue to be raised by some people, despite overwhelming evidence showing that these issues have been or will be resolved. With regard to safety, the nuclear industry has an outstanding safety record. This does not occur by chance but rather from a careful review of the safety systems and the redundancy built into these safety systems. The primary concern in any such review is the health and safety of the public. While the necessary regulations implementing a long-term waste disposal program are still being developed, the technology for safely and efficiently dealing with radioactive waste now exists. With respect to fuel availability, the industry is making the commitments to develop an adequate supply of uranium to meet its needs, as evidenced by the increased uranium exploration effort in 1974. TVA itself is involved in an active program to develop its own uranium reserves to meet long-range requirements. With regard to nuclear safeguards, there are stringent regulations in effect today to safeguard nuclear materials, and further regulations are being developed in response to questions which have been raised from within the industry and the public. In our opinion, the questions being raised about nuclear power by some critics are nothing new, nor do they disqualify the nuclear alternative. While answers may not exist to the satisfaction of all concerned, positive steps are being taken in each of these areas.

At this time, TVA does not have specific plans for coal-fired plants. We are, however, heavily committed to utilizing the fossil energy resource in our existing plants that have a generating capacity of 17,725,335 kilowatts. Recent evaluations of nuclear and coal-fired generating capacity have shown nuclear to be the preferred type of new generating capacity on an economic, energy resource utilization, and environmental basis. Such an analysis is made each time new generating facilities are being considered. Should future studies show a fossil plant to be the best alternative, however, we would expect to adopt it.

TVA has the financial and staff resources to accomplish both its new nuclear construction and cleanup of existing fossil steam plant emissions subject to appropriate increases in the limits to TVA's borrowing authority and reasonable solutions and timetables for meeting air quality and water quality requirements.

APPENDIX B

LETTERS AND STATEMENTS SUBMITTED FOR THE RECORD

TESTIMONY SUBMITTED TO THE UNITED STATES SENATE PUBLIC WORKS COMMITTEE

As a leader of the free world it is the obligation of the United States of America to establish the energy principles that are in consistence with clean future environment. It is an awesome responsibility because many countries with meagre resources and technological skills look toward the United States for a way out of not only existing energy, economic and sociological problems but safety and well-being of future generations. Proliferation of nuclear power plants in the United States is an issue that is a classic example of how the developing nations are already setting the stage for following in the footsteps of this great nation, and in the wake of these disturbing events it is worth asking ourselves, will these nations exercise the caution and control that are the absolute demands of power production by nuclear means. The Americans have reasons to be proud of the past accomplishments of the Tennessee Valley Authority, and it is a fact that many nations have tried to mimic this agency in their own soils with the hopes of reaching the same success levels. This adds a tremendous burden of responsibility on TVA as a people's agency to exercise utmost caution in entering the field of nuclear power. Instead, TVA should be planning to enter the field of harnessing and utilizing clean and environmentally safe solar energy, and let the rest of the world follow its leadership.

The long term harmful implications of proliferation of nuclear power plants greatly exceed the benefits. A student told me once, "What

good is limitless energy if whole generations of future Americans are too sick to enjoy it?". It will be unfortunate if the response to this question is, "....so that we could spend the limitless energy to cure the maladies of mankind caused by the limitless energy production activities" It is equally unfortunate that many people - political leaders included - tend to equate nuclear power plant construction and operation with any and all other types of industries moving into town as good neighbors to provide jobs for the residents. Obviously it makes more sense to unimaginative men to look at this in terms of dollars and cents rather than in terms of genetic abnormalities which might possibly occur many generations removed. There is no justification for calling nuclear energy as "clean"; radiation releases by total nuclear activity cannot be seen, touched, smelled, heard or tasted, which probably what makes it so insidious. Radiation recognizes no political boundaries. So the responsibility of the United States as a technological giant in the area of nuclear activity goes far beyond its territories. It has to prove to the aspiring nations that energy problems can be solved without jeopardizing the future welfare of all men.

Man may design a nuclear power plant to work perfectly, but it still has to be operated by man who is imperfect and often irrational which will sometime or other lead to imperfect and irrational occurrences. The Browns Ferry fire and the Enrico Fermi plant accident are classic examples, among others, of this, and no man can promise the future generations that disastrous accidents will not take place. What promise is there that irrational men calling themselves terrorists will not sabotage a nuclear facility to achieve their political goals? What promise is there that such suicide squads will not pick and choose the power plant for disruption? If we assume that such events will not occur it can only be said that either we

are ignorant or lack the desire to learn what history has to teach us. This very possibility was recently proved by the Meinhof-Puig Antich group in Fessenheim. With all the good intentions of honorable men events of this kind can never be stopped in the face of nuclear plant proliferation in a society that cherishes the freedom of the individual. The only way to prevent terrorist activities is to police the populace constantly - an activity that should be abhorrent to the free American spirit. A panel of nuclear experts met in Vienna recently under the auspices of the International Atomic Energy Agency and suggested stricter control of nuclear materials. This is an expression that obviously confirms the fear that theft and sabotage of nuclear material from power plants and other sources are real. It is worth letting our imagination free to see what kind of a society one will be leaving behind for our children with domestic nuclear police forces in every community that has a nuclear power plant, or a reprocessing plant, burial site and endless miles of radwaste carrying transportation system.

The United States had only 23 nuclear power plants operating in 1972; the number is expected to reach 200 in 1985. This proliferation is expected to meet the power demands of the future according to the proponents of nuclear power. Unfortunately nuclear power plants along with other nuclear activities pose certain hidden threats to the safety and welfare of individuals, not in terms of sulfur dioxide, benzopyrene or fly ash but as thermal and radioactive pollution. An aspect of nuclear power that is often overlooked in most discussions is the collective ancillary activity required for the operation of such a power plant. It is repeatedly emphasized by the proponents of nuclear power that radio-

active discharge from a "normally" operating power plant is infinitesimally small. What is not told the public is that nuclear power plants cannot exist without uranium mining, fuel fabrication, reprocessing, disposal, and transportation activities, which are significantly more hazardous activities than the actual process of power production. The fact that the policy of continued support for the proliferation of nuclear power plants in the face of serious questions of safety raised by responsible nuclear scientists deserves to be reconsidered by the policy makers. The questions that cry for answers and problems that demand solutions must be squarely dealt with now, because this is one energy production process in which if a serious mistake is made mankind does not get another chance to correct it.

From the standpoint of atmospheric quality in the vicinity of a power plant, nuclear power plants are preferable; but a nuclear plant's threat with respect to thermal pollution is formidable. When compared to a fossil fuel plant the nuclear power plant produces about 40% more waste heat per kilowatt of power produced. When one considers 200 plants dotted along every river in the United States by 1985, one can only imagine the consequences of this activity on the water resources of this nation. The discharged heat will bring about complex, yet little understood, changes in the fragile aquatic ecosystem by reducing levels of dissolved oxygen. The consequences will be compounded by the fact that the same water supply is called upon to meet the demands of many municipalities, recreation facilities and industrial activities. One particularly dangerous group of externalized waste substances is the radioactive isotopes, many of which are absorbed only selectively. Populations

of aquatic organisms at one trophic level concentrate such waste in certain cells at levels far greater than its concentration in the surrounding water. Such selective absorption may be passed on from one trophic level to the other thus increasing the increasing the concentration of the substance. Radioactive effluents from global nuclear activity are the main sources of artificially produced radioactive contamination of marine waters. The tragedy is that little is known and much less is understood about the long-term ecological destiny of isotopes with longer half-lives like chromium-51 and zinc-65.

Increased nuclear power generating activity will definitely subject mankind to ever-increasing levels of radiation, however small. Although the amount of radiation from a properly operating (a must!) nuclear plant would be negligible, it is essential for us to consider the possible effects of chronic exposure to levels of ionizing radiation for several years. The often used "average" population dose that is supposed to be "acceptable" according to the standards is meaningless because fetuses and infants are much more sensitive to radiation than adults. I often wonder what the pregnant women and breast feeding mothers have to say about this average acceptable dose levels we read about in various environmental reports! It is totally unimaginative to suggest that a nuclear plant can and will be operated at all times throughout its lifespan without any abnormal occurrences many of which might easily release larger than usual amounts of radiation. Bone marrow, blood lymphocytes, lymph nodes, leucocytes, epithelial cells and connective tissue have various levels of radiation sensitivity, which complicates the process of arriving at an average acceptable population dose. The effects

of low-level chronic radiation are varied. After a period of years serious maladies such as sterility, anemia and cataract develop. This is one of the reasons why many biologists demand more accumulation and analysis of data on the effects of low level radiation on man before extensive expansion of nuclear activity is planned. What we need is more information on man than on beagles. The argumant that nuclear power industry has 200 or so years of operating experience is biologically meaningless because biological entities age and undergo cellular changes chronologically, which many decision makers have trouble comprehending.

The chance of a catastrophic accident in a nuclear power plant may be one in a million. But, what if it does happen? Most of the communities surrounding the proposed nuclear facilities by TVA are not at all equipped to handle radiation victims. The loss of lives and possible genetic damage in the event of a catastrophic accident cannot definitely be equated with a localized accident in a coal powered steam generating plant even though the physical damage might be immense in the vicinity of the plant. If a gene in modern man undergoes mutation it will probably be a harmful one, and it is well established in scientific literature that mutation rates can be artificially increased by radiation. Any amount of radiation exposure, no matter how small, is potentially damaging to the genetic material. Failure to control abnormal occurrences of certain kinds in a nuclear power plant will release some radiation and may eventually result in damage to the sex cells of humans at a cost which will only be paid by generations yet unborn. Since such effects are not expressed immediately it is

difficult to convince laymen about what unpleasant genetic surprises might be in store for us!

It is estimated that by 1980 (only five years from now!) only about 210,000 tons of low cost uranium (U_3O_8) can be produced. Such a scarcity of uranium, in addition to boosting the price of energy produced by nuclear fission plants, will undoubtedly encourage the development and commissioning of breeder reactors as a "limitless" energy source. So far nobody has come up with a reasonable and acceptable solution to the problem of handling the long-term nuclear waste. In terms of activities of man in a free society the moral cost of safeguarding plutonium will be unimaginatively prohibitive. The easiest answer will be to say that our children and our children's children will figure out a way out of this dilemma.

A truly great nation like the United States is in a position to decide to launch a crash program if only her leaders so decide to harness solar energy and convert it into electrical power with the same fervor and dedication as it channeled into the development of the atom bomb during the second world war. Instead, if the leadership seeks to find immediate answers to energy problems to satisfy the short-range demands, then this free nation will be faced with the prospect of an uncontrolled proliferation of nuclear power plants; and consequently unavoidable gradual increases in radiation exposure well into the next century. It is easy to see the immediate promises of unquestioned material benefits of such a decision, but only men of vision can see the biological and future societal trade-offs of gigantic proportions. Many countries are falling in line to catch this nuclear-energy-tiger by the tail, and these

countries are looking up to the Tennessee Valley Authority as the world's largest power producer, which does not seem to have the financial resources to go into the nuclear power plant business. Few men who control this agency have a global obligation to reach the right decision on this nuclear power issue, and if their decisions are proved to be wrong we will enter the next century with many a nuclear mausoleum stretching into the air of the Tennessee Valley. In the event of a gross plant function, admittedly an unlikely event, the potential for human misery is mind boggling. It is time we quit comparing a nuclear power plant development to the period of Edison's electric bulbs abd Stephenson's steam engines. Let us not forget that these were not accused of threatening the genetic potential of mankind. It is not an empty feeling that the future of the free world is in the welfare of America, and what this nation does or fails to do will decide the global course of energy production possibilities. America cannot afford to say 25 years from now that the nuclear decision of 1975 was a total mistake, because it will be too late for our children.

TESTIMONY SUBMITTED TO THE UNITED STATES SENATE PUBLIC WORKS COMMITTEE ON INVITATION DT. 04/21/75. SEN. JENNINGS RANDOLPH, CHAIRMAN.

Respectfully Submitted,

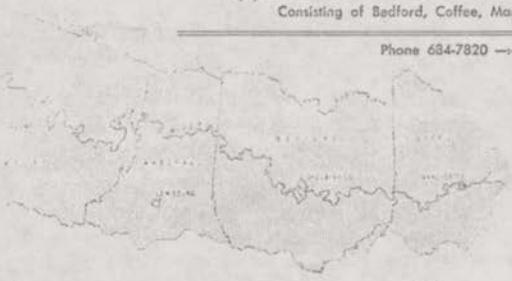
May 10, 1975

S. K. Ballal, Ph.D.
Cookeville, TN. 38501

PRESIDENT C. F. Norman | VICE PRESIDENT W. D. Copeland | SECRETARY R. M. McKay, Jr. | TREASURER J. C. Leonard | EXECUTIVE DIRECTOR Claybourne Ross

Upper Duck River Development Association
Consisting of Bedford, Coffee, Marshall and Maury Counties

Phone 684-7820 —:— Courthouse —:— Shelbyville, Tennessee 37160



May 5, 1975

Senator Jennings Randolph, Chairman
Senate Public Works Committee
Senate Office Bldg.
Washington, D. C.

Dear Mr. Chairman:

May we take this occasion to reiterate our position relative to TVA's purchase of the Peabody Coal Company. We note that you are currently holding Hearings on this matter. We would like for the attached Resolution to be included as a part of the Committee's record.

We are convinced that the TVA's purchase of the Peabody Coal would be in interest of the Tennessee Valley and the Nation. The distribution of TVA electric power extends far beyond the boundaries of the Tennessee Valley. In periods of power shortage, TVA is known to divert power to distant areas to help meet crisis.

The directors of the Upper Duck River Development Agency and Association in regular meeting last month directed me to communicate with your Committee and reitereate their position.

Sincerely,

Claybourne Ross
ExecutiveSecretary

CR/cs
Enc.

RESOLUTION
ADOPTED BY THE DIRECTORS OF THE UPPER DUCK RIVER DEVELOPMENT
AGENCY AND ASSOCIATION
JANUARY 17, 1975

WHEREAS, electric power is a primary source of energy of this area.

WHEREAS, TVA is the sole supplier of electric energy in the area.

WHEREAS, 80% of TVA's electric energy is produced from coal.

WHEREAS, TVA's purchase of the Peabody Coal Company is under negotiation.

WHEREAS, we realize that this acquisition will assure the people of the Tennessee valley a continuing supply of adequate electric power at minimum cost and also that any other economic benefits accrued by this acquisition will be passed on to the citizens and industry of this area.

THEREFORE, BE IT RESOLVED that the Directors of the Upper Duck River Development Agency and Association in its special January meeting endorse TVA's purchase of the Peabody Coal Company.

BE IT FURTHER RESOLVED that copy of this Resolution be forwarded to the TVA Directors, our Congressmen, our Senators and our Governor.

Wade Arnold, Pres.
Upper Duck River Agency

Charles F. Norman, Pres.
Upper Duck River Assn.

Statement
of

ALAN L. SUSMAN,
Chairman
of
WEST VIRGINIA SENATE MINES AND MINING COMMITTEE
and Cochairman of the
WEST VIRGINIA LEGISLATURE'S COAL STUDY

before the
U. S. SENATE PUBLIC WORKS COMMITTEE,
Jennings Randolph, Chairman

considering
FEDERAL POLICIES
relating to the
TENNESSEE VALLEY AUTHORITY

May 6, 1975

The Chairman of the Tennessee Valley Authority has correctly stated to this Committee that his agency should "apply the principles of balanced perspective to the myriad, interlocking problems man faces * * *." He also correctly points out that the TVA has a responsibility to help meet the need for jobs of the Appalachian region which is a large portion of the area it serves.

Unfortunately, there is some considerable evidence that the present TVA is not considering the broad range of problems their energy policies are creating, and they may seriously harm the job situation in Appalachia if these policies are not changed at once. It is my belief that the Congress must establish a mechanism for changing these policies of the TVA at the earliest possible time. To understand the need for such increased Congressional control, this Committee must look beyond the generalized statements used to defend the TVA's policies in the energy area. In particular, you must develop an appreciation of the Appalachian coal industry and how it works in order to understand the deficiencies of past TVA practices and how they need to be changed.

Past TVA policies in the energy-producing area have contributed, in my opinion, to instability in the Appalachian coal industry, higher coal costs to TVA customers, poor surface mine reclamation practices and resistance to organization by the United Mine Workers by non-union mines with TVA coal contracts. Present

TVA policy appears to be to promote development of nuclear power at the expense of future coal industry expansion generally, to promote high sulfur midwestern coal over low sulfur Appalachian coal, and western low sulfur coal over eastern coal.

These issues are vitally important, not only because TVA is America's largest purchaser of coal, but because it is a Federal agency its actions will encourage our private investment community and our coal industry to see its policies as the de-facto national energy policy of our government.

Such a policy of promoting western coal, high sulfur coal and fission nuclear power for electrical power generation is bound to lead to unnecessary costs to the TVA customer (thus decreasing the region's potential for industrial expansion), fewer jobs in the coal fields of Appalachia and an increased dependence on foreign nations for the diesel fuel oil to haul western coal east and foreign uranium to fuel the proposed nuclear fission plants of the Authority. Additionally, this policy will strengthen certain western railroads at the expense of the hard-pressed eastern railroad systems. Typical of this unhealthy fuel policy is the TVA proposal to invest over a billion dollars to purchase the nation's largest coal company, a company that owns almost no low-sulfur coal east of the Great Plains and which does not mine any coal in West Virginia, Virginia, eastern Kentucky and Tennessee.

I would like to discuss these points here and to state that I, other members of our Coal Study and our staff would be

pleased to provide additional details on these points to this Committee and its staff if you would be interested in such.

The TVA buys no significant amount of coal from West Virginia, so far as I can learn, even though West Virginia has the largest coal reserves in Appalachia and the largest mineable low sulfur coal reserves (when adjusted for BTU value) in the United States. Yet, when I contacted the TVA as President of the Bank of Mt. Hope in October of 1974 about providing them low sulfur West Virginia coal, I received a telephone call indicating to me the "line of credit" needed to get coal production started was not possible. Later on, I learned that same month TVA was arranging to provide Peabody Coal Company some $23 Million in financing for a high sulfur coal mine, while my producer required only $500,000. Let me add that, in addition to huge reserves of coal, West Virginia also has inexpensive water transportation for low sulfur coal to the western part of the TVA system, from the navigable Kanawha River and major loading facilities directly on the Ohio River near Huntington, West Virginia. The cost for barging coal from our State to major TVA power plants such as Paradise & Shawnee can be less than $3 per ton, I am told. On the other hand, the most eastern of the TVA's coal burning plants, John Sevier, is only some ninety air miles from West Virginia's McDowell County, which is our State's #1 coal producer. Virtually all its coal has a sulfur content of 1% or less. This compares to an admitted

transportation cost of $13.81 per ton, for transportation alone, of Montana's sub-bituminous fuel to TVA's Shawnee Plant. I am aware that the TVA has informed the Chairman of this Committee that TVA is turning west for coal "because of this inability to obtain a sufficient supply of coal at acceptable prices" from eastern coal fields. The stated total cost of this low BTU Montana fuel to Shawnee was listed in November of 1974 to equal a delivered price of around $26.64 per ton for a 12,000 BTU eastern coal.

The TVA has now made a bid to purchase a coal company that mines virtually no low sulfur coal in the East and has vast low sulfur reserves in the West. A Wyoming newspaper reports that this year "The Tennessee Valley Authority is buying up both coal and uranium reserves in the Rocky Mountains." A Kentucky paper says TVA "has no plans to build new coal-fired plants" this year. This combination of facts might cause reasonable men to doubt Chairman Aubrey Wagner's statement to Senator Jennings Randolph of November 7, 1974, that "We have no preference for western coal as such. On the contrary, we would prefer to procure coal as we have in the past, from supply areas which are contiguous to our system, but we do not know what additional steps we can take to obtain offers of a sufficient amount of coal * * *."

I will admit that, right now, TVA has problems obtaining coal in Appalachia. I would suggest that most of this problem is the fault of TVA, itself, however. The normal method TVA uses to

obtain coal--competitive bidding, together with contract provisions that encourage surface mining reclamation standards far lower than those required by states like West Virginia and Pennsylvania, and which limit contract price increases in case a union (United Mine Workers) organizational effort increases production costs at a certain mine--all tend to make it difficult for West Virginia coal producers to compete for TVA coal contracts.

Typical of the bad reputation TVA has with Appalachian coal operators is the recent statement in Coal Week which read: "The love-hate relationship between the Tennessee Valley Authority and small and medium-sized eastern coal operators is about to enter another of its hate phases * * *." An official of a large company, Consolidation Coal, is reported to say his firm now sells its Tennessee coal to foreign buyers "because TVA refused to pay a fair price * * * ." Other coal operators say privately that TVA is often late in making its payments for coal delivered and that TVA officials are not candid in their dealings with the coal producers. Some coal operators say any operator who hopes to ever sell coal to TVA is afraid to make any public criticism of this Federal agency for fear it will be cut out from any further TVA coal contracts. These individuals point out that since TVA has, in effect, an automatic fuel adjustment clause, it can always refuse to buy their coal for one reason or another even if their bid might be lower. The automatic fuel adjustment clause of TVA, also, will allow it to import all the western coal it wants to into

its system. Long-term contracts with proper financing would bring similar quality Appalachian coal to its generating plants at lower prices.

I would note that this sort of problem has encouraged the Legislature of West Virginia and the Public Service Commission of Florida to abolish automatic fuel clauses for electric utilities in their States. This is the only way the public can be sure that a utility really is obtaining its needed fuel at the lowest possible cost.

At the same time, the TVA should be prevented from further shifting from coal to nuclear fission power for this century. There are three good reasons this policy should be enforced, besides its obvious job benefits to the American coal industry. One is that, after many years and billions of dollars in research and educational work, large segments of the American public still fear the safety and environmental effects of nuclear fission power generation. A second is that, after billions of dollars spent on development of nuclear power, we now read of continuing "operating problems" with TVA's nuclear plants. Congressman Joe Evins is quoted as saying these problems increased TVA's rates more in recent years than those of any private electric utility. At the same time, a recent report states five TVA nuclear plants had cost overruns in only one year of over $1 Billion, $700 Million, compared to a $25 Million overrun for one new coal-burning plant! A third reason for admitting nuclear fission is a "light that failed" is contained in a 1974 report by the Atomic Energy Commission, recently confirmed to

our staff by a U.S. Geological Survey official. The report indicates that current nuclear power plants will make us dependent on foreign nations for supplies of uranium. This compares with our current dependence for foreign oil and the mammoth problems brought about by that situation.

How do I suggest these problems facing TVA and Appalachia be solved? I believe one way is to have the Congress require the Federal Power Commission to act as a state public service commission would act with a private utility. The FPC should be authorized and required to hold hearings and take testimony on all actions by the TVA that would increase its rate base expenses and/or its fuel clause charges. The legislation establishing such powers for the FPC over the TVA should require the FPC to judge the fairness, justness and reasonableness of TVA's energy proposals, and whether or not they reflect good faith management and sound business policy decisions. Guidelines to help the FPC determine these items should be included in such legislation. These should include investigations of the total cost to the consumer of long-term contract coal possibly obtained with financial help to the coal operator, as opposed to "spot" market purchases and foreign or western coal imports. Such would be similar to legislation now governing the Public Service Commission of West Virginia. Surely, it is consistent and proper to have a Federal regulatory agency represent the public interest in dealings with a multi-state, non-elected Federal utility operation.

A second proposal I would make is for legislation to authorize the TVA to issue $500 Million worth of bonds which would be utilized as an investment in Appalachian coal, especially the low and medium sulfur coals of Virginia, West Virginia, eastern Kentucky, Tennessee and Alabama. Such investments should be intended to provide TVA with enough low sulfur coal to allow it, when blended with its existing higher sulfur coal supplies, to meet Federal Clean Air Act standards. These funds should be earmarked so as to require new surface mine operators in all the Appalachian states supplying TVA coal to meet fully the reclamation requirements of a Federal surface mine reclamation law. These funds should be utilized strictly to open new mining operations or greatly expand existing ones. Long-term contracts, financial help and incentive-motivated "cost-plus" contracts should be encouraged where needed. I would conservatively estimate that such an investment in Appalachia could open twenty new deep mines of one million tons' production per year for each. Employment for over 8,000 new miners would result. Additionally, twenty new surface mines of 500,000 tons per year, employing 1,000 new surface miners could well develop. This would release some 30 million tons of new coal production per year, once the program was in full operation. The recent guaranteed $3 per ton profit for Island Creek Coal Company, the advancing of $23 Million to Peabody Coal Company, and the "emergency contracting procedures" TVA used from October, 1973, until this year, all indicate the Federal agency,

itself, recognizes the old "beat them on the head" method of dealing with the coal industry is out of date.

To counter the effects of past TVA coal policy, while acting to stabilize the Appalachian coal industry, the TVA must be directed and funded to make a new "opening" to many of the Appalachian coal owners. Such a program would help fight the recession in areas traditionally hard hit by unemployment, while fighting inflation and conserving our limited oil supplies. It would tend to stabilize the prices of TVA coal from mines near the consuming power plants. The result would be a reduced use of diesel fuel to haul coal from the mines to the plants as western mines require. Remember, western coal will not be transported by trains burning lignite, only oil-burning trains.

I would suggest that legislation along these lines specifically forbid the purchase of any coal company for the operation of "captive" mines by the TVA. We do not need a Federal agency competing with private coal operators. It is bad enough that some private utilities are doing so. Aside from the promotion of free enterprise resulting from such a policy, the evidence does not seem to demonstrate that the TVA will be able to produce coal more cheaply than experienced coal operators. I note that an experiment to eliminate highwalls on a surface mine in Tennessee, set up by TVA and done by an operator on a cost-plus basis, cost over $1 Million in excess of "normal" mining costs. No use of

consultants from West Virginia or Pennsylvania with practical experience in highwall elimination without subsidy was recorded. I understand a similar project is being planned by TVA for eastern Kentucky, again, without utilizing experienced steep slope operators from West Virginia or northern Pennsylvania.

I would hope such legislation would forbid approval of any additional nuclear fission plants and allow for cancellation of current proposals when the facts support such action. This action would recognize the TVA's responsibility to the employment and transportation components of the Appalachian economy. I would propose that such legislation forbid the purchase by the TVA of foreign coal or western coal.

It is time the TVA stops saying it cannot find enough low sulfur eastern coal to meet proposed sulfur emission standards for its power plants. When TVA can go to Ohio and pay a price of $23.85 a ton for high sulfur coal from an existing surface mine, it is clear the agency is not afraid to buy certain kinds of coal from entirely new market areas. Until TVA has offered reasonable contracts to West Virginia's three largest (according to a study done by the Huntington Herald-Dispatch) coal owners, it is not possible for reasonable men to believe TVA had to go to Ohio to deal with Sumitomo Shoji America, Inc. because no better quality coal existed in West Virginia. Much of the coal owned by our "big three" in West Virginia (as well as their holdings in Virginia, eastern Kentucky and Tennessee) is low in sulfur (1% and less) and

the TVA coal purchasers are well aware of this fact. If the TVA does not want to burn low sulfur coal or to meet air quality standards, it should just say so. It should not be allowed to rationalize its opposition to meeting Federal sulfur restrictions on the grounds that meeting them will force it to help make Wyoming the West Virginia of tomorrow. Until Norfolk & Western Railroad, Chessie System, Consolidation Coal Company and many smaller owners of West Virginia low sulfur coal have been contacted with proper contract offers by TVA, such rationalization is not valid.

In closing, I would urge the Congress to establish a mechanism to direct TVA's future energy policies toward a short and mid-range expansion of its investment in low and medium sulfur coal mines in Appalachia. Contracts should be given that encourage new mine openings, not merely increasing the pressure on (and price of) existing coal production. The TVA should be prohibited from utilizing coal from foreign nations (as proposed by a joint EPA-TVA study last year) or coal from west of the Missouri and Oklahoma coal fields.

The TVA should be prevented from wasting further billions of dollars in its excessively expensive love affair with nuclear fission, a form of energy that continues to lack public confidence in its safety and environmental effects. Instead, Federally funded experimental work on safe nuclear fusion power production for the

future should be considered. Additional long-range power sources should be developed for TVA use. These should include solar power and, as Governor Blanton has proposed, magneto-hydrodynamic processes for developing electricity directly from coal. Such a balanced program of near and long-range solutions to TVA's energy needs will maximize coal mining and railroad employment in Appalachia, minimize electric bills for TVA customers and indicate clearly to America's private sector that the Federal Government truely is interested in the eastern American coal industry, as well as western coal.

Bonding capacity additions for the TVA should, under no circumstances, be approved for its purchase of Peabody Coal Company. However, the TVA should be required to develop the $500 Million coal development package mentioned earlier which would be intended to stimulate new coal mines in Appalachian states in and near TVA's service area. Such a package should be designed to insure that TVA obtains a dependable supply of low sulfur coal at reasonable cost and with minimum transportation costs. It, also, would make a tremendous contribution toward expansion and stabilization of the Appalachian coal fields, which would benefit employment in that area and, surely, would be of benefit to our entire nation.

ALAN L. SUSMAN
West Virginia State Senator

WEST VIRGINIA COAL RESERVES

COUNTIES	ORIGINAL MINEABLE RESERVES* SHORT TONS	REPORTED PRODUCTION 1883-1973 (INCLUSIVE) SHORT TONS	ESTIMATED LOSS IN MINING ** SHORT TONS	ESTIMATED RECOVERABLE RESERVE SHORT TONS
Barbour.....	3,585,619,298	156,394,586	156,394,586	1,636,415,063
Berkeley.....	-	246	246	-
Boone.....	8,142,970,465	299,019,059	199,346,039	4,586,763,220
Braxton.....	2,323,332,633	9,179,541	9,179,541	1,152,486,776
Brooke.....	360,000,000	87,420,839	87,420,839	92,579,161
Cabell.....	44,167,156	-	-	22,083,578
Calhoun.....	251,017,114	-	-	125,508,557
Clay.....	3,237.869.854	43,244,834	28,829,889	1,899,477,079
Doddridge.....	1,119,317,757	2,790	1,860	671,587,864
+ Fayette.....	4,420,505,039	701,702,019	467,801,346	1,950,601,004
+ Gilmer.....	1,019,245,455	12,729,854	12,729,854	496,892,874
Grant.....	969,014,155	26,640,700	17,760,467	554,767,793
Greenbrier....	1,220,293,321	72,861,511	48,574,341	659,314,481
Hancock.....	500,000,000	3,340,986	3,340,986	246,659,014
Harrison.....	2,172,730,581	448,113,187	448,113,187	638,252,104
Kanawha.....	5,901,324,612	559,474,324	372,982,882	2,981,320,444
Lewis.....	2,776,037,160	14,004,293	14,004,293	1,374,014,287
Lincoln.....	1,770,813,665	4,331,369	2,887,579	1,058,156,830
Logan.....	8,149,879,105	990,522,817	660,348,544	4,097,509,210
Marion.....	4,317,089,326	587,724,636	587,724,636	1,570,820,027
Marshall.....	4,448,857,374	109,199,200	109,199,200	2,115,229,487
Mason.....	339,976,480	17,060,366	17,060,366	152,927,874
McDowell.....	5,340,598,171	1,333,209,857	888,806,571	1,871,149,046
Mercer.....	506,829,312	196,828,619	131,219,079	107,268,968
Mineral.....	809,834,066	33,455,402	33,455,402	371,461,631
Mingo.....	6,332,263,181	312,068,974	208,045,983	3,487,288,934
Monongalia....	3,748,630,971	458,400,282	458,400,282	1,415,915,204
Nicholas.....	6,172,807,449	155,245,628	103,497,085	3,548,438,842
Ohio.....	910,000,000	105,401,680	105,401,680	349,598,320
Pleasants.....	-	82,429	82,429	-
Pocahontas....	508,644,743	5,336,236	3,557,491	299,850,610
Preston.....	3,212,323,508	125,908,829	125,908,829	1,480,252,925
Putnam.....	433,090,336	21,620,592	14,413,728	238,233,610
Raleigh.....	4,283,368,262	666,794,108	444,529,405	1,903,226,849
Randolph.....	4,183,643,819	64,626,728	43,084,485	2,445,559,564
Roane.....	674,768,793	-	-	404,861,276
Summers.....	18,678,528	235,134	156,756	10,971,983
Taylor.....	1,327,767,239	48,419,215	48,419,215	615,464,405
Tucker.....	486,964,209	57,891,985	57,891,985	185,590,120
Tyler.....	948,133,232	-	-	474,066,616
Upshur.....	3,554,551,754	37,506,877	37,506,877	1,739,769,000
Wayne.....	1,471,495,778	8,568,693	5,712,462	874,328,774
Webster.....	6,305,536,510	40,315,721	26,877,147	3,743,006,185
Wetzel.....	3,321,923,236	93,425	93,425	1,660,868,193
Wirt.....	22,302,720	-	-	11,151,360
Wyoming.....	5,061,292,844	356,871,017	237,914,011	2,679,904,690
Small Mines...	-	25,028,400	25,028,400	-50,000,000
TOTALS.....	116,705,415,231	8,196,876,988	6,243,703,408	57,951,593,832

*Estimate by W.Va. Geological Survey using One Foot as the Minimum Mineable Thickness.
**Loss resulting from the Undermining of a Coal Bed not included.
+ Calculation error, 1971, accounts for tonnage increase in column 5.

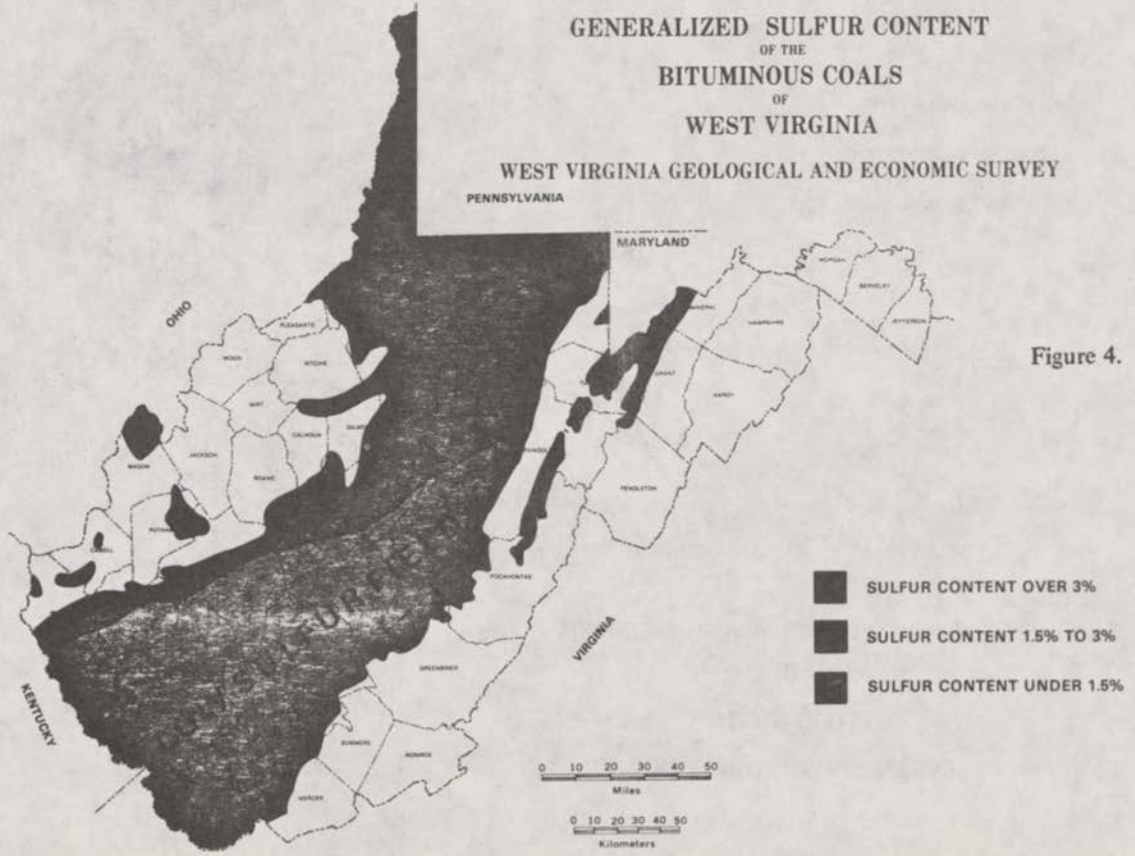

GENERALIZED SULFUR CONTENT
OF THE
BITUMINOUS COALS
OF
WEST VIRGINIA
WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY
PENNSYLVANIA
MARYLAND
OHIO
KENTUCKY
VIRGINIA
SULFUR CONTENT OVER 3%
SULFUR CONTENT 1.5% TO 3%
SULFUR CONTENT UNDER 1.5%
0 10 20 30 40 50
Miles
0 10 20 30 40 50
Kilometers

Figure 4.

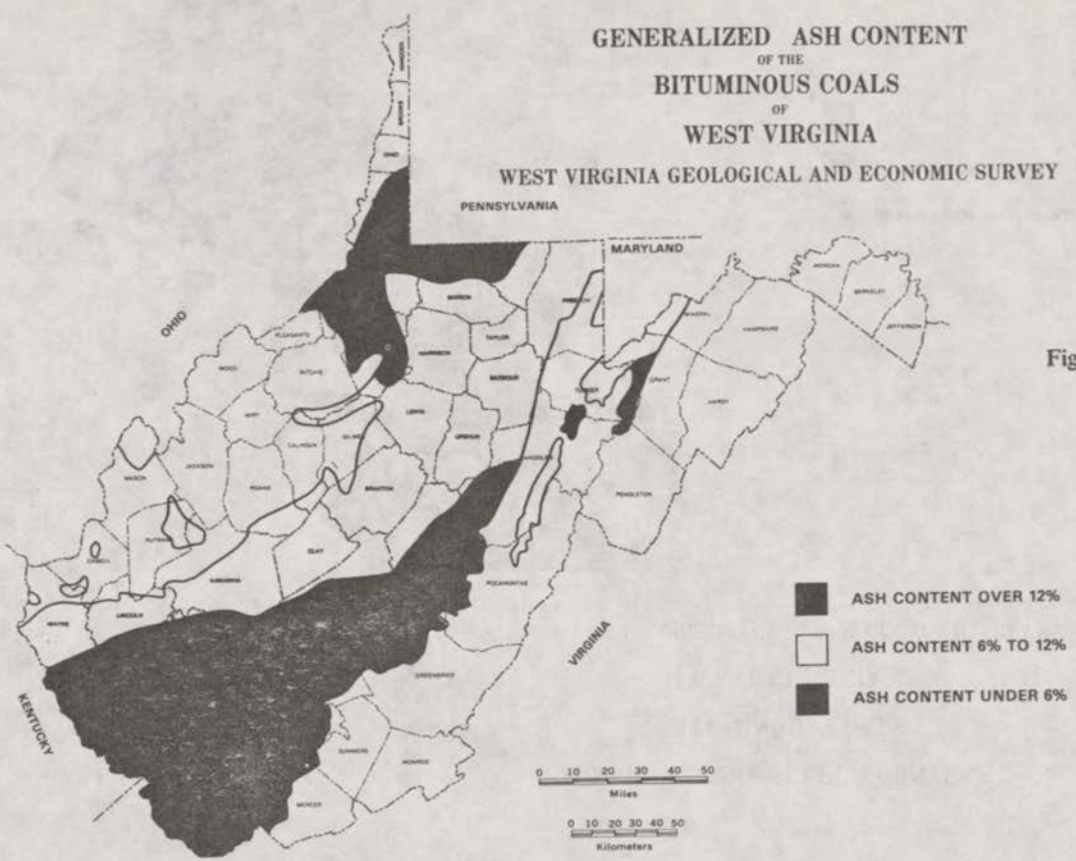

GENERALIZED ASH CONTENT
OF THE
BITUMINOUS COALS
OF
WEST VIRGINIA
WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY
PENNSYLVANIA
MARYLAND
OHIO
VIRGINIA
KENTUCKY
ASH CONTENT OVER 12%
ASH CONTENT 6% TO 12%
ASH CONTENT UNDER 6%
0 10 20 30 40 50
Miles
0 10 20 30 40 50
Kilometers

Figure 3.



Figure 13. Btu—As-Received

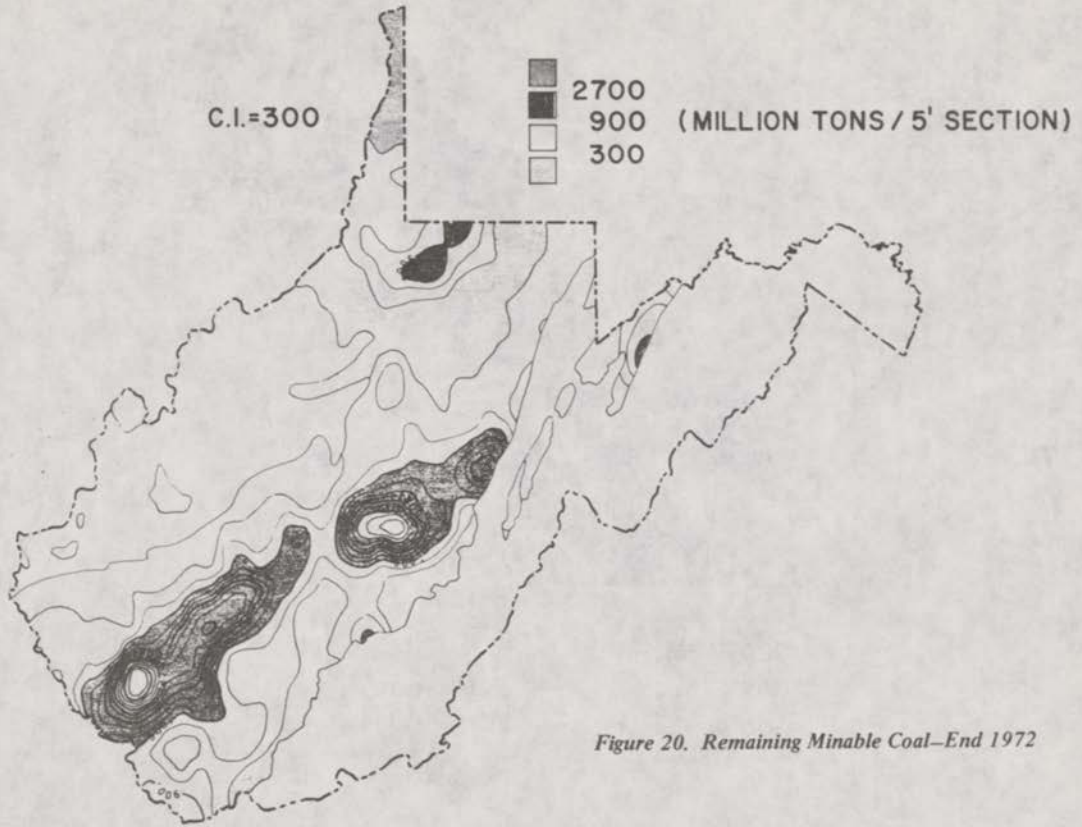


Figure 20. Remaining Minable Coal–End 1972

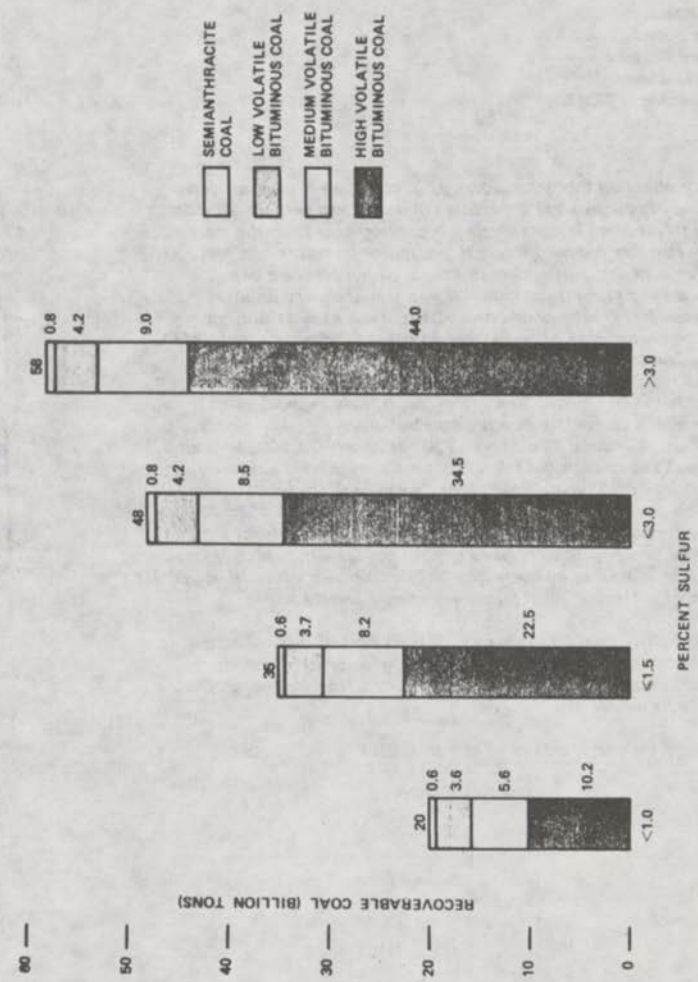


Figure 17. Recoverable Coal as Function of Rank and Sulfur Content

October 25, 1974

Mr. Aubrey J. Wagner
Chairman of the Board
Tennessee Valley Authority
403 New Sprankle Bldg.
Knoxville, Tennessee 37902

Dear Mr. Wagner:

It has come to my attention that your agency, in an effort to meet environmental regulations, has had some problems obtaining low sulfur coal from the Eastern coal fields, and is considering importing coal from the West (South Africa). For this reason I thought you might be interested in certain low sulfur coal that I have access to and which can be made available within a very short lead time. If you would desire further information, please feel free to phone or write as soon as possible, so that we can arrange a meeting to go further in consideration of a possible arrangement to mine this coal.

The coal in question is in Central West Virginia, a little over 25 miles from navigable water which can easily reach a number of your power plants. It has a sulfur content of around 1% and a B.T.U. of nearly 13,000 per pound, as mined. Because the area in question has been extensively explored and can be mined by "drift" mine operations, some coal production from this area would be possible within two months, we believe. A $500,000.00 line of credit is necessary as part of any arrangement and contract for this coal, to be used for the purchase of used mining equipment, which is another factor in production of coal at an early date. The operator who will supervise this mining is an experienced local mine operator, I should add.

The amount of coal that could be made available as part of this operation can be greatly increased if there is a demand for greater production. Some idea of your needs would be necessary before a final tonnage offer on our part would be made.

Please let me hear from you if this is of any interest to you.

Cordially yours,

Alan L. Susman
President

COAL AGE • March 1974

Belco and Duke Power sign 10-year contract

BELCO PETROLEUM CORP. said last month it has agreed to supply Duke Power Co. one million tons a year of low-sulfur coal, beginning in 1975. Under the agreement, Peter White Coal Mining Corp., a Belco unit, will open deep and surface mines in southern West Virginia.

Duke Power will arrange the financing for the project, and Peter White will receive a fee for each ton of coal produced, said Belco. The contract, valued at $125 million, expires in 1985 but may be extended for 10 years by the utility.

MAY 1974 KEYSTONE NEWS BULLETIN

NORTH CAROLINA

Carolina Power & Light Co. -- Company has moved into coal-mine ownership with purchase of an 80 per cent interest in a new mine to be opened by Pickand Mather & Co. CP&L will get 800,000 tons of coal per year of 7% ash, 0.77% sulfur, 12,800 Btu/lb coal. It also has an option for another 800,000 tons per year from a second mine.
Page 376

Ala. Power, J. Walter sign 2nd coal pact

ANOTHER long-term coal agreement has been penned by Alabama Power Co. and US Pipe & Foundry Co., a subsidiary of Jim Walter Corp., this one for 2 million tons of premium-grade, low-sulfur coal annually over a 21-year period beginning in 1976. More than 3 million tons of coal now will be sold annually to the Birmingham-based electric utility under the two agreements which will amount to over $1 billion in additional revenues to US Pipe over the lives of the contracts.

In February 1973 the companies signed an agreement covering 1,250,000 tons of coal a year over a 14-year period beginning this year from more than 300 million tons of reserves held by US Pipe in Alabama (COAL AGE, April 1973, p 48). Supplies to fulfill the first contract will come from US Pipe's $25-million Blue Creek Mine No. 3 near Adger, Ala., which will begin production this April. For the first nine months the mine will yield 500,000 tons, and thereafter 1,750,000 tons annually, of which 1,250,000 tons will go to Alabama Power.

Coal to be sold under the new agreement will be produced at the $36-million Blue Creek Mine No. 4 to be constructed in Tuscaloosa County, Alabama, about 40 miles southwest of Birmingham. This mine will have three shafts, each more than 1,900 ft deep.

Initial shipments will begin in 1976, with full production scheduled for late 1977.

The Alabama Power contracts mark the major entry of US Pipe into the coal marketing business.

COAL AGE • February 1974

NATIONAL COAL ASSOCIATION'S "COAL NEWS"

N&W Will Build 2,000 Larger Coal Hoppers

The Norfolk and Western Railway this week announced it will start late this year building 2,000 coal hopper cars with an average capacity of 100 tons of coal, five tons more than that of the newest hoppers now in service on its lines. Robert B. Claytor, executive vice president, said the commitment "shows our confidence in the future of coal in both the metallurgical and power-generating categories."

The first of the new hoppers is scheduled to roll off the assembly line at the company's Roanoke shops in early December, and present plans call for a rate of five hoppers a day, N&W said. It added that all should be built by August, 1976, at a total cost of $35.6 million, or $17,800 for each hopper.

No. 4208 / 4-12-74 / Page

Mapco Announces Long-Term Utility Coal Contracts

Mapco Inc. said this week it has signed contracts with two major--but unidentified--electric utilities to supply a total of 2 million tons of low-sulfur coal annually over a 20-year period from its Martiki mine, being developed in Martin County, Ky. The total value of the agreements, based on initial price levels, is about $600 million, the company said.

Mapco said initial production from the mine is scheduled for late September, and an annual production of 3 million tons should be reached by early 1976. It added that it is negotiating with other utilities for the mine's remaining production.

No. 4206 / 3-29-74

$33 Million Clear Fork Mine To Be Backed By French Company

A $33 million mine which will provide coal for French steel mills is being planned for the Clear Fork area, a Chessie System representative said today.

The mine is slated for full production in three years, the spokesman said, and will employ an estimated 250 persons.

The mine will be financed by France's largest coal company—Union Siderurgique du Nord et de l'Evt de la France, known as Usinor—and the official French coal import agency, Association Technique de L 'Importation Charbonniere, A.T.I.C.

It will be operated by The New River Co., a subsidiary of Western Pocahontas Corp., a coal land development company which is in turn a subsidiary of the Chessie System.

According to Chessie spokesman M. B. Dolinger of the Cleveland office, the new mine will be located on the Clear Fork of the Coal River in the Beckley seam of coal.

The mine will be developed in cooperation with the U. S. Bureau of Mines, which will test a new degasification process prior to the mine's opening. The bureau will make borings in the land to be mined and use those "wells" to extract potentially dangerous methane gas, Dolinger said.

If sufficient methane gas is recovered, he added, it could be sold commercially for heating purposes.

According to New River Co. president E. V. Bowman, the degasification project is in early planning stages and no definite information is available as to who will bear the cost of the testing. He did say that the bureau would probably underwrite the cost "to some extent."

The mine is expected to produce one million tons of high quality, low volatile coal used only in making steel, Chessie president John W. Hanifin told a stockholders meeting in Richmond, Va.

He estimated the mine's minimum productive life at 35 years.

The coal from the underground mine will be moved by the Chesapenke and Ohio Railway Co. to Chessie's deepwater port at Newport News, Va. The coal then will be shipped to Dunkirk, France, where Unisor operates steel mills, Hanifin said.

Hanifin also told stockholders Chessie's shipments of coal continue to climb because of the oil and gasoline shortage, especially shipments to the electric power industry. He said shipments to electric utilities were up 20 per cent over the same period in 1973.

The Raleigh Register

BECKLEY, WEST VIRGINIA, (25801) WEDNESD AY AFTERNOON, MARCH 27, 1974—15

THE COURIER-JOURNAL, TUESDAY, NOVEMBER 12, 1974

TVA official says miners' strike could force agency to cut service

By BYRON DAVIS
Associated Press

CHATTANOOGA, Tenn. — Cold showers, cold oatmeal and cold homes are strong possibilities in the Tennessee Valley with coal miners out on strike.

The Tennessee Valley Authority, the nation's largest coal consumer and biggest utility, says mandatory cuts will be needed when the United Mine Workers strike today. Even without the strike, TVA is having trouble getting enough coal to keep its steam-generating plants running at the capacity required by the businesses, industry and homes in the seven-state area it serves.

The agency's general manager, Lynn Seeber, was quoted at one point as saying mandatory power cuts will go into effect immediately when coal miners strike. At the end of last week, when the strike became certain, Albert O. Daniels, TVA's emergency energy coordinator, said the measures won't be that severe.

The agency persuaded the Atomic Energy Commission to reduce its consumption of electric power by 60 per cent at two uranium-enrichment plants — one in Paducah, Ky., and the other at Oak Ridge. The plants have been using 2,240,000 kilowatts of power from TVA and have agreed to reduce this by 1,435,000 kilowatts.

The plants have been consuming 15 per cent of TVA's total power output in producing uranium for atomic weapons and enriching fuel for nuclear power plants.

"We do not intend to overreact," said Daniels of the impending strike. "We'll continue to monitor the situation very closely and take whatever steps are necessary to watch TVA's power output with the demand."

But a strike of four to five weeks would force TVA to cut service, Daniels said, because the agency just doesn't have enough coal on hand to keep its steam-generating plants operating.

TVA was created by Congress in 1933 to control floods along the Tennessee River and provide a navigational channel upstream to Knoxville. It was authorized to provide hydroelectric power through dams built for flood control and navigation. The 1933 act also gave TVA authority to acquire a fertilizer plant at Muscle Shoals, Ala.

But low-cost electricity, in what was a backward, underdeveloped area when the agency was created, produced such a demand that hydroelectric power could not fill it. Thus, TVA got into the power business in a big way and built 12 huge coal-fired steam plants, which now produce about 75 per cent of the agency's output of electricity.

Because a coal shortage has been gradually building, TVA began building nuclear generating plants several years ago. So far it has one such generator, near Decatur, Ala., in operation. Its output accounts for only 7 per cent of the total, with the rest coming from the hydroelectric dams authorized in 1933.

In addition to virtually all of southern Tennessee, Kentucky, north Alabama, TVA serves parts of Virginia, North Carolina, Georgia and Mississippi.

"When no coal is delivered, our stockpiles shrink at the rate of 100,000 tons a day," Daniels said. "The strike threat comes at a time when we are moving into our peak season, when the weather normally turns colder and homes and industry have to use more electricity."

TVA once was able to get all the coal it needed from fields nearby in Kentucky, Tennessee and West Virginia, but Daniels said the agency has been forced to go as far as Montana to get coal to feed the TVA's weekly winter appetite of 900,000 tons a week.

"We've been in the marketplace every day," Daniels said. "But we've found that increasingly the coal we have under contract has become less and less. Some producers are not delivering on their contracts."

TVA recently signed a contract with a Montana firm, paying almost $30 a ton for coal that cost only $5 a ton five years ago.

TVA has been embroiled in controversy since its creation but only in recent years has it been the target of a great deal of criticism in its own backyard.

Some coal suppliers say TVA's problem in buying coal are the agency's own fault: when they bid coal to sell, TVA wouldn't buy it.

Paul Callis, board chairman of Tennessee Consolidated Coal Co., Inc., said his company operates several underground mines in the Marion-Grundy County area of southeast Tennessee and was forced in 1969 to look for foreign markets because TVA refused to pay a fair price.

Tennessee Consolidated now ships about 1 million tons a year down the Tennessee, Ohio and Mississippi rivers to the Gulf of Mexico, where they are loaded on ocean vessels and taken to Japan for the manufacture of steel.

Callis said the Mine Health and Safety Act of 1969 also has put many small operators out of business.

Surface miners in nearby Sequatchie County also are bitter about federal regulations and past purchasing policies of TVA.

"TVA maneuvered for years to keep the price of coal low by beating my head against the heads of other coal operators with their sealed, competitive bid system," said Dale Studer, a veteran miner and part owner of the Walden Ridge Coal Co. "Now the shoe is on the other foot with TVA not receiving bids and coming up short of coal."

"For the future, TVA's major commitment is to nuclear generation," said Daniels. But for now, TVA must rely primarily on coal it says it can't get.

The agency has asked residents of the Tennessee Valley, where 65 per cent of the homes are electric powered, to conserve. Communities have tried to set an example by turning off street lights wherever practical.

Chattanooga is headquarters for TVA's power division. A huge sign on the downtown Market Street bridge across the Tennessee river reads: "Tennessee's Finest — Chattanooga." Until a few months ago it read: "Tennessee's Finest — Chattanooga, the Electric City."

FANNY SEILER: Affairs of State

Coal Capital Stressed



Sunday GAZETTE-MAIL
Charleston, West Virginia October 6, 1974

The need for capital in the coal industry to open new mines was stressed last week by both Gov. Moore and State Sen. Alan Susman, D-Raleigh, at a federal hearing in Philadelphia. The coal industry agrees.

Last week, a spot survey was made of larger coal companies to determine if they had adequate reserves to supply coal to a large utility, and if they would open new mines to furnish that coal.

H. H. Cobb, vice president of marketing of Eastern Associated Coal in Pittsburgh, said his company isn't financially in a position to open reserves for utility coal, and coal operators won't gamble new investment if two years from now new federal antipollution regulations will make the coal unacceptable for burning in steam generating facilities.

In addition, Cobb said an available labor force is important to opening new mines, and so is the availability of materials and equipment.

Eastern's coal is currently delivered under long-term contract, and Cobb said a long-term contract for any new production would be desirable.

HAWLEY COAL Co.'s operation in West Virginia recently signed a contract with Duke Power Co. to furnish coal, and the utility provided the financing for opening new reserves.

Hawley, a New York based company, produces 45,000 tons a day now and nearly 1.9 million tons of coal annually. It has 120 million tons in reserve and "wouldn't turn down any talks" for a similar long-term arrangement from an electric utility.

But Hawley would have to have a long-term contract to open up a new mine. And the least amount of money that would be required to open up a mine would be $30 million.

Hawley's coal reserves are in Southern West Virginia, while Eastern's is in the south and north. Both companies have low and high sulfur coal reserves.

On the other hand, Carbon Fuel Sales of Charleston, says its reserves are already committed under long-term contracts.

The question of where to turn for reasonably priced coal is begging for an answer since the demand for low sulfur coal currently is so great that it has forced coal prices to more than double what they were a little over a year ago.

1400

Coal Upsurge Creates New Industry

By RICHARD HAAS
Daily Mail Business Editor

Southern West Virginia's rebounding coal industry has attracted a new industry to the Charleston area that is expected to provide 50 new jobs within the next year.

Alan Sheppard, president of the newly formed International Magnetics, Ltd., announced Tuesday his company is now constructing the world's first plant to manufacture magnetite, an iron-oxygen compound used principally in the heavy medium coal washing process. The new facility will be located on W.Va. 61 between Marmet and Chesapeake on a tract of land leased from Carbon Fuel Corp.

The development of more efficient coal cleaning processes has created a demand for a quality of magnetite not now available, Sheppard said. Coal companies now obtain the compound from magnetite mines in Canada and upstate New York, he said.

The new process, which involves the conversion of another iron-oxygen compound into magnetite, was tested extensively at Carnegie-Mellon University and several Pittsburgh metals companies, Sheppard said.

When coal and magnetite are mixed in a water slurry, Sheppard explained, the magnetic properties of the compound attract the impurities in the coal and allow the clean coal to float to the surface.

The International Magnetics plant, he said, will have the capacity to produce one-third of the magnetite now used in the coal industry. Discussions with coal company officials indicate, however, that more cleaning plants will be converted to a magnetite process and this should stimulate demand for the product.

The company is prepared to greatly expand its Charleston area facility and to build a second plant if the demand is sufficient.

The ability of the Kanawha River to handle large barge shipments of raw materials and the highway access to the southern West Virginia coal fields make the plant site an ideal location for International Magnetics, Sheppard said. The attractiveness of the site will be enhanced if the Marmet routing of Appalachian Corridor G is accepted, he noted.

Financing for the new venture was obtained through the Kanawha Banking and Trust Co., the West Virginia Business Development Corp. and the West Virginia Industrial Development Authority. The project represents a $500,000 investment, Sheppard said. The committee of 100 was instrumental in securing a plant site and obtaining financing, he said.

WED., JULY 10, 1974 Charleston Daily Mail

TVA says N-power paying off

By HOWARD FINEHAN
Courier-Journal Staff Writer

High coal prices are giving the Tennessee Valley Authority (TVA) new support for its plan to build $6.2 billion worth of nuclear power plants by 1982.

In its 41st annual report to the President and Congress, released today, the federal utility said its decade-old nuclear program for the first time "has begun to pay off" by supplementing coal-generated electric power.

Furthermore, the agency said, coal prices have reinforced its faith in a 17-unit nuclear system, which it describes as "the largest commitment in the nation to nuclear power generation by a single utility."

TVA consumes more coal than any other customer in the nation and is a major buyer of Kentucky coal. Agency spokesmen said that while TVA will not reduce its purchases of coal, it has no plans to build new coal-fired plants.

"The rising cost and short supply of coal was by far the most pressing problem affecting the power system during the year," the report states.

In an accompanying summary the agency concludes that the coal situation "demonstrate(s) more clearly than ever that it is now more economical for TVA to construct and operate nuclear power plants than coal-fired facilities."

By 1982, TVA plans to generate as much electricity by nuclear power as it now does by coal — about 80 billion kilowatt hours annually.

Sites have been selected for four new nuclear plants, three in Tennessee and one in Alabama. One site, where four units will be built in 1980-82, is in Tennessee near the southern Kentucky border opposite Allen County, Ky.

Two of three units at the TVA's first nuclear plant at Browns Ferry, Ala., began generating electricity this year — one commercially, the other in tests.

The No. 1 unit provided about 2 per cent of TVA's total output, and did so at a rate of reliability significantly higher than all but one of the nine largest TVA coal-fired units.

Until this year, said TVA spokesman Chris Eckl, a case could be made that coal-fired plants were as cheap in the long run as nuclear ones because building costs for coal plants were comparatively low.

But the report says the cost of enriched uranium to power the Alabama nuclear facility is "running only one-third" that of coal shipped on long-term contracts signed before last year.

Nuclear fuel costs are "only about 10

See TVA
Back page, col. 2, this section

TVA says high coal costs making nuclear power pay

Continued From Page One

to 20 per cent" of those for coal purchased on new contracts signed in the midst of the coal boom.

"The old argument was that nuclear power was not really preferable economically," said Eckl. "But with coal at 35 and 40 dollars a ton — and with uranium not looking like it's going to escalate greatly — nuclear power is clearly the choice."

Over the next 10 years TVA plans to expand its present generating capacity of 23.3 million kilowatts to about 47 million. Ninety per cent of the proposed expansion will be nuclear.

Sites for four units have yet to be selected, but TVA spokesman Lee Sheppeard said it is unlikely any will be in Kentucky.

TVA plants at Paradise and Paducah, Ky., were built to take advantage of their proximity to coalfields.

TVA serves 2.5 million customers in the southeastern United States, including customers of cooperatives in Southern Kentucky from the Mississippi River to the counties southeast of Bowling Green.

TVA raised its power rates twice during the 1973-74 fiscal year. It also adopted a billing system that automatically passes on monthly changes in fuel costs.

(E COURIER-JOURNAL & TIMES, WEDNESDAY, JANUARY 1, 1975

8A Charleston Daily Mail SAT., DEC. 8, 1973*

BY HOUSE SPEAKER

TVA Coal Burning Directive Sought

By THE ASSOCIATED PRESS

House Speaker Lewis McManus, D-Raleigh, says the federal government should consider directing the Tennessee Valley Authority to purchase West Virginia coal.

"This would allow the Authority to maintain its regular 90-day coal supplies at all of its plants while meeting air quality standards," he said.

In a proposal to William E. Simon, newly appointed executive director of President Nixon's Emergency Action Group, McManus also suggested that the energy crisis could be eased if most Eastern power plants would convert back from oil to coal.

"Many of these plants burned coal exclusively before 1966, when foreign oil was allowed to enter the country," he noted.

Depending on what air quality standards are finally set, McManus said there is sufficient low-sulfur coal in West Virginia and neighboring states to meet demand.

McManus said blending of coals would permit coal usage to meet air pollution standards of all but the most polluted cities.h

Noting that there might be a rise in fuel prices, the speaker said prices on Mideast and Canadian oil and Russian gas were also going to rise.

"I hope you will reconsider the views asserted in some federal and private studies that eastern coal and especially eastern low sulfur coal, is either not available or is too difficult to produce in major amounts in the near future," he said.

Fri., April 25, 1975 The Birmingham News

Cost overruns—

On TVA near $1.5 billion

WASHINGTON (AP) — Cost overruns on Tennessee Valley Authority power projects totaled almost $1.5 billion in one year, TVA board Chairman Aubrey Wagner told a budget subcommittee hearing Thursday.

Wagner and his staff, responding to questions from Rep. Joe L. Evins, D-Tenn., chairman of the public works subcommittee of the House Appropriations Committee, blamed the overruns on construction delays and faulty estimates.

"We're trying now to get our estimates right," Wagner said.

THE OVERRUNS were listed as: — The Hartsville nuclear power plant, which increased from $1.5 billion in fiscal 1975 to $2.5 billion, for an overrun of $925 million.

—The Watts Bar nuclear power plant, from $700 million to $805 million or more.

—The Bellefonte nuclear plant in Alabama, from $725 million to $1 billion, or an increase of $275 million.

—The Raccoon Mountain pump storage plant near Chattanooga, from $192 million to $240 million, up $8 million.

—The Sequoyah nuclear power plant in Alabama, which more than doubled from $336 million to $675 million.

—The third unit at Browns Ferry nuclear power plant, up $65 million from $750 million to $815 million.

—The Cumberland steam plant in Stewart County, Tenn., up $25 million from $10 million to $435 million.

The Courier-Journal

around kentucky

Tuesday, April 22, 1975 Section B

With higher coal prices

Nuclear power plant shutdown contributed to TVA rate rise

By HOWARD FINEMAN
Courier-Journal Staff Writer

Nuclear power, which the Tennessee Valley Authority hopes eventually will provide cheap and dependable power, for the time being is driving power prices up because of operating troubles.

TVA has announced another substantial (about 20 per cent) increase in its monthly "fuel adjustment charge." It said the "loss of low-cost generation" at its first nuclear plant was "partly responsible" for extra demand for higher-cost coal-fired power.

The plant, located in Northern Alabama near Decatur, has been shut down for inspection and repair since March 22, when wiring insulation caught fire and shortcircuited the plant's emergency control systems. TVA officials said there was no radiation problem or damage to the reactors.

The latest fuel adjustment increase will show up on May bills to account for the cost of fuel in March. TVA's May fuel charge will be $3.08 per 1,000 kilowatt hours, compared to $2.55 in April and $2.09 in March.

Depending on local rate schedules for the 17 companies that sell TVA power in Kentucky, electric bills for a typical user will be about $31 for 1,000 kilowatt hours, according to TVA.

However, bills for the "all-electric" homes of many TVA customers could be as much as four times higher.

The increased fuel costs are also due to higher prices for coal TVA receives on long-term contracts, which were formally "renegotiated" upward this month.

The new contracts, accounting for about one-third of TVA's supply, contain firmer delivery guarantees of more coal, but at an average price of $15.68 per ton, compared to $8.84 under the old contracts.

TVA serves 175,000 homes, businesses and industries in Southern and Western Kentucky and is the largest consumer of Kentucky coal.

TVA last summer joined the other six Kentucky power suppliers in using the fuel adjustment clause to automatically — without public hearings — reflect changes in the cost of fuel, which is primarily coal in Kentucky.

Utilities' requests for general rate increases are subject to public hearings before the Kentucky Public Service Commission (PSC), except for TVA, which is a federal agency.

The fuel adjustment clause has been the object of some critical attention in Kentucky, but more for the price differences it produces among customers of various companies than for the concept itself.

Some consumers also have complained that there is not enough information publicly available to check utilities' coal purchases against fuel adjustment rates.

In West Virginia, where fuel adjustments have become a major political issue, the state Public Service Commission and the legislature have taken measures to abolish such adjustments and to open up utility coal-buying practices.

The West Virginia PSC, according to rate analyst David Ellis, abolished use of the clause as of April 1, asking utility companies instead to account for fuel costs in general rate increase requests.

Overriding a veto by Gov. Arch Moore, the state legislature on April 13 banned use of the charge even if the PSC would seek to reinstitute it.

The legislature said utility companies must make their coal purchase contracts public for consideration at general rate increase hearings.

"We had seen a serious erosion of public trust in the regulatory process," said Ellis. "People were being hit with monthly increases in their bills with no notice, no hearing and no way of being heard.

"What we're doing now is trying to treat coal expenses as we would any other item," he said.

A related issue in West Virginia is the use of coal from the West. A subsidiary of the American Electric Power Co. has brought some Western coal into the state, arguing that the need for non-polluting, low-sulfur coal cannot be met using West Virginia coal.

The utilities' contention was angrily debated in the legislature.

TVA rates increased most

WASHINGTON (AP)—The Tennessee Valley Authority's electric rates have increased faster than those of any public or private utility in the country, Rep. Joe L. Evins, D-Tenn., has said.

Evins said Wednesday TVA's electric rates have increased 127.8 per cent since 1967, "the highest percentage increase of any public or private utility in the nation."

Evins, long a supporter of TVA, made the comment at hearings on TVA's request for 17.4 per cent more funds for non-power projects.

He is chairman of the public works subcommittee of the House Appropriations Committee and dean of Tennessee's congressional delegation.

He and TVA Chairman Aubrey J. Wagner clashed sharply over TVA's escalating rates.

Evins repeatedly asked Wagner and Robert Marquis, TVA general counsel, why they had not protested more vigorously the increase in coal prices. These increases have been blamed by TVA for its own rate hikes.

"That's my complaint with TVA," Evins said. "You talk about it, but you haven't done anything about it."

Wagner replied that TVA has asked its attorneys to look for the basis of antitrust suits against oil companies.

"You haven't written a letter, or telephoned them or called on them, or made a report," Evins responded. "I don't think you have . . . made a request for antitrust action. You just sit down there in Knoxville."

Wagoner said TVA had no evidence to justify a lawsuit.

Concerning rates, Wagner said TVA's rates have "remained lower than almost anywhere else in the nation."

1405

Needed for nuclear power

U.S. uranium reserves low, AEC says

By LEE DYE
© L.A. Times-Washington Post Service

America may be unable to acquire the uranium it will need to fuel its nuclear power plants in the years ahead, according to recent studies by the Atomic Energy Commission (AEC).

The studies reveal that domestic reserves of uranium are far below the amount needed in the near future, and even the most optimistic estimates of "potential" U.S. reserves are far below the anticipated demand.

Ironically, the concern over fuel supply is coming at the very time the nuclear industry is making statements of assurance that only the atom can free the nation of dependence on foreign energy sources.

The availability of uranium today closely parallels the oil situation of just a few years ago. As in oil, a few industrialized nations are using more than their share of the resource—which is concentrated in the hands of a few largely underdeveloped nations.

Some public utilities already are having trouble securing long-term contracts for uranium to fuel their atomic reactors, according to testimony before the congressional Joint Committee on Atomic Energy (JCAE) this month.

News analysis

As a result, if uranium can be acquired in adequate quantities in the years ahead, much of it will have to come from foreign sources—mostly Australia, Canada and in south and southwest Africa.

But the competition for uranium undoubtedly will be fierce in light of the growing worldwide commitment to nuclear power.

And there simply is no guarantee of adequate supplies.

Frank P. Baranowski, director of the AEC's division of production and materials management, testified March 5 that demand for uranium for U.S. reactors will exceed "production capability from known resources" within eight years.

During his testimony before the JCAE, Baranowski expressed serious concern over whether the demand could be met at all toward the end of the century.

Such concerns raise the specter of a nation heavily dependent on multi-billion dollar nuclear plants for its electricity — and with too little fuel to run the plants to supply the electricity and amortize enormous investments.

Breeder has problems

The nuclear industry and the AEC have maintained in the past that the supply of uranium was not a critical factor, particularly in view of the "fast breeder" reactor scheduled to go into commercial operation in the middle of the next decade.

The breeder makes more fuel than it consumes.

Unfortunately, Baranowski's bleak forecast of a uranium shortage was based partly on the assumption that the breeder would go into commercial operation in 1986.

The breeder is still in the developmental stage and there is some doubt in scientific circles over whether it will ever become commercially feasible.

But even if it does, it appears now that the uranium shortage could cripple the nation's public utilities.

The AEC estimates that by the mid-1980s there will be more than 200 "non-breeder" commercial reactors in operation in this country, all of which will require enormous amounts of uranium in an estimated 35 years of service.

Cost, supply linked

As with any resource, the amount of uranium that can be recovered is dependent partly on how much the consumer is willing to pay for it.

At a cutoff cost of $8 a pound, known U.S. reserves total 275,000 tons. At $10 a pound, the reserves rise to 340,000 tons, and at $15 a pound, the amount climbs to 525,000 tons.

In other words, at $15 a pound, it is economically feasible to mine lower grade deposits, thus nearly doubling U.S. reserves.

The AEC generally uses the $8 cutoff figure in its estimates, partly because uranium at that price gives the nuclear power industry a competitive edge over nearly all other forms of energy.

While it is impossible to pinpoint the amount of reserves yet to be discovered, the estimates of undiscovered reserves are not particularly encouraging. Even at $15 a pound, the undiscovered reserves are estimated at about 1 million tons.

That is less than half the estimated demand of 2.4 million tons for the rest of the century.

The AEC's recent conclusions lend support to a one-man campaign that has been under way for about a decade by a Washington-based engineer.

Utility bankruptcy forecast

Morgan Huntington, a mining engineer who also studied chemical and nuclear engineering, has been contending for years that the AEC and the nuclear industry have been overestimating the availability of uranium.

He argues that the public utility industry has purchased or ordered $100 billion worth of nuclear reactors that will burn 9 million tons of uranium during their lifetime.

Huntington maintains that even at five times the current cost, U.S. uranium reserves are equal to no more than the coal the nation normally burns in five years.

The uranium shortage will lead many public utilities into bankruptcy, Huntington maintains.

"They simply won't be able to amortize their investment" in nuclear power plants, he said in an interview.

Although the AEC stops considerably short of reaching a similar conclusion, there have been warnings lately out of AEC headquarters over the possible consequences of a uranium shortfall.

1406


PEABODY COAL COMPANY
SUBSIDIARY OF KENNECOTT COPPER CORPORATION
MAP SHOWING NEW OPERATING DIVISIONS
AND OTHER FACILITIES OF THE COMPANY
July 22, 1971
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
NEBRASKA
IOWA
WESTERN GROUP
KANSAS
NEW MEXICO
TEXAS
WISCONSIN
MICHIGAN
EAST DIVISION
EASTERN GROUP
NEW YORK
PENNSYLVANIA
MARYLAND
VIRGINIA
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
MISSISSIPPI
LOUISIANA
MAINE
VT.
N.H.
MASS.
CONN.
N.J.
SALES OFFICES
OTHER FACILITIES
Tennessee
Missouri
Illinois
Wisconsin
District of Columbia
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA

STATEMENT BY

J. ROBERT WADE, PRESIDENT

KENTUCKY FARM BUREAU FEDERATION

BEFORE THE

SENATE SUBCOMMITTEE

ON

PUBLIC WORKS

As president of Kentucky Farm Bureau, I represent more than 157,000 member families, and on behalf of all of them, let me state our appreciation for this opportunity to place this testimony on your record.

The proposal by the Tennessee Valley Authority (TVA) to purchase Peabody Coal Company, as I understand it, does not require Congressional approval. But the increase in bonding authority necessary to secure TVA's purchase loan is subject to the review of this committee, and subsequent approval by Congress.

We at Farm Bureau oppose the proposed purchase, and we therefore oppose approval of this increased bonding.

TVA was formed, as you well know, for the primary purpose of flood control, and its tremendous capacity for electrical production was viewed orginally as a corollary. Since the 30's, this agency of the federal government has grown much the same as other government agencies, like a mushroom.

The growth, in itself, is not bad. For much of the high standard of living and increased industrialization which has occurred in the Valley area can be traced to TVA electricity. But the directions of this growth have been at times disturbing, and this planned entry of the federal government into the coal mining business is one of those times.

TVA claims that if Peabody, the nation's largest producer of strip mined coal, is under TVA ownership, the coal will cost it much less, even half of today's purchase prices. Thus, the purchase of Peabody will enable TVA to provide electricity at

much less cost to the consumer, the argument goes.

But I ask you, when is the last time you knew of an instance where governmental control of an activity produced cost savings or increased efficiency. One shudders at the thought of running a coal-mining operation with the same techniques that, for instance, have characterized the post office, or welfare, or OSHA, or the Pentagon.

In reality, the private coal industry has been and continues to be a reliable supplier of fuel to our public utilities. Coal prices have gone up at times, and come down at other times, but over the long haul, the coal industry has been reasonable in its pricing and has operated under the laws of supply and demand.

I find it hard to imagine that TVA's management has access to some specialized technology which will enable it to produce coal more cheaply than the industry itself. And if TVA did realize an economic advantage through coal company ownership, other utilities, under management and consumer pressure to meet TVA price competition, would then begin looking for a coal company to buy.

Thus, this purchase of Peabody by TVA could be harmful in two respects. One, it would constitute an entry into the private coal mining business by an agency of the federal government. Secondly, it would be a giant step toward further centralization in ownership of the nation's energy resources.

It seems inconsistent, for instance, for one federal agency, the Federal Trade Commission, to require the sale of Peabody by Kennecott Copper because of monopolistic tendencies, while another federal agency stands in the wings as a possible purchaser. Is it less monopolistic for a federally owned electrical producer to own one of the nation's largest coal suppliers, than for Kennecott to own the coal company?

And what about the impact, on the overall coal supply? Currently, TVA uses about 20 per cent of Peabody's total production, but that's just one-third of the company's needs. Total TVA coal requirements equal approximately 50 per cent of

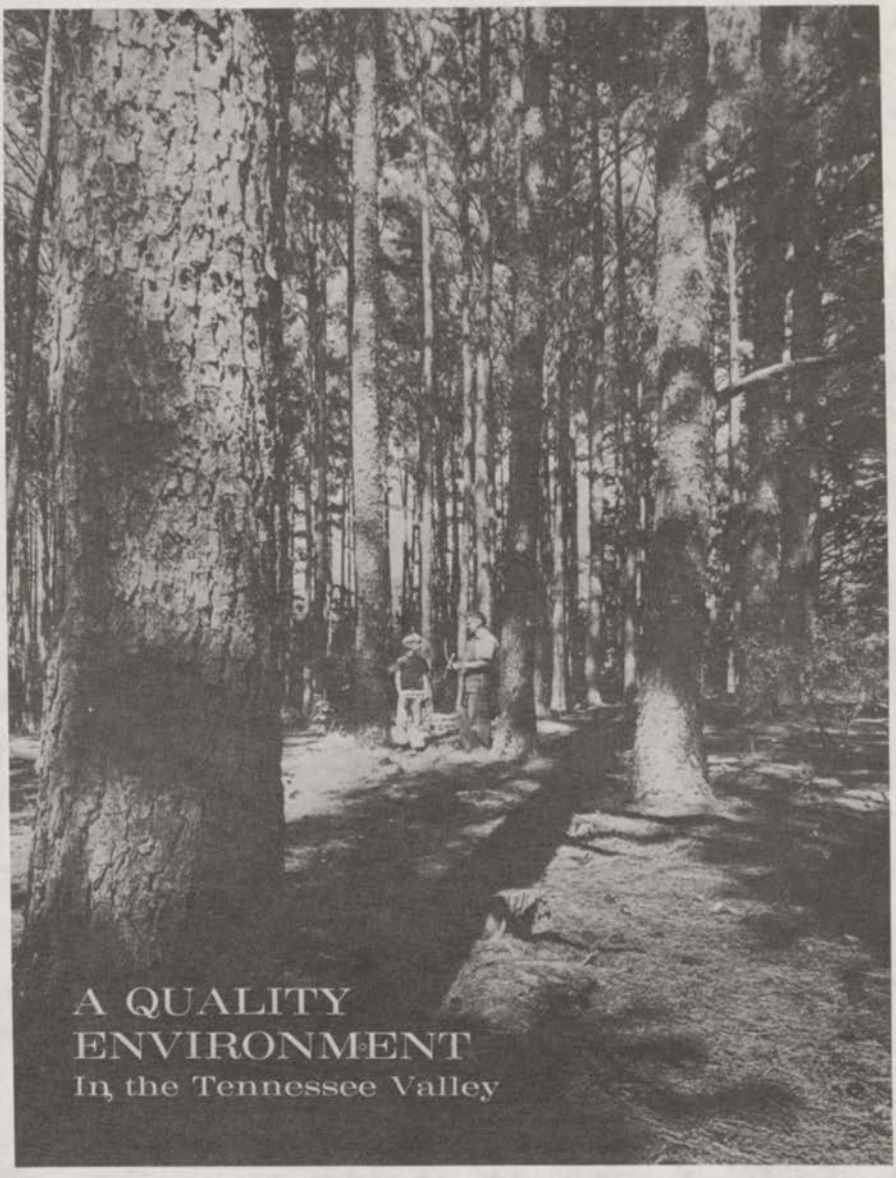
current Peabody production. This leaves a vast amount of coal for other buyers, including other utilities. If TVA were to buy Peabody and curtail production of coal over their own needs, as their public statements have seemed to indicate, supplies of coal could easily tighten and prices could go up. This could cause higher costs for other electricity producers, and consumers, and would constitute unfair competition in the energy industry by the federally subsidized TVA. Although there's no definite indication this would happen, there's also no assurance it would not.

An additional question concerns the potential loss of tax revenue to my state of Kentucky. Currently Peabody pays more than $7 million to the commonwealth just in coal severance taxes, not counting corporate income and other taxes. What would happen to this revenue if the non-taxpaying TVA were to assume ownership? It seems unlikely that TVA would volunteer to continue payments to governmental treasuries at the rates which the law requires of private firms.

In summary, Kentucky Farm Bureau's objections to the purchase of Peabody Coal Company by TVA are related to energy supplies, energy prices and the private enterprise system. We do not believe that the availability and price of coal, upon which we all depend for electricity, will be favorably affected by this purchase. We likewise oppose this incursion by the federal government into the private coal industry. Your support for our position will be greatly appreciated.

APPENDIX C

MATERIAL REFERRED TO DURING THE PROCEEDINGS AND SUBMITTED FOR THE RECORD


A QUALITY
ENVIRONMENT
In the Tennessee Valley

ON THE COVER — Over the past four decades, Tennessee Valley landowners have reforested more than a million acres of abandoned cropland and cutover woodlands. This stand of pines was planted more than 40 years ago by Knoble Mantooth of Polk County, Tennessee, shown here with his grandson Scott.

CONTENTS

	Page
A QUALITY ENVIRONMENT IN THE TENNESSEE VALLEY	1
"A House in Poor Repair . . ."	1
RESTORING FIELDS AND FORESTS	3
Demonstrations Lead the Way	3
Rebuilding the Forests	3
Healing Strip Mine Scars	4
Reclamation Research	5
MORE CLEAN WATER	6
Heated Water Discharges	6
Other Special Studies	7
The Problem of Mercury	8
Continuing Improvement in Water Quality	8
EXPANDING OUTDOOR ENJOYMENT	9
Land Between the Lakes	9
Protecting Scenic Values	11
FISH AND WILDLIFE	12
Fifty Times More Fish	12
Wildlife and Forests	13
Wildlife in the Valley's Future	13
RESERVOIR ECOLOGY	14
An Unwelcome Import	14
CLEAN AIR TO BREATHE	15
AESTHETIC VALUES	18
Putting Power Lines Underground	18
PLANNING AND THE ENVIRONMENT	19
Staying Out of Nature's Path	19
"Operation Townlift"	19
New Town Prospects	20
THE GROWING REFUSE PROBLEM	21
POWER SUPPLY AND THE ENVIRONMENT	23
The Benefits from Growth —	23
— and the Problems	23
The Breeder Reactor	24
Other New Energy Sources	25
Conserving Energy	25
Electric Rates and Consumption	27
The Cost of Environmental Protection	28
The Public Interest vs. the Public Interest	29

Tennessee Valley Authority, Knoxville, Tennessee 37902 • September 1973

LIBRARY OF CONGRESS CATALOG CARD NO. 77-602111

A QUALITY ENVIRONMENT

In the Tennessee Valley

In the 1970's the United States has set out to curb the growth of air and water pollution, and to guarantee that future Americans will have the opportunity to live in a clean environment. This job is not a simple one, because today's environmental problems have resulted from the same economic and industrial growth that have made it possible for most Americans to have a standard of living once enjoyed only by a privileged few.

The challenge is to provide a quality environment for the future, without sacrificing the basic economic gains so hard-won in the past.

The Tennessee Valley provides an unusual chance to take a look at that challenge, because here both of those objectives have been part of a unique regional resource development program. In 1933 Congress created the Tennessee Valley Authority, directing it to aid in "the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and . . . adjoining territory." This unified program saw in the region's water, land, forests and minerals one interrelated set of opportunities for improving the living standards of its people.

This work has resulted in an unusually broad and diverse organization. The work of some TVA staff members is to help this region develop its fish and wildlife, protect its air and water quality, reclaim eroded and mined lands, renovate towns. Others are economists concerned with adequate employment and income opportunities, and the engineers and power producers and waterway specialists whose work helps make economic progress possible. These groups work together to meet the joint goals of a quality environment and a quality standard of living for the region's people.

This booklet describes TVA environmental activities, which in turn are part of a broad effort by many organizations and interests to maintain the quality of the region's air, water, and land.

"A House in Poor Repair . . ."

For most people in the Tennessee Valley, the years since the 1930's have brought a real improvement in the human environment — the surroundings in which we live and work.

A survey was made in 1935 of living standards among the farm families affected by one of TVA's first projects, Wheeler Dam on the Tennessee River in north Alabama. The typical home was a house in poor repair at the edge

A TVA environmental education specialist helps a school group with water sampling on a field trip near Norris Dam.



54-380 O - 75 - pt. 2 - 28



Resource development has helped change the way of life that prevailed in much of the Tennessee Valley 40 years ago.



Wheeler Dam — an instrument for change in Alabama.

of a dusty field, crowding a large family into perhaps three rooms. Among several hundred homes, only one had electric lights. One had telephone service. None had an indoor bathroom. Malaria was endemic, sapping the strength of one person out of every three. Farm laborers worked for 50 cents to a dollar a day. The one cash crop, cotton, was selling for five cents a pound, and farms were being sold for taxes. Almost no industrial jobs were available.

That survey gives us a benchmark for measuring the change that has taken place since. Wheeler Dam and others like it provided low-cost electricity, recreation opportunities, a navigation channel for modern river traffic, lakefront plant sites for industry with ample water supplies and protection from flooding. At nearby Muscle Shoals TVA established a fertilizer development and education program to help make farming more efficient, and a nursery producing tree seedlings to reforest eroded hillsides. Malaria was eliminated.

The area around Wheeler Lake is a different scene today. Towboats push their strings of barges to and from the new industries that now line the waterfront for miles at Decatur — providing jobs for thousands of people who no longer must scratch a living from the cotton fields.

Saturn booster rockets to launch moon flights, too large to move overland, traveled the same waterway from NASA's test facilities at the Huntsville space flight center on the first leg of their journey to Cape Kennedy. At the one-time site of Browns Ferry Landing, the world's largest nuclear power plant is being built to help meet the region's expanding demands for electricity.

Many of the promising young people who once would have sought opportunities elsewhere now can find them closer to home. Farming supports fewer people, but for most it is a changed way of life. Low-cost electricity has brought running water and the conveniences of modern living while it eases the burdens of farming operations. Substandard housing today is the exception, no longer the rule.

This transformation of the Wheeler Lake area is one of the more dramatic examples of the improved living standards that economic growth has brought to the Tennessee Valley. It is worth remembering as we take stock of the changes in our environment. Sometimes it is easy to imagine that our surroundings were always tidier and greener before the factories came — but that image does not fit the past reality of ramshackle homes and back-breaking toil for too many people.

The job of economic development in the Tennessee Valley is not over, in spite of the gains that have been achieved. Population projections indicate the region may need another 1,400,000 jobs by the end of this century to accommodate a 50-percent increase in the labor force. This projection is not some sort of wish for thoughtless growth. Instead, it presents a measure of the human problem of finding useful outlets for the talents of the region's young people.

Environmental needs, economic needs — two objectives that often conflict and present difficult choices. TVA is sometimes asked how it can be in the position of trying to serve both of these goals. The answer is simple: this fundamental conflict must be faced and resolved not only in this region but across the Nation as a whole. We must find ways to meet both kinds of human needs — a decent living, and a livable environment as well.

RESTORING FIELDS AND FORESTS

Farming was man's chief work in the Tennessee Valley when TVA was established, and the most evident misuse of the environment by man was in the fields and forests. Farm income came mainly from corn and cotton and tobacco — row crops that left the topsoil exposed to the beating rains that fall in winter. On millions of acres erosion was spreading, valuable topsoil washed away, worn-out fields abandoned.

The scars in the woodlands were not so obvious. From a distance trees still covered hillsides with green, but a closer look showed the once-great virgin hardwood stands nearly gone. What remained were the leftovers from years of heavy timber harvests, unchecked forest fires, and general neglect. Too often timber cutters had taken the good trees and left the defective ones to reproduce the next generation — survival not of the fittest but of the unwanted. Timber growth was not enough to replace what was harvested.

Demonstrations Lead the Way

As TVA organized programs of reclamation and conservation, it was important to measure scientifically the effects of reclamation methods and to demonstrate their value to landowners who could put them into use on a large scale. TVA set up research-demonstration watersheds to accomplish this. One of them was the 88-acre Pine Tree Branch Watershed near Lexington, Tennessee, chosen because it was typical of the abandoned lands in the western Tennessee Valley. Long years of farming had left the area riddled with gullies, erosion carried away an average of 24 tons of soil a year from each acre of land, and the rush of water off the hillsides after each storm fed frequent downstream floods.

After careful measurement of soil loss and streamflow for comparison with later results, TVA planted the whole watershed in pine seedlings. Erosion control measures such as check dams in gullies were used in addition to providing protection from fire and grazing. Within five years there were dramatic reductions in soil losses. After 15 years erosion was virtually stopped and the runoff from a rainstorm flowed out over a period of days instead of minutes. More recently, careful tree harvesting has been carried out to show the income reforestation can provide as an incentive to landowners. Pine Tree Branch, and dozens of other demonstration projects carried out across the Valley with the guidance of TVA foresters, have shown landowners that reforestation benefits both land and owner.

At the other end of the Tennessee Valley, in a section of typical Appalachian hill farms, TVA and North Carolina State University carried out a different sort of watershed demonstration project. In an area of this kind, it is nearly impossible for some farmers to adopt "ideal" conservation measures that cost money and offer no immediate increase in already-low farm incomes. This project on Parker Branch sought instead to help them adopt practical changes in farming designed to provide quick improvement in conservation and in farm income as well. It was a success in reaching both goals.

These demonstrations are only examples, designed to provide lessons other farmers and landowners could apply. The same kinds of improvements have been accomplished on a broad scale throughout the Valley. One of TVA's initial assignments was to convert a government munitions facility at Muscle Shoals, Alabama, to development and



Parker Branch watershed has shown how Appalachian farmers can improve soil and water conservation while raising farm income.

production of improved fertilizers. Through demonstrations on individual farms — more than 50,000 Valley farmers have taken part — new fertilizers from Muscle Shoals were used as a starting point toward better farm management. Much of the emphasis was on switching land unsuitable for row crops into pasture grasses and other forage crops for livestock, which was then a minor part of the Valley agriculture. Since the 1930's row crops in the Valley have been reduced by three million acres, and livestock now brings farmers more income than crops do. As one factor in this chain of events, fertilizers have helped promote plant growth to provide more protective cover and to increase the water-absorbing capacity of the soil. The result is better use of soil and water resources.

Rebuilding the Forests

Tennessee Valley forests today contain nearly twice as much wood as they did 40 years ago, and are growing over three times as much wood as the amount being harvested. Although various kinds of development are taking some forest land, the Valley's forest area is actually larger than it was in 1933 because of reforestation.

TVA set up large forest nurseries to provide the seedlings needed for reforestation. These were supplied first to Civilian Conservation Corps planting crews in the 1930's, then to landowners as demonstration projects convinced them of the value of tree plantations. TVA supplied more than 600 million seedlings for reforestation, then ended production as supplies became available from other sources.

While a million acres were being reforested, the public was alerted to the extensive losses due to forest fires. TVA worked with the states in improving facilities and methods for fire detection, enabling state fire control agencies to extend suppression work to nearly every piece of Valley woodland. Where ten thousand fires (and ten thousand sources of air pollution) once damaged or destroyed ten percent of the Valley's forest annually, the yearly loss now is less than half of one percent.

Landowners have been encouraged to undertake forest management on 12 million acres, increasing wood production and often serving wildlife and recreation as well. Demonstrations of watershed-protective logging methods have taught timber harvesters how to conserve the litter cover on the forest floor, and to reduce water runoff and stream sedimentation.



Without reclamation, strip mining leaves scars that are long in healing (above). Below is a similar strip mine 8 years after reclamation measures were carried out.



Healing Strip Mine Scars

The coal deposits that underlie much of the Appalachian region extend through parts of the eastern Tennessee Valley, from the western end of Virginia to northern Alabama.

Strip mining uses earthmoving equipment to strip overlying earth and rock from shallow coal seams so the coal can be dug from open pits. This method of coal mining dates back more than 50 years. As equipment has grown in size and efficiency, strip mining has been used for an increasing portion of coal production here and elsewhere.

Where seams lie close to the surface, strip mining usually makes more complete use of the coal resource, is more economical than other methods and in some cases makes available a resource which would otherwise be unavailable. In terms of the miner's safety, strip mining has a wide advantage over deep mining.

Strip mining's advantages can be offset by severe disadvantages if steps are not taken to minimize them, however. This kind of mining scars the landscape as the land is turned upside down to expose coal. Without a conscientious reclamation program these scars are long in healing; meanwhile the bare earth and exposed coal wastes can open the way to erosion and acid pollution of streams.

With careful mining and reclamation, stream pollution can be checked and erosion controlled. On mined lands as on abandoned fields, planting trees and other vegetation can stabilize the loose earth and in time make the surface productive and attractive.

In the mid-1940's, TVA foresters began trying to encourage mining firms and landowners to reclaim and replant this disturbed land voluntarily. The effort had only limited success. Most Tennessee Valley strip mining was in remote mountain areas where it was little noticed. Individual mine operators, facing a competitive coal market, were reluctant to stand the cost of reclamation, which often was more dollars per acre than land prices on these poorly-stocked timberlands.

State laws to regulate all surface mining and require reclamation seemed to be the most promising answer. Kentucky was the first state in this region to enact this kind of legislation. Other states were slow to follow — partly because the need for reclamation and practical techniques for achieving it were not widely recognized.

Meanwhile, in the 1950's TVA itself was becoming a large user of coal as the region's use of electricity outgrew its water power potential and big coal-fired generating plants were built to meet the demand. TVA supported the effort for state regulation of strip mining. It worked on cooperative studies to show the extent of strip mining and to publicize the effects on land and water (its 1963 report "An Appraisal of Coal Strip Mining in the Tennessee Valley" was used nationally as a reference source). TVA surveyed mining and reclamation methods throughout the Appalachian and Midwest coal fields, and carried out a series of demonstration projects to show that reclamation could be workable and effective in Valley strip mining.

In 1965 TVA began including reclamation requirements in its coal contract awards, wherever the coal was to be produced by strip mining. (This was recognized as only a limited approach, since TVA buys only about 15 percent of the coal strip-mined in the major states of its coal purchase area. The rest goes to other users and is not affected by TVA requirements.) These provisions

have been strengthened as experience has indicated where changes and improvements were needed. Meanwhile the states involved have adopted reclamation laws of their own.

As a public agency with conservation responsibilities, TVA is sometimes criticized for being "the country's largest user of strip-mined coal." That statement is true — but it is misleading. TVA is the country's largest producer of electricity, yet it buys only about one-fourteenth of the coal produced by surface mining in this country. And TVA has done much more than any other coal user to try to correct the serious environmental impact of strip mining.

TVA has considered the alternative of refusing to use coal from strip mines. But this could create critical problems in maintaining electric power service for nearly 6,000,000 people. And in the end this policy would be largely a hollow gesture, at the consumer's expense, because most of the same strip mine coal production would simply be freed for other purchasers.

Because of the national importance of adequate fuel supplies for power plants, and because of the inherent safety and other problems involved in any wholesale shift to all-underground coal mining, TVA instead has tried to overcome the most severe problems involved in strip mines. Present TVA contract requirements include approval of a mining and reclamation plan before strip-mined coal can be considered for a contract award. Other requirements include water runoff and erosion control measures, immediate revegetation with grasses through hydraulic seeding, appropriate planting of trees and shrubs for the planned land use after mining, and other measures. Part of the coal payment is diverted to an escrow account until satisfactory reclamation is completed. Surface mining is prohibited in designated wilderness or scenic areas, and anywhere that adequate reclamation cannot be obtained.

Some of the concern over strip mining has resulted from the rapid increase in this form of mining in recent years. However, no substantial increase is expected in TVA's present level of coal purchases from surface mines. Its newest coal-burning power plant (now being completed) is supplied mainly from two large underground mines under long-term contract. With the advent of nuclear power, no additional coal-fired plants are included in TVA's present schedule of additional generating capacity through the 1970's.

Present reclamation laws apply only where current mining takes place. This still leaves extensive unreclaimed areas that were mined and abandoned before these laws were enacted. For the most part these "orphan" mines are being restored only through nature's slow process, except where they are reclaimed in connection with subsequent mining operations. Several problems stand in the way of an effective program to restore Appalachia's orphan strip mines. TVA has proposed cooperative demonstration projects to reclaim them, so far without success. The use of state severance taxes to finance this work also has been proposed.

Reclamation Research

Four reclamation projects established by TVA in 1963 are serving as laboratories for finding better ways of restoring mined lands. The erosive water runoff was



TVA strip mine reclamation requirements include hydraulic seeding (top photo) to establish a quick grass cover and control erosion. In the lower photo, sweet clover was used to provide wildlife food and ground cover on this strip mine.

controlled, the acid coal wastes buried. Now young trees and wildlife plantings cover the spoil banks. TVA biologists studying the value of reclamation measures designed to attract wildlife have found encouraging results. These findings suggest that large mining acreages with the right kind of reclamation followed by wildlife management can provide attractive habitat for animal life, accessible (over the mine haul roads) for hunting, camping, bird-watching, and for other outdoor activities.

The first large-scale demonstration of this concept started in 1969 when the Penn Virginia Corporation signed an agreement with TVA and state agencies for establishment of a wildlife management area of nearly 10,000 acres in southwest Virginia. It combines wildlife development, under the Virginia Game Commission, with timber management and strip mining reclamation.

Other TVA research includes studies on the adaptability of various plant species to strip mined land; the value of fertilizers, soil conditioners and mulches in speeding the growth of strip mine plantings; and the effects of reclamation on water quality, aesthetics, and wildlife.

An experiment in advanced mining and reclamation techniques has been established under a special contract with one surface mine operator in east Tennessee. This project will separate and measure the cost of reclamation procedures as they apply to mountainous terrain in the Southern Appalachians. The operation involves eliminating the vertical rock "highwall" that remains after contour mining by returning the land to approximate original contour, and limiting the amount of earth placed on the slope below the coal seam.



MORE CLEAN WATER

Growing population and industry mean additional wastes that can increase stream pollution — but this does not have to be so. The waters of the Tennessee River basin are generally of excellent quality, but there are certain sources of wastes which must be kept under surveillance to determine the extent to which they can or do degrade water quality. TVA believes that development of the Valley can continue if sufficient attention is given to planning and operating waste treatment facilities in such a manner that good quality water is returned to the streams for reuse.

As a whole, Tennessee Valley cities and towns have made good progress in installing sewage treatment facilities. Continuation of programs now under way should result in adequate sewage treatment facilities for the Valley's cities.

In the early years of TVA no state in the Valley region had an effective stream sanitation program. Many stretches of the Tennessee River and its tributaries were used for nothing but waste disposal. In 1936 TVA began a series of fact-finding surveys to report on pollution in these streams, and set out to encourage establishment of effective state pollution control programs throughout the region. Tennessee was the first of these states to adopt a specific and comprehensive pollution control law, in 1945, and gradually the others followed suit.

TVA works with pollution control agencies to help bring about effective treatment of wastes from commercial and industrial developments along the lakes behind its dams, and from floating craft on the lakes. Although TVA does not have direct authority to regulate stream pollution generally, it uses its land rights along shorelines to require the builders of new industrial or commercial developments there to install adequate waste treatment facilities.

Using a well-equipped laboratory at its Chattanooga offices, TVA does extensive "before-and-after" monitoring around these shoreline developments to detect any changes in water quality. TVA staff members make some 70,000 water quality analyses a year in the lab and in the field.

At its own installations TVA takes the necessary steps to control and treat waste discharges to streams.

Heated Water Discharges

Steam-electric power plants usually are located on large rivers or lakes so cooling water can be pumped from an upstream intake through the plant's condensers to cool and condense spent steam from the turbines. This water flows back to the river downstream, essentially unchanged except for a higher temperature than it had when it entered the plant.

This warm water discharge does not pose a serious problem at older TVA steam plants. In fact, the most obvious effect has been the popular fishing at steam plant discharge basins where large numbers of fish often congregate in the warm water. But as growing power demands require more and larger plants across the Nation, both nuclear and conventionally fueled, there is increasing concern about what effects these heated water discharges may have on fish and other aquatic life — so-called "thermal pollution."

Cooling towers, which transfer heat from a plant's condensers to the air instead of to a river, were added to TVA's Paradise Steam Plant when it was expanded in the late 1960's. Condenser water from this large generating unit is cooled and recirculated, and the towers also permit operation of the original two generating units without river cooling water during periods of low streamflow in the Green River.

Several new nuclear power plants now under construction or planned on the TVA system will be equipped

with cooling towers to reduce the thermal impact of the warmwater discharges. In addition, some of these power plants will also be equipped with special diffuser pipes to mix the warmwater discharge rapidly with the receiving stream. At each plant a series of monitoring stations will continuously measure water temperature to ensure compliance with temperature standards.

To learn more about the effects of increased water temperature on aquatic life, TVA and the Environmental Protection Agency have constructed a large experimental facility at Browns Ferry Nuclear Plant. A series of channels will be stocked with various species of fish and supplied with water flowing at different temperatures. This will allow biologists to study long-term effects of heated water on fish life, reproduction, and food supplies under scientifically controlled conditions.

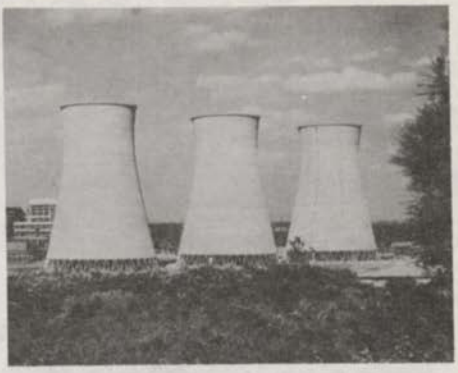
At Colbert Steam Plant in Alabama, the warmwater discharge flows through a small creek before reaching Pickwick Lake, where the heat is dissipated. TVA scientists are studying this short reach of the creek to determine the impact of the heated water discharge on significant forms of aquatic life, including microscopic plants and animals, bottom-dwelling life, and fish.

TVA is also engaged in experiments to determine beneficial uses of heated water from power plants — such as greenhouse and field production of high-value crops, commercial fish production, and heating and cooling for livestock and poultry housing. An experimental greenhouse has been built at the TVA Fertilizer Center for preliminary studies, in cooperation with Oak Ridge National Laboratory. Continuing experiments at Gallatin Steam Plant to evaluate the use of heated water in the commercial rearing of catfish have already shown significant benefits in an increased growth rate and a longer growing season.

Other Special Studies

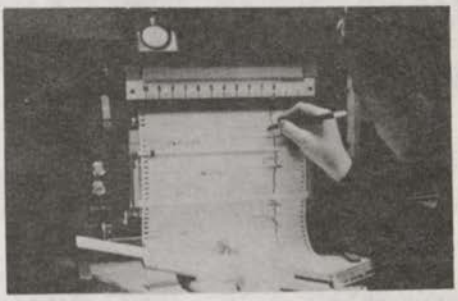
Under certain conditions the water released through low-level outlets at dams can be low in oxygen content, a potential hazard to aquatic life downstream. TVA has conducted extensive research on the conditions that can lead to this situation and has tested devices that are being included in the design of new dams to reaerate the water discharge and restore its dissolved oxygen content. Engineers also are conducting research to develop ways of aerating the turbine discharge at existing dams. At Fort Patrick Henry Dam a device has been installed that injects tiny bubbles of oxygen just upstream from the turbine intakes, to determine whether this approach is feasible.

Another area of TVA study is the possible effects on water quality of plant nutrients washed off by rain or dissolved into groundwater from land where agricultural fertilizers have been applied. These studies include small, controlled watersheds that allow researchers to account for all water that enters and leaves and all fertilizer that is applied, so that they can assess the relationship between the two. Results so far indicate that fertilizer use does not present any serious pollution threat under the conditions tested by TVA. The subject is a complex one because soil characteristics, rainfall and other hydrologic conditions, and fertilizer use vary from one area to another.



Cooling towers at Paradise Steam Plant.

TVA's Water Quality Laboratory.



Testing reaeration of low-level discharges.





Air and water pollution often are more difficult to control in older factories like this one than in modern plants designed to include pollution controls. Since this photo was made several years ago, the company operating this plant has committed more than $22 million to upgrade pollution controls here.

The Problem of Mercury

In the spring of 1970, the Food and Drug Administration established 0.5 part per million as the country's first working guideline on the maximum amount of mercury considered permissible in the flesh of fish meant for human consumption. FDA made its recommendation following events that indicated that potentially dangerous mercury contamination might be more widespread than had been suspected.

TVA immediately began an intensive program of fish sampling in Tennessee Valley reservoirs and river reaches, with particular attention to areas where there were possible sources of mercury. These samples are analyzed for mercury in TVA's Water Quality Laboratory in Chattanooga, where water and sediment samples are also analyzed. Based on monitoring results from TVA and other agencies, state and Federal regulatory bodies took steps to limit the consumption of fish from two areas where fish samples were found with mercury concentrations higher than the suggested criterion (restrictions on sport fishing have been lifted since that time).

The only significant sources of mercury in TVA reservoirs are industries that produce chlorine and caustic by a mercury-cell process. These industries were required to reduce mercury discharges to a small fraction of previous levels. By 1972, TVA's continuing program of monitoring showed an encouraging trend toward lower mercury concentrations in fish samples from Pickwick and Kentucky Lakes. This trend is believed to represent a gradual sealing off of mercury-bearing bottom sediments (deposited in the past) as they are covered by new sediment free of mercury.

Mercury concentrations remain high in fish from the North Fork Holston River in Virginia and upper east Tennessee. The plant which was the source of this mercury has since shut down.

Continuing Improvement in Water Quality

There are still some serious water quality problems in the Tennessee Valley. For example, water quality is considered unacceptable for swimming in a 10-mile reach of the Tennessee River below Knoxville, and from Chattanooga downstream to the old Hales Bar Lock — although both cities have made improvements in waste treatment facilities that have reduced the extent of this pollution in recent years.

Industries have found it difficult to provide adequate waste control at some older plants in the Valley that were built before the problem of stream pollution was taken seriously. One industry has closed and another has announced plans to close because of the high costs of modifying them to meet present water quality standards.

Yet these problems need to be viewed against the background of progress already accomplished in cleaning up the Valley's streams. Its cities and towns, encouraged by state water quality programs and Federal grants, have acted one by one to install and improve waste treatment facilities. Because major industrial growth in a comparatively recent development in this region, most of its factories are modern — built after industry began to recognize that waste treatment and control must be accepted as part of the cost of new industrial installations. Many of its older plants are improving waste treatment as well.



EXPANDING OUTDOOR ENJOYMENT

As Americans have moved from the farm to the city, and as shortened workweeks have expanded our leisure time, opportunities for enjoying outdoor recreation have become increasingly necessary to a balanced environment for today's way of life.

In the Tennessee Valley the lakes created by TVA dams are a major part of that opportunity, offering more than 600,000 acres of water and 11,000 miles of shoreline. Here there is room for satisfying a wide range of needs for contact with the out-of-doors, from the excitement of a water-skiing run to the tranquillity of a quiet cove at sunset.

The response to the leisure-time appeal of the outdoors, by a people who now do most of their work indoors, is reflected in recreational use of TVA lakes and reservations. In 1947, when most of its major lakes had been impounded, recreation use totaled 9 million visits for the year. Now it amounts to about 60 million visits annually.

TVA has carried on a continuing program to assist public and private interests in the development of the Valley's recreation resources. Waterfront tracts it acquired in the process of buying land for reservoir construction have been made available for development as state and local parks, or sold for commercial recreation projects. Today recreation on TVA lakes is served by a hundred state and local parks, 300 boat docks, a hundred group camps and club sites, and some 400 lake access areas. In addition, certain lands such as islands are set aside by TVA to remain as open areas, protecting the natural features of the shoreline and remaining available for informal public use.

The recreation and tourist use of these lakes also has become a significant part of the region's economy. One measure of this impact is the estimated $400 million value of the recreation developments and equipment on these lakes.

Land Between The Lakes

In 1961 TVA recommended to President John F. Kennedy that a large tract of thinly-populated land between Kentucky Lake and Lake Barkley in west Kentucky and Tennessee be developed as an outdoor recreation area. These two big man-made lakes run parallel for a distance of about 40 miles with a narrow, 170-000-acre wooded peninsula sandwiched between. Recognizing the critical need for additional public recreation space, President Kennedy in 1963 assigned TVA the task of acquiring and developing Land Between The Lakes as a national demonstration in outdoor recreation and environmental education.

A major purpose of TVA's demonstration in Land Between The Lakes is to show how an area drained of most natural resources can be restored to serve a wide range of national recreation needs and provide an economic asset to the surrounding region.

Land Between The Lakes offers a wide range of opportunities for camping, fishing, boating, hunting, hiking, and other outdoor activities. Camping facilities range from the modern to the primitive, from lakeside



Environmental education is a main objective at Land Between The Lakes, which provides nature study opportunities for both school groups and individual families. But most of the two million visitors a year come simply to enjoy the outdoors.





family sites to year-round group camps that provide indoor housing and dining. Each year visitors from every state and several foreign countries are recorded in Land Between The Lakes.

One of the greatest national impacts of Land Between The Lakes may well come from its demonstration in environmental education programs. "Urbanization, with consequent removal of most of our population from lands where wildlife is raised, makes it more difficult for man to appreciate the soil-plant-animal-man relationship on which his existence depends." Frederick B. Emerson pointed out in *Tennessee Valley Wildlife*. Those who can learn to enjoy nature will better understand the need to conserve it.

In Land Between The Lakes a 5,000-acre Environmental Education Center (EEC) has been set aside to help meet this goal — to create a greater awareness in young and old alike of the need for maintaining and conserving a quality environment. A Youth Station provides housing and dining facilities where classroom groups come with their teachers to live and study in the outdoors. A professional TVA staff helps teachers, through workshops and other consultations, with techniques and methods for teaching in the outdoors. Since 1966 more than 20,000 students and 2,000 teachers have participated in a resident educational program at the Youth Station. An even greater number of classroom groups utilize the facilities and programs in the EEC for one-day field trips in outdoor education.

The major emphasis in TVA's program is to demonstrate to school administrators and teachers the value of establishing environmental education programs in their own school systems or districts. The success in Land Between The Lakes has led to a Valleywide TVA program offering assistance and guidance to school systems and community action groups who are interested in setting up environmental education programs and facilities. Several school systems are already including environmental education in their regular curricula, and in some areas of the Valley several school systems are combining

efforts to initiate district environmental education programs.

The Environmental Education Center in Land Between The Lakes is a favorite day-use center with family vacationers as well as school groups. At Center Station films, slides, and displays on the recreational attractions and history of the area are available. Several hiking trails wind through the wooded area providing opportunities to see a wide variety of wildlife including deer and turkey. At Empire Farm the young and old alike can get a glimpse of life on the farm as it used to be. In school groups or family visits, they have a chance to learn about agriculture and see and touch farm animals.

Protecting Scenic Values

In the Tennessee Valley, a combination of manmade lakes and natural scenery together offer a balance of opportunities for outdoor enjoyment. Those reaches of streams that have unusual scenic values represent a unique and irreplaceable resource. TVA has begun an inventory of the streams in the Valley and will evaluate and classify them according to their scenic quality and recreation potential, as a basis for future action by public agencies or conservation groups.

Steps are already being taken to protect the scenic values of some of the Valley's streams. Two streams in the region, the Obed River in east Tennessee and the Buffalo River in middle Tennessee, were identified for study in the National Wild and Scenic Rivers Act of 1968. An interagency task force composed of representatives of the State of Tennessee, the U. S. Bureau of Outdoor Recreation, and TVA has completed a study of the Obed River and has recommended that it be included in the national scenic rivers system. Work has begun on a similar cooperative study of the Buffalo River in middle Tennessee.

At the state level, TVA is cooperating with the Tennessee Department of Conservation, the Tennessee Game and Fish Commission, and the U. S. Forest Service in developing the Hiwassee River in southeast Tennessee as part of the Tennessee Scenic Rivers System. The flow of this river is controlled by releases from TVA's Apalachia powerhouse. Following the recommendations of the interagency task force, TVA is scheduling releases of water from the powerhouse to enhance floating and fishing during the prime recreation season, and granting the State a scenic easement on TVA land along the river.

As population growth creates new demands for reservoir projects to provide flood control, water supply, navigation, lake-oriented recreation and other benefits, an increasing number of situations pose a choice between these needs and the value of maintaining free-flowing streams. In trying to meet these conflicting needs, TVA looks for workable answers that will take into account the intangible values of the natural environment as well as economic considerations.



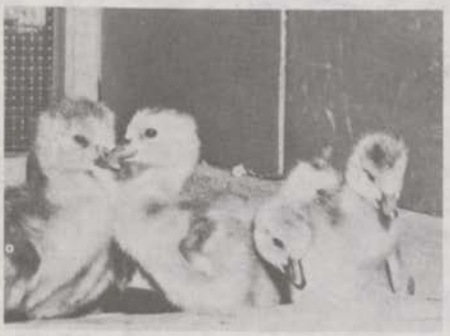
The Tennessee Valley offers a balance of opportunities for scenic enjoyment — the majesty of broad lakes and the unique beauty of isolated stream reaches like the Obed River gorge above.





Land has been provided for upland wildlife.

Goslings hatched to start resident flocks of Canadas.



Giant Canada geese in flight.



FISH AND WILDLIFE

When TVA began work on Norris Dam in the 1930's the native deer were long gone from that area. As land was bought for the project, it was impractical to provide access to the isolated lower end of the peninsula that would be created between the Clinch and Powell River arms of the new lake, so TVA purchased that land. In 1936 its biologists released 17 deer there. The deer propagated, and later TVA transferred this 24,000-acre area to the State of Tennessee, which has developed it as a wildlife management area. It has been managed for upland game — deer, turkey, grouse, and squirrels — and for recreation and timber. With thousands of deer, it has become the deer center of east Tennessee.

To provide suitable areas for waterfowl and wildlife, TVA has made available 190,000 acres of lakeshore land and water to federal and state wildlife agencies. This has provided land for two major national waterfowl refuges and 21 state wildlife management areas. And this total does not include the 170,000-acre Land Between The Lakes, where TVA is conducting a wildlife management program in coordination with state agencies. Together these areas total 360,000 acres — larger than an average-size Valley county.

State and federal agencies have produced impressive results with management programs on the lands TVA has provided. In 1940 a midwinter waterfowl census showed 10,000 ducks and 30 geese along the Tennessee River. Now the annual count amounts to about a quarter-million ducks and tens of thousands of geese, including those on the Lake Barkley shore of Land Between the Lakes. TVA and the Tennessee Game and Fish Commission currently are working to establish year-round flocks of resident Canada geese on lakes and farm ponds in selected Valley counties.

Fifty Times More Fish

When TVA began building dams, man-made lakes were in poor repute as fish producers. The common belief was that they provided abundant fishing for a short time and then became "biological deserts." TVA set up a fact-finding biological organization to make reservoir studies, and at first this group accepted that prevailing theory. A fish hatchery was set up at TVA's first dam project to supply the young fish the man-made lakes supposedly would not be able to produce.

That was not to be a problem, as it turned out. As wild, muddy rivers were transformed into clear lakes producing large amounts of basic fish food, the fish that had done well in the rivers did better in the lakes. Fishing increased 50 to 100-fold.

Research by the TVA biologists showed that only a small proportion of game fish were taken by fishermen in the normal short fishing season. Based on these studies, TVA encouraged the Valley states to eliminate closed fishing seasons on all these lakes, and the policy later was adopted by most other states as well. Even today similar studies show that anglers miss a sizable share of the sport fish on these lakes; most die without ever seeing a fisherman's hook.

TVA has continued its fisheries research, in cooperation with state agencies. Spawning observations led to special water control operations each spring to stabilize lake levels during the spawning period. Waters suitable for trout

have been located and stocked. Preimpoundment surveys by TVA biologists have had a part in establishing game fish populations in new lakes.

Wildlife and Forests

As TVA foresters guide landowners toward better forest management, they can often interest owners in improving wildlife habitat on these lands as well. Timber management and wildlife can be compatible goals in a multiple-use management plan.

One owner, for example, has large land holdings near a city where there are few places to hunt. He is cutting openings in the forest for wildlife food production and nesting places, saving den trees, encouraging berry bushes and vines, protecting stream banks.

Meanwhile TVA has added a new feature to its periodic timber inventories throughout the Valley. At the same time forest productivity is being measured, the land is rated according to its suitability for game animals. Gradually this is building up a store of wildlife habitat information on every one of the Valley's 125 counties, providing a valuable guide for long-range game management planning.

TVA forestry and fisheries research is housed in a laboratory on the Norris Dam reservation. A visitor center there has exhibits describing work in these fields, and the public is welcome.

Fisheries studies carried out at this laboratory include fish identification, food habits of the various fish species, their reproductive processes, and age and growth studies. Here, too, biologists make preliminary determinations on diseases and parasites affecting fish. They study the microscopic plants and animals (plankton) that are vital in the fishes' food chain.

Wildlife in the Valley's Future

In fish and wildlife development, as in other fields, TVA coordinates its activities with those of other agencies and organizations. This means TVA concentrates on the tasks it is in the best position to carry out, or on tasks that will not be done otherwise. TVA engaged Dr. Frederick R. Emerson as a consultant to make a Valley-wide survey of wildlife resources and the growing man-made pressures on their survival, to propose what needs to be done to attain ideal wildlife populations and who should do it.

The result was a challenging and provocative 1968 report, *Tennessee Valley Wildlife: Outlook for Year 2000*. The course it charts is useful to anyone concerned about wildlife — and a paragraph from the report itself expresses the reasons we should all be concerned:

> **Wildlife and what becomes of it is inextricably tied to a host of other factors — size of human population, environmental quality, land use, extent of industrialization, development and use of outdoor recreation resources, standards of human life. What happens with these has infinitely greater impact on wildlife than the usual efforts aimed specifically at wildlife. Six million American women currently swallowing "The Pill" are unknowingly doing more potential good for wildlife than the efforts of all professional wildlife workers combined. Conversely, polluters of environment are doing more harm to wildlife than legions of wildlife workers can hope to set right. To talk about wildlife, therefore, is to talk about nearly everything else too.**



A good catch on Apalachia Lake.

Biologists "planting" trout eggs.



TVA's Forestry and Fisheries Laboratory.





Mosquito research.



Watermilfoil.

RESERVOIR ECOLOGY

The title of this chapter may reflect, in a subtle way, man's increased concern for his effects on his surroundings. "Ecology" means the whole pattern of relationships among living things and their environment — an intricate web where pulling one thread can dislocate many others. It is a word that has come into common use (and misuse) today as more people seek to learn about their environment.

When a river is turned into a lake, ripples of change spread among living and growing things. To deal with these changes, TVA maintains a staff of ecological scientists at Muscle Shoals, Alabama. They are supported by specially equipped laboratories where experiments and studies related to water and air quality are carried out.

One of the first environmental challenges that faced TVA involved malaria — the mosquito-borne disease that affected a third of the population near some of the swampy areas along the original Tennessee River. Malaria, which drains the energy of its victims and sometimes kills them, was a major barrier to development of the South's human resource. When TVA began building dams on the Tennessee, there was concern that the new lakes would mean more mosquito breeding habitat and more malaria.

TVA did not accept this as inevitable. Instead it organized a cooperative program with state health agencies to suppress the malaria mosquito, educate the public about the disease, and promote protective measures and treatment. Malaria not only failed to increase, it began to decline and finally vanished. A few years later, the disease all but disappeared from the rest of the South.

TVA continues a program of mosquito control research and operations to suppress mosquito species that are merely unwelcome pests as well as those that carry disease. The emphasis is on natural control methods — eliminating breeding spots by preparing shorelines before new reservoirs fill, removing water from low areas, mowing shoreline vegetation, and fluctuating lake levels in a way that interferes with mosquito habitats. In areas where chemical control is needed in addition to these naturalistic methods, TVA uses a degradable (short-lived) larvicide that has no detectable side effects on fish and wildlife. It is applied at a rate of only $\frac{1}{250}$th of a pound per acre.

Mosquito research has led to some unusual experiments, including planting water-tolerant cypress trees along shorelines to create a habitat unfavorable to the malaria mosquito.

An Unwelcome Import

The growth of a pest problem from the careless introduction of a foreign animal, insect, or plant is an old story to biologists.

Eurasian watermilfoil is a lacy water plant sometimes used to adorn fishbowls or aquariums. In larger bodies of water, it is not so ornamental. There is can spread quickly through shallow water, forming dense mats at the surface, blocking small boats and swimmers, clogging water intakes, and creating ideal habitats for mosquito breeding. Each fragment that breaks off a watermilfoil plant has the potential to take root and establish a new colony.

In the Tennessee Valley, watermilfoil first became established on one of TVA's mainstream lakes in the late 1950's — perhaps dumped from a fishbowl. Very quickly it became the most serious water weed problem confronting TVA ecologists. A variety of chemical and naturalistic control measures have been tried on watermilfoil. But no method has yet been able to eliminate this weed completely, and each surviving plant is a source of reinfestation. Water level management and applications of 2,4-D herbicide remain the most effective control measures. TVA continues to seek a more effective answer, testing new control methods, conducting research, and supporting further studies at two universities. Meanwhile it is working to keep the weed from spreading further.



CLEAN AIR TO BREATHE

What city has the most electrically-heated homes among all the cities of the world? New York? London? Tokyo? Los Angeles? None of them or others of the very largest cities. It is Nashville, Tenn., with a population of 170,000.

Twenty-two years ago Nashville had only 29 electrically-heated homes. Today it has 75,000. The reason: low-cost electricity supplied wholesale by the Tennessee Valley Authority and promoted vigorously by the city's distribution system. No smoke. No soot. No residues.

—St. Louis Post Dispatch, 1969

The Tennessee Valley traditionally used soft coal for heating. In the oldest districts of Nashville or Chattanooga or Knoxville, on a winter morning, coal smoke still rises from some chimneys. But there are no lines of smoke where newer homes have been built. Most new homes in this region are heated by electricity, which costs about a penny a kilowatt-hour for this purpose.

The Tennessee Valley is the national center for electric heating. As more new houses have been built, the total of electrically-heated homes has climbed to about a third of all the homes in the region. Office buildings, schools, public housing are turning to electric heat as well. Coal smoke, a major element in the pollution breathed by city-dwellers, is gradually being reduced.

The heat still comes ultimately from coal, in large part, but from coal burned in generating stations built outside urban areas, in highly efficient boilers where soot is eliminated and ash particles can be trapped by collecting equipment.

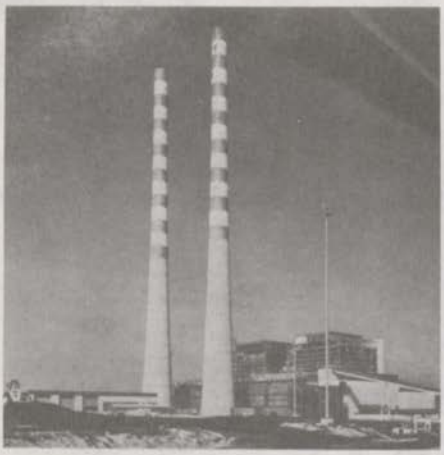
TVA emphasizes control of pollution from its own operations, but it is also concerned with the conservation of air quality throughout the Tennessee Valley, and cooperates with other agencies in air pollution control and research programs. Under a policy adopted in recent years, new industries locating on waterfront sites involving TVA land rights must agree to provide effective air pollution controls.

Air Quality at Power Plants

When the power requirements of this region began to outgrow the waterpower potential of its rivers, TVA started building large coal-fired power plants to meet this need. In 1950, before the first of these large steam-electric plants began operation, TVA started a program of air quality studies and control that became one of the most comprehensive efforts of its kind anywhere. Its air quality control staff pioneered in adapting monitoring systems and special field study techniques to implement this work. Findings from this program have been published and have been widely used in predicting and minimizing the effects of power plants on air quality. In recent years TVA has made increasing use of this experience in assisting local, state and Federal agencies in air quality control programs in the Tennessee Valley states.

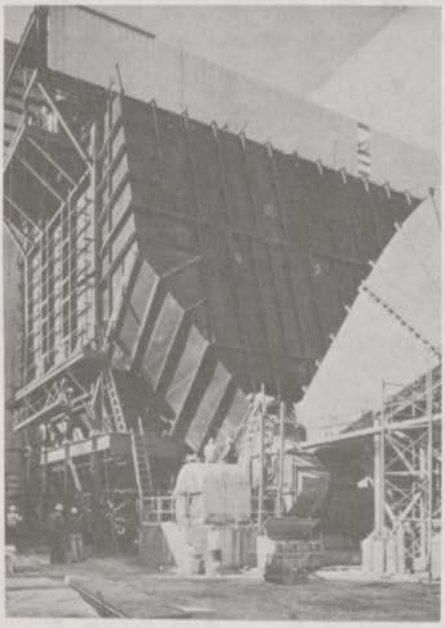
One result of these studies has been the use of tall stacks at power plants to reduce ground-level concentrations of furnace gases and ash particles. At TVA stream plants built in the past ten years, the heights of these towering chimneys range from 500 feet — about as tall as the Washington monument — to the 1,000-foot stacks at Cumberland Steam Plant.

Early TVA steam plants were equipped with mechanical ash collectors to remove 60 to 80 percent of the dust-like fly ash particles that form the visible smoke from plant stacks. In 1959, before Federal or state air pollution standards had been developed for power plants, TVA began equipping its new plants with electrostatic precipitators designed for 98 to 99 percent efficiency in ash removal. In 1966 a program was started to add precipitators to older power plants — 63 generating units were to be equipped by 1975. This program was well advanced by 1972 when the states established very strict new standards for fly ash control, and TVA began a $270,000,000 program to expand and improve these control systems so the new standards will be met at all plants.



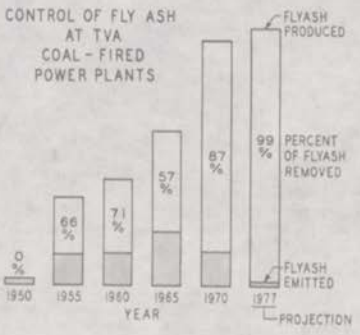
1000-foot-tall stacks at Cumberland Steam Plant.

TVA is installing giant fly ash collectors.



TVA also is finding ways to guard against effects of sulfur dioxide, a gas produced when coal containing sulfur is burned in power plant boilers. Recent federal and state standards, designed to protect human health and vegetation from any harmful effects of sulfur dioxide, specify the safe ground-level or "ambient" concentrations that can be allowed. TVA experiments have demonstrated a method that can meet these ambient standards reliably, economically, and without delay. It uses a combination of tall stacks to disperse the sulfur dioxide under normal conditions, and reducing power generation as necessary to avoid unacceptable ambient concentrations during the occasional periods of unusual weather conditions that interfere with normal dispersion of sulfur dioxide from the stacks. This approach has worked successfully at one TVA power plant since 1969, and is being adopted at other plants wherever necessary to meet the ambient standards.

For future coal-burning plants, the goal is to reduce the amounts of sulfur dioxide coming from plant stacks — and this is likely to be much more difficult. The chemistry involved in removing sulfur dioxide from stack gas is well developed, but engineering problems must be



solved before these processes come into widespread commercial use. Otherwise power systems could be in the position of committing very large investments (out of consumers' future electric bills) to build unproven and possibly unreliable facilities. Strenuous efforts to overcome these technical obstacles are under way by TVA and many other organizations involved in power production or pollution control.

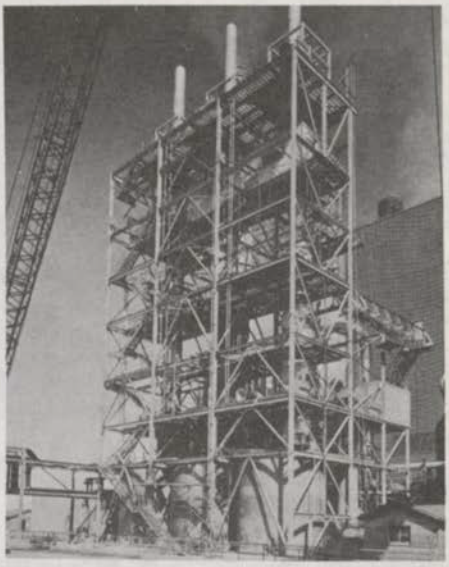
Another approach is to use low-sulfur fuel, but large amounts of coal with very low sulfur content are available only in the Western states. If that becomes the chief answer to sulfur dioxide control, it will mean paying heavy transportation costs (larger than the cost of the coal itself) and major disruptions of the existing coal industry. There are also severe problems involved in trying to burn low-sulfur Western coal at plants where neither the boilers nor the fly-ash control facilities were designed to handle it.

In years to come, new technology may allow us to turn contaminants from the furnaces of fuel-burning power plants into raw material for adjacent fertilizer factories.

The unique combination of electric power and chemical engineering expertise in the TVA resource development program has given it a natural role in the present worldwide effort to develop effective ways of limiting sulfur dioxide emissions from power plants — and if possible to recover potentially valuable sulfur compounds in the process. TVA is now conducting studies in cooperation with the Environmental Protection Agency to compare the feasibility of various processes of sulfur oxide removal. Included is a full-scale test of one control method at one TVA steam plant. At another of its plants a more advanced process is being tested on small-scale equipment to get information needed in planning full-scale installations, and in evaluating methods of recovering sulfur products. All of these projects rely heavily on studies by scientists and chemical engineers at the TVA National Fertilizer Development Center at Muscle Shoals, who have had long experience in some of the technology these processes require, and on work by its power plant design and operating staffs and air pollution control specialists.

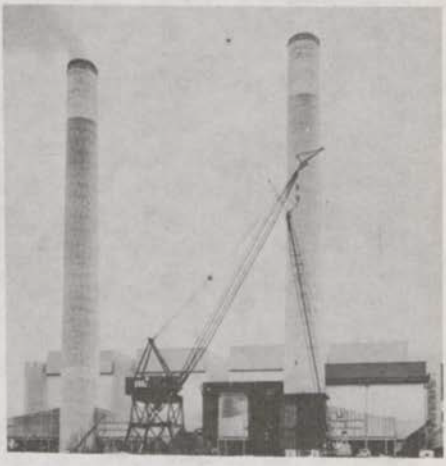
To demonstrate sulfur dioxide removal on a large scale, TVA is installing an experimental wet scrubber facility, expected to cost $42 million, on a giant 550,000-kilowatt generating unit at Widows Creek Steam Plant.

Another approach is to clean the sulfur from the coal before it is burned. Conversion of coal to a clean gas or liquid fuel is under intense study. The Electric Power Research Institute is funding a TVA design and cost study of one process for producing a clean gas from coal; this will permit a direct cost comparison between this approach and the use of scrubbing methods to clean stack gas after the coal is burned. If results of this and other current studies are promising, a TVA test program on the fixed-bed gasification process could begin in 1974. In addition to its own efforts TVA is participating as an associate member of a Westinghouse-led industrial team working on a more advanced type of coal gasification. Also, as a member of the Electric Power Research Institute, TVA will help support a wide range of research and development projects in this field.



Part of TVA's effort to help develop workable controls for sulfur dioxide emissions at power plants is this $8 million cooperative project at Shawnee Steam Plant to test equipment that "scrubs" sulfur dioxide from furnace gases.

Fly ash control at John Sevier Steam Plant: two units operating without controls on left chimney, and one operating with new electrostatic collector on right chimney.



54-380 O - 75 - pt. 2 - 29



A modern industrial facility need not be unsightly to serve its purpose, but instead can fit attractively into its setting. This is Bull Run Steam Plant.

The practice of putting neighborhood power distribution lines underground is becoming increasingly common in new residential areas.



AESTHETIC VALUES

In 1940 the Museum of Modern Art in New York City presented a photographic exhibit of TVA projects, reflecting the high standards set by the agency's early architects and engineers in designing these structures. As new steam plants became part of the TVA power system, it again tried to set high standards — not only in plant design but in the maintenance necessary to keep a plant clean and orderly even while it burns thousands of tons of coal a day.

From the start TVA has believed that modern industrial architecture need not be unsightly to serve its purpose, and it has received repeated recognition through the years for its "total environment" design of projects. This concept seeks to provide installations that will not only please the eye but also offer safe, efficient, and pleasant working environments. It involves care in preserving attractive natural features of project sites, and in providing pleasing landscaped settings. It emphasizes good design as an integral part of the building structure, not an added facade.

Part of the philosophy behind this approach is a continuing idea: the dams and steam plants built by TVA belong to the people, and they should be attractive places for the public to visit. This was a step away from the old view that industrial installations were only a place to turn out a product. Today, more and more progressive industries have adopted the "total environment" design concept.

Putting Power Lines Underground

One of the most striking trends today in electric power is the development of more attractive facilities for distributing electricity to the consumer. Among the local electric systems that distribute TVA power, and across the nation, there is a rapidly spreading use of new materials and methods to blend distribution lines more suitably with the setting, to put them underground, and to screen transformers and small substations from view.

Underground distribution facilities are being installed extensively in many areas of the Tennessee Valley. TVA has actively encouraged this means of serving new customers.

Replacing the vast networks of existing overhead distribution lines in this country will take much longer, but it will ultimately be accomplished. It may even be feasible someday to place underground the high-voltage transmission lines that carry bulk power supplies long distances between power plants and cities. This involves much more difficult technical problems than underground lines at lower voltages, but research is being pushed in this field too. TVA is supporting a national Electric Research Council study on underground power transmission at extremely low temperatures, one possible way of breaking through the technical barriers. By the 1980's this technique may be used to bring bulk power supplies into congested urban areas.

Meanwhile development of extra-high-voltage transmission facilities is helping to limit the proliferation of lines that would be necessary otherwise as power demands grow. It would take ten or more lines of the highest voltage formerly used on the TVA system to carry as much power as one of the 500,000-volt lines built on this system in recent years.

PLANNING AND THE ENVIRONMENT

The 11,000 miles of shoreland along TVA lakes represent an important resource for the Tennessee Valley. Large sections of this shoreland have been set aside for wildlife management, or placed in national forest and park areas. Other portions of the shore have proved to be uniquely suited for various types of recreation, for scenic homesites, or to fit the needs of specific industries.

Like some other resources, these shorelands once seemed almost limitless. But we have learned to plan their use more carefully as pressures have grown from the many competing uses for waterfront sites. In 1938 TVA began working with state agencies to help communities along its new lakes meet and take advantage of the new conditions the lakes created. This provided the initial impetus for the planning help these states offer to local communities today, and for the widespread local planning programs that resulted.

Where TVA has built dams in recent years it has joined with local and state planning agencies from the start of each project, to relate the proposal to existing area and community plans and to study in detail all the factors that can determine the best use of each section of shoreland. A land use concept for the entire shoreline is developed even before the lake fills, as a guideline for future uses. A process is established for the cooperating agencies to fit these plans to new needs as they emerge. This kind of planning can have an important role in determining the kind of environment that results.

Staying Out of Nature's Path

Since the 1930's, great engineering projects have been built across the United States to help protect sections of cities and towns that had grown up on lands vulnerable to floods. These dams and levees and channel improvements have been of vast help in reducing flood losses — but meanwhile it makes little sense to continue building homes and industries in areas that are still subject to flooding.

In the 1950's TVA began a program to help local communities guide new development away from flood danger zones. Based on this experience, it helped prepare a landmark report to Congress in 1966 proposing a "Unified National Program for Managing Flood Losses," which has led to increasing emphasis across the country on keeping development out of the water's way. *From Sea to Shining Sea*, a 1968 report on the American environment by the President's Council on Recreation and Natural Beauty, explained:

> **The report which the President sent to Congress recommended national application of concepts pioneered in the Tennessee Valley. Under TVA's local flood damage prevention program a community may request TVA to undertake an engineering survey of its flood problems — the frequency of flooding which is likely, the depth and swiftness of flows, the areas of the city which would be affected. With this information, the community may get assistance from its state planning commission on methods of restricting the types and extent of development to be allowed in the flood-vulnerable sections, thus guiding urban growth away from the dangerous lands.**

In the past 20 years more than 150 Tennessee Valley communities have obtained planning and engineering help from TVA under the program of local flood damage reduction described in that report. Some 80 of these communities have followed through with regulations designed to minimize future flood damages. These regulations fit into overall community planning.



In Operation Townlift, sketches and models like this one give local people a chance to visualize the improvements that can be made in their communities.

"Operation Townlift"

There has been a great population shift within the Tennessee Valley. In 1940, over 50 percent of the Valley's population lived and worked on farms. The 1970 census shows only 9 percent of the Valley's population are farm families. Many of those who have left the farm have resettled in small and medium-sized communities within the Valley. This is reflected by a population increase of 35 percent during the 1960's in Valley communities in the 10,000 to 50,000 population range.

To help communities improve their economic vitality and attractiveness in the developing Tennessee Valley, TVA inaugurated the Townlift program in 1963. This effort originated in the concern of local leaders about beautification of central business districts that had deteriorated and were not serving the role they once did. It soon became obvious that peeling paint on buildings in these business districts was just a symptom of wider-reaching community problems. The TVA Townlift program expanded to include a team of planners, economists, engineers, architects, and landscape architects to take a broader view of communities. In addition to helping communities with their downtown areas, the Townlift team now helps with recreation, industrialization, low-income neighborhoods, strip highway commercial areas, and other areas in need of special attention.

Townlift community planners are available to work with local officials, community planning commissioners, and civic leaders in identifying problems and deciding courses of action. Economists contribute by making special studies of specific areas of a community's economy. The engineers assist in testing the feasibility of development or redevelopment proposals. Architects and landscape architects help by preparing materials that give local people a vision of what might be accomplished.

After the Townlift team provides a community with an analysis and a suggested remedy for their problem area, it is up to the local people to take action. If they catch the vision, they will see that Operation Townlift involves creating a better living environment. TVA has given Operation Townlift help to approximately 125 communities to date and is presently working in thirty others.

New Town Prospects

Many of the environmental problems of our cities and towns are difficult to solve once they have been created —air and water pollution, lack of enough open space, crowded neighborhoods and buildings, narrow streets, inadequate parking, inadequate governmental services. There is a growing interest in "new towns," planned in advance to avoid these problems, as one way to provide a more livable environment for man.

Besides providing for a full range of commercial and public services, recreational and cultural opportunities, a "free-standing" new town must develop its own economic base including opportunities for industrial development. Such an opportunity will be provided with the completion of Tellico Reservoir on the Little Tennessee River. In addition to flood control, navigation, power production and recreation, the Tellico project will create an unusual opportunity for development of an industrial complex.

Experience elsewhere on the Tennessee River system has shown that basic industries tend to develop at locations offering a special combination of industrial needs —water, rail, and highway transport; water supply; controlled land base; suitable terrain and foundation conditions. Only a limited number of Tennessee waterfront areas have the potential for this kind of development. Several thousand acres of land on the shores of the Tellico Reservoir have been identified as having the potential for developing into one of these major industrial complexes. TVA and industrial consultants forecast that industrial employment could reach about 6,000 jobs during the first 20 years after the reservoir is completed, along with 16,000 recreation, commercial, service and other jobs. These new employment opportunities will have a significant impact on a rural area which has experienced economic lag and loss of its young people to jobs elsewhere.

Joint public and private planning is under way for a new community on the future shores of Tellico Lake. This TVA model shows a possible layout for the new town of Timberlake.



When the project began, local officials and citizens of the three counties directly affected by the project began working together to ensure that development of the reservoir shoreland would make the maximum contribution to the economy of their region. To accomplish their purpose, they formed the Tellico Area Planning Council. Working with the Tennessee State Planning Office, the East Tennessee Development District, and TVA, the Tellico Area Planning Council helped determine the most appropriate uses of reservoir-related lands. Consequently they recommended to TVA that a "model new community of national significance" be developed to accommodate part of the Tellico-related growth. Based on studies by TVA and consultants in private industry, a new community to be called Timberlake has been proposed for the purpose of organizing Tellico growth and to help achieve a high-quality living environment.

Timberlake residents would include people employed in the larger surrounding urban areas as well as many of those employed in the approximately 16,000 manufacturing, recreation and service jobs projected for the 20-year development period. Timberlake is expected to have a population of approximately 30,000 people by 1995.

Timberlake will not only provide a high quality of life for its residents but will also include several features that will serve as national demonstrations. One will be the use of the new community as a stimulus and focus for regional development. New employment opportunities will be provided for the residents of the surrounding area, as well as an improved level of public services and facilities. Another unusual aspect of Timberlake is the development of the new community through the cooperative effort of both public and private sectors, including a major role for public agencies in conceptual planning and setting standards. Private developers will have the primary role in the physical development of the new town (other than the basic public facilities).

Environmental control and the use of technological innovations will be another important feature of Timberlake. This will include high standards of air and water quality, and an environmental monitoring system that will provide an opportunity to study both the physical and socio-economic changes resulting from the transition of the area from rural to urban.

TVA's planning experience has been called upon to assist groups interested in looking at the potential for new community development. Currently its planners are working on new community concepts for an area in the Elk River Valley and on a rural community in Morgan County, Alabama. New town planning is not new to TVA. A well-known planned community of the 1930's was Norris, Tennessee, an earlier demonstration project built by TVA as a construction village for the Norris Dam project. It was later sold to private owners and today serves as a permanent residential community with a population of about 1,400 persons. Although it involved limited objectives, Norris in its time was a model new town and demonstrated ideas that have been adopted elsewhere.

THE GROWING REFUSE PROBLEM

Across America, cities and towns are increasingly hard-pressed to find acceptable disposal methods and sites for the growing volume of solid wastes produced by an affluent society. Rural areas, most of them lacking even refuse collection service, are having more and more roadside locations despoiled by trash dumping.

To help solve these problems, TVA is working with several dozen local governments and organizations across the Tennessee Valley to aid in planning refuse collection programs for rural areas. Judging from the current upswell of interest, the Seventies may bring for the first time a real change in the long-established practice of random trash dumping in areas where other methods of waste disposal have not been available.

TVA also is leading, in the Tennessee Valley, the national "Johnny Horizon '76" environmental campaign of the Department of the Interior. Civic organizations, business and industry, schools and individuals across the Valley are conducting cleanup projects as part of this program.

In cooperation with the U. S. Public Health Service, TVA built and operated an experimental plant at Johnson City, Tennessee, to compost the city's garbage and sewage sludge into a soil conditioning product. TVA agricultural specialists have tested the compost product in a variety of uses — lawns and crops, erosion control, reforestation, and strip mine reclamation. The relatively high cost of composting makes it unlikely to come into widespread use for municipal waste disposal in the near future, but eventually it may help answer the problem in areas where other waste disposal methods are no longer acceptable. This experimental project and others have helped provide valuable knowledge about both the potential and the limitations of the composting approach.

Recovering resources from city trash, either by recycling materials or by burning combustible wastes as fuel, is becoming more economically feasible as sites for landfill disposal grow scarce. TVA is participating in several studies of these recovery methods.

A three-year-old TVA junk car collection demonstration program has led to the recycling of more than 25,000 abandoned vehicles that once marred the Valley landscape. This program received the 1972 "Keep America Beautiful" regional award and has attracted national attention. TVA has received more than 1,100 inquiries from organizations in all 50 states (and abroad) interested in establishing similar junk car collection programs.

The principal problem in setting up an auto recycling operation is to bring together abandoned vehicles from many scattered locations so that commercial salvage becomes practical. The TVA program shows local governments how they can economically carry out this key operation. TVA loans special collection vehicles to local governments for two to four months to get these programs under way. It has also developed plans which are used by local agencies to build their own collection vehicles at low cost. TVA has issued a booklet giving a step-by-step procedure for establishing an effective local junk car recycling project.



TVA agronomists have carried out extensive tests of this soil conditioner made by composting city garbage.



Roadside refuse and open garbage dumps are being attacked with TVA assistance to local governments in establishing modern sanitary landfills and county-wide waste collection systems.

A TVA demonstration designed to rid the countryside of junked cars is attracting national attention. More than 1,100 inquiries concerning the program have been answered.





keeps milk cool



keeps people warm



untangles traffic



and air traffic



pumps gasoline

creates jobs



Electricity:

powers waste treatment



cleans smoke



saves steps



saves lives



POWER SUPPLY AND THE ENVIRONMENT

At 3:30 p.m. on August 9, 1972, a bolt of lightning caused a key piece of equipment to explode in the switchyard of one of the country's largest power plants, the Widows Creek Steam Plant in northeast Alabama. Nearly a million kilowatts of power flowing into the TVA system from this plant was cut off — an amount equal to the average power requirements of a million typical U. S. homes. Power supplies across a wide area could have been disrupted. Instead, automatic equipment switched this massive power load almost instantaneously to reserve sources which were available on this and neighboring power systems, so electric service was not interrupted.

Electricity is a unique product. Almost any other product can be stockpiled in some way for use when demand is greatest. But an electric system must be able to produce — at any given moment — enough power to supply every use of electricity at that time by nearly every consumer connected to that system (there are a few specialized exceptions). If it does not, somewhere the system breaks down and the power goes off.

Most of us take it for granted, when we flip the light switch on the wall, that the electricity will be there. Behind that simple assumption is a complex job for power suppliers in anticipating the level of power demands years in advance, planning and building the facilities to supply those demands, and operating them in a way that will avoid or localize any interruption in electric service.

Today that basic objective — providing a reliable electric power supply for whatever use the consumer may have — is being challenged. The reason, ironically, is our society's spectacular success in making electricity useful. Instead of growing in a straight line, this county's use of electricity has been doubling about every ten years. It is expected to double again in the 1970's. If demands continued to multiply at that rate, the national electric utility industry would have to produce eight times as much electricity in the year 2000 as it did in 1970. (Instead, the growth pattern is expected to slow considerably before that time, for reasons outlined later.)

The Benefits from Growth —

This growing use of electricity has had an enormous impact on life in America. Electricity has made it possible for more homes to have water from a faucet instead of from a hand pump, indoor plumbing instead of a fly-ridden privy. It has meant that food which once would have spoiled can be kept fresh in a refrigerator or freezer. It has meant more work accomplished with less drudgery, from factories to farming to the housewife's laundry. Electricity provides a thousand tools for jobs that need to be done — traffic lights, radar, educational television, pollution control, sophisticated medical equipment.

We have been able to make electricity useful in so many ways because its cost is low. And in turn the growing use over the past several decades made electricity more economical because of the savings obtained through large-scale production and distribution of power. In 1930 the U. S. average rate for electricity used in homes was 6 cents a kilowatt-hour, and use was limited. By the 1960's that average had dropped to about 2 cents a kilowatt-hour nationally, and 1 cent in the Tennessee Valley. Although rising power system costs have now reversed that long-time downward trend, electricity would cost much more today if use had not grown to its present levels.

— and the Problems

Growing power consumption has brought problems as well as benefits. Pollution control measures that were adequate for power plants built in the past are not enough to meet today's stricter environment protection standards. Far more expensive and technically difficult measures are being undertaken today in attempting to meet these standards.

Growing consumption presents problems with fuel supplies as well. The major source of basic energy today is the reserve of fossil fuels — coal, oil, natural gas — deposited in the earth over a 300-million-year span of prehistoric time. But we have been consuming larger amounts of these fuel reserves each year, not only in electric power plants but in automobiles and trucks, in heating systems for buildings, in industrial furnaces and boilers. There are still enough undeveloped reserves of these fuels that we are not going to run out in the immediate future. But it is clearly possible that within the lifetimes of people being born today — and buildings being built today — natural gas reserves will be used up and oil could become prohibitively expensive for many uses.

The present petroleum crisis, following the cutoff of some Middle East supplies, is an early and perhaps temporary warning of the basic long-range problems involved in meeting the demand for oil. Natural gas supplies already are difficult to obtain for industrial uses, including power generation. We probably have enough coal to last for several more centuries, but the environmental problems involved in mining and burning coal are raising serious problems for power systems that try to rely on coal for fuel. Sharp cost increases for these fuels have already occurred, and are likely to continue in the future. Because of these problems, the electric power industry expects to use nuclear plants for much of the additional power supplies that will be needed to meet the growing use of electricity in coming years.

The picture is much the same in the Tennessee Valley region. The dams built by TVA in the 1930's and 1940's provided most of the region's supply of electricity at that time. Unlike fuels, waterpower is a constantly renewed energy source that will remain available so long as rains fall and rivers flow. About 20 years ago, however, the region's use of electricity outgrew the amount of hydroelectric power that could be developed at available damsites. To meet this growing demand TVA turned to coal, the fuel most readily available in this part of the country (in terms of fuel resources, power plants can utilize a low grade of coal that has little value for other purposes).

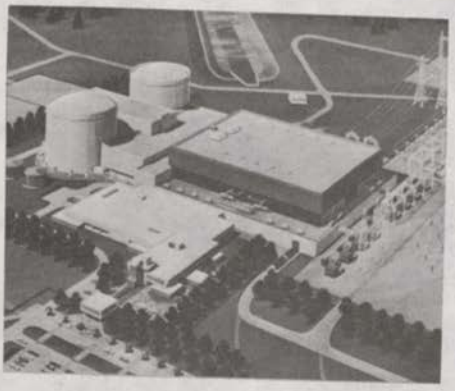
Generating capacity on the TVA system grew from about 3 million kilowatts in 1951 to more than 22 million in 1973, with 11 large coal-burning plants providing most of that increase. Today TVA is building a series of nuclear power plants to meet most of the additional power requirements projected for the region over the next ten years.

Three nuclear plants are now under construction and more are being planned. Although these plants will qualify as "heavy industry" in terms of size, their impact on the environment will be a different story. A nuclear plant can be designed to fit attractively into its setting. It requires no coal-handling facilities with accompanying dust and noise, no coal stockpile. It does not emit smoke or ash from stacks.

These nuclear plants generate power in basically the same way as other steam-electric plants, except that the heat to produce steam comes from a nuclear reactor rather than from a furnace burning coal or other fossil fuel. Because radioactive materials are involved, stringent safeguards are enforced throughout the design, construction, and operation of nuclear power plants. The extra safety precautions that are taken for these plants are to guard against any harmful release of radioactivity. These include engineered safeguards against natural disasters, accidents, and any type of equipment malfunction that might occur. Before construction of nuclear reactors can begin, plans are subjected to review on every significant detail that could affect safety, public health, or the environment. On current nuclear power plants this planning and review process typically requires more than two years before a construction license is issued. Then thorough review and inspection continue throughout construction before the plant can be licensed for operation.

Extensive controls and waste treatment methods have been developed that will reduce radiation exposure to the public from the operation of these plants to extremely low levels — much smaller than that due to naturally occurring background radiation to which everyone is exposed constantly. An environmental radiation monitoring program is started around a nuclear facility two years before nuclear fuel is received. Soil, air, vegetation, water, milk, and aquatic life are analyzed on a frequent schedule to determine normal background radiation levels in the area surrounding the plant site, out to a radius of as much as 50 miles. These measurements enable health physicists to compare levels measured before and after plant startup and to make a continuing check on the effectiveness of plant controls.

Nuclear power plants will provide most of the additional power supply needed during the 1970's in the TVA area. This is Sequoyah Nuclear Plant, now under construction north of Chattanooga.



The Breeder Reactor

A search is on for new technology that could expand our energy resources in the future. TVA has a major role in that search. The method that appears closest to practical development is the breeder reactor, which can produce more nuclear fuel than it consumes.

This strange-sounding accomplishment is possible because of the composition of natural uranium. The type of reactor used in most of today's nuclear power plants depends on atomic fission of the uranium isotope U-235. But U-235 makes up only a tiny fraction (less than one percent) of natural uranium. Most of it is the isotope U-238, which is essentially unusable in these reactors. This means our reserves of uranium ore — at least those that can be readily and economically developed — might be used up within a few decades to provide enough U-235 for this type of reactor.

But the fast breeder reactor offers a way to put the much more abundant U-238 to work as well. The breeder can operate on another kind of nuclear fuel, plutonium, and at the same time turn U-238 into more plutonium. The breeder will use two byproducts of present technology, byproduct plutonium created in today's reactors and surplus U-238 from the enrichment process used to concentrate uranium for present-day fuel. So today's light water reactor and tomorrow's breeder form a natural team that could extend nuclear fuel supplies for centuries to come.

The fast breeder is not a new idea. In fact, the concept was demonstrated more than 20 years ago in the EBR-I reactor in Idaho, which provided mankind's first experimental small-scale generation of power from the atom. Breeder research and development have been under way since, and prototype plants are being built in several countries.

The next step for the United States is to build a full-scale demonstration power plant. A project to build this plant on the TVA power system has been organized by TVA and the Commonwealth Edison Company of Chicago, in cooperation with the Atomic Energy Commission and the national electric utility industry. The site is on the Clinch River at Oak Ridge, Tennessee, and the demonstration plant will have a generating capacity of about 400,000 kilowatts. Construction is expected to begin around the end of 1974 and take about five years.

There is general agreement in the electric power industry that progress toward commercially practical breeder power production is vital to help meet the country's future energy needs. The Oak Ridge plant will be designed to help show how a safe, efficient breeder power plant can be developed that is capable of meeting utility system requirements for reliable and economical operation.

The breeder demonstration project also is a major milestone for the national electric power industry in another respect. Electric systems across the country — utility corporations as well as public and cooperative systems — have joined in pledging nearly $250 million of the estimated $700 million cost for this national project. This appears likely to be the forerunner for similar large-scale support for a broad research and development program to help meet both energy resource and environmental protection needs in electric power production.

Other New Energy Sources

Several other developments offer possible future help in meeting the energy squeeze. Although many of the power plants now in use will continue to be part of our power supply for several decades, new methods of producing power may be part of the additional and replacement generating capacity that will be needed in the future. Tests are under way using city trash and garbage as fuel. Ultimately we may harness sunlight, underground geothermal steam, wind, and the power of the tides to produce electricity (each of these methods may be practical only in certain areas of the country). All of these approaches are technically possible; TVA and the national electric power industry are supporting initial development efforts on some of the more promising possibilities.

Coal is such a major part of our energy resources that it must continue to play a role in power generation. Research is under way now on converting coal to a clean-burning gas or liquid that would minimize today's air pollution problems from coal-fired boilers.

More efficient conversion of fuel to electricity is another possibility for extending fuel reserves. Today's large coal-fired power plants already produce twice as much electricity from each ton of coal as the first steam plant on the TVA system, but there is an inherent limit in the efficiency of the steam-turbine system of driving generators. Efforts are under way in several countries to develop magnetohydrodynamic (MHD) generators that would produce electricity directly from hot ionized gases. This might gain 50 percent more electricity than the steam-turbine system from the same amount of fuel.

One ultimate answer to man's need for energy could be hydrogen fusion — the energy source that has powered the sun and the stars for billions of years. While today's nuclear reactors operate by fission (splitting) of complex atomic structures, the fusion plant would operate by combining simple ones such as deuterium and tritium, which are isotopes of hydrogen. And there is enough deuterium in the oceans to give mankind a comfortable energy supply throughout foreseeable time.

Articles in the popular press sometimes create the impression that one or another of these approaches offers an instant solution to the need for more energy. In the real world of technology, however, the new approach that looks successful in small-scale experiments often requires years of development before it is practical for large-scale use. In the late 1940's, for example, power from the atom seemed to be just around the corner. But it is only now beginning to provide a significant part of America's power supply. For fusion power, with all its future promise, the year 2000 is commonly mentioned as the earliest date this energy source might be ready for general use.

Meanwhile the fast breeder reactor offers a new energy source already developed to the point where commercial use may be possible by the mid-1980's. A reliable energy supply is so vital for America's future that it demands a major national commitment to develop this and other potential energy sources.

To help meet this need, the electric power industry has organized the Electric Power Research Institute to provide large-scale financial support for research and development. Under a formula based on power sales by each participating electric system, this program is designed to raise as much as $150 million a year (with full nation-wide participation). James E. Watson of TVA is the current Board Chairman of the Institute.

Conserving Energy

The difficulties involved in meeting America's overall energy needs, and doing it without damaging the environment, are focusing new attention on power demands themselves. Can the growth of power demand be curbed, so that we do not face an eightfold increase between 1970 and the end of the century? Several trends already are pointing to a change — the rising cost of electricity, basic patterns of power consumption, and increasing efforts to conserve all forms of energy. All these factors make it likely that the 10-year-doubling rate of power growth in the past will slow down in the future.

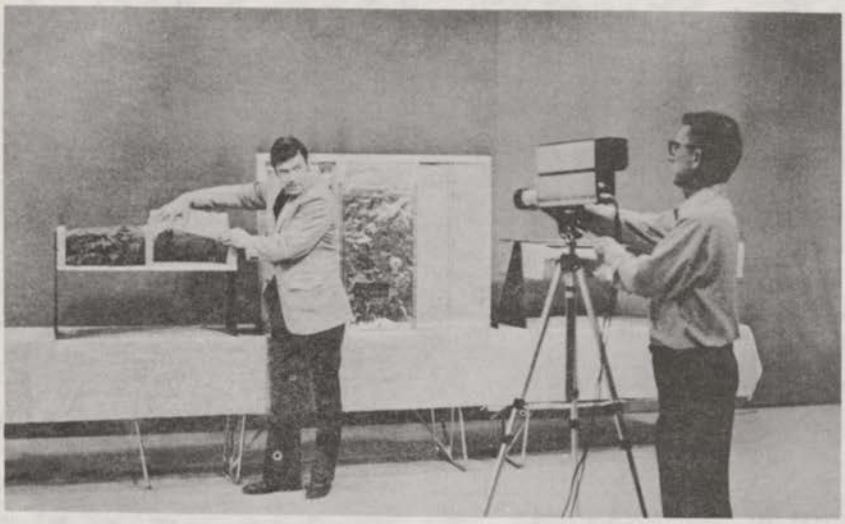
This does not mean we can expect any permanent cutback in power use. More realistically, the savings that are possible in some areas will be more than offset by new power needs in others, and America will have to continue building the power plants to supply these needs. The major emphasis must be on finding ways to incorporate effective environmental protection and efficient use of resources in power production and use.

To get a better look at ways to curb power demand, we need first to clear away a misconception. The proliferation of minor home appliances has created a common impression that "gadgets" are responsible for the growth in power use. But the fact is that the electric carving knife and can opener and toothbrush use almost insignificant amounts of electricity. (The electric shaver uses much less energy than is needed to heat water for a shave with a razor.) Small savings do add up, but an effective home power conservation effort must concentrate on uses that consume the most electricity.

ELECTRICITY REQUIREMENTS FOR HOME USES

(Average annual kilowatt-hours in typical use)

10,000-11,000	Heat pump (heating and cooling)	Under 200	Radiant heater
			Humidifier
			Iron
12,000	Resistance heating		Radio-phonograph
3,000- 4,500	Central air conditioning		Automatic washing machine
	Water heater	Under 100	
			Deep-fat fryer
1,000- 2,000	Food freezer		Hot plate
	Refrigerator-freezer		Radio
	Range		Washing machine
	Lighting	Under 50	
			Circulating fan
500- 1,000	Clothes dryer		Garbage disposer
	Refrigerator		Sandwich grill
	Room air conditioner		Toaster
	Color television		Vacuum cleaner
			Waffle iron
Under 500	Attic fan	Under 20	
	Dehumidifier		Clock
	Dishwasher		Egg cooker
	Furnace fan		Floor polisher
	Oil burner or stoker		Food blender
	Television (black and white)		Food mixer
			Hair dryer
	Water pump		Heat lamp
	Roaster		Sewing machine
			Sun lamp
Under 200	Electric blanket	Under 10	
	Broiler		Heating pad
	Coffee maker		Carving knife
	Window fan		Toothbrush
	Frying pan		Shaver



TVA has prepared a videotaped demonstration on the value of building insulation, to encourage more efficient use of electricity.

Most of the growth in home use of electricity has occurred because an increasing number of families have been able to make use of basic electric appliances such as ranges, water heaters, refrigerators, air conditioners, clothes washers, and dryers.

There are many ways electricity can be used more efficiently to avoid waste. TVA and the local electric systems that distribute TVA power are making a special effort to inform consumers about these opportunities. *(See back cover.)* They also work with builders to encourage proper use of insulation and other steps that can cut power requirements for heating and cooling — uses which offer the biggest chance to save on consumption.

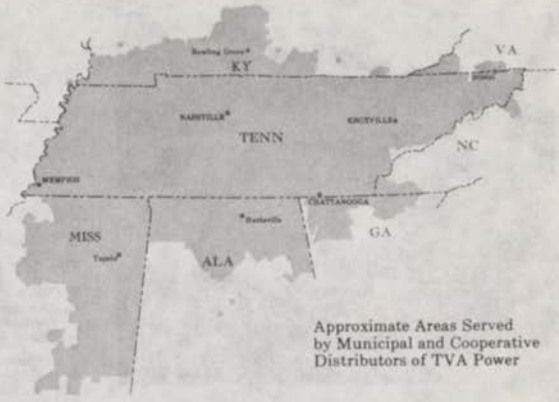
TVA has prepared new insulation standards for commercial buildings as well as homes, for proposed use in building codes throughout the region. TVA and local electric systems also are providing information to help consumers select more efficient air conditioners. Some air conditioning units are only half as efficient as others in their use of electricity.

About a third of the homes in the Tennessee Valley region are heated electrically. For an all-electric home in this region, the electric heat pump — an extremely efficient device that both heats and cools — can save about 7,000 kilowatt-hours of electricity a year compared to other forms of electric heat. And in this region the electric heat pump requires only about 70 percent of the basic energy used by a home gas or oil furnace. Today heat pumps represent only about 5 percent of electric home heating installations in the Tennessee Valley region, so this offers a major opportunity for more efficient use of electricity. However, past experience by some consumers with poor reliability in heat pump installations has created an obstacle to wider public acceptance of this efficient heating and cooling system. To help overcome this problem, TVA and power distributors are establishing a heat pump certification program to identify reliable models and to train local dealer servicemen in proper heat pump installation and maintenance.

More than half the regions' power consumption is in industrial and commercial uses. Power use specialists for TVA and local power systems work throughout the region to help develop energy conservation measures for factories, stores, offices, and institutional buildings.

For example, TVA showed a grocery chain how to recover enough waste heat from refrigeration motors to supply the winter heating requirements of a store until outside temperatures are below 30 degrees. Air conditioning requirements for a garment factory were reduced from 700 to 300 tons after TVA designed individual ventilating systems to remove heat coming from steam pressers. Conservation measures drawn up for a large school building, including correcting improper settings on the ventilation system controls, saved a million kilowatt-hours of electricity a year.

Even before today's stepped-up power conservation campaign, home use of electricity in the Tennessee Valley no longer showed the rapid growth rate of earlier decades. An analysis of the growth in home use over a recent 10-year period on the region's local distribution systems helps to show why. In communities where the level of use had been lowest (under 5,000 kwh a year), it continued to grow rapidly, increasing 100 percent or more over 10 years. But in communities where use already was at fairly high levels (over 12,000 kwh) that



Approximate Areas Served by Municipal and Cooperative Distributors of TVA Power

10-year increase was only 30 to 40 percent. Once a home is equipped with the uses of electricity that require the largest amounts of energy, there is less room for additional rapid growth in that home's power consumption.

This trend, and the new consciousness of power conservation among consumers, suggest that the long-term future growth rate in home power use will be less than the past growth rate. How much less is difficult to predict. That will depend in part on whether new devices come into general use that require significant amounts of electricity — such as the electric car. Most of the new appliances introduced in the past 20 years have not added much to consumption.

Environmental protection programs will increase power requirements. Such devices as wastewater treatment plants, air pollution control facilities, and cooling towers typically have large power demands. In the effort to reduce dependence on the automobile in cities, new public transit systems such as electrified subways and monorails would add significant power requirements. So would recycling of used metals, paper, and other materials, although recycling usually takes less overall energy than making the same product from raw material.

Population growth also will continue to increase the demand for electricity. Although the birth rate in the United States has dropped to about two births per woman — lowest since the 1930's — today's huge generation of young people under age 20 will be growing up, forming households, and having children. This means the population total, and the number of homes, will continue to grow. However, the rapid growth rate in this country's use of electricity has resulted less from population growth than from the increase in average per capita power use overall — in industries as well as in homes.

Electric Rates and Consumption

Charging large power users more for electricity is being suggested by some groups as a way of discouraging consumption. In its simplest form, this argument often assumes that present rate structures are "unfair" because they charge less per kilowatt-hour at high levels of use than at low ones.

However, this idea can overlook the basic fact that power systems face different costs in serving various kinds and levels of use, a difference that is reflected in most rate structures. For example, a large industrial power user may buy electricity for about half as much per kilowatt-hour as a typical home consumer. But the industry buys power in bulk, directly from a high-voltage substation. To serve home consumers, power must be taken from a similar substation and delivered to thousands of homes through a complex series of steps on a local distribution system. In the TVA area, nearly half the average home electric bill goes for this distribution operation — a "delivery charge" that must be added to the basic cost for bulk power supply.

In residential service, higher use per customer means lower operating costs per kilowatt-hour, and this saving is passed on to the consumer. Here are examples of monthly home electric bills in 1973 under a typical retail rate schedule used by distributors of TVA power:

Kilowatt-Hours Consumed	*Charge*	*Cost per kWh*
3,000	*$34.11*	*1.1¢*
1,000	*$14.51*	*1.5¢*
500	*$ 9.61*	*1.9¢*
75 (or less)	*$ 2.50*	*

*The $2.50 minimum bill is based on the minimum cost of making power service available rather than the amount of power used.

Another element of confusion in the argument for changing rates is an assumption that poor families use little electricity, and are penalized by the present rate structure. Actually it is not so much family income



In east Tennessee, one of the region's oldest electric power projects (built before World War I) is being converted to a nature study area. TVA has retired the powerhouse at Nolichucky Dam and is repairing the old dam. A waterfowl sanctuary will be created around the reservoir.

that determines power consumption as the choice between electricity and natural gas (or other fuel) for major uses such as heating, stoves, and water heaters.

A low-income family that uses electricity for these basic purposes has a higher level of power consumption than a more affluent home that does not (even though it may have the whole array of small electric appliances). Changing electric rates simply to penalize consumption can mean arbitrarily charging the first home more than the real cost for its electric service, and charging the second home less than the true cost.

Are present rate trends encouraging unnecessary use of electricity? Take a look. Beginning in the late 1960's, drastic increases in fuel, interest, and other costs for power systems have pushed electric rates upward nationwide. These factors have had a heavy impact on TVA because electric rates in this region had been unusually low. From 1967 to 1973, this rapid rise in costs produced a 62 percent increase in power rates for the region's home consumers and a 48 percent increase for large industrial power users. Further rate increases are likely (barring some dramatic change in cost factors).

These rate increases strike hard at industries in the region that require large amounts of electricity in their operations — several of them with power bills running into the millions of dollars annually. When industries have had to face cost increases on this scale, they already have a strong incentive to use electricity as conservatively as they can.

Adding some type of surcharge on electric bills to discourage consumption may have to be considered as an emergency measure in the energy crisis. But it would be very difficult to apply without creating inequities among various consumers and risking serious effects on economic activity and employment.

The Cost of Environmental Protection

TVA is spending over three million dollars a week on environmental protection programs as more projects are begun to meet new air and water quality standards established by state and federal governments.

Most of this cost involves TVA power funds and must be paid directly or ultimately out of customers' electric bills. As increasing restrictions are placed on activities that affect the environment, the resulting costs are becoming a significant factor in rising electric rates.

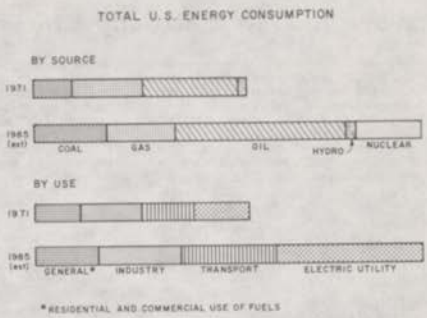
The eventual effect on the consumer can only be estimated, because it will depend on what measures prove to be necessary to meet air and water quality standards (as well as additional restrictions that may be imposed in other areas).

The full impact on costs from environmental standards being adopted today may not be felt for several years, because much of this expense is capital investment financed largely through bonds. In 1972 it was estimated that environmental protection measures then under way or planned on the TVA system eventually would require about $75 million a year in current power revenues. Additional work has been scheduled since then, however, and more extensive steps may be required under a variety of new regulations. TVA estimates that the maximum cost to the region's power consumers could be between $440 million and $830 million a year. (These are very rough estimates because there are still unknowns in the best technology for meeting these standards, and what it will cost.)

This would mean an average cost per family ranging from about $33 a year for the "minimum" actions to as much as $360 a year under the maximum cost estimate. Roughly one-third to one-half of this cost would come directly through home electric bills (now averaging $200 a year) and the rest through the higher cost of goods and services and higher taxes resulting from increased electric rates to business and government.

APPROXIMATE POWER COST IMPACT OF ENVIRONMENTAL PROTECTION ON THE TVA SYSTEM

ENVIRONMENTAL PROBLEM	POSSIBLE ANNUAL COSTS (millions of dollars) MAXIMUM	MINIMUM
STRIP MINE REGULATION	30 - 100	10
IMPROVED MINE SAFETY	30 - 45	15
FLY ASH REMOVAL	35	15
SULFUR DIOXIDE CONTROL	200 - 300	30
SULFUR TAX	40 - 235	-
WASTE HEAT CONTROL	50	5
DELAYS FOR ENVIRONMENTAL REASONS	55 - 65	-
TOTALS	440 - 830	75
UNDERGROUND TRANSMISSION	1,000	-



The Public Interest Versus The Public Interest

The energy question may become one of the more difficult challenges our society has faced, because it involves a fundamental conflict between the public's interest in an improved environment and the public's interest as consumers.

Many people seem to have the impression that environmental problems could be solved easily if industry were just more willing, and less concerned with profit. But the TVA electric power system — operating *without* the profit motive — also faces very difficult decisions about how to protect the environment adequately without creating serious problems for the consumer and the whole economy.

No one wants more strip mine scars, more air pollution. Yet at the same time Americans are still concerned about improved living standards for the poor, full employment for the Nation's work force, advantageous prices and services for the consumer. All of those goals have been served by providing a reliable and economical electric power supply — and all of them could be threatened by arbitrary or careless actions in trying to solve environmental problems facing the electric utility industry.

In early 1972, a strike by British coal miners caused a sharp cutback in that country's electric power supplies. Service to various areas was cut off on a rotating schedule. Within weeks, British industry laid off more than 1,500,000 workers, and life was disrupted for the population generally. The same result might be brought about in this country, on a broader scale, simply by adopting tomorrow any one of several major proposals that have been suggested for meeting current issues in the electric power industry — a ban on coal strip mining, immediate limits on power plant stack emissions, or a moratorium on construction of nuclear power plants.

We are seeking other answers to these problems through new technology, but technological advances can be difficult, slow, and expensive. Better pollution controls, more attractive and economical power sources may be just around the corner — or they may be frustrating years away.

Most Americans still have a deep-rooted belief that when there is a challenge to be faced, somehow we will get the job done — whether it is opening a frontier, sending men to the moon, or providing better living standards for the underprivileged. Today there is the same kind of enthusiasm for solving environmental problems. Ironically, these problems exist precisely because the environment was ignored in the past while America took that same single-minded "full speed ahead" approach to other national challenges.

We are on the way to finding answers, but we cannot expect them to come quickly or cheaply. Many of the possible solutions to these environmental problems raise legitimate concerns about technical uncertainties, costs, and risks to reliable power service — concerns that inevitably conflict with our impatience to see these environmental problems solved. Yet these conflicting concerns over environmental needs and power supply are only different facets of the same underlying public interest, and they must be reconciled if the public interest is to be served in the long run.

The basic issues of how much energy our society will use, where we get it, and how we avoid resource depletion and environmental damage are too complex to be considered in terms of a single power plant project or a single power system. They can only be answered with a national policy that considers all of the needs and problems involved, that sets priorities in meeting them.

While electric power supply seems beset with problems today, it is still the key to living standards for future generations. Electricity is not a source of energy in itself, but a versatile way of putting to work the natural energy available in today's fossil fuels, in the nuclear power technology that is just now becoming significant, and in the breeder reactor and other new energy sources for tomorrow. These give electricity the potential for providing more energy in useful form in the future than it does today.

Ways to Use Electricity Efficiently

An adequate wiring system is the first step toward efficient, economical, and safe use of electricity. If your wiring system is not big enough to carry your home's electrical load, operation of your appliances and other electric equipment slows down. This wastes electricity and could damage your appliances and equipment.

Designing an adequate wiring system is no job for an amateur. Deal with a reputable electrical contractor when checking or installing wiring. Or, ask your power distributor to design a complete wiring layout for you at no cost.

ELECTRIC HEATING AND AIR CONDITIONING

The proper installation and operation of equipment can measurably increase the efficiency of electric heating and air conditioning systems.

Insulation: Adequate insulation permits you to keep a comfortable indoor temperature level **economically.** If your home does not have the recommended amount of insulation, additional electricity will be needed to heat or cool it. Heating costs for a fully insulated home can be as much as 55 percent lower than for a home without insulation. Check with your power distributor to determine the amount of insulaton your home needs for operating your heating and cooling systems efficiently.

Install a properly designed duct system for an even distribution of air flow.

Caulk around door and window frames and eaves.

Weatherstrip outside doors.

Have thermostat checked to see that it is operating properly. A faulty thermostat can waste electricity.

Clean air filters frequently. Clogged filters make your system work harder and less efficiently.

Install a moisture barrier on the ground underneath your house.

Choose the correct size of heating and cooling system for your particular home. If it is too big, it is wasteful; if too small, it will not do the job properly.

MORE TIPS ON HEATING

Maintain the proper humidity. The drier the air, the more heat it takes to keep you comfortable. If necessary, install a humidifier to add moisture. You can then reduce your thermostat setting several degrees and still be comfortable.

Use storm windows (or insulating glass panes) and storm doors to reduce heat loss.

Close the fireplace damper to avoid loss of heat.

Use fireplace sparingly for open fires. This wastes heat from your heating system.

Draperies can help to increase your system's heating efficency. Close them at night to keep out cold; open them in the daytime to admit heat from sunlight.

F7419

Set thermostat back a few degrees when you're away for more than a day. **Turn off thermostats in unused rooms,** and close doors to them. **Keep heat leakage into the attic at a minimum** by sealing all openings into it. But, keep outdoor air vents open in the attic to prevent condensation of moisture on insulation or other building materials.

MORE TIPS ON AIR CONDITIONING

Keep return air grill clear. Blocking this grill interferes with air flow, and your system can't operate properly. (This applies to heat pumps year round.)

Close draperies on sunny side of house.

Use a ventilating fan in the attic to lower the cooling requirements of your air conditioning system.

Keep the outdoor section of the system clear of obstructions that interfere with air flow. (Applies to both central air conditioning systems and heat pumps.)

Set the thermostat up (about five degrees) if you are away for a day or more, and set the fan on automatic. Set thermostat to normal on return.

Keep windows and outside doors closed.

Turn off unused lighting. Heat produced by lighting must be removed by your air conditioning system.

MAJOR APPLIANCES

For efficient use of major electric appliances, study the manufacturers' booklets for instructions on their operation. Keep these booklets nearby in a handy spot — and consult them when necessary.

Before calling a repairman, make certain the appliance is plugged in firmly and that the power is on. (Check fuses or circuit breakers.) Then, check to see whether the appliance is turned on properly. You may discover the trouble and prevent a service call.

ELECTRIC WATER HEATER

When you locate your water heater near the spot of greatest hot water use, you save on both the installation and operation. If locations of hot water needs are widely separated, you may find it more economical to install more than one water heater.

Leaky faucets waste both electricity and water. A leak of 60 drops a minute wastes seven gallons of hot water in 24 hours.

ELECTRIC RANGE

Use correct temperatures for each kind of food and cooking process.

Put several foods in the oven at the same time that have compatible temperatures and cooking times. (For best circulation of heat, pans should not touch each other.)

When cooking on the surface units, use utensils with flat bottoms and tight-fitting covers. Select utensils that fit the units as closely as possible. (Pans should never extend more than one inch beyond trim ring of unit.) Bring foods to cooking temperature on high heat, then reduce heat to finish cooking.

Misuse of aluminum foil can reduce the efficiency of your range. If aluminum foil is placed on the oven shelf of the range, it interferes with cooking. (Used in a self-cleaning oven, aluminum foil can damage the oven if left in it during cleaning.)

ELECTRIC REFRIGERATOR-FREEZER

Do defrost (if your model isn't frost-free) at least twice a month.

Clean the condenser (located either at the bottom or rear of refrigerator) at least twice a year, using the nozzle attachment of your vacuum cleaner. (Be sure to unplug refrigerator before cleaning condenser.) Dust on the condenser acts as insulation, making it less efficiept.

If you have a separate freezer, defrost it according to the manufacturer's directions. Frost accumulation reduces operating efficiency.

Do not open the door — or leave it open — more than necessary.

DISHWASHER

Use cycle recommended by manufacturer for the kind of dishes being washed.

For more efficient use of your dishwasher, you may hold small loads of dishes and wash them only when dishwasher is full.

Use only dishwasher detergents. Other cleaning agents can block the washing action, causing overflow. This could damage your dishwasher.

If your dishwasher has a filter screen, clean it as food waste accumulates.

AUTOMATIC WASHER

Wash full loads when possible for extra efficiency. But, do not overload (use manufacturer's directions).

Remove collected lint after each load if lint filter is not self-cleaning.

Make sure washer is level to prevent excessive vibration.

AUTOMATIC DRYER

Clean your dryer's lint filter after each use. Collected lint decreases efficiency.

Do not overdry clothes. Overdrying is wasteful and sets wrinkles in clothes.

Vent your dryer to prevent excess-moisture damage inside the house.

Don't overload your dryer to the point of cutting its efficiency.

Use Electricity Wisely

1974 Directory of TVA Environmental Programs

Air Quality

Energy Conservation

Environmental Education

Health Programs

Natural and Scenic Resources

New Town Planning

Radiological Research

Resource Recovery

Solid Waste Management

Strip Mine Reclamation

Vector and Weed Control

Water Quality

Wildlife and Waterfowl Resources



TENNESSEE VALLEY AUTHORITY
Knoxville, Tennessee 37902
APRIL 1974

F74125

1445

FOREWORD

The 1974 Directory of TVA Environmental Programs is intended as a comprehensive reference source for other agencies and organizations doing related work, for teachers and students, industry, etc. It contains listings of nearly 200 projects or activities the agency is conducting and encompasses environmental programs in the broadest sense.

Items are listed under the name, address and phone number of the TVA office from which further information is available. The index at the front of the directory groups items by categories and subcategories. Each listing gives the project category(s), a brief description and any related reference items.

This directory is available without charge from the

INFORMATION OFFICE
Tennessee Valley Authority
Knoxville, Tennessee 37902

ENVIRONMENTAL CONCERN

Founded upon the concept of unified resource development, TVA from its beginning has been concerned not only with the physical environment, but with the living environment of people unable to earn enough for adequate housing, education, and health care. Today most people are able to have a living standard once enjoyed by only a privileged few. But the economic and industrial growth that made this possible created a new and different set of environmental problems. For the Valley as for the Nation, the challenge now is to provide a clean and livable environment for the future without sacrificing the gain in human living standards so hard-won in the past.

As TVA has moved to help meet the growing environmental challenge both in its regional work and in its own operations, environmental protection has become a central part of its program. TVA conducts experimental and demonstration projects that can help nationally to achieve more effective control of water and air pollution, reclamation of strip mines, and disposal of solid waste.

One measure of this emphasis is the nearly $170 million budgeted for fiscal year 1974 to include the following estimated expenditures:

(a) Pollution control facilities at new plants, $102,138,000. Much of this total is for continuing work on cooling tower systems required to meet state standards for control of heated water discharges at TVA nuclear power plants now under construction.

(b) Pollution control improvements at existing plants, $37,992,000. The bulk of this amount is for continuing work on TVA's $270 million program of air pollution control improvements at coal-burning power plants. Work is under way on major projects to add new electrostatic ash collectors at the John Sevier and Johnsonville plants, at the Kingston plant (including two new 1,000-foot chimneys), and Colbert plant Unit 5. In addition to power facilities, the total also includes $1,407,000 for continuing work on water pollution abatement at the National Fertilizer Development Center.

(c) Power system operating and maintenance costs for existing pollution control facilities, $3,704,000.

(d) Research, development, and demonstration projects, $23,421,000. Over $14 million of this amount is for continuing work on research facilities for control of sulfur dioxide from coal-burning power plants, principally the experimental full-scale limestone wet scrubber system under construction on a large generating unit at Widows Creek Steam Plant. About $4.5 million is for environmental projects financed by the Environmental Protection Agency, including TVA research studies on sulfur dioxide control and the biothermal research facility TVA is building at Browns Ferry Nuclear Plant to learn more about water temperature effects on aquatic life. Another $4.5 million (including equipment costs) is for a variety of TVA research and demonstration projects involving many aspects of air and water quality, solid waste disposal, and environmental improvements in electric power operations.

1446

(e) Monitoring and surveillance of pollution sources, $2,379,000. Part of this is for TVA's regional programs of air and water quality monitoring and research, part for monitoring at its own power facilities.

(f) Technical support by TVA specialists for state, local, and interstate pollution control agencies, primarily for water quality planning and disposal of solid wastes, $259,000.

ENVIRONMENTAL STATEMENTS

A detailed environmental statement is prepared on each TVA project or activity which is deemed to have a significant effect on the environment. Each statement covers alternatives to the proposed project; its effects on land, air, and water environments; socio-economic effects; and the adversities and benefits involved in the construction and/or operation of the project.

The following environmental statements are available from the TVA Information Office as of April 1974:

Allen Gas Turbine Plant, Units 1-16 (10-29-71)
Allen Gas Turbine Plant, Units 17-20 (3-31-72)
Bear Creek Project (12-29-72)
Bellefonte Nuclear Plant (3-6-73)*
Brainerd Area Flood Relief Plan (12-10-73)*
Briceville Flood Relief Project (3-16-73)*
Browns Ferry Nuclear Plant (9-1-72)
Coal--Policies Relating to Sources of Coal for TVA Plants (12-6-71)
Colbert Gas Turbine Plant, Units 1-8 (3-31-72)
Control of Eurasian Watermilfoil in TVA Reservoirs (9-29-72)
Duck River Project (4-28-72) and supplement (4-18-74)
Elkmont Rural Village (3-26-74)*
Nolichucky Project Rehabilitation (3-10-72)
Pickwick Landing Dam--New Lock (9-13-72)
Sequoyah Nuclear Plant (2-13-74)
Shelby 500-Kv Substation (9-22-71)
Tellico Project (2-10-72)
Vector Control Program (4-10-74)
Watts Bar Nuclear Plant (11-19-72)
Widows Creek Steam Plant--Experimental SO_2 Removal System and Waste Disposal Pond (1-15-73)
Yellow Creek Port Project (11-30-71)

*Draft statement (final not yet completed)

54-380 O - 75 - pt. 2 - 30

1447

1974 DIRECTORY OF ENVIRONMENTAL PROGRAMS INDEX

-A-

Aesthetic Resources
- Ecosystems survey and analyses . . . 27
- Improvement of Forest, Wild Land and Waterways . . . 21
- Landscape Treatment . . . 55
- Strip mine reclamation . . . 30

Agricultural Covers
- Effects on hydrology . . . 36

Air Quality
- ASTM evaluation methods . . . 5
- Atmospheric dispersions . . . 3
- Coal gasification . . . 52
- Cooling tower plume behavior . . . 4
- Electrostatic precipitators
  - Effects of flue gas conditioning on performance . . . 47
  - Gas ducts in performance . . . 10
  - Particulate control . . . 51
- Fertilizer plants; pollution abatement at . . . 6
- Flue gas conditioning
  - Effects on electrostatic precipitator performance . . . 47
- Fly ash removal . . . 48
- Forest and wildland; effects on . . . 31
- Limestone scrubbing . . . 10
- Nox
  - Emissions . . . 53
  - Formation . . . 51
- Power plant emissions effects
  - On animals . . . 18
  - On crop and forest species of vegetation . . . 11
- Regional air quality management . . . 31
- Sulfur dioxide research
  - Ammonia scrubbing . . . 50
  - Atmospheric loading . . . 11
  - Limestone injection . . . 48
  - Limestone scrubbing . . . 10,48,49,50,61,63,65
  - Limited layer mixing dispersion . . . 4
  - Low-BTU coal gasification . . . 52,63
  - Peak-to-mean ratios of concentration . . . 5
  - Recovery . . . 6
  - Removal
    - Bench-scale studies . . . 63
    - Comparison of processes . . . 62
    - Conceptual design and cost studies . . . 64
    - Sludge from . . . 53
- Sulfuric acid, marketing from abatement sources . . . 62
- Trace elements in coal consumed at power plants . . . 18
- Waste management, design and systems . . . 10

-A- (cont'd)

- Ambulance Demonstrations . . . 45
- Ammonia Scrubbing . . . 50
- Archaeology . . . 37,69
- Ash Storage Ponds
  - Close loop recirculation . . . 48
- Aquatic Plant Control
  - Competition . . . 12
  - Herbicides . . . 13
  - Management . . . 12
  - Monitoring . . . 11
  - Nutrition . . . 12
  - Phytophagous insects . . . 13
  - White amur fish . . . 2
- Aquatic Systems . . . 24

-B-

- Beautification Projects
  - Johnny Horizon Campaign . . . 54

-C-

- Cleanup Projects . . . 68
  - Johnny Horizon Campaign . . . 54
- Coal Gasification . . . 52,63
- Community Health . . . 44
- Conservation Education . . . 37-38
  - Archaeological studies . . . 37
- Cultural Resources . . . 57

-E-

- Electrostatic Precipitators
  - Effects of flue gas conditioning on performance . . . 47
  - Gas ducts in performance . . . 10
- Emergency Medical Equipment . . . 45

-E- (cont'd)

Energy Conservation
Consumer programs 47

Energy, Efficient use
Consumer programs 47

Energy Resources
Coal gasification 52
Geologic and geophysical maps 34
Solid waste as fuel supplement 19,67

Environmental Concern II

Environmental Education
Comprehensive environmental education master plans 8
Development of conservation and environmental education material . . 8
Environmental education center 38
Environmental education mobile laboratory 8
Environmental health technician program 8
Environmental quality handbook for students, teachers and community groups 8
Johnny Horizon Campaign 54
Natural resource awareness 21
Planning and implementation model 8
Resource materials center 8
School environmental education program 8
Strip mine reclamation and revegetation project 2

Environmental Statements IV

-F-

Farm income 1

Fertilizer Research
Controlled released fertilizers 7
Nonradioactive nitrogen depleted fertilizers 7
Nutrient losses 57
Pollution abatement at fertilizer plants 6
Soil contamination 7
Trace elements in fertilizers 7

Fisheries Resources
Aquatic systems analysis 24
Bear Creek Channelization 25
Biothermal research 25
Environmental assessment and monitoring
Bellefonte Nuclear Plant 25
Browns Ferry Nuclear Plant 24
Hartsville Nuclear Plant 25
Sequoyah Nuclear Plant 24
Watts Bar Nuclear Plant 24

-F- (cont'd)

Fisheries ecology 22
Management programs 22,23
Smallmouth bass 23
Stream reclamation 23
Tailwater evaluations 22

Flood Control
Local problems 41,42
National program 42

Flue Gas Conditioning
Effects on electrostatic precipitator performance 47

Fly Ash Removal 48

Forest Resources
Air quality, effects on forest and wildland 31
Development 26
Ecosystems survey and analysis 27
Hydrology 27
Influence studies 31
Lantern damage to trees 39
Management
Extension 26
Effects on hydrology 35
Technology and practices 26
Planning of wild land use 25
Plant genetics and breeding 27
Plant physiology 28
Revegetation of reservoir inundation 31
Strip mine reclamation 30
Surveys and forecasts 26
Utilization of residues and associated pollution abatement 32
Vegetation
Production and establishment 29

-H-

Health
Ambulance demonstration 45
Community health 44
Emergency services 45
Fairs 44
Helicopter demonstration 45
Medical equipment 43
Medical techniques 43
Occupational health 43
Personnel exchange 44
Vectors of spotted fever 15

1449

-H- (cont'd)

Health Fairs 44

Heat Transfer 9,70

Heated Water Discharges
  At nuclear plants 9
  Beneficial uses of
    Catfish culture 52
    Greenhouse heating 1
  Effects on aquatic life 20,71
  Hydraulic model for 9

Helicopter demonstrations 45

Highway Area Development 46

Hydraulic Models
  For heated water discharges at nuclear plants 9

Hydrology
  Effects of agricultural covers 36
  Effects of forest management 27,35
  Effects of urbanization on streamflow 35

-I-

Industrial Hygeine
  Hazard control information system 18

-J-

Johnny Horizon Campaign 54

Junk Car Removal 54

-L-

Land Pollution
  Cleanup projects 68
  Johnny Horizon Campaign 54
  Municipal dump closing 68

Land Reclamation 60

Land Use
  Landscaping 65
  Mapping 43
  Transmission line rights of way 66
  Watershed improvement 1

-L- (cont'd)

Limestone Injection 48

Limestone Scrubbing 10,48,49,50,61,63,65

Litter Prevention 68

-M-

Mapping
  Land use 43

Medical Services
  Ambulance demonstrations 45
  Community health 44
  Emergency services 45
  Equipment
    Loans 44
    Mobile 45
  Health fairs 44
  Helicopter demonstrations 45
  Occupational health 43
  Personnel exchange 44
  Techniques 43

Mercury Pollution 19,20

Mineral Resources 34

Mobile Medical Equipment 45

Mosquito Control
  Abatement programs for municipalities 15
  Beaver ponds 16
  Buttonbush, effects on habitat 14
  Habitat management 17
  Insect-pest and vector distribution 14
  Larvicide evaluations 16
  Operational larvicides 14
  Pickwick reservoir 13
  Reservoir shoreline multiple usage 14
  Soil tillage 15
  Survey of problem areas and problems 17
  Training program for pesticide applicators certification 17

Municipal Waste Disposal 59

-N-

Natural and Scenic Resources
Cultural areas 57
Research areas 31
Streams 57
Trails 56
Urban areas 32
Wild areas 56

New Town Planning 45

Nuclear Plants
Heated water discharges 9
Radiological impact 19

-O-

Occupational Health 43

Outdoor Education 38

Outdoor Recreation
Motorcycle riding, effect on campgrounds 39
Recreation plan 55
Recreation products in prevention of lantern damage to trees 39
Trail bikers, needs and habits 39

Oxygenation Studies 69,70

-P-

Plant Succession 40

Public Use Areas 55

-R-

Radiological Research
Nuclear power impact 19
TLD dosimeters in radiation surveillance 54

Rare and Endangered Species 32

Recreation, Outdoor
Motorcycle riding, effects on campgrounds 39
Recreation plan 55
Recreation products in prevention of lantern damage to trees 39
Trail bikers; needs and habits 39

-R- (cont'd)

Recreation Planning 56

Recreation Resource Development
Outdoor recreation plan 55
Public use areas 55
Recreation planning 56
Scenic streams 57
Scenic trails 56
Wild areas 56

Recycling
Discarded automobile tires 67
Waste paper 68
Waste rubber 68

Reservoir Dynamics 9

Resources
Energy 19,34,52,67
Mineral 34
Natural and scenic 31,32,56,57

Resource Management
Demonstration trail 40
Natural resources 40
Off-road vehicle area monitoring 39
Plant succession 40
Wildlife management 26
Wildlife research 41
Vegetation study areas 41

Resource Recovery
Discarded automobile tires in asphalt paving 67
Paper mill bark in soybean production 2
Solid waste as fuel supplement 19,67
Solid waste incineration 68
Sulfur recovery 6
Sulfuric acid from abatement sources 62
Waste rubber conversion 68

Rocky Mountain Spotted Fever Carriers 15

Rural Development 45

-S-

Sanitary Landfills 66,67

Scenic Trails 56

-S- (cont'd)

Siltation 1

Soil Contamination 7

Solid Waste Management
- Broiler house litter in corn production 2
- Cleanup projects 68
- Coal tipple transfer station 67
- Compost, effects on soils and plants 60
- Discarded automobile tires in asphalt paving 67
- Forest industry residue utilization 32
- Incineration 68
- Industrial wastes; design and systems 10
- Johnny Horizon Campaign 54
- Junk Car Removal 54
- Municipal dump closing 68
- Municipal waste disposal on agricultural soils 59
- Paper mill bark in soybean production 2
- Sanitary landfills 66,67
- Sludge from sulfur dioxide and particulate removal 53
- Solid waste as fuel supplement 19,67
- Waste collection 67
- Waste paper recycling 68
- Waste rubber conversion 68

Stream Reclamation 23

Strip Mine Reclamation
- Aesthetic enhancement 32
- Contract compliance 30
- Elementary school program 2
- Research and demonstration 30,32,53,60

Sulfur Dioxide Research
- Ammonia scrubbing 50
- Atmospheric loading 11
- Limestone injection 48
- Limestone scrubbing 10,48,49,50,61,63,65
- Limited layer mixing dispersion 4
- Low-BTU coal gasification 63
- Peak-to-mean ratios of concentration 5
- Recovery 6
- Removal
  - Bench-scale studies 63
  - Comparison of processes 62
  - Conceptual design and cost studies 64
  - Sludge from 53

Sulfur Recovery 6

-T-

Temperature Monitoring, thermal scanning 9

Temperature Prediction; reservoir 9,70

Townlift 46

Trace Elements In Fertilizers 7

Trails, scenic 56

-U-

Urban Natural Areas 32

Urbanization
- Effects on water quality 35

Urban Planning 46

-V-

Vector Control
- Biting fly bioassays 20
- Mosquito control . . . . .
  - Abatement programs for municipalities 15
  - Beaver ponds 16
  - Buttonbush, effects on habitat 14
  - Habitat management 17
  - Insect-pest and vector distribution 14
  - Larvicide evaluations 16
  - Operational larvicides 14
  - Pickwick reservoir 13
  - Reservoir shoreline multiple usage 14
  - Soil tillage 15
  - Survey of problem areas and problems 17
  - Training program for pesticide applicators certification 17

Rocky Mountain Spotted Fever Carriers 15

Visual Enhancement 55,65

Visual Impacts 65

-W-

Waste Collection 67

-W- (cont'd)

Waste Management, Solid
- Broiler house litter in corn production . . . 2
- Cleanup projects . . . 68
- Coal tipple transfer station . . . 67
- Compost; effects on soils and plants . . . 60
- Discarded automobile tires in asphalt paving . . . 67
- Forest industry residue utilization . . . 32
- Industrial wastes; design and systems . . . 10
- Incineration . . . 68
- Johnny Horizon Campaign . . . 54
- Junk Car Removal . . . 54
- Municipal dump closing . . . 68
- Municipal waste disposal on agricultural soils . . . 59
- Paper mill bark in soybean production . . . 2
- Sanitary landfills . . . 66,67
- Sludge from sulfur dioxide and particulate removal . . . 53
- Solid waste as fuel supplement . . . 19,67
- Waste collection . . . 67
- Waste paper recycling . . . 68
- Waste rubber conversion . . . 68

Waterfowl Resources
- Ecosystems survey and analysis . . . 27
- Planning of wild land use . . . 25
- Waterfowl management
  - Migratory . . . 33
  - Resident . . . 33
- Waterfowl uses . . . 33

Watershed Research . . . 35,36

Weed Control
- Competition . . . 12
- Herbicides . . . 13
- Management . . . 12
- Monitoring . . . 11
- Nutrition . . . 12
- Phytophagous insects . . . 13
- White amur fish . . . 2

Water Quality
- Ash storage ponds; closed loop recirculation . . . 48
- Aquatic plant control
  - Competition . . . 12
  - Herbicides . . . 13
  - Management . . . 12
  - Monitoring . . . 11
  - Nutrition . . . 12
  - Phytophagous insects . . . 13
  - White amur fish . . . 2
- Forest influence studies . . . 31

Water Quality (cont'd)
- Heat transfer . . . 9
- Heated water discharges . . . 1,9,20,52,71
- Mercury pollution . . . 19,20
- Oxygenation studies . . . 69,70
- Pollution abatement at fertilizer plants . . . 6
- Runoff waters . . . 36
- Sanitary landfill area leachates . . . 67
- Strip mine reclamation . . . 30
- Temperature monitoring . . . 9
- Temperature prediction . . . 9,70
- Urbanization; effects of . . . 35
- Waste management; design and systems for . . . 10

Wild Areas . . . 56

Wildlife Resources
- Ecosystems surveys and analyses . . . 27
- Forest and wildland
  - Development . . . 26
  - Hydrology . . . 27
  - Planning . . . 25
  - Surveys . . . 26
- Management
  - Demonstration trail . . . 40
  - Extension . . . 26
  - Technology and practices . . . 26
- Off-road vehicle area monitoring . . . 39
- Plant genetics and breeding . . . 27
- Plant physiology . . . 28
- Production techniques . . . 34
- Research . . . 41
- Strip mine reclamation . . . 2,30
- Use in forest and uplands . . . 34
- Vegetation; production and establishment . . . 29

TVA Division of Agricultural Development, National Fertilizer Development Center, Muscle Shoals, Alabama 35660 Phone: (205) 383-4631. Copies of starred reference items available on request.

Categories: Siltation, Farm Income, Land Use.

IMPROVED LAND USE IN A SMALL WATERSHED. Parker Branch watershed in Buncombe County, North Carolina, a badly eroded area, was selected for intensive study of the effects on hydrology that might result from changes in farm land use. The methodology involved cooperation with the 49 landowners in implementing on their farms changes in organization and land use that would help achieve a high level of farm income. Changes on the farms were motivated by interests of the farmers in using their soils and other resources to increase net income. The hydrologic effects of these changes were measured in terms of infiltration capacities, surface runoff, and sediment loads.

Tennessee Valley Authority and North Carolina State University, "Parker Branch Research Watershed: Project Report." 1953 through 1962; (Knoxville, Tennessee: Tennessee Valley Authority, 1963)*

Tennessee Valley Authority and North Carolina State University, "Parker Branch: Two Decades of Progress." Circular Z-29, February 1972* (Popular)

TVA Agricultural Resource Development Branch, F-120 NFDC, Muscle Shoals, AL 35660 Phone: Muscle Shoals (205) 383-4631, ext. 244. Copies of starred reference items available on request.

Category: Heated Water Discharges.

GREENHOUSE HEATING AND COOLING WITH WARM WATER DISCHARGE. A greenhouse which uses warm water for direct contact heat exchange heating and for evaporative cooling is operating to determine the feasibility of using power plant discharge water as a resource. Crops and crop management methods compatible with the relatively high humidity environment in the greenhouse are being studied. This is a joint project between TVA and Oak Ridge National Laboratory (ORNL). The basic heating and cooling system was designed by engineers at ORNL. TVA's Agricultural Resource Development Branch (ARDB) supervised the design and construction of the actual facility with funds being supplied by TVA's Office of Power. The facility is currently being operated by ARDB staff on branch funds. Operation began in October 1973 and is scheduled to continue for three years. Construction cost was $129,000 and annual operating cost is $68,000.

B. J. Bond, Carl E. Madewell, John B. Martin, Jr., and David A. Mays, "TVA Projects--Beneficial Uses of Waste Heat," paper presented at the National Conference on Complete WateReuse, Washington, DC, April 23-27, 1973.

Gerald G. Williams, "TVA Programs--Waste Heat Utilization in Greenhouses and Other Agriculturally Related Projects," Waste Heat

Utilization Proceedings of the National Conference, October 27-29, 1971, Gatlinburg, Tennessee.

J. C. Ringling and C. E. Madewell, "A Comparison of Two Greenhouse Tomato Production Systems in the Tennessee Valley," 1973.

L. D. King and W. K. Furlong, "The TVA Pilot Greenhouse for Waste Heat Research," presented at Southern Section of American Society of Agricultural Engineers, February 5, 1974.

Categories: Solid Waste Management, Resource Recovery.

USE OF BARK AS A SOIL AMENDMENT 1972-77. Research in use of bark from a paper mill as a soil amendment for soybean production in Kentucky. Objectives also include the use of soil as a disposal medium for paper mill waste product. Results reported in ARDB annual report.

Category: Solid Waste Management.

USE OF BROILER HOUSE LITTER FOR CORN PRODUCTION. Demonstrations on use of broiler house litter for corn production in Alabama. These demonstrations have continued annually for more than ten years and will be continued. Reported annually in ARDB annual report.

Categories: Strip Mine Reclamation, Environmental Education.

STRIP MINE RECLAMATION AND REVEGETATION PROJECT. Program to introduce elementary school students to strip mine spoils and illustrate adverse conditions of these areas upon the environment, and teach them methods for transplanting seedling in such a growing medium. Project was started in Southwest Virginia in 1972 and will be continued. Will be reported in ARDB annual report.

Category: Weed Control.

BIOLOGICAL WEED CONTROL IN FARM POND. This project is a field research test evaluating the effectiveness of the white amur fish in controlling weeds in a farm pond. A weed infested farm pond was stocked in 1972 at the rate of six 3-pound fish per surface acre of water. Observations to date indicate the abundance of aquatic weeds has been reduced, the water quality has not been degraded, and the general utility of the pond has been increased. Weed control in farm ponds is a problem in the Tennessee Valley. It is estimated that two-thirds or more of the ponds have aquatic weed problems. Farmers are concerned about the effect of using chemicals and are seeking advice on farm pond weed control. If the use of the white amur fish to control farm pond weeds proves environmentally feasible, this could result in significant savings to Valley farmers; the cost of aquatic herbicides is about $57 per acre per year--estimated cost of using the white amur is about $10 per acre per year. This project does not deal with the production of the white amur for food purposes or recreation and/or sporting possibilities. The project began in 1972 and is expected to continue through 1974. An evaluation report has been completed for 1972 and the 1973 evaluation will be completed in March 1974. Three divisions of TVA are cooperating in this project: Division of Environmental Planning, Division of Forestry, Fisheries, and

Wildlife Development, and Division of Agricultural Development.

Laboratory Investigations of the Feeding Characteristics of Immature White Amur Using Three Species of Submersed Aquatic Macrophytes, Division of Environmental Planning, May 1973.

Interim Report Aquatic Macrophyte Control and Management by the White Amur (Ctenopharyngodon Idella [Val.]), Bradford Pond, Lawrence County, Alabama, Division of Environmental Planning, July, 1973.

"Studies of the White Amur, An Herbivorous Fish," by A. L. Bates, E. D. Shackelford (Division of Environmental Planning); Ben Jaco (Division of Forestry, Fisheries, and Wildlife Development); and Carl Madewell (Division of Agricultural Development). Paper presented at the 1973 TVA Water Resources Research Task Force Seminar, Muscle Shoals, Alabama, October 18-19, 1973*

"Environmental and Economic Aspects of Recycling Livestock Wastes--Algae Production Using Waste Products," by Carl E. Madewell, John B. Martin (Division of Agricultural Development) and Billy G. Isom, (Division of Environmental Planning), TVA, 1971.*

TVA Air Quality Branch, ROB, Muscle Shoals, Alabama 35660 Phone: (205) 383-4631, ext. 555. Copies of starred reference items available upon request.

Category: Air Quality.

ATMOSPHERIC DISPERSION AND INTERACTION OF SO_2, H_2SO_4, NO_x, O_3, AND PARTICULATES IN STACK EMISSIONS FROM COAL-FIRED POWER PLANTS--Studies to determine relative dispersion of SO_2 and particulates in plume and to analyze particle size distributions; to relate surface concentrations of SO_2, NO_x, and O_3, to plant operations, meteorological conditions, and travel time of plume; and to evaluate chemical interactions of coal-fired power plant plumes. Aircraft field study of relative distribution of particulates and SO_2 was completed. First atmospheric chemistry aircraft field study completed in March 1973. Particulates, SO_2, NO_x, NO, O_3, total sulfur, temperature profiles, wind speed and direction, humidity, and solar irradiance data were obtained; also, some data on nitrous acid and aromatic hydrocarbons. This project is being conducted by TVA under partial support from EPA under contract TV-34426A. A technical report covering the FY 1971 - FY 1973 study completed. Second aircraft field study planned for spring FY 1974. Instruments are being trailer mounted for surface measurements between aircraft studies.

Huang, C-M, Coleman, J. H., Montgomery, T. L., and Gartrell, F. E., "Atmospheric Chemical Interactions in Coal-Fired Power Plant Plumes," paper no. 72-70, presented at the 65th annual meeting of the Air Pollution Control Association, Miami Beach, June 18-22, 1972.*

Huang, C-M, Garber, R. W., and Huff, O., "Investigation of Atmospheric Chemical Interactions in Coal-Fired Power Plant Plumes," Division of Environmental Planning, Tennessee Valley Authority, in preparation.

TVA Air Quality Branch, ROB, Muscle Shoals, Alabama 35660 Phone: (205) 383-4631, ext. 555. Copies of starred reference items available upon request.

Category: Air Quality.

LIMITED LAYER MIXING DISPERSION--Study to obtain sufficient field and operational data to define the level of surface SO_2 concentrations occurring when vertical dispersion of plume is inhibited by stable air aloft and to relate this concentration to the source with respect to distance and level of SO_2 concentrations for comparison with concentrations resulting from coning and inversion breakup dispersion. Data for this project were collected under sponsorship of the Environmental Protection Agency (EPA/TVA Contract TV-29388A), however, TVA is responsible for the analyses and preparation of the report. A technical report on the limited layer mixing dispersion model is under preparation. No future studies are now planned.

Carpenter, S. B., Montgomery, T. L., Leavitt, J. M., Colbaugh, W. C., and Thomas, F. W., "Principal Plume Dispersion Models: TVA Power Plants," JAPCA, 21 (8), 491-495 (August 1971).*

Montgomery, T. L., Norris, W. B., Thomas, F. W., and Carpenter, S. B., "A Simplified Technique Used to Evaluate Atmospheric Dispersion of Emissions from Large Power Plants," JAPCA, 23 (5), 388-394 (May 1973).*

TVA Air Quality Branch, ROB, Muscle Shoals, Alabama 35660 Phone: (205) 383-4631, ext. 555. Copies of starred reference items available upon request.

Category: Air Quality.

COOLING TOWER PLUME BEHAVIOR--Study to obtain data to relate hyperbolic natural-draft cooling tower plume configuration and environmental effects to accompanying meteorological and tower operating conditions. Three full-scale field studies were conducted at the Paradise Steam Plant. Data have been evaluated for final analyses and preparation of project report. Model presented in report relates plume length to tower parameters and to ambient temperature, wind speed, pressure, and humidity.

These studies have provided data essential to environmental impact analysis. Two technical papers have been presented at professional meetings; a technical report has been completed and is undergoing internal review prior to release; another technical report is under preparation.

Colbaugh, W. C., Blackwell, J. P., and Leavitt, J. M., "Interim Report on Investigation of Cooling Tower Plume Behavior," presented at the 68th National Meeting of the American Institute of Chemical Engineers, Houston, Texas, February 28 - March 4, 1971.*

Slawson, P., Coleman, J. H., and Fred, J. W., "Some Observations on Cooling Tower Plume Behavior at the Paradise Steam Plant," presented at the U. S. Atomic Energy Commission Symposium "Cooling Tower Environment - 1974," University of Maryland Adult Education Center, College Park, Maryland, March 4-7, 1974.*

TVA Air Quality Branch, ROB, Muscle Shoals, Alabama 35660 Phone: (205) 383-4631, ext. 555. Copies of starred reference items available upon request.

Category: Air Quality.

ASTM AIR QUALITY EVALUATION METHODS--Validation of 35 ASTM standard methods for sampling and analyzing ambient air and stationary source emissions. Objective is to determine repeatability and accuracy of methods. Will include inter-laboratory studies based on simultaneous on-site sampling and analyses of real atmospheres. Project duration is approximately 4 years at an estimated total cost in excess of $2 million. The work will be divided into 5 phases. Phase I covers 6 ambient parameters. This phase is essentially completed. Phase II will analyze methods for 6 stationary source emission parameters. This phase is now underway. Phase III will cover 6 additional ambient parameters. This is in the planning stage. Phase IV will seek to validate instrumental methods for monitoring air pollutants. This is in the early planning stage. Phase V will cover about 8 other ambient and stationary source parameters. This phase has had only basic preliminary planning. TVA contributed financial support to ASTM project threshold in 1972 and is represented on the committee. TVA may provide a site for tests pertaining to ambient monitoring of ozone and fluoride.

Garber, R. W., Hamby, J. W., Titcomb, G. E., and Montgomery, T. L., "A Field Evaluation of Ambient Sulfur Dioxide Monitors by the Tennessee Valley Authority," presented at the East Central Section of Air Pollution Control Association Annual Meeting, Cleveland, Ohio, September 28, 1973.*

TVA Air Quality Branch, ROB, Muscle Shoals, Alabama 35600 Phone: (205) 383-4631, ext. 555. Copies of Starred reference items available upon request.

Category: Air Quality.

PEAK-TO-MEAN RATIOS OF SO_2 CONCENTRATIONS--Evaluation of relationships between SO_2 concentrations for various time periods and their dependence upon averaging time and plant stack height. Study includes peak-to-mean ratios for mean time periods of from one hour to one year, and an analysis of the dependence of these ratios upon averaging time. An additional ratio, related to maximum concentrations, has been included and examined for dependence upon stack height. A technical paper has been completed and is undergoing internal review for publication.

Montgomery, T. L., Carpenter, S. B., and Lindley, N. E., "The Relationship Between Peak and Mean SO_2 Concentrations," presented at the American Meteorological Society Conference on Air Pollution Meteorology, Raleigh, North Carolina, April 5-8, 1971.*

TVA Division of Chemical Development, A203, National Fertilizer Development Center, Muscle Shoals, Alabama 35660. Phone: (205) 383-4631, ext. 304. Copies of starred reference items available upon request.

Categories: Air Quality, Sulfur Recovery, Resource Recovery, Ammonia Scrubbing.

DEVELOPMENT OF NEW PROCESSES FOR RECOVERING SULFUR. A long-range project with the objective of finding and developing economical processes for recovering useful products from stack gas sulfur dioxide. Emphasis is on recovery of elemental sulfur. Work to date has identified a variation of ammonia scrubbing which has relatively good economic potential. The process is being tested on pilot-plant scale. Future work will include studies of H_2S removal during coal gasification as well as support of pilot-plant SO_2 recovery projects.

Categories: Air Quality, Water Quality, Fertilizer Research.

POLLUTION ABATEMENT AND CONTROL IN FERTILIZER PLANTS. Means are sought for recovery and control of effluents from fertilizer processes that may affect the environment adversely. Principal losses occur in dusts, fume, and entrainment from process stacks, and aqueous wastes. The general problem in the country is of such magnitude as to demand intensive coordinated effort by the industry and TVA.

Pollution control will be emphasized in new process developments at TVA and in continued surveillance of demonstration-plant facilities. Developments of equipment, techniques, and know-how will be made available to the fertilizer industry. Particular effort will be made to help operators of small plants, since they usually are short on technical capabilities and facilities. This effort will include assistance in measuring losses, in determining operating practices that decrease the problems, and in selecting recovery equipment such as dust collectors and scrubbers.

"Pollution Control Interrelationships," F. E. Gartrell and J. C. Barber. Chemical Engineering Progress 62 (10), 44-7 (October 1966). Technical.

"The Cost of Pollution Control," J. C. Barber. Chemical Engineering Progress 64 (9), 78-82 (September 1968). Technical.*

"Waste Effluent; Treatment and Reuse," J. C. Barber. Chemical Engineering Progress 65 (6), 70-3 (June 1969). Technical.*

"Conductivity Measurements Monitor Waste Streams," P. A. Corrigan, V. E. Lyons, G. D. Barnes, and P. G. Hall. Environmental Science and Technology 4, 116-21 (February 1970). Technical.*

"Fluoride Recovery from Phosphorus Production," J. C. Barber and T. D. Farr. Chemical Engineering Progress 66, 56-62 (November 1970).*

"Environmental Protection--TVA Experience," F. E. Gartrell and J. C. Barber. Journal of Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers 96 SA6 1321-34 (December 1970). Technical.*

"A Pollution Solution for Granulation Plants." F. P. Achorn, H. L. Balay, E. D. Myers, and R. D. Grisso. Farm Chemicals 134, 28-31 (August 1971). Technical.*

"Agricultural Chemicals in Relation to Environmental Quality: Chemical Fertilizers, Present and Future." L. B. Nelson. Journal of Environmental Quality 1, 2-6 (January-March 1972). Technical.

"Bulk Blenders--Environmental Control and OSHA." Frank Achorn and Jim Barber. Fertilizer Progress 3:24-7, 42, 47-9 (September-October 1972) 3, 10-13 (November-December 1972). Technical.*

Paper--"Pollution Control in Fertilizer Manufacture." J. C. Barber; to American Society of Agronomy (November 11-16) and Journal of Environmental Quality.

Categories: Fertilizer Research, Soil Contamination.

DEVELOPMENT OF ANALYTICAL METHODS FOR DETERMINATION OF TRACE AMOUNTS OF HEAVY METALS IN FERTILIZER MATERIALS--Methods for determining very small quantities of heavy-metal contaminants such as mercury, cadmium, chromium, and arsenic are developed to aid in the investigation of possible buildup of these metals in the soil by introduction through fertilizers. The analytical methods will be applied in coordinated greenhouse and field studies.

Category: Fertilizer Research.

PRODUCTION OF ^{15}N-DEPLETED FERTILIZERS FOR AGRONOMIC AND ENVIRONMENTAL STUDIES--Fertilizers containing a lower concentration of ^{15}N (nonradioactive isotope) than that found naturally in nitrogen substances will be used in agronomic tests. The lower ratio of ^{15}N is a distinguishing characteristic that makes possible its use as a tracer. When added to soils as fertilizer nitrogen, it can be monitored to follow its movement in plants, soils, and surface and subsurface waters. The application is expected to be a breakthrough in studies of nitrogen in the environment.

Category: Fertilizer Research.

DEVELOPMENT OF CONTROLLED RELEASE FERTILIZERS--TVA work continues on fertilizers that release their nutrient content at controlled rates over a full growing season or longer. Potential advantages are increased uptake by plants, lower application costs, elimination of luxury consumption, avoidance of vegetative damage, and minimization of losses by decomposition and leaching. In areas where streams may be polluted by runoff or subsurface movement of highly soluble fertilizers, particularly nitrogen materials, the controlled release fertilizers may offer solutions to problems of contamination.

TVA Education Relations and Manpower Development Staff, 300 Farragut Hotel, Knoxville, Tennessee 37902 Phone: (615) 637-0101, ext. 2102. Copies of starred reference items available upon request.

Category: Environmental Education.

ENVIRONMENTAL QUALITY HANDBOOK. TVA is cooperating with the University City Science Center, Philadelphia, Pennsylvania, in the development of an environmental quality handbook for students, teachers, and community groups. It will include activities and projects which students (kindergarten through grade 12), teachers, and community groups can perform to measure the quality of the environment--air, water, noise, etc.--in their particular communities. Workshops to familiarize teachers with the handbook will be held in those areas in the Tennessee Valley where interest has been shown. The handbook will be published and ready for distribution in the spring of 1974.

ENVIRONMENTAL EDUCATION LABORATORY. TVA is cooperating with the Kingsport, Tennessee, school system in the operation of a mobile environmental education laboratory. The mobile environmental education laboratory is equipped with a variety of scientific instruments for conducting environmental studies. Publications available are Investigations for a Mobile Environmental Education Laboratory* and Mobile Environmental Education Laboratory Project Final Report*. Special environmental education curriculum guides at the junior and senior high school levels are being developed on the subjects of energy, soil, water, and air. They will be available for distribution in the spring and fall of 1974.

ENVIRONMENTAL HEALTH TECHNICIAN PROGRAM. TVA, in cooperation with other agencies, is assisting Walters State Community College in developing and operating its Environmental Health Technician Program. TVA assists by serving on the College's Advisory Council. The Council makes decisions on manpower and curriculum needs.

SCHOOL ENVIRONMENTAL EDUCATION PROGRAM. TVA is cooperating with the Fayetteville, Tennessee, school system in the development of an environmental education program for grades 1 through 9. Curriculum material and an outdoor laboratory are being developed.

COMPREHENSIVE ENVIRONMENTAL EDUCATION MASTER PLANS. A TVA planner is serving on the Tennessee Environmental Education Advisory Council to assist with the development of a comprehensive environmental education master plan for the State of Tennessee. Another TVA planner is serving on the Alabama Environmental Education Advisory Council and assisted in the development of a master plan, titled Environmental Education in Alabama--A Comprehensive Approach*.

DEVELOPMENT OF CONSERVATION AND ENVIRONMENTAL EDUCATION MATERIAL. TVA planners are assisting the Tennessee Conservation League in the development of conservation and environmental education material for schools and the general public.

PROCESS MODEL FOR PLANNING AND IMPLEMENTING A COMPREHENSIVE, PROBLEM-FOCUSED ENVIRONMENTAL EDUCATION PROGRAM. A planning model which will have application in other Federal agencies, state departments of education, educational cooperatives, school systems, etc., is being developed. The model will be ready for dissemination in the spring of 1974.

ENVIRONMENTAL EDUCATION RESOURCE MATERIALS CENTER. The TVA Education Relations and Manpower Development Staff operates the center which includes some of the model environmental education curriculum guides and program material that have been developed in the country. This material deals with all aspects of the

environment--population, energy, air, water, noise, land use, etc., as these areas relate to formal and informal education--and is disseminated insofar as practical, to those individuals or groups inside or outside TVA who request it.

TVA Engineering Laboratory, P. O. Drawer E, Norris, Tennessee 37828
Phone: (615) 494-7137 or (615) 637-3121. Copies of starred reference items available upon request.

Categories: Nuclear Plants, Heated Water Discharges, Hydraulic Models, Water Quality.

DESIGN OF HEATED DISCHARGE STRUCTURE FOR BROWNS FERRY NUCLEAR PLANT. Analytical and hydraulic model studies used to design and investigate the impact of a multi-port diffuser to discharge heated water from Browns Ferry Nuclear Plant into Wheeler Reservoir.

"Browns Ferry Nuclear Plant - Internal Hydraulics of the Cooling Water Diffuser," Advance Report No. 10, Engineering Laboratory, August, 1968. Technical.*

"Prediction and Control of Water Temperatures in Wheeler Reservoir During Operation of the Browns Ferry Nuclear Plant," Advance Report No. 14, Engineering Laboratory, April, 1972. General; semi-technical.*

Categories: Water Quality, Reservoir Dynamics, Heat Transfer, Temperature Prediction, Water Temperature Monitoring by Thermal Scanning.

THERMO-HYDRODYNAMICS OF RESERVOIRS. Field measurements of temperature and velocities in TVA impoundments. Basic studies of water movements and heat transfer and their effect on water quality.

"Evaluation of Fontana Reservoir Field Measurements," Proceedings, ASCE Specialty Conference on Current Research into the Effects of Reservoirs on Water Quality, January, 1968, Wunderlich, W. O. and Rex A. Elder. Technical.*

"Effect of Intake Elevation and Operation on Water Temperature," Journal, Hydraulics Division, ASCE, HY6, November, 1969, Wunderlich, W. O. and Rex A. Elder. Technical.*

"Graphical Temperature and D. O. Prediction Methods," Water Resources Research, Advance Report No. 9, Engineering Laboratory, April, 1969. Technical.*

"The Dynamics of Density-Stratified Reservoirs," Engineering Laboratory, April, 1971, Wunderlich, W. O. General.*

"Heat and Mass Transfer Between a Water Surface and the Atmosphere," Water Resources Research, Lab Report No. 14, Engineering Laboratory, April, 1972. Technical.*

"Prediction of Density Currents in the Tellico-Fort Loudoun Navigation Canal," Advance Report No. 13, Engineering Laboratory, June, 1973. Technical.*

"Water Temperature Monitoring by Thermal Scanning," A paper for inclusion in the Proceedings of the Second Annual Remote Sensing of Earth Resources Conference, March, 1973, S. Vigander. Technical.*

Category: Air Quality.

STEAM PLANT GAS DUCTS FOR BETTER FLY-ASH PRECIPITATOR PERFORMANCE. Model studies to shape the ducts and develop necessary flow guiding devices for optimum distribution of gas flow and fly-ash across the working sections of the electrostatic precipitators. These studies include problems in hopper flow and fly-ash plugging in the ducts. Nearly all TVA steam plants have been tested. Study temporarily suspended. Model studies are necessary because the high degree of flow uniformity needed for good precipitator performance cannot be obtained by any other means. Particularly new and upgraded precipitators with removal efficiencies better than 95 percent require detailed knowledge of the gas flow distribution, intensity and scale of gas flow turbulence, suspended fly-ash concentration distribution, and fly-ash deposit propensity.

Categories: Air Quality, Water Quality, Solid Waste Management.

DESIGN AND SYSTEMS FOR WASTE MANAGEMENT. Study to measure the basic fluid mechanic parameters for horizontal two- and three-phase air/water/fly-ash flows necessary for the evaluation of concepts for the simultaneous transport and partial treatment of liquid and gaseous industrial effluents. The concepts of centralized waste treatment and integrated transportation could be realized with possible savings under appropriate circumstances.

Category: Air Quality.

TWO-PHASE FLOWS IN SULPHUR DIOXIDE SCRUBBER. Studies to ensure specified performance level of SO_2-wet-limestone scrubber, it is necessary to understand and to predict the two-phase flows in the scrubber. The study aims at the development of model techniques, and flow guiding devices within the scrubber to insure desired flow patterns. Studies continuing with measurements in both model and field installation of characteristics of the counter current mist-flow regime.

TVA Environmental Biology Branch, EDB, Muscle Shoals, Alabama 35660
Phone: (205) 383-4631, ext. 728. Copies of starred reference items available upon request.

Category: Air Quality.

FIELD AND LABORATORY STUDIES OF THE EFFECTS OF ATMOSPHERIC EMISSIONS FROM COAL-FIRED STEAM PLANTS ON CROP AND FOREST SPECIES OF VEGETATION. The objective of these studies is to define the relationship between pollutant dose and effects on foliar appearance, growth, and yield of selected crops of economic importance in the Tennessee Valley. Studies were begun in 1971 and have involved the use of both field plots and field exposure chambers in the vicinity of TVA's Widows Creek Steam Plant and controlled fumigation experiments conducted in the laboratory. Pollutants under study are SO_2, NO_2, and O_3. Field operations, 1971-76; laboratory operations, 1973-77; evaluation report scheduled for 1977.

Category: Air Quality.

CUMBERLAND TOTAL ATMOSPHERIC SO_2 LOADING. The objective of this study is to identify and characterize the impacts of SO_2 emissions from the Cumberland Steam Plant on the acidity of precipitation and in turn, the effects of acid precipitation on terrestrial ecosystems. The preoperational phase of the study was initiated in 1969.

"Preoperational Atmospheric Monitoring in the Cumberland Steam Plant Area. I. The pH and Sulfate Content of Precipitation." H. C. Jones, Division of Environmental Planning, TVA. 1974. Report for external distribution being prepared. Technical.*

Categories: Water Quality, Aquatic Plant Control, Weed Control.

MONITORING OF AQUATIC PLANTS AND THEIR RESPONSES IN RELATION TO HABITAT ALTERATION. The objective of these studies is to develop better management techniques for enhancing environmental quality while simultaneously meeting program objectives.

"Current Status of Baldcypress Plantings for Mosquito Habitat Manipulation." Memorandum, A. L. Bates to Dr. T. F. Hall dated October 24, 1972.*

"Tree Plantations for Mosquito Control," Smith, G. E., T. F. Hall, and E. Pickard. Mosquito News 29:161-166. 1969.*

"Photosynthesis in Eurasian Watermilfoil (Myriophyllum spicatum L.) Stanley, R. A. and A. W. Naylor. Plant Physiol. 50:149-151. 1972.*

"Monitoring Ecological Conditions Associated with Wide-Scale Applications of DMA 2,4-D to Aquatic Environments," Wojtalik, T. A., T. F. Hall, and L. O. Hill. Pesticides Monitoring Journal 4:184-203. 1971.*

Categories: Water Quality, Weed Control, Aquatic Plant Control.

AQUATIC PLANT NUTRITION. Study to determine the minimal nutrient requirements of nuisance aquatic plants common in the Tennessee River Watershed, for possible use in the control program. The effects of single-nutrient variation on Eurasian watermilfoil (Myriophyllum spicatum) were determined and reported. Nutrient requirements of parrotfeather (M. brasiliense) have also received some attention. These studies provide a methodology for study and evaluation of response of other aquatic plants to individual nutrients.

"Photosynthesis in Eurasian Watermilfoil (Myriophyllum spicatum L.)," R. A. Stanley, and A. W. Naylor, Plant Physiology, Volume 50, pp. 149-151, July, 1972.

TVA Environmental Biology Branch, EDB, Muscle Shoals, Alabama 35660. Phone: (205) 383-4631, ext. 728. Copies of reference items are available upon request.

Categories: Water Quality, Aquatic Plant Control, Weed Control.

MANAGEMENT OF AQUATIC PLANTS. The objective of these studies is to learn to manage aquatic plants more effectively by means of waterlevel manipulation, by herbicides, and by biological agents.

"Program Diversity and Control of Eurasian Watermilfoil in the Tennessee Valley," 1974. R. A. Stanley, A. L. Bates, J. A. Bedsole, and T. F. Hall. 19 pp.*

"Control of Buttonball with Picloram," 1974 (In Press). R. A. Stanley, A. T. Taberemus, Jr., and T. F. Hall. To be published in Hyacinth Control Jr.*

"Studies of the White Amur - An Herbivorous Fish," A. L. Bates, E. D. Shackelford, B. Jaco, and C. Madewell. 1973. Paper presented at the 1973 Water Resources Research Task Force Seminar, October 1973. Muscle Shoals. 16 pp.*

Categories: Water Quality, Weed Control, Aquatic Plant Control.

AQUATIC PLANT COMPETITION. Study to evaluate biological control of aquatic plants through study of interspecies competition. Study started in 1969 by planting American lotus (Nelumbo lutea) in field areas infested by Eurasian watermilfoil (Myriophyllum spicatum); observations are continuing on competitive relationships between these two plants.

Categories: Water Quality, Weed Control, Aquatic Plant Control.

AQUATIC PLANT CONTROL WITH HERBICIDES. Study to determine the minimum amount of herbicide required to control certain aquatic plants, the most appropriate mode and time of application, and effect on nontarget organisms. Studies on Eurasian watermilfoil (Myriophyllum spicatum) and buttonball (Cephalanthus occidentalis) have been completed and reported, covering 2,4-D and synergism between 2,4-D and various ions. An evaluation methodology was developed.

Category: Weed Control.

BIOLOGICAL CONTROL OF ALLIGATORWEED WITH PHYTOPHAGOUS INSECTS. The objectives of this study were to determine whether certain insect species (Agasicles hygrophila and Vogtia malloi) could survive in the Tennessee Valley region and whether they could be used to control alligatorweed. Flea beetles (Agasicles hygrophila) released in the spring reproduced and inflicted severe damage to alligatorweed, but they were not able to survive the winter. Only one release of the moth (Vogtia malloi) was made. Observations 1 year later revealed that none had overwintered. If cold-hardy individuals can be obtained from Argentina, releases will again be made on alligatorweed plots. This project was conducted in cooperation with the U.S. Department of Agriculture.

"Potential for Biological Control of Alligatorweed (Alternanthera philoxeroides) in the Tennessee Valley" by Joseph C. Cooney and Eugene Pickard. Environmental Biology Branch Report, February 1972.*

Category: Vector Control.

STUDY TO DETERMINE NECESSITY FOR CHEMICAL CONTROL ON PICKWICK RESERVOIR. Because of budgetary limitations and efforts to avoid unnecessary environmental contamination, a study will be made to determine whether satisfactory mosquito control can be obtained on Pickwick Reservoir without the use of chemical larvicides. Population levels of Anopheles quadrimaculatus have been consistently low on Pickwick Reservoir for the past 29 years when compared with levels for Kentucky Reservoir, which are consistently higher. Stabilization of the reservoir, a suitable water level schedule, emphasis on drainage, and other factors indicate that it may no longer be necessary to routinely larvicide this reservoir. A study will be made to determine whether satisfactory control of anopheline mosquitoes can be obtained by water level management and reservoir maintenance. Entomologists will monitor anopheline production on Pickwick Reservoir and on another reservoir still receiving larvicidal applications. A report is scheduled for January 1977.

Category: Vector Control.

EFFECTIVENESS OF OPERATIONAL LARVICIDE. Field and laboratory bioassays are conducted continuously to evaluate the effectiveness of operationally applied larvicides. Factors included are: (1) toxicity to target and nontarget organisms, (2) dispersal patterns of the insecticide, (3) susceptibility of larvae to the toxicant, and (4) demonstrated degree of control in the field. A report is prepared for each bioassay conducted. Branch reports on these activities are available.*

Category: Vector Control.

IMPORTANCE OF BUTTONBUSH AS A HABITAT FOR ANOPHELES QUADRIMACULATUS. Extensive areas in several of the TVA reservoirs are colonized by common buttonbush, an emergent woody semiaquatic plant. A study of the mosquito production associated with this woody plant in one embayment of Wheeler Reservoir in 1960 showed that mosquito production in buttonbush varied according to various environmental factors. An extensive and expensive mowing program is conducted by TVA to eliminate buttonbush habitats. It is necessary to reassess the importance of buttonbush as an anopheline habitat in light of existing environmental conditions that have changed since the original survey of 1960. A long-term study will be conducted on selected plots of buttonbush in different age classes, which are located in different reservoirs and are growing under different ecological situations, to establish the relative importance of buttonbush as a habitat for Anopheles quadrimaculatus. A preliminary report is scheduled for 1977.

"Comparative Studies Between the Production of Anopheles quadrimaculatus in Buttonball and Other Ecological Situations, Flint Creek, Wheeler Reservoir, 1960," Malaria Control Branch, 1961.*

Category: Vector Control.

MULTIPLE USAGE OF RESERVOIR SHORELINE. In an effort to better utilize the reservoir zone between the normal winter drawdown contour and approximately 2 feet above the full summer pool contour, a long-term cooperative, interdivisional study will be conducted to determine how this zone can best be utilized. Studies will also be conducted to determine the potential utilization of shoreline tree plantings and soil tillage in this zone to reduce the production of mosquitoes and at the same time provide a better habitat for wildlife.

Category: Vector Control.

INSECT-PEST AND VECTOR DISTRIBUTION - PREIMPOUNDMENT AND POSTIMPOUNDMENT SURVEYS. Mosquito habitats often can be reduced significantly or "built out" during the construction phase of a reservoir if adquate preimpoundment data are available on the mosquito species inhabiting the area. Surveys will be made to determine the presence and relative abundance of insect pests and vectors before impoundment and also the impact, if any, of reservoir impoundment on the populations of these insects. This information will be included in the appropriate environmental impact statements and most often will provide additional benefit figures for the project by demonstrating a reduction in these insect populations after impoundment. Preimpoundment and postimpoundment reports will be made on each project surveyed.

1460

Category: Vector Control.

COOPERATIVE PROJECT TO ESTABLISH INSECT VECTOR ABATEMENT PROGRAMS FOR CONCERNED MUNICIPALITIES. Each year TVA receives complaints concerning arthropod annoyances and requests for assistance from various government officials. The problem in many cases is unrelated to TVA activities, yet assistance by TVA is requested because of its interest and past record of success dealing with insect vectors. Plans are being made to cooperate with municipalities within the Tennessee Valley region by providing consultation and technical service and helping them establish their own insect control programs. A written report will be prepared at the termination of TVA's involvement in the establishment of each project. This program costs about $40,000 annually.

Category: Vector Control.

FLOODWATER MOSQUITO CONTROL BY SOIL TILLAGE. Data from small-plot tests showed that good control of floodwater mosquitoes in open, grassy depressions could be obtained by tilling the soil and thereby displacing the eggs deeper into the soil. Large-field demonstration plots have been established and will be evaluated regarding the duration of effectiveness and applicability to the control program. Laboratory studies have shown that larvae will not emerge if the eggs are covered with as little as one-fourth inch of soil. A report is scheduled for January 1977.

Categories: Vector Control, Health.

ZOONOTIC STUDIES ON THE ECOLOGY OF ROCKY MOUNTAIN SPOTTED FEVER IN THE TENNESSEE VALLEY. In cooperation with the U.S. Public Health Service, studies were conducted at Land Between The Lakes to determine the incidence of both tularemia and spotted fever in natural mammal populations. Results of these studies indicated the need for additional work to clarify the relationship of rabbits and small rodents to the natural cycle of spotted fever. Studies were begun to determine the natural tick vectors of spotted fever in a four-county area of northwest Alabama where a number of human cases have recently been reported and where ticks constitute a prime health hazard. Preliminary results have shown a high incidence of antibody-positive blood sera from wild cottontail rabbits and a high infectivity rate in certain species of ticks. A report of the Alabama study is being prepared and should be available by early 1975.

"Comparative Tick Control Field Tests - Land Between The Lakes - 1970," by Joseph C. Cooney and Eugene Pickard. Down To Earth, Vol. 28, No. 1, Summer 1972.*

"Zoonotic Potential (Rocky Mountain Spotted Fever and Tularemia) in the Tennessee Valley Region. I. Ecologic Studies of Ticks Infesting Mammals in Land Between The Lakes," by Joseph C. Cooney and Willy Burgdorfer. The American Journal of Tropical Medicine and Hygiene, Vol. 23, pp. 109-117, 1974.*

"Zoonotic Potential (Rocky Mountain Spotted Fever and Tularemia) in the Tennessee Valley Region. II. Prevalence of Rickettsia rickettsi and Francisella tularensis in Mammals and Ticks from Land Between The Lakes," by Willy Burgdorfer and Joseph C. Cooney. The American Journal of Tropical Medicine and Hygiene, Vol. 23, pp. 109-117.*

Category: Vector Control.

MOSQUITO LARVICIDE EVALUATIONS. A program for testing and evaluating potentially useful insecticides for mosquito control is continued annually, and the effects of these compounds on nontarget aquatic organisms are observed. Periodic bioassays and susceptibility tests of Anopheles quadrimaculatus larvae to various concentrations of insecticidal compounds are conducted and results are compared with those from identical tests using susceptible insectary larvae. Tests beginning in 1970 have shown that Abate and Dursban larvicides are very effective for the control of both permanent pool and floodwater species of mosquitoes. These compounds have demonstrated little effect on other aquatic life in TVA reservoirs. Cost of this program is about $25,000 annually.

"Evaluation of An Experimental Larvicide (MON-0585) Against Aedes canadensis Mosquitoes," by Joseph C. Cooney and Eugene Pickard. Environmental Biology Branch Report, 1972. EB-72-1.*

"Susceptibility of Anopheles quadrimaculatus Larvae to Abate Insecticide," by Joseph C. Cooney and W. W. Barnes. Environmental Biology Branch Report, 1973. EB-73-14.*

"Field Tests With Abate and Dursban Insecticides for Control of Floodwater Mosquitoes in the Tennessee Valley Region," by Joseph C. Cooney and Eugene Pickard. Mosquito News, Vol. 34, No. 1, 1974.*

"Comparative Field Effectiveness of Two Formulations of Abate Insecticide Applied for Control of Anopheles quadrimaculatus Larvae, Summer 1973," by Eugene Pickard and Joseph C. Cooney. Environmental Biology Branch Report, 1974. I-EB-74-2.*

Category: Vector Control.

MOSQUITO CONTROL IN BEAVER PONDS. A two-year study was conducted to determine the amount of mosquito (Anopheles quadrimaculatus) production associated with beaver ponds and its effect on the mosquito control program. Dipping records showed high mosquito production in some of the beaver ponds. No significant reduction in mosquito production was observed with the introduction of larvivorous fish. Introduction of an aquatic plant species (Lemna minor) that limits anopheline mosquito production was unsuccessful in colonizing a beaver pond. Water level management by using plastic tubes through beaver dams to regulate flow was impractical. The use of granular insecticide formulations will be investigated as a possible mosquito control measure. A final report is scheduled for 1975.

Category: Vector Control.

MOSQUITO CONTROL THROUGH HABITAT MANAGEMENT. Studies were initiated in 1969 to determine the feasibility of controlling mosquito production in certain areas by planting water-tolerant trees, thereby creating habitats unsuitable for mosquito production. Observations on changes in mosquito habitats and populations in plantations of baldcypress, sycamore, and loblolly pine will be made over a period of several years. Tree plantations have been established in both permanent pool and floodwater mosquito habitats. An interim report is scheduled for 1975.

"Tree Plantings for Mosquito Control, 1969," Mosquito News, Vol. 29, No. 2. by Gordon E. Smith, T. F. Hall, and Eugene Pickard.*

Category: Vector Control.

FLOODWATER MOSQUITO SURVEY OF PROBLEM AREAS AND PROBLEM DEFINITION. Water level management for flood control and surcharge for malaria control may in some situations create conditions suitable for the production of floodwater mosquito species. Control programs for floodwater mosquitoes in the past have been restricted to a few city areas where the problem sites were defined in 1955. However, numerous additional complaints of floodwater mosquito production in the vicinity of TVA property are received each year from many areas. A survey will be made to identify those areas where significant floodwater mosquito production is occurring on TVA lands or waters or elsewhere as a result of TVA activities. After these areas are identified and defined, methods of control will be recommended. A report will be prepared after completion of the survey--tentatively 1976.

Category: Vector Control.

TRAINING PROGRAM FOR CERTIFICATION OF PESTICIDE APPLICATORS. The passage of the Federal Environmental Pesticide Control Act of 1972, which regulates the use of pesticides, requires that applicators of pesticides classified for restricted use must be certified or that pesticides must be applied under the direct supervision of a certified applicator. A training course will be conducted for all TVA applicators or their supervisors to prepare them for a certification examination. The course will include basic concepts and strategies of pest management; ecology and identification of specific pests; application, storage, and disposal of pesticides and their uses, toxicities, mode of action, properties, etc.; safety in handling pesticides; and safety equipment.

"Training Program for the Certification of Pesticide Applicators and Supervisors," by Joseph C. Cooney, T. F. Hall, Eugene Pickard, and W. W. Barnes. Environmental Biology Branch, 1974.*

TVA Division of Environmental Planning, 268 401B, Chattanooga, Tennessee 37401
Phone: (615) 755-3011, ext. 3161. Copies of starred reference items available upon request.

Category: Air Quality.

TRACE ELEMENT MATERIAL BALANCES FOR COAL-FIRED POWER PLANTS. Study to determine the fate of trace elements in coal consumed in the generation of electricity at a large power plant, by obtaining mass balances via in-plant sampling of coal, bottom ash, fly ash, etc. (In a complementary phase of the study, ORNL is sampling in the environment around the plant to ascertain the fate of these elements.) Results through January 1973 (Allen Steam Plant) are approximate mass balances for many elements, as measured by neutron activation analysis, spark source mass spectrometry, and atomic absorption spectroscopy. Average imbalances are negative, with relatively volatile elements (Hg, As, Sb, Se, etc.) yielding unsatisfactory balance. New electrostatic precipitators are efficient for most elements in fly ash.

Future sampling to be directed improving measurements, locating sources of anomalies.

Category: Air Quality.

PHYSIOLOGICAL RESPONSES TO SULFUR DIOXIDE, SULFURIC ACID, FLY ASH, AND THEIR MIXTURES. Laboratory study by Hazleton Laboratories and TVA to determine the biological effects of the long-term exposure of experimental animals to relatively low-level concentrations of sulfur dioxide, sulfuric acid mist, and fly ash.

Four groups of cynomolgus monkeys were exposed to these (inhalation) mixtures:

Mixture	SO_2, ppm	H_2SO_4 (< 1 um), mg/m^3
1	0.11	0.10
2	1.04	0.10
3	5.15	0.11
4	5.23	0.97

Histophathological evaluation of selected tissues revealed no adverse changes in animals chronically exposed to above mixtures. No well defined changes attributable to the exposure conditions could be ascertained from the results of pulmonary function tests or physiological measurements. Studies are completed and papers are being prepared for publication in The Archives of Environmental Health.

Category: Industrial Hygiene.

DEVELOPMENT OF AN INTEGRATED HAZARD CONTROL INFORMATION ACQUISITION AND PROCESSING SYSTEM. Design and implementation of a system to acquire workplace and employee hazard exposure data; to provide systematically to management the information needed for curtailment and prevention of hygiene hazards; and to coordinate these data with medical operations. Project started in April 1973.

1462

Categories: Nuclear Energy, Radiological Research.

POTENTIAL RADIOLOGICAL IMPACT OF THE NUCLEAR POWER INDUSTRY. An interagency study of the radiological impact through the year 2000 of an expanding nuclear power economy on the Tennessee-Cumberland River basins. The objective is an indepth appraisal of the generation, management, and control of radioactive effluents from nuclear facilities through the cooperative efforts of AEC, TVA, ORNL, HEDL, and ATDL/NOAA. A computer model (HERMES) developed for the AEC in 1970 by HEDL was critiqued by TVA, ORNL, and NOAA to determine applicability to the Tennessee Valley Region (TVR). Based on critique and on results for Upper Mississippi Region, HEDL staff are revising model. TVA and ORNL are transmitting data to HEDL for use in HERMES, including demographic data and comprehensive nuclear facility specifications.

Categories: Solid Waste Management, Energy Resources, Resource Recovery.

ENERGY RECOVERY BY USE OF PREPARED REFUSE AS A FUEL SUPPLEMENT IN A COAL-FIRED STEAM-ELECTRIC PLANT - MEMPHIS/ALLEN STEAM PLANT. The development, in cooperation with the city of Memphis, Tennessee, of a project demonstrating practical recovery of energy from soild refuse. Sewage sludge will be included. There is high probability that the system will be financed through revenue bonds. Economic analysis shows promise of net benefit in power production costs, as well as elimination of a major disposal problem for Memphis.

Category: Water Quality.

MERCURY RECYCLING IN RESERVOIRS. An investigation of possible ways to deactivate or reduce to a safe level mercury pollution in lakes and streams. Study is directed toward (1) determining chemical form, distribution, and availability of mercury in sediments, (2) evaluating natural deactivation rates and mechanisms, and (3) evaluating feasibility of artificial deactivation methods such as dredging, reservoir manipulation, and chemical treatment. Pickwick Reservoir selected as one study site since reservoir was closed for fishing in 1970 due to mercury contamination. Bottom sediments obtained by TVA and analyzed by TVA, ORNL, and Vanderbilt laboratories. Additional sediment cores collected in late 1972 and sent to Vanderbilt to be used in bioassay studies of mercury uptake.

"Experience with Heavy Metals in the Tennessee Valley Authority System," W. R. Nicholas and B. A. Brye, presented at the International Conference on Heavy Metals in the Aquatic Environment, December 1973, Nashville, Tennessee. Final paper available April 1974.*

"Mechanisms of Mercury Transformation in Bottom Sediments," Peter A. Krenkel, W. Dickinson Burrows, Eung Bai Shin, Kathleen I. Taimi, Elizabeth D. McMillen, Technical Report Number 32, Environmental and Water Resources Engineering, Vanderbilt University, Nashville, Tennessee, October 1973.

"Mechanisms of Mercury Transformation in Bottom Sediments," Peter A. Krenkel, Robert E. Reimers, W. Dickinson Burrows, Technical Report Number 31, Environmental and Water Resources Engineering, Vanderbilt University, Nashville, Tennessee, May 1973.

"Mechanisms of Mercury Transformation in Bottom Sediments," Progress Report, Peter A. Krenkel, Robert E. Reimers, Eung Bai Shin, W. Dickinson Burrows, Technical Report Number 27, Environmental and Water Resources Engineering, Vanderbilt University, January 1972.

"Mercury in Flesh of Fish Taken From TVA Reservoirs," W. R. Nicholas, June 1973.*

Categories: Water Quality, Mercury Pollution.

MERCURY FIXATION, TRANSLATION, AND METHYLATION IN RESERVOIRS. A study by TVA and the Sport Fishery Research Foundation to investigate mercury pollution and the feasibility of methods of nullifying its adverse effects on reservoir biota. Principal findings indicate that mode of transport of HG contamination from Pickwick and Kentucky Reservoirs was by sediment transport and the Hg in sediments in Pickwick will eventually be "sealed off" by deposition of new uncontaminated silt. No practical way of accelerating sealing or to deactivate Hg in sediments has been identified. A significant study conclusion is that not all Hg in fish is methyl Hg, and that methods of Hg analyses in fish and sediments are of questionable validity.

"Experience with heavy metals in the Tennessee Valley Authority System," W. R. Nicholas and B. A. Brye, presented at the International Conference on Heavy Metals in the Aquatic Environment, December, 1973, Nashville, Tennessee, final paper available April, 1974.*

"Mechanisms of Mercury Transformation in Bottom Sediments," Peter A. Krenkel, W. D. Burrows, E. B. Shin, K. I. Taimi, E. D. McMillen, Technical Report #32, Environmental and Water Resources Engineering, Vanderbilt University, Nashville, Tennessee, October, 1973.

Categories: Water Quality, Heated Water Discharges.

AQUATIC LIFE RESEARCH PROJECT. A cooperative research program by TVA and EPA to investigate the effects of heated water on aquatic life under controlled conditions. Construction began in spring of 1973, and will be completed in 1974. Channel conditioning prior to testing will require one year, to be followed by testing at normal seasonal temperature "envelope," and at 5° C and 10° C above envelope.

Category: Vector Control.

BITING FLY BIOASSAYS. Studies were conducted in 1972 to determine the effectiveness of the insecticide Dibrom 14 when applied as a thermal fog against adult biting flies (Stomoxys calcitrans). Results from these preliminary studies showed that the insecticide was effective against caged stable flies at a distance of up to 100 yards from the portable fogger. Because of other program priorities, additional studies have been delayed and are not planned for 1974 or 1975.

Division of Forestry, Fisheries, and Wildlife Development, Forestry Building, Norris, Tennessee 37828 Phone: (615) 494-7173. Copies of starred reference items available on request.

Category: Aesthetic Resources.

AESTHETIC IMPROVEMENT OF FORESTS, WILD LANDS, AND WATERWAYS. The protection and re-establishment of natural visual environmental resources in the Tennessee Valley by identifying unique visual entities, establishing pre-planning procedures in potentially landscape-damaging forest activities, developing adequate reclamation processes, and promoting improved management procedures. Its objectives are (1) to identify and protect and where needed enhance and/or restore the natural scenic resources of the Tennessee Valley, (2) to ensure full contribution of scenic resources to the public, primarily on TVA lands, and (3) to minimize detrimental visual impact to landscapes resulting from wild land resource management operations, such as strip mining and logging.

Category: Environmental Education.

NATURAL RESOURCE AWARENESS AND ACTION. A program to inform and educate people about problems and opportunities for improving the Valley's environment. Precise aims are to develop appropriate information materials and implement demonstration education programs to bring people to a greater awareness of environmental problems and stimulate action which can result in taking advantage of these opportunities.

Use That Campus*

Arbor Day booklet*

Study Units prepared for teachers (Grades 4-9)
All units include: Introduction to subject area (teachers' briefing); pre-site, on-site, and post-site encounters (activities); sources of available related materials (i.e., publications, films); and reference list.

Units available -*

1. Natural recycling
   Uses natural systems of recycling to demonstrate the roles of various aquatic and terrestrial organisms in the recycling process. Compares the processes with ones in the human community related to soild waste disposal problems.

2. Soil erosion
   Describes the processes involved in building soil; types and effects of erosion; conservation practices.

3. Forestry
   Discusses the importance of forestry as related to economics, aesthetics, wildlife benefits, clean water, etc. Activities involve the use of forester's tools and measurements.

Similar units to be available in spring 1974:*

Air quality
Water quality
Population density
Seed dispersal
Plant succession
General ecology

Category: Fisheries Resources.

FISHERIES ECOLOGY. Study to obtain new and basic knowledge on the ecology of Valley reservoir fishes for contribution to the agency-wide data base and for use in making optimum resource management decisions, and to evaluate concepts and techniques.

Fish Monitoring Investigations: Quarterly reports issued for Browns Ferry Nuclear Plant, Wheeler Reservoir, Alabama; Cumberland Steam Plant, Cumberland River, Tennessee; and Sequoyah Nuclear Plant, Chickamauga Reservoir, Tennessee.*

Also the fish inventories of the above reservoirs.*

Category: Fisheries Resources.

TAILWATER EVALUATIONS. The assessment of limnological conditions related to tributary and main stream tailwater fisheries for contributions to the agency-wide data base and for developing optimum fisheries management of specific tailwaters. Its objectives are (1) to assess and evaluate limnological conditions in three to five tributary tailwaters and one main stream tailwater each year, and (2) on the basis of limnological determinations, to recommend specific fish management actions.

Category: Fisheries Resources.

NORRIS RESERVOIR MANAGEMENT PROGRAM. The development and implementation of an optimum sport fishery management program on Norris Reservoir. Its objectives are (1) to be able to predict the location, both spatial and seasonal, of sport fish, with emphasis on sauger, walleye, white bass, and crappie, through easily measurable parameters such as water temperature, dissolved oxygen, or water level, (2) to add to the body of knowledge concerning the life history of these fish which will enable development of long-range management programs, (3) to determine present sport fish harvest patterns and disseminate such information to sport fishermen, along with the seasonal distribution data as they are gathered, thus realizing immediate payoffs, and (4) to determine present access needs and to provide more convenient facilities for fishermen.

Norris Reservoir Fertilizer Study: Part I. Effects of Fertilizer on Food Chain Organisms and Fish Production. Carl E. Wood and Tommy L. Sheddan. Reprinted from Papers for Joint Industry/Govt. Task Force Meeting on Eutrophication, Muscle Shoals, Alabama, April 29-30, 1970.*

Category: Fisheries Resources.

MELTON HILL RESERVOIR MANAGEMENT PROGRAM. Project to develop and implement a comprehensive fisheries management plan for Melton Hill Reservoir. Its objectives are (1) to create and maintain a sport fishery in Melton Hill Reservoir comparable in harvest and opportunity with those other lake fisheries which are providing such conditions, and (2) to develop management procedures and techniques which may be applied to other lakes with similar physical characteristics, and possibly to the management of any lake fishery.

Fish Habitat and Population Changes Resulting from Impoundment of Clinch River by Melton Hill Dam. Richard E. Fitz. Reprinted from Journal of the Tennessee Academy of Science, January 1968.*

Category: Fisheries Resources.

NORRIS TAILWATER MANAGEMENT. The design and implementation of a fishery management plan for Norris Dam tailwater, in cooperation with the State of Tennessee and the U.S. Fish and Wildlife Service, which will optimize the potential trout fishery. Its objectives are (1) to define the limnological (water quality, physical, and biological) conditions which limit the potential trout fishery in the Norris Dam tailwater, and (2) to design a management plan which will optimize trout fishing within these limits and to suggest methods whereby limiting factors may be reduced or eliminated to improve the trout fishing capability of this tailwater. Seasonal sampling of fish and bottom fauna began in January 1971; cooperative project is for three years and evaluation will be continued as necessary. Project is continuing on schedule.

Category: Fisheries Resources.

SMALLMOUTH BASS IN WILSON TAILWATER. Study to determine the characteristics of the smallmouth bass population, its ecological relationships, and its sport fishery in Wilson Dam tailwater (Pickwick Reservoir), Alabama. Its objectives are (1) to define the extent, magnitude, and seasonality of the sport harvest of smallmouth bass in Wilson tailwater, (2) to determine characteristics of the life history and ecology of smallmouth bass in Wilson tailwater, and (3) to identify the unique characteristics of the Wilson Dam tailwater habitat.

Categories: Fisheries Resources, Stream Reclamation.

RECLAMATION OF STREAMS. The assessment and implementation of plans to hasten the recovery of damaged streams following pollution abatement. Its objectives are to (1) to facilitate the biological recovery of damaged streams by identifying and recommending means of alleviating habitat conditions which may be limiting to biological recovery and by rejuvenating damaged streams through faunal transplanting, restocking, and habitat improvement, and (2) to extend the range of certain valued species of fish and mollusks by transplanting them into available habitat of recovering streams.

Category: Fisheries Resources.

UPPER CLINCH-POWELL RIVERS. An assessment of biological and physical conditions in these rivers to better manage the Norris Reservoir and the Clinch and Powell River fisheries, while preserving the unique faunal assemblages and their habitats. Its objectives are (1) to assess the fishery potential

and seasonal migrations of fish from Norris Reservoir into the Clinch and Powell Rivers, (2) to evaluate the effect of sport fish harvest on the fishery of both rivers and Norris Reservoir, (3) to assess and preserve the unique mollusk populations and their habitats in the Clinch and Powell Rivers, and (4) to evaluate the present commercial harvest of mussels and its effect on the mussel resources.

Category: Fisheries Resources.

SEQUOYAH NUCLEAR PLANT ENVIRONMENTAL ASSESSMENT AND MONITORING. A determination of the effects of operation of the plant on species composition, relative abundance, fisherman catch, and movement of fishes in Chickamauga Reservoir.

Fish Monitoring Investigations: Quarterly reports for Sequoyah Nuclear Plant.*

Category: Fisheries Resources.

BROWNS FERRY NUCLEAR PLANT ENVIRONMENTAL ASSESSMENT AND MONITORING. A determination of the effects of the plant's operation on species composition, relative abundance, fisherman catch, movement, and larval fishes in Wheeler Reservoir.

*Fish Monitoring Investigations: Quarterly reports for Browns Ferry Nuclear Plant

Category: Fisheries Resources.

WATTS BAR NUCLEAR PLANT ENVIRONMENTAL ASSESSMENT AND MONITORING. A determination of the effects of operation of plant on species composition, relative abundance, fisherman catch, and movement of fishes in Chickamauga Reservoir.

*Fish Monitoring Investigations: Quarterly reports for Chickamauga Reservoir

Categories: Fisheries Resources, Aquatic Systems.

AQUATIC SYSTEM ANALYSIS. Studies to acquire an understanding of the dynamics of the Valley's fisheries resources and to develop an information base in terms of habitats and populations, their interactions, and responses to them from environmental changes. Its objectives are (1) to develop first-generation (generalized) models relating existing biological data to ecological and limnological parameters, (2) to broaden the necessary data base on aquatic resources as indicated by analysis of first-generation models, and (3) to develop descriptive and predictive aquatic-systems models for use in developing integrated resource management and utilization strategies.

Tennessee Valley Streams: Their Fish, Bottom Fauna, and Aquatic Habitat.* Separate technical reports as follows:*

The Emory River, 1968
The Powell River Drainage Basin, 1968
The Flint River Drainage Basin, 1969
Upper Little Tennessee River Drainage Basin, June 1970
Sequatchie River Drainage Basin, June 1970
Buffalo River Drainage Basin, September-October 1971

Fish Inventory Data. Separate reports as follows:*
Chickamauga Reservoir, 1970
Wheeler Reservoir, 1972
Guntersville Reservoir, 1971
Pickwick Reservoir, 1971
Watauga Reservoir, 1971
Nickajack Reservoir, 1972
South Holston Reservoir, 1972
Fort Loudoun Reservoir, 1972
Douglas Reservoir, 1973

Categories: Fisheries Resource, Heated Water Discharges.

BIOTHERMAL RESEARCH PROJECT. A determination of the lethal and sublethal effects of elevated water temperatures on warmwater reservoir fish species in relation to power plants operating on the Carnot cooling cycle. An effort will be made to document the effects of heated water discharge (at an existing power plant) in relation to fish larvae entrainment, seasonal population abundance, temperature tolerance, reproduction and feeding.

Categories: Fisheries Resources, Waterfowl Resources.

BELLEFONTE NUCLEAR PLANT ENVIRONMENTAL ASSESSMENT AND MONITORING. A study to obtain basic biological data about the fisheries and terrestrial plants and animals including species composition, relative abundance, standing crop of larval and adult fishes, movement, distribution, and growth in Guntersville Reservoir.

Category: Fisheries Resources.

HARTSVILLE NUCLEAR PLANT ENVIRONMENTAL ASSESSMENT AND MONITORING. Project to sample adult fish with all suitable methods in every season over a two-year period in the river, backwater, and creeks in the site vicinity; intensive larval fish sampling in appropriate season; standing crop, age, and growth analyses and creel census.

Category: Fisheries Resources.

BEAR CREEK CHANNELIZATION. A study to determine the effects of channelization on the quality and kinds of bottom food organisms for fish in selected areas of Bear Creek and two of its major tributaries--Little Bear and Cedar Creeks, Alabama.

Categories: Fisheries Resources, Waterfowl Resources, Forest Resources, Wildlife Resources.

COMPREHENSIVE PLANNING OF WILD LAND USE. The Development of a comprehensive land-use guide for forest and wild land areas as an integral part of TVA's overall planning for more efficient use and improvement of the Valley's natural resources. Its objectives are (1) provide essential facts about present and potential forest and wild land use, (2) forecast Valley land use based on interdisciplinary planning of future needs for timber, wildlife, fisheries, recreation, agriculture, and other uses of land, (3) develop comprehensive plans for all subregions of the Valley, and (4) explore incentives and legal ways for guiding the development of land

resources into better use combinations.

Categories: Forest Resources, Wildlife Resources.

EXTENDING FOREST AND WILDLIFE MANAGEMENT. A program to increase the number of acres in the Tennessee Valley being managed for timber, wildlife, and related benefits, and to provide landowners with the best available resource management knowledge they need to realize their individual objectives for owning forested land and motivate these people to action. The objectives or desires are varied and complex, ranging from monetary returns to personal enjoyment, such as wildlife observation or the serenity of an unspoiled woodland setting.

A Forest Management Sales Notebook. Roger W. Bollinger and Eugene Ohlson. Reprinted from Journal of Forestry, June 1972.*

Categories: Forest Resources, Wildlife Resources.

FOREST AND WILDLIFE MANAGEMENT TECHNOLOGY AND PRACTICES. A development and test of up-to-date technical knowledge, management models, and decision-making tools for owners and managers of forest and wild lands in the Tennessee Valley. It's objectives are (1) to secure biological knowledge to predictably optimize development and protection of forest and wild lands, (2) to develop and test models and techniques to manipulate wild land ecological systems consistent with landowner objectives, and (3) to evaluate and continually reappraise management technology, being sensitive to changing resource demands, environmental patterns, and human attitudes.

A System Analysis/Ecological Control Approach to Multiresource Forest Management. Thomas H. Ripley and David O. Yandle. Reprinted from Journal of Forestry, November 1969.*

A Wildlife Looks at Forest Resource Management. Thomas H. Ripley. Reprinted from Journal of Forestry, July 1973.*

Categories: Forest Resources, Wildlife Resources.

FOREST AND WILD LAND DEVELOPMENT OF TVA PROPERTIES. Protection and management of TVA's forest and wild lands in order to maximize public benefits from the forestry, fisheries, and wildlife resources. Its objectives are (1) to secure full development and protection of forest and wild land resources from TVA lands, reflecting changing social, economic, and environmental needs of the Tennessee Valley, (2) to develop and provide TVA land managers with the best knowledge and management techniques to predictably optimize forest and wild land benefits, (3) to evaluate and continually reappraise TVA land management, being sensitive to changing resource demands, environmental patterns, and human attitudes, and (4) to demonstrate on TVA lands that a high order of comprehensive resource management can be implemented on private and other public lands in the Tennessee Valley region.

Categories: Forest Resources; Wildlife Resources.

FOREST AND WILD LAND RESOURCE SURVEYS AND FORECASTS. A study to maintain fact-finding inventories for analyses of forest and wild land resources, land use and ownership, ecological and hydrologic conditions, wildlife

food and habitat, and recreational and scenic resources in order to (1) evaluate past program results, predict trends, and provide information for establishing new program direction, (2) keep apprised of timber growth and harvest relationships, changes in land use, ecological and environmental conditions, (3) produce the basic resource information for answering numerous requests each year from development groups and cooperating agencies, and (4) help identify resource problems and opportunities that need specific attention.

Forest Inventory Statistics. Separate 18-20 page reports on 60 county units in the Valley.*

Categories: Forest Resources, Wildlife Resources.

FOREST AND WILD LAND HYDROLOGY. A determination of water regimen relationships for forest and other wild lands to achieve the most effective protection, management, and use of all land and water resources in the Tennessee Valley. Its objectives are (1) to determine the effects of forest cover and forest management practices--including tree planting, erosion control measures, logging road construction, timber cutting, fertilization, special wildlife development, and other multiple-use activities--on runoff, infiltration, sedimentation, water quality, and other elements in the water cycle.

Forest Hydrologic Research Conducted by the Tennessee Valley Authority. Birger W. Ellertsen. Reprinted from Water Resources Bulletin, June 1968.*

Categories: Forest Resources, Wildlife Resources, Aesthetic Resources.

ECOSYSTEMS SURVEYS AND ANALYSES. A study to expedite the understanding and use of terrestrial ecosystem data in the planning process. Its objectives are (1) to inventory and document current knowledge about the terrestrial ecosystems of the Tennessee Valley Region; encourage and guide new studies to enhance the understanding and appreciation of the forest and wild land resource, (2) to develop the capability to assess the likely impact of predicted or proposed land-use or policy decisions on the terrestrial ecosystems of the region, (3) to develop the capability to systematically evaluate the terrestrial landscape to answer questions regarding the suitability of land treatment practices, potential productivity, suitability for intensive use and optimal route or site selection, (4) to translate terrestrial ecosystem and landscape data into understandable form such as indices to aid the planning community, and (5) to develop an effective liaison with other federal, regional, and state agencies and institutions to exchange ideas and encourage the utilization of the TVA region where appropriate as a test-bed to demonstrate and test new research and technology.

Categories: Forest Resources, Wildlife Resources.

PLANT GENETICS AND BREEDING. A program to improve forest and wild land vegetation in the Tennessee Valley through genetic research and development. Its objectives are (1) to establish breeding populations of forest and wild land vegetation from which we can develop materials with such characteristics as fast growth and high-quality wood in trees, and exceptional food quantity and quality in wildlife shrubs, but being sure that during this development period we recognize, identify, and control potentially dangerous

situations such as disease or insect susceptibility, alternate host development, or over-agressive vegetation that might upset ecosystems or plant communities, (2) identify and verify genetic superiority and manipulate the breeding population to produce genetically superior plant material, (3) assure establishment of adequate seed production areas to meet Valley state seed demands, (4) investigate and determine best methods to incorporate the genetically improved material into Valley forests and revegetation programs, and (5) produce new genetical, physiological, and silvicultural knowledge for direct application in this program and those of other agencies and regions.

Micro-bioassay Method Applied to the Chestnut Blight Fungus. Paul E. Barnett. Reprinted from Plant Disease Reporter, August 1973.*

Loss of Shortleaf Pine Flowers under Natural Conditions. Donovan C. Forbes. Reprinted from Tree Planters Notes, Vol. 22, No. 1.*

Genetic Improvement of Hardwood Fiber Production in the North-Central Region: Potential and Breeding Alternatives. R. E. Farmer, Jr. Reprinted from Proceedings 10th Lake States Forest Tree Improvement Conference. USDA Forest Service General Technical Report NC3, 1973.*

Decision Making for Development and Use of Genetically Improved Hardwoods. R. E. Farmer, Jr. Reprinted from Journal of Forestry, February 1973.*

Genetic Improvement of Eastern Cottonwood. Robert E. Farmer, Jr. and Carl A. Mohn. Reprinted from Proceedings of 19th Annual Forestry Symposium, Louisiana State University, 1970.*

Categories: Forest Resources, Wildlife Resources.

PLANT PHYSIOLOGY. A study to secure new physiological and silvical information and associated techniques needed in breeding, establishing and culturing forest and wild land vegetation. Its objectives are (1) to develop information and seed handling techniques to establish vegetation, (2) to develop seedling production and handling information and techniques to establish vegetation, (3) to develop vegetative propagation procedures for use in tree and shrub breeding programs, (4) to develop procedures to control flowering and fruiting in breeding arboreta and seed orchards, (5) to advance TVA's contribution in the area of tree and shrub nutrition, and (6) to produce new knowledge in basic plant science.

Mist Propagation of Black Cherry Cuttings: Some Early Results and Prospects for Use in Forestry. Robert E. Farmer, Jr. and Geraldine C. Hall. Reprinted from Combined Proceedings International Plant Propagators Society, 1969.*

Gibberellic Acid Induces Germination and Growth of Dormant Black Cherry Seed. R. E. Farmer, Jr. and G. C. Hall. Reprinted from Tree Planters Notes, Vol. 22, No. 2, 1971.*

In vitro Germination of Black Walnut Pollen. Geraldine C. Hall and Robert E. Farmer, Jr. Reprinted from Canadian Journal of Botany, Vol. 49, No. 6, 1971.*

Rooting Black Walnut Cuttings. Robert E. Farmer, Jr. Reprinted from The Plant Propagator, Vol. 17, No. 2, May 1971.*

Phenology and Foliar Control of Floral Morphogenesis in Prunus serotina. Robert E. Farmer, Jr. and Geraldine C. Hall. Reprinted from Phytomorphology, Vol. 21, No. 1, March 1971.*

In Vitro Growth of Black Cherry Callus. James G. Caponetti, Geraldine C. Hall, and R. E. Farmer, Jr. Reprinted from Botanical Gazette, Vol. 132, No. 4, December 1971.*

Precocious Flowering of Black Cherry. Robert E. Farmer, Jr. and Paul E. Barnett. Reprinted from Canadian Journal of Forest Research, Vol. 2, No. 1, 1972.*

Black Cherry Seed Germination. Donovan C. Forbes. Reprinted from Tree Planters Notes, No. 23, No. 3, August 1972.*

Altitudinal Variation in Seed Characteristics of Black Cherry in the Southern Appalachians. Robert E. Farmer, Jr. and Paul E. Barnett. Reprinted from Forest Science, Vol. 18, No. 2, June 1972.*

Juvenile Growth of Planted Northern Red Oak; Effects of Fertilization and Size of Planting Stock. A. A. Foster and R. E. Farmer, Jr. Reprinted from Tree Planters Notes, January 1970.*

Effects of Nitrogen and Phosphorus Fertilization on Juvenile Growth of Planted Yellow-poplar on an Eroded Old Field. R. E. Farmer, Jr., E. A. Snow, and J. W. Curlin. Reprinted from Soil Science Society of America Proceedings, March-April 1970.*

Response of Pine and Mixed Hardwoods Stands in the Tennessee Valley to Nitrogen and Phosphorus Fertilization. R. E. Farmer, Jr., G. W. Bengtson, and J. W. Curlin. Reprinted from Forest Science, June 1970.*

Categories: Forest Resources, Wildlife Resources.

PRODUCTION AND ESTABLISHMENT OF VEGETATION. A program to secure the production and establishment of plant materials to meet revegetation needs in the Tennessee Valley region. Its objectives are (1) to identify revegetation needs of the Tennessee Valley and estimate kinds and amounts of plant materials required to meet these needs, (2) to assure adequate supplies of required plant materials are available, (3) to develop and secure adoption of improved technology for plant materials production and establishment, and (4) produce new basic knowledge concerning the production and establishment of vegetation.

Pokeweed Seed Germination: Effects of Environment, Stratification, and Chemical Growth Regulators. R. E. Farmer, Jr. and Geraldine C. Hall. Reprinted from Ecology, Vol. 51, No. 5, 1970.*

Categories: Forest Resources, Wildlife Resources, Strip Mine Reclamation Aesthetic Resources, Water Quality.

STRIP MINE RECLAMATION. Research and Demonstration to assure surface mined lands are restored for useful production of wildlife, other forest products, and to protect environmental values. Its objectives are (1) to develop and secure adoption of improved mining and reclamation technology for current mining, (2) to reclaim orphan lands in the Tennessee Valley region, and (3) to secure comprehensive planning (and implementation) of surface mined areas (including transportation systems, renewable forest resources, water protection and management and aesthetics) consistent with regional needs and opportunities.

Strip Mine Reclamation Demonstration, Fonde, Bell County, Kentucky. FF&WD and Ky. Strip Mine Research Coord. Committee, December 1967.*

Strip Mine Reclamation after 5 years - Wise County, Virginia. TVA, N.Y. Mining & Mfg. Co., and Va. Div. of Mined Land Reclamation, 1968.*

Water Control. A Key to Reclaiming a Mountain Strip Mine in Morgan County, Tennessee. 1969.*

Reclamation Brings Wildlife Back to Paradise Strip Mine. 1969.*

Sequatchie Strip Mine Reclamation Benefits Wildlife. 1970.*

Three Years Development of a Public Use Wildlife Area on a Mountain Coal Surface Mine in Southwest Virginia. Dale K. Fowler and Charles H. Peery, III. Reprinted from Research and Applied Technology Symposium on Mined Land Reclamation, March 1973.*

Evaluation of Municipal Compost for Strip Mine Reclamation. David H. Scanlon, Carroll Duggan, and S. D. Bean. Reprinted from Compost Science, Vol. 14, No. 3, May-June 1973.*

Categories: Forest Resources, Wildlife Resources, Strip Mine Reclamation, Aesthetic Resources, Water Quality.

COAL STRIP MINE RECLAMATION COMPLIANCE. A program to secure, through contract provisions, effective mined land planning, environmental protection, and reclamation of all lands disturbed in supplying coal to TVA. Its Objectives are (1) to maintain surface mining and reclamation contract provisions consistent with developing technology and standards, (2) to provide an effective proving ground for surface mining reclamation techniques in support of adequate legislation and enforcement, and (3) to secure maximum environmental protection of areas affected by deep mining operations supplying coal to TVA.

Categories: Forest Resources, Air Quality.

REGIONAL AIR QUALITY MANAGEMENT. A program to monitor air quality, evaluate effect of man's activities on forest and wild land resources, and formulate preventative or mitigative measures. Its objectives are (1) to measure air quality conditions and their effect on forest and wild land resources in the Tennessee Valley and in the vicinity of industrial installations operated by TVA, (2) to describe and evaluate impacts of air pollutants on the terrestrial ecosystems, (3) to identify and promote remedial strategies, and (4) to produce new knowledge concerning the terrestrial environments and the factors affecting it.

Categories: Forest Resources, Wildlife Resource, Aesthetic Resources.

REVEGETATION OF THE RESERVOIR INUNDATION ZONE. Identification of plants having wildlife, aesthetic, and erosion control values which are adaptable to environmental conditions of periodic inundation; to test techniques (notably hydroseeding) for establishing these plants. Tested barge hydroseeding technique on Cherokee Reservoir in 1971 and on Norris Reservoir in 1972; evaluated wildlife usage of revegetated sites on Norris Reservoir. Equipment modification is indicated.

Category: Forest Resources.

EVEN-AGED MANAGEMENT OF HARDWOODS. A program to evaluate the effect of even-aged management of hardwoods in the Tennessee Valley to determine effects of clean-cutting on regeneration, species composition, wildlife, aesthetics, and water quality. Initial tree species regeneration counts have been completed on one 50-acre area; songbird and small mammal studies are under way in this and a second 25-acre area. Aesthetics are being evaluated and limited data on water quality are being assessed.

Categories: Forest Resources, Water Quality.

FOREST INFLUENCES STUDIES. To determine basic relationships between the effect of forest cover and forest management practices on runoff, infiltration, water quality, and other elements involved in the water cycle; and to determine hydrologic effects of reforestation, other erosion control practices, logging road construction and use, timber cutting, wildlife management, and other multiple land use activities. Forest cover and hydrologic information assembled for 3 experimental watersheds in east (White Hollow) and west (Pine Tree Branch) Tennessee, and north Alabama (Upper Bear Creek); studies to continue through F.Y. 1973. White Hollow study will be terminated; summary report scheduled next year will describe multiple-use activities 1958-1972. Terrestrial ecology survey to be completed on Pine Tree Branch watershed and followed by commercial cutting operations beginning in F. Y. 1974. Hydrologic and water quality data on two small-paired watersheds in north Alabama will further calibrate and refine mathematical models for forest management.

Category: Natural and Scenic Resources.

RESEARCH NATURAL AREAS. Identification and preservation of unique examples of natural ecosystems for scientific and environmental study. A redcedar area has been identified and acquisition of outstanding agricultural rights for this area are under way.

Category: Rare and Endangered Species.

IDENTIFICATION AND PROTECTION OF CRITICAL, UNIQUE, AND ENDANGERED TERRESTRIAL ORGANISMS. Protection and preservation of critical, unique, and endangered terrestrial organisms and the ecosystems upon which they depend; and in this context, detection and description of ecological problems affecting the quality of man's environment.

Categories: Solid Waste Management, Forest Resources.

UTILIZATION OF RESIDUES AND ASSOCIATED POLLUTION ABATEMENT. A program to assist forest industries to efficiently and economically increase their use of wood residues and to decrease their present contribution to the Valley's pollution load. Its objectives are (1) to assist forest products industries to process and utilize wood and wood residues economically, (2) to bring to the attention of the forest products industries new or improved methods of controlling pollutants from the plants, and (3) to assist the pulp, paper, and other chemical conversion industries in eliminating pollution.

A Guide to 1970 Wood Residue Volumes in the 125 Tennessee Valley Counties, Technical Note B4, April 1973.*

Wood Residues Produced at Planing Mills, Tennessee Valley Area, Technical Note B5, March 1973.*

Category: Strip Mine Reclamation.

NEW METHODS AND TECHNIQUES FOR SURFACE MINING COAL IN MOUNTAINOUS AREAS. Study to explore techniques and costs of mountain stripping, including best methods for materials handling, earth shaping, soil stabilization, and landscape values. Mining is proceeding on a 3,000-foot-long section near the west end of the south side of Massengale Mountain. Mining will proceed in an easterly direction to the lease boundary. The benches are being backfilled as the mining proceeds easterly. Revegetation follows closely the backfilling. Work started in July 1972, and it is anticipated that two years will be spent in mining the subject area.

Categories: Strip Mine Reclamation, Aesthetic Resources.

AESTHETIC RECLAMATION OF COAL STRIP MINED LANDS. Program to develop techniques that will restore scenic beauty to landscapes disturbed by coal surface mining; to apply and demonstrate improvement techniques to critical areas.

Category: Urban Natural Areas.

URBAN NATURAL RESOURCES DEVELOPMENT. The purpose of this project is to obtain effective planning and development of urban natural areas which provide improved urban living quality; the benefits include resource related recreation, shade, wind reduction, cooling, vehicular safety, noise reduction, air pollution reduction, and aesthetic improvements. Its objectives are (1) to identify and describe major types of urban natural areas and determine and assess their utility and limitations, (2) to identify and solve special

1469

problem of urban natural area establishment and management, and (3) to demonstrate program of optimal urban natural area development.

Use That Campus. A Guide for Teachers and Administrators, 1971.*

Category: Waterfowl Resources.

RESIDENT WATERFOWL MANAGEMENT. Program to supplement and complement the natural supply, distribution, and use of the region's waterfowl resource with resident species of ducks and geese. Its objectives are (1) to establish 25,000 resident waterfowl in the Tennessee Valley watershed by 1982, (2) to secure distribution of resident waterfowl that maximizes the use benefits, (3) to secure greater public and private involvement in the program, (4) to identify and minimize nuisance and depredation, and (4) to develop and demonstrate environmental quality monitoring benefits.

Category: Waterfowl Resources.

MIGRATORY WATERFOWL MANAGEMENT. Study to attain optimum migratory waterfowl populations in the Tennessee Valley (kinds, numbers, and distribution) by protecting and/or developing all areas identified on TVA reservoirs (or influenced by TVA projects) as being crucial to their continued well-being. Its objectives are (1) to identify all areas along TVA reservoirs and Valley streams crucial to migratory waterfowl, (2) to have waterfowl habitat available to maintain at least 500,000 ducks and 150,000 Canada geese each winter, (3) to protect and/or restore wood duck breeding habitat to achieve at least a 25-percent increase in the breeding population of wood ducks in the Tennessee Valley, (4) through development of new areas and improvement of existing management, increase the number of waterfowl in the eastern part of the Valley from the present 5 percent of the Valley population to at least 25 percent, and (5) increase the percentage of diving ducks wintering in the Tennessee Valley to at least one-third of the total number of migrants.

Quarterly monitoring reports as follows:*

Wood Duck Population Survey. X-14 and X-15 Steam Plant Site, Spring-Summer 1972.
Migrant and Wintering Populations--Steam Plant Sites, Fall-Winter, 1972-1973.
Wood Duck-Shorebirds Populations Surveys at Proposed and Existing Nuclear Steam Plant Sites, Spring-Summer 1973.

Category: Waterfowl Resources.

USES OF VALLEY WATERFOWL. A program to obtain optimum mix of consumptive and nonconsumptive public uses of the Tennessee Valley's migratory and resident waterfowl resources, emphasizing quality experiences. Its objectives are (1) to document each year the waterfowl-oriented uses on TVA reservoirs and projects, (2) to increase nonconsumptive opportunity and activities on TVA reservoirs' resident and migratory waterfowl management areas and refuges from the present 1.4 million visits to 3 million by the year 1990, (3) to improve waterfowl hunting on TVA reservoirs and adjacent lands, increasing hunting opportunities from the present 38,000 trips to 50,000 trips by the

year 1990, and (4) to establish sanctuaries for resident and migratory waterfowl near urban centers to provide waterfowl study and environmental education.

Category: Wildlife Resources.

USE OF WILDLIFE IN FORESTS AND UPLANDS. A program to increase the opportunity for consumptive and nonconsumptive wildlife use to meet the growing demands of Valley residents and visitors. Its objectives are (1) to enhance the quality of life for Valley residents and visitors by increasing wildlife utilization opportunities, (2) to identify and describe the major components and factors influencing wildlife utilization in the Tennessee Valley, (3) to forecast demand trends in utilization of wildlife resources, and (4) to specify wildlife supply needs to satisfy user demand and opportunity including development of marketing strategies.

What Can You Do to Benefit Wildlife on Your Land? FF&WD and Tennessee Game & Fish Commission, 1969.*

Tennessee Valley Wildlife. An Outlook for the Year 2000. Frederick B. Emerson, Jr., January 1968.*

Category: Wildlife Resources.

WILDLIFE PRODUCTION TECHNIQUES. Program to determine maximum potential wildlife production on a large forested area (10,000 acres) while employing optimum habitat development techniques on the site. Timber inventory and forest-wildlife management planning is under way. Associated habitat improvement plantings are also under way.

TVA Geologic Branch, 51 Evans Building, Knoxville, Tennessee 37902
Phone: (615) 637-0101, ext. 2731.

Categories: Mineral Resources, Energy Resources.

GEOLOGIC AND GEOPHYSICAL MAPS ON THE TVA AREA. An ongoing cooperative program with the states of Tennessee, North Carolina, and Alabama, to provide basic geologic and geophysical data useable in the assessment and evaluation of mineral and energy resources of the region. The objective is to provide complete geologic and geophysical mapping coverage of the TVA area. Present expenditure level is $225,000 per year shared approximately on a two to one basis between TVA and participating states. Program started in 1962 and is of indefinite duration.

Individual geologic and geophysical maps are available as they are issued from either the geological surveys of the cooperating states or from TVA, Maps and Surveys Branch, Haney Building, Chattanooga, Tn 37401.

TVA Hydraulic Data Branch, 350 Evans Building, Knoxville, Tennessee 37902 Phone: Knoxville (615) 637-0101, ext. 2208. Copies of starred erference items available on request.

Categories: Hydrology, Water Quality, Urbanization.

EFFECTS OF URBANIZATION UPON THE QUALITY AND QUANTITY OF STREAMFLOW. This project was begun in 1971 to study the effect of urbanization upon the quality and quantity of streamflow. Four watersheds in Knoxville, Tennessee, are instrumented to provide information on precipitation and streamflow. Two water quality samplers are also installed. To date a continuous daily streamflow model has been adapted for use in simulating the effect of urbanization upon daily flows and some preliminary results presented in the second reference below. A technique for predicting parameters in the mineral quality constituent transport feature of the daily streamflow model based upon geologic variables and percent forest has been devised. This is the first step to developing an urban water quality model. Studies are in process to adapt a storm hydrograph model for use in urban planning and to develop source area models for both quality and quantity. The project will continue to June 1975.

"Fecal Coliform Concentrations in Stormwaters" R. P. Betson and R. A. Buckingham, presented at 51st Annual Meeting American Geophysical Union, Washington, D.C., April 1970. Technical.*

"Evapotranspiration Needs from the Viewpoint of Applied Hydrology" R. P. Betson, presented at the Fall Meeting American Geophysical Union, San Francisco, December 1973. Technical.*

Categories: Hydrology, Watershed Research, Forest Resources.

THE EFFECT OF FOREST MANAGEMENT UPON HYDROLOGY AT PINE TREE BRANCH. Since 1941 TVA has conducted hydrologic research on the 88-acre watershed of Pine Tree Branch located near Lexington, Tennessee. This study was originally conducted to evaluate the effect of reforestation on this critically eroded area, typical of many areas in the western Tennessee Valley. Beginning in 1963 with the construction of timber access roads and a managed harvest in 1966 the study was aimed at evaluating the effect of these practices upon hydrology. A report on the latter phases of the study is pending.

"Influences of Reforestation and Erosion Control Upon the Hydrology of the Pine Tree Branch Watershed 1941-1950" Knoxville, Tn, 1955. General, non-technical.

"Reforestation and Erosion Control Influences Upon the Hydrology of the Pine Tree Branch Watershed 1941-1960" Knoxville, Tn, 1962. General, non-technical.

Categories: Hydrology, Watershed Research, Forest Resources.

THE EFFECT OF FOREST MANAGEMENT UPON HYDROLOGY AT WHITE HOLLOW. This project was a study and demonstration of the effects of land management programs on the hydrology of a small forested watershed located about 50 miles north of Knoxville, Tennessee. The watershed had been under various levels of cultivation for about 150 years until 1934 when it was acquired by TVA and

placed under forest protection and management. The effect of reforestation upon streamflow and erosion was studied until 1965 when timber-access roads were installed. Beginning in 1966 two timber-harvesting programs were carried out to minimize impact to the water resource. The project was discontinued September 1972. An evaluation report covering the latter phases of the study is pending.

"Effect of 15 Years of Forest Cover Improvements Upon Hydrologic Characteristics of White Hollow Watershed" Knoxville, Tn, June 1951. General discussion, non-technical.

"Forest Cover Improvement Influences Upon Hydrologic Characteristics of White Hollow Watershed 1935-1958" Knoxville, Tn, May 1961. General discussion, non-technical.

"Effects of Forest Cover Upon Hydrologic Characteristics of a Small Watershed in the Limestone Region of East Tennessee" Hydrology of Fractured Rocks, Symposium in Dubrovnik, Hungary, October 1965. General, non-technical.*

Categories: Hydrology, Watershed Research, Agricultural Covers.

THE EFFECT OF FOUR AGRICULTURAL COVERS ON HYDROLOGY OF SMALL WATERSHEDS. In 1949 TVA and North Carolina State University began a cooperative research project to study the effect of four major agricultural covers and their associated management upon watershed hydrology in the vicinity of Waynesville in western North Carolina. The study involved a rather detailed investigation into the hydrology of small watersheds and from it evolved a series of findings that has implications in agriculture, in land management, and in future hydrologic studies in general. The project was completed June 1970.

"Watershed Research in Western North Carolina" TVA and N.C. State University, Knoxville, Tn, June 1970. General, portions are technical.*

Category: Water Quality.

QUALITY OF RUNOFF WATERS. In 1968 TVA initiated a nutrient loss study on a 12-acre agricultural watershed in western North Carolina. The objective of this study was to determine the relationships between fertilizer use and nutrient content of surface and ground-water runoff. Water samples were analyzed for a period of 16 months before the first application of fertilizer; applications were made once each year thereafter. The study was completed in June 1973. Early results of the study indicate very little change in nutrient content of runoff from fertilizer applications. Significant increases in nutrient content of runoff were observed during storms occurring soon after fertilizers were applied. Final analysis of data is pending. In 1969 nutrient water-quality measurements were begun on two small watersheds in upper Bear Creek drainage area in Lawrence County, Alabama. Studies were to provide information on the "Relationship Between Use of Fertilizers on Agricultural Lands and Chemical Composition of Surface and Ground Waters." Final analysis of data is pending. In 1968 two watersheds were selected at the Mountain Experiment Station of North Carolina State University, Waynesville, North Carolina. These watersheds were selected in cooperation with North Carolina State University to study the effect of fertilization on nutrient losses via surface runoff and base flow on steeply sloping grassed watersheds.

The conclusion reached in this study is that nitrogen fertilization in recommended rates of bluegrass sod in western North Carolina will result in 10 percent or less of the applied N getting into drainage waters.

"Nutrient Losses From Small Watersheds," Victor J. Kilmer and Robert T. Joyce. Presented at the Irrigation and Drainage Division Speciality Conference, American Society of Civil Engineers, at Miami Beach, Florida, November 4-6, 1970. General, non-technical.*

"Monitoring Nutrient Losses From Small Watersheds," Victor J. Kilmer and Robert T. Joyce. Presented at the National Fertilizer Solutions Association Roundup, St. Louis, Missouri, July 25-26, 1972. General, non-technical.*

"Loss of Fertilizer Nutrients From Soils to Drainage Waters," V. J. Kilmer, J. W. Gilliam, R. T. Joyce, and J. F. Lutz. TVA and North Carolina State University. General, non-technical.*

TVA Land Between The Lakes, Golden Pond, Kentucky 42231
Phone: Canton (502) 924-5602.

Categories: Archaeology, Conservation Education.

ANCIENT MAN IN LAND BETWEEN THE LAKES. Study prepared by Dr. Jack D. Nance, formerly of Murray State University, of existing archaeological sites in the area, the bulk of which are located in the Crooked Creek drainage north of U.S. 68. A two phase project, Phase I involved surveying of 39 previously unknown sites near Crooked Creek and excavation of Dead Beaver campsite; Phase II consisted of preparation of a manuscript on the activities of prehistoric man; salvage excavation of an endangered site; additional survey work locating nine previously unknown sites; a proposal for an informative-educational trail along Crooked Creek; and nomination of three sites (Mississippian Mound, Mississippian Stone-Box, and late Archaic) for the National Register for Historic Place Inventory. Financing of the project was by the Tennessee Valley Authority.

"Ancient Man in Land Between The Lakes," Jack D. Nance, 1973. Tennessee Valley Authority, Chattanooga, Tennessee, 40 p., non-technical.

TVA Land Between The Lakes Environmental Education Staff, Golden Pond, Kentucky 42231. Phone: Canton (502) 924-5602. Copies of starred reference items available on request.

Categories: Environmental Education, Conservation Education, Outdoor Education.

ENVIRONMENTAL EDUCATION CENTER. Demonstration of the application of environmental education both in the formal educational systems and informally with programs for general public. The Environmental Education Center consists of 5,000 acres in Land Between The Lakes. Demonstration areas include the following:

YOUTH STATION — Multi-Use Residential Facility - capable of supporting 72 individuals in resident programs with overnight visits ranging from 2 days to several weeks; includes dormitory type living facilities, cafeteria, commons area, multi-use art building and laboratory; fully winterized, semi-private area, not normally open to general public although used extensively by educational groups on a year-round basis.

EMPIRE FARM — Demonstration Farm - used as housing for broad range of domestic animals. Demonstration also includes special and seasonal presentations such as beekeeping, sheepshearing, weaving and spinning, and candle dipping. Display areas include collections of farm implements, tools and machinery (circa 1900-1960), farm produce area, living beehive enclosed in glass for observation and items of local interest. Small lecture/classroom available for school use both in residential and day-use programs. Open to the public and to schools on year-round basis.

CENTER STATION — Interpretive Building - used as central site for basic orientation and information relating to Environmental Education Center. Display areas include historical and pre-historical exhibits, common wildlife of the area, and relief maps of the Environmental Education Center. Publications relating to wildlife programs, history, flora and fauna, trail systems, and general points of interest are disseminated through this station. Audio-visual programs presented as introduction to facilities and as explanation of the role of TVA as the developmental and administrative agent of Land Between The Lakes. This station used frequently by students in day-use programs, is open to the public and to the schools on a year-round basis.

The objectives of the Environmental Education Center include the use of the demonstration areas for the purposes of developing environmental awareness and ethical concern among the citizenry, and for enriching the existing curriculum of formal educational programs through direct experiences with the natural environment. Overall this program seeks to serve as a national model for both formal and informal environmental education programs.

"Youth Station, Guidelines to Use - Land Between The Lakes," 50 p., available for distribution to schools and other agencies, non-technical.*

TVA Land Between The Lakes Recreation Staff, Golden Pond, Kentucky 42231
Phone: Canton (502) 924-5602.

Category: Outdoor Recreation.

MOTORCYCLE AREAS IN CAMPGROUNDS. Determination of the effects of riders and non-riders. Main objective is to help find design and management answers for campground managers. Conducted by Department of Recreation and Parks, Texas A&M University, Ed Fillmore chief investigator, Dr. Richard Bury project director. This was made possible by seed money ($1,000 each) from the Motorcycle Industry Council (MIC), the American Motorcycle Association (AMA), and TVA Land Between The Lakes. Research conducted on two Land Between The Lakes mini-bike areas and the Turkey Bay ORV (off-road vehicle) Area.

Study available from Texas A&M, January 1974.

Category: Outdoor Recreation.

PROFILE: THE TRAIL BIKER. Who is the trail bike user? What are his needs and riding habits? Conducted by Department of Forestry, Southern Illinois University, Kazys Kupcikcuicius, graduate student, and Dr. Kenneth Chilman, Associate Professor of Forestry. Research conducted on Land Between The Lakes' 2,500-acre Turkey Bay ORV Area.

Thesis available from SIU in January 1974.

Categories: Outdoor Recreation, Forest Resources.

LANTERN DAMAGE TO TREES. How much damage is caused by lanterns? How can this be minimized or eliminated with education and new recreation products? Conducted by Department of Forestry, Southern Illinois University, Donald Nekrosius, on-site investigator, Dr. K. C. Chilman, project director. Initial studies made possible by two grants of $1,000 each from the Coleman Company. A lantern hanger will be marketed in 1974 as a result of the study.

Report available from the Coleman Company or Southern Illinois University, Carbondale, IL.

TVA Land Between The Lakes Resource Management Staff, Golden Pond, KY 42231
Phone: Canton (502) 924-5602

Categories: Resource Management, Wildlife Resources.

MONITORING OF OFF-ROAD VEHICLE AREA IN LAND BETWEEN THE LAKES. The 2,500-acre ORV area in Land Between The Lakes was opened in July 1972 to trail bikes and 4-wheel vehicles. A plan was developed and implemented to monitor the area from the standpoint of number of users and impact on the soil, woody vegetation, and wildlife. It is not a highly technical plan but an

attempt to measure the changes, if any, that occur. Cost estimate $1,000 per year. Duration indefinite.

Monitoring Report for ORV Area, 1973. Manuscript. Copies of this report are available on request. No plans for technical publication in near future.

Category: Resource Management.

MANAGEMENT OF NATURAL RESOURCES IN LAND BETWEEN THE LAKES. The major objectives of the resource management program in Land Between The Lakes are to restore and/or improve the depleted resources of the 170,000-acre area to provide optimum opportunity to serve the outdoor recreational and educational needs of a rapidly urbanizing society. Detailed procedures for managing the resources have been developed, and modified as needed to reflect new and changing technology. The demonstration program has been the basis for operation in the area for almost 10 years. Letters of Agreement with the game and fish departments of Kentucky and Tennessee provide for cooperation among agencies in management of the area.

Resource Management Plan - Land Between The Lakes. 1970. Manuscript, semi-technical. A limited number of copies are available for distribution to schools and to other agencies. A brochure is in preparation.

Categories: Resource Management, Wildlife Management.

RESOURCE MANAGEMENT DEMONSTRATION TRAIL. Small-scale demonstrations of the management practices employed at Land Between The Lakes for wildlife, forest, and open lands. The 1½-mile trail called "Trail Of These Hills" is interpreted with the aid of audio devices and numerous signs. The trail was established in May 1973 and will be modified as needed to reflect changes in management practices.

Categories: Resource Management, Plant Succession.

SECONDARY PLANT SUCCESSION ON ABANDONED FARMLAND. Cooperative study between TVA and the Biology Department, Austin Peay State University, Clarksville, Tennessee. This continuing long-term study is conducted on thirteen 1- to 5-acre plots distributed over the Tennessee portion of Land Between The Lakes. Plants are identified and collected for comparison at various stages of succession. Financing is by Austin Peay State University; TVA's contribution involved designating and exempting the plots from future management activities. The project was started in 1968 and will continue for at least 10 years.

Early Secondary Succession on Abandoned Farmland in Land Between The Lakes, Stewart County, Tennessee. Thesis. M. L. McReynolds, 1969. 32 p. Biology Department, Austin Peay State University, Clarksville, Tennessee. Technical publication anticipated but timing uncertain.

Categories: Resource Management, Resource Study Areas.

PRESERVATION OF SELECTED VEGETATION TYPES FOR RESEARCH AND STUDY. Three Research Natural Areas have been established according to the guidelines of the Society of American Foresters, and 15 preserve areas have been designated by Land Between The Lakes forestry staff. Some of the preserve areas, which range in size from 2 to 100 acres, have been inventoried and described in detail in anticipation of use by school or research groups. No studies are being conducted in these areas by outside groups at the present time.

Categories: Resource Management, Wildlife Research.

A STUDY OF THE COMPATIBILITY OF THE EASTERN WILD TURKEY WITH RECREATIONAL AND LAND MANAGEMENT ACTIVITIES AT LAND BETWEEN THE LAKES. Cooperative study between TVA and the Alabama Cooperative Wildlife Research Unit, Auburn University, Auburn, Alabama. The study utilizes tranquilized bait, cannon-netting, radio telemetry, marking and banding, and direct observation to study reaction of the wild turkey to recreational and land management activities in the area. Total Cost $26,000; financed by TVA. Three-year study scheduled to be completed December 1974.

Final report due April 30, 1975. Anticipated date of technical publication - 1976.

Categories: Resource Management, Wildlife Research.

ECOLOGY AND POPULATION DYNAMICS OF FALLOW DEER. Cooperative study between TVA and the Cooperative Wildlife Research Laboratory at Southern Illinois University, Carbondale, Illinois. The study utilized cannon-netting, radio telemetry, marking, observation, and other research tools to study various characteristics of the fallow deer herd in Land Between The Lakes, including interactions with native white-tailed deer. Total Cost $15,500; financed by TVA. Two-year study completed December 1973.

Final report now in preparation by staff of Cooperative Wildlife Research Laboratory. Technical publication anticipated by 1975.

TVA Local Flood Relations Staff, 410 Evans Building, Knoxville, Tn 37902. Phone: (615) 637-0101, ext. 2717.

Category: Flood Control.

DAMAGE PREVENTION. Learning to adjust to nature's whims to stay out of the path of nature's fury is the best approach to solving flood problems. By learning to live where nature's requirements are recognized, future increases in flood damage can be prevented. Beginning 20 years ago TVA began a demonstration which has been the basis of a national effort to prevent continued unwise encroachment on nature's flood plains. TVA provides basic engineering information on a community's flood problems. This becomes the basis for continuing assistance to the community in guiding the use of flood plain and adjacent

lands to prevent future increases in flood damage. Reports are available for 133 communities, and local ordinances are available for 89. Titles of one of each of these are:

"Past and Probable Floods, Duck River, in Vicinity of Centerville, Tennessee," TVA, Knoxville, 1954, 27 pp., 5 plates (Report O-5471). Technical information in non-technical language.

"Subdivision Regulations, Maryville Planning Region," East Tennessee Section, Tennessee State Planning Office, Knoxville, Tennessee, 1966, 50 pp., 5 plates. Non-technical.

Category: Flood Control.

INTERDISCIPLINARY APPROACH. From earlier experience in the preventive approach for solving flood problems, it became increasingly evident that many problems are closely related to flood problems. Sound flood plain management develops land to its best use and combines all possible elements of flood loss reduction. In several communities this led to comprehensive redevelopment projects. These projects provided solutions to the flood problems and to a number of other problems as well. Such projects have been completed in five communities, are underway in two others, and are at completion of the planning stage at four others. A typical report for a completed project is:

"Oliver Springs Redevelopment Program," TVA, Knoxville, 1968, 76pp., tables, exhibits, photographs. Non-technical.

Category: Flood Control.

NATIONAL PROGRAM FOR REDUCING FLOOD LOSSES. Based on experience gained in a program of assistance to communities within the seven Valley states, TVA presented a report to Congress recommending a national program for reducing flood losses. The recommended program, although recognizing the tremendous value of previous flood control structures, warned of the dangers of an over-reliance on engineering structures. This report led directly to preparation, with TVA assistance, of a 1966 House Document which outlined a national program for managing flood losses. This program is now being implemented nationwide and involves many Federal agencies.

"A Program for Reducing the National Flood Damage Potential," TVA, Memorandum of the Chairman to Members of the Committee on Public Works, U.S. Senate, 86th Congress, 1st Session. Washington: Government Printing Office, 1959, 70 pp. (86th Congress, 1st Session, Committee Print). Non-technical.

"A Unified National Program for Managing Flood Losses," U.S. President's Task Force on Federal Flood Control Policy, Washington, August 1966, 89 pp. Non-technical.

1474

TVA Maps and Surveys Branch, 200 Haney Building, Chattanooga, Tn 37401 Phone: (615) 755-2133. Copies of starred reference items available on request.

Category: Land Use Mapping.

LAND COVER MAPS. An interdisciplinary task force consisting of TVA's FP&WD, WCF, and ND&RS Divisions and The Oak Ridge National Laboratory's Regional Environmental Systems Analysis Group has created several demonstration land cover maps. The purpose is to develop methods of delineating land use/cover data from high altitude color infrared photography and to explore useable presentation format(s.) Methods and corresponding costs appear in the papers listed below:

"Application of Hyper-Altitude Color Infrared Photography to Land Use Mapping in the Tennessee River Watershed," A. R. Stevens, Proceedings of the American Society of Photogrammetry, Washington, D.C., March 1973.*

"Land Cover Delineation Methods and Presentation Alternatives Applicable to the Tennessee River Watershed," A. R. Stevens, Proceedings, Remote Sensing of Earth Resources Symposium, University of Tennessee Space Institute, March 1973.*

"Alternatives for Land Use/Cover Mapping in the Tennessee River Watershed," A. R. Stevens and D. L. Malone, Proceedings, TVA Water Resources Task Force Symposium, October 1973.*

TVA Division of Medical Services, 320 Edney Building, Chattanooga, Tn 37401 Phone: (615) 755-2091. Copies of starred reference items available on request.

Categories: Occupational Health, Medical Equipment, and Medical Techniques.

OCCUPATIONAL HEALTH. Conduct of a modern occupational health program for TVA employees contributes toward improvement of both the work environment and the public environment. Demonstrations of new equipment and techniques are given for interested groups. For example, computerized electrocardiography has been demonstrated for hospitals, physicians, and student groups. Operations of the automated Central Medical Laboratory have been demonstrated to visiting groups. The occupational health program also provides a cooperative earning-learning project for student nurses from cooperating regional colleges.

"TVA's Medical Services Program," (Leaflet)*

"Health Care Delivery Systems of the Tennessee Valley Authority." James L. Craig, M.D., Medical Progress Through Technology, Springer-Verlag, 1972.*

Annual Report, Division of Medical Services, Fiscal Year 1973.*

Categories: Community Health, Health Fairs, Interagency Medical Personnel Exchange, Equipment Loans, Mobile Medical Equipment.

HEALTH FAIRS. The adaptation of some of TVA's occupational health techniques to show their application in community health care delivery has been accomplished in cooperative demonstrations sponsored primarily by university and other groups. "Health Fairs" are held during the summer months in selected rural communities where free medical examinations are offered to residents of the areas. TVA's Mobile Health Clinic, with its technicians and its multiphasic health testing capability, has been particularly useful in helping to provide meaningful health profiles on examinees. Also, automated analyses of blood samples obtained in the fairs have shown the usefulness of automation for mass blood testing. Cost of TVA participation for 14 health fairs held in the summers of 1972 and 1973 was $56,346, for an average of about $6.30 for each of the 8,900 examinations.

INTERAGENCY PERSONNEL LOANS. Because it is advantageous both to the region's people and to the accomplishment of TVA goals that specific community health work be pursued, TVA occasionally supplements the staffs of health agencies through the assignment of Health Service Representatives to work in designated programs. One such representative is presently assigned to the Tennessee Department of Public Health where he is planning and implementing the establishment of primary health care centers in the state of Tennessee. Another is working with the Alabama Department of Public Health to help in the planning and provision of health services in a 13-county area of north Alabama.

EQUIPMENT LOANS. To help conduct the summer health fairs, Vanderbilt University medical or nurse students organized community health councils composed of local residents. Medical data from the health fair examinations disclosed such need for some kind of continuing health services that a number of councils did not disband but, instead, began working toward the establishment of permanent health clinics where nurses and visiting doctors could provide regular service. Since immediate space was a necessity before some clinics could begin service, TVA leased, at minimal cost, trailer units to health councils at three locations for use as health clinics until permanent quarters become available. These locations are Bricevillle, Clairfield, and Stoney Fork, Tennessee. Other trailer loans are anticipated.

"Adaptation of Occupational Medicine Techniques to Community Health Care." James L. Craig, M.D., Journal of Occupational Medicine, January 1972.*

"TVA's Medical Services Program" (Leaflet).*

"Health Care Delivery Systems of the Tennessee Valley Authority." James L. Craig, M.D., Medical Progress Through Technology, Springer-Verlag, 1972.*

Annual Report, Division of Medical Services, Fiscal Year 1973.*

Categories: Emergency Medical Services, Ambulance Demonstrations, Helicopter Demonstrations.

CONFORMATION OF STATE AMBULANCE STANDARDS. In two ways TVA has helped the state of Tennessee to meet the provisions of Congressional legislation which require states to conform to minimum standards for both ambulance operation and ambulance attendants. First, an ambulance built to legal specifications was obtained for a TVA construction project and, at the request of the state, was exhibited widely until needed at the construction site. Second, an injured TVA employee was rehabilitated and became adept in emergency medical services training. He was then assigned to the Division of Emergency Medical Services (Tennessee Department of Public Health) where he is serving both the public and the TVA interest by helping to train individuals who render emergency medical service for the public.

PUBLIC USE HELICOPTER DEMONSTRATION. Because of TVA's experience in using helicopters to carry injured employees from remote work sites to places where they could receive medical attention, the University of Tennessee's Memorial Hospital in Knoxville asked TVA's cooperation in a public-use demonstration helicopter project. TVA agreed to furnish or underwrite the cost of emergency helicopters to bring critically ill patients, particularly premature infants, from points in east Tennessee to the hospital where they could receive the specialized attention they needed. From July 1, 1972, through June 30, 1973, helicopters made 54 flights which cost $8,700.

Annual Report, Division of Medical Services, Fiscal Year 1973.*

TVA Navigation Development and Regional Studies, 509 Arnstein Building, Knoxville, Tennessee 37902. Phone: Knoxville (615) 637-0101, ext. 3358. Copies of starred reference items available on request.

Categories: Rural Development, New Town Planning.

LOWER ELK CONCEPT. A proposal for the development of some 1,000 square miles in three counties of Lincoln and Giles, Tennessee, and Limestone, Alabama, into a national demonstration of ways to provide necessary services to make rural areas attractive for living while preserving the rural setting and environment. The proposal calls for the development of a high level of services and amenities at key locations in the area to attract residents into a system of well planned new rural villages as an alternative to the unplanned, inefficient sprawl development which is occurring around so many of the nation's urban centers and throughout much of the rural countryside. TVA has, since 1971, provided planning assistance to the Elk River Development Association on the development of this proposal.

"An Alternative Rural Development Pattern: A Proposal for a National Demonstration in the Lower Elk Area," Navigation Development and Regional Studies, TVA, May 1973. General discussion, non-technical.*

Categories: Townlift, Urban Planning.

PADUCAH, KENTUCKY TOWNLIFT. A revitalization scheme for (1) the length of Broadway from Seventh Street to the river, and (2) the Market House area. Plans for the first area included improvements of the downtown sidewalks by extending the sidewalk in places to accommodate planters, benches, and waste receptacles. Also suggested were sign control and a canopy system. Suggestions for the second area included renovating surrounding buildings in an effort to preserve the section as a historical district and modifying the sidewalks to better accommodate parallel parking.

"A Planning Report for Paducah, Kentucky," Prepared by the Paducah Planning Commission and the Paducah Downtown Retail Merchants Association with technical assistance from the Tennessee Valley Authority, October 1973.*

Categories: Townlift, Highway Area Development.

GEORGIA HIGHWAY 2A TOWNLIFT. A developmental plan for the area along Georgia Highway 2A which suggests a wide mix of land uses including apartments, townhouses, neighborhood shopping, highway and tourist-oriented business, communitywide shopping and office, regional business, and a light industrial park. Included in the plan is a recommendation for a frontage road and a buffer strip.

"Highway 2A Development Study - Fort Oglethorpe, Ga.," April 1971. Done in conjunction with Fort Oglethorpe Planning Commission, write to TVA, Navigation Development and Regional Studies.*

Categories: Townlift, Urban Planning.

BOWLING GREEN, KENTUCKY TOWNLIFT. Report identified the problem areas as (1) poor circulation around and through the Central Business District (CBD) area, (2) inadequate and poorly designed parking facilities in the downtown district, (3) deteriorated buildings and poorly displayed signs throughout much of the CBD, (4) a general lack of aesthetic qualities in the downtown area, and (5) recent decline in retail trade within the core city coupled with low levels of investment in retail space improvements. The basic concept for enhancing downtown requires phasing work with improving the circulation and parking first, then upgrading the quality of the commercial center and finally developing a new governmental center.

"Bowling Green Townlift Report," Navigation Development and Regional Studies, TVA.*

Categories: Townlift, Highway Area Development.

TENNESSEE U.S. 129 (ALCOA HIGHWAY) TOWNLIFT. The plan identified as a problem the conflict between the two basic highway functions of (1) facilitating high-speed transit for commuters, and (2) providing access for motorists to land uses on abutting property. The highway is not designed to handle both conditions simultaneously. Recommendations include: (1) design standards and implementation tools to

preserve the high-speed connector route function of U.S. 129, (2) a land-use concept for the entire corridor, (3) master plans for each of the three activity nodes, (4) design standards and implementation tools for State Route 33, and (5) means for enhancing the visual identity of U.S. 129 as a major entrance to Knoxville and East Tennessee.

"U.S. 129 A Highway Corridor Study," TVA, Nagivation Development and Regional Studies, 1973.*

TVA Power, Division of Power Marketing, 815 Power Building, Chattanooga, Tennessee 37401. Phone: (615) 755-2321. Copies of starred items available on request.

Categories: Energy Conservation, Efficient Energy Use.

CONSUMER CONSERVATION PROGRAMS. The TVA and the 160 distributors of TVA power have several conservation programs underway. Some activities are of long standing, such as adequate insulation in electrically heated homes. However, all existing programs have been reexamined and modified as necessary to meet present conditions, and new programs have been developed to insure that all groups of power users participate in conserving electricity in several ways and to the full extent possible. The program outlines efforts to gain adequate insulation, technical assistance to large commercial and industrial firms, information for educators, heat pump program, and guides to efficient appliance use.

The following folders or booklets are available:*

Insulate for Savings and Comfort.
Conserve Energy and Save Money by Using Electricity Efficiently.
Guide to Home Climate Control.
Guide for Buying an Electric Range.
Guide for Buying an Electric Dishwasher.
Guide for Buying a Food Disposer.
Guide for Buying a Trash Compactor.
Guide for Calculations of Electric Heating and Cooling.
Detecting and Controlling Moisture Problems in the Home.

TVA Power, Division of Power Production, 716 Edney Building, Chattanooga, Tennessee 37401. Phone: (615) 755-2471.

Categories: Air Quality, Flue Gas Conditioning, Electrostatic Precipitators.

FLUE GAS CONDITIONING BY SULFUR TRIOXIDE INJECTION. Investigation of the effect of gas conditioning on the performance of electrostatic precipitators when high-resistivity fly ash results from burning low-sulfur coal. Cost $62,000. Based on the results of the investigation, the 950-MW Bull Run

Steam Plant near Oak Ridge, Tennessee, has been equipped for such conditioning. Evaluation of the installation to continue in 1974. Test report of the investigation available.

Categories: Air Quality, Sulfur Dioxide Research, Limestone Injection.

DRY LIMESTONE INJECTION PROCESS FOR SO_2 REMOVAL FROM POWER PLANT STACK GASES. Study by TVA and EPA to provide the Office of Air Programs and TVA with an evaluation of the feasibility, effectiveness, and economics of the dry limestone injection process for removal of SO_2 from stack gases of coal-fired power plants. This $3,750,000 project is complete and a final report is available.

Categories: Water Quality, Ash Storage Ponds.

CLOSED LOOP ASH POND WATER RECIRCULATION STUDY. Future water pollution abatement standards may prevent the discharge of water from TVA ash storage ponds. In order to continue to utilize the ponds for ash storage, it may be necessary to recycle the water used to sluice ash from the collection point to storage pond. The objective of the project is to identify and seek solutions to operating problems associated with closed loop operation. Duration of project is from October 1973 to June 1974. Estimated cost is $90,000. An internal TVA report describing the project, objectives, and schedules has been prepared. No future publications are anticipated unless results with industry-wide significance are obtained.

TVA Power Research Staff, 503 Power Building, Chattanooga, Tennessee 37401. Phone: (615) 755-2884. Copies of starred reference items are available on request.

Categories: Air Quality, Fly Ash Removal, Sulfur Dioxide Removal.

WIDOWS CREEK WET SCRUBBER PROJECT. A full-scale research and demonstration limestone wet scrubber for removal of both fly ash and sulfur dioxide from power plant flue gas. This scrubbing system will be retrofitted to the coal-fired, 550-megawatt unit 8 at Widows Creek Steam Plant near Stevenson, Alabama. Objective is to work out design and operating problems that affect both SO_2 removal efficiency and process reliability. Project is financed by TVA; cost estimate is $42,000,000. Data from the pilot plant at Colbert are being used for design. Target SO_2 removal efficiency is 80 percent with outlet particulate grain loading of 0.02 grain/ft.^{3}. Date started FY 1970; facility construction began FY 1973; estimated completion date FY 1976.

"The TVA Widows Creek Limestone Scrubbing Facility: Part I--Full-Scale Facility," B. G. McKinney, A. F. Little, and A. J. Hudson. Paper presented at Flue Gas Desulfurization Symposium sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.*

"The TVA Widows Creek Limestone Scrubbing Facility: Part II--Pilot-Plant and Prototype Operating Experience," J. J. Schultz, T. M. Kelso, J. L. Graham, J. K. Metcalfe, and N. D. Moore. Paper presented at

Flue Gas Desulfurization Symposium sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.*

Tennessee Valley Authority Environmental Statement, Experimental SO_2 Removal System and Waste Disposal Pond - Widows Creek Steam Plant, January 15, 1973, TVA-EP-EIS-73-1.*

"Widows Creek Project for Sulfur Dioxide Removal: Sources and Cost of Limestone Supply," Process Engineering Branch, Division of Chemical Development, TVA Report S-464, p.27, March 1972.*

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Limestone Slurry: Design Considerations for Demonstration Full-Scale System at TVA," B. G. McKinney and A. F. Little. Paper presented at the Second International Lime/Limestone Wet Scrubbing Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, November 8-12, 1971.*

Categories: Air Quality, Sulfur Dioxide Removal, Limestone Scrubbing.

WET LIMESTONE SCRUBBING PILOT PLANT TEST PROGRAM. This is a research and development program on limestone slurry scrubbing of sulfur dioxide on power plant stack gases. Test work is performed on a 1-megawatt, pilot plant at Colbert Steam Plant near Tuscumbia, Alabama. Purpose of this work is to obtain test data to design a full-scale system to be installed on unit 8 at the Widows Creek Steam Plant near Stevenson, Alabama. Cost estimate is $1.1 million at present; first pilot unit built in 1971, second pilot unit built in 1972, experimental operating period through 1973.

"The TVA Widows Creek Limestone Scrubbing Facility - Part II.--Pilot Plant and Prototype Operating Experience," by J. J. Schultz, T. M. Kelso, J. L. Graham, J. K. Metcalfe, and N. D. Moore. Paper presented at the Flue Gas Desulfurization Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.*

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Limestone Slurry: TVA Pilot Plant Tests - Part I.--Scrubbing-Type Comparison," T. M. Kelso, P. C. Williamson, and J. J. Schultz; "Part II.--Experimental Design and Data Analysis for Spray and Mobile-Bed Scrubbers," N. D. Moore. Paper presented at the Second International Lime/Limestone Wet Scrubbing Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, November 8-12, 1971.*

Categories: Air Quality, Sulfur Dioxide Removal, Limestone Scrubbing.

ORGANIC ACIDS PILOT PLANT TEST PROGRAM. A 1-megawatt pilot plant research program on technical evaluations of the use of organic acids or a promoter for SO_2 absorption with wet limestone scrubbing. The program is being carried out in one of the existing pilot plants at the Colbert Steam Plant near Tuscumbia, Alabama. Tests were made with the addition of organic acids to limestone wet scrubbing systems to determine the ability of this additive to increase both limestone utilization and sulfur dioxide absorption. One

of the objectives of the investigation is the derivation of a possible backup process for the 550-megawatt Widows Creek Steam Plant sulfur dioxide removal demonstration system. Project funded by the Environmental Protection Agency and TVA; approximately $550,000. Project began in 1971 and is funded through 1974.

"Use of Weak Acids to Improve Sulfur Oxide Absorption by Limestone Slurries," J. D. Hatfield and J. M. Potts. Paper presented at the 72nd National Meeting, American Institute of Chemical Engineers, St. Louis, Missouri, May 21-24, 1972.*

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Limestone Slurry: Use of Organic Acids," J. D. Hatfield and J. M. Potts. Paper presented at the Second International Lime/Limestone Wet Scrubbing Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, June 1972.*

Categories: Air Quality, Sulfur Dioxide Removal, Limestone Scrubbing.

DOUBLE-ALKALI PILOT PLANT TEST PROGRAM. A 1-megawatt pilot plant research program of processes using solution-type scrubbing of sulfur dioxide from power plant stack gas with subsequent reaction of the soluble sulfite-sulfate salts formed with lime or limestone for throwaway of the more insoluble calcium-sulfite-sulfate salts. This program is being carried out in one of the existing pilot plants at the Colbert Steam Plant near Tuscumbia, Alabama. One of the objectives of the investigation is the derivation of a possible backup process for the 550-megawatt Widows Creek Steam Plant sulfur dioxide removal demonstration system. Cost estimate is $150,000; test program began in 1973.

Categories: Air Quality, Sulfur Dioxide Removal, Ammonia Scrubbing.

AMMONIUM-BISULFATE PILOT PLANT PROGRAM. A 1-megawatt-size pilot plant research program to test the ability to remove sulfur dioxide from power plant stack gas with ammonia scrubbing. Regeneration of the scrubbing liquor by acidulation with bisulfate to produce concentrated sulfur dioxide. This process is being investigated at the Colbert Steam Plant near Tuscumbia, Alabama. This study will be used to develop and solve problems concerned with the process chemistry, practical engineering, and equipment. This project was started in 1969 as an EPA-funded ammonia scrubbing program and became a joint EPA/TVA program in FY 1972. Total funding by EPA/TVA through FY 1974 is $2,464,000, evaluation report due July 1975.

"Sulfur Dioxide Removal from Stack Gases," J. E. Jordan and G. M. Newcombe. Defensive Publication T909,017, U.S. Patent Office (909 P.G. 795), (April 17, 1973).*

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Ammoniacal Solutions: Pilot Scale Studies at TVA," G. A. Hollinden, N. D. Moore, P. C. Williamson, and D. A. Denny. Paper presented at the Flue Gas Desulfurization Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.*

"Sulfur Oxide Removal from Waste Gases by Ammonium-Bisulfate Process," G. M. Newcombe, J. E. Jordan, and A. V. Slack. Paper presented at the 72nd National Meeting, American Institute of Chemical Engineers, St. Louis, Missouri, May 21-24, 1972.*

Category: Air Quality.

CONTROL OF NO_x FORMATION IN WALL, COAL-FIRED UTILITY BOILERS. This study will concentrate on refining combustion modification techniques for the reduction of NO_x and related pollution emissions from a TVA wall, coal-fired boiler, a type which represents a significant portion of utility boilers. The long-term testing (4 to 6 months) will study intensively the effects that combustion modifications have on corrosion and boiler performance. This is a TVA/EPA funded study which began in June 1973 and is funded through FY 1974. Cost estimate is $250,000.

"NO_x Control at TVA Coal-Fired Steam Plants," Gerald A. Hollinden, Shirley S. Ray, Neal D. Moore, John T. Reese, and Chris Gottschalk. Paper presented at the ASME Air Pollution Control Division National Symposium, Philadelphia, Pennsylvania, April 24-25, 1973.*

"Control of NO_x Formation in Wall, Coal-Fired Utility Boilers: TVA-EPA Interagency Agreement," Gerald A. Hollinden and Shirley S. Ray. Paper presented at the Pulverized Coal Combustion Seminar, sponsored by the Environmental Protection Agency, Research Triangle Park, North Carolina, June 19-20, 1973.*

Categories: Air Quality, Electrostatic Precipitators.

PARTICULATE CONTROL BY ELECTROSTATIC PRECIPITATORS. Investigation of the theoretical and practical aspects of electrostatic precipitation--research project includes (1) an investigation of rapping reentrainment, (2) a study of electrode failure, and (3) an investigation on flue gas conditioning for the purpose of improving particulate collection by electrostatic fly ash collectors. The objectives of rapping-reentrainment investigation are to relate quantitatively dust reentrainment to intensity of rapping, electrical properties of the dust thickness of dust layer, and adhesive properties of the dust. The objective of gas conditioning investigation will be to secure additional information relative to mechanism of ammonia and sulfur trioxide conditioning for overcoming exceptionally high- or low-resistivity ash. Project cost of $150,000 is financed by TVA with Southern Research Institute as the contractor. The contracted period ends June 1974.

Theoretical and Practical Aspects of Electrostatic Precipitation--first, second, and third quarterly report to Tennessee Valley Authority, Research Agreement TV-36921A by Southern Research Institute, Birmingham, Alabama, October 31, 1973. Technical.*

Categories: Air Quality, Energy Resources, Coal Gasification, Sulfur Dioxide Removal.

STUDY OF LOW-BTU COAL GASIFICATION PROCESS FOR RETROFITTING TO EXISTING COAL-FIRED ELECTRIC POWER PLANTS. The study will investigate the conversion of medium- to high-sulfur coals of various caking qualities into a low-Btu gas (100-200 Btu's/ft^3) using fixed-bed (non-Lurgi) gasifier technology and the purification of this gas to remove sufficient sulfur to meet environmental standards. The study will concentrate on gasifier conditions and cleanup systems, particularly suitable for retrofitting existing boilers or integrating with new boilers of conventional fossil-steam design. Both high-temperature and low-temperature sulfur removal methods would be investigated.

Categories: Water Quality, Heated Water Discharges.

CATFISH CULTURE AS BENEFICIAL USE OF REJECTED HEATED WATER FROM STEAM PLANTS. Research project to determine the feasibility of high-density raceway production of catfish, using heated water discharges from the Gallatin Steam Plant near Nashville, Tennessee. Objective is use of a waste product to promote economic expansion of catfish production in the Tennessee Valley region. TVA is cooperating with Cal-Maine Foods, Inc., in this research. Cost estimate is $625,000--financed by TVA and Cal-Maine. Facility construction began in 1970, experimental operating period 1970-1975. Waste characterization report, blood chemistry report, and general report on 1973's results are scheduled for 1974. General reports on the previous year's progress are also scheduled for 1975 and 1976.

"Control of Epistylis on Channel Catfish in Raceways," Wayne A. Hubert and Mark C. Warner. Paper submitted for publication. Technical.*

"Utilization of Waste Heat--The Gallatin Catfish Project," L. Barry Goss. Paper presented at the 1973 Water Resources Research Seminar, Muscle Shoals, Alabama, October 18-19, 1973. General, non-technical.

"TVA Projects--Beneficial Uses of Waste Heat," B. J. Bond, Carl E. Madewell, John B. Martin, Jr., and David A. Mays. Paper presented at the National Conference on Complete Water-Reuse, Washington, DC, April 23-27, 1973. General, non-technical.*

"Economic and Related Considerations Before Entering or Expanding a Commercial Catfish or Trout Farming Operation," Carl. E. Madewell. Paper presented at Fish Farming Conference, Montgomery Bell State Park, Burns, Tennessee, November 4, 1971. General, non-technical.*

Producing and Marketing Catfish in the Tennessee Valley, Conference Proceedings, June 30-July 1, 1971, sponsored by the Division of Agricultural Development; Division of Forestry, Fisheries, and Wildlife Development; and Office of Tributary Area Development, Bulletin Y-38, Tennessee Valley Authority, November 1971. General, non-technical.*

54-380 O - 75 - pt. 2 - 32

Categories: Air Quality, Solid Waste Management.

SLUDGE DISPOSAL FROM AIR POLLUTION CONTROL EQUIPMENT. This is a study to summarize and evaluate existing data pertaining to sludge produced from sulfur dioxide and particulate removal processes, investigate the potential methods for improving the characteristics of sludge, and recommend future testing required. The objective of this program is to evaluate data which are available on sludge disposal to determine problem areas and to develop a test program for improving the characteristics of sludge. Starting date for this study was FY 1973 with an estimated completion date of FY 1975. The project is TVA funded; funding to date is $35,000. Data on the chemical and physical characteristics of sludges and fly ash have been studied and will be in a final report in 1974. Processes for treating the sludge are being studied. A report on this and recommended testing is scheduled for late 1974.

"Disposal and Use of Byproducts from Flue Gas Desulfurization Processes: Introduction and Overview," A. V. Slack and J. M. Potts. Paper presented at the Flue Gas Desulfurization Symposium, sponsored by the Environmental Protection Agency, May 14-17, 1973, New Orleans, Louisiana.*

"Current Utility Approaches to Sludge Disposal," A. V. Slack, T. M. Kelso, and J. L. Crowe. Paper presented at Electrical World Conference, Waste Disposal in Utility Environmental Systems: The Problem Beyond Removal, October 30-31, 1973, Chicago, Illinois.*

TVA Division of Power Resource Planning, 403 Power Building, Chattanooga, Tennessee 37401. Phone: (615) 755 2065.

Category: Air Quality.

STACK GAS NITROGEN OXIDES. Tests to determine the effectiveness of varying operating conditions in reducing nitrogen oxides emissions in stack gases. The following units have been tested: Shawnee 10, Paradise 1, Widows Creek 7, and Widows Creek 6. Further testing planned for late F. Y. 1973. Esso published document entitled "Systematic Field Study of NO_x Emission Control Methods for Utility Boilers": which reviews testing on Shawnee 10, Paradise 1, and Widows Creek 7. A TVA paper entitled "NO Control at TVA Coal-Fired Steam Plants," which reviews all testing of TVA boilers, was presented at the 1973 ASME Air Pollution Control Division National Symposium.

Category: Strip-mine Reclamation.

LONG PIT STRIP MINING RECLAMATION DEMONSTRATION PROJECT. An experimental coal surface mining operation has been established in eastern Tennessee to develop improved reclamation methods for surface mining. Minimum spoil outslopes will be created and final grading will be obtained on this

method of mining for comparison with conventional mining methods in the same area. Estimated cost $3 million, financed by TVA. Work began in 1973 and expected to be completed in 1975. An evaluation report will be prepared upon completion of the project.

TVA Radiological Hygiene Branch, River Oaks Building, Muscle Shoals, Alabama 35660. Phone: (205) 383-4631, ext. 576. Copies of starred reference items available on request.

Category: Radiological Research.

SUITABILITY OF TL DOSIMETERS FOR ENVIRONMENTAL RADIATION SURVEILLANCE. TVA is using TL dosimeters to monitor the natural gamma radiation levels in the environment around its nuclear power plants. An investigation was conducted to quantify the operational parameters of this dosimeter so that it can be accurately and effectively used.

"Suitability of Glass-Encapsulated CaF_2:MN Thermoluminescent Dosimeters for Environmental Radiation Surveillance," J. E. Partridge and S. T. Windham of the U.S. Environmental Protection Agency; and J. A. Oppold and J. L. Lobdell of TVA. June 1973. Technical.*

TVA Recreation Resources Branch, 123 West Cumberland Building, Knoxville, Tennessee 37902. Phone: (615) 637-0101, ext. 3273. Copies of starred reference items available on request.

Categories: Solid Waste Management, Junk Car Removal.

JUNK CAR REMOVAL PROGRAM. A demonstration with county and municipal governments on the collecting and disposing of abandoned junk cars. TVA furnishes a retriever truck and technical assistance; the government unit performs the actual collecting work and contracting for disposal. "The Junk Car From Field to Foundry," a handbook describing the program, is available on request as are blueprints for the retriever trucks.

Categories: Land Pollution, Environmental Education, Cleanup Projects, Beautification Projects, Johnny Horizon Campaign.

JOHNNY HORIZON PROGRAM. In cooperation with the U.S. Department of the Interior and other agencies, TVA sponsors the Johnny Horizon Program in the Tennessee Valley. Johnny Horizon is a symbol of the thoughtful user of the environment, and this symbol is used to

promote awareness of the environment and concern for its protection and beauty. Speakers are available for classroom groups, civic clubs, and other organizations interested in the environment. Literature and films to capture attention and promote action are available. Litter bags are provided to support cleanup activity. A Johnny Horizon Sponsor Kit* contains samples of literature and litter bags and a how-to booklet.

Categories: Aesthetic Enhancement, Visual Enhancement.

LANDSCAPE TREATMENT OF TVA PROPERTIES. TVA has traditionally developed and maintained its dam and steam plant reservations in a manner which will be pleasing to the eye while providing a safe and efficient working environment. A wide variety of visitor use facilities have been provided on the reservations demonstrating that through proper design, recreational and industrial uses may be compatible, both functionally and visually. A summary of reservation maintenance standards used by TVA is available on request.

Categories: Recreation Resources Development, Public Use Areas.

TVA PUBLIC USE AREAS PROGRAM. Selected areas on TVA reservoir shorelines and dam reservations are improved to the minimum extent necessary to help assure safe and sanitary access for recreationists and to protect the land. Public use area facilities are designed primarily for day-use recreation activities. The program grew out of a need to relieve concentrated public use of undeveloped TVA shoreline. This use resulted in undesirable conditions for users and abuse of the land. The program is continually monitored and updated. The Tennessee Valley Outdoor Recreation Plan (also listed) will include projections of the public use areas needed through the year 2000.

Categories: Recreation Resources Development, Outdoor Recreation.

TENNESSEE VALLEY OUTDOOR RECREATION PLAN. Land units are defined and classified according to their natural capability to attract and sustain specified recreation activities. Based on physical capabilities and regional recreation demands, outdoor recreation plans are developed for TVA reservoirs. The basic purpose of the plan is to provide a tool for fostering the optimum development and use of the recreation resources of the Tennessee Valley while maintaining the environmental integrity of those resources. The plan is scheduled for completion in 1974.

The Tennessee Valley Outdoor Recreation Plan. Division of Reservoir Properties, Recreation Resources Branch, 1974.

Vol. I. Methodology*

Vol. II. County Outdoor Recreation Capability Classifications

Part 1. Western District
Part 2. Southern District
Part 3. Central District
Part 4. Eastern District

Vol. III. Current and Projected Activity Participation Rates and Facility Needs

Vol. IV. Reservoir Recreation Plans

Part 1. Western District
Part 2. Southern District
Part 3. Central District
Part 4. Eastern District

Categories: Recreation Resources Development, Recreation Planning.

PROGRAM OF TECHNICAL ASSISTANCE IN RECREATION PLANNING. A program of providing aid in identifying, evaluating, and planning for the development of recreation resources on a regional basis and in developing specific recreation projects and programs. Assistance is given free of charge to county and municipal governments; regional authorities; planning commissions; recreation, park, and conservation boards; nonprofit organizations; quasi-public groups, and private firms and individuals. Assistance is offered in the specific areas of site planning; community recreation program development; development of promotional programs for recreation; application assistance for Federal grant or other funding programs; and market studies, economic feasibility studies, visitation studies, and other recreation research projects.

A Recreation Development Plan for the South Cumberland Area. Division of Reservoir Properties, Recreation Resources Branch, 1971. A 50-page report describing the proposed development of the natural recreation resources of a 1,000-square-mile region in southeast Tennessee.*

Categories: Natural and Scenic Resources, Recreation Resources Development, Scenic Trails.

TENNESSEE VALLEY AUTHORITY TRAILS PROGRAM. A program designed to protect scenic values as well as provide public recreation resources through development of a system of trails on TVA lands. Inventory of existing trails began in 1973. The need for additional trails will be determined and a development program will be initiated. Emphasis will be placed on joining trails on TVA lands with regional and national trails systems.

Categories: Natural and Scenic Resources, Recreation Resources Development.

TVA SMALL WILD AREAS PROGRAM. Scenically attractive settings with limited access will be set aside and preserved in a natural state for the enjoyment of the visitor and the protection of physical resources. Much of TVA's land resource is in marginal strips; consequently, many of the areas will be small in size. Development of the areas will be limited primarily to hiking trails. The Divisions of Reservoir Properties and Forestry, Fisheries, and Wildlife Development are jointly heading the program.

1481

Categories: Natural and Scenic Resources, Recreation Resources Development.

PROTECTION OF SCENIC STREAMS. TVA is cooperating with the Valley states, local governmental bodies, the Bureau of Outdoor Recreation, and the U.S. Forest Service to protect streams with unusual scenic qualities. Overall program began in 1967 and is continuing. Detailed information of starred items available on request.

"Obed Wild and Scenic River Study." U.S. Department of the Interior, Bureau of Outdoor Recreation, and Tennessee Department of Conservation, 1973.*

"Hiwassee Recreation Riverway." Division of Reservoir Properties, Recreation Resources Branch, TVA, 1970.*

"The Buffalo Scenic Riverway." Division of Reservoir Properties, Recreation Resources Branch, TVA, 1968.*

Elk Recreational Riverway Study
Duck Recreational River Study
Bear Creek Recreational River Study

Categories: Natural and Scenic Resources, Cultural (Historic, Archaeological, or Architectural) Resources.

PROGRAM OF IDENTIFICATION AND PROTECTION OF AREAS OF NATURAL, SCENIC, AND CULTURAL SIGNIFICANCE. A program of cooperation with public agencies and private organizations in identifying areas in the Valley having natural, scenic, or cultural significance and considering these areas for preservation, enhancement and/or appropriate public use. Included in the program are provisions for technical assistance to others; cooperative and direct action for protection and preservation of areas on TVA lands; and consideration of natural, scenic, and cultural values in the investigation, planning, and design of TVA projects and other actions.

Soils and Fertilizer Research Branch, F-137 NFDC, Muscle Shoals, Alabama 35660 Phone: (205) 383-4631, ext. 202. Copies of starred reference items are available on request.

Category: Fertilizer Research.

FERTILIZER NUTRIENT LOSSES. Past and current activities involve research on various topics, including: (a) Runoff losses of fertilizer- and nonfertilizer-derived plant nutrients in agricultural and forested watersheds, (b) Percolation losses of plant nutrients and heavy metals applied to soils as fertilizer or municipal waste materials currently being carried out in a new lysimeter facility at Muscle Shoals , (c) Testing of newly developed slow release fertilizers such as sulfur-coated urea and sulfur coated potassium chloride in relation to minimizing the soil losses of nitrogen and other nutrients through water pathways, and (d) Use of the stable isotope ^{15}N to trace the movement of fertilizer nitrogen in the nitrogen cycle. Most

of these research activities are carried out at laboratory, greenhouse, and field facilities located at Muscle Shoals, however, some research is done at outlying research facilities in cooperation with Land Grant Universities throughout the U.S.

Soils and Fertilizer Research Branch publications in this activity include:

"Nitrogen Release from Sulfur-Coated Urea, as Affected by Coating Weight, Placement, and Temperature," S. E. Allen, C. M. Hunt and G. L. Terman, Agronomy Journal 63:529-33. 1971

"Sulfur-Coated Fertilizers for Controlled Release: Agronomic Evaluation," S. E. Allen, and D. A. Mayes, Journal Agric. Food Chem. 19:809-12. 1971.

"Soluble and Slow-Release Nitrogen Fertilizer Effects on Grass Forage as Influenced by Rate and Placement," S. E. Allen, G. L. Terman and C. M. Hunt. Journal of Agricultural Science 77:397-404. 1971.

"Release of Nitrogen from Sulfur-Coated Urea in Flooded Soil," P. M. Giordano and J. J. Mortvedt, Agronomy Journal 62:612-14. 1970.

"Significance of the Nitrification Reaction in Nitrogen Balances." R. D. Hauck and J. M. Bremner. In Biology and Ecology of Nitrogen, Conf. Proc., pp. 31-39. Natl. Acad. Sci., Washington, D.C. 1969.

"Recovery of ^{15}N-Labeled Fertilizers in Field Experiments," R. L. Westerman, L. T. Kurtz and R. D. Hauck, Soil Science Society of America Proceedings 36:82-6. 1972.

"Nitrogen Tracers in Nitrogen Cycle Studies--Past Use and Future Needs," Roland D. Hauck, J. Environmental Quality 2:3;7-27. 1973.

"The Role of Fertilizers in Soil and Water Conservation." V. J. Kilmer, In Proc. 22nd Annual Meeting, Soil Conservation Society of America, pp. 118-122, Ankey, Iowa. 1967.

"Solving Dealer Problems--Monitoring Nutrient Losses from Small Watersheds," Proceedings 1972 NFSA Round-Up, pp. 25-34. St. Louis, Mo. 1972.

"Fertilizer Use and Misuse," Victor J. Kilmer and James C. Barber, in Proceedings of symposium, Nitrogen in Soil and Water, Hespeler, Ontario, Canada. March 31, 1971.

"The Relationship of Soil and Fertilizer Phosphorus to Water Quality, Victor J. Kilmer, prepared for FAO Panel, Effects of Intensive Fertilizer Use on the Human Environment, Rome, Italy, January 25-28, 1972.

"A Coordinated Program for Nitrogen and Water Quality Research," Victor J. Kilmer and Roland D. Hauck, Proceedings of the Second Annual Plant and Soil Conference, Sacramento, California, January 31, February 1 and 2, 1973.

"Monitoring Nutrient Losses from Small Watersheds," Victor J. Kilmer and Robert T. Joyce, presented at Mississippi Water Resources Conference, Vicksburg, April 10-11, 1973.

"The Impact of Fertilizer Use on Environmental Quality," Victor J. Kilmer, Second Fertilizer Conference, Cocoa Beach, Florida, May 18, 1972.

"Sulfur Resources Available to the Fertilizer Industry, the Fertilizers Made, Their Role, and the Problems Involved in Their Manufacture," D. W. Bixby and V. J. Kilmer, presented at symposium, Sulphur in Australasian Agriculture, Canberra, Australia, February 19-21, 1974.

"Nutrient Losses from Fertilized Grassed Watersheds in Western North Carolina," by V. J. Kilmer, et al, a cooperative investigation by TVA and North Carolina State University Agricultural Experiment Station as authorized under the Water Resources Research Act of 1964.

"Sulfur-Coated Urea and Uncoated Soluble Nitrogen Fertilizers for Fescue Forage," by D. A. Mays and G. L. Terman, Agronomy Journal 61:489-492. 1969.

"Leaching of Soluble and Slow-Release N and K Fertilizers from Lakeland Sand Under Grass and Fallow," G. L. Terman and S. E. Allen, Proceedings Soil Crop Science Society Florida 30:130-40. 1970.

Categories: Municipal Waste Disposal, Solid Waste Management.

MUNICIPAL WASTE DISPOSAL ON AGRICULTURAL SOILS. In an effort to learn more about the potential use of agricultural land for disposal of municipal solid and liquid wastes, research is being done in the laboratory, greenhouse, rhizotron-lysimeter, and field, on various aspects of this problem. Measurements are being made regarding the beneficial and detrimental effects of municipal wastes applied to soils, including crop yield response, effects of municipal wastes on physical and chemical soil properties, and movement and accumulation of potentially toxic heavy metals in soils as a result of heavy applications of these waste materials. Research in this area is financed partly by the Environmental Protection Agency.

Soils and Fertilizer Research Branch publications in this phase of environmental research include:

"Municipal Compost: Effects on Crop Yields and Soil Properties," D. A. Mays, G. L. Terman and J. C. Duggan. J. Environmental Quality 2:89-92. 1973.

"Municipal Waste Compost: Effects on Crop Yields and Nutrient Content in Greenhouse Pot Experiments," G. L. Terman, J. M. Soileau and S. E. Allen. Journal of Environmental Quality 2:84-9. 1973.

Category: Solid Waste Management.

EFFECTS OF COMPOST ON SELECTED SOILS AND PLANTS. Greenhouse and field studies to determine the effects of municipal compost and sewage sludge applications on crop growth, leaching losses, and accumulation of heavy metals in soils, plants, and drainage waters. The objectives of this project are to evaluate potential harmful or beneficial environmental effects of using municipal compost and sewage sludge on selected soils and plants; to determine the extent of nitrogen and phosphorus contributions to ground waters resulting from heavy and repeated compost or sewage sludge applications to cropped soils; to evaluate the effects of heavy applications of municipal wastes on plant growth, including root systems and soil physical and chemical characteristics.

References available are "Evaluation of Municipal Compost for Strip Mine Reclamation"* by David H. Scanlon, Carrol Duggan, and S. D. Bean; and "Evaluation of Municipal Refuse Compost for Ash Pond Stabilization"* by J. Carroll Duggan and David H. Scanlon. Numerous other publications related to this project are available upon request from the Technical Library, Muscle Shoals, and the TVA Division of Environmental Planning, Chattanooga.

Categories: Strip Mined Reclamation, Land Reclamation.

LAND RECLAMATION. The rehabilitation of strip-mined and other spoiled land areas by application of soil amendments and revegetation with forage and tree crops has been investigated for several years. Most recent research involves the potential use of horticultural tree crops on rehabilitation of spoil land of the Cumberland Plateau coal mining region.

Recent publication in this phase of environment research include:

"Revegetation of Coal Spoil in Northeastern Alabama: Effects of Timing of Seeding and Fertilization on Establishment of Pine-Grass Mixtures," Research and Applied Technology Symposium on Mined-Land Reclamation. pp. 208-14. Pittsburgh, Pa., March 7-8, 1973.

1483

TVA Stack Gas Emission Studies Staff, T102 National Fertilizer Development Center, Muscle Shoals, Alabama 35660. Phone: (205) 383-4631, ext. 516. Copies of reference items available on request.

Categories: Air Quality, Sulfur Dioxide Removal, Limestone Scrubbing.

SHAWNEE SULFUR DIOXIDE REMOVAL PROTOTYPE TEST FACILITY. A cooperative EPA, Bechtel Corporation, and TVA research and development program for sulfur dioxide removal from power plant stack gases using three parallel, 10-megawatt, prototype scrubber trains at the Shawnee Steam Plant near Paducah, Kentucky. Using sidestreams from the 150-megawatt, coal-fired Unit 10, several different scrubber configurations are being tested to determine the best devices for sulfur dioxide removal by limestone and lime slurry scrubbing and the necessary design parameters for scale-up to larger sizes. Cost estimate $8 million, financed by EPA, designed by Bechtel, constructed and operated by TVA. Project started in 1970, completion expected by 1975, first phase evaluation report scheduled for 1975.

"Operability and Reliability of the EPA Lime/Limestone Scrubbing Test Facility." H. W. Elder, L. Sybert, J. E. Williams, and P. E. Stone. Paper presented at the Flue Gas Desulfurization Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.

"Removal of Sulfur Dioxide from Stack Gases: Recent Developments in Lime-Limestone Wet Scrubbing Technology." H. W. Elder and W. H. Thompson. Transactions of the ASME, Journal of Engineering for Power, July 1973.

"EPA Alkali-Scrubbing Test Facility--Shawnee Power Plant: Interim Report of Corrosion Studies." G. L. Crow and H. R. Horsman, 43 pp., October 1, 1973.

Categories: Air Quality, Energy Resources, Sulfur Dioxide Removal.

WIDOWS CREEK SULFUR DIOXIDE REMOVAL SYSTEM DEMONSTRATION. A full-scale demonstration of sulfur dioxide removal from power plant stack gases by a limestone slurry scrubbing system retrofitted to the coal-fired, 550,000-kilowatt Unit 8 at Widows Creek Steam Plant near Stevenson, Alabama. The project will provide experience on the effectiveness, reliability, and cost of such systems which might improve air quality and at the same time enable the use of more available, less costly, high-sulfur coal as fuel. Cost estimate $42 million; plant modifications and construction started in 1973 with startup scheduled for early 1976.

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Limestone Slurry: Design Considerations for Demonstration Full-Scale System at TVA." B. G. McKinney and A. F. Little. Paper presented at the Second International Lime/Limestone Wet Scrubbing Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, November 8-12, 1971.

"Widows Creek Project for Sulfur Dioxide Removal: Sources and Cost of Limestone Supply." Process Engineering Branch, Division of Chemical Development, TVA Report S-464, 27 pp., March 15, 1972.

"The TVA Widows Creek Limestone Scrubbing Facility." Part I. "Full Scale Facility," B. G. McKinney, A. F. Little, and J. A. Hudson. Part II. "Pilot-Plant and Prototype Operating Experience," J. J. Schultz, T. M. Kelso, J. L. Graham, J. K. Metcalfe, and N. E. Moore. Paper presented at the Flue Gas Desulfurization Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.

Categories: Air Quality, Resource Recovery.

MARKETING SULFURIC ACID FROM ABATEMENT SOURCES. The potential for marketing sulfuric acid which could be produced from sulfur dioxide abatement systems is being examined in a multiphase study. The expected market volume, end uses, approach, and pricing policy are being evaluated to determine the best methods of disposing of byproduct acid. The net sales revenue is determined after expenses for transportation, selling, and storage are deducted. Power plants having the best net sales revenue can be predicted from the computer-based model. The first phase covers only acid which might be produced in the TVA power system. Cost of study - first phase $25,000, financed by EPA, Phase I started and completed 1973, subsequent phases to follow, Phase I report to be issued in early 1974.

"Marketing Sulfuric Acid from Sulfur Dioxide Abatement Sources: Phase I - The TVA Hypothesis." G. G. McGlamery, D. A. Waitzman, J. L. Nevins, and G. A. Slappey. Paper presented at the Electrical World Conference "Waste Disposal in Utility Environmental Systems: The Problem Beyond Removal," Chicago, Illinois, October 30-31, 1973.

Marketing H_2SO_4 from SO_2 Abatement Sources: Phase I - The TVA Hypothesis." D. A. Waitzman, J. L. Nevins, and G. A. Slappey. Prepared for Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C., January 1974.

Categories: Air Quality, Sulfur Dioxide Removal.

FIVE PROCESS ECONOMIC COMPARISON FOR REMOVAL OF SULFUR OXIDES. A comparative economic appraisal of the five most advanced stack gas desulfurization processes for removal of sulfur oxides from power plant stack gas. Investment and operating cost estimates are being prepared for limestone slurry scrubbing, lime slurry scrubbing, magnesia slurry scrubbing - acid manufacture, sodium solution scrubbing - sulfur dioxide reduction to sulfur, and catalytic oxidation of sulfur dioxide to form sulfuric acid. Design data currently available from pilot test programs or demonstration-size systems are to be utilized. Cost of project $155,000, financed by EPA, expected completion of study April 1974. Report to be published around third quarter of 1974.

Categories: Air Quality, Energy Resources, Coal Gasification, Sulfur Dioxide Removal.

STUDY OF ATMOSPHERIC AND PRESSURIZED LOW-BTU COAL GASIFICATION PROCESSES FOR RETROFITTING POWER PLANTS. A design and economic study of processes for gasifying bituminous coal to produce low-Btu fuel gas to burn in an existing plant. A comparison of the economics between atmospheric and pressure-type gasifier systems including sulfur removal systems and boiler modifications. The cost values are derived for comparison to leading stack gas desulfurization processes toward defining process potential. Cost of study $130,000, financed by the Electric Power Research Institute, project started December 1973, expected completion September 1974, evaluation report to be prepared by end of 1974.

Categories: Air Quality, Sulfur Dioxide Removal.

BENCH-SCALE SULFUR DIOXIDE REMOVAL STUDIES. Bench-scale laboratory investigations of processes or chemistry for removal of sulfur dioxide from power plant stack gases. These tests are used to search out improved processing steps, to define basic physical chemistry, or to predict operating conditions of promising concepts. The work is performed in the chemical development laboratories at the National Fertilizer Development Center in Muscle Shoals, Alabama. Cost of program $1,340,000. Studies carried out since 1967, continuing program.

"Absorption of Sulfur Dioxide in Limestone Slurry: Small-Scale Tests at TVA." A. V. Slack. Paper presented at the International Symposium on Lime/Limestone Scrubbing for SO_2 Control, sponsored by the National Air Pollution Control Administration, Pensacola, Florida, March 16-20, 1970.

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Limestone Slurry: Operational Aspects of the Scaling Problem" A. V. Slack and J. D. Hatfield. Paper presented at the Second International Lime/Limestone Wet Scrubbing Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, November 8-12, 1971.

"Removal of Sulfur Dioxide from Stack Gases by Scrubbing with Limestone Slurry: Small-Scale Studies at TVA." J. M. Potts, A. V. Slack, and J. D. Hatfield. Paper presented at the Second International Lime/Limestone Wet Scrubbing Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, November 8-12, 1971.

"Sulfur Oxide Removal from Power Plant Stack Gas: Study of the Effect of Organic Acids on the Wet - Limestone Scrubbing Process." J. D. Hatfield, Y. K. Kim, and R. C. Mullins. (TVA report No. S-458) Prepared for the Office of Air Programs, Environmental Protection Agency, U.S. Department of Health, Education, and Welfare, February 24, 1972.

"Use of Weak Acids to Improve Sulfur Oxide Absorption by Limestone Slurries." J. D. Hatfield and J. M. Potts. Paper presented at the 72nd National Meeting of the American Institute of Chemical Engineers, St. Louis, Missouri, May 21-24, 1972.

"Disposal and Use of Byproducts from Flue Gas Desulfurization Processes: Introduction and Overview." A. V. Slack and J. M. Potts. Paper presented at the Flue Gas Desulfurization Symposium, sponsored by the Environmental Protection Agency, New Orleans, Louisiana, May 14-17, 1973.

Categories: Air Quality, Sulfur Dioxide Removal.

CONCEPTUAL DESIGN AND COST STUDIES. A series of conceptual design and cost studies on processes for removing sulfur dioxide from power plant stack gases has been carried out since 1967. Thus far, evaluations have been prepared on five processes: dry limestone injection into a boiler, wet slurry scrubbing with limestone, wet scrubbing with ammonia solutions to produce fertilizer materials, catalytic oxidation for removal of NO and SO_2, and wet slurry scrubbing with magnesia with absorbent regeneration and manufacture of sulfuric acid. Process design variations are projected with capital and operating costs estimated. Cost of series to date $850,000, financed by EPA. Studies list.

"Sulfur Oxide Removal from Power Plant Stack Gas: Sorption by Limestone or Lime--Dry Process." Tennessee Valley Authority. Springfield, Virginia 22151: National Technical Information Service. (PB 178-972) (1968).

"Sulfur Oxide Removal from Power Plant Stack Gas: Use of Limestone in Wet-Scrubbing Process." Tennessee Valley Authority. Springfield, Virginia 22151: National Technical Information Service. (PB 183-908) (1969).

"Sulfur Oxide Removal from Power Plant Stack Gas: Ammonia Scrubbing--Production of Ammonium Sulfate and Use as Intermediate in Phosphate Fertilizer Manufacture." Springfield, Virginia 22151: National Technical Information Service. (PB 196-804) (1970).

"Sulfur Oxide Removal from Power Plant Stack Gas: Magnesia Scrubbing - Regeneration: Production of Concentrated Sulfuric Acid." G. G. McGlamery, R. L. Torstrick, J. P. Simpson, and J. F. Phillips, Jr. Tennessee Valley Authority (under contract with the Environmental Protection Agency). PB 222-509. National Technical Information Service, Springfield, Virginia 22151. May 1973. 372 pp.

"Magnesia Scrubbing." G. G. McGlamery. Paper presented at the EPA Flue Gas Desulfurization Symposium, New Orleans, Louisiana, May 14-17, 1973.

Section on "Process Chemistry, Properties, and Kinetics." J. F. Phillips, Jr. From "Sulfur Oxide Removal from Power Plant Stack Gas Lime-Limestone Wet Scrubbing Processes" (conceptual design and cost study, in preparation for the Environmental Protection Agency) (September 13, 1973).

Categories: Air Quality, Sulfur Dioxide Removal.

DOUBLE-ALKALI PILOT-PLANT TEST PROGRAM. A 1,000 kilowatt pilot-plant research and development program on technical evaluations of processes using solution-type scrubbing of sulfur dioxide from power plant stack gas with subsequent reaction of the soluble sulfite-sulfate salts formed with lime or limestone for throwaway of the more insoluble calcium-sulfur salts. The program is being carried out in one of the existing pilot plants at the Colbert Steam Plant near Tuscumbia, Alabama. One of the objectives of the investigation is the derivation of a possible back-up process for the 550-megawatt Widows Creek Steam Plant sulfur dioxide removal demonstration system. Cost estimate $150,000, test program began 1973.

TVA Power, Division of Transmission Planning and Engineering, 701 Chattanooga Bank Building, Chattanooga, Tennessee 37401. Phone: (615) 755-2244.

Categories: Land Use, Visual Enhancement.

SUBSTATION LANDSCAPING TECHNIQUES AND STRUCTURAL DESIGN. This is a continuing practical demonstration to improve the general appearance of TVA substation facilities. For several years, TVA has been actively involved in applying landscape techniques to soften the harshness of substations and blend them with local environs. These techniques include: the planting of trees and shrubs to retain a proper scaled relationship with the station structures and existing plant materials; the construction of decorative walls, fences and earthen berms; the application of various ground cover materials and plantings to slopes; interspersing grassed areas in expanses of crushed limestone; paved drive and parking areas; and painting station equipment and structures in colors selected to harmonize with the surroundings and reduce visual impact.

In addition to landscape applications, new tapered steel structures have been developed for substation use to provide a more modern and clean appearance than conventional lattice-type structures. A major reduction in structure heights, as accomplished by the low-profile design, was achieved by revising switching schemes and providing all bypass circuits in the same horizontal plane. These structures present a pleasing silhouette and are contributing significantly in removing the cluttered look usually associated with substation design.

Categories: Land Use, Visual Impact, Wildlife Resources.

ASSESSMENT OF TRANSMISSION LINE RIGHT OF WAY CLEARANCE PRACTICES. This project is a long-term (2-3 years) undertaking to assess the economic, environmental and visual impacts which are likely to accrue to all defined transmission line right of way clearing practices and methods. Major emphasis will be placed on quantifying and qualifying the adverse effects as well as benefits to wildlife on these rights of way. The conclusion of this project will provide program guidance for further action related to TVA's transmission line right of way clearing and maintenance policies.

TVA Office of Tributary Area Development, 139 Evans Building, Knoxville, Tennessee 37902. Phone: (615) 637-0101, ext. 2911. Copies of specific counties and/or municipalities reports and studies available upon request.

Categories: Solid Waste Management, Sanitary Landfills.

SANITARY LANDFILL FEASIBILITY STUDIES. Technical assistance program to local governments in the Tennessee Valley region designed to help them meet state regulations and laws relating to land disposal facilities. Prepared reports are submitted by local government applicant to state health department for approval prior to initiation of detailed planning and design activities. Items in the studies include: (1) background information on service area such as climate, topography, political entities, transportation system, major economic contributors, population density, trends and projections; (2) existing disposal practices including type, quantity, and methods of processing and disposal presently used, labor and equipment employed, administration, and environmental effects of present operations; (3) proposed method to be used in processing and disposal including type and quantity of waste, general design plans and criteria, ultimate use of land disposal site, equipment to be used, and proposed administration; (4) fiscal program for plan implementation including initial required capital and budget; and (5) maps, exhibits, and other related pertinent data to show graphically the nature of the proposed disposal facility.

Categories: Solid Waste Management, Sanitary Landfills.

SANITARY LANDFILL OPERATIONAL DESIGN AND CONSTRUCTION PLANS. Technical assistance program to local governments in the Tennessee Valley region. Demonstration plans are prepared to show the technical specifications for constructing, implementing, and operating a land disposal facility. Plans are a prerequisite to final state health department approval of a sanitary landfill and aid counties, municipalities, and regions to develop a cleaner and healthier environment. Technical items include construction plans graphically showing the site location, site topography, method of landfilling, cell development procedures with cross sections, final grading and landscaping, specifications for installation of site facilities, specifications for landfill construction, landfill operational procedures, and day-to-day administration of the landfill.

Categories: Solid Waste Management, Waste Collection.

RURAL COLLECTION SYSTEMS ASSISTANCE. Technical assistance program to local governments in the Tennessee Valley region. Collection systems design plans are prepared recommending a collection method a public entity can use so that its residents may conveniently dispose of refuse without dumping it indiscriminately. Assistance usually involves preparing technical plans for a countywide rural bulk container system, house-to-house curbside pickup, or a combination of these two methods. Plans normally include detailed information, especially with regard to the existing local collection practices, recommended type of collection equipment, route layout, suggested container stations, administrative arrangements, and the total cost of the system.

Category: Solid Waste Management.

COAL TIPPLE TRANSFER STATION DESIGN. Demonstration of a new and relatively inexpensive type of transfer station based on the design of a coal tipple and for use by small municipalities. Basic design incorporates a chute and hopper with attendant supporting structure constructed on slope of hill. Municipal collection vehicles and users deposit waste into the hopper of the tipple. A large county-operated, front-end-loading-type compactor collection vehicle would service the station at periodic intervals, compact the refuse into compactor body, and haul it for the small municipality to a state-approved, centrally located county disposal facility. Following a use period, efficiency will be determined with results disseminated to other localities.

Categories: Solid Waste Management, Water Quality, Sanitary Landfills.

MONITORING OF LEACHATE FROM LANDFILLS. Project to investigate the factors contributing to landfill area leachates, to improve method of leachate detection, and to study the chemical, biological, and physical characteristics and parameters of leachate evolving from an operating landfill. Future plans include use of this information to aid in site selection and design engineering plans for land disposal sites, including the use of abandoned strip mines.

Categories: Solid Waste Management, Energy Resources, Resource Recovery.

ENERGY AND RESOURCE RECOVERY FROM SOLID WASTE. Research study into the use of municipal solid waste as a supplemental fuel for TVA coal-fired boilers. Objective is to alleviate the solid waste problem while, at the same time, providing two useful products: (1) a burnable gas for use as a supplemental fuel and (2) a slag-type residue which has several potential applications. Research may result in a feasible project.

Categories: Resource Recovery, Recycling, Solid Waste Management.

DISCARDED AUTOMOBILE TIRES IN ASPHALT PAVING. Demonstration of the exceptional road surface sealing qualities of asphalt treated with ground rubber from discarded automobile tires. The resurfacing treatment has been shown

to retard by several years fatigue or "alligator" cracking, the most common maintenance fault of asphalt paved surfaces. Equipment furnished by TVA. Evaluation and staff assistance also furnished by Federal Highway Administration.

Categories: Resource Recovery, Recycling, Solid Waste Management.

WASTE RUBBER CONVERSION. A research project for chemical conversion of discarded automobile tires to petroleum products. Research completed to date has yielded a patentable process for producing a liquid petroleum. Economic recovery appears reasonable, but engineering details for pilot plant testing are not complete. TVA has provided financial assistance to the University of Tennessee which has enabled study of the process and purchase of a liquid chromatograph for analysis of liquid petroleum products. Further research is planned which may result in a feasible project.

Categories: Solid Waste Management, Resource Recovery.

SOLID WASTE INCINERATION. Technical assistance program to community and regional organizations to help them evaluate various municipal incinerators and to select the one best suited to their needs. Objective is to help local and regional organizations to select the most economically and environmentally sound incinerator which will meet their needs. The incinerator process recommended may or may not include resource recovery in the form of steam.

Categories: Solid Waste Management, Recycling, Resource Recovery.

WASTE PAPER RECYCLING--COMMUNITY. Technical assistance program to help local governments and entrepreneurs in developing wastepaper collection and marketing arrangements in their communities. The objective is to encourage maximum recycling of used paper. Active projects in Tuscumbia, Alabama, and Lewisburg, Tennessee.

Categories: Solid Waste Management, Land Pollution, Litter Prevention.

COUNTYWIDE CLEANUP PROJECTS. Demonstration in the organization and implementation of rural cleanup project. Similar to municipal community cleanup projects only larger in scope and includes random dump and junk car removal. One dozer and loboy furnished by TVA. Additional equipment and all personnel furnished locally.

"How to Conduct Rural Cleanup Projects." Program Planning Staff, OTAD, TVA, 1973, nontechnical.*

Categories: Solid Waste Management, Land Pollution.

MUNICIPAL DUMP CLOSING. Demonstration of techniques of closing municipal dumps. Objectives are to reclaim large municipal dumps into useful sites through the use of good landscaping principles. Plans and supervision of construction provided by TVA. Rat poison and supervision of baiting provided by TVA. All other input provided locally.

TVA Division of Water Control Planning, 404 Evans Building, Knoxville, Tennessee 37902. Phone: (615) 637-0101, ext. 3161.

Category: Archaeology.

ARCHAEOLOGICAL INVESTIGATIONS. Conducted at TVA reservoirs, steam plants, substation sites, and along transmission line locations in conjunction with area universities and other governmental organizations. The program began in 1934 and is continuing. Objectives are to increase the knowledge of prehistory and to ensure that valuable archaeological resources and information are not destroyed. As a result of the program, the Universities of Alabama, Kentucky, and Tennessee have some of the Nation's finest and most extensive collections of artifacts and other materials together with information which permits reconstruction of early cultures and history. Some examples of current investigations for which interim reports may be requested from the cooperating university are:

1. Tellico project in Monroe and Loudon Counties, Tennessee, and Duck River project in Maury, Marshall, Bedford, and Coffee Counties, Tennessee:

   Department of Anthropology
   University of Tennessee
   Knoxville, Tennessee 37921

2. Bear Creek project in Franklin and Marion Counties, Alabama:

   Department of Arts and Sciences
   Archaeological Research
   University of Alabama
   University, Alabama 35486

TVA Water Quality Branch, 248 401B, Chattanooga, Tennessee 37401. Phone: (615) 755-3011, ext. 3164.

Categories: Water Quality, Oxygenation Studies.

EUTROPHICATION IN RESERVOIRS. Study to determine the causes and effects of euthrophication in impoundments. One objective is development of a procedure to predict timing and extent of dissolved oxygen depletions in outflows from proposed reservoirs. Another is determination of the feasibility of modifying the design and operation of water control structures to improve the quality of water discharged through storage dams. Variations in the water quality of reservoirs with length, depth and time are being studied in "prototype" situations throughout the Tennessee Valley, especially changes in temperature and dissolved oxygen in the reservoirs and tailrace streams. Several mechanisms of dissolved oxygen depletion have been investigated at Cherokee, Douglas, Chatuge, Fontana, South Holston, and Watauga Reservoirs.

"Effects of Impoundments on Water Quality: Observations of Several Mechanisms of DO Depletion" W. R. Nicholas and John A. Gordon, Presented at 1972 ASCE Annual and National Environmental Engineering Meeting, Houston, Texas, October 16-22, 1972. Technical.*

"Effects of Impoundments on Water Quality Report of Research Conducted at Cherokee Reservoir from 1966-1970" John A. Gordon, September 1971. Technical.*

"Effects of Impoundments on Water Quality Report of Research Conducted at South Holston and Watauga Reservoirs During 1970-1971" John A. Gordon, April 1972. Technical.*

"Studies of Eutrophication in TVA Lakes," Charles D. Gates, August 1969.

"TVA Activities Related to Study and Control of Eutrophication in the Tennessee Valley," National Fertilizer Development Center, Muscle Shoals, Alabama, April 1970; papers discussed at meeting of the Joint Industry/Government Task Force on Eutrophication.*

Categories: Water Quality, Oxygenation Studies.

OXYGENATION STUDIES. Tests to develop oxygenation methods that can be efficiently utilized for the reaeration of turbine discharges from deep storage reservoirs during the fall months when such reservoir releases are low in dissolved oxygen.

The method of oxygen gas bubbling in the lake immediately upstream from the turbine intakes is being developed through field and laboratory studies. Equipment has been developed to measure the performance characteristics of fine pore diffusers. System aeration efficiencies are measured in the field.

"Oxygenation of Turbine Discharge from Fort Patrick Henry Dam," R. J. Ruane and S. Vigander, Proceedings of the Specialty Conference on Applications of Commercial Oxygen to Water and Wastewater Systems (in print).*

"Investigations of Methods for Increasing Dissolved Oxygen Concentrations Downstream from Reservoirs," R. J. Ruane, Proceedings of the 11th Environmental and Water Resources Engineering Conference, June 1972.*

Categories: Water Quality, Heat Transfer, Temperature Prediction.

METHODS FOR PREDICTING THE RATE AT WHICH RECEIVING WATERS WILL LOSE EXCESS HEAT. Study to improve techniques of predicting how rapidly heated water will lose added heat as warm waters flow downstream from thermalelectric power plants. To develop methodology to allow the heat gained by a cold water release from a stratified reservoir to be predicted in both a stream and reservoir situation. Field data are continually collected in vicinity

of TVA fossil-fuel and hydroplants. Additional data will be collected at the biothermal research facility to be constructed at the Browns Ferry Nuclear Plant. Here rates of heat loss from water elevated various amounts above ambient can be observed and related to meteorological variables.

Categories: Water Quality, Effects of Heated Water Discharges, Thermal Discharges, Limnological Thermal Tolerance.

EFFECTS OF WASTE HEAT FROM COLBERT POWER PLANT ON AQUATIC LIFE. To assess the impact on aquatic life in Cane Creek of heated water discharged from Colbert Power Plant.

Water in a three-mile reach of creek is elevated in temperature at least 10°F at all times, and on occasion temperatures reach 100°F. This reach provides ideal setting to observe effects of heated water on all forms of aquatic life. Technical aspects of study were outlined and agreed upon. Project authorization for two-year study approved. Automatic water temperature monitoring equipment has been installed. Final report due by June 30, 1974.

E-EB-73-3

TENNESSEE VALLEY AUTHORITY

INVESTIGATION OF ALLEGED AIR POLLUTION EFFECTS ON YIELD OF SOYBEANS IN THE VICINITY OF THE SHAWNEE STEAM PLANT

DIVISION OF ENVIRONMENTAL PLANNING

E-EB-73-3

TENNESSEE VALLEY AUTHORITY

Division of Environmental Planning

INVESTIGATION OF ALLEGED AIR POLLUTION EFFECTS ON YIELD OF SOYBEANS IN THE VICINITY OF THE SHAWNEE STEAM PLANT

Prepared by

H. C. Jones, J. R. Cunningham, S. B. McLaughlin,
N. T. Lee, and Shirley S. Ray

Chattanooga, Tennessee
August 1973

CONTENTS

Page

Summary vii

Introduction 1

Methods 2

Delineation of Area of Effects on Vegetation 2
Preharvest Sampling 2

Extensive Sampling 2
Intensive Sampling 3
Measurements of Foliar Injury 3
Calculation of Injury Class 3

Sampling at Harvest 3

Locations of Yield Sample Plots 5
Selection of Unaffected or "Control" Fields 5
Harvesting Yield Plots 5
Soil Sampling 5
Threshing of Soybean Samples 7
Calculation of Yield 7
Soil Analyses 7

Interviewing of Farmers 8
Data for Soil Type and Productivity Class 8
Statistical Analyses of Data 9

Analysis of Variance 9
Stepwise Regression Analyses 9

Results 10

Delineation of Sulfur Dioxide Affected Areas 10
Sampling Before Harvest 17

Extensive Sampling 17
Intensive Sampling 18

Sampling at Harvest 18

Analyses of Variance of Yield Data 19
Regression Analyses of Yield Data 23

Dare Variety 23
Hood Variety 23
York Variety 25
Pickett Variety 27
Clark-63 Variety 29

CONTENTS
(Continued)

Page

Discussion 33

Conclusions 35

APPENDIXES

A. List of Species Exhibiting Foliar SO_2 Effects in the Vicinity of the Shawnee Steam Plant, July 30 and August 11, 1971.

B. Procedure for Sampling Yields and Factors for Converting Weight of Soybeans per Acre to Bushels per Acre at 13% Moisture Content.

C. Procedure for Bioassaying TVA Soil Samples for Soybean Cyst Nematode and Results of the Bioassays.

D. Estimated Average Acre Yields of Principal Crops on Soils of McCracken Work Unit.

E. Computer Printouts for Stepwise Regression Analyses of Soybean Data.

F. Tabulation of Number of Observations and Measurements Taken for Five Varieties of Soybeans.

G. Data Tabulations for Observations and Measurements Made for Each Field.

H. Summary of Yields by Field, Variety, and Owner.

INVESTIGATION OF ALLEGED AIR POLLUTION EFFECTS ON YIELD OF SOYBEANS IN THE VICINITY OF THE SHAWNEE STEAM PLANT

Summary

Following air pollution injury to the foliage of soybeans and other vegetation growing in the vicinity of the Shawnee Steam Plant in July 1971, the Tennessee Valley Authority (TVA), in cooperation with the Environmental Protection Agency (EPA), the Kentucky Agricultural Extension Service, and a number of farmers whose fields were affected, undertook an investigation to determine whether the injury would adversely affect soybean production.

Two types of air pollution effects were detected on the foliage of soybean plants—intercostal necrosis and chlorosis—both symptoms of injury sometimes caused by sulfur dioxide (SO_2). Soon after the injury occurred, necrosis, chlorosis, disease, and insect injury were estimated for 62 injured fields, totaling 1,300 acres.

The SO_2 injury occurred at an early stage in the development of the soybean plants, before they bloomed when they were about 18 in. tall. The plants increased considerably in size and appeared to have fully recovered by the time they reached full growth, which reduced the probability of any permanent effect on their productivity.

A total of 118 fields was investigated, but 8 of these were eliminated from analysis because they were harvested before yield data had been collected. Yields and soils were sampled in the remaining 110 fields, which included 68 affected fields, 38 unaffected fields, and 4 unclassified fields. Figure 1 shows the distribution of yields by injury class and variety for the fields that were sampled. The average yield for both affected and unaffected fields was 30 bushels per acre (bu/A), which was the same as the average yields for Ballard and McCracken Counties. The lack of any difference in average yields indicates that the SO_2 injury had no effect on yields. Yields in 1971 were 5 bu/A more than those in 1970.

Soil analyses made by the University of Kentucky showed that, for most of the fields sampled in the investigation, soil fertility and pH were low and in many cases extremely low. Tests for soybean cyst nematodes were positive for more than one-half (62%) of the fields. These findings alone would indicate that maximum yields should not have been expected.

Statistical analyses for most varieties showed that soybeans grown in fields that were either free of nematodes or were planted in corn or pasture during the previous growing season (1970) produced significantly higher yields than those grown in fields infested with nematodes or planted in soybeans the previous year. No significant differences were detected between yields from unaffected fields and those from affected fields, except for the Clark-63 variety. However, the number of unaffected fields of the Clark-63 variety available for the analysis (2 compared with 5 to 13 for the other varieties) was insufficient for a valid comparison. Evidence was presented that indicated the difference was probably attributable to factors other than SO_2 injury.

54-380 O - 75 - pt. 2 - 33

Stepwise regression analyses of the data showed that 71 to 100% of the variation in yields among fields of a given variety could be explained by differences in soil fertility and pH, cultural practices, and soybean cyst nematode infestation. The way in which these variables predicted and explained yields for specific fields is illustrated in figure 2 for two fields of each variety. Neither necrosis nor chlorosis was significant (90% confidence level) in explaining variation in yields among fields planted with the same variety of soybeans. The results of the analysis for the Clark-63 variety are admittedly subject to question because there were only four fields for which complete data, including those for soils, were available. The four fields, however, represented a broad range of injury, soil fertility, pH, and yields. The analysis of these data was considered to provide the most reasonable explanation of variations in yields among the Clark-63 fields.

A number of shortcomings are inherent in investigations of the type reported here. Many important variables that influence the response being measured cannot be controlled. In this investigation, in which the response being measured was yield, a broad range in variability of factors affecting yield was to be expected. Although a large number of variables known to influence yield were considered in the statistical analyses, other variables might also have been important. However, the variables that were considered accounted for at least 70% of the variability in yields. In one variety, statistical analyses were limited by the unavailability of control fields that represented the range in variables of soil characteristics and farming practices typical of other fields within the variety. Finally, the accuracy of some of the data used in the analyses was dependent on the memory of the farmers.

Foliar SO_2-injury had no detectable effect on soybean production. Production was limited by low soil fertility and pH, soybean cyst nematode infestation, and cultural practices and possibly by other factors that were not considered in the investigation. Maximum yields will not be attained in most fields unless steps are taken to correct these conditions.

LEGEND:

Base Yield:

Yield of hypothetical field for indicated variety possessing all characteristics--low soil fertility, suboptimal cultural practices, and soybean cyst nematode infestation--associated with lowest yields.

Increment increase in Yield above Base Yield Attributable to:

Soil fertility level (pH, K or P or combinations of any of the variables).

Optimal cultural practices with respect to previous crop, planting date, or row width or combinations of any of the variables.

Nematode-free soils

Difference between predicted and actual yields.

$^{1}D_{36}$ Injury class Variety - Yield (bu/A)

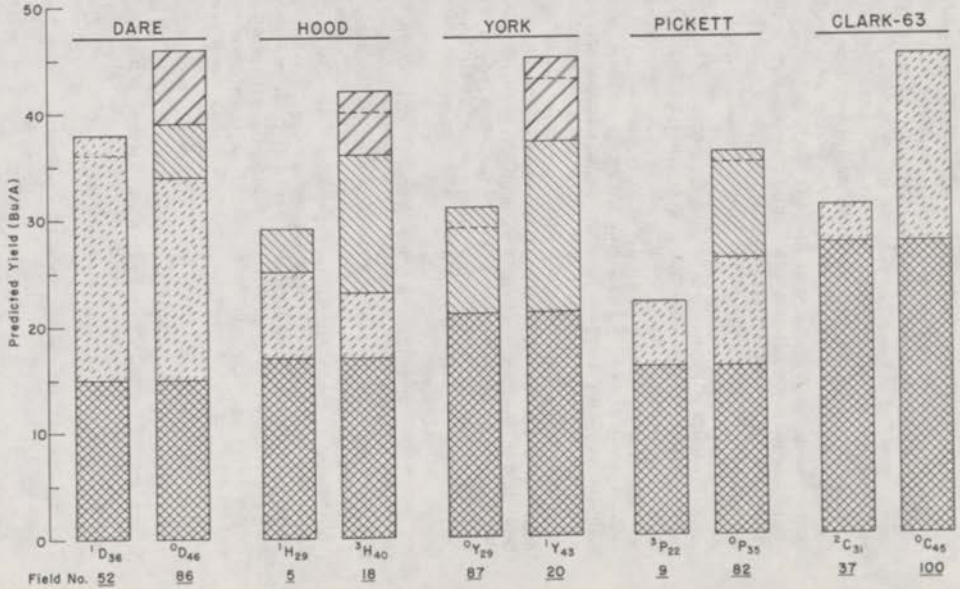


Figure 2

The Way in Which Variables Identified by Stepwise Regression Analysis Predicted and Explained Yields of Specific Fields for Each Variety of Soybeans

x

INVESTIGATION OF ALLEGED AIR POLLUTION EFFECTS ON YIELD OF SOYBEANS IN THE VICINITY OF THE SHAWNEE STEAM PLANT

Introduction

On the morning of July 29, 1971, while conducting a routine survey for air pollution effects on vegetation in the vicinity of the Shawnee Steam Plant, a Tennessee Valley Authority (TVA) biologist observed the plumes from the steam plant moving in a southwesterly direction. It appeared that the plume was near ground level. The next morning, July 30, the biologist observed intercostal necrosis of foliage on 28 species of plants (Appendix A), including such sensitive sulfur dioxide (SO_2) indicator plants as giant ragweed and wild sunflower. Soybeans exhibited the same type of effects. The effects were new and had obviously occurred during the preceding 24-hour period. Pronounced effects were observed on ragweed growing within a 6,000-acre area, about 1.5 miles wide, that extended from 3 to 12 miles west-southwest of the steam plant. Effects on soybeans were confined to a smaller area, 1 mile wide and 7 miles long, within the larger area.

The Shawnee Steam Plant is but one of several sources of air contaminants in the immediate area where the foliar injury was observed. Since no monitoring equipment was being used in the area at the time, it was impossible to determine what contaminants were present in the air and in what quantities. Other factors besides air contaminants, can cause foliar injury; however, for the purpose of this report, all foliar injury will be treated as if it were caused by SO_2 and will be referred to as "SO_2 injury."

The Environmental Protection Agency (EPA) notified TVA on August 5 of complaints by farmers of air pollution injury to their crops and other vegetation in the vicinity of the steam plant. TVA biologists met with representatives of the farmers whose fields were affected, EPA, the Kentucky Air Pollution Control Commission, and the University of Kentucky Agricultural Extension Service to inspect the affected vegetation. The inspection revealed that forage crops such as red clover and annual lespedeza had almost completely recovered from the effects. Very light foliar markings which might have been caused by exposure to SO_2 were detected on a few Burley tobacco plants at a single location. Soybean plants exhibited the only foliar injury considered to be of significance, and they showed considerable recovery, which was attributed to conditions favorable for rapid growth.

At the time of the inspection, it was estimated that even in the most severely injured fields intercostal necrosis occurred on less than 5 percent of the total leaf area. However, the affected plants were exhibiting a more conspicuous type of injury, yellowing or chlorosis of affected foliage, that had not been observed on July 30.

In the meeting that followed the inspection tour, biologists outlined TVA's plans to investigate the air pollution incident:

1. To delineate the affected area and locate the affected soybean fields.

2. To determine the severity of injury to foliage of soybean plants.

3. To determine whether injury to foliage of soybean plants had caused reductions in yields of affected fields.

The other representatives agreed that TVA should undertake the investigation and that they would cooperate with TVA in the investigation. Subsequently, EPA requested supplemental sampling and analysis, which they agreed to sponsor.

TVA began its investigation of the SO_2 injury to the soybean crop on August 9. This report presents the results of the investigation that are pertinent to the primary objective of determining the effect of foliar injury on soybean production.

Methods

Delineation of Area of Effects on Vegetation

A survey was made of the area south of the Ohio River within a 13-mile radius of the Shawnee Steam Plant during the week of August 9 to determine the extent of SO_2 effects on vegetation. Damaged foliage of giant ragweed, a species known to be particularly sensitive to injury by SO_2 was used to locate areas where crops might have been exposed to high concentrations of SO_2 at ground level. Crops within the area of affected ragweed were inspected for injury, and, if injury was observed, their locations were plotted on topographic maps.

A second survey was made August 18-20 after new SO_2 effects were detected on giant ragweed.

Because the rapid recovery of the soybean plants might preclude obtaining data on injury for all affected fields, soybean fields in the Shawnee area were tentatively classified into four categories of relative degree of injury based on the information obtained from these surveys: (1) unaffected, (2) light, (3) moderate, and (4) severe. The purpose of this classification was to facilitate the collection of data before harvest from soybean fields representing several relative intensities of effects that could later be correlated with data on yield at harvest.

Sampling Before Harvest

Two types of sampling were conducted during these surveys: (1) extensive sampling, which consisted of visual estimates of injury for all affected fields, and (2) intensive sampling, which consisted primarily of collection of sample plants for measurement of injury in a limited number of fields. Estimates of injury for fields within a variety were obtained at intervals of 7 to 9 days.

Extensive Sampling—Necrosis, chlorosis, and effects of the types caused by insects and disease were estimated at 3 to 15 sampling points in each affected field. The sampling points were systematically located within a field, depending on its size and shape, to provide a representative estimate of the condition of plants within a field. By using an index of 0 through 10 (0 = 0%, 1 = 10% etc.), investigators estimated (1) the percentage of area of the average leaf affected, (2) average percentage of leaves affected per plant, and (3) the percentage of plants exhibiting effects. The average percentage of total leaf area affected at each sampling point was calculated by multiplying the three estimates. The percentage of total leaf area affected within a field was obtained by averaging each set of estimates for each point and multiplying the averages of each set. For example, if the injured area on the average affected leaf were 50%, the number of injured leaves on an average affected plant were 80%, and the number of plants affected were 80% of the total, then the percentage of total leaf area affected in a field would be $0.50 \times 0.80 \times 0.80 = 0.32$ or 32%.

A soil sample was collected at each sampling location about 6 in. from the midline of a row. The samples for a field were composited. Soils of two injured Clark-63 fields (nos. 28 and 31) were inadvertently not sampled during this phase of the investigation.

Height and the total number of nodes were determined on a plant selected at random from each sampling point. Height and the number of nodes to the first affected foliage, to the first leaf shed, and to the first pod set were also determined.

Intensive Sampling—It was recognized that, because of the rapid recovery of the affected soybean plants, it would be impossible to obtain actual measurements of injury for all affected fields. Therefore, 11 fields representing the various classifications of injury, including unaffected fields and three varieties of soybeans, were selected for intensive sampling to obtain measurements of injury for comparison with visual estimates. Plots consisting of 2-ft-long segments of row were systematically located within a field to provide a sampling intensity of one plot per acre of soybeans.

Effects were estimated visually, height was measured, and nodes were counted on plants growing in each plot in the same manner as described in the section on "Extensive Sampling." Soil samples were also taken. In addition, counts were made of the total number of plants in the 2-ft-long segment of row, of the number exhibiting necrosis, and of the number exhibiting chlorosis.

Foliage was collected from three randomly selected plants on every other plot and stored in a plant press for measurement of necrosis, chlorosis, and injury caused by insects and diseases.

Measurements of Foliar Injury—Injury on the samples of pressed foliage from the intensively sampled plots was measured with a Hewlett-Packard Digitizing System. The system consists of a Model 9100A electronic calculator and a 9107A digitizer. Affected areas were measured on each leaf of a composited 3-plant sample. Each type of effect was expressed as the average percentage of total area affected per plot.

Calculation of Injury Class—Injured fields were classified into three classes, depending on the amount of necrotic and chlorotic types of injury:

Class 1 - Necrosis less than 1% or chlorosis greater than 5% (but less than 50%)

Class 2 - Necrosis 1 to 5% or necrosis greater than 0% but less than 1% and chlorosis greater than 50%

Class 3 - Necrosis greater than 5%

However, the actual values for visual estimates of necrosis and chlorosis were used in the stepwise regression analysis of data.

Sampling at Harvest

The scheme used to sample both yield and factors influencing yield is shown in figure 3. The plan was to sample at least four fields within each injury class, if they were available, and at least the same number of unaffected fields for each variety of soybeans. Thereafter, as many fields as possible in each category would be sampled, depending on whether they had been harvested by the farmer. We recognized that variations in yields among soybean fields would be great and that a large sample size would be desirable for stepwise regression analyses to isolate and explain the variations.

The original plan was to determine yield by combining whole fields; however, because of the large number of fields to be sampled, it became evident that such a plan would be impractical. On the recommendation of the University of Kentucky's Agricultural Extension Service (Appendix B), a systematic sampling scheme employing a variable number

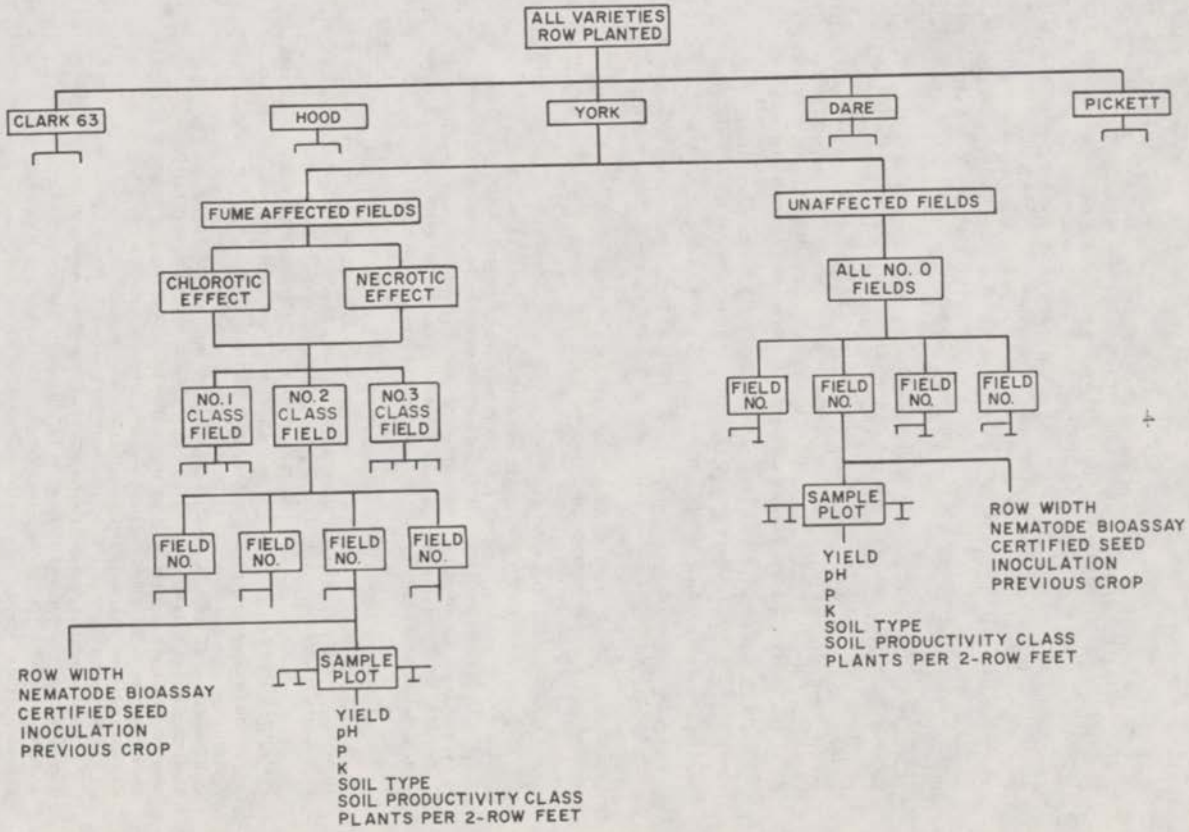


Figure 3
Harvest Sampling Scheme - Soybean Investigation - Kevil, Kentucky

of 12.5 row-ft plots, depending on size of field, was adopted. Data to be collected for each plot included yield, phosphorus (P) and potassium (K) content of the soil, soil pH, soil type, soil productivity class, and number of plants per 2 ft of row; information on the use of certified seed and Rhizobium inoculum, infestation by soybean cyst nematodes, and crop grown during the preceding season (1970) were necessarily collected by fields. It would have been desirable but impractical to have had data for nematode infestation by plots.

Sampling of the fields planted with Clark-63 variety was the only exception to the scheme discussed above. Those fields were sampled for yield before plans for the harvest phase of the investigation were completed. We later decided to obtain fertility and pH data at harvest time for each sample plot. The soils of three fields, nos. 28, 31, and 37 (figure 5, "Results"), had been fertilized and plowed under before the samples could be collected. However, information on soil fertility and pH before harvest was available for field no. 37. In addition, three small fields of Clark-63 variety (nos. 29, 30, and 32) were sampled to document their yield. No estimates of injury were made for these fields during the phase of the investigation before harvest because these fields were not at that time known to exist. Observations of injury in surrounding fields suggest that these fields would have been in injury class 3. Data for these fields were not included in the statistical analyses unless specifically mentioned in the text.

Locations of Yield Sample Plots—Samples consisting of 12.5 row-ft of soybean plants were collected from each field as follows:

Size of field, acres	No. of samples
0 - 5	8
6 - 19	10
20 - 50	13
51+	18

To locate 8, 10, 13, or 18 sampling plots within a field, the width of a field was divided by 4, 5, 6, or 8, respectively, to determine the spacing between sampling strips (see figure 4). Alternating strips of 3 and 2 sampling plots were located back and forth across the field. For the 3-sample strips, the plots were located in successive rows at one-fourth, one-half, and three-fourths the length of the field. Similarly, for the 2-sample strips, the plots were located at one-third and two-thirds the length of the field.

Selection of Unaffected or "Control" Fields—Unaffected or "control" fields were selected for comparison of their yields with those of the affected fields. They were selected on the basis of (1) healthy appearance and absence of visible SO_2 injury, (2) soil types similar to those of affected fields, and (3) low weed populations. Using these criteria, we identified an adequate number of unaffected Hood (13), Dare (13), York (5), and Pickett (6) fields for comparison with affected fields of the same varieties; however, only two unaffected fields could be found for the Clark-63 variety.

Harvesting Yield Plots—Each 12.5-ft plot was measured with a tape, and all soybean plants in the plot were cut with hand clippers and placed in burlap bags. Care was taken to avoid loss of beans. Plants were counted in the 2 ft of row immediately following the sample plot to determine plant density.

Soil Sampling—Six soil samples were systematically collected to a 6-inch depth using a soil sampling probe along each plot and composited. A sample was collected from each side of the row at points about 1, 6, and 11 ft within the plot and 6 in. from the midline of the row.

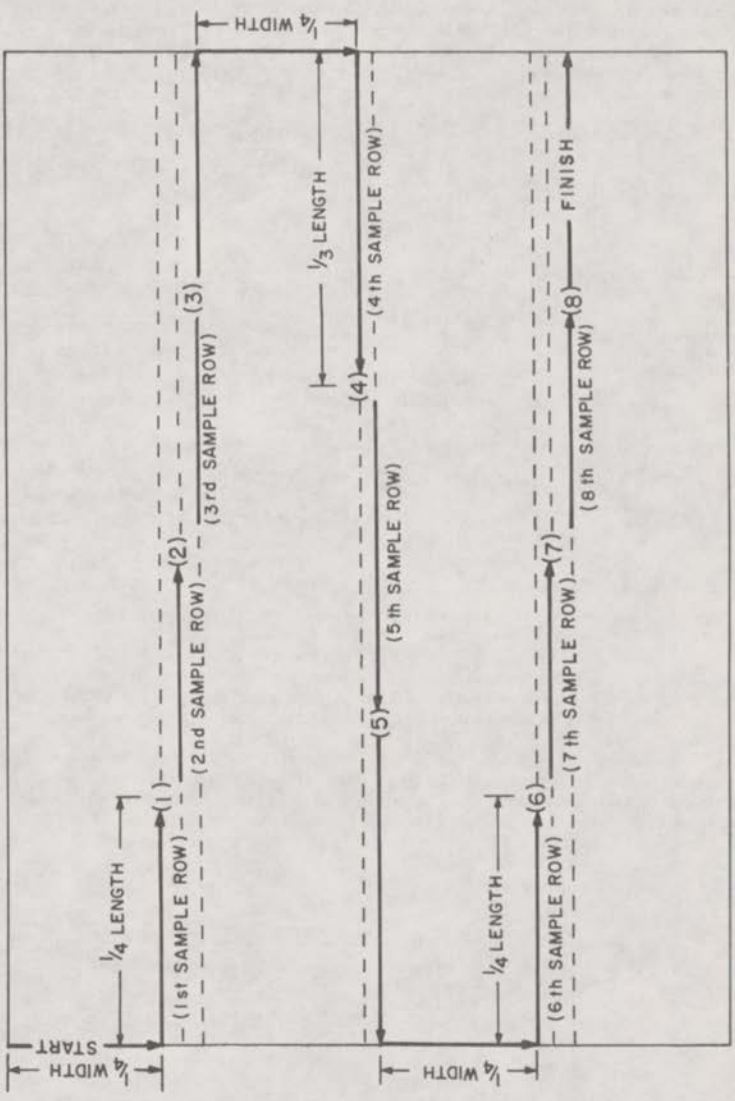


Figure 4
Scheme for Locating Eight 12.5-Foot Sample Plots in Fields Up to 5 Acres

Threshing of Soybean Samples—The soybean samples were threshed at a central location with a small thresher loaned by the University of Kentucky. Care was taken to minimize loss and shattering of beans. The beans were bagged and transported to a TVA laboratory at Muscle Shoals, Alabama, where their weight and moisture content were determined. A subsample of approximately 100 beans was randomly selected from each sample, counted, and weighed to determine average bean weight.

Calculation of Yield—The yield for each sample was calculated by the formula

$$\text{Yield in bu/A} = \frac{\text{sample weight in lb} \quad \frac{43{,}560 \text{ ft}^2/\text{A}}{(12.5 \text{ ft} \times \text{row width in ft})}}{\text{factor for conversion to 13\% moisture (Appendix B) in lb/bu}}$$

Soil Analyses—The Soils Testing Laboratory, Division of Regulatory Services, University of Kentucky, analyzed the soil samples for pH, phosphorus content, and potassium content. The values for phosphorus and potassium were expressed in pounds per acre and were classified into four categories as shown below:

CLASSIFICATION OF DATA FOR PHOSPHORUS, POTASSIUM, AND pH

Class	Phosphorus (lb/A)	Potassium (lb/A)	pH
1 (very low)	<16	<61	<5.3
2 (low)	16-30[a]	61-125[a]	5.3-6.0
3 (medium)	31-60	126-200	6.1-6.7[b]
4 (high)	>60	>200	>6.7

a. For soil testing low, recommended application of P_2O_5 or K_2O is 40-80 lb/A.
b. Normal range for soybean production.

Actual phosphorus, potassium, and pH values were used for the computer analyses. Lime requirements were also determined from the water pH method, the buffered pH method, or both for each sample and expressed as tons per acre.

Subsamples of the soil samples were composited by field and bioassayed for infestation by soybean cyst nematodes by Dr. Richard A. Chapman, Department of Plant Pathology, University of Kentucky. The methods used by Dr. Chapman are discussed in Appendix C. For computer analysis of the data, nematode infestation was classified into three categories:

Classification of Soybean Cyst Nematode Bioassay Data

Class	Conditions
0	No cysts found on roots of bioassay plants or less than 2 cysts found in soil
1	Cysts found in soil (except where 25 or more new cysts found) but not on roots
2	Nematodes or cysts found on roots or 25 or more new cysts found in soil

In February 1972, 21 additional samples were collected from selected fields to check the original nematode bioassays (Appendix C).

Interviewing of Farmers

Farmers were interviewed to get the following information pertaining to both the affected and unaffected soybean fields: (1) crop grown in 1970, the year before the air pollution episode occurred; (2) use of Rhizobium inoculum at the time of planting; (3) date of planting; and (4) use of certified soybean seed. Most of the farmers were interviewed at the beginning of the investigation and again after the harvest. In several incidences conflicting answers were given with respect to the use of certified seed and inoculum; therefore, data for these two variables are of questionable value. The farmers were also asked about the use of molybdenum. It was apparent from their answers that many of them were unsure whether they had used it; therefore, these data were deleted from the analyses.

The data collected in the interviews with the farmers were classified; higher class numbers were assigned to treatments that might be expected to result in higher yields, as shown below:

CLASSIFICATION OF DATA OBTAINED FROM INTERVIEWS

	Class			
Treatment	1	2	3	4
Planting of certified seed	No	Yes		
Use of inoculum	No	Yes		
Date of planting	After 7/1	6/16-30	6/1-15	Before 6/1
Previous crop	Wheat	Soybeans	Corn	Other[a]

a. Mainly pasture

Data for Soil Type and Productivity Class

Soil type for each plot sampled for yield was obtained from Soil Conservation Service soil survey maps for McCracken and Ballard Counties, Kentucky. Soil productivity classifications for soybeans were also obtained from the Soil Conservation Service (Appendix D). Soil type and productivity classifications were coded for computer analyses as shown on page 9.

SOIL TYPE AND PRODUCITIVITY CODES

Soil Type	Map Symbol[a]	Soil Code	Productivity Code[b]	Hard Pan[c]
Grenada silt loam	52A, 52A1	1	3	2
	52B1	2	3	2
	52B3	3	1	2
	52C3	4	1	2
Calloway silt loam	53A, 53A1	5	1	2
	53B1, 53B	6	1	2
	53B2	7	1	2
Henery silt loam	54, 54A	8	1	2
Vicksburg silt loam	162	9	4	1
Falaya silt loam	166	10	3	1
Calloway silt loam, terrace	463A	11	1	2

a. Listed in order of increasing slope and erosion.
b. 1 - 20 bu/A, 2 - 25 bu/A, 3 - 30 bu/A, 4 - 35 bu/A.
c. 1 - No hard pan, 2 - Hard pan.

Statistical Analyses of Data

Analysis of Variance—One-way analysis of variance was used to compare mean yields for fields that were (1) affected and unaffected by SO_2, (2) infested and not infested by nematodes; and (3) planted in soybeans and planted in other crops during the previous growing season. The comparisons were made within varieties. It must be emphasized that valid use of analysis of variance in comparing treatment means (i.e., mean yield of affected fields compared to that for unaffected fields) requires that other conditions that might affect yields be the same among all fields. Because of the considerable variation in soil fertilization and pH and other cultural practices encountered in an investigation of this type, this requirement cannot be met. However, analysis of variance can serve to indicate conditions that might be important in determining yields and should be examined further.

Stepwise Regression Analyses—A multiple correlation program obtained from Stat Systems, General Electric Corporation, was used to determine the extent that the data for SO_2 injury and other variables explained variation in yield among fields planted with the same variety of soybeans.

A stepwise regression is used to build the regression model. The program first calculates the correlation matrix. The first independent variable chosen for the regression equation is the one with the highest simple correlation with the response variable. Partial correlations of the remaining independent variables and the response variable are then calculated. This step can be considered mathematically as a calculation of the simple correlations between the residuals from the regression of the response variable on the independent variables already entered into the equation and the residuals from a regression of one of the remaining independent variables on those already entered. The independent variable that has the highest partial correlation with the response variable is then added to the regression equation, provided that its partial F value exceeds a preselected point (F=3, 90% probability level, for data analyses in this report) of the appropriate F distribution. At each stage of the process, new partial correlation coefficients are calculated, and an additional variable is tested for entrance into the regression. At each stage, all the variables that have previously been added to the regression model are checked by calculating the partial F value for each variable in the regression and comparing it with the preselected point (F=3, in this case), as above. In this manner, the contribution of each variable to the

regression is uniformly estimated by treating it as though it were the last variable to enter the equation. In tests of the variables previously added to the regression, any variable whose partial F value is not significant is dropped from the model. This process terminates when no more variables are being either added to the model or dropped from it.

Each analysis (Appendix E) follows the same pattern of presentation. The mean and standard deviations for each variable within a variety are given, followed by the correlation matrix. The correlation of the indicated variable with each of the variables listed vertically is printed from left to right in the matrix. The correlation of each variable with the dependent variable, yield, is the last entry given for that variable. The process of model structure is then exhibited; at each step, a variable is either added or removed.

Following the steps of construction of the regression is the prediction equation of the form

$$\hat{y}_i = a + b_1x_{1i} + b_2x_{2i} + b_3x_{3i} + \ \ldots \ + b_nx_{ni},$$

where

$\hat{y}_i$ = predicted yield of the i^{th} observation,

a = constant term,

x_{ki} = value of the independent k^{th} variable in the prediction equation at the i^{th} observation, and

b_k = coefficient of the k^{th} independent variable in the equation.

The prediction equation may be constructed from the table, which lists the variables (x_k) and their coefficients (b_k). The table also lists the standard error of each coefficient and the F levels of significance for each variable entered into the regression. The last line gives the constant term for the equation and the residual standard error of the regression. The percentage of the total variation explained by the regression (the sum of the squares for regression divided by the total sum of the squares corrected for the mean) is then presented. Diagonal elements of the inverse of the correlation matrix are also included. In some cases (where the percentage of the variation explained by regression is 50% or greater), the table of observed yields, yields as predicted from the regression equation, and residuals (the differences between the observed and predicted values) is produced.

The key to the abbreviations used in the analyses is shown on the first page of Appendix E.

Results

Delineation of SO_2-Affected Areas

During the survey conducted the week of August 9, 1971, SO_2 effects were detected on the foliage of giant ragweed in five areas, A, B, C, D, and E, as shown in figure 5. Acreage, location, and principal species affected are summarized in table 1. Area A is the area where SO_2 effects on vegetation were observed on July 30. Effects on ragweed were generally severe over the entire area.[1] No new effects had occurred since the July 30 survey. Classical SO_2 markings were observed on the foliage of species listed in Appendix A. The injury shown on the sensitive SO_2 indicator giant ragweed (figure 6) is typical of that observed on the species in the affected areas. The two kinds of SO_2 injury that occurred on soybeans—intercostal necrosis and chlorosis—are shown in figures 7 and 8. Figure 9 is a

1. For ragweed the injury index was employed: light (less than 10% leaf area affected); moderate (10 to 25% leaf area affected); severe (more than 25% leaf area affected).



Figure 6
Typical Sulfur Dioxide Injury Observed on Giant Ragweed in the Affected Areas in the Vicinity of the Shawnee Steam Plant



Figure 7
Intercostal Necrosis (Within Circle) of Soybean Foliage

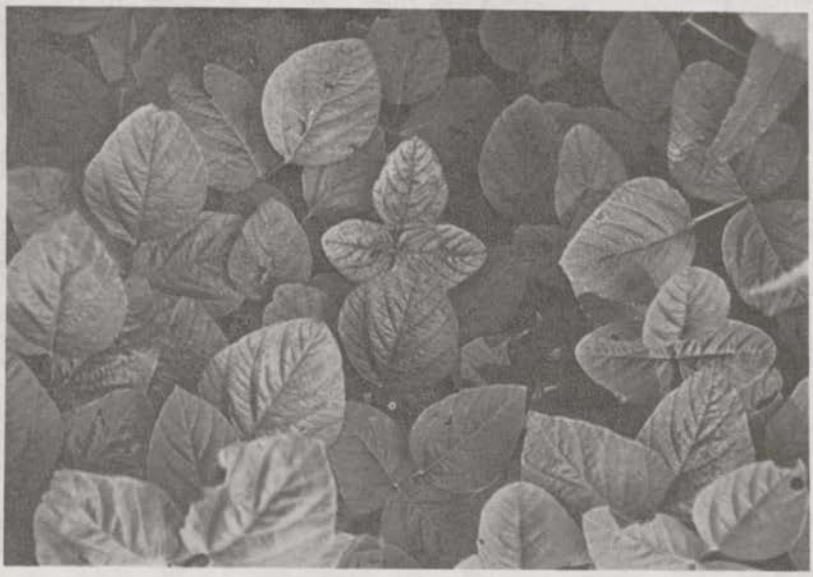


Figure 8
Intercostal Chlorosis of Soybean Foliage



Figure 9
Hood Soybeans in One of the More Severely Affected Fields
Showing Severe Chlorosis of the Lower Foliage and
Excellent Recovery 13 Days After Exposure to Sulfur Dioxide

photograph taken 13 days after the plants had been exposed to ground-level concentrations of SO_2. The photograph shows the extent of chlorosis in one of the more severely affected fields planted with the Hood variety and demonstrates the growth and recovery of the soybeans after exposure to SO_2. Giant ragweed and soybeans exhibited SO_2 injury in areas B and C, while giant ragweed was the only species affected in areas D and E.

Effects were detected on the foliage of giant ragweed, soybeans, pokeweed, wild sunflower, and poison ivy growing within a new area, F, on August 18-19. The effects on ragweed ranged from moderate to severe, while the effects on soybeans were mostly intercostal chlorosis or yellowing of foliage, amounting from 5% to about 50% of the total leaf area.

Table 1

AREAS WHERE SULFUR DIOXIDE EFFECTS WERE OBSERVED ON VEGETATION

Survey Date	Area No.	Acreage	Location From Shawnee Steam Plant: Distance (miles)	Location From Shawnee Steam Plant: Direction	Principal Species Affected[a]
August 9-13	A	6,700	2.5-12.5	WSW	1, 2
	B	3,500	2.75-8.4	SW	1, 2
	C	4,800	2.5-6.9	S	1, 2
	D	8,600	5.9-12.0	W	1
	E	3,800	3.6-6.8	W	1
August 18-19	F	11,400	1.0-10.2	SW	1, 2
Total Affected Area		38,800			

a. Giant ragweed 1, Soybeans 2

The locations of soybean fields in which plants exhibited foliar injury are shown in figure 5, and the injury classification for each field is noted.

Sampling Before Harvest

The number and type of observations and measurements made during the phase of the investigation before harvest are summarized in Appendix F. Data for observations and measurements made during phases of the investigation before harvest and at harvest are included in Appendix G. For the purpose of this report, only the data directly related to determination of the effect of SO_2 injury on soybean yields were analyzed, mainly those related to visual estimates and measurements of injury.

Extensive Sampling—Visual estimates of SO_2 injury of foliage of soybean plants were made for 88 fields. Affected varieties and the number and area of affected fields are summarized by injury class in table 2. Table 3 shows by variety the average node at or below which foliage exhibited SO_2 injury. Foliage was injured when the plants were about 18 in. tall, while at the beginning of the investigation plants in many affected fields were 36 to 42 in. tall. The effects occurred before full flowering for most fields and varieties.

Table 2

SUMMARY OF SOYBEAN VARIETIES, NUMBER OF FIELDS, AND ACREAGE BY INJURY CLASS

Variety	Average Injury Class 1		2		3		Totals		Range of Average Estimated Injury	
	No. of Fields	Total Acreage	No. of Fields	Total Acreage	No. of Fields	Total Acreage	No. of Fields	Acreage	Necrosis (%)	Chlorosis (%)
Hood	23	355	4	61	1	22	28	438	0.0-4.8	3-58
Dare	25	603	1	12	1	39	27	654	0.0-7.1	8-56
York	4	47	0	0	0	0	4	47	0.0-1.4	7-36
Pickett	3	74	0	0	1	17	4	91	0.0-8.4	26-56
Clark-63	1	4	1	11	3	15	5	30	0.0-9.6	34-50
Custer	4	32	0	0	0	0	4	32	0.0-0.8	4-23
Cutler	1	6	0	0	0	0	1	6	0.0	41
Cutler & Dare	1	6	0	0	0	0	1	6	0.0	41
Totals	62	1127	6	84	6	93	74	1304		

Table 3

YOUNGEST AVERAGE NODE WITH FOLIAGE EXHIBITING SULFUR DIOXIDE INJURY

Variety	Youngest Average[a] Node	Standard Deviation (Nodes)	Range (Node No.)
Hood	9th	1.28	6-11
Dare	10th	2.22	6-16
York	10th	1.76	7-13
Clark-63	8th	0.98	6-9
Pickett	8th	1.64	5-10

a. Counting from cotyledonary scars.

Intensive Sampling—Comparison of measurements of effects on plants from the fields sampled intensively with visual estimates (table 4) indicates that there was a strong tendency to overestimate foliar injury. Field no. 27 appeared to be one of the more severely injured fields, yet measured necrosis and chlorosis were less than 5% and 11%, respectively. In most of the fields sampled intensively, more leaf area had been destroyed by insects than by necrosis caused by exposure to SO_2.

Sampling at Harvest

The number of observations and measurements made during the phase of the investigation at harvest are summarized in Appendix F. Although data for yield and various factors that influence yield were collected from 110 fields, only those data for 97 row-planted fields and 5 varieties were analyzed. The remaining data were for fields of mixed varieties, for varieties for which there was only one or two fields, for fields for which injury estimates were not obtained, or for fields that had been planted with a grain drill. The harvest data, except for yield, are summarized in table 5. Soybean fields sampled for yield and their yields, acreages, and owners are shown in Appendix H.

Table 4

COMPARISON OF MEASUREMENTS AND VISUAL ESTIMATES OF TOTAL LEAF AREA AFFECTED BY SULFUR DIOXIDE, DISEASE, AND INSECTS

Field No.	SO_2 Injury[a] Necrosis (%) Estimated	Necrosis (%) Measured	Chlorosis (%) Estimated	Chlorosis (%) Measured	Disease[a] (% Measured) Necrosis	Chlorosis	Insect Injury[a] (% Measured)
6	0.4	0.012	48	8	0.833	10	2.7
7	0.1	0.002	23	17	0.274	9	1.7
8	0.1	0.015	26	9	0.133	15	4.1
11	0.0	0.000	0	0	0.003	10	3.5
18	5.3	0.488	46	30	0.207	3	1.9
20	0.4	0.296	36	29	0.328	3	2.0
21	0.0	0.028	7	12	0.377	2	1.6
22	0.0	0.000	1	12	0.199	5	3.5
26	0.7	0.668	34	34	0.282	6	1.5
27	10.0	4.544	49	11	0.069	4	1.8
37	4.4	2.948	34	34	1.083	3	1.5

a. Mean of plot values

The data show that most of the 100 fields were (1) planted in wide rows (37-40 in.), (2) low in pH, phosphorus, and potassium, (3) infested with soybean cyst nematodes, (4) planted with uncertified seed, and (5) planted in soybeans during the previous growing season. The first four of these conditions tend to reduce yields.

Analyses of Variance of Yield Data—Analyses of variance showed the average yields from fields of the Hood, Dare, and York varieties that were infested with nematodes were significantly lower (table 6) than yields from similar fields that were not infested with nematodes. There were insufficient data on nematode infestation in the fields of Clark-63 variety for comparison. Similarly, fields of Hood, Dare, York, and Pickett varieties that had been planted in corn or other crops during the preceding (1970) growing season produced significantly higher yields (table 7) than those that had been planted in soybeans the previous year. Fields of Clark-63 variety showed a similar, although not significant, trend.

No significant differences between the average yields of affected fields and unaffected fields that would indicate that SO_2 effects might have caused reductions in yields were found within any of the varieties except Clark-63. For all varieties as a group, the average yield of all affected fields was the same as that for all unaffected fields (table 8).

Two control fields should not be considered an adequate replication for an investigation of this type, considering the multiplicity of factors other than SO_2-injury that might influence yields. Therefore, we further evaluated the effects of injury on yield by additional analyses of the plot data for the injured fields of Clark-63 variety. Comparisons of plot yields from fields in injury classes 1, 2, and 3 showed that there was no significant difference between the mean plot yields of class 1 and class 3 fields. The mean yields for plots of both class 1 and class 3 fields were higher than the mean yield for the class 2 field. Similarly, comparisons were made of plot yields for soybeans grown on soil types 4 and 9, the predominant soil types of five of the fields planted with Clark-63 variety (nos. 27, 29, 30, 31, and 32). The fields were small (1 to 8 acres), scattered over a relatively small area,

Table 5

SUMMARY OF OBSERVATIONS AND MEASUREMENTS
OF SOYBEAN VARIETIES

Observations and Measurements	Variety					Total
	Hood	Dare	York	Pickett	Clark 63	All Varieties
Total Number of Fields	36	36	9	9	10	100
Number of Fields Planted						
Before June 1	4	2	1	0	3	10
June 1-June 15	25	17	4	6	1	53
June 16-June 30	4	17	3	3	6	33
After June 30	3	0	1	0	0	4
No. of Fields With Row Widths						
28-30 (in.)	9	10	2	0	6	27
31-33 (in.)	2	2	3	0	0	7
34-36 (in.)	0	2	1	2	0	5
37-40 (in.)	25	22	3	7	4	61
Total Number of Yield Plots	394	371	100	95	82	1,042
Total Number of Soil Types	10	9	7	7	6	10
Soil P Content (Number of Fields)						
Low (<31 lb P/A)	36	35	9	9	4	93
Moderate (31-60 lbs P/A)	0	0	0	0	0	0
High (>60 lb P/A)	0	0	0	0	0	0
No Information	0	1	0	0	6	7
Soil K Content (Number of Fields)						
Low (<125 lb K/A)	36	34	9	8	4	91
Moderate (126-200 lb K/A)	0	1	0	1	0	2
High (>200 lb K/A)	0	0	0	0	0	0
No Information	0	1	0	0	6	7
Soil pH (Number of Fields)						
Very low (pH <5.3)	8	17	0	2	1	28
Low (pH 5.3-6.0)	22	14	7	6	0	49
Normal (pH 6.1-6.7)	5	3	1	1	3	13
High (pH >6.7)	1	1	1	0	0	3
No Information	0	1	0	0	6	7
Range of Soil Productivity Class (bu/A)	20-35	20-35	20-30	20-30	20-35	20-35
Nematode Bioassay						
Number of Fields Positive	21	24	5	6	0	56
Number of Fields Negative	15	12	4	3	4	38
Number of Fields Not Sampled	0	0	0	0	6	6
Number of Fields Inoculated	36	31	8	5	9	89
Number of Fields Not Inoculated	0	5	1	4	1	11
Nodule Concentration (Number of Fields)						
Light	12	21	0	3	0	36
Moderate	8	3	3	0	3	17
Heavy	0	0	0	0	0	0
No Information	16	12	6	6	7	47
Previous Crop (Number of Fields)						
Wheat	1	2	0	0	0	3
Soybeans	26	18	4	6	4	58
Corn	6	10	0	1	1	18
Other	3	6	5	2	5	21
Injury Class (Number of Fields)						
0	13	13	5	6	2	39
1	18	21	4	2	1	47
2	4	1	0	0	1	5
3	1	1	0	1	3	6
Certified Seed (Number of Fields)	10	5	2	0	9	26
Uncertified Seed (Number of Fields)	26	31	7	9	1	74

owned by a single farmer, and showed considerable variation in yields (33 to 42 bu/A). Injury had not been visually estimated for fields 29, 30, and 32, but we believe that they would have been classified as no. 3 fields. Yields for plots on soil type 4 were significantly higher (by 10 bu/A) than those on soil type 9. Of the five fields, field 32, which was predominantly soil type 9, produced the lowest yield; this demonstrates the importance of soil characteristics in explaining differences in yields among the fields of Clark-63 soybeans. The results of the plot analyses indicate that factors other than SO_2 were affecting yields of the fields of Clark-63 soybeans; therefore, comparisons of the difference in yields between affected and unaffected fields by analysis of variance was not valid. Therefore, stepwise regression analysis, which also takes into consideration the influence of other variables such as variations in soil characteristics and farming methods, was used to determine the effect of SO_2 injury on yield.

Table 6

COMPARISON BETWEEN AVERAGE YIELDS
OF FIELDS INFESTED WITH
SOYBEAN CYST NEMATODES
AND THOSE WITH NO NEMATODES

Variety	Average yield (bu/A)		Difference in average yield (bu/A)	F ratio
	No nematodes	Nematodes		
Dare	34	27	7	6.0[a]
Hood	36	29	7	16.0[a]
York	43	34	9	6.1[a]
Pickett	27	28	-1	0.1

a. Difference significant at 95% level.

Table 7

COMPARISON BETWEEN AVERAGE YIELDS
OF FIELDS PLANTED IN SOYBEANS
AND THOSE PLANTED IN OTHER CROPS
DURING THE PRECEDING GROWING SEASON
(1970)

Variety	Average yield (bu/A)		Difference in average yield (bu/A)	F ratio
	Soybeans	Other crops[a]		
Dare	26	34	8	13.9[b]
Hood	29	40	11	46.2[b]
York	34	43	9	6.1[b]
Pickett	25	33	8	6.2[b]
Clark-63	35	39	4	2.8

a. Mainly corn or pasture.
b. Difference significant at 95% level.

Table 8

SUMMARY OF YIELD BY SOYBEAN VARIETIES FOR FIELDS AFFECTED AND UNAFFECTED BY SULFUR DIOXIDE

Variety	No. of fields	Mean yield (bu/A)	Standard deviation (bu/A)
Dare:			
All fields	36	30	8
All affected fields	23	28	8
Injury class:			
1	21	28	8
2	1	31	-
3	1	33	-
Unaffected fields	13	32	9
Hood:			
All fields	36	32	7
All affected fields	23	33	7
Injury class:			
1	18	33	6
2	4	33	10
3	1	40	-
Unaffected fields	13	29	6
York:			
All fields	9	38	7
All affected fields	4	39	7
Injury class:			
1	4	39	7
2	0	-	-
3	0	-	-
Unaffected fields	5	36	7
Pickett:			
All fields	9	28	6
All affected fields	4	25	3
Injury class:			
1	2	26	3
2	0	-	-
3	1	22	-
Unaffected fields	6	29	7
Clark-63:			
All fields	7	38	5
All affected fields	5	36[a]	4
Injury class:			
1	1	36	-
2	1	31	-
3	3	37	4
Unaffected fields	2	44	1
All varieties:			
All fields	100	32	8
All affected fields	61	32	8
Injury class:			
1	46	31	8
2	7	32	8
3	8	32	10
Unaffected fields	39	32	8

a. Difference in average yield (8 bu/A) between affected and unaffected fields significant at 95% level.

Regression Analyses of Yield Data—Stepwise regression analyses of variables affecting yield were first attempted at the plot level. The analyses were relatively unsuccessful in explaining variation in yield among the plots because variables that were applicable to whole fields and that had the same value for every plot within a field were the principal variables in the resultant regression equation for explaining variation in yield. These variables were previous crop, nematode infestation, row width, and planting date. Therefore, stepwise regression analyses of data were performed for field averages for each variety. The complete results of the regression analyses are presented in Appendix E. The variables that were important in explaining yield among fields within a variety are discussed below.

Dare Variety—Stepwise regression analysis of the data for Dare soybeans (table 9) showed that variation in phosphorus, potassium, pH, nematode infestation, use of certified seed, and row width explained 75% of the variation in yield among the fields. The variable "previous crop soybeans," which showed a relatively high negative correlation with yield, was removed from the regression by the analysis procedure, because it was correlated with some other variable that better explained variation in yield. The regression coefficients show that increases in phosphorus, potassium, pH, row width, and planting of certified seed increased yield, while nematode infestation decreased yield. Neither necrosis nor chlorosis was significant in explaining variation in yield.

Table 9

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FIELDS OF THE DARE VARIETY

Step[a]	Variable	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[b]
1	Previous Crop Soybeans	0.56	-	-	-
2	Phosphorus	0.67	0.356	0.137	6.7
3	Nematode Infestation (Level 2)	0.74	-7.059	1.399	22.6
4	pH	0.78	8.144	1.436	32.1
5	Previous Crop Soybeans (Removed)	0.75	-	-	-
6	Certified Seed Used	0.81	8.411	2.329	13.0
7	Row Width	0.85	0.691	0.222	9.6
8	Potassium	0.87	0.065	0.034	3.7
	Constant		-44.881	4.423	(Residual)

75% Variation Explained: 8 steps

a. Sequence Variables Entered Into Regression Model
b. F = 3, approximately 90% level of significance used in testing partial F for selection of variables.

The equation for the Dare regression model—$\hat{Y}$ (bu/A) = -44.881 + 8.144 pH + 0.065 K + 0.691 RW + 8.411_{CSN} - 7.058_{NEM2}—was used to construct the bar diagrams in figure 10, which illustrate how the variables identified by the regression analysis predicted and explained yields among fields of Dare soybeans.

Hood Variety—Among the Hood fields (table 10), 65% of the variation in yield was explained by the variables "previous crop soybeans," "no nematode infestation," and "previous crop wheat." Where the previous crop was wheat or soybeans, yield was reduced; where there were no nematodes, yield was increased. Air pollution effects did not contribute significantly to variation in yield.

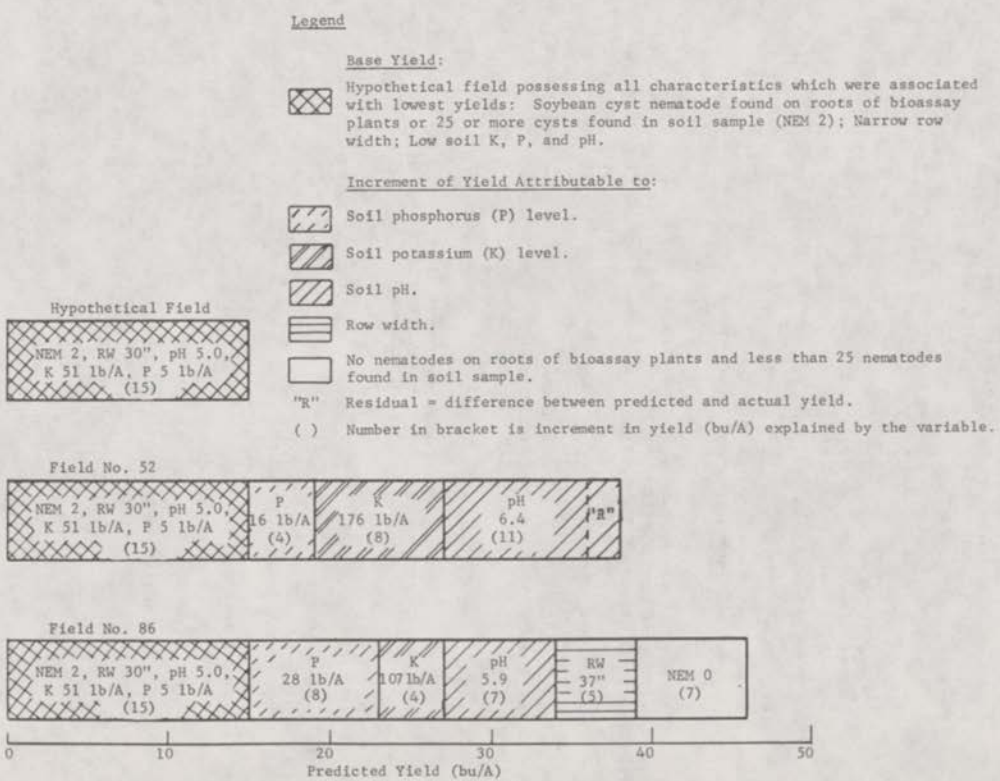


Figure 10
Manner in Which the Stepwise Regression Model Predicted Yields for Individual Fields and Explained Variation Among Fields for the Dare Soybean Variety

Table 10

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FIELDS OF THE HOOD VARIETY

Step[a]	Variable	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[b]
1	Previous Crop Soybeans	0.70	-9.532	1.742	30.0
2	No Nematode Infestation	0.78	3.963	1.538	6.6
3	Previous Crop Wheat	0.81	-9.276	4.482	4.3
	Constant		37.136	4.097	(Residual)

65% Variation Explained: 3 steps

a. Sequence Variables Entered Into Regression Model.

b. F = 3, approximately 90% level of significance used in testing partial F for selection of variables.

The data for the variables "previous crop soybeans," "previous crop wheat," "previous crop corn," and "previous crop other" were placed into two groups—"previous crop soybeans or wheat" and "previous crop corn or other"—because F tests showed no significant difference between yields from fields planted in wheat or soybeans or between yields from fields planted in corn or other. Reexamination of the data by regression analysis (table 11) showed that higher yields were associated with "previous crop corn or other," "no nematode infestation," and "increasing potassium content of the soil." Fields planted before June 1 produced lower yields. Again, air pollution effects failed to account for any variation in yields.

Table 11

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FIELDS OF THE HOOD VARIETY

Step[a]	Variable	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[b]
1	Previous Crop Corn or Other	0.76	9.184	1.623	32.0
2	No Nematode Infestation	0.81	5.670	1.585	12.8
3	Potassium	0.82	0.075	0.035	4.4
4	Planting Date (May 16-31)	0.84	-4.064	2.260	3.2
	Constant		21.078	3.790	(Residual)

71% Variation Explained: 4 steps

a. Sequence variables entered into regression model.

b. F = 3, approximately 90% level of significance used in testing partial F for selection of variables.

The bar diagrams in figure 11, which were constructed by using the regression equation $\hat{Y}$ (bu/A) = $21.078 + 9.184_{PC3 \text{ or } 4} + 5.670_{NEMO} + 0.07\ K - 4.064_{PD4}$ for the regression model discussed in the preceding paragraph, demonstrate how the model predicted and explained variation in yields among the fields of Hood soybeans.

York Variety—Analyses attributed the variation in yield among the York fields to the variables "nematode infestation 2," "planting date 1 (after July 1)," and "previous crop other" (table 12). Ninety percent of the variation was explained by the three variables. Soybean cyst nematode infestation and late planting reduced yields, while fields planted in

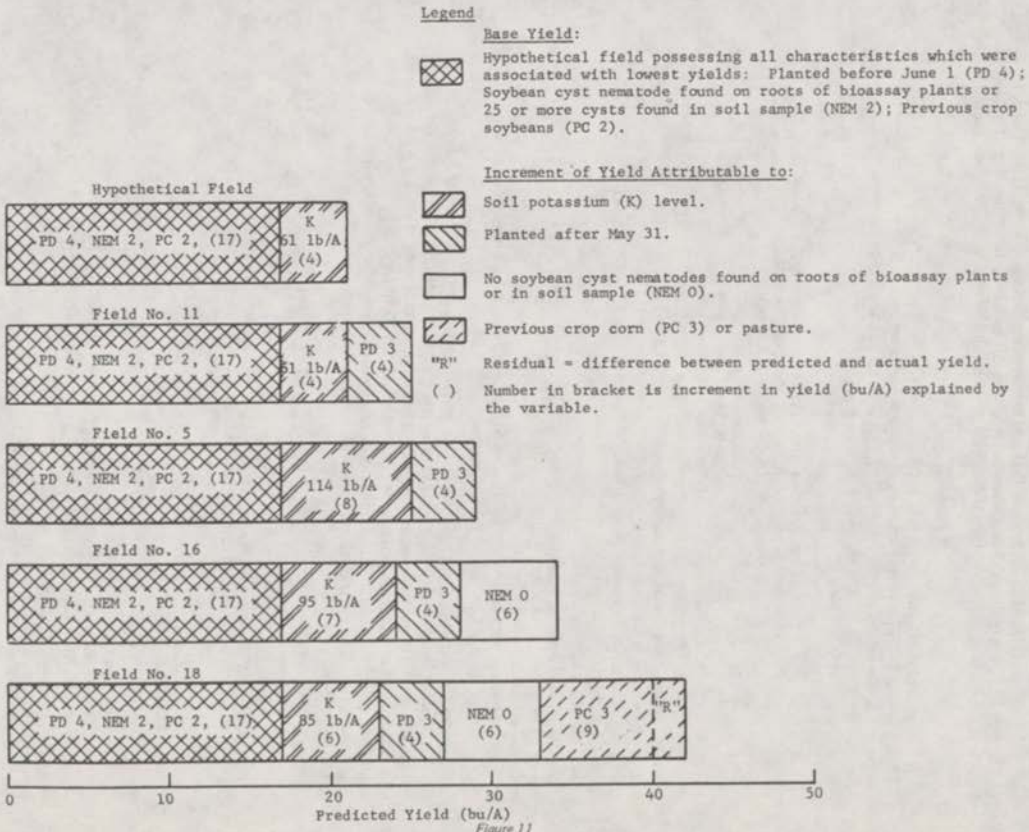


Figure 11

Manner in Which the Stepwise Regression Model Predicted Yields for Individual Fields and Explained Variation Among Fields for the Hood Soybean Variety

other crops (mainly pasture) the previous growing season produced higher yields. Stepwise regression of the plot data indicated that narrow spacing between rows (30-32 in.), row width, and use of inoculum were also associated with high yields among the York fields. No significant relationships were detected between yield and necrosis or chlorosis caused by SO_2.

The equation for the York regression model—$Y\ (bu/A) = 38.715 + 6.415_{PC4} - 8.178_{NEM2} - 10.250_{PD1}$—was used to construct the diagrams in figure 12, which illustrate the way that the model explained variation in yields among the fields sampled.

Table 12

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FIELDS OF THE YORK VARIETY

Step[a]	Variable	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[b]
1	Nematode Infestation (Level 2)	0.79	-8.178	2.451	11.1
2	Planting Date (After June 30)	0.88	-10.250	3.102	10.9
3	Previous Crop Other	0.95	6.415	2.451	6.8
	Constant		38.715	2.685	(Residual)

90% Variation Explained: 3 steps

a. Sequence variables entered into regression model.

b. F = 3, approximately 90% level of significance used in testing partial F for selection of variables.

Pickett Variety—Eighty-eight percent of the variation in yield among fields of the Pickett variety was explained by the variables "previous crop other" and "potassium content of soil" (table 13). Fields that were planted in pasture the previous growing season and the soils that had high potassium content produced higher yields. Stepwise regression analysis of the plot data indicated that higher yields were also associated with earlier planting dates. No significant relationship between air pollution injury and yield was detected.

Table 13

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FIELDS OF THE PICKETT VARIETY

Step[a]	Variable	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[b]
1	Previous Crop Other (Pasture)	0.74	10.069	1.886	28.51
2	Potassium	0.94	0.108	0.026	17.00
	Constant		15.587	2.352	(Residual)

88% Variation Explained: 2 steps

a. Sequence variables entered into regression model.

b. F = 3, approximately 90% level of significance used in testing partial F for selection of variables.

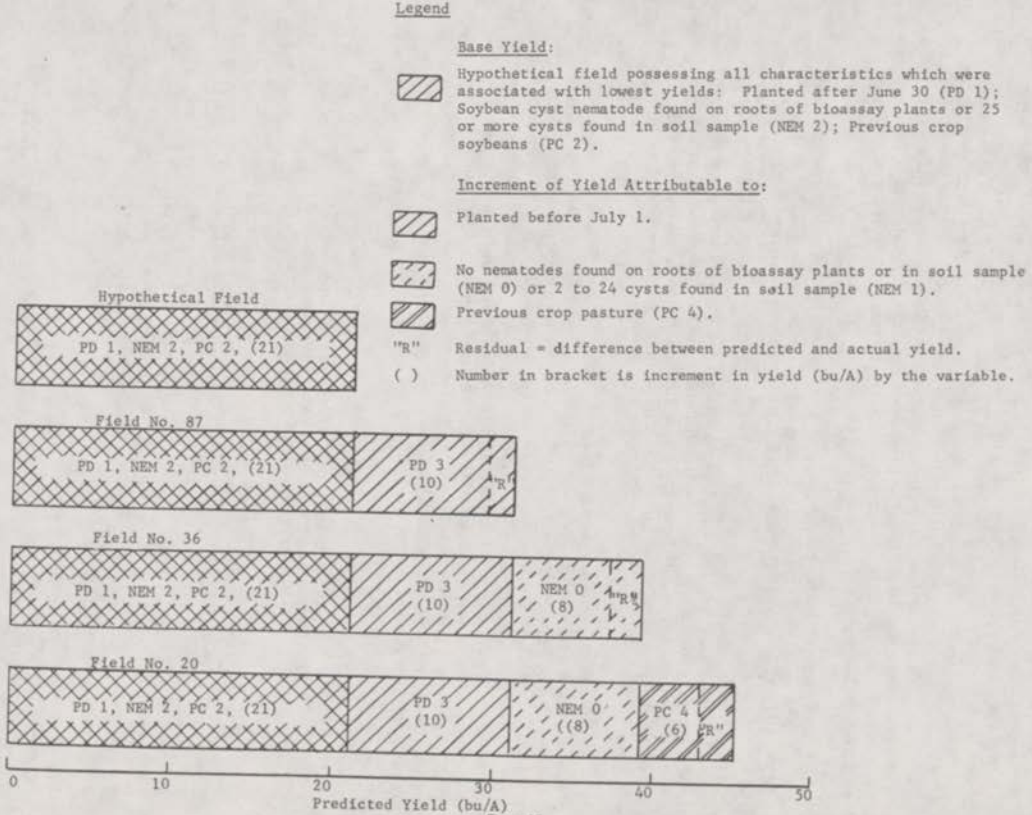


Figure 12

Manner in Which the Stepwise Regression Model Predicted Yields for Individual Fields and Explained Variation Among Fields for the York Soybean Variety

The data for the fields of Pickett soybeans were analyzed in two ways—with and without the variable "use of inoculum"—because the regression equation showed that 65% of the variation among the Pickett fields could be explained by that variable alone. Lower yields were associated with use of inoculum, a condition that seems illogical. However, when soybeans have been grown in same field for several successive years, a response to inoculum would be unlikely. Data were obtained for only nine fields, and four of the unaffected fields that produced the highest yields belonged to a single farmer who did not use inoculum at planting time. As mentioned in the section on "Methods," data on use of inoculum and certified seed, which had to be based on sometimes contradictory information from the farmers, were considered to be of questionable value; therefore, "use of inoculum" was deleted from the analysis.

Figure 13 illustrates how the regression model for the Pickett variety predicted and explained variation in yields among the fields sampled. The regression equation $\hat{Y}$ (bu/A) = $15.587 + 10.068_{PC4} + 0.0108$ K was used to construct the bar diagrams for the specific fields.

Clark-63 Variety—Statistical analysis of data for the Clark-63 variety was restricted by the paucity of information on soil pH and fertility for the fields and an insufficient number of unaffected (control) fields for which yields could be compared with those of affected fields. Because of these limitations, the results reported below are subject to question.

In the initial stepwise regression analysis, data for soil fertility and pH were necessarily excluded because they were not available for all seven fields on which SO_2 injury was observed. At a preselected F = 3.78 for the 90% confidence level, the analysis failed to explain any variation in yields among the fields; this indicates that none of the partial F values for the variables, including "necrosis" or "chlorosis," equaled or exceeded the preselected F. The F was lowered to 2.5 (80-85% confidence level), and a regression equation was obtained that explained 95% of the variation in yield as attributable to "soil type 3," "necrosis," and "soil type 4" (table 14). The regression model would suggest that "necrosis" reduced yields, a conclusion that was anticipated in the absence of the soils data because of the high yields of the two control fields.

Table 14

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FIELDS OF THE CLARK-63 VARIETY

Step[a]	Variable	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[c]
1	Soil type 3[b]	0.60	-8.279	1.622	26.0
2	Soil type 4[b]	0.88	6.599	2.118	9.7
3	Necrosis[b]	0.97	-1.189	2.088	32.4
			44.300	1.762	(Residual)

91% Variation Explained: 3 steps

a. Sequence variables entered into regression model.

b. See code in "Methods" section.

c. F = 2.5 approximately 80-85% level of significance used in testing partial F for selection of variables.

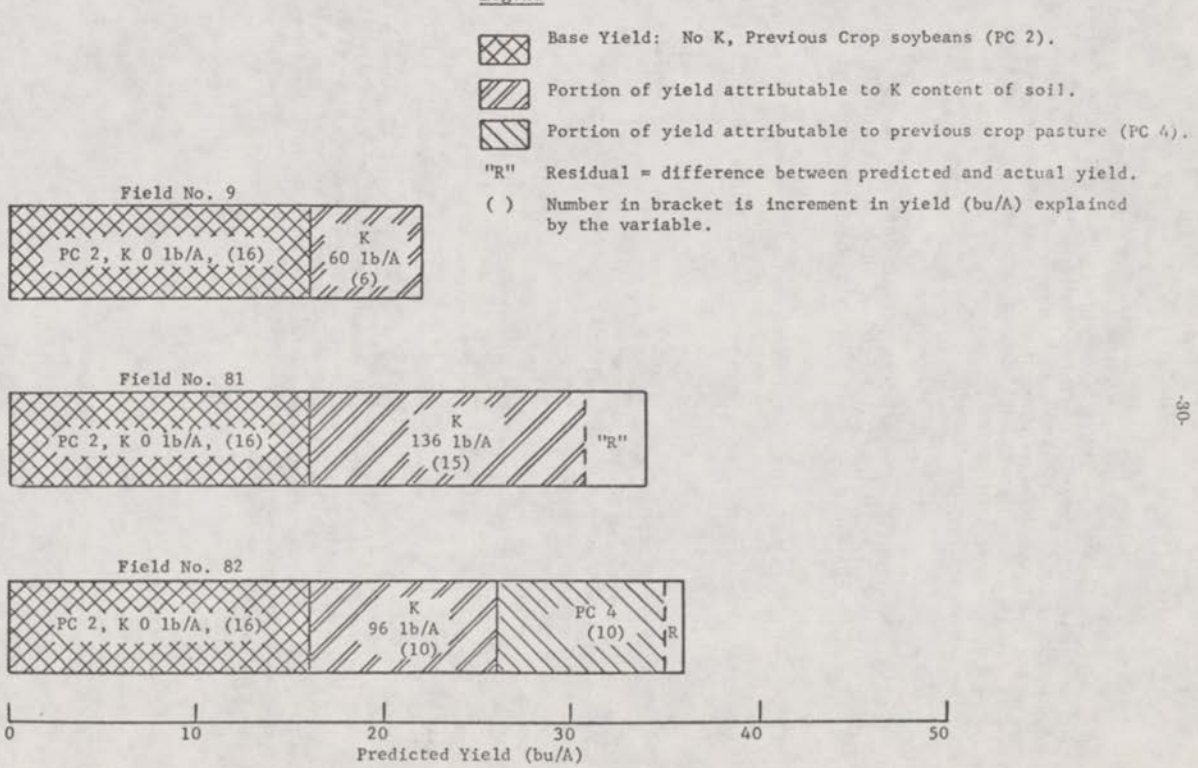


Figure 13
Manner in Which the Stepwise Regression Model Predicted Yields for Individual Fields and Explained Variation Among Fields for the Pickett Soybean Variety

Complete data, including those for soil fertility and pH, were obtained for four fields (nos. 19, 27, 37, and 100). The fields represented a broad range of injury, pH, fertility, and yields. Stepwise regression analysis of these data, using a preselected F value corresponding to the 90% level of significance, showed that 99.9% of the variation in yields among the four fields was explained by variation in soil pH and potassium levels (table 15). Yields were greater in fields with higher soil pH and potassium content. No significant effect of necrosis or chlorosis on yield was detected.

Table 15

DEVELOPMENT OF STEPWISE REGRESSION EQUATION EXPLAINING VARIATION IN YIELDS AMONG FOUR FIELDS OF THE CLARK-63 VARIETY FOR WHICH SOIL DATA WERE AVAILABLE

Step[a]	Correlation Coefficient (R)	Coefficient for Regression Equation	Standard Error (bu/A)	Partial F[b]
1 pH	0.99	12.340	0.476	673
2 potassium	1	0.043	0.008	27
Constant		-43.061	0.268	(Residual)

a. Sequence variables entered into regression model.
b. F = 5.5, approximately 90% level of significance used in testing partial F for selection of variables.

The results of the two analyses clearly demonstrate that soil fertility and pH must be considered in any explanation of variation in yields among the fields of the Clark-63 variety. The fact that, in the first analysis, none of the variables contributed significantly to an explanation of variation among the fields at the 90% level reduces the probability that SO_2 injury had any real effect on yield. Furthermore, the analysis that included fertility and pH data shows that factors other than absence of SO_2 injury contributed to the high yield of one of the unaffected fields (no. 100) and made the data for that field unacceptable for use in statistical analyses that do not include the soils data. There is a strong possibility that fertility would explain the high yield of the remaining unaffected field, because it had been planted in corn the previous year. For these reasons, the stepwise regression equation ($\hat{Y}$ (bu/A) = -44.061 + 12.340 pH + 0.043 K) obtained in the second analysis was considered to be the "better" explanation of the variation in yields among the fields of Clark-63 variety. It was used to construct the diagrams in figure 14, which illustrate how the variable selected by the regression analysis explained variation in yields among the fields.

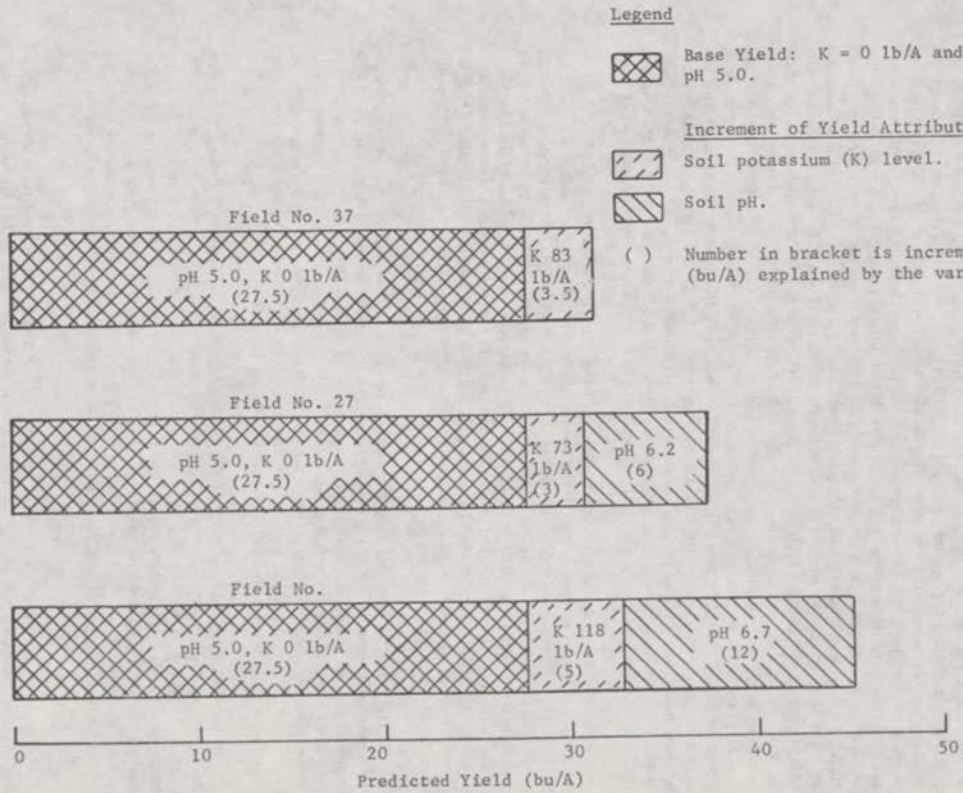


Figure 14
Manner in Which the Stepwise Regression Model Predicted Yields for Individual Fields and Explained Variation Among Fields for the Clark-63 Soybean Variety

54-380 O - 75 - pt. 2 - 35

Discussion

The results of this investigation show that a number of factors other than the high concentrations of SO_2 that occurred in July and August 1971 limited soybean production in the affected areas. Soil fertility and pH of most of the affected fields were well below levels recommended for maximum soybean yields (1, 2). In fact, a good evaluation of the relationship between yields and increasing levels of soil fertility and pH could not be made because so few fields were in the medium and high classes for phosphorous, potassium, and pH that the range of data was too limited. However, the ranges in phosphorous, potassium, and pH were sufficient to allow detection of a response in yields of four varieties (Dare, Hood, Pickett, and Clark-63) to increasing levels of soil fertility or pH. It might be argued that soil tests at harvest are not meaningful with respect to the 1971 crop. However, results of analyses of soil samples collected in early August, before pods developed, were the same as those at harvest; this indicates that the soils were low in nutrients during the critical period of pod development (3). Analyses of foliage samples from a few fields that had soil low in phosphorous and potassium indicated that levels of these nutrients in the soybean plants were also generally low (3). Treatment of seed with the micronutrient molybdenum, a practice that is reported to increase average yields by 2 to 7 bu/A on acid soils, is recommended for soybeans grown on soils with pH 6.0 or below (4, 5). Although soils of most of the fields were acid, it is doubtful that many of the farmers used the micronutrient, for farm suppliers in the area stated that they had not sold much molybdenum in 1971.

Many of the lower yielding fields sampled in the investigation were found to be infested with soybean cyst nematodes. The nematode is reported to cause losses in yield up to 60% (6, 7), and it appears to be the most important single factor limiting soybean production in the area near Shawnee Steam Plant. Average yields of Dare, Hood, and York soybeans from fields that were infested with the nematode were 7 to 9 bu/A less than those of fields that were not infested. The effectiveness of crop rotation in reducing nematode populations might be illustrated by the significantly higher yields of soybeans from fields planted in corn or other crops during the previous growing season as compared with yields from those planted in soybeans.

The effect of previous crop on soybean production detected in this investigation is not completely understood but would appear to be of agronomic importance and should be explored further, particularly if the farmers continue to grow soybeans in the same fields year after year. The lower yields produced by soybeans in fields where the same crop was grown the previous year may be related to increased nematodes or may reflect the overall lower fertility of the fields with respect to plant nutrients (including nitrogen content), organic content, moisture retention, or conservation of top soil.

Dare was the only variety of soybeans for which the spacing between rows was detected to affect yields. The analyses showed that higher yields were associated with increased spacing between rows. Normally, soybeans planted in narrow rows (20-30 in.) would be expected to produce higher yields than those planted in wider rows, provided the seeding rate were reduced proportionally (3). The contradictory finding for the Dare fields may be attributable to a too-high seeding rate, for most of the fields with narrow rows had about 10 surviving plants per row-foot compared with about 8 for the fields with wider rows.

Most of the variation in yields among soybean fields planted with the same variety was explained by variation in the factors that normally influence yield (3), including those discussed above plus planting date. More variation in yields might have been explained had other variables such as rainfall, weed density, organic content of the soil, and nitrogen content of the soil been considered in the analyses or had it been possible to assign

quantitative values to such variables as "previous crop" and "cyst nematode infestation." Inclusion of data for previous crop for the three or four years before 1971 in the regression analyses might also have provided a better explanation of variation in yields since we suspect that many of the fields that produced low yields had been planted in soybeans for several successive years.

With the possible exception of the fields of Clark-63 variety, which will be discussed later, variations in necrosis and chlorosis failed to account for any of the variation in yields. The fact that the variables for injury were not picked in the regression analyses of the data for the other four varieties is not surprising considering the small amount of injury to the foliage of the soybean plants and the stage of growth of the plants at the time the injury occurred. Although there is no information in the literature on the effect of foliar SO_2 injury on yield of soybeans, studies have shown that necrosis has to exceed 5% of the total leaf area before significant reductions in yields of most crop species can be detected (8). While visual estimates for necrosis exceeded 5% of total leaf area for some fields, measurements of foliar injury indicated that necrosis actually amounted to less than 5%. Values for both necrosis and chlorosis would have decreased considerably by the time the plants reached their full height. In many cases insect injury accounted for a greater area of leaf damage than necrosis. Also, various investigators have demonstrated that up to 75% of the foliage of soybean plants can be destroyed before blooming or pod development without significantly reducing yield (9, 10). The SO_2 injury occurred before the plants bloomed when they were about 18 in. tall, and foliage above the 8th or 10th node was not affected. By the time the soybean canopy closed, most, if not all, of the affected leaves were heavily shaded; the contribution of these leaves to pod development, even if they had not been injured, would probably have been negligible as compared with that of leaves in the upper part of the canopy.

In the analyses of the data for the seven fields of Clark-63 variety (five affected and two unaffected), significant differences existed between affected and unaffected fields, and necrosis explained a portion of variation in yields among the Clark-63 fields at a relatively low level of significance. However, as mentioned in the "Results" section, the results of these analyses cannot be considered to be valid because (1) the number of unaffected fields was insufficient to be representative of the normal range in variability of factors influencing yields within the variety, (2) soil fertility and pH, which were shown to be important in explaining variations among yields in four of the fields, were not used in the analyses, and (3) among the affected fields, there was no relationship between degree of injury and yield (i.e., the yields of the most severely injured fields in class 3 were as high or higher than those less severely injured). Both of the unaffected fields produced exceptionally good yields (44 bu/A) in 1971 and had histories of producing high yields in previous years. The average yield (35 bu/A)[1] of the affected fields was considerably above the average yields (30 bu/A)[2] for Ballard and McCracken Counties in 1971 (11), and, according to the owners, was much better than the 30 bu/A or less obtained from these fields in the past. Even the field that produced the lowest yield (no. 37)—which was low in pH (5.7), phosphorous, and potassium and had been planted in soybeans the previous year—equaled the county average. In contrast, the three fields that produced the highest yields for which soils data were available were higher in pH (6.2 or above) and had been planted in corn or pasture the previous year. For these reasons, the stepwise regression model for the four fields for which there were complete data is considered to provide the most reasonable explanation of yields among the fields of Clark-63 variety: the variation in yields was attributable to variation in soil pH and potassium and not to foliar SO_2 injury.

---

1. Weighted average based on acreage minus harvest loss (1.6 bu/A).
2. Rounded off to nearest whole bushel.

The results provide no evidence that air pollution effects caused yield reductions or, indeed, that yields were other than normal for the conditions that existed among fields in the area. The average yield (30.0 bu/A)[1] of all affected fields was the same as the Ballard and McCracken County averages (30.0 bu/A) for 1971 (11) and substantially higher than the average for the two counties (25.0 bu/A) for 1970. The same was also true for unaffected fields. The above average yields in McCracken and Ballard Counties are most probably attributable to high soil moisture during July, August, and September, the critical period for bean development. Rainfall measured at the Shawnee Steam Plant and at the Paducah Airport was 6 in. above normal and fairly evenly distributed over the 3-month period (12). Adequate soil moisture would be particularly beneficial to soybeans growing in the fields under investigation. The soils of most of the fields have a hardpan which, in many cases, is only 6 to 10 in. beneath the soil surface. It is reported that soybeans do not produce well in such soils (5); root growth is restricted, rendering crops grown on them more susceptible to the effects of drought than those grown on soils in which root growth is not restricted.

The conclusions reached in this investigation should not be extrapolated to situations in which soybeans are exposed to SO_2 under conditions other than those reported here. Had the injury occurred during pod development or had yields not been limited by other factors in the environment, the results might have been different.

Conclusions

The foliar SO_2 injury that occurred on soybean plants growing in the vicinity of the Shawnee Steam Plant in 1971 had no significant effect on soybean production. Production was being limited by low soil fertility and pH, soybean cyst nematode infestation, and possibly also by other variables that were not considered in this investigation. Maximum yields should not be expected in the future unless steps are taken to correct the low fertility and pH of the soil and soybean cyst nematode infestations.

---

1. Weighted average based on acreage minus harvest loss (1.6 bu/A).

REFERENCES CITED

1. University of Kentucky Cooperative Extension Service. *Growing Soybeans in Kentucky.* Lexington: Extension Service Leaflet 178-E. 1969.

2. University of Kentucky Cooperative Extension Service. *Lime and Fertilizer Recommendation Guide.* Lexington: Extension Service Circular 619. 1968.

3. Scott, W. O. and S. R. Aldrich. *Modern Soybean Production.* Cincinnati: The Farm Quarterly, 1970.

4. Luck, H. W. *Soybean Production in Tennessee.* University of Tennessee Agricultural Extension Service Publication 421, 1970.

5. McKie, J. W. and K. L. Anderson. *The Soybean Book.* State College, Mississippi: W. R. Thompson and Associates, 1967.

6. U.S. Department of Agriculture. *The Soybean Cyst Nematode.* Washington, D.C.: Agricultural Research Service, Crops Research Division and Plant Pest Control Division Publication PA-333, 1968.

7. Graves, Charles R. *1970 Performance of Field Crop Varieties.* Knoxville: University of Tennessee Agricultural Experiment Station Bulletin 474, 1971, pp. 61-62.

8. Webster, C. C. *The Effects of Air Pollution on Plants and Soil.* Agricultural Research Council, Great Britain, 1967, 53 pp.

9. Begum, Anwars and W. G. Eden. "Influence of Defoliation on Yield and Quality of Soybeans," *Journal of Economic Entomology*, vol. 58 (1965), pp. 591-592.

10. Laster, L. M. "Insects Affecting Soybeans in the South," *The Soybean Digest* vol. 22, No. 9 (1962), p. 18.

11. Kentucky Crop and Livestock Reporting Service. "Kentucky Agricultural Statistics, 1971," Louisville, April 1971, 116 pp.

12. Tennessee Valley Authority. "Precipitation in Tennessee River Basin," in Division of Water Control Planning, Hydraulic Data Branch, *Annual Report* 1971.

APPENDIXES

A-1

APPENDIX A
SPECIES SHOWING CLASSICAL SULFUR DIOXIDE MARKINGS IN THE SHAWNEE STEAM PLANT AREA ON JULY 30 AND AUGUST 11, 1971

Common Name	Scientific Name
Trees	
White ash	*Fraxinus americana*
Black walnut	*Juglans nigra*
Red maple	*Acer rubrum*
Black oak	*Quercus velutina*
Northern red oak	*Quercus rubra*
Loblolly pine	*Pinus taeda*
Sassafras	*Sassafras albidum*
Black locust	*Robinia pseudoacacia*
Shrubs	
Blackberry	*Rubus* sp.
Elderberry	*Sambucus canadensis*
Smooth sumac	*Rhus glabra*
Winged sumac	*Rhus copallina*
Vines	
Wild grape	*Vitis* sp.
Poison ivy	*Rhus radicans*
Herbs	
Garden and Field Crops	
Red clover	*Trifolium incarnatum*
Soybean	*Glycine max*
Field pea[a]	*Vigna sinensis*
Zinnia[a]	*Zinnia* sp.
Marigold[a]	*Tagetes* sp.
Annual lespedeza	*Lespedeza* sp.
Halfrunner beans[a]	*Phaseolus* sp.
Sweet potato[a]	*Ipomoea batatas*
Peanut[a]	*Arachis hypogaea*
Cucumber[a]	*Cucumis sativus*
Watermelon[a]	*Citrullus vulgaris*
Touch-me-not[a]	*Impatiens* sp.
Burley tobacco[a]	*Nicotiana tabacum*
Weeds	
Beggar-lice	*Desmodium* sp.
Evening primrose, common	*Oenothera biennis*
Pennsylvania smartweed	*Polygonum pensylvanicum*
Prickly lettuce	*Lactuca* sp.
Giant ragweed	*Ambrosia trifida*
Lesser ragweed	*Ambrosia artemisiifolia*
Wild carrot	*Daucus carota*
Wild sunflower	*Helianthus* sp.
Blackeyed susan	*Rudbeckia hirta*
Sand thistle	*Solanum carolinense*
Violet	*Viola* sp.

a. Markings observed August 11.

APPENDIX B

UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY 40506

COLLEGE OF AGRICULTURE
RESIDENT INSTRUCTION
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE

DEPARTMENT OF AGRONOMY

September 21, 1971

Dr. Herbert Jones
Environmental Biology Division
Tennessee Valley Authority
Muscle Shoals, Alabama 35660

Dear Dr. Jones:

I have discussed the matter of determining yields of SO_2-damaged soybean fields with Drs. Wells and Bitzer since their meeting with you. They have outlined a proposed procedure for sampling the fields.

I do not feel that we can afford the time and personnel for the sampling and threshing operations; however, we are desirous of making whatever contributions we can. We feel some commitment to the farmers and should be able to provide a thresher and a specialist for observing most of the operation. There should be no necessity to enter into a contractual agreement.

The suggested procedure for sampling the field follows:

1. Take the following number of 12.5 foot section samples per field according to size:

   0 to 5 acres - 8 samples (12 fields)
   6 to 19 acres - 10 samples (32 fields)
   20 to 50 acres - 13 samples (34 fields)
   51 + acres - 18 samples (7 fields)

2. Samples to be taken in each field as diagramed on page 2.

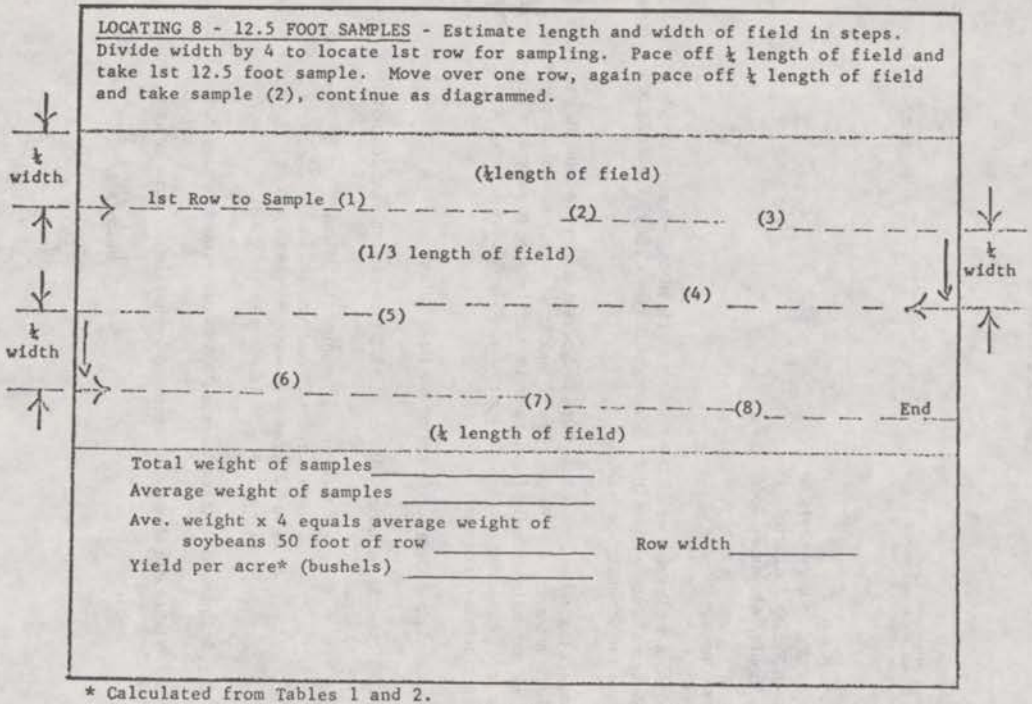
3. Yield estimates to be converted to bushels per acre by using tables 1 and 2.

Sincerely,

Jack Hiatt

A. J. Hiatt
Chairman

AJH/pt
cc: Dr. K. Wells
Dr. M. Bitzer
Mr. Emerson Jones



* Calculated from Tables 1 and 2.
To take 10, 13, or 18 samples from a field, simply divide widths of fields by 5, 6, and 8, respectively, and add alternate strips of 2 and 3 samples back and forth across fields as needed for number os samples required.

Table 1. Factors for converting weight of soybeans from 50 foot row to weight per acre.

Row width in inches	Multiply 50 foot sample by
18	580.80
20	522.74
22	475.28
24	435.54
26	402.09
28	373.41
30	348.43
32	326.69
34	307.50
36	290.36
38	275.10
40	261.37
42	248.91

Table 2. Factors for converting weight of soybeans per acre to bushels per acre at 13 percent moisture.

Actual moisture content	Divide weight per acre by	Actual moisture content	Divide weight per acre by
8.0	56.74	17.0	62.89
8.5	57.05	17.5	63.27
9.0	57.36	18.0	63.66
9.5	57.68	18.5	64.05
10.0	58.00	19.0	64.44
10.5	58.33	19.5	64.84
11.0	58.65	20.0	65.25
11.5	58.98	20.5	65.66
12.0	59.32	21.0	66.07
12.5	59.66	21.5	66.50
13.0	60.00	22.0	66.92
13.5	60.35	22.5	67.35
14.0	60.70	23.0	67.79
14.5	61.05	23.5	68.23
15.0	61.41	24.0	68.68
15.5	61.77	24.5	69.14
16.0	62.14	25.0	69.60
16.5	62.51		

APPENDIX C

Bioassay of TVA-Soil Samples

for Soybean Cyst Nematode

March 24, 1972

R.A. Chapman

Subsamples of soil samples brought by Dr. Herbert Jones, Agronomist, Tennessee Valley Authority to Mr. John Harrison, Department of Regulatory Services, Kentucky Agricultural Experiment Station, in December, 1971 for analyses, were placed in 4" pots in the greenhouse on January 13 and 14, 1972. Five seeds of 'Clark' soybean were sown in each pot. The pots were set on top of inverted 4" pots in pans. Pots were spaced apart and carefully watered individually to prevent contamination by splashing. The pots were taken down during the period March 6 to March 17, 52-64 days after sowing.

Roots were examined and records were kept as follows:

0 = no cysts found.

+ = 1-2 cysts found after considerable search.

++ = few cysts found after some search.

+++ = several cysts found readily.

The presence of cysts attached to roots of the susceptible 'Clark' variety is essentially proof

of the presence of the soybean cyst nematode, Heterodera glycines Ichinohe 1952. Other species of Heterodera are rarely found on soybean. The degree of infection on the roots is a measure of the level of infestation in the soil in the pot, but not necessarily the level of infestation of the fields from whence the soil was collected. The numbered samples included from 1 to 20 samples in separate soil-sample-boxes. The soil in the boxes was frequently dry and lumpy and could not be mixed uniformly. Portions of soil were taken from each box of the same number and combined for the bioassay. These portions were not representative of each box and, therefore are not representative of the fields.

When cysts were not found on roots, the soil was processed by a modification of the method of Dunn (1) in which cysts are collected on a 60 mesh screen. Cysts (1 - 25) were found in soil from 28 pots wherein cysts were not found on roots. In all but two of these, there were new, recently developed cysts. The presence of cysts in soil, especially new ones, is indicative of the presence of H. glycines, but is not as good evidence as the presence of cysts attached to roots.

The data from the bioassay are presented

in Tables 1 and 2.

(1) Dunn, R. A. 1969. Extraction of cysts of Heterodera species from soil by centrifugation in high density solutions. J. Nematol. 1:7 (Abstr.).

C-4

TABLE 1. Cysts of Heterodera found on roots and in soil of pots of 'Clark' soybean in TVA-soil samples in a greenhouse at Lexington, Kentucky.

TVA sample number	Cysts on roots	Cysts in soil	"New" cysts	Days in greenhouse
1	0	15	+	62
2	+++			62
3*	0	0	0	62
4	+++			62
5	+++			60
6	+			60
7*	0	0	0	62
8	0	3	+	62
9	0	1	?	62
10	++			60
11 A-C	0	1	+	62
12	+++			62
12 A	+			64
12 B	0	7	?	64
13	No sample			
14	0	4	+	62
14 A*	0	0	0	64
15*	0	0	0	62
16*	0	0	0	64
17*	0	0	0	63
18*	0	0	0	64
19	No sample			

C-5

TVA-SCN

TABLE 1. (cont.)

20*	0	0	0	64
21	No sample			
22*	0	0	0	64
23	0	1	+	64
24*	0	0	0	64
25*	0	0	0	63
26	No sample			
27*	0	0	0	63
28	0	12	+	64
29	No sample			
29 A*	0	0	0	63
30	0	25+	+	64
31	0	8	+	64
32	0	4	+	64
33	0	22	+	64
34	No sample			
35	No sample			
36	No sample			
37	0	4	+	64
38	No sample			
39	0	7	+	64
40*	0	0	0	63
41	No sample			
42	No sample			
43	No sample			

TABLE 1. (cont.)

44	No sample			
45*	0	0	0	63
46*	0	0	0	63
47	No sample			
48	++			63
49*	0	0	0	63
50*	0	0	0	63
51	No sample			
52	0	25+	+	63
53	No sample			
54	0	8	+	63
55	+++			63
56	+++			63
57	+++			63
59*	0	0	0	52
60	No sample			
61*	0	0	0	56
62	No sample			
63	0	12	+	56
64	0	8	+	55
64 A	0	2	+	56
65	No sample			
66	+			52
67	+++			52
68	++			52
69	+			52

TABLE 1. (cont.)

70	0	8	+	53
71	+++			55
72	+			56
73	+			52
74	0	6	+	52
75*	0	0	0	53
76	+++			59
77	+++			59
78	+			56
79	No sample			
80	+++			53
81*	0	0	0	53
82	0	6	+	53
83	0	4	+	53
84	0	2	+	53
85*	0	0	0	56
86	++			56
87	0	25+	+	56
88	No sample			
89	0	25+	+	56
90	No sample			
91	No sample			
92*	0	0	0	59
93*	0	0	0	59
94*	0	0	0	59
95	No sample			

TABLE 1. (cont.)

96	+++			59
97	No sample			
98*	0	0	0	59
99	No sample			
100	No sample			
101	No sample			
102*	0	0	0	59
103*	0	0	0	59
104	No sample			
105	+			59
106*	0	0	0	59
107	+++			59
108	0	1	+	59
109	No sample			
110*	0	0	0	59
111*	0	0	0	59
112*	0	0	0	60
113	+++			59
114	+			60
115	++			60
116	0	3	+	60
117*	0	0	0	60
118	No sample			
119	++			60
120*	0	0	0	60
121*	0	0	0	60

TABLE 1. (cont.)

122	++			60
123*	0	0	0	60
124	+			55
125*	0	0	0	55
126*	0	0	0	55
127	No sample			
128	No sample			
129	No sample			
130	No sample			
JS-1*	0	0	0	56
JS-1A*	0	0	0	55

---

* no cysts found

+++ = found cysts on roots easily

++ = found cysts on roots with some difficulty

\+ = found cysts on roots with much difficulty

\+ under "New" cysts = yellow cysts and/or cysts with eggs and larvae

? under "New" cysts = condition of cysts doubtful.

TABLE 2. Summary of bioassay of TVA-soil samples. 'Clark' soybean.

Number of samples			
with cysts on roots	with cysts in soil but not on roots	without cysts	Total
32	28	41	101

C-11

UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY 40506

COLLEGE OF AGRICULTURE
RESIDENT INSTRUCTION
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE

DEPARTMENT OF PLANT PATHOLOGY

June 6, 1972

Dr. Herbert Jones
Environmental Biology Branch
E & D Building
Tennessee Valley Authority
Muscle Shoals, Alabama 35660

Dear Dr. Jones:

Here are the results of our tests of the N series for soybean cyst nematode (SCN). 'Clark' soybeans grew in the soil for 53-63 days. We have replanted the samples that were negative for SCN or that came from fields of 'Pickett' soybean. The notation scheme is the same as the one we used in the report of March 24, 1972.

Sincerely yours,

Richard A. Chapman
Professor of Plant Pathology

RAC/dg

Enclosure

C-12

TVA
6-6-72

TVA "N" SERIES FOR SCN

N number	Cysts on roots	Cysts in soil	Old Field number	3-24-72 report of cysts on roots	3-24-72 report of cysts in soil
1	+++		8	0	3
2	++		9	0	1
3	++		10	++	
4	++		12A	+	
5	0	0	14	0	4
6	0	0	29A	0	0
7	0	0	29B	No sample	
8	+++		30	0	25+
9	+++		31	0	8
10	+++		32	0	4
11	+++		58	No sample	
12	0	0	61	0	0
13	+++		63	0	12
14	+++		67	+++	
15	+		68	++	
16	++		72	+	
17	+++		73	+	
18	++		6	+	
19	0	0	116	0	3
20	+		102	0	0
21	++		68A	No sample	

Samples N- 5,6,7,12 and 19 have been replanted for another check on them.

Samples N- 2 and 20 have been replanted because they came from fields of Pickett.

D-1

APPENDIX D

ESTIMATED AVERAGE ACRE YIELDS OF PRINCIPAL CROPS
ON SOILS OF McCRACKEN WORK UNIT

Soil Mapping Unit						HAY			Pasture
Name	Stnd. Map Symbol	Corn bu.	Wheat bu.	Soy-beans bu.	Tobacco lbs.	Alfalfa Grass tons	Red Clover Grass tons 1st-2nd	Lespedeza tons	Animal Unit Grazing Days
Brandon sil	51031	75	30	-	1800	2.9	.9-2.3	1.7	[illegible]
Brandon sil	B2	65	25	-	1600	2.7	.8-2.0	1.5	[illegible]
Brandon sicl	B3	40	15	-	1400	2.1	.5-1.5	1.1	[illegible]
Brandon sil	C1	70	30	-	1700	2.8	.8-2.1	1.6	[illegible]
Brandon sil	C2	55	25	-	1500	2.5	.7-1.8	1.4	[illegible]
Brandon sicl	C3	-	15	-	1300	1.9	.5-1.4	1.1	[illegible]
Brandon sil	D1	-	25	-	-	2.7	.8-2.0	1.5	[illegible]
Brandon sil	D2	-	20	-	-	2.4	.6-1.7	1.3	[illegible]
Brandon sicl	D3	-	-	-	-	-	- -	-	105
Brandon sil	E1	-	-	-	-	-	- -	-	110
Brandon sil	E2	-	-	-	-	-	- -	-	125
Brandon sicl	E3	-	-	-	-	-	- -	-	100
Bruno lfs	130A	50	19	-	1550	2.0	.7-1.8	1.1	125
Calloway sil	53 A1	50	15	20	1540	-	- -	1.6	130
Calloway sil	B1	55	15	20	1500	-	- -	1.7	130
Calloway sil	B2	40	15	-	1350	-	- -	1.5	135
Falaya sil	166	80	30	30	1800	3.0	1.1-2.8	2.0	175
Oinat sil	352	35	-	-	1300	-	- -	1.6	140
Grenada sil	52 A1	75	25	30	-	2.4	1.0-2.7	2.0	165
Grenada sil	B1	75	25	30	-	2.5	1.1-2.8	2.0	170
Grenada sil	B2	65	25	25	-	2.1	.9-2.5	2.0	150
Grenada sicl	B3	50	15	20	-	1.6	.7-1.9	1.4	110
Grenada sil	C1	70	25	25	-	2.3	1.0-2.6	2.0	155
Grenada sil	C2	55	20	20	-	2.0	.9-2.3	1.9	130
Grenada sicl	C3	-	-	-	-	1.5	.7-1.8	1.4	105

The above estimates are for long time average yields under "improved management." This management includes (1) the use of adapted recommended varieties; (2) proper seeding rates, dates of planting and efficient harvesting methods; (3) control of weeds, insects and plant diseases; (4) fertilizer application equal to or above the current recommendations of the University of Kentucky Agriculture Experiment Station or that equal to or above the need shown by properly interpreted soil tests; (5) adequate lime applications; (6) drainage for naturally wet soils which are feasible to drain; (7) crop rotations that control erosion and maintain soil structure and organic matter; (8) applicable conservation measures applied as contour tillage, terracing, strip cropping and sod waterways; (9) use of cover crops and/or crop residues to increase supplies of organic matter and control erosion; and (10) use of all the applicable pasture management practices. (Does not include irrigation). These yields do not define the maximum production but are those most farmers will find it practical to reach, if they choose to apply the proper practices.

D-2

ESTIMATED AVERAGE ACRE YIELDS OF PRINCIPAL CROPS
ON SOILS OF McCRACKEN WORK UNIT

Soil Mapping Unit						HAY			Pasture
Name	Stnd. Map Symbol	Corn bu.	Wheat bu.	Soy-beans bu.	Tobacco lbs.	Alfalfa Grass tons	Red Clover Grass tons 1st-2nd	Lespedeza tons	Animal Unit Grazing Days
Guin v. gr. sil	58 C1	-	-	-	-	2.3	.6-1.7	1.3	100
Guin v. gr. sil	D1	-	-	-	-	-	- -	-	95
Guin v. gr. sil	E1	-	-	-	-	-	- -	-	90
Henry sil	54	40	-	-	-	-	- -	1.5	145
Huntington sil	10 A	110	45	40	2200	4.0	1.1-3.0	2.0	195
Iola v. gr. loam	460A1	55	20	20	1650	2.7	.9-2.3	1.6	130
Iola v. gr. loam	B1	50	20	20	1600	2.6	.8-2.2	1.5	125
Iola v. gr. loam	B2	40	15	-	1300	2.2	.7-1.9	1.5	105
Iola v. gr. loam	C1	45	20	-	1450	2.5	.8-2.1	1.4	115
Iola v. gr. loam	C2	40	15	-	1200	2.2	.7-1.8	1.1	100
Iola v. gr. loam	C3	-	-	-	-	1.7	.5-1.5	75	
Iola v. gr. loam	D								
Iola v. gr. loam	D3	-	-	-	-	-	- -	-	100
Loring sil	51 B1	85	35	30	2000	3.2	1.1-2.9	1.9	175
Loring sil	B2	80	30	25	1800	2.9	1.0-2.6	1.7	165
Loring sil	C1	85	35	30	1800	3.0	1.1-2.8	1.8	170
Loring sil	C2	75	30	25	1650	2.7	.9-2.5	1.7	160
Loring sicl	C3	55	20	20	1400	2.2	.8-2.0	1.3	130
Loring sil	D1	-	30	-	-	3.0	1.0-2.7	1.7	165
Loring sil	D2	-	25	-	-	2.7	.9-2.4	1.6	155
Loring sicl	D3	-	20	-	-	2.1	.7-1.9	1.3	130
Loring sil	E1	-	-	-	-	2.8	1.0-2.6	1.6	160
Loring sil	E2	-	-	-	-	2.5	.9-2.3	1.5	150
Loring sicl	E3	-	-	-	-	2.0	.6-1.7	1.2	120
Melvin sil	117	70	25	30	1550	-	- -	1.8	170
Memphis sil	50 B1	85	35	30	2000	3.9	1.1-3.0	2.0	185
Memphis sil	B2	75	30	30	1800	3.6	1.1-2.8	2.0	175
Memphis sicl	B3	60	20	25	1600	3.0	.9-2.3	1.6	145
Memphis sil	C1	80	30	30	1850	3.6	1.1-2.9	2.0	175
Memphis sil	C2	70	30	25	1650	3.4	1.0-2.7	1.9	170
Memphis sicl	C3	55	20	20	1450	2.9	.8-2.2	1.6	145
Memphis sil	D1	-	30	25	-	3.5	1.1-2.8	1.9	170
Memphis sil	D2	-	25	25	-	3.3	1.0-2.6	1.9	165
Memphis sicl	D3	-	20	-	-	2.8	.8-2.1	1.6	140
Memphis sil	E1	-	-	-	-	3.3	1.0-2.7	1.9	165
Memphis sil	E2	-	-	-	-	3.2	.9-2.5	1.8	155
Memphis sicl	E3	-	-	-	-	2.7	.8-2.0	1.5	135
Memphis sil	F1	-	-	-	-	-	- -	-	155
Memphis sil	F2	-	-	-	-	-	- -	-	140
Memphis sicl	F3	-	-	-	-	-	- -	-	120

D-3

ESTIMATED AVERAGE ACRE YIELDS OF PRINCIPAL CROPS
ON SOILS OF PICKAWAY WORK UNIT

Soil Mapping Unit						HAY			Pasture
Name	Stnd. Map Symbol	Corn bu.	Wheat bu.	Soy-beans bu.	Tobacco lbs.	Alfalfa Grass tons	Red Clover Grass tons 1st-2nd	Lespedeza tons	Animal Unit Grazing Days
Newark sil	112	85	30	35	1750	3.1	.9-2.5	1.8	185
Sciotoville sil	348A1	80	30	30	1900	2.3	1.0-2.6	2.0	170
Sciotoville sil	B1	80	30	30	1950	2.5	1.0-2.7	2.0	175
Sciotoville sil	B2	70	25	25	1750	2.2	.9-2.5	1.9	160
Sciotoville sil	C1	75	25	30	1800	2.3	1.0-2.6	1.9	160
Sciotoville sil	C2	65	20	25	1650	2.1	.9-2.3	1.9	150
Sciotoville sicl	C3	-	15	-	1450	1.5	.7-1.8	1.5	120
Shannon gr. l, loc.all,ph.	202	65	25	25	1650	3.6	1.1-3.0	1.9	170
Sharkey clay	179	70	-	30	-	3.0	1.1-2.8	1.8	150
Vicksburg sil	162	95	40	35	1900	3.8	1.1-3.0	2.0	190
Waverly sil	168	70	20	25	1550	-	.7-1.9	1.7	170
Weinbach sil	350	55	15	20	1500	-	- -	1.7	155
Wheeling sil	345A1	100	40	35	2200	4.0	1.1-3.0	2.0	190
Wheeling sil	B1	100	40	35	2150	3.9	1.1-3.0	2.0	185
Wheeling sil	B2	90	35	30	2050	3.6	1.1-3.0	2.0	180
Wheeling sil	C1	95	40	-	2050	3.6	1.1-3.0	2.0	180
Wheeling sil	C2	85	35	30	1850	3.4	1.1-3.0	1.9	170
Wheeling cl	C3	65	25	25	1750	2.9	1.0-2.6	1.6	145
Wheeling sil	D1	90	35	30	1800	3.5	1.1-3.0	1.9	175
Wheeling sil	D2	70	30	25	1700	3.3	1.1-3.0	1.8	165
Wheeling cl	D3	-	20	-	-	2.8	.9-2.5	1.6	140
Wheeling sil	E1	-	-	-	-	3.3	1.1-3.0	1.9	165
Wheeling sil	E2	-	-	-	-	3.2	1.1-2.9	1.8	160
Wheeling cl	E3	-	-	-	-	2.7	.9-2.4	1.5	135

APPENDIX E

KEY FOR VARIABLES USED IN STEPWISE REGRESSION ANALYSES

Code	Variable
RW	Row-width
P	Phosphorus
K	Potassium
pH	pH
CSN	Certified seed planted
PC 1, 2, 3, or 4	Previous crop 1, 2, 3, or 4
PCR	Previous crop 3 and 4 grouped
PD 1, 2, 3, or 4	Planting date 1, 2, 3, or 4
NEM 0, 1, or 2	Nematodes 0, 1, or 2
NEC	Necrosis
CHL	Chlorosis
PZF	Plants per 2 row-feet
INCN	Inoculum used
ST 1, 2, 3, . . . or 11	Soil type 1, 2, 3, . . . or 11
SP 1, 2, 3, or 4	Soil productivity class 1, 2, 3, or 4
Y	Yield

E-2

DARE FIELDS
F=3.0

VARIABLE	MEAN	STD. DEVIATION
RW	3.544444E+01	4.024528E+00
P	9.194444E+00	6.273843E+00
K	8.769444E+01	2.456806E+01
PH	5.355556E+00	6.253888E-01
INCN	8.611111E-01	3.507362E-01
CSN	1.388889E+01	3.507362E-01
PD2	4.722222E-01	5.063094E-01
PD3	4.722222E-01	5.063094E-01
PD4	5.555556E-02	2.323107E-01
PC1	5.555556E-02	2.323107E-01
PC2	5.000000E-01	5.070926E-01
PC3	2.777778E-01	4.542568E-01
PC4	1.666667E-01	3.779645E-01
NEW0	3.333333E-01	4.780914E-01
NEW1	1.666667E-01	3.779645E-01
NEW2	5.277778E-01	5.599036E-01
NEC	5.111111E-01	1.433034E+00
CHL	2.205278E+01	2.118139E+01
Y	2.966083E+01	8.127920E+00

CORRELATION MATRIX:

VARIABLE:					
RW	1.0000000	-0.3509140	-0.2939101	-0.4562185	-0.1979140
	-0.0247393	-0.4564846	0.3848181	0.1561936	-0.1188429
	0.2940012	-0.4914276	0.2692236	0.1286939	0.0438271
	-0.0943922	0.2869496	0.1421969	-0.0615636	
P	-0.3509140	1.0000000	0.3659359	0.2382010	-0.0912506
	0.0912506	0.3930144	-0.3175597	-0.1644499	0.1688062
	-0.1930854	0.1208604	0.0100407	0.0444523	0.0823341
	-0.1276530	0.0083332	-0.2858395	0.4715265	
K	-0.2939101	0.3659359	1.0000000	0.2953193	0.1308796
	-0.1176167	0.0854325	-0.1075084	0.0481133	0.0581254
	-0.2678177	0.3585585	-0.0805116	-0.2318969	0.3440974
	-0.0627155	0.0961843	0.0825147	0.3706867	
PH	-0.4562185	0.2382010	0.2953193	1.0000000	-0.0419717
	-0.2576195	0.2215724	-0.1664299	-0.1201802	0.0961441
	-0.5856093	0.5877921	0.0201456	0.0509647	-0.1128152
	0.0281053	-0.0462976	0.0162294	0.4872851	
INCN	-0.1979140	-0.0912506	0.1308796	-0.0419717	1.0000000
	0.1612903	-0.1027923	0.3798847	-0.6039088	0.0974047
	0.0803219	0.2490677	-0.4669738	-0.3975733	-0.0359211
	0.3839363	-0.0991635	0.0548574	-0.2510195	
CSN	-0.0247393	0.0912506	-0.1176167	-0.2576195	0.1612903
	1.0000000	0.1027923	-0.0581000	-0.0974047	-0.0974047
	0.0803219	-0.0697390	0.0359211	-0.1135924	-0.1796053
	0.1980303	-0.1452714	-0.0875474	0.0985787	
PD2	-0.4564846	0.3930144	0.0854325	0.2215724	-0.1027923
	0.1027923	1.0000000	-0.8947368	-0.2294157	0.2564058
	-0.1669245	0.1587340	-0.1244181	0.0393445	0.1741854
	-0.1987735	-0.1413251	-0.3948223	0.1748610	
PD3	0.3848181	-0.3175597	-0.1075084	-0.1664299	0.3798847
	-0.0581000	-0.8947368	1.0000000	-0.2294157	-0.2294157
	0.1669245	-0.0897192	0.0248836	-0.0768889	-0.2737199
	0.3051593	0.0122511	0.2565668	-0.2463606	
PD4	0.1561936	-0.1644499	0.0481133	-0.1201802	-0.6039088
	-0.0974047	-0.2294157	-0.2294157	1.0000000	-0.0588235
	0.0000000	-0.1504142	0.2169305	0.0857493	0.2169305
	-0.2318625	0.2613103	0.3013209	0.1558297	
PC1	-0.1188429	0.1688062	0.0581254	0.0961441	0.0974047
	-0.0974047	0.2564058	-0.2294157	-0.0588235	1.0000000
	-0.2425356	-0.1504142	-0.1084652	0.0857493	-0.1084652
	-0.0122033	-0.0877307	-0.2560953	0.0532378	
PC2	0.2940012	-0.1930854	-0.2678177	-0.5856093	0.0803219
	0.0803219	-0.1669245	0.1669245	-0.0000000	-0.2425356
	1.0000000	-0.6201737	-0.4472136	-0.3535534	0.1490712
	0.2515773	0.2988146	0.0948309	-0.5640310	
PC3	-0.4914276	0.1208604	0.3585585	0.5877921	0.2490677
	-0.0697390	0.1587340	-0.0897192	-0.1504142	-0.1504142
	-0.6201737	1.0000000	-0.2773501	-0.0438529	0.0554700
	-0.0312043	-0.1892183	0.1590801	0.3149658	
PC4	0.2692236	0.0100407	-0.0805116	0.0201456	-0.4669738
	0.0359211	-0.1244182	0.0248836	0.2169305	-0.1084652
	-0.4472136	-0.2773501	1.0000000	0.4743416	-0.2000000
	-0.2925228	-0.1195672	-0.1610140	0.3454633	
NEW0	0.1286939	0.0444523	-0.2318969	0.0509647	-0.3975733
	-0.1135924	0.0393445	-0.0768889	0.0857493	0.0857493
	-0.3535534	-0.0438529	0.4743416	1.0000000	-0.3162278
	-0.6756897	-0.1890523	-0.4599843	0.3879973	

E-3

NEA	0.0338271	0.0823341	0.3440974	-0.1128152	-0.0359211
	-0.1796053	0.1741854	-0.2737199	0.2169305	-0.1084652
	0.1490712	0.0554700	-0.2000000	-0.3162278	1.0000000
	-0.4275334	0.2918846	0.2929419	0.1200216	
NEM2	-0.0943922	-0.1276530	-0.0627155	0.0281053	0.3839363
	0.1980303	-0.1987735	0.3051593	-0.2318625	-0.0122033
	0.2515773	-0.0312043	-0.2925228	-0.6759897	-0.4275334
	1.0000000	-0.0538094	0.2743958	-0.4764937	
NEC	0.2869496	0.0083332	0.0961843	-0.0462976	-0.0991635
	-0.1452714	-0.1413251	0.0122511	0.2813103	-0.0677307
	0.2988146	-0.1892163	-0.1195672	-0.1890523	0.2918846
	-0.0538094	1.0000000	0.3010406	0.0232266	
CHL	0.1421969	-0.2658395	0.0825147	0.0162294	0.0548574
	-0.0875474	-0.3948223	0.2565668	0.3013209	-0.2560953
	0.0948309	0.1590801	-0.1610140	-0.4599843	0.2929419
	0.2743958	0.3010406	1.0000000	-0.2130155	
Y	-0.0615636	0.4715265	0.3706867	0.4872851	-0.2510195
	0.0985767	0.1748610	-0.2463506	0.1558297	0.0532378
	-0.5640310	0.3149658	0.3454633	0.3879973	0.1200216
	-0.4764937	0.0232266	-0.2130155	1.0000000	

STEP 1	VARIABLE PC2	ENTERED : R=	5.640310E-01
STEP 2	VARIABLE P	ENTERED : R=	6.743268E-01
STEP 3	VARIABLE NEM2	ENTERED : R=	7.447124E-01
STEP 4	VARIABLE PH	ENTERED : R=	7.764433E-01
STEP 5	VARIABLE PC2	REMOVED : R=	7.540144E-01
STEP 6	VARIABLE CSN	ENTERED : R=	8.078791E-01
STEP 7	VARIABLE RW	ENTERED : R=	8.504901E-01
STEP 8	VARIABLE K	ENTERED : R=	8.686727E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
RW	6.905179E-01	2.223368E-01	9.645550E+00
P	3.558496E-01	1.372348E-01	6.723645E+00
K	6.544294E-02	3.405027E-02	3.693894E+00
PH	8.143578E+00	1.436464E+00	3.213963E+01
CSN	8.410994E+00	2.329008E+00	1.304226E+01
NEM2	-7.058528E+00	1.398654E+00	2.264707E+01
CONSTANT	-4.488125E+01	4.423423E+00	(RESIDUAL)

75.46 % VARIATION EXPLAINED: 8 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

1.0000	1.0000	1.0000	1.0000	0.7597	1.0000	0.6578
0.7004	0.8814	0.9529	0.5648	0.5332	0.8038	0.4361
0.6589	1.0000	0.8613	0.7931	0.2454		

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
3.064000E+01	2.824719E+01	2.392811E+00
3.898000E+01	3.238524E+01	6.594763E+00
3.054000E+01	2.722821E+01	3.311790E+00
3.230000E+01	3.526929E+01	-2.969293E+00
2.133000E+01	2.429443E+01	-2.964425E+00
2.262000E+01	2.402530E+01	-1.405295E+00
3.109000E+01	2.760872E+01	3.481282E+00
2.244000E+01	1.964115E+01	2.798853E+00
2.909000E+01	2.878103E+01	3.089683E-01
2.321000E+01	2.790974E+01	-4.699743E+00
3.322000E+01	3.786050E+01	-4.640497E+00
4.911000E+01	4.361176E+01	5.498235E+00
3.617000E+01	3.816620E+01	-1.936203E+00
1.944000E+01	1.771488E+01	1.725124E+00
1.873000E+01	1.923324E+01	-5.032353E-01
2.971000E+01	3.234876E+01	-2.638763E+00
2.589000E+01	2.881459E+01	-2.924588E+00
3.238000E+01	3.428957E+01	-1.909571E+00
1.839000E+01	1.747404E+01	9.159582E-01
1.704000E+01	2.261410E+01	-5.574099E+00
3.280000E+01	3.462956E+01	-1.829563E+00
3.941000E+01	3.837574E+01	1.034259E+00
2.389000E+01	2.861049E+01	-4.720493E+00
2.812000E+01	2.992419E+01	-1.804187E+00
2.278000E+01	2.075021E+01	2.029791E+00
3.120000E+01	3.065346E+01	5.4654*3E-01
2.197000E+01	2.861867E+01	-6.648667E+00
2.206000E+01	2.683730E+01	-4.777303E+00
3.561000E+01	3.723236E+01	-1.622365E+00
4.606000E+01	4.568120E+01	3.787999E-01
3.600000E+01	3.219408E+01	3.805922E+00
4.011000E+01	2.629208E+01	1.381792E+01
4.386000E+01	4.039183E+01	3.468167E+00
3.200000E+01	2.904964E+01	2.950357E+00
2.805000E+01	3.025795E+01	-2.207949E+00
2.155000E+01	2.083332E+01	7.166841E-01

E-4

HOOD FIELDS
F=3.0

VARIABLE	MEAN	STD. DEVIATION
RW	3.577 3E+01	4.092579E+00
P	7.333 3E+00	4.309458E+00
K	8.536111E+01	1.894376E+01
PH	5.572222E+00	5.305583E-01
CSN	2.777778E-01	4.542568E-01
PD1	8.333333E-02	2.803060E-01
PD2	1.111111E-01	3.187276E-01
PD3	6.944444E-01	4.671766E-01
PD4	1.111111E-01	3.187276E-01
PC1	2.777778E-02	1.666667E-01
PC2	7.222222E-01	4.542568E-01
PC3	1.666667E-01	3.779645E-01
PC4	8.333333E-02	2.803060E-01
NEW0	4.166667E-01	5.000000E-01
NEW1	1.111111E-01	3.187276E-01
NEW2	4.722222E-01	5.063094E-01
NEC	4.319444E-01	1.193264E+00
CHL	1.504833E+01	1.842395E+01
Y	3.164583E+01	6.614951E+00

CORRELATION MATRIX:

VARIABLE:					
RW	1.0000000	0.0253798	-0.2690653	-0.2489854	-0.1963762
	-0.5313262	-0.4624089	0.7255924	-0.1338552	-0.2420176
	0.1656390	0.0430984	-0.1826434	0.1303172	-0.1995660
	-0.0030641	0.0752124	0.0703687	-0.0415327	
P	0.0253798	1.0000000	0.2585186	0.1053842	-0.1800066
	0.2638299	-0.0485363	0.0520355	-0.2773501	0.2651974
	-0.1118960	0.0526235	-0.0473050	-0.1856382	0.0138675
	0.1745951	0.1292727	-0.1601711	-0.0175597	
K	-0.2690653	0.2585186	1.0000000	-0.1800542	-0.0086694
	0.0910224	-0.1582596	-0.0194600	0.1067332	0.1596204
	-0.0942568	0.2267869	-0.2479576	-0.1792273	0.0925372
	0.1187406	0.0018134	-0.1071730	0.1381977	
PH	-0.2489854	0.1053842	-0.1800542	1.0000000	0.1988987
	0.4770914	0.1032522	-0.0698026	-0.4205181	0.3967070
	-0.0803498	0.0949853	-0.2337428	-0.2351521	0.2046271
	0.1034066	-0.0667042	0.0504856	-0.0395201	
CSN	-0.1963762	-0.1800066	-0.0086694	0.1988987	1.0000000
	0.2617852	0.1754116	-0.2617851	-0.0219264	-0.1048285
	0.2461538	-0.1109400	-0.1869894	-0.1467599	0.1754116
	0.0345074	-0.1275292	-0.1194298	-0.0522799	
PD1	-0.5313262	0.2838299	0.0910224	0.4770914	0.2617852
	1.0000000	-0.1066004	-0.4545454	-0.1066004	0.5606119
	-0.0373979	-0.1348400	-0.0909091	-0.2548236	0.2132007
	0.1174358	-0.0338124	-0.1723079	-0.0819371	
PD2	-0.4624089	-0.0485363	-0.1582596	0.1032522	0.1754116
	-0.1066004	1.0000000	-0.5330018	-0.1250000	-0.0597614
	-0.1754116	-0.1581139	0.5330018	0.0597614	-0.1250000
	0.0196722	0.0054256	0.1158319	0.1396702	
PD3	0.7255924	0.0520355	-0.0194600	-0.0698026	-0.2617851
	-0.4545454	-0.5330018	1.0000000	-0.5330018	-0.2548236
	0.2617852	0.1348400	-0.4545454	-0.1732800	0.0426401
	0.1442782	0.1051386	0.1909744	-0.1353137	
PD4	-0.1338552	-0.2773501	0.1067332	-0.4205181	-0.0219264
	-0.1066004	-0.1250000	-0.5330018	1.0000000	-0.0597614
	-0.1754116	0.0790569	0.2132007	0.4183300	-0.1250000
	-0.3344280	-0.1297967	-0.2442168	0.1307263	
PC1	-0.2420176	0.2651974	0.1596204	0.3967070	-0.1048285
	0.5606119	-0.0597614	-0.2548236	-0.0597614	1.0000000
	-0.2725541	-0.0755929	-0.0509647	-0.1428571	-0.0597614
	0.1786974	0.0672425	-0.0562777	-0.0981111	
PC2	0.1656390	-0.1118960	-0.0942568	-0.0803498	0.2461538
	-0.0373979	-0.1754116	0.2617852	-0.1754116	-0.2725541
	1.0000000	-0.7211103	-0.4861724	-0.3564168	0.0219264
	0.3381724	-0.1017598	-0.0164435	-0.6976415	
PC3	0.0430984	0.0526235	0.2267869	0.0549853	-0.1109400
	-0.1348400	-0.1581139	0.1348400	0.0790569	-0.0755929
	-0.7211103	1.0000000	-0.1348400	0.2267787	0.0790569
	-0.2737199	0.1747395	0.2092924	0.6088044	
PC4	-0.1826434	-0.0473050	-0.2479576	-0.2337428	-0.1869894
	-0.0909091	0.5330018	-0.4545454	0.2132007	-0.0509647
	-0.4861724	-0.1348400	1.0000000	0.3567530	-0.1066004
	-0.2852012	-0.1106910	-0.2220999	0.3680042	
NEW0	0.1303172	-0.1856382	-0.1792273	-0.2351521	-0.1467599
	-0.2548236	0.0597614	-0.1732800	0.4183300	-0.1428571
	-0.3564168	0.2267787	0.3567530	1.0000000	-0.2988072
	-0.7994359	0.1925491	-0.0667609	0.5662713	

E-5

NE-1	-0.1995660	0.0138675	0.0925372	0.2046271	0.1754116
	0.2132007	-0.1250000	0.0426401	-0.1250000	-0.0597614
	0.0219264	0.0790569	-0.1066004	-0.2988072	1.0000000
	-0.3344280	-0.1260405	-0.2500554	-0.0539799	
NEM2	-0.0030641	0.1745951	0.1187406	0.1034066	0.0345074
	0.1174358	0.0196722	0.1442782	-0.3344280	0.1786974
	0.3381724	-0.2737199	-0.2852012	-0.7994359	-0.3344280
	1.0000000	-0.1108057	0.2233418	-0.5252337	
NEC	0.0752124	0.1292727	0.0018134	-0.0667042	-0.1275292
	-0.0338124	0.0054256	0.1051386	-0.1297967	0.0672425
	-0.1017568	0.1747395	-0.1106910	0.1925491	-0.1260405
	-0.1108057	1.0000000	0.6265914	0.1102127	
CHL	0.0703667	-0.1601711	-0.1071730	0.0504856	-0.1194288
	-0.1723079	0.1158319	0.1909744	-0.2442168	-0.0562777
	-0.0164435	0.2092924	-0.2220999	-0.0667609	-0.2500554
	0.2233418	0.6265914	1.0000000	0.1062560	
Y	-0.0415327	-0.0175597	0.1381977	-0.0355201	-0.0522799
	-0.0819371	0.1396702	-0.1353137	0.1307263	-0.0981111
	-0.6976415	0.6088044	0.3680042	0.5662713	-0.0539799
	-0.5252337	0.1102127	0.1062560	1.0000000	

STEP 1 VARIABLE PC2 ENTERED : R= 6.976415E-01
STEP 2 VARIABLE NEMO ENTERED : R= 7.760583E-01
STEP 3 VARIABLE PC1 ENTERED : R= 8.057471E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
PC1	-9.276181E+00	4.481604E+00	4.284218E+00
PC2	-9.531867E+00	1.741825E+00	2.994657E+01
NEMO	3.963482E+00	1.538338E+00	6.638199E+00
CONSTANT	3.713618E+01	4.097301E+00	(RESIDUAL)

64.92 % VARIATION EXPLAINED: 3 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

0.9071	0.8945	0.9326	0.8075	0.9320	0.6519	0.9556
0.8750	0.8241	1.0000	1.0000	0.3875	0.7045	1.0000
0.8817	0.3494	0.9538	0.9861	0.3508		

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
3.404000E+01	2.760431E+01	6.435687E+00
2.772000E+01	2.760431E+01	1.156869E-01
3.365000E+01	3.156780E+01	2.082205E+00
3.520000E+01	2.760431E+01	7.595687E+00
2.943000E+01	2.760431E+01	1.825687E+00
2.724000E+01	2.760431E+01	-3.643131E-01
3.661000E+01	3.156780E+01	5.042205E+00
2.590000E+01	2.760431E+01	-1.704313E+00
2.025000E+01	2.760431E+01	-7.354313E+00
2.539000E+01	2.760431E+01	-2.214313E+00
2.313000E+01	2.760431E+01	-4.474313E+00
2.263000E+01	2.760431E+01	-4.974313E+00
4.395000E+01	4.109966E+01	2.850337E+00
4.382000E+01	4.109966E+01	2.720337E+00
3.404000E+01	3.156780E+01	2.472205E+00
2.550000E+01	3.156780E+01	-6.067795E+00
4.025000E+01	4.109966E+01	-8.496628E-01
3.742000E+01	4.109966E+01	-3.679663E+00
4.110000E+01	4.109966E+01	3.371239E-04
3.930000E+01	3.156780E+01	7.732205E+00
2.612000E+01	2.760431E+01	-1.484313E+00
3.225000E+01	2.760431E+01	4.645687E+00
2.786000E+01	2.786000E+01	2.384186E-07
4.009000E+01	3.713618E+01	2.953820E+00
3.558000E+01	3.713618E+01	-1.556180E+00
3.035000E+01	2.760431E+01	2.745687E+00
2.837000E+01	3.156780E+01	-3.197795E+00
2.648000E+01	2.760431E+01	-1.124313E+00
2.687000E+01	2.760431E+01	-7.343132E-01
3.460000E+01	2.760431E+01	6.995687E+00
4.030000E+01	4.109966E+01	-7.996626E-01
3.946000E+01	4.109966E+01	-1.639663E+00
2.197000E+01	2.760431E+01	-5.634313E+00
2.591000E+01	2.760431E+01	-1.694313E+00
2.721000E+01	3.156780E+01	-4.357795E+00
2.926000E+01	3.156780E+01	-2.307795E+00

E-6

HOOD FIELDS
F=3.0

VARIABLE	MEAN	STD. DEVIATION
RN	3.577778E+01	4.092579E+00
P	7.333333E+00	4.309458E+00
K	8.536111E+01	1.894376E+01
PH	5.572222E+00	5.305583E-01
CSN	2.777778E-01	4.542568E-01
PCR	2.500000E-01	4.391550E-01
PD1	8.333333E-02	2.803060E-01
PD2	1.111111E-01	3.187276E-01
PD3	6.944444E-01	4.671766E-01
PD4	1.111111E-01	3.187276E-01
NEW0	4.166667E-01	5.000000E-01
NEW1	1.111111E-01	3.187276E-01
NE+2	4.722222E-01	5.063094E-01
NEC	4.319444E-01	1.193264E+00
CHL	1.504833E+01	1.842395E+01
Y	3.164563E+01	6.614951E+00

CORRELATION MATRIX:

VARIABLE:					
RN	1.0000000	0.0253798	-0.2690653	-0.2489854	-0.1963762
	-0.0794853	-0.5313262	-0.4624089	0.7255924	-0.1338552
	0.1303172	-0.1995660	-0.0030641	0.0752124	0.0703687
	-0.0415327				
P	0.0253798	1.0000000	0.2585186	0.1053842	-0.1800066
	0.0150970	0.2838299	-0.0485363	0.0520355	-0.2773501
	-0.1856382	0.0138675	0.1745951	0.1292727	-0.1601711
	-0.0175597				
K	-0.2690653	0.2585186	1.0000000	-0.1800542	-0.0086694
	0.0369196	0.0910224	-0.1582596	-0.0194600	0.1067332
	-0.1792273	0.0925372	0.1187406	0.0018134	-0.1071730
	0.1381977				
PH	-0.2489854	0.1053842	-0.1800542	1.0000000	0.1988987
	-0.0674441	0.4770914	0.1032522	-0.0698026	-0.4205181
	-0.2351521	0.2046271	0.1034066	-0.0667042	0.0504856
	-0.0355201				
CSN	-0.1963762	-0.1800066	-0.0086694	0.1988987	1.0000000
	-0.2148345	0.2617852	0.1754116	-0.2617851	-0.0219264
	-0.1467599	0.1754116	0.0345074	-0.1275292	-0.1194288
	-0.0522799				
PCR	-0.0794853	0.0150970	0.0369196	-0.0674441	-0.2148345
	1.0000000	-0.1740776	0.2041241	-0.1740777	0.2041241
	0.4226900	-0.0000000	-0.4176202	0.0797395	0.0383673
	0.7588669				
PD1	-0.5313262	0.2838299	0.0910224	0.4770914	0.2617852
	-0.1740776	1.0000000	-0.1066004	-0.4545454	-0.1066004
	-0.2548236	0.2132007	0.1174358	-0.0338124	-0.1723079
	-0.0819371				
PD2	-0.4624089	-0.0485363	-0.1582596	0.1032522	0.1754116
	0.2041241	-0.1066004	1.0000000	-0.5330018	-0.1250000
	0.0597614	-0.1250000	0.0196722	0.0054256	0.1156319
	0.1396702				
PD3	0.7255924	0.0520355	-0.0194600	-0.0698026	-0.2617851
	-0.1740777	-0.4545454	-0.5330018	1.0000000	-0.5330018
	-0.1732600	0.0426401	0.1442782	0.1051386	0.1909744
	-0.1353137				
PD4	-0.1338552	-0.2773501	0.1067332	-0.4205181	-0.0219264
	0.2041241	-0.1066004	-0.1250000	-0.5330018	1.0000000
	0.4183300	-0.1250000	-0.3344280	-0.1297967	-0.2442168
	0.1307263				
NE+0	0.1303172	-0.1856382	-0.1792273	-0.2351521	-0.1467599
	0.4226900	-0.2548236	0.0597614	-0.1732800	0.4183300
	1.0000000	-0.2986072	-0.7994359	0.1925491	-0.0667609
	0.5662713				
NE+1	-0.1995660	0.0138675	0.0925372	0.2046271	0.1754116
	-0.0000000	0.2132007	-0.1250000	0.0426401	-0.1250000
	-0.2986072	1.0000000	-0.3344280	-0.1260405	-0.2500354
	-0.0539799				
NE+2	-0.0030641	0.1745951	0.1187406	0.1034066	0.0345074
	-0.4176202	0.1174358	0.0196722	0.1442782	-0.3344280
	-0.7994359	-0.3344280	1.0000000	-0.1108057	0.2233418
	-0.5252337				
NEC	0.0752124	0.1292727	0.0018134	-0.0667042	-0.1275292
	0.0797395	-0.0338124	0.0054256	0.1051386	-0.1297967
	0.1925491	-0.1260405	-0.1108057	1.0000000	0.6265914
	0.1102127				

E-7

CHL	0.0703667	-0.1601711	-0.1071730	0.0504856	-0.1194268
	0.0383673	-0.1723079	0.1158319	0.1909744	-0.2442168
	-0.0667609	-0.2500564	0.2233418	0.6265914	1.0000000
	0.1062560				
Y	-0.0415327	-0.0175567	0.1381977	-0.0355201	-0.0522799
	0.7588669	-0.0819371	0.1396702	-0.1353137	0.1307263
	0.5662713	-0.0539799	-0.5252337	0.1102127	0.1062560
	1.0000000				

STEP 1 VARIABLE PCR ENTERED : R= 7.588669E-01
STEP 2 VARIABLE NEKO ENTERED : R= 8.057219E-01
STEP 3 VARIABLE K ENTERED : R= 8.239917E-01
STEP 4 VARIABLE PD4 ENTERED : R= 8.421379E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
K	7.451689E-02	3.537126E-02	4.438215E+00
PCR	9.184013E+00	1.622787E+00	3.202890E+01
PD4	-4.063631E+00	2.260053E+00	3.232892E+00
NEKO	5.670150E+00	1.585478E+00	1.278995E+01
CONSTANT	2.107794E+01	3.789805E+00	(RESIDUAL)

70.93 % VARIATION EXPLAINED: 4 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

0.8614	0.8332	1.0000	0.7398	0.9470	1.0000	0.9265
0.9670	0.6996	1.0000	1.0000	0.8907	0.3530	0.9019
0.9250	0.2907					

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
3.404000E+01	2.659219E+01	7.447813E+00
2.772000E+01	2.823156E+01	-5.115560E-01
3.365000E+01	3.336009E+01	2.699094E-01
3.520000E+01	2.806253E+01	7.117475E+00
2.643000E+01	2.957286E+01	-1.428630E-01
2.724000E+01	2.539992E+01	1.840063E+00
3.661000E+01	3.107007E+01	5.539933E+00
2.590000E+01	2.525088E+01	6.491165E-01
2.025000E+01	2.614509E+01	-5.895085E+00
2.539000E+01	2.562347E+01	-2.334678E-01
2.313000E+01	2.934931E+01	-6.219312E+00
2.263000E+01	2.726284E+01	-4.632839E+00
4.395000E+01	4.166990E+01	2.280099E+00
4.382000E+01	4.181893E+01	2.001065E+00
3.404000E+01	3.382719E+01	2.128081E-01
2.550000E+01	3.129362E+01	-5.793618E+00
4.025000E+01	4.226604E+01	-2.016036E+00
3.742000E+01	4.189345E+01	-4.473452E+00
4.110000E+01	3.995601E+01	1.143987E+00
3.930000E+01	3.524301E+01	4.056987E+00
2.612000E+01	2.674122E+01	-6.212213E-01
3.225000E+01	2.838059E+01	3.869407E+00
2.786000E+01	2.875318E+01	-8.931775E-01
4.009000E+01	3.890591E+01	1.184090E+00
3.558000E+01	3.920398E+01	-3.623978E+00
3.035000E+01	2.733736E+01	3.012644E+00
2.837000E+01	3.159169E+01	-3.221685E+00
2.648000E+01	2.711381E+01	-6.338057E-01
2.687000E+01	2.636864E+01	5.013630E-01
3.460000E+01	2.979641E+01	4.803586E+00
4.030000E+01	3.753175E+01	2.768247E+00
3.946000E+01	3.872402E+01	7.359767E-01
2.197000E+01	2.741187E+01	-5.441373E+00
2.591000E+01	2.748639E+01	-1.576390E+00
2.721000E+01	3.043421E+01	-3.224213E+00
2.926000E+01	2.954001E+01	-2.800105E-01

E-8

YORK FIELDS
F=3.0

VARIABLE	MEAN	STD. DEVIATION
RA	3.366667E+01	3.741657E+00
P	1.166667E+01	7.648529E+00
K	8.055556E+01	1.761931E+01
PH	5.911111E+00	3.532731E-01
P2F	1.544444E+01	1.740051E+00
INCN	6.388889E-01	3.333333E-01
CaN	2.222222E-01	4.409585E-01
Pd1	1.111111E-01	3.333333E-01
Pd2	3.333333E-01	5.000000E-01
Pd3	4.444444E-01	5.270463E-01
Pd4	1.111111E-01	3.333333E-01
PC1	5.555556E-01	5.270463E-01
PC4	4.444444E-01	5.270463E-01
SP1	5.555556E-01	5.270463E-01
SP3	4.444444E-01	5.270463E-01
RE=0	4.444444E-01	5.270463E-01
RE=1	2.222222E-01	4.409585E-01
RE=2	3.333333E-01	5.000000E-01
INC	2.666667E-01	5.261503E-01
CHL	1.128889E+01	1.412006E+01
Y	3.770111E+01	6.760391E+00

CORRELATION MATRIX:

VARIABLE:

RA	1.0000000	-0.5765567	0.1118631	-0.4146221	0.4671815
	0.5679301	0.6565991	0.4342995	0.0668153	-0.4225771
	0.1336306	0.0422577	-0.0422577	-0.5282214	0.5282214
	-0.0422577	-0.7071068	0.6681531	-0.3030458	-0.2515816
	-0.6609325				
P	-0.5765567	1.0000000	0.1372671	0.4086198	-0.3068138
	-0.2124591	-0.2347289	-0.0817151	0.2286022	0.1033623
	-0.4249183	-0.3204231	0.3204231	0.7828635	-0.7828635
	0.3204231	0.3582705	-0.6537205	0.1606040	-0.0507341
	0.7338055				
K	0.1118631	0.1372671	1.0000000	0.4075543	-0.0291158
	-0.3039774	0.1254981	0.4302449	0.1449738	-0.3756312
	-0.0537806	0.2957726	-0.2957726	0.0828163	-0.0828163
	-0.2957726	0.3482131	0.0046766	0.0406543	-0.3555330
	-0.2971033				
PH	-0.4146221	0.4086198	0.4075543	1.0000000	-0.3693226
	-0.0602475	-0.0626214	0.3313614	-0.1958044	0.1952824
	-0.3464233	-0.0666818	0.0666818	0.6191880	-0.6191880
	0.0666818	0.6546784	-0.6476609	0.7229927	0.3163479
	0.3351929				
P2F	0.4671815	-0.3068138	-0.0291158	-0.3693226	1.0000000
	0.5268045	-0.3077207	-0.0957826	0.6704784	-0.6512162
	0.1197283	-0.1665902	0.1665902	-0.4391923	0.4391923
	0.1665902	-0.6335425	0.3831305	-0.0905061	0.2724118
	-0.0875005				
INCN	0.5679301	-0.2124591	-0.3039774	-0.0602475	0.5268045
	1.0000000	0.1889822	0.1250000	0.2500000	-0.3952847
	0.1250000	-0.3162278	0.3162278	-0.3162278	0.3162278
	0.3162278	-0.6614378	0.2500000	0.1889822	0.1537411
	0.0621862				
CaN	0.6565991	-0.2347289	0.1254981	-0.0626214	-0.3077207
	0.1889822	1.0000000	0.6614378	-0.3779645	0.0597614
	-0.1889822	-0.0597614	-0.0597614	-0.0597614	0.0597614
	0.0597614	-0.2857143	0.1889822	-0.2857143	-0.4532699
	-0.4739192				
Pd1	0.4342995	-0.0817151	0.4302449	0.3313614	-0.0957826
	0.1250000	0.6614378	1.0000000	-0.2500000	-0.3162278
	-0.1250000	-0.3952847	0.3952847	0.3162278	-0.3162278
	0.3952847	-0.1889822	-0.2500000	-0.1889822	-0.2998099
	-0.1564875				
Pd2	0.0668153	0.2286022	0.1449738	-0.1958044	0.6704784
	0.2500000	-0.3779645	-0.2500000	1.0000000	-0.6324555
	-0.2500000	-0.3162278	0.3162278	-0.3162278	0.3162278
	0.3162278	-0.3779645	0.0000000	-0.1889822	-0.0383615
	0.3175359				
Pd3	-0.4225771	0.1033623	-0.3756312	0.1952824	-0.6512162
	-0.3952847	0.0597614	-0.3162278	-0.6324555	1.0000000
	-0.3162278	0.3500000	-0.3500000	0.3500000	-0.3500000
	-0.3500000	0.5976143	-0.1581139	0.4183300	0.4156257
	-0.0390974				
Pd4	0.1336306	-0.4249183	-0.0537806	-0.3464233	0.1197283
	0.1250000	-0.1889822	-0.1250000	-0.2500000	-0.3162278
	1.0000000	0.3162278	-0.3162278	-0.3952847	0.3952847
	-0.3162278	-0.1889822	0.5000000	-0.1889822	-0.2998099
	-0.2579979				

E-9

PC2	0.0422577	-0.3204231	0.2957726	-0.0666818	-0.1665902
	-0.3162278	-0.0597614	-0.3952847	-0.3162278	0.3500000
	0.3162278	1.0000000	-1.0000000	-0.3500000	0.3500000
	-1.0000000	0.4780914	0.6324555	0.2988072	0.0294876
	-0.6628986				
PC4	-0.0422577	0.3204231	-0.2957726	0.0666818	0.1665902
	0.3162278	0.0597614	0.3952847	0.3162278	-0.3500000
	-0.3162278	-1.0000000	1.0000000	0.3500000	-0.3500000
	1.0000000	-0.4780914	-0.6324555	-0.2988072	-0.0294876
	0.6628986				
SP1	-0.5282214	0.7028635	0.0628163	0.6191880	-0.4391923
	-0.3162278	-0.0597614	0.3162278	-0.3162278	0.3500000
	-0.3952847	-0.3500000	0.3500000	1.0000000	-1.0000000
	0.3500000	0.4780914	-0.7905694	0.2988072	0.2411264
	0.5386709				
SP3	0.5282214	-0.7028635	-0.0628163	-0.6191880	0.4391923
	0.3162278	0.0597614	-0.3162278	0.3162278	-0.3500000
	0.3952847	0.3500000	-0.3500000	-1.0000000	1.0000000
	-0.3500000	-0.4780914	0.7905694	-0.2988072	-0.2411264
	-0.5386709				
NEA0	-0.0422577	0.3204231	-0.2957726	0.0666818	0.1665902
	0.3162278	0.0597614	0.3952847	0.3162278	-0.3500000
	-0.3162278	-1.0000000	1.0000000	0.3500000	-0.3500000
	1.0000000	-0.4780914	-0.6324555	-0.2988072	-0.0294876
	0.6628986				
NEX1	-0.7071068	0.3582705	0.3482131	0.6546784	-0.6335425
	-0.6614378	-0.2857143	-0.1889822	-0.3779645	0.5976143
	-0.1889822	0.4780914	-0.4780914	0.4780914	-0.4780914
	-0.4780914	1.0000000	-0.3779645	0.5714286	0.2373421
	0.0850278				
NEY2	0.6681531	-0.6537204	0.0046766	-0.6476609	0.3831305
	0.2500000	0.1889322	-0.2500000	0.0000000	-0.1581139
	0.5000000	0.6324555	-0.6324555	-0.7905694	0.7905694
	-0.6324555	-0.3779645	1.0000000	-0.1889822	-0.1782334
	-0.7948258				
NEC	-0.3030458	0.1606040	0.0406543	0.7229927	-0.0905061
	0.1889822	-0.2857143	-0.1889822	-0.1889822	0.4183300
	-0.1889822	0.2988072	-0.2988072	0.2988072	-0.2988072
	-0.2988072	0.5714286	-0.1889822	1.0000000	0.7171568
	0.1338081				
CHL	-0.2515816	-0.0507341	-0.3555330	0.3163479	0.2724118
	0.1537411	-0.4532699	-0.2996099	-0.0383615	0.4156257
	-0.2998099	0.0294876	-0.0294876	0.2411264	-0.2411264
	-0.0294876	0.2373421	-0.1782334	0.7171568	1.0000000
	0.1677102				
Y	-0.6609325	0.7338055	-0.2971033	0.3351929	-0.0875005
	0.0621862	-0.4739192	-0.1564875	0.3175359	-0.0390974
	-0.2579979	-0.6828966	0.6828987	0.5386709	-0.5386709
	0.6826967	0.0850278	-0.7948258	0.1338081	0.1677102
	1.0000000				

STEP 1 VARIABLE NEX2 ENTERED : R= 7.948258E-01
STEP 2 VARIABLE PD1 ENTERED : R= 8.753980E-01
STEP 3 VARIABLE PC4 ENTERED : R= 9.494136E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
PD1	-1.025000E+01	3.100775E+00	1.092716E+01
PC4	6.415000E+00	2.451378E+00	6.848143E+00
NE-2	-8.178333E+00	2.451378E+00	1.113036E+01
CONSTANT	3.871500E+01	2.685350E+00 (RESIDUAL)	

90.14 % VARIATION EXPLAINED: 3 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

0.0714	0.5068	0.5023	0.2743	0.5436	0.5625	0.4286
1.0000	0.6667	0.6000	0.7500	0.0000	1.0000	0.3000
0.3000	1.0000	0.0000	1.0000	0.6667	0.8351	0.0986

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
4.304000E+01	4.513000E+01	-2.090000E+00
4.384000E+01	4.513000E+01	-1.290000E+00
4.651000E+01	4.513000E+01	1.380000E+00
4.086500E+01	3.871500E+01	2.135000E+00
3.658000E+01	3.871500E+01	-2.135000E+00
2.934000E+01	3.053667E+01	-1.196667E+00
3.486000E+01	3.486000E+01	0.
3.305000E+01	3.053667E+01	2.513333E+00
2.922000E+01	3.053667E+01	-1.316667E+00

E-10

PICKETT FIELDS
F=3.0

VARIABLE	MEAN	STD. DEVIATION
RW	3.755556E+01	1.130388E+00
P	1.244444E+01	8.442617E+00
K	9.000000E+01	3.156343E+01
PH	5.400000E+00	5.024938E-01
P2F	1.888889E+01	2.522124E+00
PD2	3.333333E-01	5.000000E-01
PD3	6.666667E-01	5.000000E-01
PC2	6.666667E-01	5.000000E-01
PC3	1.111111E-01	3.333333E-01
PC4	2.222222E-01	4.409585E-01
NE10	3.333333E-01	5.000000E-01
NE11	2.222222E-01	4.409585E-01
NE12	4.444444E-01	5.270463E-01
NEC	1.344444E+00	2.915095E+00
CHL	1.161111E+01	1.971322E+01
Y	2.758778E+01	5.942537E+00

CORRELATION MATRIX:

VARIABLE:					
RW	1.0000000	-0.6709091	-0.3643607	-0.3080915	-0.3263985
	0.5160468	-0.5160468	-0.5160468	0.1474420	0.4736865
	-0.3686049	0.2229113	0.1631883	0.5226475	0.5746629
	0.0952560				
P	-0.6709091	1.0000000	0.7242626	0.2327713	-0.2380766
	-0.1875406	0.1875406	0.1875406	0.0246764	-0.2313046
	-0.0098706	-0.2648811	0.2309795	-0.2645043	-0.3664761
	0.2804157				
K	-0.3643607	0.7242626	1.0000000	-0.0488637	-0.3752816
	0.0871261	-0.0871261	-0.0871261	0.1425701	-0.0089811
	0.1821729	0.0449053	-0.2103949	-0.2820334	-0.1896445
	0.5694970				
PH	-0.3080915	0.2327713	-0.0488637	1.0000000	-0.0986309
	0.3980149	-0.3980149	-0.3980149	-0.0746278	0.5077198
	-0.3960149	0.3384798	0.0943975	-0.4616618	-0.7072897
	0.4705572				
P2F	-0.3263985	-0.2380766	-0.3752816	-0.0986309	1.0000000
	-0.2643274	0.2643274	0.2643274	0.4625730	-0.6493915
	0.2312865	0.2497660	-0.4283868	0.0687622	0.0882735
	-0.6343671				
PD2	0.5160468	-0.1875406	0.0871261	0.3980149	-0.2643274
	1.0000000	-1.0000000	-1.0000000	0.5000000	0.7559289
	-0.5000000	0.7559289	-0.1581139	-0.0285868	-0.1056820
	0.6843318				
PD3	-0.5160468	0.1875406	-0.0871261	-0.3980149	0.2643274
	-1.0000000	1.0000000	1.0000000	-0.5000000	-0.7559289
	0.5000000	-0.7559289	0.1581139	0.0285868	0.1056820
	-0.6843318				
PC2	-0.5160468	0.1875406	-0.0871261	-0.3980149	0.2643274
	-1.0000000	1.0000000	1.0000000	-0.5000000	-0.7559289
	0.5000000	-0.7559289	0.1581139	0.0285868	0.1056820
	-0.6843318				
PC3	0.1474420	0.0246764	0.1425701	-0.0746278	0.4625730
	0.5000000	-0.5000000	-0.5000000	1.0000000	-0.1889822
	-0.2500000	0.6614378	-0.3162278	0.3030204	0.2632278
	0.0449443				
PC4	0.4736865	-0.2313046	-0.0089811	0.5077198	-0.6493915
	0.7559289	-0.7559289	-0.7559289	-0.1889822	1.0000000
	-0.3779645	0.3571429	0.0597614	-0.2614763	-0.3339323
	0.7419846				
NE10	-0.3686049	-0.0098706	0.1821729	-0.3980149	0.2312865
	-0.5000000	0.5000000	0.5000000	-0.2500000	-0.3779645
	1.0000000	-0.3779645	-0.6324555	-0.3459007	-0.1627503
	-0.1259283				
NE11	0.2229113	-0.2648811	0.0449053	0.3384798	0.2497660
	0.7559289	-0.7559289	-0.7559289	0.6614378	0.3571429
	-0.3779645	1.0000000	-0.4780914	0.0983238	0.0471340
	0.4047285				
NE12	0.1631883	0.2309795	-0.2103949	0.0943975	-0.4283868
	-0.1581139	0.1581139	0.1581139	-0.3162278	0.0597614
	-0.6324555	-0.4780914	1.0000000	0.2458867	0.1149634
	-0.2191541				
NEC	0.5226475	-0.2645043	-0.2820334	-0.4616618	0.0687622
	-0.0285868	0.0285868	0.0285868	0.3030204	-0.2614763
	-0.3459007	0.0983238	0.2458867	1.0000000	0.9308900
	-0.2954307				
CHL	0.5746629	-0.3664761	-0.1896445	-0.7072897	0.0882735
	-0.1056820	0.1056820	0.1056820	0.2632278	-0.3339323
	-0.1627503	0.0471340	0.1149634	0.9308900	1.0000000
	-0.3691453				

E-11

Y	0.0952960	0.2604157	0.5694970	0.4705572	-0.6343671
	0.6843318	-0.6843318	-0.6843318	0.0449443	0.7419845
	-0.1259263	0.4047265	-0.2191561	-0.2954307	-0.3691453
	1.0000000				

STEP 1 VARIABLE PC4 ENTERED : R= 7.419643E-01
STEP 2 VARIABLE K ENTERED : R= 9.394307E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
K	1.0c4642E-01	2.634479E-02	1.69567VE+01
PC4	1.706903E+01	1.765737E+00	.351102E+01
CONSTANT	1.558664E+01	2.351932E+00 (RESIDUAL)	

88.25 % VARIATION EXPLAINED: 2 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

0.6459	0.4245	1.0000	0.7403	0.4330	0.4198	0.4198
0.4198	0.9444	1.0000	0.8252	0.8701	0.9524	0.8508
0.8514	0.1175					

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
2.240000E+01	2.209569E+01	3.043061E-01
2.630000E+01	2.665203E+01	1.6479935+00
2.421000E+01	2.741142E+01	-3.201484E+00
2.046000E+01	2.122782E+01	-7.378173E-01
2.181000E+01	2.079378E+01	1.016119E+00
2.660000E+01	2.903568E+01	-2.438679E+00
3.375000E+01	3.034049E+01	3.409510E+00
3.537000E+01	3.607015E+01	-7.001476E-01
3.536000E+01	3.465985E+01	7.001472E-01

E-12

CLARK FIELDS
F=2.5 (ABOUT 80% TO 85% LEVEL)

VARIABLE	MEAN	STD. DEVIATION
RM	3.457143E+01	4.276180E+00
INCN	8.571429E-01	3.779645E-01
CSN	8.571429E-01	3.779645E-01
PD2	4.285714E-01	5.345225E-01
PD3	1.428571E-01	3.779645E-01
PD4	4.285714E-01	5.345225E-01
PC2	2.857143E-01	4.879500E-01
PC3	1.428571E-01	3.779645E-01
PC4	5.714286E-01	5.345225E-01
ST1	1.428571E-01	3.779645E-01
ST2	1.428571E-01	3.779645E-01
ST3	2.857143E-01	4.879500E-01
ST4	2.857143E-01	4.879500E-01
ST11	1.428571E-01	3.779645E-01
SP1	7.142857E-01	4.879500E-01
SP3	2.857143E-01	4.879500E-01
NEC	4.800000E+00	4.871687E+00
CHL	2.770000E+01	2.266598E+01
Y	3.810714E+01	5.383966E+00

CORRELATION MATRIX*

VARIABLE*					
RM	1.0000000	-0.3535534	-0.3535534	-1.0000000	0.3535534
	0.7500000	-0.0912871	0.3535534	-0.1666667	0.3535534
	-0.4714045	0.5477226	-0.7302967	0.3535534	0.0912871
	-0.0912871	-0.9472511	-0.8666601	0.1668740	
INCN	-0.3535534	1.0000000	-0.1666667	0.3535534	0.1666667
	-0.4714045	0.2581989	0.1666667	-0.3535534	-1.0000000
	0.1666667	0.2581989	0.2581989	0.1666667	0.6454972
	-0.6454972	0.4344698	0.5388936	-0.5350558	
CSN	-0.3535534	-0.1666667	1.0000000	0.3535534	-1.0000000
	0.3535534	0.2581989	0.1666667	-0.3535534	0.1666667
	0.1666667	-0.6454972	0.2581989	0.1666667	-0.2581989
	0.2581989	0.4344699	0.2665286	0.1725798	
PD2	-1.0000000	0.3535534	0.3535534	1.0000000	-0.3535534
	-0.7500000	0.0912871	-0.3535534	0.1666667	-0.3535534
	0.4714045	-0.5477226	0.7302967	-0.3535534	-0.0912871
	0.0912871	0.9472511	0.8666601	-0.1668740	
PD3	0.3535534	0.1666667	-1.0000000	-0.3535534	1.0000000
	-0.3535534	-0.2581989	-0.1666667	0.3535534	-0.1666667
	-0.1666667	0.6454972	-0.2581989	-0.1666667	0.2581989
	-0.2581989	-0.4344699	-0.2665286	-0.1725798	
PD4	0.7500000	-0.4714045	0.3535534	-0.7500000	-0.3535534
	1.0000000	0.0912871	0.4714045	-0.4166667	0.4714045
	-0.3535534	0.0912871	-0.5477226	0.4714045	-0.0912871
	0.0912871	-0.6400345	-0.6781959	0.2889064	
PC2	-0.0912871	0.2581989	0.2581989	0.0912871	-0.2581989
	0.0912871	1.0000000	-0.2581989	-0.7302967	-0.2581989
	-0.2581989	0.3000000	0.3000000	-0.2581989	0.4000000
	-0.4000000	0.3365369	0.4083835	-0.5414256	
PC3	0.3535534	0.1666667	0.1666667	-0.3535534	-0.1666667
	0.4714045	-0.2581989	1.0000000	-0.4714045	-0.1666667
	-0.1666667	-0.2581989	-0.2581989	1.0000000	0.2581989
	-0.2581989	-0.4344698	-0.5388936	0.4719911	
PC4	-0.1666667	-0.3535534	-0.3535534	0.1666667	0.3535534
	-0.4166667	-0.7302967	-0.4714045	1.0000000	0.3535534
	0.3535534	-0.0912871	-0.0912871	-0.4714045	-0.5477225
	0.5477226	0.0000000	0.0082539	0.1605035	
ST1	0.3535534	-1.0000000	0.1666667	-0.3535534	-0.1666667
	0.4714045	-0.2581989	-0.1666667	0.3535534	1.0000000
	-0.1666667	-0.2581989	-0.2581989	-0.1666667	-0.6454972
	0.6454972	-0.4344698	-0.5388936	0.5350558	
ST2	-0.4714045	0.1666667	0.1666667	0.4714045	-0.1666667
	-0.3535534	-0.2581989	-0.1666667	0.3535534	-0.1666667
	1.0000000	-0.2581989	-0.2581989	-0.1666667	-0.6454972
	0.6454972	0.4344698	0.4085475	-0.4215627	
ST3	0.5477226	0.2581989	-0.6454972	-0.5477226	0.6454972
	0.0912871	0.3000000	-0.2581989	-0.0912871	-0.2581989
	-0.2581989	1.0000000	-0.4000000	-0.2581989	0.4000000
	-0.4000000	-0.3645838	-0.1145282	-0.5972539	
ST4	-0.7302967	0.2581989	0.2581989	0.7302967	-0.2581989
	-0.5477226	0.3000000	-0.2581989	-0.0912871	-0.2581989
	-0.2581989	-0.4000000	1.0000000	-0.2581989	0.4000000
	-0.4000000	0.7011227	0.6329191	0.1437397	
ST11	0.3535534	0.1666667	0.1666667	-0.3535534	-0.1666667
	0.4714045	-0.2581989	1.0000000	-0.4714045	-0.1666667
	-0.1666667	-0.2581989	-0.2581989	1.0000000	0.2581989
	-0.2581989	-0.4344698	-0.5388936	0.4719911	

E-13

SP1	0.0912871	0.6454972	-0.2581989	-0.0912871	0.2581989
	-0.0912871	0.4000000	0.2581989	-0.5477225	-0.6454972
	-0.6454972	0.4000000	0.4000000	0.2581989	1.0000000
	-1.0000000	-0.0000000	0.1009657	-0.0879114	
SP3	-0.0912871	-0.6454972	0.2581989	0.0912871	-0.2581989
	0.0912871	-0.4000000	-0.2581989	0.5477226	0.6454972
	0.6454972	-0.4000000	-0.4000000	-0.2581989	-1.0000000
	1.0000000	0.0000000	-0.1009657	0.0879114	
NEC	-0.9472511	0.4344698	0.4344699	0.9472511	-0.4344699
	-0.6400345	0.3365389	-0.4344698	0.0000000	-0.4344698
	0.4344698	-0.3645838	0.7011227	-0.4344698	-0.0000000
	0.0000000	1.0000000	0.9660553	-0.3831896	
CHL	-0.8666601	0.5388936	0.2665286	0.8666601	-0.2665286
	-0.6781959	0.4083835	-0.5388936	0.0082539	-0.5388936
	0.4085475	-0.1145282	0.6329191	-0.5388936	0.1009657
	-0.1009657	0.9660553	1.0000000	-0.5692557	
Y	0.1668740	-0.5350558	0.1725798	-0.1668740	-0.1725798
	0.2889064	-0.5414256	0.4710911	0.1605035	0.5350558
	-0.4215627	-0.5972539	0.1437397	0.4719911	-0.0879114
	0.0879114	-0.3831896	-0.5692557	1.0000000	

STEP 1 VARIABLE ST3 ENTERED : R= 5.972539E-01
STEP 2 VARIABLE NEC ENTERED : R= 8.793176E-01
STEP 3 VARIABLE ST4 ENTERED : R= 9.728555E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
ST3	-8.279213E+00	1.621975E+00	2.605493E+01
ST4	6.598609E+00	2.118162E+00	9.705367E+00
NEC	-1.189213E+00	2.098168E-01	3.243311E+01
CONSTANT	4.429548E+01	1.761998E+00	(RESIDUAL)

94.64 % VARIATION EXPLAINED: 3 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

0.0533	0.6100	0.5040	0.0533	0.5040	0.5360	0.5434
0.6100	0.9670	0.6100	0.1066	1.0000	1.0000	0.6100
0.3660	0.3660	1.0000	0.0015	0.0536		

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
3.600000E+01	3.601627E+01	-1.626968E-02
3.688000E+01	3.900216E+01	-2.122157E+00
3.296000E+01	3.287903E+01	8.096600E-02
4.160000E+01	3.947784E+01	2.122157E+00
3.0d0000E+01	3.078373E+01	1.626921E-02
4.3a7000E+01	4.429548E+01	-4.254832E-01
4.464000E+01	4.429548E+01	3.445168E-01

E-14

FOUR CLARK FIELDS FOR WHICH SOILS DATA IS AVAILABLE F=5.5 (ABOUT 10% LEVEL)

VARIABLE	MEAN	STD. DEVIATION
PD2	2.500000E-01	5.000000E-01
PD3	2.500000E-01	5.000000E-01
PD4	5.000000E-01	5.773503E-01
RA	3.600000E+01	4.000000E+00
P	1.125000E+01	5.560276E+00
K	8.475000E+01	2.364142E+01
PH	6.200000E+00	4.082483E-01
ST1	2.500000E-01	5.000000E-01
ST3	5.000000E-01	5.773503E-01
ST4	2.500000E-01	5.000000E-01
PC	5.000000E-01	5.773503E-01
INC	7.500000E-01	5.000000E-01
CS	7.500000E-01	5.000000E-01
CHL	2.425000E+01	2.160825E+01
NEC	3.500000E+00	4.725816E+00
Y	3.708000E+01	5.709594E+00

CORRELATION MATRIX:

VARIABLE:					
PD2	1.0000000	-0.3333333	-0.5773503	-1.0000000	-0.6294652
	-0.2749412	0.	-0.3333333	-0.5773503	1.0000000
	-0.5773503	0.3333333	0.3333333	0.7635971	0.9169493
	-0.0233525				
PD3	-0.3333333	1.0000000	-0.5773503	0.3333333	0.4496180
	-0.6133304	0.	-0.3333333	0.5773503	-0.3333333
	0.5773503	0.3333333	-1.0000000	-0.3162372	-0.4937419
	-0.1261035				
PD4	-0.5773503	-0.5773503	1.0000000	0.5773503	0.1557522
	0.7692658	0.	0.5773503	0.	-0.5773503
	0.	-0.5773503	0.5773503	-0.3874250	-0.3665083
	0.1294327				
RA	-1.0000000	0.3333333	0.5773503	1.0000000	0.6294652
	0.2749412	0.	0.3333333	0.5773503	-1.0000000
	0.5773503	-0.3333333	-0.3333333	-0.7635971	-0.9169493
	0.0233525				
P	-0.6294652	0.4496180	0.1557522	0.6294652	1.0000000
	0.4266423	0.7342231	0.6894142	-0.0519174	-0.6294652
	0.9864309	-0.6894142	-0.4496180	-0.9689450	-0.8616383
	0.7051603				
K	-0.2749412	-0.6133304	0.7692658	0.2749412	0.4266423
	1.0000000	0.6043923	0.9376200	-0.5738967	-0.2749412
	0.2808431	-0.9376200	0.6133304	-0.5492482	-0.3117775
	0.7107073				
PH	0.	0.	0.	0.	0.7342231
	0.6043923	1.0000000	0.8164966	-0.7071068	0.
	0.7071068	-0.8164966	0.	-0.5423676	-0.3455474
	0.9895698				
ST1	-0.3333333	-0.3333333	0.5773503	0.3333333	0.6894142
	0.9376200	0.8164966	1.0000000	-0.5773503	-0.3333333
	0.5773503	-1.0000000	0.3333333	-0.7481709	-0.4937419
	0.8827247				
ST3	-0.5773503	0.5773503	0.	0.5773503	-0.0519174
	-0.5738967	-0.7071068	-0.5773503	1.0000000	-0.5773503
	0.	0.5773503	-0.5773503	-0.0133595	-0.3665083
	-0.7442382				
ST4	1.0000000	-0.3333333	-0.5773503	-1.0000000	-0.6294652
	-0.2749412	0.	-0.3333333	-0.5773503	1.0000000
	-0.5773503	0.3333333	0.3333333	0.7635971	0.9169493
	-0.0233525				
PC	-0.5773503	0.5773503	0.	0.5773503	0.9864309
	0.2808431	0.7071068	0.5773503	0.	-0.5773503
	1.0000000	-0.5773503	-0.5773503	-0.9218044	-0.8551861
	0.6552532				
INC	0.3333333	0.3333333	-0.5773503	-0.3333333	-0.6894142
	-0.9376200	-0.8164966	-1.0000000	0.5773503	0.3333333
	-0.5773503	1.0000000	-0.3333333	0.7481709	0.4937419
	-0.8827247				
CS	0.3333333	-1.0000000	0.5773503	-0.3333333	-0.4496180
	0.6133304	0.	0.3333333	-0.5773503	0.3333333
	-0.5773503	-0.3333333	1.0000000	0.3162372	0.4937419
	0.1261035				

E-15

CHL	0.7635971	-0.3162372	-0.3874250	-0.7635971	-0.9689450
	-0.5492482	-0.6423676	-0.7481709	-0.0133595	0.7635971
	-0.9218044	0.7481709	0.3162372	1.0000000	0.9352052
	-0.6442181				
NEC	0.9169493	-0.4937419	-0.3665083	-0.9169493	-0.8916383
	-0.3117775	-0.3455474	-0.4937419	-0.3665083	0.9169493
	-0.8551861	0.4937419	0.4937419	0.9352052	1.0000000
	-0.3350321				
Y	-0.0233525	-0.1261035	0.1294327	0.0233525	0.7051603
	0.7107073	0.9895698	0.8827247	-0.7442382	-0.0233525
	0.8552532	-0.8827247	0.1261035	-0.6442181	-0.3350321
	1.0000000				

STEP 1 VARIABLE PH ENTERED : R= 9.895898E-01
STEP 2 VARIABLE K ENTERED : R= 9.996330E-01

VARIABLE	COEFFICIENT	STD. ERROR	PARTIAL F
K	4.284707E-02	6.212204E-03	2.722218E+01
PH	1.234035E+01	4.755639E-01	6.733446E+02
CONSTANT	-4.306147E+01	2.679054E-01	(RESIDUAL)

99.93 % VARIATION EXPLAINED: 2 STEPS

DIAGONAL ELEMENTS OF INVERSE OF CORRELATION MATRIX:

0.8809	0.4073	0.0677	0.8809	0.4605	1.0000	1.0000
0.0226	0.4662	0.8809	0.4662	0.0226	0.4073	0.5465
0.5639	0.0007					

Y VARIABLE: Y

Y-ACTUAL	Y-CALCULATED	RESIDUAL
3.600000E+01	3.614808E+01	-1.480761E-01
3.638000E+01	3.666224E+01	2.177591E-01
3.080000E+01	3.083484E+01	-3.484082E-02
4.464000E+01	4.467484E+01	-3.484106E-02

F-1

APPENDIX F

TABULATION OF NUMBER OF OBSERVATIONS AND MEASUREMENTS TAKEN FOR THE INDICATED SOYBEAN VARIETIES

	Observations and Measurements	Variety					Total All Varieties
		Hood	Dare	York	Pickett	Clark 63	
Yields and Soils Data	Total number of fields	36	36	9	9	10	100
	Variety	396	373	100	97	83	1,049
	Planting date	396	373	100	97	83	1,049
	Row width (in.)	396	373	100	97	83	1,049
	Total number of plots	396	373	100	97	83	1,049
	Yield (bu./A)	394	371	100	95	82	1,042
	Weight of beans (g)	395	371	100	97	60	1,023
	Number of beans	395	371	100	97	60	1,023
	P (lb/A)	394	359	100	97	38	988
	P Class	394	359	100	97	38	988
	K (lb/A)	394	359	100	97	38	988
	K class	394	359	100	97	38	988
	pH	394	359	100	97	38	988
	pH Class	394	359	100	97	38	988
	Soil type	386	363	100	97	85	1,031
	Soil productivity class	386	363	100	97	85	1,031
	Nematode class	396	359	100	97	8	960
	Inoculation	396	373	100	97	85	1,051
	Nodule Concentration	228	271	31	43	26	599
	Previous crop	396	373	100	97	85	1,051
	Plants/2 feet of row	396	360	100	94	0	950
	Injury class	396	373	100	97	85	1,051
	Number of nodes to first pods	47	44	33	48	0	172
	Certified seed	396	373	100	97	85	1,051
	Harvest loss (beans/10 ft^2)	270	221	47	58	22	618
Preharvest Data	Necrosis (% actual)	34	0	26	0	12	72
	Necrosis (% estimated)	382	388	124	98	90	1,082
	Chlorosis (% actual)	34	0	26	0	12	72
	Chlorosis (% estimated)	357	369	111	90	90	1,017
	Plants necrotic (% actual)	67	0	75	8	25	175
	Plants necrotic (% estimated)	68	0	75	0	25	168
	Plants chlorotic (% actual)	67	0	72	0	25	164
	Plants chlorotic (% estimated)	68	0	75	0	25	168
	Insect damage (% actual)	34	0	26	0	12	72
	Insect damage (% estimated)	199	244	65	44	54	600
	Total number of nodes	100	260	63	31	30	484
	Total number of nodes affected	73	260	38	31	25	427
	Highest shed node	98	257	50	31	30	466
	Number of nodes to first pods	50	2	49	0	20	121
	Total node height (in.)	141	260	63	31	30	525
	Highest affected node (in.)	155	252	38	21	25	491
	Height of plant (in.)	104	37	0	12	0	153
	Height of effects (in.)	37	0	0	12	0	49

APPENDIX G

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 1 Variety Hood Average Injury Class 0 Planting Date After June 10 Row Width (In.) 28 Nematode Class 1

Nodulization No data Seed Inoculated Yes Certified Seed Yes

Yield and Soils Data																									Preharvest Data																									
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Harvest	Total Node Height (In.)	Highest Affected Node (In.)	Weight of Plant (In.)	Height of Effects (In.)
1	47.08	15.21	117	14	1	75	2	6.4	3	5	1	2	15	0	-	1	50	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	31.57	14.15	107	18	2	75	2	6.9	4	8	1	2	10	0	-	2	89	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	25.86	13.44	107	12	1	80	2	7.0	4	8	1	2	10	0	-	3	21	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	30.36	14.68	114	9	1	70	2	5.8	2	8	1	2	24	0	-	4	51	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	33.77	13.96	100	9	1	63	2	7.0	4	8	1	2	12	0	-	5	34	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	38.81	14.68	112	19	2	89	2	6.3	3	8	1	2	12	0	-	6	44	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	29.03	13.54	102	9	1	63	2	6.9	4	8	1	2	12	0	-	7	56	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	38.90	14.09	100	11	1	90	2	6.5	3	8	1	2	9	0	-	8	75	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	25.75	14.46	108	8	1	61	2	6.9	4	8	1	2	18	0	-	9	86	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	39.28	14.23	103	16	2	79	2	6.4	3	8	1	2	6	0	-	10	58	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1568

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 2 Variety Hood Average Injury Class 1 Planting Date After June 30 Row Width (In.) 28 Nematode Class 2

Modulization No data Seed Inoculated Yes Certified Seed Yes

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 3 Variety Hood Average Injury Class 2 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed No

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 4 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Pickaxout	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	33.27	15.44	105	13	1	140	3	5.7	0	6	1	2	15	1	-	1	11	1	-	0.2	-	60	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
2	39.82	15.40	110	18	2	96	2	6.3	3	5	1	2	14	1	-	2	31	1	-	0.2	-	60	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
3	38.89	15.32	107	6	1	71	2	5.6	2	5	1	2	16	1	-	3	47	1	-	0.2	-	60	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
4	34.60	15.75	112	8	1	80	2	4.9	1	5	1	2	20	1	-	4	58	1	-	0.2	-	40	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
5	31.20	13.92	107	12	1	99	2	5.3	2	5	1	2	15	1	-	5	58	1	-	0.2	-	40	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
6	36.21	15.00	100	11	1	125	2	5.3	2	5	1	2	13	1	-	6	18	1	-	0.2	-	60	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
7	39.63	18.72	121	7	1	80	2	6.4	3	5	1	2	16	1	-	7	35	1	-	0.2	-	40	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
8	32.42	14.73	104	8	1	70	2	6.5	3	5	1	2	17	1	-	8	37	1	-	0.2	-	40	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
9	33.11	17.25	114	5	1	75	2	5.8	2	6	1	2	16	1	-	9	44	1	-	0.2	-	40	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
10	32.39	16.28	111	11	1	105	2	5.8	2	6	1	2	11	1	-	10	41	1	-	0.2	-	60	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 5 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed No

Plot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Yield (Bu./A.)	27.98	27.66	32.19	24.39	39.23	35.69	28.24	31.16	27.41	35.51	26.44	25.91	22.14
Weight of Beans (Gm.)	14.21	15.22	15.99	14.77	15.60	16.73	16.20	15.38	13.75	12.41	13.24	14.19	13.82
Number of Beans	101	111	105	106	107	111	105	103	100	102	100	103	104
P (Lb./A.)	58	80	10	12	83	88	12	11	21	17	41	15	12
P Class	3	2	1	1	2	2	1	1	2	2	3	2	1
K (Lb./A.)	110	130	99	92	103	97	109	134	130	122	115	91	151
K Class	2	3	2	2	2	2	2	3	3	2	2	2	3
pH	4.7	5.6	5.6	4.9	5.6	5.3	5.0	5.1	5.2	5.4	5.0	5.6	4.7
pH Class	1	2	2	1	2	2	1	1	1	2	1	1	1
Soil Type	1	1	1	3	3	3	1	1	3	3	3	1	1
Soil Productivity Class	3	3	2	2	1	2	3	3	1	2	2	3	1
Previous Crop	2	2	2	2	2	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	13	13	12	12	10	14	16	18	16	15	16	17	17
Injury Class	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Nodes to First Pods at Harvest	-	-	-	-	-	-	-	-	-	-	-	-	-
Subplot Number	1	2	3	4	5	6	7	8	9	10	-	-	-
Harvest Loss (Beans/10 Ft.^{2})	210	351	126	86	91	102	77	61	168	235	-	-	-

Yield and Soils Data

Subplot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
% Necrosis (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Chlorosis (Estimated)	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
% Plants Necrotic (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Plants Necrotic (Estimated)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Plants Chlorotic (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Plants Chlorotic (Estimated)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Insect Damage (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-
% Insect Damage (Estimated)	-	-	-	-	-	-	-	-	-	-	-	-	-
Subplot Number	1	1	1	1	1	1	1	1	1	1	1	1	1
Total Number of Nodes	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Number of Nodes Affected	-	-	-	-	-	-	-	-	-	-	-	-	-
Highest Shed Node	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of Nodes to First Pods at Preharvest	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Node Height (In.)	-	-	-	-	-	-	-	-	-	-	-	-	-
Highest Affected Node (In.)	39	39	39	39	39	39	39	39	39	39	39	39	39
Height of Plant (In.)	50	50	50	50	50	50	50	50	50	50	50	50	50
Height of Effects (In.)	-	-	-	-	-	-	-	-	-	-	-	-	-

Preharvest Data

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 6 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed No

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 7 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 8 Variety Hood Average Injury Class 1 Planting Date 6/2-15 Row Width (In.) 40 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

Plot Number	1	2	3	4	5	6	7	8
Yield (Bu./A.)	35.53	23.33	20.30	24.71	32.14	22.46	24.21	24.51
Weight of Beans (Gm.)	16.97	13.81	13.73	13.74	14.40	14.06	13.89	13.69
Number of Beans	109	111	103	104	106	108	105	110
P (Lb./A.)	13	7	4	3	8	5	6	5
P Class	1	1	1	1	1	1	1	1
K (Lb./A.)	64	46	57	50	70	45	54	68
K Class	2	1	1	1	2	1	1	2
pH	5.8	5.8	5.6	5.9	5.2	4.9	5.5	5.2
pH Class	2	2	2	2	1	1	2	1
Soil Type	3	5	5	5	6	5	5	5
Soil Productivity Class	1	1	1	1	1	1	1	1
Previous Crop	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	16	14	16	15	19	21	17	21
Injury Class	1	0	0	1	1	1	0	1
Number of Nodes to First Pods at Harvest	-	-	-	-	-	-	-	-
Subplot Number	1	2	3	4	5	6	7	8
Harvest Loss (Beans/10 Ft.^{2})	59	35	44	26	58	37	33	94

Yield and Soils Data

Subplot Number	7	6	5	4	3	2	1	8	9	10
% Necrosis (Actual)	0.0	-	0.0	-	0.0	-	0.0	-	-	-
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-
% Chlorosis (Actual)	18.0	-	5.0	-	5.0	3.8	5.3	-	-	-
% Chlorosis (Estimated)	12.6	0.4	3.0	50.4	0.3	30.0	0.3	50.4	6.3	-
% Plants Necrotic (Actual)	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	-
% Plants Necrotic (Estimated)	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	-
% Plants Chlorotic (Actual)	83.3	48.9	33.3	77.8	50.0	50.0	20.0	77.8	-	-
% Plants Chlorotic (Estimated)	70.0	20.0	30.0	90.0	60.0	80.0	10.0	80.0	30.0	-
% Insect Damage (Actual)	5.3	-	3.7	-	-	2.6	5.2	-	-	-
% Insect Damage (Estimated)	7.0	12.0	7.0	8.0	6.3	-	5.0	8.0	-	-
Subplot Number	7	6	5	4	2	1	3	8	9	-
Total Number of Nodes	16	15	16	18	14	15	14	18	16	-
Total Number of Nodes Affected	9	9	9	9	9	9	9	9	9	-
Highest Shed Node	3	4	5	5	5	1	4	5	4	-
Number of Nodes to First Pods at Preharvest	-	-	-	-	-	-	-	-	-	-
Total Node Height (In.)	17	12	15	20	17	20	14	20	14	-
Highest Affected Node (In.)	17	16	14	16	17	12	14	16	14	-
Height of Plant (In.)	-	-	-	-	-	-	-	-	-	-
Height of Effects (In.)	-	-	-	-	-	-	-	-	-	-

Preharvest Data

54-380 O - 75 - pt. 2 - 38

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 9 Variety Pickett Average Injury Class 3 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 10 Variety Hood Average Injury Class 2 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 11 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 12 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed No

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 13 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 1

Nodulization No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Yield No. 14 Variety Hood Average Injury Class 2 Planting Date 6/1-15 Row Width (In.) 40 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																				Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Fishkreek	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	46.10	15.61	105	9	1	75	2	6.3	3	6	1	3	17	2	-	1	142	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
2	45.64	16.49	103	4	1	85	2	6.5	3	5	1	3	20	2	-	2	139	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
3	48.32	15.61	103	9	1	105	2	6.1	3	3	1	3	21	2	-	3	92	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
4	45.69	16.17	102	3	1	75	2	6.0	2	5	1	3	17	2	-	4	101	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
5	40.16	15.11	101	7	1	83	2	6.0	2	6	1	3	15	2	-	5	92	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
6	39.22	16.17	104	5	1	77	2	6.5	3	6	1	3	20	2	-	6	100	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
7	36.20	15.75	100	4	1	88	2	6.9	4	5	1	3	13	2	-	7	113	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
8	44.16	17.70	107	5	1	70	2	6.9	4	6	1	3	20	2	-	8	119	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
9	52.16	17.73	102	4	1	60	1	6.3	3	5	1	3	13	2	-	9	23	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
10	44.40	15.37	101	4	1	57	1	6.9	4	5	1	3	11	2	-	10	56	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
11	44.20	14.63	105	3	1	61	2	6.2	3	6	1	3	17	2	-	-	-	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
12	42.60	15.37	107	3	1	68	2	6.0	2	6	1	3	17	2	-	-	-	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24
13	42.06	15.77	103	6	1	98	2	6.1	3	5	1	3	21	2	-	-	-	1	-	2.0	-	36.0	-	-	-	-	6.0	1	-	-	-	-	-	-	34	24

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 15 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 40 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

	Yield and Soils Data														
Plot Number	1	2	3	4	5	6	7	8	9	10	11	12	13		
Yield (Bu./A.)	48.02	45.29	34.81	48.66	42.83	45.21	46.64	37.66	48.02	42.91	44.61	42.19	42.76		
Weight of Beans (Gm.)	14.30	16.37	16.29	16.74	17.57	17.15	16.90	15.96	18.15	16.94	16.75	16.90	15.49		
Number of Beans	100	104	105	101	104	102	104	101	107	103	104	102	102		
P (Lb./A.)	28	7	6	6	27	27	3	5	7	5	27	12	10		
P Class	2	1	1	1	2	2	1	1	1	1	2	1	1		
K (Lb./A.)	70	69	81	80	63	75	77	100	76	87	85	70	99		
K Class	2	2	2	2	2	2	2	2	2	2	2	2	2		
pH	6.5	6.3	6.1	6.3	6.6	6.8	6.5	6.2	6.0	6.0	6.5	6.0	5.9		
pH Class	3	3	3	3	3	3	3	3	2	2	2	2	2		
Soil Type	5	5	5	5	5	5	6	6	6	5	5	5	6		
Soil Productivity Class	1	1	1	1	1	1	1	1	1	1	1	1	1		
Previous Crop	3	3	3	3	3	3	3	3	3	3	3	3	3		
Plants/2 Ft. of Row	16	18	13	16	16	17	15	15	19	21	7	11	13		
Injury Class	1	1	1	1	1	1	1	1	1	1	1	1	1		
Number of Nodes to First Pods at Harvest															
Subplot Number	1	2	3	4	5	6	7	8	9	10	11	12	13		
Harvest Loss (Beans/10 Ft.^{2})	48	75	155	47	40	111	136	70	69	68					

	Preharvest Data														
Subplot Number															
% Necrosis (Actual)															
% Necrosis (Estimated)															
% Chlorosis (Actual)															
% Chlorosis (Estimated)															
% Plants Necrotic (Actual)															
% Plants Necrotic (Estimated)															
% Plants Chlorotic (Actual)															
% Plants Chlorotic (Estimated)															
% Insect Damage (Actual)															
% Insect Damage (Estimated)															
Subplot Number															
Total Number of Nodes															
Total Number of Nodes Affected															
Highest Shed Node															
Number of Nodes to First Pods at Preharvest															
Total Node Height (In.)															
Highest Affected Node (In.)															
Height of Plant (In.)															
Height of Effects (In.)															

1582

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 16 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 17 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})
1	27.93	14.70	107	8	1	81	2	5.5	2	6	1	2	10	1	-	1	44
2	20.86	13.96	103	3	1	55	1	4.8	1	10	3	2	18	1	-	2	105
3	29.10	14.95	105	5	1	71	2	5.4	2	6	1	2	16	1	-	3	94
4	29.43	15.17	105	4	1	68	2	7.4	4	6	1	2	15	1	-	4	33
5	29.83	15.67	111	5	1	71	2	5.6	2	6	1	2	14	1	-	5	30
6	25.24	15.00	121	4	1	75	2	5.9	2	5	1	2	17	1	-	6	116
7	22.79	14.25	111	8	1	48	1	5.5	2	5	1	2	13	1	-	7	42
8	22.66	14.05	103	4	1	61	2	5.6	2	5	1	2	16	1	-	8	63
9	19.43	15.72	118	6	1	32	1	5.5	2	5	1	2	16	1	-	9	87
10	27.70	14.93	105	10	1	51	1	5.0	1	8	1	2	17	1	-	10	61

Plot Number	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shod Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
2	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
3	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
4	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
5	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
6	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
7	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
8	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
9	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18
10	1	-	0.1	-	14.0	-	-	-	-	-	6.3	1	-	-	-	-	-	-	30	18

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 18 Variety Hood Average Injury Class 3 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Yield and Soils Data																			Preharvest Data																								
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	42.98	18.47	110	41	3	165	3	5.3	2	5	1	3	11	2	3	1	19	1	0.2	1.6	28.1	64.0	75.0	80.0	100.0	100.0	1.7	-	1	14	7	-	-	32	12	-	-
2	43.43	15.57	102	13	1	89	2	5.6	2	5	1	3	15	3	3	2	43	3	0.3	8.0	24.7	43.0	85.7	80.0	100.0	100.0	1.1	-	2	15	7	-	-	34	14	-	-
3	40.89	14.90	101	9	1	80	2	5.3	2	1	3	3	18	3	5	3	23	4	-	21.6	-	80.0	81.0	90.0	76.2	100.0	-	-	3	14	7	-	-	31	9	-	-
4	32.92	15.44	114	11	1	88	2	5.2	1	1	3	3	16	3	4	4	42	6	-	11.2	-	60.0	68.2	70.0	86.4	100.0	-	-	4	12	6	-	-	26	10	-	-
5	35.10	15.03	103	9	1	69	2	6.0	2	5	1	3	17	2	4	5	23	8	-	2.0	-	72.0	83.3	40.0	55.6	90.0	-	-	5	14	7	-	-	30	10	-	-
6	41.11	15.54	106	9	1	77	2	5.7	2	1	3	3	17	2	4	6	51	11	0.3	3.2	37.3	40.0	53.3	80.0	86.7	100.0	1.6	-									
7	42.60	15.40	109	13	1	69	2	6.2	3	5	1	3	21	3	5	7	39	12	-	14.0	-	12.0	72.7	100.0	90.9	80.0	-	-									
8	32.78	14.40	115	13	1	80	2	5.3	2	5	1	3	19	1	4	8	28	13	0.8	9.9	26.2	44.8	83.3	30.0	94.4	80.0	1.3	-									
9	46.32	14.16	103	14	1	82	2	6.8	4	1	3	3	18	2	5	9	27	17	0.3	1.2	42.3	19.2	55.0	30.0	95.0	80.0	2.3	-									
10	40.89	14.71	105	4	1	77	2	5.2	1	6	1	3	22	3	5	10	15	18	-	9.0	-	48.6	73.1	60.0	84.6	90.0	-	-									

1585

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 18 Variety Hood Average Injury Class 3 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Yield and Soils Data																Preharvest Data																				
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Harvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Fibers (In.)
11	39.38	15.95	114	23	2	73	2	5.5	2	1	3	3	15	1	4	-		19	0.0	0.1	40.2	48.0	44.4	10.0	94.4	100.0	1.8	-									
12	38.85	15.29	108	18	2	80	2	6.0	2	5	1	3	15	3	3	-		20	-	11.2	-	30.4	59.1	80.0	81.8	90.0	-	-									
13	45.98	15.60	102	14	1	80	2	6.5	3	5	1	3	14	2	3	-		21	0.4	0.6	30.6	56.0	23.5	30.0	76.5	100.0	1.1	-									
																		2	-	9.6	-	64.0	66.7	80.0	100.0	100.0	-	-									
																		5	0.2	0.9	29.5	19.6	37.5	30.0	75.0	70.0	2.9	-									
																		7	0.4	1.8	21.2	22.5	92.3	30.0	92.3	90.0	1.4	-									
																		9	1.6	1.5	25.1	54.0	66.7	50.0	93.3	100.0	0.8	-									
																		22	-	12.6	-	36.0	64.3	70.0	100.0	90.0	-	-									
																		10	-	2.0	-	51.6	68.0	40.0	80.0	90.0	-	-									
																		14	-	0.9	-	43.2	78.9	30.0	94.7	90.0	-	-									
																		15	0.4	1.6	21.8	32.0	43.8	40.0	75.0	100.0	5.2	-									
																		16	-	0.6	-	20.0	25.9	30.0	85.2	80.0	-	-									

G-19

1586

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 19 Variety Clark-63 Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 20 Variety York Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 32 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 21 Variety York Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 32 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 22 Variety York Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 32 Nematode Class 0

Nodulization No Data Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	55.20	21.41	123	32	3	87	2	6.4	3	5	1	4	18	0	3	1	12	1	0.0	0.0	8.5	0.7	0.0	0.0	11.1	10.0	3.3	-	1	16	-	2	-	41	-	-	-
2	45.81	18.70	105	28	2	93	2	6.6	3	5	1	4	9	0	4	2	27	2	-	0.0	-	0.0	0.0	0.0	12.5	0.0	-	8.0	2	15	-	3	-	48	-	-	-
3	46.21	19.23	107	23	2	85	2	6.7	3	8	1	4	16	0	3	3	19	3	0.0	0.0	17.3	0.0	0.0	0.0	14.3	0.0	2.9	7.0	3	15	-	4	-	38	-	-	-
4	49.98	20.46	113	29	2	76	2	5.3	2	8	1	4	14	0	4	4	21	4	-	0.0	-	0.0	0.0	0.0	6.7	0.0	-	4.8	4	15	-	4	-	44	-	-	-
5	44.20	19.88	112	68	4	115	2	5.4	2	6	1	4	14	0	3	5	24	4	-	0.0	-	0.0	0.0	0.0	6.7	0.0	-	4.8	4	15	-	4	-	44	-	-	-
6	60.69	24.36	130	32	3	110	2	5.5	2	6	1	4	15	0	4	6	13	4	-	0.0	-	0.0	0.0	0.0	6.7	0.0	-	4.8	4	15	-	4	-	44	-	-	-
7	54.59	18.26	100	38	3	93	2	6.0	2	8	1	4	16	0	3	7	24	3	0.0	0.0	17.3	0.0	0.0	0.0	14.3	0.0	2.9	7.0	3	15	-	4	-	38	-	-	-
8	40.05	19.70	108	14	1	51	1	4.8	1	5	1	4	20	0	4	-	-	5	0.0	0.0	10.6	0.7	0.0	0.0	0.0	10.0	4.6	-	5	18	-	5	-	40	-	-	-
9	43.38	18.84	107	8	1	55	1	5.1	1	8	1	4	19	0	4	-	-	6	-	0.0	-	4.8	0.0	0.0	-	30.0	-	8.0	6	17	-	6	-	39	-	-	-
10	44.95	18.90	106	5	1	60	1	5.7	2	6	1	4	15	0	4	-	-	7	0.0	0.0	10.1	0.8	0.0	0.0	5.3	0.0	3.7	8.0	7	10	-	4	-	28	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 23 Variety Hood Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 31 Nematode Class 0

Nodulation No Data Seed Inoculated Yes Certified Seed No

Yield and Soils Data

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})
1	33.08	15.64	101	5	1	56	1	5.4	2	6	1	4	15	0	.	1	120
2	37.63	16.80	102	5	1	51	1	4.8	2	6	1	4	18	0	.	2	47
3	23.56	16.10	100	9	1	80	2	5.5	1	6	1	4	15	0	.	3	63
4	61.96	16.17	105	4	1	84	2	5.0	2	6	1	4	17	0	.	4	53
5	37.18	16.00	106	4	1	60	1	5.3	1	6	1	4	12	0	.	5	68
6	53.31	15.63	106	8	1	60	1	5.3	1	5	1	4	15	0	.	6	41
7	31.40	16.45	106	14	1	128	3	4.7	1	5	1	4	14	0	.	7	32
8	25.42	16.69	111	26	2	77	2	4.7	1	6	1	4	9	0	.	8	30
9	38.89	16.30	105	12	1	90	2	4.6	1	6	1	4	19	0	.	9	45
10	51.99	16.74	101	15	1	116	2	4.8	1	5	1	4	15	0	.	10	71

Preharvest Data

Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	.	0	.	0	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	7	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	8	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	9	.	.	.	.	.	.	.	.
1	.	0	.	0	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.

54-380 O - 75 - pt. 2 - 39

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 24 Variety Hood Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 31 Nematode Class 0

Nodulisation No data Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																			Preharvest Data																				
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Fruiterest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	46.97	15.44	103	4	1	55	1	4.8	1	5	1	4	22	0	-	-	32	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	46.72	17.91	104	3	1	47	1	5.0	1	5	1	4	28	0	-	-	35	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	29.56	15.31	105	2	1	50	1	4.8	1	5	1	4	25	0	-	-	32	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	32.69	15.25	102	4	1	48	1	6.1	3	6	1	4	21	0	-	-	25	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	39.20	18.44	103	4	1	45	1	5.9	2	6	1	4	18	0	-	-	26	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	40.20	16.02	101	4	1	70	2	5.2	1	5	1	4	13	0	-	-	10	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	33.88	14.98	105	8	1	69	2	4.9	1	5	1	4	12	0	-	-	15	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	35.34	13.82	100	5	1	61	2	4.8	1	6	1	4	24	0	-	-	16	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	52.08	16.67	103	3	1	53	1	7.4	4	5	1	4	14	0	-	-	15	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	39.77	15.49	101	3	1	50	1	7.0	4	5	1	4	20	0	-	-	20	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	48.48	15.79	103	28	2	55	1	6.6	3	5	1	4	16	0	-	-	-	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	49.21	16.68	103	13	1	52	1	6.7	3	5	1	4	26	0	-	-	-	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	40.19	15.77	101	5	1	53	1	6.1	3	5	1	4	22	0	-	-	-	1	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 25 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed Yes

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 26 Variety York Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 1

Nodulization No Data Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																	Preharvest Data																							
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	63.06	19.70	117	17	2	110	2	6.5	3	6	1	2	9	1	-	1	90	16	-	0.6	-	28.8	20.0	30.0	100.0	90.0	-	3.0	1	15	9	-	-	40	17	-	-
2	45.68	16.47	103	10	1	73	2	7.3	4	6	1	2	18	2	-	2	21	14	-	2.4	-	37.8	50.0	40.0	100.0	90.0	-	4.0	2	17	9	-	-	37	15	-	-
3	26.15	16.26	111	19	2	62	2	7.4	4	6	1	2	9	2	-	3	51	11	1.2	4.0	28.3	27.0	50.0	50.0	100.0	90.0	0.6	2.4	3	17	9	-	-	36	15	-	-
4	38.45	17.59	109	25	2	85	2	6.4	3	6	1	2	18	3	-	4	33	12	-	5.4	-	12.0	90.9	90.0	100.0	80.0	-	10.8	4	17	8	-	-	38	17	-	-
5	39.84	17.19	111	15	1	87	2	7.5	3	6	1	2	12	2	-	5	89	15	1.3	3.2	22.8	57.6	77.8	80.0	100.0	90.0	2.0	7.0	5	18	9	-	-	38	18	-	-
6	26.69	15.90	116	11	1	60	1	7.8	4	6	1	2	13	1	-	6	24	3	0.1	0.2	34.0	22.5	33.3	20.0	100.0	90.0	3.7	-	-	-	-	-	-	-	-	-	-
7	46.61	17.33	100	27	2	175	3	7.0	4	6	1	2	16	1	-	7	38	5	0.1	0.3	39.6	28.8	53.8	30.0	84.6	90.0	0.8	-	-	-	-	-	-	-	-	-	-
8	25.44	16.56	110	13	1	76	2	6.4	3	8	1	2	16	1	-	8	39	8	-	0.3	-	43.2	57.1	30.0	100.0	90.0	-	4.5	-	-	-	-	-	-	-	-	-	-
9	56.49	19.30	111	26	2	75	2	6.8	4	5	1	2	17	2	-	9	57	7	0.1	2.4	28.6	43.2	42.9	60.0	100.0	90.0	2.1	1.8	-	-	-	-	-	-	-	-	-	-
10	40.06	17.21	108	10	1	74	2	7.6	4	5	1	2	10	2	-	10	44	4	-	1.2	-	24.0	50.0	40.0	92.9	80.0	-	0.9	-	-	-	-	-	-	-	-	-	-
																		1	2.2	0.9	23.7	20.0	41.2	30.0	100.0	80.0	1.6	-	-	-	-	-	-	-	-	-	-	-
																		2	-	1.2	-	37.8	76.0	40.0	100.0	90.0	-	-	-	-	-	-	-	-	-	-	-	-
																		13	1.0	0.6	39.4	21.6	66.7	30.0	100.0	90.0	0.9	3.6	-	-	-	-	-	-	-	-	-	-
																		6	-	2.4	-	44.1	61.1	40.0	94.4	90.0	-	0.3	-	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 26 Variety York Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 1

Nodulization No Data Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | Preharvest Data | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 27 Variety Clark-63 Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed Yes

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 28 Variety Clark-63 Average Injury Class 3 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 0

Nodulation Moderate Seed Inoculated Yes Certified Seed Yes

Plot Number	Yield and Soils Data																		Preharvest Data																	
	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Treatment	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	29.39	20.64	115	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
2	39.18	16.61	112	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
3	27.96	15.69	108	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
4	33.56	18.30	109	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
5	40.25	18.96	113	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
6	35.87	15.90	109	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
7	25.42	14.83	102	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-
8	32.07	18.14	106	-	-	-	-	-	-	2	3	4	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 29 Variety Clark-63 Average Injury Class Unknown* Planting Date 6/16-30 Row Width (In.) 30 Nematode Class No data

Nodulization No data Seed Inoculated Yes Certified Seed Yes

	Yield and Soils Data																	Preharvest Data																	
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	37.33	16.74	103	-	-	-	-	-	-	E	1	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	34.98	16.66	100	-	-	-	-	-	-	E	1	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	39.94	16.55	102	-	-	-	-	-	-	E	1	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Probably injury class 3 based on condition of soybeans in surrounding fields.

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 30 Variety Clark-63 Average Injury Class Unknown* Planting Date 6/16-30 Row Width (In.) 30 Nematode Class No data

Modulation No data Seed Inoculated Yes Certified Seed Yes

Plot Number	1	2	3
Yield (Bu./A.)	39.36	36.63	36.35
Weight of Beans (Gm.)	18.72	16.01	18.12
Number of Beans	100	104	112
P (Lb./A.)	"	"	"
P Class	"	"	"
K (Lb./A.)	"	"	"
K Class	"	"	"
pH	"	"	"
pH Class	"	"	"
Soil Type	4	4	4
Soil Productivity Class	1	1	1
Previous Crop	2	2	2
Plants/2 Ft. of Row	"	"	"
Injury Class	"	"	"
Number of Nodes to First Pods at Harvest	"	"	"
Subplot Number	"	"	"
Harvest Loss (Beans/10 Ft.^{2})	"	"	"

Yield and Soils Data

Subplot Number	"	"	"
% Necrosis (Actual)	"	"	"
% Necrosis (Estimated)	"	"	"
% Chlorosis (Actual)	"	"	"
% Chlorosis (Estimated)	"	"	"
% Plants Necrotic (Actual)	"	"	"
% Plants Necrotic (Estimated)	"	"	"
% Plants Chlorotic (Actual)	"	"	"
% Plants Chlorotic (Estimated)	"	"	"
% Insect Damage (Actual)	"	"	"
% Insect Damage (Estimated)	"	"	"
Subplot Number	"	"	"
Total Number of Nodes	"	"	"
Total Number of Nodes Affected	"	"	"
Highest Shed Node	"	"	"
Number of Nodes to First Pods at Preharvest	"	"	"
Total Node Height (In.)	"	"	"
Highest Affected Node (In.)	"	"	"
Height of Plant (In.)	"	"	"
Height of Effects (In.)	"	"	"

Preharvest Data

*Probably injury class 3 based on condition of soybeans in surrounding fields.

1599

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 31 Variety Clark-63 Average Injury Class 3 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class No data

Nodulization No data Seed Inoculated Yes Certified Seed Yes

	Yield and Soils Data																	Preharvest Data																							
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Weight of Plant (In.)	Height of Effects (In.)
1	44.40	15.16	100	-	-	-	-	-	-	2	3	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
2	41.34	17.89	109	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
3	39.20	16.74	110	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
4	38.61	16.41	110	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
5	44.91	15.96	101	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
6	42.47	15.82	104	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
7	46.03	15.64	109	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
8	35.40	15.54	101	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
9	37.21	15.70	100	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-
10	46.44	16.02	106	-	-	-	-	-	-	E	1	E	-	3	-	-	-	1	-	9.6	-	48.7	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-

1600

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 32 Variety Clark-63 Average Injury Class Unknown* Planting Date 6/16-30 Row Width (In.) 30 Nematode Class No data

Nodulation No data Seed Inoculated Yes Certified Seed Yes

Plot Number	1	2	3	4	5	6	7	8
Yield (Bu./A.)	43.81	31.92	26.72	22.19	38.61	60.80	20.35	32.13
Weight of Beans (Gm.)	15.47	15.06	16.63	16.95	17.14	18.32	16.95	17.67
Number of Beans	103	103	102	104	105	110	104	100
P (Lb./A.)	'	'	'	'	'	'	'	'
p Class	'	'	'	'	'	'	'	'
K (Lb./A.)	'	'	'	'	'	'	'	'
K Class	'	'	'	'	'	'	'	'
pH	'	'	'	'	'	'	'	'
pH Class	'	'	'	'	'	'	'	'
Soil Type	9	9	9	9	9	4	9	9
Soil Productivity Class	4	4	4	4	4	1	4	4
Previous Crop	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	'	'	'	'	'	'	'	'
Injury Class	'	'	'	'	'	'	'	'
Number of Nodes to First Pods at Harvest	'	'	'	'	'	'	'	'
Subplot Number	'	'	'	'	'	'	'	'
Harvest Loss (Beans/10 Ft.^{2})	'	'	'	'	'	'	'	'

Yield and Soils Data

Preharvest Data

Subplot Number	'	'	'	'	'	'	'	'
% Necrosis (Actual)	'	'	'	'	'	'	'	'
% Necrosis (Estimated)	'	'	'	'	'	'	'	'
% Chlorosis (Actual)	'	'	'	'	'	'	'	'
% Chlorosis (Estimated)	'	'	'	'	'	'	'	'
% Plants Necrotic (Actual)	'	'	'	'	'	'	'	'
% Plants Necrotic (Estimated)	'	'	'	'	'	'	'	'
% Plants Chlorotic (Actual)	'	'	'	'	'	'	'	'
% Plants Chlorotic (Estimated)	'	'	'	'	'	'	'	'
% Insect Damage (Actual)	'	'	'	'	'	'	'	'
% Insect Damage (Estimated)	'	'	'	'	'	'	'	'
Subplot Number	'	'	'	'	'	'	'	'
Total Number of Nodes	'	'	'	'	'	'	'	'
Total Number of Nodes Affected	'	'	'	'	'	'	'	'
Highest Shed Node	'	'	'	'	'	'	'	'
Number of Nodes to First Pods at Preharvest	'	'	'	'	'	'	'	'
Total Node Height (In.)	'	'	'	'	'	'	'	'
Highest Affected Node (In.)	'	'	'	'	'	'	'	'
Height of Plant (In.)	'	'	'	'	'	'	'	'
Height of Effects (In.)	'	'	'	'	'	'	'	'

*Probably injury class 3 based on condition of soybeans in surrounding fields.

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 33 Variety Hood Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 2

Nodulization Moderate Seed Inoculated Yes Certified Seed Yes

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 34 Variety Hood Average Injury Class 2 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed Yes

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 35 Variety Hood Average Injury Class 1 Planting Date After June 30 Row Width (In.) 30 Nematode Class 2

Nodulization Moderate Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																	Preharvest Data																							
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Harvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	26.94	18.99	129	7	1	162	3	6.2	3	10	3	1	20	1	4	1	38	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
2	12.92	14.17	106	20	1	199	3	6.1	3	10	3	1	18	1	4	2	24	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
3	28.92	15.39	112	12	1	100	2	6.5	3	9	4	1	14	1	4	3	39	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
4	25.44	14.93	115	10	1	109	2	6.6	3	10	3	1	20	1	4	4	30	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
5	32.67	14.86	106	7	1	74	2	6.7	3	10	3	1	16	1	4	5	46	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
6	24.69	13.71	107	18	2	70	2	7.2	4	10	3	1	20	1	3	6	36	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
7	39.42	14.54	105	14	1	62	2	7.2	4	10	3	1	15	1	4	7	64	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
8	26.72	13.32	114	11	1	65	2	7.2	4	10	3	1	16	1	3	8	46	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
9	28.49	14.76	109	18	2	102	2	6.9	4	10	3	1	21	1	4	9	37	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-
10	32.40	14.13	107	21	2	85	2	7.0	4	10	3	1	19	1	3	10	57	1	-	0.9	-	9.0	-	-	-	-	-	-	2.5	1	-	-	-	-	12	8	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 36 Variety York Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 28 Nematode Class 1

Nodulization No data Seed Inoculated No Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 36 Variety York Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 28 Nematode Class 1

Nodulation No data Seed Inoculated No Certified Seed No

Yield and Soils Data	Plot Number																					
	Yield (Bu./A.)																					
	Weight of Beans (Gm.)																					
	Number of Beans																					
	P (Lb./A.)																					
	P Class																					
	K (Lb./A.)																					
	K Class																					
	pH																					
	pH Class																					
	Soil Type																					
	Soil Productivity Class																					
	Previous Crop																					
	Plants/2 Ft. of Row																					
	Injury Class																					
	Number of Nodes to First Pods at Harvest																					
	Subplot Number																					
	Harvest Loss (Beans/10 Ft.^{2})																					
Preharvest Data	Subplot Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	% Necrosis (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Chlorosis (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.7	0.0	0.0	0.6	0.0	0.0	0.8	1.8	0.8	0.0
	% Plants Necrotic (Actual)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Plants Necrotic (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Plants Chlorotic (Actual)	18.8	0.0	0.0	0.0	6.3	50.0	0.0	0.0	6.7	0.0	11.1	10.0	0.0	0.0	10.0	0.0	0.0	16.7	10.0	-	40.0	30.0	25.0	10.0
	% Plants Chlorotic (Estimated)	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	10.0	0.0	0.0	10.0	0.0	0.0	20.0	30.0	10.0	0.0
	% Insect Damage (Actual)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	% Insect Damage (Estimated)	9.0	-	-	9.0	-	8.0	-	-	6.3	-	8.0	8.0	-	-	6.0	-	-	5.0	8.0	4.5	5.0	8.0	8.0	8.0
	Subplot Number	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total Number of Nodes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total Number of Nodes Affected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Highest Shed Node	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Number of Nodes to First Pods at Preharvest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total Node Height (In.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Highest Affected Node (In.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Height of Plant (In.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Height of Effects (In.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1606

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 37 Variety Clark-63 Average Injury Class 2 Planting Date Before June 1 Row Width (In.) 38 Nematode Class No data

Nodulization No data Seed Inoculated Yes Certified Seed Yes

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 36 Variety Dare Average Injury Class 2 Planting Date Before 6/1 Row Width (In.) 38 Nematode Class 1

Nodulization Light Seed Inoculated No Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 59 Variety Dare Average Injury Class 1 Planting Date Before June 1 Row Width (In.) 38 Nematode Class 0

Nodulation Light Seed Inoculated No Certified Seed No

Yield and Soils Data

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})
1	32.01	15.34	102	3	1	84	2	5.2	1	5	1	4	27	1	-	1	44
2	41.73	17.70	107	4	1	110	2	5.7	2	2	3	4	23	1	-	2	16
3	42.11	15.16	105	3	1	96	1	6.1	3	5	1	4	21	1	-	3	79
4	39.80	13.52	101	5	1	135	3	5.0	1	2	3	4	13	1	+	4	117
5	25.02	15.20	107	4	1	107	2	4.9	1	5	1	4	26	1	+	5	42
6	33.22	16.10	103	5	1	105	2	4.9	1	3	1	4	17	1	+	6	49
7	35.75	13.02	100	3	1	90	2	5.2	1	2	3	4	25	1	+	7	79
8	41.36	15.04	104	2	1	75	2	5.8	2	6	1	4	18	1	+	8	96
9	44.22	13.29	100	3	1	55	1	5.7	2	5	1	4	26	2	+	9	47
10	39.33	14.33	101	3	1	80	2	5.0	1	5	1	4	25	2	-	10	33
11	38.22	15.00	106	4	1	75	2	5.2	1	5	1	4	24	2	-	-	-
12	35.03	13.32	100	3	1	51	1	5.9	2	6	1	4	20	1	-	-	-
13	37.46	13.10	104	9	1	54	1	5.-	2	5	1	4	22	1	-	-	-
14	46.39	14.01	103	5	1	81	2	5.-	2	5	1	4	18	1	-	-	-

Preharvest Data

Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	-	0.0	-	96.0	-	-	-	-	-	6.0	1	15	11	8	-	33	28	-	-
2	-	0.0	-	49.0	-	-	-	-	-	8.0	2	16	12	7	-	40	30	-	-
3	-	0.0	-	49.0	-	-	-	-	-	8.0	2	16	12	7	-	40	30	-	-
4	-	0.0	-	49.0	-	-	-	-	-	8.0	2	16	12	7	-	40	30	-	-
5	-	0.0	-	96.0	-	-	-	-	-	6.0	1	15	11	8	-	33	28	-	-
6	-	0.0	-	96.0	-	-	-	-	-	6.0	1	15	11	8	-	33	28	-	-
7	-	0.0	-	96.0	-	-	-	-	-	6.0	1	15	11	8	-	33	28	-	-
8	-	0.0	-	96.0	-	-	-	-	-	3.0	3	15	11	8	-	32	22	-	-
9	-	4.8	-	2.1	-	-	-	-	-	10.0	4	13	11	6	-	25	20	-	-
10	-	4.8	-	2.1	-	-	-	-	-	10.0	4	13	11	6	-	25	20	-	-
11	-	4.8	-	2.1	-	-	-	-	-	10.0	4	13	11	6	-	25	20	-	-
12	-	0.0	-	96.0	-	-	-	-	-	3.0	3	15	11	8	-	32	22	-	-
13	-	0.0	-	49.0	-	-	-	-	-	8.0	2	16	12	7	-	40	30	-	-
14	-	0.0	-	49.0	-	-	-	-	-	8.0	5	13	11	-	-	31	17	-	-

1609

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 39 Variety Dare Average Injury Class 1 Planting Date Before June 1 Row Width (In.) _____ Nematode Class 0

Nodulization Light Seed Inoculated No Certified Seed No

	Yield and Soils Data																	Preharvest Data																	
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
15	46.01	14.50	102	3	1	76	2	5.6	2	2	3	4	20	1	"	-	-	5	"	0.0	"	49.0	"	"	"	"	"	8.0	5	13	11	7	"	31	17	"	"
16	37.87	15.16	104	3	1	111	2	5.9	2	2	3	4	16	1	"	"	"	6	"	0.0	"	72.0	"	"	"	"	"	7.0	6	16	12	7	"	33	22	"	"
17	48.28	15.74	103	6	1	110	2	5.1	1	2	3	4	25	1	"	"	"	6	"	0.0	"	72.0	"	"	"	"	"	7.0	6	16	12	7	"	33	22	"	"

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 40 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 33 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Brown	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	21.00	12.34	106	8	1	85	2	5.4	2	2	3	1	23	0	-	-	1	170	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
2	21.04	11.05	101	3	1	65	2	5.1	1	3	1	1	24	0	-	-	2	41	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
3	29.32	13.37	108	4	1	121	2	5.2	1	1	3	1	14	0	-	-	3	65	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
4	37.46	14.19	100	19	2	172	3	6.0	2	3	1	1	19	0	-	-	4	47	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
5	43.64	12.61	109	3	1	85	2	5.3	2	3	1	1	26	0	-	-	5	102	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
6	30.93	13.60	111	4	1	90	2	5.3	2	2	3	1	17	0	-	-	6	157	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
7	32.57	13.53	102	74	4	250	4	5.0	1	3	1	1	12	0	-	-	7	71	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
8	31.79	13.26	104	17	2	75	2	6.3	3	5	1	1	19	0	-	-	8	69	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
9	30.76	12.90	110	8	1	60	1	5.7	2	5	1	1	22	0	-	-	9	55	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-
10	26.84	11.94	106	11	1	73	2	4.9	1	3	1	1	19	0	-	-	10	170	1	-	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	17	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 41 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 34 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 42 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 2

Nodulization Moderate Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (lb./A.)	P Class	K (lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	33.71	14.30	104	2	1	115	2	5.0	1	8	1	3	12	1	-	1	52	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
2	73.15	15.23	102	4	1	86	2	5.3	2	8	1	3	13	1	-	2	34	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
3	37.37	15.92	100	2	1	108	2	5.3	2	8	1	3	8	1	-	3	99	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
4	47.83	15.86	106	6	1	115	2	5.1	1	8	1	3	18	1	-	4	31	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
5	37.39	16.70	103	5	1	138	3	6.1	3	8	1	3	19	1	-	5	41	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
6	35.15	14.10	100	2	1	121	2	5.3	2	8	1	3	14	1	-	6	104	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
7	35.14	16.30	102	3	1	122	2	5.9	2	8	1	3	9	1	-	7	178	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
8	37.17	15.21	104	4	1	128	3	6.0	2	8	1	3	18	1	-	-	-	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
9	26.87	14.99	105	2	1	115	2	5.8	2	8	1	3	17	1	-	-	-	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-
10	37.15	14.42	103	2	1	110	2	6.4	3	8	1	3	12	1	-	-	-	1	-	0.0	-	40	-	-	-	-	-	-	7.0	1	17	11	8	-	33	17	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 43 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (lb./A.)	P Class	K (lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Harvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	35.94	16.20	102	4	1	95	2	5.3	2	8	1	3	12	1	-	-	-	2	-	0.2	-	8.4	-	-	-	-	-	5.4	2	18	16	9	-	40	33	-	-
2	42.54	17.29	101	2	1	91	2	5.9	2	8	1	3	14	0	-	-	-	3	-	0.0	-	0.8	-	-	-	-	-	5.4	3	14	13	9	-	39	33	-	-
3	46.86	17.76	107	9	1	97	2	6.8	4	8	1	3	16	0	-	-	-	5	-	0.0	-	2.8	-	-	-	-	-	6.3	5	18	17	7	-	45	40	-	-
4	47.99	17.62	111	10	1	127	3	6.0	2	8	1	3	11	0	-	-	-	5	-	0.0	-	2.8	-	-	-	-	-	6.3	5	18	17	7	-	45	40	-	-
5	38.08	16.13	105	4	1	124	2	5.3	2	8	1	3	10	1	-	-	-	2	-	0.2	-	8.4	-	-	-	-	-	5.4	2	18	16	9	-	40	33	-	-
6	23.34	17.17	116	3	1	145	3	4.8	1	8	1	3	11	1	-	-	-	2	-	0.2	-	8.4	-	-	-	-	-	5.4	2	18	16	9	-	40	33	-	-
7	26.27	16.61	107	4	1	121	2	5.4	2	8	1	3	10	1	-	-	-	4	-	0.0	-	12.6	-	-	-	-	-	5.4	4	16	14	7	-	42	37	-	-
8	49.54	16.88	109	3	1	71	2	6.8	4	8	1	3	16	1	-	-	-	5	-	0.0	-	2.8	-	-	-	-	-	6.3	5	18	17	7	-	45	40	-	-
9	10.97	18.02	112	12	1	195	3	4.8	1	8	1	3	16	1	-	-	-	5	-	0.0	-	2.8	-	-	-	-	-	6.3	5	18	17	7	-	45	40	-	-
10	34.22	16.78	110	5	1	135	3	5.4	2	8	1	3	17	1	-	-	-	2	-	0.2	-	8.4	-	-	-	-	-	5.4	2	18	16	9	-	40	33	-	-
																		1	-	0.1	-	14.0	-	-	-	-	-	5.4	1	16	13	7	-	42	35	-	-
																		6	-	0.0	-	14.4	-	-	-	-	-	5.4	6	20	16	8	-	42	32	-	-

Yield and Soils Data | Preharvest Data

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 44 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 45 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 45 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 46 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 30 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Fruiting	Total Node Height (In.)	Highest Affected Node (In.)	Weight of Plant (In.)	Height of Effects (In.)
1	43.13	15.04	106	6	1	65	2	5.6	2	5	1	3	13	1	-	-	-	6	-	0.0	-	35.0	-	-	-	-	-	-	6.0	6	16	9	7	-	39	15	-	-
2	49.32	15.27	103	8	1	60	1	6.0	2	6	1	3	18	1	-	-	-	6	-	0.0	-	35.0	-	-	-	-	-	-	6.0	6	16	9	7	-	39	15	-	-
3	26.27	14.25	105	11	1	95	2	7.2	4	2	3	3	19	1	-	-	-	5	-	0.0	-	48.0	-	-	-	-	-	-	6.0	5	16	11	6	-	35	22	-	-
4	28.87	13.24	104	12	1	129	3	6.1	3	2	3	3	20	1	-	-	-	7	-	0.0	-	25.0	-	-	-	-	-	-	7.0	7	17	10	7	-	36	17	-	-
5	30.48	15.78	106	6	1	103	2	5.3	2	5	1	3	17	1	-	-	-	8	-	0.0	-	63.0	-	-	-	-	-	-	6.0	8	14	10	7	-	36	17	-	-
6	31.05	15.99	101	10	1	120	2	6.1	3	5	1	3	18	1	-	-	-	8	-	0.0	-	63.0	-	-	-	-	-	-	6.0	8	14	10	7	-	38	17	-	-
7	29.35	14.65	103	26	2	142	3	5.6	2	5	1	3	21	1	-	-	-	7	-	0.0	-	25.0	-	-	-	-	-	-	7.0	7	17	10	7	-	39	17	-	-
8	10.28	13.34	103	10	1	131	3	5.2	1	2	1	3	22	1	-	-	-	7	-	0.0	-	25.0	-	-	-	-	-	-	7.0	7	17	10	7	-	39	17	-	-
																-	-	9	-	0.0	-	56.0	-	-	-	-	-	-	5.0	9	15	9	7	-	33	17	-	-
																-	-	10	-	0.0	-	15.0	-	-	-	-	-	-	5.0	10	17	11	7	-	37	18	-	-
																-	-	1	-	0.0	-	56.0	-	-	-	-	-	-	5.0	1	14	7	6	-	42	14	-	-
																-	-	2	-	0.0	-	56.0	-	-	-	-	-	-	4.0	2	16	7	6	-	40	21	-	-
																-	-	3	-	0.0	-	40.0	-	-	-	-	-	-	6.0	3	16	9	8	-	31	14	-	-
																-	-	4	-	0.0	-	35.0	-	-	-	-	-	-	6.0	4	15	9	7	-	34	15	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 47 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 29 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																				Preharvest Data																															
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Prjharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	22.69	13.42	107	-	-	-	-	-	-	2	3	3	25	0	-	1	60	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
2	26.03	11.68	102	-	-	-	-	-	-	2	3	3	18	0	-	2	29	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
3	19.53	11.18	104	-	-	-	-	-	-	2	3	3	26	1	-	3	17	2	-	0.0	-	11.2	-	-	-	-	-	1.0	2	15	14	8	-	27	25	-	-
4	14.09	10.21	100	-	-	-	-	-	-	2	3	3	33	1	-	4	53	2	-	0.0	-	11.2	-	-	-	-	-	1.0	2	15	14	8	-	27	25	-	-
5	15.49	10.72	105	-	-	-	-	-	-	2	3	3	28	0	-	5	41	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
6	13.06	11.25	103	-	-	-	-	-	-	1	3	3	26	0	-	6	11	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
7	23.48	12.23	108	-	-	-	-	-	-	2	3	3	-	0	-	7	26	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
8	23.20	11.85	104	-	-	-	-	-	-	2	3	3	21	1	-	8	16	2	-	0.0	-	11.2	-	-	-	-	-	1.0	2	15	14	8	-	27	25	-	-
9	30.26	11.01	105	-	-	-	-	-	-	2	3	3	21	1	-	9	46	2	-	0.0	-	11.2	-	-	-	-	-	1.0	2	15	14	8	-	27	25	-	-
10	33.34	11.18	102	-	-	-	-	-	-	1	3	3	22	0	-	10	34	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
11	33.20	11.09	101	-	-	-	-	-	-	1	3	3	23	0	-	-	-	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
12	21.78	11.69	106	-	-	-	-	-	-	1	3	3	14	0	-	-	-	1	-	0.0	-	0.4	-	-	-	-	-	1.0	1	14	12	7	-	30	25	-	-
13	15.49	14.12	107	-	-	-	-	-	-	3	1	3	28	1	-	-	-	2	-	0.0	-	11.2	-	-	-	-	-	1.0	2	15	14	8	-	27	25	-	-
14	22.16	15.43	106	-	-	-	-	-	-	3	1	3	20	1	-	-	-	2	-	0.0	-	11.2	-	-	-	-	-	1.0	2	15	14	8	-	27	25	-	-

1619

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 48 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																Preharvest Data																							
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	25.06	12.27	110	3	1	60	1	5.0	1	2	3	3	24	1	-	1	34	1	-	0.0	-	56.7	-	-	-	-	-	3.6	1	13	13	7	-	27	27	-	-
2	20.77	11.57	101	3	1	59	1	5.5	2	2	3	3	21	1	-	2	54	3	-	0.0	-	12.6	-	-	-	-	-	5.4	3	14	13	9	-	24	22	-	-
3	25.09	12.38	104	2	1	63	2	5.5	2	2	3	3	23	1	-	3	32	4	-	0.0	-	25.6	-	-	-	-	-	1.0	4	14	14	7	-	27	27	-	-
4	17.34	11.77	102	3	1	60	1	5.9	2	2	3	3	17	0	-	4	52	5	-	0.0	-	4.8	-	-	-	-	-	1.0	5	14	13	7	-	29	26	-	-
5	26.15	13.93	107	3	1	63	2	5.5	2	2	3	3	22	1	-	5	16	2	-	0.0	-	28.8	-	-	-	-	-	5.4	2	15	15	8	-	24	24	-	-
6	27.71	14.02	105	3	1	57	1	6.2	3	2	3	3	31	1	-	6	27	8	-	0.0	-	12.6	-	-	-	-	-	1.0	8	17	16	7	-	31	27	-	-
7	26.99	13.22	100	3	1	59	1	6.1	3	2	3	3	30	0	-	7	52	5	-	0.0	-	4.8	-	-	-	-	-	1.0	5	14	13	7	-	29	26	-	-
8	34.18	14.08	113	2	1	99	2	5.2	1	3	1	3	29	1	-	8	65	6	-	0.0	-	38.4	-	-	-	-	-	1.0	6	16	14	7	-	37	32	-	-
9	34.26	14.21	104	3	1	60	1	6.2	3	2	3	3	31	1	-	9	21	6	-	0.0	-	38.4	-	-	-	-	-	1.0	6	16	14	7	-	37	32	-	-
10	47.15	16.25	103	3	1	120	2	6.0	2	2	3	3	29	1	-	10	53	8	-	0.0	-	12.6	-	-	-	-	-	1.0	8	17	16	7	-	31	27	-	-
11	32.57	15.02	110	2	1	50	1	6.0	2	3	1	3	24	1	-	-	-	8	-	0.0	-	12.6	-	-	-	-	-	1.0	8	17	16	7	-	31	27	-	-
12	36.45	14.76	103	1	1	110	2	5.4	2	2	3	3	21	1	-	-	-	7	-	0.0	-	33.6	-	-	-	-	-	1.0	7	15	13	7	-	38	34	-	-
13	24.45	13.93	101	3	1	72	2	6.6	3	2	3	3	28	1	-	-	-	6	-	0.0	-	38.4	-	-	-	-	-	1.0	6	16	14	7	-	37	32	-	-

1620

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 49 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 2

Nodulization Moderate Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	23.98	11.24	107	4	1	71	2	6.4	3	6	1	3	16	1	-	1	11	1	-	0.0	-	42.0	-	-	-	-	-	5.0	1	14	10	7	-	27	17	-	-
2	15.84	11.87	130	3	1	47	1	6.0	2	6	1	3	29	1	-	2	19	1	-	0.0	-	42.0	-	-	-	-	-	5.0	1	14	10	7	-	27	17	-	-
3	22.28	12.50	118	2	1	100	2	5.6	2	2	3	3	16	1	-	3	43	2	-	0.0	-	42.0	-	-	-	-	-	5.0	2	13	10	7	-	32	21	-	-
4	23.78	10.87	118	3	1	66	2	7.0	4	6	1	3	13	1	-	4	23	2	-	0.0	-	42.0	-	-	-	-	-	5.0	2	13	10	7	-	32	21	-	-
5	18.12	10.16	112	3	1	60	1	6.7	3	6	1	3	12	1	-	5	13	4	-	0.0	-	36.0	-	-	-	-	-	7.0	4	16	11	9	-	30	18	-	-
6	18.69	9.79	109	3	1	45	1	6.4	3	6	1	3	22	1	-	6	17	4	-	0.0	-	36.0	-	-	-	-	-	7.0	4	16	11	9	-	30	18	-	-
7	23.15	12.09	106	6	1	63	2	7.5	4	6	1	3	32	1	-	7	3	3	-	0.0	-	40.0	-	-	-	-	-	6.0	3	15	11	9	-	37	19	-	-
8	36.16	13.63	108	5	1	120	2	6.4	3	6	1	3	20	1	-	8	8	3	-	0.0	-	40.0	-	-	-	-	-	6.0	3	15	11	9	-	37	19	-	-
9	24.42	11.69	107	6	1	70	2	7.1	4	1	3	3	24	1	-	9	12	6	-	0.0	-	40.0	-	-	-	-	-	6.0	6	14	10	7	-	36	20	-	-
10	25.66	13.85	112	7	1	85	2	5.7	2	6	1	3	25	1	-	10	53	5	-	0.0	-	48.0	-	-	-	-	-	4.0	5	15	12	9	-	28	18	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 50 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 1

Nodulization No data Seed Inoculated Yes Certified Seed No

Yield and Soils Data																			Preharvest Data																								
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods At Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	26.82	14.35	100	24	2	123	2	6.0	2	10	3	3	14	1	3	-	-	1	-	0	-	48	-	-	-	-	-	-	1	18	10	7	-	43	23	-	-
2	32.40	12.84	116	34	3	125	2	5.3	2	10	3	3	10	1	4	-	-	2	-	0	-	64	-	-	-	-	-	-	2	16	10	5	-	46	24	-	-
3	50.51	17.80	120	29	2	110	2	5.2	1	10	3	3	12	1	5	-	-	2	-	0	-	64	-	-	-	-	-	-	2	16	10	5	-	46	24	-	-
4	42.31	17.61	111	24	2	140	3	5.0	1	10	3	3	9	1	4	-	-	2	-	0	-	64	-	-	-	-	-	-	2	16	10	5	-	46	24	-	-
5	34.06	17.62	104	16	2	78	2	6.1	3	10	3	3	13	1	5	-	-	1	-	0	-	48	-	-	-	-	-	-	3	18	10	7	-	43	23	-	-

G-56

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 51 Variety ____ Date ____ Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 21 Nematode Class 1

Nodulization No data Seed Inoculated Yes Certified Seed No

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 52 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 2

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	24.71	15.29	103	7	1	100	2	6.4	3	10	3	3	12	0	-	1	35	1	-	0.0	-	4.0	-	-	-	-	-	-	4.0	1	13	8	6	-	38	23	-	-
2	37.05	16.87	104	3	1	95	2	6.6	3	10	3	3	8	1	-	2	116	2	-	0.0	-	8.0	-	-	-	-	-	-	4.0	2	12	9	3	-	40	28	-	-
3	49.76	18.33	100	6	1	87	2	6.7	3	10	3	3	12	1	-	3	17	3	-	0.0	-	6.0	-	-	-	-	-	-	3.0	3	15	9	6	-	60	22	-	-
4	29.51	16.33	107	27	2	480	4	4.9	1	3	1	3	16	1	-	4	40	2	-	0.0	-	8.0	-	-	-	-	-	-	4.0	2	12	9	3	-	40	23	-	-
5	30.41	14.84	100	5	1	165	3	6.9	4	3	1	3	16	0	-	5	54	1	-	0.0	-	4.0	-	-	-	-	-	-	4.0	1	13	8	6	-	38	23	-	-
6	40.65	15.73	102	5	1	160	3	5.0	1	6	1	3	19	0	-	6	60	4	-	0.0	-	0.0	-	-	-	-	-	-	4.0	4	17	0	6	-	35	0	-	-
7	42.26	15.40	111	66	4	232	4	7.6	4	3	1	3	22	1	-	7	101	5	-	0.0	-	7.0	-	-	-	-	-	-	6.0	5	17	12	5	-	40	21	-	-
8	28.02	15.85	104	12	1	152	3	7.3	4	3	1	3	21	1	-	-	-	6	-	0.0	-	6.0	-	-	-	-	-	-	6.0	6	19	11	5	-	45	26	-	-
9	46.38	15.50	103	10	1	141	3	6.3	3	3	1	3	14	1	-	-	-	5	-	0.0	-	7.0	-	-	-	-	-	-	6.0	5	17	12	5	-	40	21	-	-
10	32.94	16.15	101	16	2	146	3	6.3	3	2	3	3	18	0	-	-	-	4	-	0.0	-	0.0	-	-	-	-	-	-	4.0	4	17	0	6	-	35	0	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 53 Variety Dare Average Injury Class 1 Planting Date 5/2-15 Row Width (In.) 39 Nematode Class 2

Modularization Light Seed Inoculated Yes Certified Seed No

Plot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Yield (Bu./A.)	11.44	19.69	27.57	13.10	13.32	25.31	14.30	24.48	18.94	23.61	23.72	14.51	17.79
Weight of Beans (Gm.)	11.75	14.19	13.79	12.96	12.97	11.99	12.27	14.70	12.10	12.35	13.45	11.59	12.01
Number of Beans	101	111	111	113	107	100	107	103	107	100	107	100	106
P (Lb./A.)	6	1	5	5	11	6	3	2	4	4	3	2	4
P Class	1	1	1	1	1	1	1	1	1	1	1	1	1
K (Lb./A.)	74	76	64	72	85	58	73	103	64	64	60	98	80
K Class	2	2	2	2	2	1	2	2	2	2	1	2	2
pH	6.9	5.0	6.8	6.0	5.3	5.1	5.6	5.0	6.5	5.0	5.0	5.1	5.3
pH Class	1	1	1	2	2	1	2	1	3	1	1	1	2
Soil Type	5	3	5	3	6	5	5	3	6	6	6	5	6
Soil Productivity Class	1	1	1	1	1	1	1	1	1	1	1	1	1
Previous Crop	2	3	2	2	2	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	14	21	15	23	19	17	19	19	16	17	23	24	19
Injury Class	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Nodes to First Pods at Harvest	,	,	,	,	,	,	,	,	,	,	,	,	,
Subplot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Harvest Loss (Beans/10 Ft.^{2})	74	18	28	10	3	51	19	21	36	21	,	,	,

Yield and Soils Data

Subplot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
% Necrosis (Actual)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Necrosis (Estimated)	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Chlorosis (Estimated)	96.0	96.0	48.0	96.0	96.0	48.0	96.0	72.0	72.0	48.0	48.0	96.0	72.0
% Plants Necrotic (Actual)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Plants Necrotic (Estimated)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Plants Chlorotic (Actual)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Plants Chlorotic (Estimated)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Insect Damage (Actual)	,	,	,	,	,	,	,	,	,	,	,	,	,
% Insect Damage (Estimated)	6.0	5.0	5.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Subplot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Total Number of Nodes	13	14	12	16	16	19	15	15	15	15	15	15	15
Total Number of Nodes Affected	10	11	9	12	12	11	11	11	11	11	11	11	11
Highest Shod Node	2	1	2	1	1	2	1	1	1	1	1	1	1
Number of Nodes to First Pods at Preharvest	,	,	,	,	,	,	,	,	,	,	,	,	,
Total Node Height (In.)	16	17	17	19	18	20	19	19	20	19	19	20	19
Highest Affected Node (In.)	15	16	16	18	17	19	18	18	19	18	18	19	18
Height of Plant (In.)	,	,	,	,	,	,	,	,	,	,	,	,	,
Height of Effects (In.)	,	,	,	,	,	,	,	,	,	,	,	,	,

Preharvest Data

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 34 and 35* Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																		Preharvest Data																	
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Harvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	23.53	12.34	103	4	1	66	2	5.1	1	S	1	2	14	1	-	1	41	1	-	0.0	-	37.8	-	-	-	-	-	1.0	1	16	12	7	-	27	19	-	-
2	21.64	14.50	110	3	1	60	1	5.0	1	S	1	2	14	1	-	2	8	1	-	0.0	-	37.8	-	-	-	-	-	1.0	1	16	12	7	-	27	18	-	-
3	19.48	13.97	111	3	1	60	1	4.9	1	S	1	2	20	1	-	3	78	2	-	0.0	-	33.6	-	-	-	-	-	1.0	2	14	10	5	-	33	16	-	-
4	26.60	14.69	119	4	1	55	1	4.6	1	S	1	2	-	1	-	4	12	3	-	0.0	-	28.8	-	-	-	-	-	1.0	3	16	13	7	-	33	24	-	-
5	21.22	17.81	106	4	1	50	1	4.7	1	S	1	2	19	1	-	5	9	5	-	0.0	-	37.8	-	-	-	-	-	1.0	5	14	12	6	-	24	18	-	-
6	13.62	13.73	124	4	1	56	1	5.0	1	S	1	2	20	1	-	6	24	5	-	0.0	-	37.8	-	-	-	-	-	1.0	5	14	12	6	-	24	18	-	-
7	15.17	12.90	107	3	1	61	2	4.8	1	S	1	2	23	1	-	7	73	4	-	0.0	-	32.4	-	-	-	-	-	1.0	4	16	12	6	-	35	24	-	-
8	17.06	13.25	112	4	1	61	2	4.8	1	S	1	2	18	1	-	8	29	3	-	0.0	-	28.8	-	-	-	-	-	1.0	3	16	13	7	-	33	24	-	-

*Field No. 34 - Plots 1, 2, & 3.
Field No. 35 - Plots 4, 5, 6, & 7.

1626

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 56 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulation Light Seed Inoculated Yes Certified Seed Yes

| Yield and Soils Data | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1973 GROWING SEASON

Field No. 57 Variety ____ Date ____ Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 1

Nodulation ____ Light ____ Seed Inoculated ____ Yes ____ Certified Seed ____ No

Plot Number	1	2
Yield (Bu./A.)	24.27	27.31
Weight of Beans (Gm.)	13.09	16.10
Number of Beans	1901	[illegible]
P (Lb./A.)	Y	Y
P Class	1	1
K (Lb./A.)	100	130
K Class	2	3
pH	5.6	4.6
pH Class	1	1
Soil Type	3	3
Soil Productivity Class	1	1
Previous Crop	2	2
Plants/2 Ft. of Row	16	19
Injury Class	1	1
Number of Nodes to First Pods at Harvest	3	3
Subplot Number	1	2
Harvest Loss (Beans/10 Ft.^{2})	26	21

Yield and Soils Data

Subplot Number	1	1
% Necrosis (Actual)	-	-
% Necrosis (Estimated)	0.0	0.0
% Chlorosis (Actual)	-	-
% Chlorosis (Estimated)	19.0	19.0
% Plants Necrotic (Actual)	-	-
% Plants Necrotic (Estimated)	-	-
% Plants Chlorotic (Actual)	-	-
% Plant Chlorotic (Estimated)	-	-
% Insect Damage (Actual)	-	-
% Insect Damage (Estimated)	0	0
Subplot Number	1	1
Total Number of Nodes	16	16
Total Number of Nodes Affected	11	11
Highest Shed Node	5	5
Number of Nodes to First Pods at Preharvest	-	-
Total Node Height (In.)	18	18
Highest Affected Node (In.)	13	13
Height of Plant (In.)	-	-
Height of Effects (In.)	-	-

Preharvest Data

1628

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 58 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed Yes

Plot Number	Yield (Bu./A.)	Height of Beans (Cm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Prehavest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	35.35	15.42	104	4	1	93	2	6.4	1	5	1	4	23	1	-	1	107	1	-	-	0.0	-	48.0	-	-	-	-	-	-	6.0	3	15	10	5	-	43	23	-	-
2	31.73	16.20	103	5	1	84	2	5.0	1	5	1	4	17	1	-	2	43	2	-	-	0.0	-	42.0	-	-	-	-	-	-	5.0	2	14	11	5	-	42	23	-	-
3	31.44	15.85	105	4	1	55	1	5.3	2	5	1	4	22	1	-	-	56	1	-	-	0.0	-	35.0	-	-	-	-	-	-	6.0	1	14	9	6	-	39	23	-	-
4	33.71	15.64	104	6	1	60	1	5.5	2	5	1	4	20	1	-	4	81	1	-	-	0.0	-	35.0	-	-	-	-	-	-	6.0	1	14	9	6	-	39	23	-	-
5	33.38	17.45	108	5	1	75	2	5.6	2	5	1	4	18	1	-	5	47	3	-	-	0.0	-	48.0	-	-	-	-	-	-	6.0	3	15	10	5	-	43	23	-	-
6	-	-	-	6	1	70	2	6.8	3	5	1	4	21	1	-	6	71	4	-	-	0.0	-	30.0	-	-	-	-	-	-	5.0	4	15	11	5	-	41	23	-	-
7	30.00	15.49	100	7	1	56	1	6.1	3	5	1	4	19	1	-	7	98	5	-	-	0.0	-	36.0	-	-	-	-	-	-	5.0	5	14	11	6	-	43	27	-	-
8	36.52	15.95	101	5	1	70	2	5.7	2	5	1	4	19	1	-	8	61	6	-	-	0.0	-	48.0	-	-	-	-	-	-	6.0	6	16	11	6	-	44	30	-	-
9	30.46	15.27	102	3	1	89	2	5.2	1	5	1	4	15	1	-	9	85	6	-	-	0.0	-	48.0	-	-	-	-	-	-	6.0	6	16	11	6	-	44	30	-	-
10	30.46	14.57	104	6	1	62	2	5.3	2	5	1	4	18	1	-	10	73	5	-	-	0.0	-	36.0	-	-	-	-	-	-	5.0	5	14	11	6	-	43	27	-	-
11	28.60	16.98	103	6	1	60	1	5.0	1	5	1	4	24	1	-	-	-	4	-	-	0.0	-	30.0	-	-	-	-	-	-	5.0	4	15	11	5	-	41	23	-	-
12	42.00	16.15	100	5	1	55	1	5.5	2	5	1	4	19	1	-	-	-	5	-	-	0.0	-	36.0	-	-	-	-	-	-	5.0	5	14	11	6	-	43	27	-	-
13	41.40	15.58	108	4	1	69	2	6.3	3	3	1	4	14	1	-	-	-	6	-	-	0.0	-	48.0	-	-	-	-	-	-	6.0	6	16	11	6	-	44	30	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 59 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																		Preharvest Data																							
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	15.66	14.71	123	2	1	44	1	4.7	1	3	1	2	16	1	-	1	98	1	-	0.0	-	48.0	-	-	-	-	4.0	1	12	9	4	-	24	17	-	-
2	27.64	14.78	112	6	1	60	1	4.6	1	6	1	2	14	1	-	2	71	1	-	0.0	-	48.0	-	-	-	-	4.0	1	12	9	4	-	24	17	-	-
3	11.66	14.01	122	3	1	64	2	4.7	1	5	1	2	21	1	-	3	71	2	-	0.0	-	64.0	-	-	-	-	3.0	2	15	13	7	-	31	22	-	-
4	23.38	14.62	121	4	1	40	1	4.7	1	6	1	2	24	1	-	4	78	3	-	0.0	-	21.0	-	-	-	-	4.0	3	9	6	4	-	25	15	-	-
5	19.48	13.33	110	3	1	49	1	4.7	1	3	1	2	19	1	-	5	64	1	-	0.0	-	48.0	-	-	-	-	4.0	1	12	9	4	-	24	17	-	-
6	17.65	12.45	107	4	1	50	1	4.8	1	5	1	2	20	1	-	6	24	4	-	0.0	-	35.0	-	-	-	-	5.0	4	13	10	6	-	24	15	-	-
7	15.81	13.33	122	3	1	40	1	4.7	1	3	1	2	20	1	-	-	-	4	-	0.0	-	35.0	-	-	-	-	5.0	4	13	10	6	-	24	15	-	-
8	10.47	13.94	120	2	1	45	1	4.5	1	3	1	2	20	1	-	-	-	4	-	0.0	-	35.0	-	-	-	-	5.0	4	13	10	6	-	24	15	-	-
9	16.83	13.80	113	3	1	40	1	4.5	1	3	1	2	22	1	-	-	-	4	-	0.0	-	35.0	-	-	-	-	5.0	4	13	10	6	-	24	15	-	-
10	25.45	14.79	119	3	1	45	1	5.0	1	3	1	2	73	1	-	-	-	4	-	0.0	-	35.0	-	-	-	-	5.0	4	13	10	6	-	24	15	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 60 Variety Dare Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 61 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 1

Soil Solubilization Light Seed Inoculated Yes Certified Seed Yes

Plot Number	1	2	3	4	5	6	7	8
Yield (Bu./A.)	23.29	33.29	40.86	30.15	30.69	33.51	18.83	30.19
Weight of Beans (Gm.)	12.60	14.70	16.35	14.72	13.98	13.70	13.63	14.81
Number of Beans	101	101	101	103	104	108	109	101
P (Lb./A.)	4	12	13	5	4	4	4	3
P Class	1	1	1	1	1	1	1	1
K (Lb./A.)	143	117	125	84	70	70	72	80
K Class	1	2	2	2	2	2	2	2
pH	5.3	5.2	5.3	5.5	5.2	5.2	5.0	5.3
pH Class	2	1	2	2	1	1	1	2
Soil Type	3	3	3	3	3	3	3	3
Soil Productivity Class	1	1	1	1	1	2	2	1
Previous Crop	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	16	12	12	12	6	23	22	21
Injury Class	0	0	0	0	0	0	0	0
Number of Nodes to First Pods at Harvest	.	.	.	.	.	.	.	.
Subplot Number	1	2	3	4	5	.	.	.
Harvest Loss (Beans/10 Ft.^{2})	61	90	98	37	90	.	.	.

Yield and Soils Data

Preharvest Data

Subplot Number	1	2	3	4	5	6	7	8
% Necrosis (Actual)	.	.	.	.	.	.	.	.
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	.	.	.	.	.	.	.	.
% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Plants Necrotic (Actual)	.	.	.	.	.	.	.	.
% Plants Necrotic (Estimated)	.	.	.	.	.	.	.	.
% Plants Chlorotic (Actual)	.	.	.	.	.	.	.	.
% Plants Chlorotic (Estimated)	.	.	.	.	.	.	.	.
% Insect Damage (Actual)	.	.	.	.	.	.	.	.
% Insect Damage (Estimated)	.	.	.	.	.	.	.	.
Subplot Number	1	1	1	1	1	1	1	1
Total Number of Nodes	.	.	.	.	.	.	.	.
Total Number of Nodes Affected	.	.	.	.	.	.	.	.
Highest Shed Node	.	.	.	.	.	.	.	.
Number of Nodes to First Pods at Preharvest	.	.	.	.	.	.	.	.
Total Node Height (In.)	.	.	.	.	.	.	.	.
Highest Affected Node (In.)	.	.	.	.	.	30	30	30
Height of Plant (In.)	30	30	30	30	30	.	.	.
Height of Effects (In.)	.	.	.	.	.	.	.	.

1632

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 62 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed Yes

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 63 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed Yes

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Weight of Plant (Gm.)	Height of Effects (In.)
1	33.76	14.24	103	14	1	131	3	4.4	1	3	1	2	19	0	-	1	68	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
2	28.71	14.60	107	4	1	60	1	5.2	1	3	1	2	18	0	-	2	47	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
3	17.88	15.71	124	3	1	55	1	5.1	1	4	1	2	23	0	-	3	52	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
4	32.02	13.57	100	4	1	93	2	5.0	1	4	1	2	19	0	-	4	56	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
5	19.97	13.11	101	9	1	119	2	4.9	1	2	3	2	19	0	-	5	20	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
6	23.09	14.68	109	20	2	62	2	6.4	3	2	3	2	19	0	-	6	15	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
7	22.55	13.80	106	5	1	90	2	5.2	1	4	1	2	21	0	-	7	66	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
8	26.60	15.18	117	4	1	68	2	5.3	2	2	3	2	22	0	-	8	67	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
9	34.51	15.37	115	5	1	77	2	5.8	2	2	3	2	17	0	-	9	78	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
10	32.06	14.61	108	3	1	110	2	5.1	1	4	1	2	20	0	-	10	94	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
11	23.51	13.86	108	3	1	60	1	6.3	3	2	3	2	16	1	-	-	-	2	-	0.0	-	19.2	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
12	24.25	14.68	112	2	1	70	2	5.3	2	4	1	2	14	1	-	-	-	2	-	0.0	-	19.2	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
13	25.39	14.10	103	4	1	69	2	5.4	2	2	3	2	17	0	-	-	-	1	-	0.0	-	0.0	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 64 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed Yes

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 65 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 66 Variety Dare Average Injury Class 3 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 67 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 68 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 39 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 69 Variety Pickett Average Injury Class _____ Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																				Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	31.10	12.22	107	43	3	139	3	4.9	1	3	1	3	28	1	-	1	100	4	-	0.3	-	1.4	-	-	-	-	-	2.0	4	16	6	5	-	37	-	-	-
2	21.25	11.28	115	4	1	150	3	4.7	1	4	1	3	23	1	-	2	129	3	-	0.0	-	5.4	-	-	-	-	-	3.0	3	16	5	4	-	33	-	-	-
3	25.80	12.44	105	5	1	79	2	5.9	2	2	3	3	19	1	-	3	76	1	-	0.2	-	2.8	-	-	-	-	-	2.0	1	16	7	6	-	36	-	-	-
4	32.06	13.86	107	6	1	74	1	6.0	2	2	3	3	13	1	-	4	61	2	-	0.2	-	2.4	-	-	-	-	-	1.0	2	13	6	4	-	29	-	-	-
5	23.84	11.56	110	40	3	150	3	4.7	1	4	1	3	26	1	-	5	107	3	-	0.0	-	5.4	-	-	-	-	-	3.0	3	16	5	4	-	33	-	-	-
6	29.73	14.96	109	46	3	186	3	4.7	1	3	1	3	16	1	-	6	84	4	-	0.3	-	1.4	-	-	-	-	-	2.0	4	16	6	5	-	37	-	-	-
7	31.02	13.04	117	46	3	226	4	4.9	1	3	1	3	15	1	-	7	44	3	-	0.0	-	5.4	-	-	-	-	-	3.0	3	16	5	4	-	33	-	-	-
8	32.54	12.85	103	6	1	75	2	5.0	1	2	3	3	19	1	-	8	44	1	-	0.2	-	2.8	-	-	-	-	-	2.0	1	16	7	5	-	36	-	-	-
9	21.84	10.65	100	4	1	98	2	5.0	1	2	3	3	21	1	-	9	50	3	-	0.0	-	5.4	-	-	-	-	-	3.0	3	16	5	4	-	33	-	-	-
10	34.05	12.93	106	10	1	81	2	6.3	3	4	1	3	23	1	-	10	31	4	-	0.3	-	1.4	-	-	-	-	-	2.0	4	16	6	5	-	37	-	-	-
11	26.22	11.45	104	5	1	69	2	5.0	1	4	1	3	32	1	-	-	-	8	-	0.8	-	37.8	-	-	-	-	-	1.6	8	16	9	5	-	34	15	-	-
12	30.10	13.71	104	5	1	72	2	5.7	2	2	3	3	22	3	-	-	-	7	-	25.0	-	50.4	-	-	-	-	-	9.0	7	15	8	4	-	30	13	-	-
13	28.78	14.19	108	6	1	60	1	5.1	2	2	3	3	24	2	-	-	-	6	-	3.0	-	40.0	-	-	-	-	-	5.0	6	14	7	4	-	28	12	-	-
14	32.73	14.00	108	3	1	59	1	5.8	2	2	3	3	25	2	-	-	-	6	-	3.0	-	40.0	-	-	-	-	-	5.0	6	14	7	4	-	28	12	-	-
15	28.14	12.69	105	6	1	75	2	5.9	2	2	3	3	22	3	-	-	-	7	-	25.0	-	50.4	-	-	-	-	-	9.0	7	15	8	4	-	30	13	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 69 Variety Pickett Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 70 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 70 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 1

Nodulization Light Seed Inoculated Yes Certified Seed No

Yield and Soils Data																			Preharvest Data																				
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
13	28.14	13.28	109	15	1	72	2	4.5	1	2	3	2	20	1	-	-	-	6	-	1.8	-	-	-	-	-	-	-	-	7.0	6	17	7	6	-	39	10	-	-
14	24.54	14.33	115	5	1	70	2	4.5	1	4	1	2	21	1	-	-	-	1	-	4.8	-	-	-	-	-	-	-	-	3.0	1	15	8	7	-	42	12	-	-
15	26.47	14.03	105	40	3	138	3	4.7	1	4	1	2	14	1	-	-	-	3	-	1.2	-	-	-	-	-	-	-	-	2.0	3	18	7	6	-	41	11	-	-
16	35.71	13.53	101	5	1	77	2	5.0	1	2	3	2	22	1	-	-	-	3	-	1.2	-	-	-	-	-	-	-	-	2.0	3	18	7	6	-	41	11	-	-
17	36.09	14.77	108	8	1	88	2	4.4	1	4	1	2	21	1	-	-	-	2	-	1.2	-	-	-	-	-	-	-	-	2.0	2	16	7	6	-	37	12	-	-
18	25.30	15.54	126	4	1	76	2	4.9	1	2	3	2	22	1	-	-	-	1	-	4.8	-	-	-	-	-	-	-	-	3.0	1	15	8	7	-	42	12	-	-
																		7	-	1.2	-	-	-	-	-	-	-	-	6.0	7	19	7	-	-	39	13	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 71 Variety Pickett Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed No

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 72 Variety Dare Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization Light Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																				Preharvest Data																															
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	24.23	12.16	101	5	1	68	2	4.4	1	2	3	2	-	1	-	1	28	2	-	0.0	-	35.0	-	-	-	-	-	8.0	2	17	11	7	-	31	13	-	-
2	13.21	11.39	114	8	1	96	2	4.6	1	4	1	2	-	2	-	2	44	3	-	1.0	-	15.0	-	-	-	-	-	7.0	3	15	10	6	-	32	18	-	-
3	37.66	15.90	109	18	2	110	2	4.2	1	4	1	2	-	2	-	3	12	4	-	1.0	-	15.0	-	-	-	-	-	6.0	4	13	9	6	-	32	17	-	-
4	28.63	15.06	104	10	1	91	2	4.4	1	4	1	2	23	2	-	4	11	3	-	1.0	-	15.0	-	-	-	-	-	7.0	3	15	10	6	-	32	18	-	-
5	24.09	12.86	101	6	1	118	2	4.4	1	2	3	2	14	1	-	5	15	1	-	0.0	-	18.0	-	-	-	-	-	9.0	1	11	7	5	-	39	14	-	-
6	36.27	14.95	103	12	1	112	2	4.4	1	4	1	2	22	1	-	6	28	1	-	0.0	-	18.0	-	-	-	-	-	9.0	1	11	7	5	-	39	14	-	-
7	22.38	12.40	103	44	3	75	2	4.4	1	2	3	2	21	2	-	7	26	3	-	1.0	-	15.0	-	-	-	-	-	7.0	3	15	10	6	-	32	18	-	-
8	20.22	11.05	102	7	1	110	2	4.6	1	2	3	2	18	2	-	8	27	4	-	1.0	-	15.0	-	-	-	-	-	6.0	4	13	9	6	-	32	17	-	-
9	14.78	11.60	109	5	1	74	2	4.6	1	2	3	2	13	1	-	9	117	8	-	0.0	-	18.0	-	-	-	-	-	8.0	8	13	9	6	-	31	19	-	-
10	15.60	10.97	107	13	1	95	2	4.7	1	4	1	2	26	2	-	10	45	6	-	2.0	-	49.0	-	-	-	-	-	5.0	6	15	8	7	-	25	14	-	-
11	23.62	12.60	108	7	1	75	2	4.6	1	2	3	2	27	2	-	-	-	5	-	4.0	-	28.0	-	-	-	-	-	7.0	5	15	11	5	-	29	18	-	-
12	94.05	11.86	107	5	1	70	2	4.3	1	2	3	2	23	2	-	-	-	6	-	2.0	-	49.0	-	-	-	-	-	5.0	6	15	8	7	-	25	14	-	-
13	25.99	13.26	100	5	1	75	2	4.5	1	2	3	2	17	1	-	-	-	8	-	0.0	-	18.0	-	-	-	-	-	8.0	8	13	9	6	-	31	19	-	-
																		7	-	1.0	-	48.0	-	-	-	-	-	8.0	7	15	10	7	-	26	16	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 73 Variety York Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 2

Nodulization Moderate Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																	Preharvest Data																			
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	37.04	17.35	104	5	1	75	2	4.8	1	2	3	4	21	2	-	1	55	6	-	2.4	-	-	-	-	-	-	-	8.0	6	19	7	-	-	48	11	-	-
2	31.88	15.80	103	3	1	67	2	5.2	1	3	1	4	14	1	-	2	99	5	-	0.0	-	-	-	-	-	-	-	18.0	5	18	0	-	-	48	0	-	-
3	38.16	15.25	100	2	1	60	1	6.2	3	2	3	4	26	1	-	3	77	5	-	0.0	-	-	-	-	-	-	-	18.0	5	18	0	-	-	48	0	-	-
4	29.08	15.81	102	3	1	56	1	6.5	3	2	3	2	21	1	-	4	50	5	-	0.0	-	-	-	-	-	-	-	18.0	5	18	0	-	-	48	0	-	-
5	31.57	15.83	101	10	1	82	2	5.4	2	1	3	2	28	1	-	5	27	5	-	0.0	-	-	-	-	-	-	-	18.0	5	18	0	-	-	48	0	-	-
6	28.40	15.84	106	4	1	80	2	5.4	2	3	1	2	23	1	-	6	39	4	-	0.0	-	-	-	-	-	-	-	14.0	4	16	0	-	-	47	0	-	-
7	22.75	15.21	105	3	1	93	2	5.2	1	2	3	2	15	1	-	7	64	4	-	0.0	-	-	-	-	-	-	-	14.0	4	16	0	-	-	47	0	-	-
8	25.87	15.04	104	5	1	86	2	5.6	2	2	3	4	21	1	-	8	28	2	-	0.0	-	-	-	-	-	-	-	4.0	2	13	0	-	-	47	0	-	-
9	34.03	16.42	103	9	1	205	4	4.8	1	3	1	4	21	1	-	9	40	3	-	0.0	-	-	-	-	-	-	-	7.0	3	16	0	-	-	47	0	-	-
10	26.20	16.60	104	3	1	70	2	6.2	3	3	1	2	10	1	-	10	32	2	-	0.0	-	-	-	-	-	-	-	4.0	2	13	0	-	-	47	0	-	-
11	10.12	11.46	107	4	1	102	2	6.3	3	2	3	2	21	1	-	-	-	3	-	0.0	-	-	-	-	-	-	-	7.0	3	16	0	-	-	47	0	-	-
12	39.79	14.25	102	8	1	115	2	6.0	2	3	1	2	17	1	-	-	-	2	-	0.0	-	-	-	-	-	-	-	4.0	2	13	0	-	-	47	0	-	-
13	26.51	16.52	105	12	1	151	3	5.6	2	4	1	2	7	1	-	-	-	1	-	0.0	-	-	-	-	-	-	-	8.0	1	17	0	-	-	42	0	-	-

54-380 O - 75 - pt. 2 - 43

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 74 Variety York Average Injury Class 0 Planting Date Before 6/1 Row Width (In.) 38 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed Yes

| Yield and Soil Data | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 75 Variety Dare Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 76 Variety Dare Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 77 Variety York Average Injury Class 0 Planting Date Before June 1 Row Width (In.) 35 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 78 Variety Pickett Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 37 Nematode Class 2

Nodulation No Data Seed Inoculated Yes Certified Seed No

Plot Number	1	2	3	4	5	6	7	8
Yield (Bu./A.)	20.75	24.24	15.42	19.12	21.49	20.98	21.64	19.27
Weight of Beans (Gm.)	13.32	12.86	13.94	12.36	14.47	15.71	12.02	12.50
Number of Beans	104	122	120	107	123	131	105	104
P (Lb./A.)	15	19	16	21	4	3	5	4
P Class	1	2	2	2	1	1	1	1
K (Lb./A.)	55	49	51	55	40	51	66	58
K Class	1	1	1	1	1	1	2	1
pH	5.4	5.5	5.4	6.9	7.0	6.3	5.4	5.2
pH Class	2	2	2	4	4	3	2	1
Soil Type	5	5	5	5	5	5	5	5
Soil Productivity Class	1	1	1	1	1	2	1	1
Previous Crop	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	15	20	27	18	20	23	23	22
Injury Class	0	0	0	0	0	0	0	0
Number of Nodes to First Pods at Harvest	7	6	8	7	8	8	7	7
Subplot Number	1	2	3	4	5	-	-	-
Harvest Loss (Beans/10 Ft.^{2})	110	40	58	191	70	-	-	-
Subplot Number	'	'	'	'	'	'	'	'
% Necrosis (Actual)	'	'	'	'	'	'	'	'
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	'	'	'	'	'	'	'	'
% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Plants Necrotic (Actual)	'	'	'	'	'	'	'	'
% Plants Necrotic (Estimated)	'	'	'	'	'	'	'	'
% Plants Chlorotic (Actual)	'	'	'	'	'	'	'	'
% Plants Chlorotic (Estimated)	'	'	'	'	'	'	'	'
% Insect Damage (Actual)	'	'	'	'	'	'	'	'
% Insect Damage (Estimated)	'	'	'	'	'	'	'	'
Subplot Number	'	'	'	'	'	'	'	'
Total Number of Nodes	'	'	'	'	'	'	'	'
Total Number of Nodes Affected	'	'	'	'	'	'	'	'
Highest Shed Node	'	'	'	'	'	'	'	'
Number of Nodes to First Pods at Prsharvest	'	'	'	'	'	'	'	'
Total Node Height (In.)	'	'	'	'	'	'	'	'
Highest Affected Node (In.)	'	'	'	'	'	'	'	'
Weight of Plant (In.)	'	'	'	'	'	'	'	'
Height of Effects (In.)	'	'	'	'	'	'	'	'

Yield and Soils Data

Preharvest Data

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 79 Variety Pickett Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 37 Nematode Class 0

Nodulisation No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 80 Variety Pickett Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 36 Nematode Class 2

Nodulization No data Seed Inoculated No Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 81 Variety Pickett Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 36 Nematode Class 0

Nodulization No data Seed Inoculated No Certified Seed No

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Bu.ns/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	31.88	14.27	109	10	1	114	2	5.8	2	3	1	2	12	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	41.34	12.50	101	11	1	104	2	6.7	3	3	1	2	21	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	41.56	13.48	100	25	2	96	2	6.4	3	3	1	2	16	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	27.99	16.26	106	4	1	119	2	5.4	2	3	1	2	20	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	35.61	13.80	100	66	4	284	4	5.3	2	3	1	2	20	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	29.11	13.61	101	10	1	90	2	5.2	1	2	3	2	21	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	33.49	11.96	103	13	1	121	2	4.9	1	2	3	2	14	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	29.04	11.67	101	59	3	161	3	4.9	1	2	3	2	24	0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 82 Variety Pickett Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 39 Nematode Class 2

Nodulization No data Seed Inoculated No Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 83 Variety Pickett Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 1

Nodulization No data Seed Inoculated No Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 84 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 0

Modification No data Seed Inoculated No Certified Seed No

	Yield and Soils Data				Preharvest Data			
Plot Number	1	2	3					
Yield (Bu./A.)	21.47	22.05	22.67					
Weight of Beans (Gm.)	12.50	12.20	12.58					
Number of Beans	105	103	107					
P (Lb./A.)	4	3	5					
P Class	1	1	1					
K (Lb./A.)	51	50	51					
K Class	1	1	1					
pH	4.9	5.1	5.0					
pH Class	1	1	1					
Soil Type	5	2	2					
Soil Productivity Class	1	3	3					
Previous Crop	2	2	2					
Plants/2 Ft. of Row	26	30	23					
Injury Class	0	0	0					
Number of Nodes to First Pods at Harvest	,	,	,					
Subplot Number	,	,	,					
Harvest Loss (Beans/10 Ft.^{2})	,	,	,					
Subplot Number				,	,	,		
% Necrosis (Actual)				,	,	,		
% Necrosis (Estimated)				0.0	0.0	0.0		
% Chlorosis (Actual)				,	,	,		
% Chlorosis (Estimated)				0.0	0.0	0.0		
% Plants Necrotic (Actual)				,	,	,		
% Plants Necrotic (Estimated)				,	,	,		
% Plants Chlorotic (Actual)				,	,	,		
% Plants Chlorotic (Estimated)				,	,	,		
% Insect Damage (Actual)				,	,	,		
% Insect Damage (Estimated)				,	,	,		
Subplot Number				,	,	,		
Total Number of Nodes				,	,	,		
Total Number of Nodes Affected				,	,	,		
Highest Shed Node				,	,	,		
Number of Nodes to First Pods at Preharvest				,	,	,		
Total Node Height (In.)				,	,	,		
Highest Affected Node (In.)				,	,	,		
Height of Plant (In.)				,	,	,		
Height of Effects (In.)				,	,	,		

1657

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 85 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 36 Nematode Class 0

Nodulization No data Seed Inoculated No Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 86 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 37 Nematode Class 0

Nodulization No data Seed Inoculated No Certified Seed No

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Freshstage	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	17.63	14.64	104	36	3	170	3	5.2	1	1	4	25	0	-	1	36	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	46.66	16.44	104	6	1	60	1	5.5	2	1	3	28	0	-	2	22	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	40.45	13.09	109	30	2	57	1	6.4	3	1	3	22	0	-	3	31	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	59.92	15.15	105	39	3	116	2	7.2	4	1	3	13	0	-	4	22	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	61.23	14.45	101	23	2	53	1	6.7	3	3	1	6	0	-	3	644	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	49.21	15.25	102	37	3	121	2	5.3	2	3	1	4	20	0	6	99	-	-	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	51.85	14.62	104	22	2	144	3	5.5	2	3	1	4	22	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	41.55	13.40	103	33	3	142	3	5.7	2	1	3	4	20	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Yield and Soils Data | Preharvest Data

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 87 Variety York Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed Yes

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 86 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 38 Nematode Class 2

Nodulization No Data Seed Inoculated Yes Certified Seed Yes

	1	2	3	4	5	6	7	8	9	10
Yield and Soils Data										
Plot Number	1	2	3	4	5	6	7	8	9	10
Yield (Bu./A.)	39.74	38.90	37.82	39.23	34.53	33.53	35.51	31.52	37.91	31.36
Weight of Beans (Gm.)	14.21	14.42	15.16	15.49	14.69	15.38	17.46	13.99	14.89	16.09
Number of Beans	101	104	103	105	106	103	109	102	106	108
P (Lb./A.)	4	4	6	5	5	9	18	31	5	4
P Class	1	1	1	1	1	1	2	3	1	1
K (Lb./A.)	85	59	96	85	100	90	102	102	85	89
K Class	2	1	1	2	2	2	2	2	2	2
pH	5.3	5.2	5.2	5.3	4.8	5.3	4.7	4.7	4.9	5.3
pH Class	2	1	1	1	1	2	1	1	1	2
Soil Type	3	2	6	6	3	3	3	3	2	3
Soil Productivity Class	1	3	1	3	1	1	1	2	3	1
Previous Crop	2	2	2	2	2	2	2	3	2	2
Plants/2 Ft. of Row	25	19	10	14	14	16	16	16	13	16
Injury Class	0	0	0	0	0	0	0	0	0	0
Number of Nodes to First Pods at Harvest	4	4	4	4	4	4	4	4	4	4
Subplot Number	1	2	3	4	5	6	7	8	9	10
Harvest Loss (Beans/10 Ft.^{2})	8	42	65	39	203	41	6	4	4	4
Preharvest Data										
Subplot Number	1	2	3	4	5	6	7	8	9	10
% Necrosis (Actual)	0	0	0	0	0	0	0	0	0	0
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	0	0	0	0	0	0	0	0	0	0
% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Plants Necrotic (Actual)	0	0	0	0	0	0	0	0	0	0
% Plants Necrotic (Estimated)	0	0	0	0	0	0	0	0	0	0
% Plants Chlorotic (Actual)	0	0	0	0	0	0	0	0	0	0
% Plants Chlorotic (Estimated)	0	0	0	0	0	0	0	0	0	0
% Insect Damage (Actual)	0	0	0	0	0	0	0	0	0	0
% Insect Damage (Estimated)	0	0	0	0	0	0	0	0	0	0
Subplot Number	1	2	3	4	5	6	7	8	9	10
Total Number of Nodes	4	4	4	4	4	4	4	4	4	4
Total Number of Nodes Affected	0	0	0	0	0	0	0	0	0	0
Highest Shed Node	0	0	0	0	0	0	0	0	0	0
Number of Nodes to First Pods at Preharvest	4	4	4	4	4	4	4	4	4	4
Total Node Height (In.)	0	0	0	0	0	0	0	0	0	0
Highest Affected Node (In.)	0	0	0	0	0	0	0	0	0	0
Weight of Plant (In.)	0	0	0	0	0	0	0	0	0	0
Height of Effects (In.)	0	0	0	0	0	0	0	0	0	0

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 89 Variety Hood Average Injury Class 1 Planting Date Before June 1 Row Width (In.) 38 Nematode Class 0

Nodulisation No data Seed Inoculated Yes Certified Seed No

	Yield and Soils Data																Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods At Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Weight of Plant (In.)	Height of Effects (In.)
1	41.31	16.62	102	2	1	65	2	4.6	1	5	1	4	22	1	-	1	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	47.92	15.08	103	3	1	84	2	4.8	1	6	1	4	25	1	-	2	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	41.94	16.81	105	3	1	81	2	4.8	1	6	1	4	22	1	-	3	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	48.32	15.61	101	3	1	75	2	4.5	1	6	1	4	22	1	-	4	107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	39.87	13.15	102	2	1	68	2	4.7	1	5	1	4	26	1	-	5	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	44.48	17.02	103	2	1	65	2	4.5	1	5	1	4	28	1	-	6	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	40.13	13.02	103	4	1	80	2	4.6	1	5	1	4	18	1	-	7	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	40.61	16.41	107	2	1	87	2	4.5	1	6	1	4	23	1	-	8	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	31.35	13.53	103	2	1	60	1	4.9	1	6	1	4	25	1	-	9	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	27.03	15.32	101	2	1	96	2	4.8	1	5	1	4	27	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 90 Variety Hood Average Injury Class 1 Planting Date Before June 1 Row Width (In.) 39 Nematode Class 0
Nodulization No data Seed Inoculated Yes Certified Seed Yes

| Plot Number | Yield and Soils Data | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 91 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 2

Nodulisation No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 92 Variety Dare Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 93- Variety Dare Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 94 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed Yes

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 93 Variety Dare Average Injury Class 0 Planting Date 6/16-30 Row Width (In.) 30 Nematode Class 0

Nodulization No data Seed Inoculated Yes Certified Seed Yes

	Yield and Soils Data									
1	Plot Number	28.92	14.42	106	21	2	85	2	4.7	1
2	Yield (Bu./A.)	25.49	13.63	104	11	1	70	2	4.4	1
3	Weight of Beans (Gm.)	27.46	14.84	102	32	3	103	2	4.4	1
4	Number of Beans	25.88	12.39	103	8	1	55	1	4.4	1
5	P (Lb./A.)	25.71	13.66	104	18	2	60	1	4.6	1
6	P Class	30.15	13.63	107	11	1	70	2	4.3	1
7	K (Lb./A.)	33.82	11.67	105	10	1	48	1	4.5	1
8	K Class	26.94	14.40	123	5	1	43	1	4.5	1
	pH									
	pH Class									
	Soil Type									
	Soil Productivity Class									
	Previous Crop									
	Plants/2 Ft. of Row									
	Injury Class									
	Number of Nodes to First Pods at Harvest									
	Subplot Number									
	Harvest Loss (Beans/10 Ft.^{2})									

	Preharvest Data									
	Subplot Number									
	% Necrosis (Actual)									
	% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Chlorosis (Actual)									
	% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Plants Necrotic (Actual)									
	% Plants Necrotic (Estimated)									
	% Plants Chlorotic (Actual)									
	% Plants Chlorotic (Estimated)									
	% Insect Damage (Actual)									
	% Insect Damage (Estimated)									
	Subplot Number									
	Total Number of Nodes									
	Total Number of Nodes Affected									
	Highest Shed Node									
	Number of Nodes to First Pods at Preharvest									
	Total Node Height (In.)									
	Highest Affected Node (In.)									
	Weight of Plant (In.)									
	Weight of Effects (In.)									

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 96 Variety Hood Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 37 Nematode Class 2

Nodulization No data Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 97 Variety Hood Average Injury Class 0 Planting Date Before June 1 Row Width (In.) 30 Nematode Class 0

Nodulation No data. Seed Inoculated Yes Certified Seed No

	1	2	3	4	5	6	7	8	9	10
Plot Number										
Yield (Bu./A.)	15.89	24.45	23.11	22.42	35.40	34.79	23.96	24.58	28.37	39.10
Weight of Beans (Gm.)	16.11	14.23	17.01	15.03	18.21	16.83	14.93	15.49	15.57	16.29
Number of Beans	102	104	101	105	109	108	103	107	106	107
P (Lb./A.)	3	3	9	4	5	3	2	4	5	4
P Class	1	1	1	1	1	1	1	1	1	1
K (Lb./A.)	90	85	185	100	97	73	83	92	121	115
K Class	2	2	3	2	2	2	2	2	2	2
pH	4.8	5.1	4.6	5.8	4.9	5.9	5.6	4.7	4.9	5.6
pH Class	1	1	1	2	1	2	2	1	2	2
Soil Type	2	4	4	4	4	4	4	4	2	2
Soil Productivity Class	3	1	2	1	2	1	2	1	3	3
Previous Crop	2	2	2	2	2	2	2	2	2	2
Plants/2 Ft. of Row	11	18	20	18	20	18	15	17	22	23
Injury Class	0	0	0	0	0	0	0	0	0	0
Number of Nodes to First Pods at Harvest	-	-	-	-	-	-	-	-	-	-
Subplot Number	-	-	-	-	-	-	-	-	-	-
Harvest Loss (Beans/10 Ft.^{2})	-	-	-	-	-	-	-	-	-	-
Subplot Number	-	-	-	-	-	-	-	-	-	-
% Necrosis (Actual)	-	-	-	-	-	-	-	-	-	-
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	-	-	-	-	-	-	-	-	-	-
% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Plants Necrotic (Actual)	-	-	-	-	-	-	-	-	-	-
% Plants Necrotic (Estimated)	-	-	-	-	-	-	-	-	-	-
% Plants Chlorotic (Actual)	-	-	-	-	-	-	-	-	-	-
% Plants Chlorotic (Estimated)	-	-	-	-	-	-	-	-	-	-
% Insect Damage (Actual)	-	-	-	-	-	-	-	-	-	-
% Insect Damage (Estimated)	-	-	-	-	-	-	-	-	-	-
Subplot Number	-	-	-	-	-	-	-	-	-	-
Total Number of Nodes	-	-	-	-	-	-	-	-	-	-
Total Number of Nodes Affected	-	-	-	-	-	-	-	-	-	-
Highest Shed Node	-	-	-	-	-	-	-	-	-	-
Number of Nodes to First Pods at Preharvest	-	-	-	-	-	-	-	-	-	-
Total Node Height (In.)	-	-	-	-	-	-	-	-	-	-
Highest Affected Node (In.)	-	-	-	-	-	-	-	-	-	-
Height of Plant (In.)	-	-	-	-	-	-	-	-	-	-
Height of Effects (In.)	-	-	-	-	-	-	-	-	-	-

Yield and Soils Data

Preharvest Data

G-104

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 98 Variety Wood Average Injury Class 0 Planting Date Before June 1 Row Width (In.) 30 Nematode Class 0

Modulation No Data Seed Inoculated Yes Certified Seed No

Plot Number	Yield and Soils Data															Preharvest Data																							
	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Fruiterset	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	35.72	17.29	107	5	1	90	2	4.7	1	4	1	2	18	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
2	28.17	16.00	107	4	1	136	3	4.8	1	2	3	2	29	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
3	23.91	16.31	105	4	1	100	2	4.8	1	2	3	2	25	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
4	29.72	16.46	111	4	1	65	2	4.9	1	2	3	2	19	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
5	30.78	16.10	104	5	1	92	2	4.7	1	2	3	2	18	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
6	28.17	16.00	107	3	1	74	2	5.4	2	4	1	2	15	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
7	30.42	16.33	101	4	1	75	2	5.4	2	2	3	2	23	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
8	32.74	15.26	100	3	1	90	2	5.0	1	2	3	2	19	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
9	23.75	17.73	105	4	1	90	2	5.1	1	4	1	2	17	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-
10	29.24	16.90	107	2	1	109	2	4.8	1	4	1	2	18	0	-	-	-	-	0.0	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 99 Variety Clark-63 Average Injury Class 0 Planting Date Before June 1 Row Width (In.) 38 Nematode Class No data

Nodulization No data Seed Inoculated Yes Certified Seed Yes

Plot Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Yield (bu./A.)	47.33	51.90	41.07	40.90	40.65	47.60	50.40	-	40.35	46.78	42.08	35.90	41.48
Weight of Beans (Gm.)	"	"	"	"	"	"	"	"	"	"	"	"	"
Number of Beans	"	"	"	"	"	"	"	"	"	"	"	"	"
P (Lb./A.)	"	"	"	"	"	"	"	"	"	"	"	"	"
P Class	"	"	"	"	"	"	"	"	"	"	"	"	"
K (Lb./A.)	"	"	"	"	"	"	"	"	"	"	"	"	"
K Class	"	"	"	"	"	"	"	"	"	"	"	"	"
pH	"	"	"	"	"	"	"	"	"	"	"	"	"
pH Class	"	"	"	"	"	"	"	"	"	"	"	"	"
Soil Type	2	11	11	11	11	2	11	11	11	2	11	10	11
Soil Productivity Class	3	1	1	1	1	3	1	1	1	3	1	3	1
Previous Crop	3	3	3	3	3	3	3	3	3	3	3	3	3
Plants/2 Ft. of Row	"	"	"	"	"	"	"	"	"	"	"	"	"
Injury Class	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Nodes to First Pods at Harvest	"	"	"	"	"	"	"	"	"	"	"	"	"
Subplot Number	"	"	"	"	"	"	"	"	"	"	"	"	"
Harvest Loss (Beans/10 Ft.^{2})	"	"	"	"	"	"	"	"	"	"	"	"	"

Yield and Soils Data

Subplot Number	"	"	"	"	"	"	"	"	"	"	"	"	"
% Necrosis (Actual)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Necrosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Chlorosis (Actual)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Chlorosis (Estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Plants Necrotic (Actual)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Plants Necrotic (Estimated)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Plants Chlorotic (Actual)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Plants Chlorotic (Estimated)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Insect Damage (Actual)	"	"	"	"	"	"	"	"	"	"	"	"	"
% Insect Damage (Estimated)	"	"	"	"	"	"	"	"	"	"	"	"	"
Subplot Number	"	"	"	"	"	"	"	"	"	"	"	"	"
Total Number of Nodes	"	"	"	"	"	"	"	"	"	"	"	"	"
Total Number of Nodes Affected	"	"	"	"	"	"	"	"	"	"	"	"	"
Highest Shed Node	"	"	"	"	"	"	"	"	"	"	"	"	"
Number of Nodes to First Pods at Preharvest	"	"	"	"	"	"	"	"	"	"	"	"	"
Total Node Height (In.)	"	"	"	"	"	"	"	"	"	"	"	"	"
Highest Affected Node (In.)	"	"	"	"	"	"	"	"	"	"	"	"	"
Height of Plant (In.)	"	"	"	"	"	"	"	"	"	"	"	"	"
Height of Effects (In.)	"	"	"	"	"	"	"	"	"	"	"	"	"

Preharvest Data

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS -- BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 100 Variety Clark-63 Average Injury Class 0 Planting Date Before June 1 Row Width (In.) 38 Nematode Class No data

Nodulization No data Seed Inoculated No Certified Seed Yes

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)*	P Class*	K (Lb./A.)*	K Class*	pH*	pH Class*	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})
1	49.95	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
2	45.17	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
3	45.48	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
4	44.10	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
5	53.58	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
6	51.42	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
7	38.99	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
8	41.67	"	"	17	2	118	2	6.7	3	2	3	4	"	0	"	"	"
9	35.94	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"
10	40.17	"	"	17	2	118	2	6.7	3	1	3	4	"	0	"	"	"

Yield and Soils Data

Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	0.0	"	0.0	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"

Preharvest Data

*Average of data plots from another harvest scheme

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 101 Variety Scott Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 39 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Yield and Soils Data																			Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	33.04	14.97	103	21	2	31	1	6.4	3	11	1	2	-	0	-	1	42	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
2	30.08	16.35	113	21	2	31	1	6.4	3	11	1	2	-	0	-	2	78	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
3	27.57	13.85	111	21	2	31	1	6.4	3	11	1	2	-	0	-	3	26	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
4	24.99	17.06	121	21	2	31	1	6.4	3	9	4	2	-	0	-	4	73	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
5	23.94	18.70	127	21	2	31	1	6.4	3	11	1	2	-	0	-	5	20	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
6	24.47	17.04	130	6	1	30	1	5.9	2	11	1	2	-	0	-	6	29	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
7	20.13	14.81	118	6	1	30	1	5.9	2	11	1	2	-	0	-	7	24	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
8	38.50	16.06	105	6	1	30	1	5.9	2	11	1	2	-	0	-	8	43	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
9	32.61	15.63	117	6	1	30	1	5.9	2	11	1	2	-	0	-	9	33	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
10	32.48	14.91	112	6	1	30	1	5.9	2	11	1	2	-	0	-	10	75	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
11	10.37	13.93	116	5	1	86	2	4.6	1	11	1	2	-	0	-	11	38	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
12	19.68	12.11	100	5	1	86	2	4.6	1	11	1	2	-	0	-	12	22	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24
13	15.13	14.51	120	5	1	86	2	4.6	1	11	1	2	-	0	-	13	26	1	-	0.0	-	1.2	-	-	-	-	-	-	2.4	1	-	-	-	-	-	-	33	24

G-107

1674

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 102 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) Grain Drill Nematode Class 1

Nodulisation Light Seed Inoculated Yes Certified Seed Yes

Yield and Soils Data																					Preharvest Data																				
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	19.81	13.20	105	6	1	46	1	6.5	3	4	1	2	-	1	5	1	29	1	-	0.4	-	31.5	-	-	-	-	-	4.0	1	16	10	9	-	32	12	-	-
2	34.37	15.94	112	10	1	55	1	6.3	3	2	3	2	-	2	5	2	111	2	-	1.5	-	12.6	-	-	-	-	-	3.6	2	15	8	9	-	37	11	-	-
3	34.89	15.03	110	7	1	50	1	6.0	2	2	3	2	-	2	4	3	39	3	-	2.4	-	39.2	-	-	-	-	-	3.2	3	18	9	8	-	35	11	-	-
4	38.24	15.26	111	7	1	120	2	6.9	4	2	3	2	-	1	4	4	14	6	-	0.1	-	5.4	-	-	-	-	-	6.3	6	16	10	9	-	40	15	-	-
5	33.65	19.20	148	8	1	52	1	6.9	4	4	1	2	-	1	5	5	19	7	-	0.0	-	38.4	-	-	-	-	-	4.0	7	17	9	8	-	42	14	-	-
6	21.13	14.93	124	6	1	56	1	6.5	3	2	3	2	-	1	6	-	-	8	-	0.8	-	33.6	-	-	-	-	-	4.0	8	18	9	8	-	32	11	-	-
7	30.88	13.71	107	6	1	50	1	6.2	3	2	3	2	-	1	6	-	-	6	-	0.1	-	5.4	-	-	-	-	-	6.3	6	16	10	9	-	40	15	-	-
8	21.94	15.43	114	7	1	50	1	6.1	3	2	3	2	-	0	7	-	-	5	-	0.0	-	2.7	-	-	-	-	-	5.4	5	16	9	8	-	37	16	-	-
9	25.52	13.78	101	8	1	63	2	6.1	3	2	3	2	-	1	5	-	-	6	-	0.1	-	5.4	-	-	-	-	-	6.3	6	16	10	9	-	40	15	-	-
10	28.74	14.04	115	6	1	61	2	6.9	4	2	3	2	-	1	5	-	-	7	-	0.0	-	38.4	-	-	-	-	-	4.0	7	17	9	8	-	42	14	-	-
																		4	-	0.1	-	40.0	-	-	-	-	-	8.0	4	18	10	9	-	44	14	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 103 Variety Dare Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) Grain Drill Nematode Class 0

Nodulization Heavy Seed Inoculated No Certified Seed No

	Yield and Soils Data																		Preharvest Data																					
Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	31.94	15.06	108	3	1	45	1	6.6	3	5	1	4	-	0	6	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
2	32.49	16.21	108	3	1	52	1	6.4	3	5	1	4	-	0	5	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
3	47.26	14.14	106	2	1	52	1	6.7	3	5	1	4	-	0	6	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
4	32.77	14.88	104	3	1	74	2	7.2	4	5	1	4	-	0	5	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
5	35.66	16.67	115	-	-	-	-	-	-	-	-	4	-	0	6	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
6	38.08	15.61	113	2	1	47	1	6.5	3	2	3	4	-	0	6	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
7	38.64	16.08	109	3	1	80	2	6.8	4	3	1	4	-	0	6	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
8	31.17	15.86	112	8	1	101	2	6.5	3	3	1	4	-	0	4	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
9	47.70	17.38	117	4	1	84	2	6.7	3	3	1	4	-	0	5	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-
10	32.35	18.27	124	3	1	57	1	7.2	4	2	3	4	-	0	6	-	-	1	-	0.0	-	2.8	-	-	-	-	-	-	1	-	-	-	-	-	-	33	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 104 Variety Dare Average Injury Class 0 Planting Date 6/11-15 Row Width (In.) Grain Drill Nematode Class 0

Modulation Heavy Seed Inoculated No Certified Seed No

Yield and Soils Data

	Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})
1	30.71	14.19	106	3	1	65	2	6.5	3	5	1	4	-	0	6	-	-
2	36.19	14.22	100	5	1	62	2	6.8	4	2	3	4	-	0	5	-	-
3	43.84	14.88	100	9	1	61	2	7.3	4	3	1	4	-	0	7	-	-
4	34.03	16.45	107	12	1	96	2	6.1	3	2	3	4	-	0	6	-	-
5	43.45	15.91	101	8	1	86	2	7.0	4	5	1	4	-	0	5	-	-
6	33.59	15.34	104	4	1	90	2	6.9	4	1	3	4	-	0	5	-	-
7	30.18	15.70	106	10	1	60	1	7.1	4	1	3	4	-	0	5	-	-
8	34.12	15.95	107	6	1	58	1	6.8	4	2	3	4	-	0	5	-	-
9	26.58	16.26	114	11	1	60	1	7.0	4	2	3	4	-	0	5	-	-
10	27.01	13.39	114	2	1	71	2	7.0	4	1	3	4	-	0	6	-	-
11	24.95	15.37	119	2	1	47	1	7.2	4	5	1	4	-	0	7	-	-
12	40.84	15.01	108	5	1	46	1	7.3	4	5	1	4	-	0	4	-	-
13	31.85	16.14	101	82	4	216	4	7.3	4	2	3	4	-	0	4	-	-
14	31.85	16.05	104	17	2	154	3	7.3	4	3	1	4	-	0	5	-	-
15	39.53	15.61	102	13	1	130	3	6.7	3	5	1	4	-	0	5	-	-
16	27.63	15.04	113	4	1	55	1	7.0	4	2	3	4	-	0	6	-	-
17	37.54	15.85	108	4	1	62	2	7.0	4	2	3	4	-	0	6	-	-
18	33.02	17.24	107	4	1	90	2	7.0	4	3	1	4	-	0	7	-	-
19	33.45	16.71	106	5	1	55	1	7.1	4	3	1	4	-	0	6	-	-
20	33.31	14.83	107	3	1	109	2	6.8	4	2	3	4	-	0	7	-	-

Preharvest Data

	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1	-	0.0	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 105 Variety Dare & Cutler Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 34 Nematode Class 0

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Plot Number	Yield and Soils Data																	Preharvest Data																							
	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	36.04	15.75	106	18	2	180	3	4.9	1	2	3	1	20	1	-	1	42	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
2	35.02	15.69	103	35	3	141	3	5.1	1	2	3	1	26	1	-	2	82	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
3	34.57	15.87	107	11	1	167	3	5.6	2	2	3	1	32	1	-	3	170	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
4	39.01	17.23	103	21	2	200	3	5.5	2	2	3	1	20	1	-	4	51	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
5	33.16	17.71	108	27	2	222	4	5.2	1	2	3	1	17	1	-	5	271	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
6	36.97	17.98	107	50	3	291	4	6.1	3	2	3	1	17	1	-	-	-	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
7	39.06	16.86	104	19	2	220	4	5.1	1	2	3	1	20	1	-	-	-	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12
8	41.03	17.62	105	53	3	192	3	5.2	1	2	3	1	22	1	-	-	-	1	-	0.0	-	13.3	-	-	-	-	-	-	1	-	-	-	-	-	8	26	12

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 106 Variety Dare Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) Grain Drill Nematode Class 0

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 107 Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) Grain Drill Nematode Class 0

Nodulization _____ Seed Inoculated Yes Certified Seed No

| | Yield and Soils Data | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 108 Variety Dyer & York Average Injury Class 0 Planting Date 6/1-15 Row Width (In.) 38 Nematode Class 2

Nodulation ____ Seed Inoculated Yes Certified Seed Yes

Plot Number	Yield (Bu./A.)	Weight of Beans (Gm.)	Number of Beans	P (Lb./A.)	P Class	K (Lb./A.)	K Class	pH	pH Class	Soil Type	Soil Productivity Class	Previous Crop	Plants/2 Ft. of Row	Injury Class	Number of Nodes to First Pods at Harvest	Subplot Number	Harvest Loss (Beans/10 Ft.^{2})
1	32.15	17.20	103	11	1	145	3	7.1	4	2	4	2	14	0	*	*	*
2	32.81	19.44	111	5	1	110	2	6.9	4	2	4	2	11	0	*	*	*
3	5.73	12.98	109	6	1	85	2	6.4	3	2	4	2	11	0	*	*	*
4	19.81	12.07	108	10	1	62	2	6.9	4	2	4	2	16	0	*	*	*
5	24.46	11.77	101	9	1	72	2	7.5	4	2	4	2	24	0	*	*	*
6	25.71	13.46	108	11	1	82	2	7.2	4	2	4	2	23	0	*	*	*
7	14.04	11.52	107	4	1	51	1	7.1	4	2	4	2	18	0	*	*	*
8	26.05	13.56	109	4	1	105	2	6.9	4	2	4	2	9	0	*	*	*
9	25.26	14.48	100	4	1	96	2	6.5	3	2	4	2	19	0	*	*	*
10	27.24	12.48	103	7	1	75	2	6.9	4	2	4	2	18	0	*	*	*
11	15.68	12.40	106	4	1	45	1	6.6	3	2	4	2	23	0	*	*	*
12	17.79	12.76	107	4	1	45	1	7.1	4	2	4	2	18	0	*	*	*
13	27.62	14.02	106	5	1	61	2	6.6	3	2	4	2	19	0	*	*	*

Yield and Soils Data

Plot Number	Subplot Number	% Necrosis (Actual)	% Necrosis (Estimated)	% Chlorosis (Actual)	% Chlorosis (Estimated)	% Plants Necrotic (Actual)	% Plants Necrotic (Estimated)	% Plants Chlorotic (Actual)	% Plants Chlorotic (Estimated)	% Insect Damage (Actual)	% Insect Damage (Estimated)	Subplot Number	Total Number of Nodes	Total Number of Nodes Affected	Highest Shed Node	Number of Nodes to First Pods at Preharvest	Total Node Height (In.)	Highest Affected Node (In.)	Height of Plant (In.)	Height of Effects (In.)
1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Preharvest Data

1681

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 109 Variety Custer Average Injury Class 1 Planting Date Before June 1 Row Width (In.) Grain Drill Nematode Class No data

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 110 Variety Custer Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) Grain Drill Nematode Class No data

Nodulization _____ Seed Inoculated Yes Certified Seed No

| Plot Number | Yield and Soils Data | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 111[a] Variety Dare Average Injury Class 1 Planting Date 6/16-20 Row Width (In.) Grain Drill Nematode Class No data

Nodulation Light Seed Inoculated Yes Certified Seed No

Yield and Soils Data

Plot Number	1		
Yield (Bu./A.)			
Weight of Beans (Gm.)			
Number of Beans			
P (Lb./A.)			
P Class			
K (Lb./A.)			
K Class			
pH			
pH Class			
Soil Type			
Soil Productivity Class			
Previous Crop	3		
Plants/2 Ft. of Row			
Injury Class	1		
Number of Nodes to First Pods at Harvest			
Subplot Number			
Harvest Loss (Beans/10 Ft.^{2})			

Preharvest Data

Subplot Number	1	2	3	
% Necrosis (Actual)				
% Necrosis (Estimated)	0.0	0.0	0.0	
% Chlorosis (Actual)				
% Chlorosis (Estimated)	12.6	16.0	7.2	
% Plants Necrotic (Actual)				
% Plants Necrotic (Estimated)				
% Plants Chlorotic (Actual)				
% Plants Chlorotic (Estimated)				
% Insect Damage (Actual)				
% Insect Damage (Estimated)				
Subplot Number	1	2	3	
Total Number of Nodes	17	16	18	
Total Number of Nodes Affected	12	13	13	
Highest Shed Node	8	8	10	
Number of Nodes to First Pods at Preharvest				
Total Node Height (In.)	34	41	36	
Highest Affected Node (In.)	19	29	23	
Height of Plant (In.)				
Height of Effects (In.)				

a. Field harvested before yield samples could be collected.

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 112[a] Variety ___ Date ___ Average Injury Class 1 Planting Date 6/15-30 Row Width (In.) Grain Drill Nematode Class No data

Modification Light Seed Inoculated Yes Certified Seed No

Yield and Soils Data	Plot Number	"	1
	Yield (Bu./A.)	"	"
	Weight of Beans (Gm.)	"	"
	Number of Beans	"	"
	P (Lb./A.)	"	"
	P Class	"	"
	K (Lb./A.)	"	"
	K Class	"	"
	pH	"	"
	pH Class	"	"
	Soil Type	"	"
	Soil Productivity Class	"	"
	Previous Crop	"	W
	Plants/2 Ft. of Row	"	"
	Injury Class	"	1
	Number of Nodes to First Pods at Harvest	"	"
	Subplot Number	"	"
	Harvest Loss (Beans/10 Ft.^{2})	"	"
Preharvest Data	Subplot Number	3	2	1
	% Necrosis (Actual)	"	"	"
	% Necrosis (Estimated)	0.0	0.0	0.0
	% Chlorosis (Actual)	"	"	"
	% Chlorosis (Estimated)	40.0	8.0	0.0
	% Plants Necrotic (Actual)	"	"	"
	% Plants Necrotic (Estimated)	"	"	"
	% Plants Chlorotic (Actual)	"	"	"
	% Plants Chlorotic (Estimated)	"	"	"
	% Insect Damage (Actual)	"	"	"
	% Insect Damage (Estimated)	5.0	3.0	5.0
	Subplot Number	3	2	1
	Total Number of Nodes	14	15	16
	Total Number of Nodes Affected	7	11	0
	Highest Shed Node	7	7	7
	Number of Nodes to First Pods at Preharvest	"	"	"
	Total Node Height (In.)	39	38	40
	Highest Affected Node (In.)	19	26	0
	Height of Plant (In.)	"	"	"
	Height of Effects (In.)	"	"	"

a. Field harvested before yield samples could be collected.

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND MCCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 113[a] Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) Grain Drill Nematode Class No Data

Nodulization - Seed Inoculated Yes Certified Seed No

Yield and Soils Data	1	Plot Number
	'	Yield (Bu./A.)
	'	Weight of Beans (Gm.)
	'	Number of Beans
	'	P (Lb./A.)
	'	P Class
	'	K (Lb./A.)
	'	K Class
	'	pH
	'	pH Class
	'	Soil Type
	'	Soil Productivity Class
	4	Previous Crop
	'	Plants/2 Ft. of Row
	1	Injury Class
	'	Number of Nodes to First Pods at Harvest
	'	Subplot Number
	'	Harvest Loss (Beans/10 Ft.^{2})
Preharvest Data	1	Subplot Number
	'	% Necrosis (Actual)
	0.0	% Necrosis (Estimated)
	'	% Chlorosis (Actual)
	28.0	% Chlorosis (Estimated)
	'	% Plants Necrotic (Actual)
	'	% Plants Necrotic (Estimated)
	'	% Plants Chlorotic (Actual)
	'	% Plants Chlorotic (Estimated)
	'	% Insect Damage (Actual)
	16.0	% Insect Damage (Estimated)
	1	Subplot Number
	12	Total Number of Nodes
	0	Total Number of Nodes Affected
	'	Highest Shed Node
	'	Number of Nodes to First Pods at Preharvest
	34	Total Node Height (In.)
	14	Highest Affected Node (In.)
	'	Weight of Plant (In.)
	'	Height of Effects (In.)

a. Field harvested before yield samples could be collected.

1686

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 116[a] Variety Custer Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) Grain Drill Nematode Class No Data

Nodulation Light Seed Inoculated Yes Certified Seed No

Yield and Soils Data	
Plot Number	1
Yield (Bu./A.)	"
Weight of Beans (Gm.)	"
Number of Beans	"
P (Lb./A.)	"
P Class	"
K (Lb./A.)	"
K Class	"
pH	"
pH Class	"
Soil Type	"
Soil Productivity Class	"
Previous Crop	"
Plants/2 Ft. of Row	"
Injury Class	1
Number of Nodes to First Pods at Harvest	"
Subplot Number	"
Harvest Loss (Beans/10 Ft.^{2})	"

Preharvest Data							
Subplot Number	1	2	3	4	5	6	
% Necrosis (Actual)	"	"	"	"	"	"	
% Necrosis (Estimated)	0.1	0.4	0.0	0.0	0.0	0.0	
% Chlorosis (Actual)	"	"	"	"	"	"	
% Chlorosis (Estimated)	28.0	40.0	56.0	0.0	7.2	6.0	
% Plants Necrotic (Actual)	-	-	-	-	-	-	
% Plants Necrotic (Estimated)	"	"	"	"	"	"	
% Plants Chlorotic (Actual)	"	"	"	"	"	"	
% Plants Chlorotic (Estimated)	"	"	"	"	"	"	
% Insect Damage (Actual)	"	"	"	"	"	"	
% Insect Damage (Estimated)	12.0	8.0	8.0	40.0	30.0	40.0	
Subplot Number	1	2	3	4	5	6	
Total Number of Nodes	20	18	19	18	18	17	
Total Number of Nodes Affected	11	6	9	0	7	6	
Highest Shed Node	8	3	6	4	5	5	
Number of Nodes to First Pods at Preharvest	"	"	"	"	"	"	
Total Node Height (In.)	41	39	44	46	44	46	
Highest Affected Node (In.)	15	13	14	0	11	12	
Height of Plant (In.)	"	"	"	"	"	"	
Height of Effects (In.)	"	"	"	"	"	"	

a. Field harvested before yield samples could be collected.

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 115[a] Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) - Nematode Class No Data

Nodulization Light Seed Inoculated Yes Certified Seed Yes

Yield and Soils Data	1	Plot Number
	'	Yield (Bu./A.)
	'	Weight of Beans (Gm.)
	'	Number of Beans
	'	P (Lb./A.)
	'	P Class
	'	K (Lb./A.)
	'	K Class
	'	pH
	'	pH Class
	'	Soil Type
	'	Soil Productivity Class
	4	Previous Crop
	'	Plants/2 Ft. of Row
	1	Injury Class
	'	Number of Nodes to First Pods at Harvest
	'	Subplot Number
	'	Harvest Loss (Beans/10 Ft.^{2})
Preharvest Data	1	Subplot Number
	'	% Necrosis (Actual)
	0.1	% Necrosis (Estimated)
	'	% Chlorosis (Actual)
	22.4	% Chlorosis (Estimated)
	'	% Plants Necrotic (Actual)
	'	% Plants Necrotic (Estimated)
	'	% Plants Chlorotic (Actual)
	'	% Plants Chlorotic (Estimated)
	'	% Insect Damage (Actual)
	10.8	% Insect Damage (Estimated)
	'	Subplot Number
	'	Total Number of Nodes
	'	Total Number of Nodes Affected
	'	Highest Shed Node
	'	Number of Nodes to First Pods at Preharvest
	'	Total Node Height (In.)
	'	Highest Affected Node (In.)
	'	Height of Plant (In.)
	'	Height of Effects (In.)

a. Field harvested before yield samples could be collected.

G-122

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 116[a] Variety Hood Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) - Nematode Class No Data

Nodulization Moderate Seed Inoculated Yes Certified Seed No

Plot Number	1
Yield and Soils Data	
Yield (bu./A.)	
Weight of Beans (Gm.)	
Number of Beans	
P (Lb./A.)	
P Class	
K (Lb./A.)	
K Class	
pH	
pH Class	
Soil Type	
Soil Productivity Class	
Previous Crop	C
Plants/2 Ft. of Row	
Injury Class	1
Number of Nodes to First Pods at Harvest	
Subplot Number	
Harvest Loss (Beans/10 Ft.^{2})	
Preharvest Data	
Subplot Number	1
% Necrosis (Actual)	
% Necrosis (Estimated)	0.0
% Chlorosis (Actual)	
% Chlorosis (Estimated)	40.0
% Plants Necrotic (Actual)	
% Plants Necrotic (Estimated)	
% Plants Chlorotic (Actual)	
% Plants Chlorotic (Estimated)	
% Insect Damage (Actual)	
% Insect Damage (Estimated)	7.0
Subplot Number	
Total Number of Nodes	
Total Number of Nodes Affected	
Highest Shed Node	
Number of Nodes to First Pods at Preharvest	
Total Node Height (In.)	
Highest Affected Node (In.)	
Height of Plant (In.)	
Height of Effects (In.)	

a. Fields not sampled because of excessive weeds.

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 117[a] Variety Hood Average Injury Class 1 Planting Date 6/16-30 Row Width (In.) 32 Nematode Class No Data

Nodulization - Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | |

INVESTIGATION OF AIR POLLUTION INJURY TO SOYBEANS - BALLARD AND McCRACKEN COUNTIES, KENTUCKY - 1971 GROWING SEASON

Field No. 118[a] Variety Cutler Average Injury Class 1 Planting Date 6/1-15 Row Width (In.) _____ Nematode Class No data

Nodulization Light Seed Inoculated Yes Certified Seed No

| Yield and Soils Data | | | | | | | | | | | | | | | | | | | Preharvest Data | | | | | | | | | | | | | | | | | | |

H-1

APPENDIX H

SOYBEAN FIELDS SAMPLED FOR YIELD IN BALLARD AND McCRACKEN COUNTIES, KENTUCKY FALL 1971

Field No.	Variety	Approx. Acreage	Yield	Owner and Address
1	Hood	17	34	Del Benton, Rt. 4, Kevil
2	Hood	7	28	Del Benton, Rt. 4, Kevil
3	Hood	29	34	Elbert and Jack Cooper, Rt. 3, Kevil
4	Hood	24	35	Elbert and Jack Cooper, Rt. 3, Kevil
5	Hood	22	29	Elbert and Jack Cooper, Rt. 3, Kevil
6	Hood	8	27	Elbert and Jack Cooper, Rt. 3, Kevil
7	Hood	16	37	Eugene Cooper, Rt. 3, Kevil
8	Hood	9	26	Eugene Cooper, Rt. 3, Kevil
9	Pickett	17	22	Eugene Cooper, Rt. 3, Kevil
10	Hood	22	20	Eugene Cooper, Rt. 3, Kevil
11	Hood	10	25	Eugene Cooper, Rt. 3, Kevil
12	Hood	6	23	Eugene Cooper, Rt. 3, Kevil
13	Hood	10	23	Eugene Cooper, Rt. 3, Kevil
14	Hood	22	44	Eugene Cooper, Rt. 3, Kevil
15	Hood	25	44	Eugene Cooper, Rt. 3, Kevil
16	Hood	24	34	Holbert Davis, Rt. 3, Kevil
17	Hood	10	26	Eugene Cooper, Rt. 3, Kevil
18	Hood	22	40	Holbert Davis, Rt. 3, Kevil
19	Clark-63	4	36	Holbert Davis, Rt. 3, Kevil
20	York	3	43	Harlon Dowdy, Rt. 4, Kevil
21	York	6	44	Harlon Dowdy, Rt. 4, Kevil
22	York	6	49	Harlon Dowdy, Rt. 4, Kevil
23	Hood	19	37	Harlon Dowdy, Rt. 4, Kevil
24	Hood	21	41	Harlon Dowdy, Rt. 4, Kevil
25	Hood	6	39	Monroe Flowers, Rt. 3, Kevil
26	York	17	41	J. R. Frields, Rt. 4, Kevil
27	Clark-63	7	37	J. R. Frields, Rt. 4, Kevil
28	Clark-63	2	33	J. R. Frields, Rt. 4, Kevil
29	Clark-63	1	37	J. R. Frields, Rt. 4, Kevil
30	Clark-63	1	37	J. R. Frields, Rt. 4, Kevil
31	Clark-63	6	42	J. R. Frields, Rt. 4, Kevil
32	Clark-63	2	35	J. R. Frields, Rt. 4, Kevil
33	Hood	27	26	J. R. Frields, Rt. 4, Kevil
34	Hood	32	32	J. R. Frields, Rt. 4, Kevil
35	Hood	15	28	J. R. Frields, Rt. 4, Kevil
36	York	26	37	Robert Harris, Rt. 1, La Center
37	Clark-63	11	31	Andrew Jenkins, Rt. 4, Kevil
38	Dare	12	31	R. Y. Jerrell, Rt. 3, Kevil
39	Dare	22	39	Billy Jerrell, Rt. 2, Kevil
40	Dare	47	31	D. L. Simmons, Rt. 4, Kevil
41	Dare	35	32	D. L. Simmons, Rt. 4, Kevil
42	Hood	20	40	Bobby Skidmore, Rt. 4, Kevil
43	Hood	13	36	Bobby Skidmore, Rt. 4, Kevil
44	Dare	10	21	Bobby Skidmore, Rt. 4, Kevil
45	Dare	63	23	Bobby Skidmore, Rt. 4, Kevil
46	Dare	100	31	Bobby Skidmore, Rt. 4, Kevil

H-2

Field No.	Variety	Approx. Acreage	Yield	Owner and Address
47	Dare	18	22	Bobby Skidmore, Rt. 4, Kevil
48	Dare	20	29	Bobby Skidmore, Rt. 4, Kevil
49	Dare	13	23	Bobby Skidmore, Rt. 4, Kevil
50	Dare	4	33	Bobby Skidmore, Rt. 4, Kevil
51	Dare	15	49	Bobby Skidmore, Rt. 4, Kevil
52	Dare	31	36	Bobby Skidmore, Rt. 4, Kevil
53	Dare	24	19	Ricke Stone, Rt. 4, Kevil
54	Dare	1	22	Ricke Stone, Rt. 4, Kevil
55	Dare	3	19	Ricke Stone, Rt. 4, Kevil
56	Dare	11	30	Ricke Stone, Rt. 4, Kevil
57	Dare	2	26	Ricke Stone, Rt. 4, Kevil
58	Dare	22	32	Ricke Stone, Rt. 4, Kevil
59	Dare	8	18	Ricke Stone, Rt. 4, Kevil
60	Dare	16	17	Ricke Stone, Rt. 4, Kevil
61	Hood	8	30	Ricke Stone, Rt. 4, Kevil
62	Hood	8	28	Ricke Stone, Rt. 4, Kevil
63	Hood	25	26	Ricke Stone, Rt. 4, Kevil
64	Hood	25	27	Ricke Stone, Rt. 4, Kevil
65	Hood	26	35	Tommie Sullenger, Rt. 2, Kevil
66	Dare	39	33	Tommie Sullenger, Rt. 2, Kevil
67	Dare	11	39	Tommie Sullenger, Rt. 2, Kevil
68	Dare	31	24	Billy Sullivan, Rt. 1, La Center
69	Pickett	56	28	Billy Sullivan, Rt. 1, La Center
70	Dare	78	28	Billy Sullivan, Rt. 1, La Center
71	Pickett	12	24	Billy Sullivan, Rt. 1, La Center
72	Dare	29	23	Billy Sullivan, Rt. 1, La Center
73	York	21	29	Tommie Sullenger, Rt. 2, Kevil
74	York	34	35	Billy Sullivan, Rt. 1, La Center
75	Dare	10	31	Billy Sullivan, Rt. 1, La Center
76	Dare	12	22	Billy Sullivan, Rt. 1, La Center
77	York	11	33	Charles Peyton, Rt. 2, Kevil
78	Pickett	5	20	Raymond Lanier, Rt. 3, Kevil
79	Pickett	13	22	Raymond Lanier, Rt. 3, Kevil
80	Pickett	4	27	N. L. Carpenter, Rt. 3, Kevil
81	Pickett	6	34	N. L. Carpenter, Rt. 3, Kevil
82	Pickett	4	35	N. L. Carpenter, Rt. 3, Kevil
83	Pickett	17	35	N. L. Carpenter, Rt. 3, Kevil
84	Dare	2	22	N. L. Carpenter, Rt. 3, Kevil
85	Dare	8	36	N. L. Carpenter, Rt. 3, Kevil
86	Dare	3	46	N. L. Carpenter, Rt. 3, Kevil
87	York	29	29	Eddie Throgmorton, Rt. 3, Kevil
88	Dare	9	36	I. H. Fuqua, Rt. 3, Kevil
89	Hood	17	40	Clifton Perkins, Rt. 2, Kevil
90	Hood	14	39	Andrew Jenkins, Rt. 4, Kevil
91	Hood	17	22	Eugene Cooper, Rt. 3, Kevil
92	Dare	13	40	Hester Sullivan, Rt. 2, Kevil
93	Dare	15	44	Hester Sullivan, Rt. 2, Kevil
94	Dare	6	32	Bobby Hook, Kevil
95	Dare	26	28	Bobby Hook, Kevil
96	Hood	16	26	Glenn Shelby, Rt. 2, Kevil
97	Hood	18	27	James Earnest, Rt. 2, Kevil

H-3

Field No.	Variety	Approx. Acreage	Yield	Owner and Address
98	Hood	11	29	James Earnest, Rt. 2, Kevil
99	Clark-63	22	44	Earl Rudolph, Rt. 1, La Center
100	Clark-63	7	45	Junior Stevens, Bandana
101	Scott	14	26	Eugene Cooper, Rt. 3, Kevil
102	Dare*	48	29	Bobby Hook, Kevil
103	Dare*	42	37	Wayne and Paul Rice, Rt. 4, Kevil
104	Dare*	93	34	Wayne and Paul Rice, Rt. 4, Kevil
105	Cutler and Dare	6	37	D. L. Simmons, Rt. 4, Kevil
106	Dare*	31	33	Bobby Skidmore, Rt. 4, Kevil
107	Hood*	23	34	Eugene Cooper, Rt. 3, Kevil
108	Dyer and York	18	23	Eddie Throgmorton, Rt. 3, Kevil
109	Custer*	8	22	Bobby Hook, Kevil
110	Custer*	16	29	Bobby Skidmore, Rt. 4, Kevil

*Wheat drilled

○