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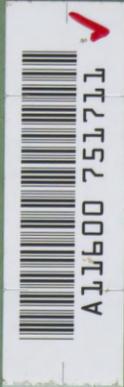
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THERMAL POLLUTION—1968

(Part 3)

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON

AIR AND WATER POLLUTION

OF THE

COMMITTEE ON PUBLIC WORKS

UNITED STATES SENATE

NINETIETH CONGRESS

SECOND SESSION

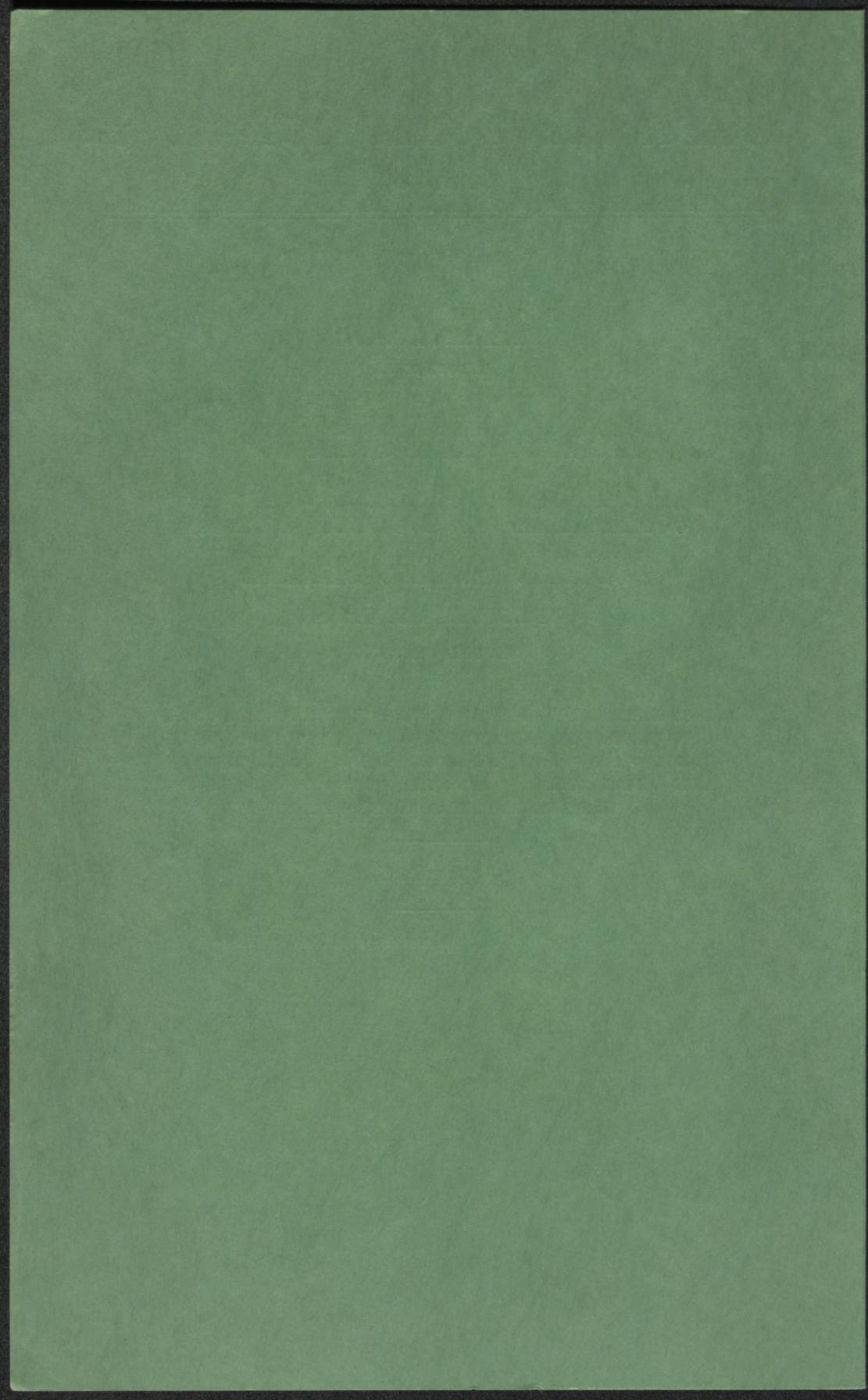
ON

THE EXTENT TO WHICH ENVIRONMENTAL FACTORS ARE
CONSIDERED IN SELECTING POWERPLANT SITES WITH
PARTICULAR EMPHASIS ON THE ECOLOGICAL EFFECTS OF
THE DISCHARGE OF WASTE HEAT INTO RIVERS, LAKES,
ESTUARIES, AND COASTAL WATERS

Appendix 1

Printed for the use of the Committee on Public Works





THERMAL POLLUTION—1968

(Part 3)

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BEFORE THE
SUBCOMMITTEE ON
AIR AND WATER POLLUTION
OF THE
COMMITTEE ON PUBLIC WORKS
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ESTUARIES, AND COASTAL WATERS

Appendix 1

Printed for the use of the Committee on Public Works



U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1968

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THERMAL POLLUTION

EXPLANATORY STATEMENT BY SENATOR MUSKIE

The Subcommittee on Air and Water Pollution continues to be concerned with the role of Federal agencies' national efforts for clean water. The Water Pollution Control Act provides specific directive to Federal agencies to assume the lead in the fight for water quality by taking necessary action to prevent and abate water pollution.

Since establishment of the Special Subcommittee on Air and Water Pollution in 1963, hearings have been held to determine the ways in which various agencies have been carrying out their responsibilities. The staff has carried on continuing review of the numerous instances in which Federal agencies have been involved in pollution controversy. Various reports have been requested and filed on Federal pollution problems.

Specific interest has been taken in the civil activities of the Corps of Army Engineers over which the Committee on Public Works has general jurisdiction. A close working relationship has been developed with the Department of Defense Committee on Environmental Quality to review the extent to which defense agencies are assuming leadership in pollution control in communities where military installations are located.

But the direct discharge of pollution from Federal facilities is only one area of Federal responsibility. In a number of cases Federal agencies contract for, license, permit or otherwise authorize and assist activities which may adversely affect water quality.

While water quality standards, now set and approved for most interstate waters, will cause installation of such control facilities as are necessary for compliance, serious question has been raised regarding the role of Federal agencies which authorize or assist such activities without requiring compliance with applicable standards.

In order to ascertain the extent to which Federal agencies are conducting such activities, the committee began, early last year, hearings on the role of the Atomic Energy Commission relative to control of waste heat discharges from federally licensed nuclear powerplants. The hearings indicated several important problems.

1. The Atomic Energy Commission does not consider its legislative authority sufficient to condition licenses relative to water quality standards for other than radioactive materials;

2. The AEC regulations specifically prohibit intervention or testimony on the subject of pollution other than radioactive discharges;

3. State agencies charged with water pollution control responsibility question their ability to require control of nuclear power-

plant waste heat discharges once that plant has been licensed for operation by a Federal agency, believing that the existence of the Federal license might preempt State regulatory authority;

4. Thermal pollution is of sufficient concern to require consideration prior to final selection of a steam electric powerplant site both because of the potential adverse effect of heated water discharges on the receiving streams and because of the land requirements associated with construction of cooling facilities if required; and

5. Waste heat discharges can seriously and adversely affect the ecological balance of the receiving waters and, though much remains to be learned about these effects, a sufficient body of evidence exists to establish standards and require control.

The information received during the hearings suggested a need for the Federal Government to become involved at an early stage in water quality control by entities which receive Federal authorization or assistance.

On September 16, the subcommittee invited comment on the extent to which the electric utilities industry should consider environmental hazards in selecting powerplant sites. This question resulted from information developed during the hearings pointing out—

1. Few utilities have considered ecological effects of waste heat discharges either in relation to site location or operation of thermal generating stations;

2. Little, if any, investigation has been made by most utilities to determine ecological background of receiving waters;

3. Use of existing cooling technology for other than conservation of water has not been considered by utilities until after intense public pressure has been exercised; and

4. The general assumption seems to be that any risk of adverse ecological effects associated with thermal pollution be taken by the public rather than the utility.

However, the correspondence which follows indicates that ecological effects are of significant importance to warrant early consideration in a utility's decision to construct new steam electric generating facilities.

Of particular interest is the following statement from the Edison Electric Institute:

Of course, the utility industry's primary responsibility is to provide electric power for the Nation reliably, in abundant amounts, and at the lowest reasonable cost. In meeting this responsibility, the industry considers a number of factors, among which is the effect its operations may have on the environment. Each decision to construct a powerplant is made within the framework of unique situations which apply to that particular site.

The committee is pleased with this response by the utility industry. But there is still serious question which can be raised regarding the point at which environmental effects are considered. Rather than being bound to a particular site and later considering the ecological effects of waste heat discharges at that site, the more appropriate course may be to select the site on the basis of environmental as well as other considerations. Not only would the public interest be better protected but the utility would have greater flexibility.

Also, the subcommittee asked Federal agencies and several concerned private groups to comment on the propriety of a requirement that licensees, permittees, etc., plan, prior to construction, to meet applicable

water quality standards. The responses, which follow, indicate a general need for Federal involvement, although the specific method is not spelled out in each case.

The subcommittee was pleased to learn that many Federal agencies, especially those in the power field, already condition their licenses and contracts—the Rural Electrification Administration, the Bonneville Power Administration, the Tennessee Valley Authority, and the Federal Power Commission are among those agencies which require consideration of the environment by the entities with which they deal.

The responses do not indicate, in all cases, the extent to which these agencies which require water quality consideration also use the facilities, the staff and the expertise of the Federal Water Pollution Control Administration. The Committee on Public Works recommended a change in section 11 of the Federal Water Pollution Control Act to require such cooperation and consultation for two reasons:

1. That Federal agencies should set such conditions on authorized or assisted activities as are necessary to insure compliance with applicable water quality standards; and
2. That the water pollution control expertise of the Federal Water Pollution Control Administration should be utilized by other Federal agencies in making such determinations.

The first point has been discussed above and is effectively summarized in the following paragraph in the letter from the General Counsel of the Commerce Department:

Accordingly, we share the concern expressed by the Department of the Interior as to the nature and extent of abatement relief which a court might grant upon complaint by the United States against a power plant constructed in compliance with the terms of a license issued by a Federal agency, even though the Federal agency did not, and was not required to, take into account ecological consideration in issuing such license.

The second point is important during this period of manpower restrictions in Federal agencies. Technical personnel should not be required to examine water pollution problems in each agency when the Federal Water Pollution Control Administration has the talent and expertise to provide information on what will be required to insure compliance with federally approved water quality standards.

At the same time it is not the intent of the committee to interfere with the legitimate function of those agencies whose authorized or assisted activities may affect water quality standards. The conditioning of licenses, leases, permits, or contracts should be the final responsibility of the parent agency. If the result of retaining final jurisdiction in the authorizing agency should not result in effective water quality control, further legislation would have to be considered.

Last year's amendment to section 11 of the Federal Water Pollution Control Act would have required those Federal agencies which issue licenses, leases, and permits, and enter into contracts, to cooperate with the Secretary of the Interior to insure compliance with water quality standards.

During congressional consideration of legislation which included this language, additional legislation was introduced which would authorize the Atomic Energy Commission to condition licenses to insure compliance with water quality standards. In response to an inquiry, Senator John O. Pastore sent the committee a Joint Atomic Energy Committee staff comparison which points out the compatibility of the two proposals.

LETTER OF SENATOR PASTORE, CHAIRMAN,
JOINT COMMITTEE ON ATOMIC ENERGY

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,

September 5, 1968.

HON. EDMUND S. MUSKIE,

*Chairman, Subcommittee on Air and Water Pollution, Committee on
Public Works, U.S. Senate, Washington, D.C.*

DEAR ED: This will acknowledge and thank you for your letter of July 19, 1968, concerning a legislative proposal now pending before the Joint Committee on Atomic Energy which would confer upon the Atomic Energy Commission regulatory authority over and responsibility for controlling the thermal effects of liquid effluents discharged from nuclear powerplants. Copies of H.R. 18667 and S. 3851, identical bills introduced on July 17, 1968, by, respectively, Representative Hollifield, for himself and Representative Price of Illinois, and Senator Anderson, for himself and Senator Aiken, are enclosed for your assistance. Your particular attention is invited to section 8 thereof, which would add a new section 111 ("Control of Thermal Effects") to the Atomic Energy Act of 1954.

After receipt of your letter I asked my staff to prepare a summary analysis of S. 3206 and to compare that bill with H.R. 18667 and S. 3851. I am enclosing a copy of that summary analysis for your information. Based on my understanding of it, and quite apart from the merits or demerits of H.R. 18667 and S. 3851, on which I have not yet formed any fixed opinion, I detect no conflict between these bills and S. 3206. If the staff's interpretation of S. 3206 is different from your understanding of the bill's import, I would very much appreciate being informed to this effect at your earliest opportunity.

One other matter is perhaps deserving of comment. The AEC has never told the Joint Committee that it had no desire or would be unwilling to exercise regulatory control over thermal pollution. The question of what role the AEC should play with respect to the regulation of nuclear powerplants from this standpoint was explored by the Joint Committee during hearings in 1967 and during more extensive hearings in 1968. In summary the Commission's position, as I understand it, is that neither the Atomic Energy Act, the Federal Water Pollution Control Act, nor Presidential Executive Order No. 11288 authorizes the Commission to regulate so-called thermal pollution from nuclear powerplants licensed by the Commission (a position which I understand was upheld in a legal opinion issued on April 15, 1968 by Assistant Attorney General Frank A. Wozencraft); that it would prefer that legislation providing for Federal regulation of thermal effects apply across the board, i.e., to both fossil-fueled and nuclear plants; but that if Congress chose to confer such authority on the AEC the Commission has or could obtain the technical staff neces-

sary to regulate nuclear plants from the thermal effects standpoint as well as from the standpoint of radiological health and safety and the common defense and security. If the Commission has taken a different position before other committees or subcommittees of Congress I would most certainly appreciate having any relevant testimony or correspondence in this regard brought to my attention.

While the Joint Committee has heard from a number of Federal agencies, including the Department of the Interior and the Water Resources Council, and from certain State officials concerning the question of conferring regulatory authority on the AEC over thermal effects, H.R. 18667 and S. 3851 were not then pending before the committee. To date only the Commission has had an opportunity to testify on these more recent bills. It may well be, therefore, that the committee will wish to hold early hearings on these bills before taking further action on them. In this connection, any comments that you may have on this legislation will of course be welcomed by the committee, particularly since the forceful role which your subcommittee has taken in attempting to combat various forms of pollution was instrumental in increasing the Joint Committee's awareness of the potential problems associated with thermal effects from nuclear powerplants.

Cordially yours,

JOHN O. PASTORE, *Chairman.*

[Enclosure]

JOINT COMMITTEE ON ATOMIC ENERGY INTEROFFICE MEMORANDUM

AUGUST 27, 1968.

To: Hon. John O. Pastore.

From: John T. Conway, Executive Director.

Subject: Summary analysis of section 5 of S. 3206.

This responds to your recent request for a summary analysis of section 5 of S. 3206 as passed by the Senate on July 10, 1968, and a comparison of it with the provisions of H.R. 18667 and S. 3851 (the so-called Holifield-Anderson bill) dealing with AEC controls over heated liquid discharges—that is, “thermal pollution”—from licensed nuclear powerplants.

Section 5 of S. 3206 would amend section 11(a) of the Federal Water Pollution Control Act to require any Federal department or agency which issues any lease, license, or permit, or enters into any contract, for any activity, to “cooperate” with the Secretary of the Interior, and in certain cases with appropriate State, local or interstate agencies, “to insure compliance with applicable water quality standards and the purposes of this Act.” At the time of Senate floor consideration of the bill, Senator Muskie, chairman of the Senate Subcommittee on Air and Water Pollution and sponsor of the bill, said that in order to carry out the purpose of the amendment, “Federal agencies will necessarily have to add such conditions to contracts, leases and permits as may be necessary to insure compliance with water quality standards.”

It is not unequivocally clear from the terms of section 5 which agency—the one possessing licensing responsibility, or that with thermal pollution control responsibility—would have the ultimate re-

sponsibility and authority for determining what "conditions" concerning compliance with water quality standards shall be included in any affected "lease, license, * * * permit * * * or contract * * *." This uncertainty, moreover, is not entirely eliminated by the rather meager legislative history of the amendment. However, a fair reading of the amendment would seem to suggest that licensing and regulatory agencies such as the Atomic Energy Commission are to determine for themselves, within the context of their existing responsibilities and authorities, whether and what conditions shall be imposed on a licensee with respect to control of thermal effects. In other words, as I interpret section 5 of S. 3206, the authority to control thermal effects would be merely another tool which the AEC would employ to regulate the nuclear industry from the standpoint of what Congress deems to be the national interest. Thus the advice of the Secretary of the Interior with respect to thermal effects would be entitled to no more nor any less consideration than the expert advice received by the Commission from such bodies as the U.S. Geological Survey, the Coast and Geodetic Survey, the Fish and Wildlife Service, the Advisory Committee on Reactor Safeguards, and the Department of Justice.

Any other interpretation of S. 3206 would, it seems to me, raise constitutional questions (since, as far as I am aware, no provision is made for an opportunity for a hearing for an affected license applicant) and most certainly grave policy questions. Thus, for example, where imposition on a licensee of a condition concerning, for instance, the construction of a water-cooling system of a specified type or capacity could have an impact on those facilities which are directly related to radiological health and safety, there would be cause for substantial concern if the AEC could not balance the thermal effects aspects of the facility against the critical—indeed, the exceedingly critical—radiological health and safety aspects thereof. Presumably the Congress would wish to give these and other questions the closest scrutiny if it were to consider reposing with the Secretary of the Interior final authority to determine whether and what conditions respecting compliance with water quality standards should be included in leases, licenses, permits, or contracts issued or entered into by other Federal departments and agencies.

If this interpretation of S. 3206 is correct, it appears that H.R. 18667 and S. 3851 are fully compatible with it. These latter bills would simply establish a formal framework within which the cooperation required by S. 3206 would be carried out. The legislation would spell out the authority of the Commission to withhold or to condition a license on the basis of thermal effects considerations. Moreover, a fixed time within which the Secretary of the Interior must furnish his advice to the Atomic Energy Commission would be established, an important consideration in view of the burgeoning demand for electrical energy and the need to avoid any unnecessary delays in getting new generating capacity into operation. As you know, the AEC and the Fish and Wildlife Service and the U.S. Geological Survey within the Department of the Interior have for some time carried out a cooperative arrangement on an informal basis whereby the AEC seeks the expert advice of both such agencies with respect to each license application for a nuclear powerplant coming before the Commission. Accord-

ing to testimony before the Joint Committee, the AEC and the Federal Water Pollution Control Administration within the Interior Department are now in the process of establishing a somewhat similar arrangement. However, the advice received from the FWPCA would relate to matters over which the AEC asserts it has no jurisdiction, that is, thermal effects. The Holifield-Anderson bills, as I understand them, would put such cooperative arrangement on a statutory basis so as to eliminate any question of the AEC's authority to exercise thermal pollution controls over its licensees.

LETTER FROM SENATOR EDMUND S. MUSKIE TO INTERESTED ORGANIZATIONS REGARDING THERMAL POLLUTION

(An identical letter was sent to those organizations which replied for the record. The replies follow, beginning on p. 983.)

U.S. SENATE,
COMMITTEE ON PUBLIC WORKS,
Washington, D.C., September 16, 1968.

HON. STEWART L. UDALL,
*Secretary, Department of the Interior,
Washington, D.C.*

SECRETARY UDALL: As you are aware, the Subcommittee on Air and Water Pollution has been conducting hearings on thermal pollution. The testimony has emphasized environmental factors considered in selecting nuclear electric generating plantsites, and the effects of waste-heat discharges on river, lake, estuary, and marine ecologies.

Two public policy questions have received particular attention. First, what should be the extent of the electric utilities industry's responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities? Second, what should be the extent of the responsibility of Federal agencies to insure compliance with applicable water quality standards when issuing a lease, license, or permit?

The activities resulting from my recent nomination as the Democratic Vice-Presidential candidate have placed such a demand on my time that further hearings of the subcommittee on this subject are not possible at this time. Therefore, in order to complete the hearing record, I am taking this opportunity to extend an invitation to you, or your designee, to submit a statement.

Your early response to this letter would be appreciated. It is our intention to close the record on October 18, 1968. Should any questions arise concerning this invitation please direct them to Mr. Richard D. Grundy of the professional staff of the subcommittee (telephone 202 225-6176).

Sincerely,

EDMUND S. MUSKIE,
Chairman, Subcommittee on Air and Water Pollution.

REPLY OF THE DEPARTMENT OF THE INTERIOR

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., November 6, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, Committee on
Public Works, U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: Your letter of September 16 raises two policy questions relative to the problem of selecting nuclear electric generating plantsites, and to the problems of waste-heat discharges on our waters and requested our comments to complete your subcommittee's hearing record on the subject.

Enclosed is my statement on this subject for the hearing record.

At the same time, I want to express my appreciation for your efforts in trying to obtain enactment of a sound water pollution bill this year. While I am naturally disappointed that we could not succeed this year, I share your view that provisions to insure compliance with water quality standards where there is a federally conducted, approved or supported activity were also a vital part of that bill. I hope that the Congress will act quickly next session to enact a good water pollution control bill with this feature.

The Bureau of the Budget has advised that there is no objection to the presentation of this statement from the standpoint of the administration's program and concurs in the recommendation made therein.

Sincerely yours,

STEWART L. UDALL,
Secretary of the Interior.

STATEMENT OF SECRETARY OF THE INTERIOR

INTRODUCTION

Mr. Chairman, I want to first take this opportunity to commend this subcommittee for focusing on one of the most critical environmental problems facing this Nation—that is, the problem of thermal pollution. The extensive hearings that you have held both in various parts of the country and in Washington during the past year have been of major assistance in defining the dimensions of the problem and charting the courses of action required to combat it. In addition, you have alerted the responsible people in industry to the problem and have impressed upon them that they have a clear responsibility to act now to cope with the problem, as other industries are doing in the case of other pollutants.

I welcome the opportunity to present this Department's views on the two public policy questions which have received particular attention during your hearings:

The extent of the responsibility of the electric utilities industry to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities; and

The extent of the responsibility of Federal agencies to insure compliance with applicable water quality standards when considering a license, lease, or permit.

THE PROBLEM

Thermal pollution, in one definition, is an increase in water temperature which will or is likely to render the waters harmful to public health, safety, or welfare, or to a legitimate water use, or to cause a nuisance as a result of increased biological activity.

The chief contributor to thermal pollution is the electric power industry, which uses vast amounts of water for cooling and condensing. Because of new interest in pollution in its less obvious forms, and because of the enormous increase in electric energy production since World War II, thermal pollution has become the object of mounting concern. With our burgeoning power demands, the amount of heat to be dissipated into the environment will continue to skyrocket. In the future, we can expect a greater demand for electric power, larger plants, a higher percentage of thermal plants, and more plants using nuclear energy.

The trend by electric utilities to "go nuclear" adds a new dimension. Projections by the Atomic Energy Commission indicate that by 1980, nuclear plants will have 25 percent of the total generating capacity in the United States. Because of less efficient use of heat, nuclear powerplants release about 40 percent more heat to the environment than conventional fossil-fuel plants or discharge the water at a higher temperature.

All of this will lead to more waste heat and, unless we take corrective steps, to an intolerable increase in the thermal pollution of the Nation's waters.

Thermal pollution has become a much-discussed water quality problem, particularly as it relates to damage to aquatic life. Discharges of heated water from fossil fuel and nuclear power generation, other industrial process cooling, and from lesser sources affect temperatures in receiving waters and may cause damage to aquatic life and impair other water uses. Often overlooked in considering problems from thermal pollution is the presence of toxic chemical contaminants in the effluent—usually as periodic discharges resulting from use of cleaning compounds and flushing out the system. Leaching of metallic ions from condensers is a potential pollution problem—resulting, in at least one instance, in "green" oysters being produced near one effluent as a result of excess accumulation of copper ions.

The warming of water accelerates most of the biological and chemical processes that occur in water, sometimes to an extent that affects the kind, as well as the degree, of water quality modifications. These effects of warming are significantly aggravated by the fact that the capacity of water to dissolve and hold oxygen is decreased as the water is warmed. Thus, the more rapid decomposition of organic material that occurs in warmed water can result in oxygen depletion. Attain-

ment of threshold temperature levels may bring about reactions that cause otherwise tolerable concentrations of materials, such as the sulfides of wood pulping, to become toxic to aquatic life.

Few major interstate streams have not been affected by heated discharges. Some, like the Mahoning River in Ohio, have been permanently affected by heat loads and reservoirs so that the "normal" temperature is well above that which existed before man made his impact.

CONTROL AND PREVENTION OF THERMAL POLLUTION

Thermal pollution can be controlled where it exists today through the water quality standards program. Abatement actions can and will be instituted by the States and the Federal Government where necessary.

Thermal pollution is, however, one form of pollution that can and should be prevented. We do not and should not have to wait to abate this form of pollution after it has despoiled the Nation's watercourses. I am convinced, however, that neither industry, nor government can do this alone. It is a joint responsibility. Federal and State governments have the responsibility to develop the means to insure that industry will act to prevent this pollution at the early stages of development. Industry, too, has responsibility to face the problem and to work with government in devising the means to insure such prevention.

The following is a discussion of how this should be accomplished.

Technological controls

Technological controls are essentially of four types; all or none of which may be effective in a given case.

(1) *The reduction of waste heat by improving the efficiency of thermal plants.*—Attempts to limit the output of waste heat in fossil- and nuclear-fired electric plants are essentially means for improving the processes by which electricity is generated so as to achieve a better conversion of the heat into useful energy. Energy conversion is more efficient today than 25 to 30 years ago. The average heat rate, or the amount of heat required to produce 1 kilowatt of electricity, is now about 10,000 British thermal units as compared with 16,500 British thermal units per kilowatt-hour in 1938. The Federal Power Commission suggests that heat rates of 8,500 British thermal units per kilowatt-hour are likely by 1980. While this would reduce the thermal discharge by almost 20 percent, it still means that only 40.2 percent of the heat will be converted to electrical energy. At best, then, by 1980, 60 percent of the heat input to a coal-fired plant (less stack and mechanical losses) is waste and will have to be put to other uses or dissipated to the environment.

(2) *The management of heat and the receiving environment to reduce the deleterious effects of the heat.*—The methods that may be considered in minimizing changes in temperature include increasing turbulence to provide aeration and cooling; introducing the heated effluent into deep portions of the receiving water; and construction of partial dams and obstructions in the original watercourse. Another approach to meeting thermal control for a powerplant may be to close down for normal maintenance during the months when the climate and other water use factors combine to make additions of heat most hazardous.

Dilution is another possibility; however, while diluting heated effluent will reduce the impact on the entire stream, it does not necessarily protect the immediate aquatic environment from the impact of the heated effluent.

Dispersion is used to spread the heated discharge through a maximum volume of the receiving water. A jet of water may be used to spread the heated water over the surface of the stream, or multiple outlet conduits can be placed far out into the water. Dispersion will reduce the total rate of heat loss to the atmosphere and might not be a desirable means in all cases.

Another important means of reducing the impact of heated discharges on the total aquatic environment is siting. Electric powerplants can be so located as to produce the least impact on the total resources.

(3) *The disposal of excess heat through cooling towers, cooling ponds, or spray ponds.*—Cooling ponds allow heat to pass from a water surface to the air immediately above. Spraying hot water into the pond or reservoir facilitates thermal exchange by allowing heat to pass from water droplets to air as well as from pond surface to air. Natural draft cooling towers—which operate by pumping water to the top of a structure, from whence it flows vertically downward, exposed to air flowing horizontally through louvers—provide heat exchange at the air/water interface. Mechanical draft cooling towers operate in much the same fashion, with the addition of fans to induce air movement through the tower. Substitutions of air or other coolants for water offer other methods of controlling thermal pollution which may, in the future under specialized conditions, be applied.

(4) *Making productive use of waste heat.*—The heat which cannot be transformed into electrical power can sometimes be put to use in some other beneficial way. This is one of the most promising approaches to the thermal pollution problem. Tests in the Pacific Northwest are being conducted to study the possibility of using heated discharges for irrigation so that the growing seasons in select locations can be extended. In the State of Washington and in parts of the East, experiments are underway to study the warm water cultivation of oysters. The idea of warming our northern beaches to increase recreational opportunities is also being considered. Desalting water, heating buildings, and industrial process heating are still other possible uses for waste heat.

Formal controls

Siting

First, let me say, that I believe the problem of thermal pollution control through site planning is a joint responsibility of industry and Government and not of industry alone.

Industry has the initial responsibility for selecting a site for a powerplant and must consider many factors in making this selection, such as market area, source of cooling water, transmission lines, costs, and environmental factors. The latter includes not only water quality, but also esthetics and other uses of the market area.

Governmental bodies also have a responsibility here. As has been the case in the development of many water impoundments in this Nation for hydroelectric purposes, a particular powerplant at a particular site may not be permitted where, for example, it would cause

irreparable damage or destruction to a valuable spawning area or wildlife habitat or where it would destroy or impair an area of national or regional or even local significance such as an historic site or a recreation area.

The power industry, like other industries, must consider the impact of its operations on the environment, and must locate plants and design facilities with a view toward minimizing adverse environmental effects. Long-range planning for power development must consider the cumulative effect of all existing and proposed plants and other dischargers located in, or proposed for, a particular area.

Problems in the siting of new steam electric plants are of increasing concern to this Department. Together with the Atomic Energy Commission, the Department of Health, Education, and Welfare, the Federal Power Commission, the Rural Electrification Administration, and the Tennessee Valley Authority, we are cooperating with the Office of Science and Technology in a study of steam powerplant siting. The preliminary indications are that the siting problem in the future will not be one of finding room for many plants, but will be one of insuring that a relatively small number of very large plants are adequately planned to achieve low-cost, reliable power while preserving the quality of the environment.

The prevention of water pollution and the assurance that developers install the necessary equipment and take other steps such as a better site selection process in order to prevent damage to the environment and aquatic resources requires that water quality and other environmental factors should be taken into consideration in the planning, design, and siting of facilities prior to making application for any Federal lease, license, or permit, where one is required. At this stage also, the appropriate State water-pollution-control agency should be consulted.

Water quality standards

The water quality standards program is today recognized as the best hope available for coming to grips with the water-pollution problems facing this Nation. It should be emphasized, however, that it is not a program aimed solely at controlling existing pollution. The standards can prevent deleterious effects as well as provide the basis for abatement of existing pollution, but for this program to be effective, all dischargers of wastes must conform.

To protect water quality and uses of interstate, including coastal, waters, where most power development will occur in future years, water-quality standards are being established pursuant to the provisions of the Water Quality Act of 1965. Many States are also setting standards for intrastate waters.

Water-quality standards protect legitimate uses of the waters through application of numerical and narrative limits on pollutants, and the specification of necessary treatment and control measures. To prevent damage to aquatic life and other uses in interstate waters from thermal pollution, all of the 50 States, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands submitted to the Department of the Interior for approval water-quality standards, including temperature criteria. The specific criteria vary from State to State. Each of the State standards which have been approved by the Secretary of the Interior includes a narrative statement limiting deleterious

effects of discharges, and numerical limits on temperature maximums and amounts of change or increase.

States have not generally specified the implementation measures that will be necessary to assure compliance with the temperature criteria. The standards require that dischargers of heated wastes take measures necessary to meet the water quality criteria assigned to protect legitimate uses in the receiving waters. Specific implementation measures were omitted on the basis that the effect of heat discharges on existing water temperatures must be studied on a case-by-case basis.

The following is a brief statement respecting temperature criteria guidelines set forth in the report of the National Technical Advisory Committee to the Secretary of the Interior of April 1, 1968. Obviously, these guidelines must be shaped to the particular conditions applicable to the waters for which water-quality standards are to be established:

"TEMPERATURE

Warm-water biota.—To maintain a well-rounded population of warm-water fishes, the following restrictions on temperature extremes and temperature increases are recommended:

"(1) During any month of the year heat should not be added to a stream in excess of the amount that will raise the temperature of the water (at the expected minimum daily flow for that month) more than 5° F. In lakes, the temperature of the epilimnion in those areas where important organisms are most likely to be adversely affected should not be raised more than 3° F. above that which existed before the addition of heat of artificial origin. The increase should be based on the monthly average of the maximum daily temperature. Unless a special study shows that a discharge of a heated effluent into the hypolimnion will be desirable, such practice is not recommended and water for cooling should not be pumped from the hypolimnion to be discharged to the same body of water.

"(2) The normal daily and seasonal temperature variations that were present before the addition of heat due to other than natural causes should be maintained.

Cold-water biota.—Because of the large number of trout and salmon waters which have been destroyed, made marginal, or nonproductive, remaining trout and salmon waters must be protected if this resource is to be preserved.

"Inland trout streams, headwaters of salmon streams, trout and salmon lakes, and the hypolimnion of lakes and reservoirs containing salmonids and other cold water forms should not be warmed or used for cooling water. No heated effluents should be discharged in the vicinity of spawning areas.

"For other types and reaches of cold-water streams, reservoirs and lakes, the following restrictions are recommended:

"(1) During any month of the year heat should not be added to a stream in excess of the amount that will raise the temperature of the water more than 5° F. (based on the minimum expected flow for that month). In lakes, the temperature of the epilimnion should not be raised more than 3° F. by the addition of heat of artificial origin.

"(2) The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes should be maintained."

Another aspect of concern in connection with water quality standards is "mixing zones" or "zones of passage." The following quote from the same report sets forth the Department's position on mixing zones:

"Any barrier to migration and the free movement of the aquatic biota can be harmful in a number of ways. Such barriers block the spawning migration of anadromous and catadromous species. Many resident species make local migrations for spawning and other purposes and any barrier can be detrimental to their continued existence. The natural tidal movement in estuaries and downstream movement of planktonic organisms and of aquatic invertebrates in flowing fresh waters are important factors in the repopulation of areas and the general economy of the water. Any chemical or thermal barrier destroys this valuable source of food and creates unfavorable conditions below or above it.

"It is essential that adequate passageways be provided at all times for the movement or drift of the biota. Water quality criteria favorable to the aquatic community must be maintained at all times in these passageways. It is recognized, however, that certain areas of mixing are unavoidable. These create harmfully polluted areas and for this reason it is essential that they be limited in width and length and be provided only for mixing. The passage zone must provide favorable conditions and must be in a continuous stretch bordered by the same bank for a considerable distance to allow safe and adequate passage up and down the stream, reservoir, lake, or estuary for free-floating and drift organisms.

"The width of the zone and the volume of flow in it will depend on the character and size of the stream or estuary. Area, depth, and volume of flow must be sufficient to provide a usable and desirable passageway for fish and other aquatic organisms. Further, the cross-sectional area and volume of flow in the passageway will largely determine the percentage of survival of drift organisms. Therefore, the passageway should contain preferably 75 percent of the cross-sectional area and/or volume of flow of the stream or estuary. It is evident that where there are several mixing areas close together they should all be on the same side so the passageway is continuous. Concentrations of waste materials in passageways should meet the requirements for the water.

"The shape and size of mixing areas will vary with the location, size, character, and use of the receiving water and should be established by proper administrative authority. From the standpoint of the welfare of the aquatic life resource, however, such areas should be as small as possible and be provided for mixing only. Mixing should be accomplished as quickly as possible through the use of devices which ensure that the waste is mixed with the allocated dilution water in the smallest possible area. At the border of this area, the water quality must meet the water quality requirements for that area. If, upon complete mixing with the available dilution water these requirements are not met, the waste must be pretreated so they will be met. For the protection of aquatic life resources, mixing areas must not be used for, or considered

as, a substitute for waste treatment, or as an extension of, or substitute for, a waste treatment facility.”

COMPLIANCE WITH WATER QUALITY STANDARDS

The Water Quality Act of 1965 provides one method of insuring compliance with water quality standards, namely an abatement action when there is a discharge that reduces the quality of the water below the standards. It is a remedy that will be pursued where pollution exists. But this is an after-the-fact remedy. It is a control measure. It is not the preventive medicine that should be practiced. Where we have other effective tools to insure compliance, we should use them and, if necessary, strengthen them.

One potentially very effective tool is the Federal lease, license, permit, and contract. This is true not only in the case of thermal pollution, but also in the case of other pollutants. The review process attendant to the issuance of a Federal lease, license, permit, or contract affords an excellent opportunity to examine, at an early stage in the development of a proposed project, its impact on the environment and to prevent or minimize damage from occurring therefrom. At this stage, the water quality impact of the project can be studied by the water pollution control officials of the affected State and the Department of the Interior, and industry can receive expert advice to insure compliance with water quality standards. The licensing, etc., agency can require the installation of the pollution control measures which are immediately necessary to protect water quality and water uses prior to construction and operation. Also, it is a means of continuing control by the licensing agency. The Federal licensee, etc., is required by the licensing agency to comply with the conditions of his license. These conditions would, under this method of control, include provisions designed to insure uniform compliance on a continuing basis with water quality standards. These conditions would, of course, be couched in general terms since the specific requirements may change over the life of the license, etc., as conditions and needs change.

The Federal Power Commission, pursuant to section 10(a) of the Federal Power Act (16 U.S.C. 802(a)), requires that public use and environmental factors be considered in the issuance of its licenses for hydroelectric powerplants to insure that a project “will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for * * * other beneficial public uses, including recreational purposes.” Fossil-fuel plants which are a major contributor to thermal pollution, however, are not licensed by the Commission under that act, except where they are a part of a federally licensed hydro project.

On September 23 of this year, the Commission issued a significant order (copy attached) respecting the application of the Arkansas Power & Light Co. for FPC approval to use lands and waters of a federally licensed project at Lake Catherine for a cooling water facility in connection with a proposed addition to its steam electric plant. The order approving the application requires the power company to finance a study, in cooperation with appropriate Arkansas State agencies, and the Federal Water Pollution Control Administration and the Bureau of Sport Fisheries and Wildlife of this Department, to deter-

mine the effect of heat load mixing in Lake Catherine and its effect on fish and wildlife resources before and after the installation and operation of the cooling water facility. The power company is required to file the results of the study and proposals for protection of the waters of the lake, downstream waters, and fish and wildlife resources by July 1971, and to advise the Commission immediately during the course of the study of any adverse effects of the plant, with proposals for remedial action. The Commission reserves the right to order appropriate remedial actions if the power company fails to act. The order extends to effects of chlorine discharges and other chemicals used to clean the condenser units.

This order is a good example of how the licensing authority can be effectively utilized to protect the environment for the benefit of the public.

The Atomic Energy Commission which licenses nuclear powerplants, advises that, unlike the Federal Power Commission, it lacks a statutory base for considering and conditioning a license in the case of thermal pollution, although the Commission does consider radiological effects. The AEC does, however, provide applicants with comments made available by the constituent agencies of the Department of the Interior which, under a memorandum of understanding with the Commission,¹ review construction permits and operating licenses with respect to their areas of interest and responsibilities. Under this agreement, the Department's U.S. Fish and Wildlife Service has provided comments to AEC regarding the potential effects of nuclear and other discharges on fish and wildlife. The Service also considers the effects of waste heat and chemicals, as well as the effect of intake facilities on fish and fish food organisms in the source water supply. The Federal Water Pollution Control Administration also reviews AEC license and permit applications in this process to assess radiological and chemical pollution effects.

Comments on radiological hazards are considered and acted upon by AEC.

Comments on temperature, chemical discharges, and intake facilities are transmitted by the Commission to the power companies with the request that they discuss them with State and Federal control agencies on a voluntary basis. The Commission does not believe, however, that it can require modifications in the license application for this purpose.

As a matter of fact, two recent amendments to the AEC's rules of practice make it abundantly clear that the AEC views the problems of thermal pollution, esthetics, and effects on other uses in the area as "irrelevant" to the issues in the case, or outside their jurisdiction, and as precluding intervention by this Department or anyone on these grounds (see 33 F.R. 8587). The amendments provide:

"Objections may be made by counsel to any questions or any line of questioning, and should be ruled upon by the board. The board may admit the testimony, may sustain the objection, or may receive the testimony, reserving for later determination the question of admissibility. In passing on objections, the board, while not bound to view

¹ "Memorandum of Understanding With Regard to Procedures for Cooperation Between the Atomic Energy Commission and the Department of the Interior Pertaining to Location and Operation of Proposed Nuclear Installations Subject to Licensing and Regulation by the Commission," March 1964.

proffered testimony according to its admissibility under strict application of the rules of evidence in judicial proceedings, should exclude testimony that is clearly irrelevant to issues in the case, or that pertains to matters outside the jurisdiction of the board or the Atomic Energy Commission. Examples of matters which are considered irrelevant to the issues in the case or outside the jurisdiction of the board or the Atomic Energy Commission include the thermal effects (as opposed to the radiological effects) of the facility operation on the environment; the effect of the construction of the facility on the recreational, economic, or political activities of the area near the site; the matters of esthetics with respect to the proposed construction. Irrelevant material in prepared testimony submitted in advance under section 2.743(b) may be subject to a motion to strike under the procedures provided in section 2.730.

"INTERVENTION

"(a) Any person whose interest may be affected by a proceeding and who desires to participate as a party shall file a written petition under oath or affirmation for leave to intervene not later than the time specified in the notice of hearing, or as permitted by the presiding officer. The petition shall set forth the interest of the petitioner in the proceeding, how that interest may be affected by Commission action, and the contentions of the petitioner in reasonably specific detail. A petition which sets forth contentions relating only to matters outside the jurisdiction of the Commission will be denied. A petition for leave to intervene which is not timely filed will be dismissed unless the petitioner shows good cause for failure to file it on time."

With this background, if the applicant fails to heed the Federal and State advice on a voluntary basis and insists on a license, it appears that the Commission would have no alternative but to grant it. This possibility gives us considerable concern.

As we have said, Interior and the States cannot with complete effectiveness carry out our responsibilities under the Water Quality Act of 1965 if the licensing agency, such as the Atomic Energy Commission, cannot refuse to issue a license for a nuclear power facility despite our advice that the facility's discharge may or will reduce the quality of waters below the applicable standards. Our only recourse then is an abatement action after the fact. We are not enchanted by the prospects this method offers once a facility costing a substantial sum of money is developed and operating under a Federal license. Recent court decisions in the *High Mountain Sheep* (387 U.S. 428) and *Storm King* (354 F. 2d 608) cases are evidence of a disposition on the part of the courts to expect the public interest, including the protection of the environment, to be considered in the issuance of Federal licenses.

We do not mean to imply, however, that Interior should have a "veto" relative to the issuance of an AEC license. That is the AEC's function, but the Commission should not be given the function of determining whether the thermal effluent will violate water quality standards. This is properly an Interior function. Also, we are not interested in approving the design of the plant or its operations. This too is properly an AEC function.

Our function is to determine that the proposed discharge will or will not meet the applicable water quality standards for that portion of

the waters where the discharge occurs. This function is primarily a pollution problem requiring a determination of whether the proposed federally licensed facility will be in compliance with applicable water quality standards. This Department has the primary responsibility in the Federal Government to control water pollution in interstate and coastal waters. This responsibility should not be fragmented. We work closely with the State water pollution control agencies. These agencies under the Water Quality Act of 1965 have the initial responsibility to adopt water quality standards for these waters. We have the sole Federal responsibility to approve and enforce them. In addition, the States, with encouragement from this Department, are adopting standards for intrastate waters.

RECOMMENDATION

It is our firm view that all Federal agencies authorizing, or assisting, through licenses, leases, permits, or other means, any activity, which discharges wastes into any waters should uniformly be required, in consultation with Interior and the State water pollution control agency, to insure compliance with applicable water quality standards.

The philosophy that supports this approach is simple. The Federal Government has a national policy of controlling water pollution. It also has a national policy of encouraging power development. The Government, however, should not close its eyes to one of these national policies—water pollution control—while encouraging the other—in this case the development of power. We must be able to deal with the pollution problem before it occurs—before the plant is developed. Where the Federal Government has the capability and responsibility—in this case through a licensing power—we should make certain that other effects are considered in the licensing process.

The Nation needs power. Power development is essential to the growth of the national economy. But the cost of measures for the control of thermal pollution is part of the cost of doing business.

Legislation (S. 3206) passed by the Senate last July which amended section 11 of the Federal Water Pollution Control Act, as amended, is consistent with this recommendation. It directed that the licensing, and so forth, agencies insure such compliance, and gave Interior and the States the role of determining whether the proposed discharge meets the applicable water quality standards. We believe that this approach is wise and workable.

I hope that a provision similar to the section 11 amendment in S. 3206 will be included in any water pollution control bill enacted in the 91st Congress.

The Bureau of the Budget has advised that there is no objection to the presentation of this statement from the standpoint of the administration's program and concurs in the recommendation made therein.

APPENDIX

RESEARCH IN THERMAL POLLUTION CONTROL

The annual report to the President and to the President's Council on Recreation and Natural Beauty, submitted in June 1968, by Laurance S. Rockefeller, chairman of the Citizens Advisory Committee on Recreation and Natural Beauty, gave primary consideration to

the impact of the electric utility industry on the environment. One of its recommendations for Federal action was the "acceleration of research aimed at satisfying safety requirements for siting of nuclear generation plants in major centers of population, and at finding better, more efficient solutions to the problem of disposal of waste heat from nuclear generation."

The report on research needs of the National Technical Advisory Committee on Water Quality Criteria, a panel of experts appointed by me under the Water Quality Act of 1965, echoes these recommendations for further study on thermal effects. The committee cites the need for heat dissipating criteria for rivers, lakes, and estuaries as well as additional research on the effect of thermal discharges on the chemistry of the receiving bodies of water and aquatic life.

To meet this well-identified need for further research, the Department of the Interior has placed a high priority on thermal pollution. We have assigned the national responsibility for research in this area to FWPCA's Pacific Northwest Water Laboratory at Corvallis, Oreg. There, the biological, engineering, and economic aspects of thermal pollution are being studied. Specific elements in the national thermal pollution research program include: (1) Measurement techniques; (2) determination of the sources of heat input to water; (3) transport and behavior of thermal discharges (fate studies); (4) effects of thermal pollution; (5) treatment processes such as cooling devices, and dilution; (6) nontreatment control (e.g., process change to decrease thermal discharges such as increased efficiencies of thermal powerplants); and (7) utilization of waste heat.

In addition to in-house research at Corvallis, and at other FWPCA laboratories, investigations are presently being carried out through a grant and contract program with universities and industry, and through joint research efforts with industry, other Federal agencies, and other interested parties. A representative list of research projects on thermal pollution awarded by the Federal Water Pollution Control Administration in fiscal year 1968 follows. Also included is a listing of on-going FWPCA research activities dealing with thermal pollution.

FWPCA research grants on thermal pollution in fiscal year 1968

- Lehigh University \$24,830: "Thermal and Industrial Pollution."
 Massachusetts Institute of Technology \$27,047: "Thermal Stratification and Reservoir Water Quality."
 Vanderbilt University \$46,763: "Project for Concentrated Research and Training in the Hydrologic and Hydraulic Aspects of Water Pollution Control."
 Vanderbilt University \$21,670: "National Symposium on Thermal Pollution."
 Vanderbilt University \$30,552: "Status of Thermal Pollution and Research Needs."
 Institute of Marine Sciences \$37,156: "Effects of Thermal Pollution on Biota of Biscayne Bay."
 Water Resources Engineering, Inc. \$46,283: "Formulation of a General Mathematical Model for the Prediction of Thermal Energy Changes in Impoundments."

FWPCA in-house activities related to thermal pollution

1. Preparation of an "Industrial Waste Guide on Thermal Pollution."
2. State-of-the-art report on the effect of thermal pollution on salmonoid fish.
3. Assisting the Columbia River Thermal Effects Study which is being conducted at the Northwest Regional Office in Portland, Oregon.
4. Studies on the design and efficiencies of cooling devices.
5. Techniques for establishing biological base lines for thermal pollution.

DESCRIPTION OF FWPCA FISCAL YEAR 1968 GRANTS AND CONTRACTS

1. *Lehigh University* "Thermal and Industrial Pollution: Delaware River."—In the 7-mile stretch of the Delaware River from Riegelsville, N.J., down to Milford, N.J., there are four papermills which produce variable discharges into the river. About half way between these two limits is a steam-electric generating station which discharges heated water. This study will operate automatic monitoring stations to develop comparative data for the river above and below the areas of cited pollution.

2. *Massachusetts Institute of Technology* "Thermal Stratification and Reservoir Water Quality."—The objective of this study is to develop a mathematical model for the prediction of the temperature distribution (as a function of depth and time) in a reservoir.

3. *Vanderbilt University* "Project for Concentrated Research and Training in the Hydrologic and Hydraulic Aspects of Water Pollution Control."—The objective of this study is to formally establish a training and research center for the study of the hydraulic and hydrologic factors affecting water pollution control.

4. *Vanderbilt University* "Status of Thermal Pollution and Research Needs."—The objective of this study is to compile an exhaustive bibliography on thermal pollution and after intensive review, to select the most meaningful and current references from the bibliography and subject these papers to critical review and summary. From this, it is expected to obtain: (1) The current stage of development of the topic, (2) major research needs and the most fruitful approaches of these needs, and (3) existing and potential water quality problems due to heated discharges.

5. *Institute of Marine Sciences* "Effects of Thermal Pollution on Biota of Biscayne Bay."—The objective of this study is to determine the effects of thermal effluent on the macro-fauna and -flora of Biscayne Bay, south Florida as successive generators (both conventional and nuclear) come into operation at the Florida Power & Light Company plant site at Turkey Point.

6. *Water Resources Engineering, Inc.*, "Following of a General Mathematical Model for the Prediction of Thermal Energy Changes in Impoundments."

DESCRIPTION OF IN-HOUSE EFFORTS ON THERMAL POLLUTION

1. *Preparation of an "Industrial Waste Guide on Thermal Pollution."*—This effort involves a literature review to gain knowledge of problems, effects, control or any new development pertaining to ther-

mal pollution so that revisions can be made to keep information up to date.

2. *State-of-the-art report on the effects of thermal pollution on salmonoid fish.*—This effort involves a literature review on the effects of temperature on salmonoid fishes.

3. *Columbia River thermal effects study.*—This effort consists of three phases: (a) phase 1 is concerned with allowable temperature levels for salmonoid in vivo; (b) phase 2 is concerned with the effects of sublethal temperature shock on tissues; and (c) phase 3 is concerned with the combined effects of temperature levels and maximum allowable levels of other pollutants.

4. *Studies on the design and efficiencies of cooling devices.*—This effort consists of the evaluation of present designs and the feasibility of new cooling devices and methods as to their efficiency and practicality as methods of reducing the heat rejected by industrial sources to nearby receiving waters.

5. *Techniques for establishing a biological baseline.*—This effort plans to assemble and evaluate biological survey plan that would assess the effect of a potential thermal discharge on the biological community of the receiving water.

FEDERAL POWER COMMISSION

(Project No. 271)

Arkansas Power & Light Company

Before Commissioners: Lee C. White, Chairman; L. J. O'Connor, Jr.,
Charles R. Ross, Carl E. Bagge, and John A. Carver, Jr.

ORDER MODIFYING LICENSE AND APPROVING REVISION OF EXHIBIT K

(Issued September 23, 1968)

On January 8, 1967 the Arkansas Power & Light Company, Licensee for Project No. 271, filed an application for Commission approval to use project lands and waters at Lake Catherine for a cooling water facility in connection with a proposed 500,000 kw steam turbine-generating unit (Unit No. 4) to be added to its existing 204,500 kw Lake Catherine steam electric plant. The plant, located adjacent to the project, has an existing intake and discharge pipe used for cooling water for Unit Nos. 1, 2 and 3. Licensee has submitted a revision to its Exhibit K, Sheet 1 (FPC No. 271-99), showing the existing and proposed cooling water intake and discharge structures located within the project boundary. A minor consumptive use of project waters in the order of one cubic foot per second is anticipated. Licensee states that the proposed intake and discharge facilities will not interfere with the reservoir, boating or other surface water traffic and will not constitute a substantial alteration of the project or its operation.

An important consideration in such project use is the question of thermal pollution. The temperature rise of the water presently being used and returned to the reservoir is approximately 13.8 degrees Fahrenheit. It is anticipated that when Unit 4 is added the overall

available temperature rise of the approximate 1130 cfs of cooling water is expected to be about 14.8 degrees Fahrenheit. The Federal Water Pollution Control Administration, Department of the Interior, commenting on the proposed use of project waters by letter dated November 22, 1967 had no objection provided that Licensee would limit the temperature of its discharge to 95 degrees Fahrenheit in accordance with approved water quality standards for the Ouachita River.

The Department notes that the effect of the existing discharges upon reservoir waters and wildlife is presently the subject of an ecological study. Information available to the Commission indicates past adverse effects upon reservoir fishery and wildlife from chemicals used in cleaning the thermal condensers of the existing units. Acting on recommendation of the Arkansas Game and Fish Commission, licensee's present practice is to treat chemical discharges experienced at the time of cleaning operations. Licensee, following conferences with representatives of the Arkansas Game and Fish Commission and the Bureau of Sport Fisheries and Wildlife, Department of the Interior, proposes to undertake further study of the reservoir and the effect of operating the proposed unit 4. Currently the reservoir and downstream areas support a warm water fishery which has been improved since the installation of the existing steam plant. The contemplated study will extend for a period of at least 12 months following the installation and operation of unit 4.¹ While it appears that the operation of this unit will conform with the water quality standards established by the Arkansas Pollution Control Commission and approved by the Federal Water Pollution Control Administration, the study will indicate whether the actual operation will in fact conform to these standards. Moreover, the study of the effect of thermal discharges upon the reservoir as well as downstream areas and their fish, wildlife and recreation resources will include an evaluation of the adequacy of the presently prescribed State thermal discharge standards. To facilitate changes in the reservoir intake and discharge facilities and heat content in condenser water discharges as may be necessary, we are providing in Article 27 herein for the modification of these facilities and licensee's thermal plant operation both during the study period and thereafter. Pending completion of the proposed study, interim Commission action may be taken to meet any demonstrated adverse effects.

The Department of the Army report on August 8, 1967 had no objection to the proposed use of project waters.

In order to insure that the proposed use of project lands and water is compatible with project recreational uses areas set aside for recreational use should be designated on a recreational use plan. Since Licensee does not have such a plan on file with the Commission, we shall require it to file one within 1 year from the date of issuance of this order.

The Commission finds:

(1) Exhibit K, Sheet 1 (FPC No. 271-99), as revised, conforms to the Commission's rules and regulations and should be approved as part of the license for the project.

¹ Licensee anticipates that unit 4 will commence operation at the end of calendar year 1969.

(2) It is appropriate for the purpose of the Federal Power Act and it is consistent with public interest to modify the license for Project No. 271 as hereinafter provided.

(3) The use of the reservoir as a source for cooling water will result in a small loss of power output of Project No. 271. However, such use will result in a savings in the cost of steam electric generation which will more than offset the project power loss. Therefore, the Commission has no objection to the proposed use of project lands and waters.

The Commission orders:

(A) The above designated and described Exhibit K revision is hereby approved as part of the license for Project No. 271.

(B) The license for Project No. 271 is hereby modified to include the following articles:

Article 26. Licensee shall within one year from the date of issuance of this order file for Commission approval its recreational use plan for Project No. 271. The plan shall conform to Section 4.41 of Commission Regulations under the Federal Power Act and include not only recreational improvements which may be provided by others, but the recreational improvements the licensee plans to provide.

Article 27. The licensee shall finance a study of reasonable scope and duration to be conducted in cooperation with the Arkansas Game and Fish Commission, the Arkansas Pollution Control Administration, the Bureau of Sports Fisheries and Wildlife and the Federal Water Pollution Control Administration, Department of the Interior, to determine the extent of heat load mixing in Lake Catherine and its effect upon fish and wildlife resources before and after the installation and operation of Unit No. 4 of Lake Catherine Steam Electric Plant of the Arkansas Power & Light Company. The results of that study and proposals for protecting the waters of Lake Catherine, downstream waters and fish and wildlife resources shall be filed with the Commission as soon as possible, but in no event later than July, 1971.

During the period of the study, as set forth above, licensee shall advise the Commission immediately of any adverse effects of the operation of the Lake Catherine Steam Electric Plant upon Lake Catherine Reservoir, downstream waters, and fish and wildlife and shall propose remedial actions. In the event of failure of licensee to take necessary action to cure such adverse effects the Commission, acting upon its own motion or at the request of others, may order appropriate remedial actions.

Upon completion of the study, licensee after consultation with the appropriate State and Federal agencies shall make or cause to be made, such reasonable modifications of the intake and outflow facilities and the method of operation of the Lake Catherine Steam Electric Plant in the interest of pollution abatement for thermal or other reasons, thus maintaining and improving fish and wildlife resources and optimum utilization of project lands and waters for all beneficial uses including recreation, all as may be ordered by the Federal Power Commission upon request or upon its own motion after notice and opportunity for hearing.

Additionally, licensee shall take or cause to be taken all necessary steps to prevent any adverse effects caused by the discharge into the reservoir of chlorine or other chemicals used in cleaning the Lake Catherine Steam Electric Plant condenser units.

(C) This order shall become final 30 days from the date of its issuance unless application for rehearing shall be filed as provided in Section 313 (a) of the Act, and failure to file such an application shall constitute acceptance of this order.

By the Commission. Commissioner Ross concurring filed a separate statement appended hereto.

GORDON M. GRANT,
Secretary.

Ross, Commissioner, *concurring*:

The Commission has decided, in my view, a very significant issue, which might well be obscured by the routine-sounding title of its order and the omission of adequately clarifying language in the body of the order.

The substantive question raised herein is that of thermal pollution expected to result from Arkansas Power & Light Company's use of the reservoir of a licensed project for cooling water for a proposed 500,000 kw steam turbine-generating unit. More immediately, the question is whether this Commission can impose requirements with respect to thermal pollution more stringent than those specified by the Federal Water Pollution Control Administration or by other federal or state agencies having authority regarding such matters—either as a legal or as a practical matter.

This Commission has decided the question in the affirmative; namely, that it has authority regarding thermal pollution of licensed project reservoirs, and further, that it stands ready to act, whenever such action, in its independent judgment, is required in the interest of comprehensive development. It has made adequate provision for the exercise of such authority in special Article 27.

In my opinion, this is the correct decision. It would have been preferable, however, if the Commission had more clearly spelled it out so that any prospective intervenor or *person interested in the question of thermal pollution* would know that *this Commission is available as a forum to consider his views.*

CHARLES R. ROSS,
Commissioner.

MEMORANDUM OF UNDERSTANDING

With Regard to Procedures for Cooperation Between the Atomic Energy Commission and the Department of the Interior Pertaining to Location and Operation of Proposed Nuclear Installations Subject to Licensing and Regulation by the Commission.

(1) Desiring that information and technical capabilities possessed by the Department may be put at the disposal of the Commission to assist it in discharging its licensing and regulatory responsibilities to protect health and safety of the public, the two signatory Agencies hereby agree to follow procedures whereby: in response to Commission requests, information and assistance within the scope of the Department's special capabilities will be made available to the Commission's Director of Regulation.

(2) As new studies, investigations or consultations are desired by the Commission, in connection with its licensing and regulatory functions, the Commission's Director of Regulation will proceed to arrange

for the desired cooperation by the appropriate Service, Bureau or Office (Henceforth in this Memorandum the term "Bureau" is understood also to apply to Departmental units called "Service" or "Office") of the Department in the following manner.

(3) The Director of Regulation will advise the Director of such Bureau of specific sites or areas for which information, studies, or other technical assistance are needed. The Director of Regulation, in coordination with the Bureau, will develop the scope of information, study, or survey desired.

(4) The Director of Regulation will provide to the Bureau all pertinent available reports, documents, and other information relating to such sites or areas. The Director of Regulation will also arrange with applicants or licensees for access by authorized personnel of the Bureau to sites, excavations, drill samples, etc., as may be necessary for the work to be performed.

(5) Staff consultation between the staffs of the Director of Regulation and of the Bureau will be held at suitable times and places as work proceeds. From time to time, the Director of Regulation may request the Bureau personnel to participate in informal staff conferences and technical discussion with the applicant or licensee and with the Advisory Committee on Reactor Safeguards. Bureau personnel may also be asked to present formal testimony at public hearings.

(6) The Bureau will prepare such reports on the work under this arrangement as may be mutually agreed upon. These may in different cases consist of preliminary surveys, memoranda, or formal reports for public release.

(7) The timing of public release of material prepared for publication by a Bureau in accordance with this procedure will be determined by the Director of Regulation after consultation with the Bureau Director, or his designated representative. Normally such releases will be made at the same time that the Commission's "Hazards Analysis" and other consultant reports are distributed to the press and the public.

(8) It is understood that the Bureau will be reimbursed for costs incurred in connection with services performed hereunder in accordance with existing or future agreements between the Bureau and the Commission.

Approved:

STEWART L. UDALL,
Secretary of the Interior.

MARCH 20, 1964.

Approved:

GLENN T. SEABORG,
Chairman, Atomic Energy Commission.

MARCH 27, 1964.

STATEMENT OF DONALD F. HORNIG, SPECIAL ASSISTANT TO THE PRESIDENT FOR SCIENCE AND TECHNOLOGY

I am pleased to make this statement for the hearing record on thermal pollution conducted by your committee.

In your letter of September 16, 1968, you asked for my views on two public policy questions that have received particular attention in the course of the hearings on thermal pollution which your Subcommittee on Air and Water Pollution has been conducting.

Your first question was, "What should be the extent of the electric utilities industry's responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities?"

While public authorities must set standards to be maintained, it is my opinion that the electric utilities industry should assume primary responsibility for avoiding long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities. The cost of pollution prevention—or management of the environment—is in reality merely another portion of the cost of production.

In the past the electric utilities industry and power consumers have not faced up to assuming responsibility for this element of the cost of production, and have left pollution costs to the general public. The public has expressed its concern for the protection of the environment and your subcommittee has responded by playing a vital role in the enactment of the Water Quality Act of 1965, the Clean Water Restoration Act of 1966, the Clean Air Act of 1967, and other legislation. It is essential that the electric companies recognize the environmental problems which power production can create and make the investments which are required in planning and technology to prevent these potential hazards.

Of course, Government must play a role in establishing the environmental standards that industry must meet but the responsibility for meeting them must be shouldered by the utilities themselves and in the final analysis by their consumers. It is only in this manner that we will develop our energy sources in a truly economic manner with each source of energy shouldering its own total cost of production.

Your next question was, "What should be the extent of the responsibility of Federal agencies to insure compliance with applicable water quality standards when issuing a lease, license, or permit?"

As I stated in response to your first question, while the primary responsibility for guarding against environmental hazards from powerplants should be shouldered by the utilities themselves, there is a need for the Government to set environmental standards and assure that these standards are enforced.

Environmental controls are expensive and the degree of protection needed is uncertain. Experience teaches us that it is unrealistic to expect utilities adequately to protect the environment without enforce-

able standards set by governmental agencies. The water quality standards, developed by the States and approved by the Secretary of the Interior, will contain criteria on allowable temperature levels for interstate and coastal waters. At this time, standards for 39 States, two territories, and the District of Columbia have been approved.

While we believe the Department of the Interior's responsibility for water quality control should not be diffused, it is appropriate that procedures be developed to assure compliance with water quality standards by Federal licensees, permittees, and lessees. It seems to me that cooperative administrative arrangements between the Atomic Energy Commission and other Federal agencies on the one hand and the Department of the Interior's Water Pollution Control Administration on the other should be implemented to assure compliance with the water quality standards and we believe that legislation that would provide the legal authority to do so would be in the public interest. Enactment of such legislation would be in accordance with the program of the administration.

REPLY OF THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
Washington, D.C., October 29, 1968.

Hon. EDMUND S. MUSKIE,
U.S. Senate,
Washington, D.C.

DEAR SENATOR MUSKIE: I apologize for my delayed response to your invitation of September 16, 1968, to Secretary Cohen to submit a statement for the record of the hearings conducted by your Subcommittee on Air and Water Pollution.

While you have indicated that the testimony has emphasized environmental factors considered in selecting nuclear electric generating plant sites and the effects of waste heat discharges on water resources, we believe it would be useful to broaden our reply to the two public policy questions noted in your letter to include a total environmental approach to location, design, construction, and operation of central station electric generating plants, both nuclear and fossil fuel. Indeed it is our firm conviction that this concept of "environmental planning" should be applied to other large industrial facilities as well.

It is clear that a number of factors are involved and must be considered in providing the facilities required to supply the Nation's ever-increasing electricity demands. These include, in addition to the specific potentials of air and water pollution: (1) the size, nature, and distribution of energy demands; (2) plant size (including multiple units); (3) fuel availability, cost, location, and transport; (4) power transmission economics; (5) other physical environmental factors such as cooling water availability, geology, seismology, soils; (6) zoning; (7) current and projected utility landholdings; (8) competing land use (for example, for recreational purposes); and (9) esthetics. This listing is not necessarily complete.

It is also important to note that a number of government institutions at the Federal, State, and local levels and industrial and private organizations have direct concern and responsibility related to these factors. As you know, there is currently a Federal interagency group working under the aegis of the President's Office of Science and Technology which is addressing itself to this overall problem.

From the standpoint of current or potential pollution of our air and water resources, there are some fundamental differences in nuclear and fossil fueled plants. While nuclear plants do not discharge combustion products in stack gases, particularly careful consideration must be given to the control of associated radioactive material under conceivable accident situations. Also the reprocessing of irradiated nuclear fuels and associated management of radioactive wastes, even though carried out at a location separated from the powerplant.

(1003)

must obviously be taken into account in any overall environmental assessment. We are, of course, actively concerned with these matters. The focal point for program activity in the Department is the Consumer Protection and Environmental Health Service.

With respect to air pollution from fossil-fueled plants, major emphasis is currently being placed on control of sulphur oxides. Within the Consumer Protection and Environmental Health Service, the National Air Pollution Control Administration is engaged in extensive programs to achieve the required control goal. These plans range from the development of criteria and standards to comprehensive research and development and control activities. Attention is being given to stack gas treatment, fuel desulphurization and form conversion, new combustion processes, and establishment of availability of low sulphur fuels.

The thermal effects problems, while different in degree in nuclear and fossil-fueled plants, because of current differences in plant thermal efficiencies, are not different in kind. In contemporary design of plants of equal capacity, a nuclear plant will discharge approximately 50 percent more heat in condenser cooling water than a fossil-fueled plant. In either case, thermal effects and related ecologic impact must be considered in light of the particular environmental situation at the plantsite. While auxiliary cooling techniques such as cooling towers or cooling ponds can be utilized in controlling thermal discharges to receiving bodies of water, they in turn may introduce environmental impacts such as fogging, icing, and possible chemical and biological effects which must be considered.

It is the Department's view that in relation to all of the considerations briefly noted above, the electric utility industry has a direct responsibility to properly evaluate these factors in terms of potential impairment of environmental quality. Further, the industry should take all steps necessary to insure that the proper control measures are incorporated in the plant as required to comply with applicable environmental standards. Such actions should be prerequisite to approval by appropriate public authorities for plant construction.

Similarly, certain Federal agencies have a responsibility to assure that environmental quality and health protection are given proper consideration and applicable environmental standards are being met. Existing legislation may dictate that the discharge of this responsibility by Federal agencies take on somewhat different forms; for example the water quality standards are promulgated and enforced by the States with Federal agency overview, whereas with respect to radiological contamination the Atomic Energy Commission has direct licensing and regulatory authority. With respect to thermal pollution, differences in the exercise of Federal responsibility should be resolved. It is our view that regulation or control in this area must be applied to both nuclear and fossil-fueled plants in a consistent manner.

In the operation of this Department's programs relating to improvement of environmental quality, it is also our policy to provide optimum choice of fuel and fuel form and utilization in full recognition of the Nation's growing energy requirements.

The opportunity to submit this statement for the record is very much appreciated.

Sincerely yours,

PHILIP R. LEE, M.D.,
Assistant Secretary for Health and Scientific Affairs.

REPLY OF THE DEPARTMENT OF AGRICULTURE

DEPARTMENT OF AGRICULTURE,
Washington, D.C., November 8, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, Committee on
Public Works, U.S. Senate.*

DEAR SENATOR MUSKIE: This is in reply to your request of October 15, 1968, for our views on two public policy questions relating to environmental effects of potential powerplant sites and design of waste disposal facilities. These questions relate to hearings held by your subcommittee on thermal pollution.

The question of thermal pollution and its impact on the environment is a major concern to the Department of Agriculture. An important impact on our responsibilities is in connection with the 187 million acres of federally owned lands in the National Forest System administered by the Forest Service. Thermal pollution affects public water supplies, fish and wildlife, recreation, and vegetation on the National Forests. When proposed powerplant projects involve National Forest lands, the Forest Service studies the potential effects upon their protection, administration, and management. These studies also take into consideration the effects of such projects on forest users and permittees, as well as the environment.

Whenever we determine that a proposed project would have significant effects on the environment, we make a detailed evaluation of its potential impact. This evaluation serves as a basis for our recommendations regarding quality standards necessary to insure resource protection. The evaluations include consideration of—

- (a) Short and long term effects of planned total development on the ecosystem.
- (b) How each proposal and carrying out that operation at that site fits into any applicable comprehensive plan for the area or basin and the management of its resources.

The Department of Agriculture's interest and concern about thermal pollution also stems from its program of rural electrification financial and technical assistance administered by the Rural Electrification Administration. REA does not own or operate any generating facilities. The generating facilities owned and operated by REA borrowers account for a very large percentage of the total installed generating facilities in the United States. Until recent years many of these generating facilities were of relatively small capacity and as a consequence did not pose a substantial problem of environmental degradation. However, with increasing emphasis on scale in thermal generation, the problem of environmental impacts has confronted REA borrowers as it has the entire electric utility industry.

Responding to your first policy question, we strongly believe that the electric utility industry has a responsibility to consider potential long term environmental effects in selection of potential powerplant sites and design of waste-disposal facilities. As a first step, industry must provide sufficient information to enable project evaluation prior to approval. Also in discharging this responsibility, the electric industry, including REA-financed systems, must select sites and design facilities within the framework of all applicable Federal, State, and local laws and regulations dealing with air and water pollution control. This Department can assist industry in this effort by providing a format for evaluation of environmental impacts wherever proposed power projects and transmission facilities affect our responsibilities. We also suggest that the electric industry has a responsibility to share in research and development activities of a scope and substance which will contribute materially to reduction and control of thermal pollution associated with powerplants.

We strongly believe that Federal agencies have a responsibility to exercise leadership in insuring compliance with applicable air and water quality standards. In connection with powerplant sites on the National Forests, resource protection stipulations are included in permits and licenses for such plants. We also provide for compliance in connection with REA loan contracts with electric borrowers. Under Executive Order 11288, dated July 2, 1966, the following requirements are included in these contracts.

"The Borrower shall, with respect to generation facilities, if any, which may be part of the System, comply with applicable water and air pollution control standards imposed by federal or state statutes or regulations."

These are Federal responsibilities which should be in addition to the formal requirements of the Water Quality Act, and they should include periodic review and surveillance of operating projects to assure that standards are being met.

We appreciate this opportunity to comment on the subject of environmental pollution and we would be glad to participate in any further studies by your committee.

Sincerely,

ORVILLE L. FREEMAN, *Secretary.*

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REPLY OF THE GENERAL COUNSEL OF THE
DEPARTMENT OF COMMERCE

GENERAL COUNSEL OF THE DEPARTMENT OF COMMERCE,
Washington, D.C., November 7, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, Committee on
Public Works, U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in reply to your letter of September 16, concerning the hearings your subcommittee has been conducting relating to thermal pollution. You advised that the testimony emphasized environmental factors considered in selecting nuclear electric generating plantsites, and the effects of waste heat discharges on river, lake, estuary, and marine ecologies. You called attention to the following two public policy questions that received particular attention and requested this Department to submit a statement thereon.

1. What should be the extent of the electric utilities industry's responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities?

2. What should be the extent of the responsibility of Federal agencies to insure compliance with applicable water quality standards when issuing a lease, license, or permit?

Our response to question 1—although the electric utility companies reportedly seek and obtain the advice of the Department of the Interior concerning thermal pollution effects, it would appear doubtful that such companies alone could be expected to coordinate their expansion programs effectively with national conservation programs. The extent of their responsibility should be to design, construct, and operate their facilities to meet applicable State or Federal water quality standards.

Our response to question 2—Federal agencies concerned should not issue leases, licenses, or permits for powerplants which would be so located or constructed that they could not meet, or be converted to meet, applicable water quality standards. These agencies have resources to evaluate proposed electric powerplant locations in relation to long-range regional conservation programs.

With respect to current agency responsibility and authority at the licensing stage for preventing or minimizing ecological impact of thermal nuclear pollution, we understand that the Atomic Energy Commission has taken the position that its statutory authority to license nuclear-fired powerplants is limited essentially to consideration of matters of radiological health and safety, and the common defense and security. This apparently leaves no Federal agency with jurisdiction over, or power to regulate, the construction and operation of

nuclear-fired powerplants in respect to the preservation of fish and wildlife and natural resources.

Section 10 of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 466g), provides for abatement of the discharge of matter into interstate or navigable waters or portions thereof which reduces the quality of such waters below standards established under the act. These standards do reflect environmental and ecological factors (sec. 10(c)(3)). Discharges of heated water from nuclear-fired or fossil-fuel powerplants do cause reduction in water quality. In entering an abatement order, however, a court must give due consideration to "the practicability and to the physical and economical feasibility of complying with such standards," and to "equities of the case" (sec. 10(c)(5)).

Accordingly, we share the concern expressed by the Department of the Interior as to the nature and extent of abatement relief which a court might grant upon complaint by the United States against a powerplant constructed in compliance with the terms of a license issued by a Federal agency, even though the Federal agency did not, and was not required to, take into account ecological consideration in issuing such license.

We appreciate your interest in asking for views on this matter and we trust the above information will be helpful.

We have been advised by the Bureau of the Budget that there would be no objection to the submission of this letter from the standpoint of the administration's program.

Sincerely,

FREDERICK SIMPICH,
General Counsel.

REPLY OF THE ATOMIC ENERGY COMMISSION

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., October 15, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution,
Committee on Public Works,
U.S. Senate.*

DEAR SENATOR MUSKIE: Thank you for your invitation of September 16, 1968, to submit a statement for the record which has been developed before your Subcommittee on Air and Water Pollution. I am pleased to offer this Commission's views on the public policy issues involved.

The need for a coordinated approach to the selection of sites for our country's expanding electric energy requirements has been of concern to this Commission for some time. In our view, there are many factors—in addition to the ecological effects of coolant water—that properly should be evaluated in site selection. Some of these other important factors are: safety; air pollution; esthetic impact; and economics.

In this connection, about a year ago my colleague, Commissioner Ramey, publicly suggested setting up a Federal Interdepartmental Committee on Electric Powerplant Siting. In making this proposal he said:

"I have in mind a group which would be comprised of experts in all the various disciplines and factors involved in siting. Just for a start, this would seem to call for people from AEC, the Department of the Interior, the Environmental Science Services Administration, the Federal Power Commission, HEW, and perhaps State and local governments. I would think the Federal Power Commission should chair such an assemblage. It also would make sense to include the Edison Electric Institute and the American Public Power Association.

"From the standpoint of overall public policy considerations, a beginning in planning and dealing with the many diverse siting issues could be to get all the interested parties together on a regular basis around a table and developing the data and delineating the factors affecting the siting of powerplants over the next 10 or 15 years. As I visualize it, the planners—as they gain experience—might recommend general guides or standards to assist utility executives and interested governmental agencies in evaluating sites and perhaps encouraging such groups to identify, reserve and protect potential sites for future use. This is a matter of urgency in some parts of the country."

There is currently underway an interagency study on the siting of electric generating stations under the aegis of the Office of Science and Technology. The study should result in a factual presentation of the public interest aspects of powerplant site selections. In addition to

OST, the following agencies are participating: AEC, FPC, Interior, HEW, TVA, and REA.

With respect to waste disposal facilities, it may be of interest to your subcommittee that the Commission is considering the establishment of a policy for the regional disposal of high-level radioactive wastes. We have under consideration a policy that would require nuclear fuel reprocessors to ship all high-level wastes to designated regional burial grounds, thus concentrating all such wastes in a very few carefully selected locations.

The question whether Federal agencies ought to employ their licensing powers to enforce water quality standards raises some complex issues. In considering this question, it is necessary to take into account the present statutory mission and developing competence of affected agencies. Any resolution of the question should not discriminate for or against any particular means for generating power or cause wasteful duplication in the licensing and regulatory process.

With respect to the problem of thermal effects, this Commission recognizes the desirability of controlling the thermal effects of the release of liquid effluents to the environment. The AEC has the necessary technical expertise, with assistance and advice from the Department of the Interior, to assume licensing responsibility for the control of thermal effects from the release of liquid effluents from nuclear powerplants. We believe, however, that legislation giving us this authority which did not appropriately reach other types of electric generating plants would have the effect of singling out nuclear plants for special treatment; the problem of thermal effects is also associated, though to a lesser degree, with large-scale fossil-fueled powerplants which are not now subject to licensing by any Federal agency.

The Water Quality Act of 1965 provides a comprehensive program through which water quality standards are developed by the States and approved by the Secretary of the Interior. These standards include criteria which limit the thermal effects of both fossil-fueled and nuclear plants. The standards for a majority of the States have already been approved by the Secretary of the Interior and standards for the remaining States are being processed.

We have been developing with the Interior Department procedures whereby the federally approved water pollution control standards can be coordinated with the licensing program of the Atomic Energy Commission. We are hopeful that license applicants for nuclear plants will cooperate in these procedures to facilitate compliance with these federally approved standards.

The problem of thermal effects and the development of solutions is a highly complex subject to which intensive efforts are being applied by the parties concerned. It is our view that pressing forward with administrative action to implement the existing law is the course that should be followed at this time since standards under the Water Quality Act of 1965 have only recently been approved and knowledge of how best to deal with the problem is far from complete.

Cordially,

GLENN T. SEABORG,
Chairman.

REPLY OF THE FEDERAL POWER COMMISSION

FEDERAL POWER COMMISSION,
Washington, D.C., October 29, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, Committee on
Public Works, U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your request for the comments of the Federal Power Commission on the water-quality problems associated with the construction and operation of electric powerplants.

Under existing law, utilities have wide discretion in selecting generating station sites, except with respect to hydroelectric projects located on lands or waterways subject to Federal control and nuclear generating facilities. Primary responsibility for thermal pollution control, therefore, must now rest with the electric power industry. In view of this fact the Commission has endeavored to stimulate industry interest in thermal and other pollution problems associated with the generation of electricity. In particular, we have requested our industry regional advisory committees, which were established to assist the Commission in its preparation of the national power survey and are presently working on the updating of that survey, to project future generation and transmission siting needs. In undertaking their studies and making their projections, the committees are to give special emphasis to environmental considerations.

The problems associated with the preservation of our environment have, however, become so critical that the Federal Government cannot fail to take a more active interest. It is essential that the Federal Government have the ability to act with respect to the thermal-pollution effects of electric powerplants prior to the construction and operation of the facilities.

Hydroelectric projects located on lands or waterways subject to Federal control must now be licensed by the Commission. In exercising its licensing responsibilities the Federal Power Commission has been sensitive to the whole range of environmental problems including the conservation of fish and wildlife, the reduction of waste disposal, and the enhancement of recreational values. To assist it in discharging these responsibilities, the Commission has invited, in its licensing proceedings, participation by all interested persons, including local and State conservation organizations, the Secretary of Interior and the Secretary of Health, Education, and Welfare. In issuing licenses the Commission may impose reasonable conditions on the construction and operation of a project by the licensee. In recent years every effort has been made to utilize the conditioning route to minimize water-quality-control problems including the reduction of thermal pollution.

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There is one other aspect to the Commission's licensing authority which is relevant to the thermal pollution problem. Before the lands or waters of a licensed hydroelectric project can be utilized in association with a thermal generating facility it is necessary to obtain the approval of the Commission. Again, the Commission's procedures invite interested parties to participate and the Commission is authorized to and has conditioned its approval so as to minimize the thermal pollution effects.

This was done, for example, in connection with a license issued to the Duke Power Co., for the Keowee-Toxaway project, the economics of which depended upon the future use of the reservoir as a source of cooling water for condensing purposes for a thermal electric plant. And, on September 23, 1968, the Commission authorized the Arkansas Power & Light Co. to utilize project lands and waters in connection with a proposed 500,000 kilowatt steam turbine generating unit. In its order the Commission stated that "[a]n important consideration in such project use is the question of thermal pollution" and it directed the licensee to take all necessary steps to prevent any adverse effects on fish and wildlife resources from the discharge of chlorine or other chemicals into the water, and to finance a study in cooperation with the Arkansas Game and Fish Commission and the Bureau of Sport Fisheries and Wildlife and the Federal Water Pollution Control Administration to determine the extent of heat-load mixing in Lake Catherine and its effect on fish and wildlife resources as a result of the new unit's operation.

It is by now becoming increasingly apparent that the entire problem of generating plant siting must be the subject of comprehensive study. The Commission is now actively participating, along with other interested Federal agencies, in such a study being undertaken by the energy policy staff, Office of Science and Technology. It is hoped that the factual report prepared at the conclusion of the study will serve as the basis for the formulation of appropriate site selection criteria.

The real difficulty stems from the fact that the great majority of conventional thermal electric generating plants are not subject to any requirement that Federal regulatory approval be obtained. Indeed, it appears that even nuclear generating facilities which are subject to Atomic Energy Commission licensing are not subject to the conditioning authority of any Federal agency with respect to thermal pollution. The Atomic Energy Commission has taken the position that under its statute its conditioning authority relates only to radiological problems. In recent months legislation has been introduced which would fill this statutory gap.

From our own hydroelectric licensing experience we agree that a licensing agency, whether for hydroelectric or nuclear stations, should have full authority to take into consideration all aspects of the public interest and to condition its approval as required to protect that interest. The Federal Power Commission has itself supported legislation in the 89th Congress which would have authorized it to license diversion dams constructed on navigable waterways for the purpose of providing cooling water for steam electric generating stations built adjacent to such waterways.

It is not sufficient, in our view, to rely on the abatement jurisdiction of the Secretary of the Interior under the Federal Water Pollution Control Act. Even assuming that the Secretary will be able to convince the Federal courts that serious thermal polluting activities should be abated, it would not seem to be in the public interest to defer consideration of pollution problems until after a costly generating facility is constructed. At that time a court may feel compelled, in view of the economic commitment that has been made in the facilities, to deny abatement notwithstanding the presence of a serious pollution problem. Accordingly, it seems to us imperative that some mechanism be established for resolving these problems at a much earlier date.

In sum, we are convinced that if the problems of thermal pollution associated with the generation of electricity are to be met, a stimulation of industry responsibility coupled with the expansion of Federal licensing authority is essential.

Sincerely,

LEE C. WHITE, *Chairman.*

REPLY OF BONNEVILLE POWER ADMINISTRATION

U.S. DEPARTMENT OF THE INTERIOR,
 BONNEVILLE POWER ADMINISTRATION,
 Portland, Oreg., October 2, 1968.

Hon. EDMUND S. MUSKIE,
 Chairman, Subcommittee on Air and Water Pollution,
 Committee on Public Works,
 U.S. Senate, Washington, D.C.

DEAR SENATOR MUSKIE: This is in reply to your letter of September 16, 1968, requesting our views on the responsibility of electric utilities to consider environmental hazards in locating powerplant sites and the role of Federal agencies to insure compliance with applicable water quality standards.

As you know, the Bonneville Power Administration does not actually construct any hydroelectric projects or thermal plants. It is the marketing agency in the Northwest for all of the hydroelectric power generated at plants built by the Corps of Engineers and the Bureau of Reclamation. Nevertheless, BPA since its inception has had a keen interest in the effects on the environment resulting from the sale of electric energy to utilities and industries in this region.

From the time the Bonneville Project Act was first proposed, considerable concern was expressed in the Pacific Northwest that the low-cost power from Federal dams would attract electroprocess industry or other developments into the Columbia Gorge area that would detract from the scenic beauties of the gorge or would increase air or water pollution. The concern over the despoilment of the gorge and pollution of its waters was expressed in Congress during consideration of the Bonneville Project Act. Therefore, the suggestion that the Bonneville Administrator play a role in preventing any such pollution has long predated the enactment of Federal pollution control legislation.

While Congress did not adopt any legislation which would have required the Administrator to include an antipollution provision in his contracts, there was sufficient discussion of the problem to form the basis of some obligation on Bonneville's part to minimize pollution problems. To that end, our power sales contracts have always included a section pertaining to the conservation of natural resources. The present language of this clause reads as follows:

"Conservation of natural resources.—The Administrator will not be obligated to deliver power pursuant to this contract to the extent of service to any plant or operation of the purchaser or to the extent of the purchaser's service to any of its industrial customers, regardless of whether such services are effected with power delivered hereunder, if the Administrator determines that the operation of such plant or activity will harm or detract from the scenic beauty of the

Columbia Gorge or if the appropriate Federal, State, or local pollution control agency shall, after due notice and opportunity for hearing, determine that the operation of such plant or activity is not in compliance with standards prescribed by such pollution control agency for the control of the discharge of waste products into the waters of the Pacific Northwest; *provided, however*, That the Administrator will give the purchaser and such pollution control agency notice of and a reasonable opportunity to correct any such condition before curtailing or terminating delivery of power hereunder. The purchaser agrees to do everything it reasonably can to assure compliance by its customers with standards prescribed by such pollution control agency."

Since the Federal Water Pollution Control Administration is a bureau within the Department of the Interior as is Bonneville, our responsibility with regard to water pollution is clearer than that attendant upon the prevention of air pollution. Nevertheless, we have now adopted the practice, before contracting to supply power to a new industry, to obtain from such industry an agreement that it will install and maintain the best commercially available equipment for the prevention of air and water pollution and to comply with Federal, State, and local laws and regulations in this matter. We also require such industries to submit to Bonneville for our approval their plans and specified performance requirements for the installation and operation of such antipollution equipment. Our obligation to provide electric service to the plant is conditioned upon the installation and proper operation and maintenance of such equipment, and compliance with such performance requirements.

At the present time, approximately 97 percent of the electric power generated in the Northwest is from hydroelectric plants which have a minimum impact upon environmental hazards. However, almost all of the available major hydroelectric powersites have now been exhausted and the region must turn immediately to the construction of large thermal plants in order to meet its load growth, a growth which is estimated to double every 10 years. The utilities of the Northwest, public and private, must construct 1 million kilowatts of thermal generation each year beginning in the early 1970's if the Northwest is not to face a severe power shortage. The first such plant, a fossil-fuel-fired plant, is now under construction and will be available for initial operation in 1971. The first nuclear plant will be completed in 1974-75.

As a consequence, Bonneville conceived and implemented the Joint Power Planning Council in 1966 in concert with the public and private utilities of the region. This Administration has taken the lead in formulating the comprehensive program for the construction of thermal plants, an essential component of which is the proper siting of such plants. It has also undertaken to work closely with the constructing utilities and with the Federal and State pollution control agencies to insure that pollution in the area will be kept at an acceptable level.

Under the Water Quality Standards Act, the States have the initial responsibility for evaluating an application for construction of a thermal plant. Such standards have already been promulgated by the individual States in the Northwest. We intend to work closely with them. We have also established an Environmental Committee in the Joint Power Planning Council which works with the State and Federal

officials in investigations and research on environmental aspects in the construction of thermal plants. Bonneville has participated in the establishment of the Columbia River temperature study, now under the auspices of the Pacific Northwest River Basins Commission, studying the temperature regimen of the main stem of the Columbia River. This agency has also supported the Columbia River thermal effects study, being conducted by the Federal Water Pollution Control Administration and the fishery agencies, on the biological effects of heat. We have also cooperated with the FWPCA in providing that agency with cost data on nuclear plants with alternate types of cooling facilities.

Bonneville Power Administration recognizes the magnitude of environmental problems which lie ahead in the face of the construction of large-scale thermal plants. We believe that a total environmental approach is required. Cooling towers, for example, may protect our rivers, but only by affecting the atmosphere, and through the condensation of vapor clouds bearing chemical impurities, the land. Cooling ponds will diminish adverse impacts on water and the atmosphere but, of necessity, will occupy large land areas. The interplay of power needs for the region combined with the necessity of preserving a healthy environmental state calls for complete cooperation on the part of all concerned Federal, State, and local agencies as well as all utilities. Our response to the challenge must be imaginative and our commitments total.

Sincerely yours,

H. R. RICHMOND,
Administrator.

REPLY OF TENNESSEE VALLEY AUTHORITY

TENNESSEE VALLEY AUTHORITY,
Knoxville, Tenn., October 11, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, U.S. Senate,
Washington, D.C.*

DEAR SENATOR MUSKIE: This is in response to your letter of September 16 requesting our comments on certain questions which have been raised in recent hearings before your Subcommittee on Air and Water Pollution.

The first question is "What should be the extent of the electric utilities industry's responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities?" We believe the industry has a substantial responsibility in these respects, and appropriate steps should be taken to assure that it assumes and discharges this responsibility. However, within the limits of what is necessary to protect the public interest in water quality, it is also essential that care be exercised so as not to burden the industry with unnecessary regulations and procedures which would prevent it from supplying on a timely, efficient, and economic basis the growing power needs of the country.

There is a pressing need for scientific development of facts concerning biological responses to various materials in the environment. Empirical assumptions concerning these responses, if followed by the establishment of arbitrary standards to protect environmental quality, could well turn out to be wasteful and not in the best overall public interest. Regulation of the electric utility industry, like the regulation of any other industry essential to the national welfare, needs to be aimed primarily at protecting the broad public interest. Consequently, as much-needed research produces new knowledge concerning the impact of the electric utility industry on the environment, regulations affecting the industry should reflect this new knowledge.

Your second question is "What should be the extent of the responsibility of Federal agencies to insure compliance with applicable water-quality standards when issuing a lease, license, or permit?" We think the lease-license-permit procedure, where available, provides an effective means of controlling pollution and should be utilized. As part of its responsibility for encouraging the proper development and use of the water resources of the Tennessee Valley, TVA has for several years been including conditions relating to water pollution in leases, licenses, and permits issued by it. More recently, we have included air quality control provisions in deeds conveying land for industrial purposes.

We think the enclosed paper which deals with TVA's experience and its plans for further research in the field of thermal pollution will be

of interest to your committee. If we can be of any further assistance, please let us know.

Sincerely yours,

AUBREY J. WAGNER, *Chairman.*

MANAGEMENT OF WASTE HEAT FROM STEAMPLANTS

TVA'S EXPERIENCE

As a regional resource development agency, TVA has continually been concerned with water quality. Its interest in thermal pollution stems directly from the problem of disposing of waste heat from TVA steamplants. The effects of TVA operations on other water uses have been a major consideration in planning for waste heat disposal.

The Watts Bar steamplant, TVA's first, has a total capacity of 240,000 kilowatts and uses 280,800 gallons of cooling water per minute through the condensers to carry off the 24.7-million B.t.u.'s of heat wasted each minute. In contrast, the Browns Ferry plant, which will be TVA's largest to date, will have a capacity of 3,450,000 kilowatts and will use cooling water at the rate of 1,980,000 gallons per minute to carry off 407-million B.t.u.'s per minute of waste heat. Data showing the waste heat for disposal at other TVA plants appear in table 1.

Like many other wastes, heat presents a problem when large quantities are added to a small stream. Prior to the construction of units 1 and 2 of the Paradise plant in 1959-63, TVA plants were small relative to the streams providing cooling water. No deleterious effects were observed which could be attributed to temperature modification. In fact, improved winter fishing near the discharges was the only biological effect noticed.

TABLE 1.—WASTE HEAT DISPOSAL AT TVA STEAM PLANTS

Steam plant	Quantity of waste heat (billion B.t.u. per hr.)	Maximum generator name plate rating (kilowatts)	Date last unit on line	Mean annual flow of river (cubic feet per second)
Allen.....	4.4	990,000	Oct. 22, 1959.....	453,000
Browns Ferry (nuclear).....	24.4	3,456,000	Oct. 1972.....	49,000
Bull Run.....	3.5	950,000	June 12, 1967.....	4,309
Colbert.....	5.9	1,373,250	Nov. 7, 1965.....	50,500
Cumberland.....	10.3	2,600,000	April 1973.....	24,000
Gallatin.....	5.4	1,255,200	Aug. 9, 1959.....	18,000
John Sevier.....	3.6	823,250	Oct. 31, 1957.....	3,543
Johnsonville.....	7.1	1,485,200	Aug 20, 1959.....	61,000
Kingston.....	7.4	1,700,000	Dec. 2, 1955.....	6,300
Paradise.....	10.2	2,558,000	Oct. 1969.....	8,374
Sequoyah (nuclear).....	16.9	2,441,000	April 1974.....	36,500
Shawnee.....	7.7	1,725,000	Oct. 12, 1956.....	255,400
Watts Bar.....	1.5	240,000	April 8, 1945.....	26,400
Widows Creek.....	7.9	1,977,985	Feb. 7, 1965.....	35,210

Temperature studies in the Tennessee River in the vicinity of the Watts Bar steamplant showed that the heated discharge is mixed with the riverflow within a short distance of the plant. The mean annual temperature rise caused by the added heat was only about 0.2° F. Under 7-day, 10-year minimum flow conditions the temperature rise would be less than a degree.

In 1959 as planning for TVA's Paradise plant on the Green River in Kentucky advanced, TVA recognized that the size of this plant in

relation to the river presented a potential problem in disposing of waste heat. A review of literature and discussion with several experts suggested the possibility that if the plant were to operate at capacity during summer months, fish might move out of the area to avoid the warm water. In addition, organisms in the food chain might be killed, causing a decrease in fish productivity downstream. The elevated temperatures might enhance algal growth, possibly resulting in taste and odor problems at downstream intakes. Other uses of the water might be generally impaired. Benefits from elevated water temperature under the circumstances were likely to be minor.

TVA decided prior to plant operation that the mixed river temperature should not be caused to exceed 95° F. Plant load would be cut back whenever necessary to prevent the temperature from exceeding 95° F. Four temperature sensors were installed in a cross section of the river downstream from the plant, and temperatures telemetered to the control room of the powerhouse. This proved a satisfactory means for monitoring temperatures and assuring the desired control.

A study of the effects of the Paradise plant was planned with the objective of determining what temperature controls would be necessary to protect aquatic life. This study consisted of several parts: (1) Preoperational and operational surveys of biological, chemical, and physical quality conducted by the Academy of Natural Sciences of Philadelphia, (2) preoperational and operational fish counts conducted by Dr. Hunter Hancock of Murray State College, (3) studies of zooplankton by TVA biologists, and (4) periphyton studies by TVA biologists.

As anticipated, the studies provided a wealth of information.

Studies by the Academy of Natural Sciences of Philadelphia

The Green River for many years has been the subject of extensive navigation improvements, including a number of dams and locks. It is not a natural, free-flowing stream and thus at the time TVA began operation of the Paradise plant the river did not possess the normal complement of biota characteristic of flowing streams. The pool on which the Paradise plant is located is maintained by ship locks, thus creating a "canal type" situation. Summer stream velocities are low because of the deep channel and low flows. Bottom-dwelling aquatic stages of insects are virtually absent in this pool situation because channel margins are too steep, and heavy barge traffic within the pool churns bottom sediments creating unstable below-surface conditions.

The stream invertebrates consist almost entirely of zooplankton and most of these are species typically found in lakes. With the virtual absence of bottom insects, the transitory zooplankton community assumes the major role in converting plant material to animal protein and thus constitutes a major link in the fish food chain.

The staff of the Academy of Natural Science of Philadelphia directed by Dr. Ruth Patrick looked at the attached and planktonic flora, the protozoa, and the invertebrate fauna of the Green River in the area of the Paradise plant. Samples were collected over a 20-mile stretch of river extending downstream from a station 1 mile above the plant. The preoperational study was conducted in 1961—about 2 years prior to plant startup. An operational study was conducted in 1965—2 years after startup of the plant.

In both surveys Dr. Patrick found a very diverse and healthy zooplankton population. The diversity was actually greater in the operational survey with about the same relative distribution within the study region. Diversity of the other life forms decreased. The invertebrates (other than protozoa) showed the greatest decline over the 4-year interval. The major changes were nearest the plant and were less severe at greater distances. The presence of coal dust and heavy barge traffic apparently contributed to the degeneration in quality.

Fish Population Studies by Dr. Hancock of Murray State College, Kentucky

Arrangements were made for an extensive study of the effect on fish population by Dr. Hunter Hancock of Murray State College. With fish, as with the food-chain organisms, diversity of species and abundance are taken as a general indication of quality. Dr. Hancock made fish counts in the summers of 1961, 1963 (after startup), 1964, 1965, 1966, and 1967. Catches were poor in 1961 and became poorer afterward. Catches were on the order of one fish per net day of effort. A general decline in catch was experienced at all stations after plant startup. The catch improved in 1965 and 1966, but was low again in 1967. Thus the relative abundance of fish in all operational years up to the use of cooling towers (1968) was lower than the 1961 preoperational level. The composition of the catch showed a smaller fraction of game fish and a larger fraction of edible rough fish. However, some game species (white bass and spotted bass) were more numerous in 1966 than in 1961 collections. Since fish were not present in great enough numbers at any time during the study to show a trend, it is difficult to conclude how much of the effect was due to the addition of waste heat.

Studies of zooplankton by TVA Biologists

Since the zooplankton have a lower temperature tolerance than the fish which feed on them, TVA biologists made a special study of the effects of temperature on these organisms. Laboratory studies indicated a lethal threshold of about 97° F. for the dominant species of the Green River. Laboratory results were substantiated by a series of field studies in May of 1964. Field studies revealed a large mixed plankton population isolated in the floating pool of warm water which develops upstream from the plant. Zooplankton were extremely abundant here at temperatures up to, but not exceeding, 96.8°. The organisms were being seeded in this area by the approaching colder water and were flourishing at temperatures below the lethal limit. Sampling in the discharge canal where temperature exceeded 101° F. indicated the organisms were not surviving passage through the condensers. It was apparent that to prevent plankton depletion of downstream reaches over extended periods or distances, either the temperatures within the condensers must be reduced below the thermal threshold for zooplankton or a portion of the streamflow must be permitted to bypass the plant and seed that flow diverted through the plant.

During the period May 15 to May 27, 1964, sufficient zooplankton bypassed the steamplant to reseed effluent water. Approximately 3 miles below the plant the zooplankton population equaled or exceeded population levels measured in unmodified upstream reaches. Rapid recovery was attributed to an accelerated reproductive rate in the thermally favorable downstream areas.

Periphyton studies

Periphyton is an association of aquatic plants, both pigmented and nonpigmented, growing attached or clinging to the various types of submerged surfaces (river bottom, logs, stems and leaves, etc.) in a river or lake. Periphyton in rivers is the principal food source for many benthic, herbivorous organisms and grazing fish; provides shelter; contributes oxygen to water; and constitutes a major production source for river phytoplankton. Studies were undertaken to determine the rate of periphyton production in the Green River. The following conclusions were drawn: (1) During the summer months periphyton growth rates in the Green River were substantially reduced in the vicinity of the steamplant. In the late fall and early winter, downstream growth rates may be moderately enhanced. (2) Complete recovery generally occurred about 15 miles downstream. (3) The station in the immediate vicinity of the Paradise Steamplant showed the largest proportion of heterotrophic slimes (those obtaining nourishment from organic matter). Below the plant the proportion of algae in the periphyton increased progressively with distance and was greater at the downstream recovery stations than at the upstream control stations. (4) Downstream from the plant, the relative periphyton production rates progressively increased. The warm water discharges clearly favored the production of the heterotrophic slimes during the warm summer months. (5) As regards the total supply of fish food in the periphyton, little net change due to the plant was observed. However, the findings indicated that the potential for problems due to slime growths would be increased for any industrial water-using operation located close downstream from the powerplant.

The first unit at Paradise went into commercial operation in May 1963. While the second unit did not go into commercial operation until November 1963, it was initially fired up on August 21, 1963. During the initial firing, flow in the Green River was less than condenser flow. During two periods in the fall of 1963 (September 12 to September 13, and September 23 to October 1), the maximum mean temperature determined at Green River mile 99.5 exceeded 95° F.

Five winter fish inventories were made by TVA and Kentucky biologists in the years 1962-66. A much larger winter fish population was consistently found in the vicinity of the discharge canal than in the river above and below the plant. Distribution of fish by type parallels summer findings, except game fish were much more numerous than in preoperational samples. Fishermen know that steamplant discharge canals are excellent spots for fishing in winter months.

The 95° F. temperature maximum recommended in 1962 remained in effect during 1963, 1964, and 1965. Because of the reduction in species diversity and abundance indicated by Dr. Patrick's 1965 study, it was concluded that the temperature criteria should be changed. About this time the construction of a third unit at Paradise was planned. Cooling towers were to be provided for the new unit. Since the existing two units were required to operate under reduced load for a long period each year to meet the 95° F. criterion, and since operation would be further curtailed by new temperature limits, it appeared desirable to provide cooling towers for all three units. A maximum mean river temperature of 93° F. was allowed until the first cooling tower was put into operation during the summer of 1968. The new criteria limit max-

imum mean river temperature to 90° F. and surface temperature to 93° F.

Investigations at other plants

At other existing TVA plants, riverflow is large in relation to condenser cooling requirements. After the waste heat is mixed with the passing flow, the temperature changes are barely detectable. The size of the region where mixing takes place varies from location to location and depends primarily on channel geometry. In these mixing zones the heated water usually occupies a small percentage of the stream cross section.

In 1966-67 biological studies were made at two steamplants—Colbert and Widows Creek. No changes in the bottom fauna could be detected at these two plants.

Proposed biological study

From these few experiences we have learned that thermal fish-kills can be avoided in our part of the country by keeping temperatures below 95° F. We have also learned that maintenance of a productive river requires protection of the food-chain organisms. However, knowledge in the latter area and of the long-term, sublethal effects of high temperature on fish in their otherwise natural environment is still limited. We are now considering the feasibility of a further study of the effects of raised temperatures on fish, invertebrates, and attached plant growth in an effort to determine the maximum tolerance limits of the community. If undertaken, the study will be conducted at TVA's Browns Ferry nuclear plant.

This study would involve determinations of the effects of varying heat increments above the ambient on such activities as reproduction and growth at various stages in the life of the aquatic biota. Particular effort would be concentrated on the relationship between the invertebrate life cycles and their availability as fish food during critical periods of fish spawning. Total biomass would be measured frequently to determine whether heated water increases, decreases, or does not affect production.

Metabolism and behavior of aquatic organisms would be studied to determine the physiological basis for any changes in total production or population structure of the community that results from raised temperatures. Although observed changes in population size and structure are extremely useful, explanations of the physiological causes for these changes would provide a firmer foundation for application of the observed results.

The use of several experimental water channels would allow us to evaluate the effect of increased temperature on the entire biological community under otherwise normal environmental conditions. This is important because much of animal behavior is affected by quality, intensity, and period of light. By altering temperature only, the results would be more applicable to natural conditions. We wish to study the effects of a 5°, 10°, and 15° F. temperature rise above ambient to evaluate the present recommended limit of a 10° F. rise. Results from these studies, correlated with analyses of temperature effects in the reservoir, should provide a sounder basis than now exists for setting standards for water temperature.

It is feasible to protect aquatic life by limiting stream temperatures. New mathematical techniques are needed for predicting stream tem-

peratures in the vicinity of the heated discharges. Exchange of heat with the rest of the environment as well as mixing of the discharge with the riverflow must be accounted for. Of particular interest are conditions that occur in reaches where mixing is incomplete. Here surface temperatures may be several degrees higher than the mean. From the variety in the outfall geometry found at the TVA plants, TVA technologists have developed reasonably good capability for anticipating temperature distribution in the receiving streams. To assure that mixing zones will be maintained at reasonable sizes at future plant-sites, TVA is developing mathematical descriptions of the temperature distribution in the area between the discharge and the point where mixing is complete.

Operational control of temperature

Devices and operational measures being used by TVA to control the temperature rise in streams adjoining its plants include skimmer walls and submerged dams, diffusers, low-condenser temperature rises, streamflow regulation, curtailment of plant load, and cooling towers.

A heated discharge normally stratifies due to the lower density of water at higher temperature. The floating warmer water tends to move upstream as well as downstream because of density gradients. The warm water can be deflected away from the condenser intake by a skimmer wall which is a baffle extending from the surface down through the warm water into the cooler water. The cooler water flows freely under the skimmer wall. A submerged dam has the opposite effect allowing the warmer water to pass over it while directing the cool water into the plant. Skimmer walls are built across intake canals and submerged dams are built across the river just downstream from the intake canals. This prevents recirculation of cooling water. These devices are used where they will pay for themselves by providing cooling water at significant lower temperature. (The lower the temperature, the greater the plant efficiency.) This means discharge temperatures are several degrees lower and mixing will occur within a shorter distance of the plant outfall.

To reduce the size of the mixing zone in Wheeler Reservoir below Browns Ferry, the cooling water discharge will be released through a multiport diffuser on the bottom of, and extending completely across, the old river channel. This diffuser will mix the heated discharge with 65 percent of the riverflow immediately, bringing temperatures down to the levels required to protect aquatic life very quickly.

As an alternative at other plant locations to this type of temperature control, the temperature can be kept low in the mixing zone by using a smaller temperature rise in the condensers. At our new Cumberland plant, the condensers are designed to accept a greater cooling waterflow and thus to provide a cooler discharge.

The riverflow may be regulated by releases from upstream impoundments when necessary to control river temperatures. This use of the upstream impoundments must be compared to alternate uses to determine where it is justifiable. Even with the diffuser at Browns Ferry some reregulation of riverflow may be necessary.

Temperatures were controlled in the Green River for several years by curtailing plant load during low flow periods. Now with the installation of cooling towers this curtailment will not be necessary. When the site was selected, it was realized that the low cost of coal at Paradise would more than offset the added cost of the towers.

Costs

The estimated *additional* costs to the Paradise, Browns Ferry, and Cumberland plants to meet water temperature control criteria are summarized in table 2.

TABLE 2.—Estimated additional costs to meet water temperature control criteria at Paradise, Browns Ferry, and Cumberland powerplants

PARADISE	
Capital costs:	
1. 2 cooling towers-----	\$6,600,000
2. Warmwater tunnels-----	1,100,000
3. Cooled water flumes, etc-----	1,350,000
4. Additional pumps-----	1,000,000
5. Underwater dam and skimmer wall-----	100,000
	10,150,000
General expenses, overheads, and contingencies-----	3,180,000
Subtotal -----	13,330,000
Operating costs: ¹	
1. Heat rate losses for units 1 and 2-----	820,000
2. Additional pumping power, units 1 and 2-----	650,000
3. Heat rate loss for unit 3-----	3,000,000
4. Additional pumping power, unit 3-----	1,000,000
Subtotal -----	5,470,000
Total for Paradise-----	18,800,000
BROWNS FERRY	
Capital costs:	
1. Diffuser system-----	1,750,000
2. General expenses, overheads, and contingencies-----	500,000
Subtotal -----	2,250,000
Operating costs: ¹	
1. Additional pumping head (4.5 feet)-----	650,000
Total for Browns Ferry-----	2,900,000
CUMBERLAND	
Capital costs:	
1. Increase in condenser and related elements-----	1,600,000
2. Diffuser walls-----	100,000
3. Additional channel bridge-----	500,000
4. Additional skimmer wall-----	120,000
	2,320,000
General expenses, overheads, and contingencies-----	780,000
Subtotal -----	3,100,000
Operating costs: ¹	
1. Heat rate evaluation-----	1,000,000
Total for Cumberland-----	4,100,000

¹ Additional operating costs during life of plant converted to present worth value.

SUMMARY

The size of TVA plants in relation to the large volumes of water available for cooling has allowed TVA in most cases to avoid any adverse effects on the stream due to waste heat. We learned from our experience at the Paradise plant that if temperatures are kept below 95° F., we can avoid fish-kills, but that further temperature control is necessary to protect the food organisms if a well-balanced aquatic population is to be maintained. Additional studies are in progress in areas where there is little knowledge at present. The biological studies planned for Browns Ferry would show us, we hope, what controls are necessary for maintaining the balance in the aquatic community. Our experience with waste heat disposal has shown us how to control temperature using several operational methods. Field studies at existing plants will improve our ability to predict temperature distribution expected at proposed plants.

REPLY OF DELAWARE RIVER BASIN COMMISSION

DELAWARE RIVER BASIN COMMISSION,
Trenton, N.J., October 3, 1968.

HON. EDMUND S. MUSKIE,
*Senate Office Building,
Washington, D.C.*

DEAR SENATOR MUSKIE: Thank you for your letter of September 23. The Delaware River Basin Commission has a strong interest in the matters you have raised. The Commission has adopted water quality standards and regulations encompassing temperature criteria, which include specific requirements for maximum permissible increases in stream temperatures due to heat discharges but not exceeding certain overall maximums, and for dimensions of heat dissipation areas, where applicable, to prevent thermal barriers and other damage to aquatic life. However, the Commission's standards neither begin nor end with numerical stream criteria but are based on the protection of desirable water uses, which include water supply, wildlife, fish and other aquatic life, and recreation.

Your letter asked two questions. The first deals with the extent of the responsibility of the electric utilities industry to consider the potential of long-term environmental hazards in selecting powerplant sites and designing waste disposal facilities.

Of course the utilities have an obligation to comply fully with all governmental regulations. These include the requirements of the Atomic Energy Commission regarding safety features having to do with radiation and the requirements of other Federal, State, and interstate agencies concerned with the control of environmental pollution. Where necessary to meet stream temperature criteria, the utilities must be prepared to build and operate cooling towers, cooling ponds or other facilities where needed. Consideration must also be given to the effects of waste heat discharges on other water quality parameters, such as the effects of elevated temperature on the solubility of oxygen in water. Furthermore, concern cannot be limited to conditions at waste heat outfalls. The cooling water intake must be designed so as to avoid trapping fish. The effects of the heat exchangers on fish spawn, phytoplankton, and other biota in the cooling waters must be considered as well as the effects of the addition of chemicals for corrosion and slime growth control.

It must be borne in mind that there will always be some detrimental effects resulting from the use of cooling waters and in numerous past instances, despite considerable thought and care exercised by all concerned, the potential for environmental damage has been underestimated. Therefore, it is essential that the utilities give consideration to the selection of sites where the potential for environmental pollution is minimized. They must also design and operate their facilities so as

to keep the production of waste heat to a minimum. Relatively short-range economic factors governing powerplants must not be allowed to take precedence over the long-range benefits to all segments of the economy and the Nation, which will accrue from prudent protection of our resources from environmental pollution. Where waste products, including heat, are inevitable, efforts should be directed to finding beneficial byproducts from the waste. The use of cooling water at moderately elevated temperatures in ponds or selected reaches to breed fish and shellfish is just one example of what might be done.

While the regulatory agencies can assure compliance with all requirements, such agencies are not in a position to initiate the development of constructive alternatives to the control of environmental pollution. Such action must remain the responsibility of the utilities. Wise use of our resources cannot result unless they exercise that responsibility.

The second question you raised deals with the extent of the responsibilities of Federal agencies in assuring compliance with water quality standards. Of course the first responsibility rests with the water pollution control agencies of the States, or interstate agencies where they exist. However, their efforts in this regard can be helped considerably by the wise and judicious use of the help of the qualified and responsible Federal agencies, particularly when such agencies have considerable depth in technical expertise which can be applied to such problems.

In the case of matters involving radiation, the Federal agencies can all turn to the Atomic Energy Commission and the USPHS. In the case of matters involving the protection of water quality, the Federal Water Pollution Control Administration is clearly the most competent on the national level. The USPHS has concern with public water supplies. There would be no point in having another agency step in and duplicate the efforts and talents of FWPCA for making the technical decisions regarding thermal, biological, and other questions concerning stream quality.

I appreciate this opportunity to express our position on these matters and hope that you will find them helpful in setting national policy.

Sincerely,

JAMES F. WRIGHT.

REPLY OF NATIONAL GOVERNORS' CONFERENCE

NATIONAL GOVERNORS' CONFERENCE,
Washington, D.C., October 14, 1968.

Senator EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, U.S. Senate,
Washington, D.C.*

DEAR SENATOR MUSKIE: Your letter of September 23, relating to the hearings of the subcommittee on the question of thermal pollution of water, invites a statement from me for inclusion in the record of such hearings.

My observations are not intended as a personal statement but as a reflection of the views of the several States, as I understand them.

First of all, the States share the concern of the National Government about the ecological impact of waste heat discharges. And they desire to preclude adverse effects of such discharges. The matter is not, however, a simple one and the data concerning the effects of discharge of cooling waters is generally limited or unavailable. In some situations there may even be justification for referring to the discharge as "thermal enrichment" rather than "thermal pollution."

The States' water quality standards were generally developed with care. The standards must be enforced but there is need for periodic review of the standards and continuing assessment of the ecological effect of the discharges of heated water within and beyond the "mixing zones."

It seems reasonably clear that the electric utilities industry has considered potential long-term environmental hazards when selecting powerplant sites. However, the actual extent of the thermal hazard posed by discharges from nuclear powerplants is not clearly known. It has thus seemed reasonable to a number of States to require that the industry assume, as a part of its cost, the responsibility for monitoring ecological changes occurring as a result of plant operations and making periodic reports thereof to the State involved. This procedure, subject to State surveillance, will provide the data that is not now available and afford a proper basis for such further requirements as may, on balance, be required.

The States, expect, of course, that the actions of Federal agencies in licensing power-generating facilities or in the issuance of other permits or leases will be consistent with the requirements of the States and the interests of other Federal agencies. The implications of the licensing role of the Federal Power Commission and the Atomic Energy Commission in relation to water pollution are obvious. It would seem quite clear that compliance with established State water quality standards should be a prerequisite to the granting of any license, lease, or permit by any agency of the National Government.

If there is any way in which we can be of further assistance to the subcommittee, please let me know.

Cordially yours,

CHARLES A. BYRLEY,
Director.

REPLY OF EDISON ELECTRIC INSTITUTE

EDISON ELECTRIC INSTITUTE,
New York, October 21, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, U.S. Senate,
Committee on Public Works, Washington, D.C.*

DEAR SENATOR MUSKIE: Thank you for the opportunity to submit a statement to the Subcommittee on Air and Water Pollution as it considers thermal effects on the ecology of rivers, lakes, estuaries, and other bodies of water. The subject is an important one. As you know, it is a matter of serious concern to the electric utility companies of this country, and has been for a number of years.

As use of electric energy has grown and as the size of electric-generating plants has increased, electric utility companies have given the environmental effects of their plants greater and greater attention. We are aware of some 100 studies currently underway having to do with the effects of electric-generating plants on water. Many more are being planned. Such studies have been going on for years. As one example, it is worth mentioning that one of the research projects sponsored by the Edison Electric Institute is in this area. The project, conducted by the Johns Hopkins University, was originated in 1961 and is a continuing one. It involves testing of thermal effects on plant and animal life at a number of generating plantsites around the country. A recommendation for extension and expansion of this research is to be considered by the electric research council before the end of the year. As a matter of interest to the subcommittee, I am enclosing copies of reports on the initial phases of this research effort. While this material may be too technical and is certainly far too bulky for inclusion in the record, you may wish to consider including the enclosed summaries of the project thus far. I am also enclosing excerpts from recent issues of a newsletter prepared by the Edison Electric Institute's Committee on Environment which indicate typical water studies carried on by several electric utility companies. Many more such summaries could be submitted, if they would be of interest to the subcommittee.

It may be of interest to the subcommittee that the Edison Electric Institute (EEI) Committee on Environment has formed a special water problems task force to review water problems associated with electric utility operations and to make recommendations for appropriate action by the institute, individual electric utility companies, or others. The formation of this task force, which has been at work for several months, emphasizes the increased concern of the industry over water problems, for it focuses the attention of the highest management levels in the industry on matters which have been treated largely by engineers and technical specialists since the early days of the industry.

The electric utility industry has a long history of concern over environmental matters. Some recent examples which might be cited include the electric research council's programs aimed at finding economic means for transmitting electric energy underground; the employment of the internationally known industrial designer, Henry Dreyfuss, to prepare designs for transmission towers which would be more esthetically acceptable; and a broad program of research and development aimed at improving the quality of the air, which has been outlined to the subcommittee elsewhere in some detail. Development of recreational facilities for the public at company hydroelectric sites, progressive attitudes of utilities toward undergrounding of distribution lines in new residential areas, and the companies' efforts to improve the appearance of all their facilities might also be cited among the regular electric utility industry practices bearing witness to an interest in the environment. Certainly, the industry's activities in these areas have been increased as the expectations of the people of the Nation have increased—and we can expect the industry to continue its responsiveness to the needs and desires of the people.

Of course, the utility industry's primary responsibility is to provide electric power for the Nation reliably, in abundant amounts, and at the lowest reasonable cost. In meeting this responsibility, the industry considers a number of factors, among which is the effect its operations may have on the environment. Each decision to construct a powerplant is made within the framework of unique situations which apply to that particular site. For example, in certain areas it is desirable to make use of cooling towers in conjunction with electric-generating plants. In 1966, cooling towers were being used in almost one-fifth of the generating plants in this country. In recent months, several companies have announced plans for very large cooling towers to be built with proposed nuclear powerplants. At the same time, because cooling towers may have their own environmental problems, under certain conditions, the industry is searching for alternate methods of providing cooling water. In all cases, the industry considers environmental factors in making its decisions, along with a multitude of other factors. The industry's responsibility is to the public at large, and it meets this responsibility by consulting with public representatives at the State and local level in cases where State and local jurisdiction is applicable. In case of Federal jurisdiction, of course, consultation is undertaken with appropriate Federal agencies.

It seems to us that the Federal Water Pollution Control Act gives the Federal Government adequate authority to review water quality standards and to insure that those standards will be met. The basic regulatory authority is and, it seems to us, should remain in the hands of the appropriate State and local agencies.

We might also note here that the industry has long been interested in finding uses for the low-level heat in the cooling water discharge from generating plants. The use of this warm water in shellfish culture, in fish hatcheries, and for irrigation are all being explored currently with some success.

One possible addition to the present regulatory process which would provide additional guarantees that water quality standards are being met would be to require a Federal licensing agency to provide as a condition of its license that the applicant obtain and keep in force the necessary permits from the State agency having jurisdiction. This is

similar to the proposal that such permits be obtained before issuance of the license but avoids the problems of delay inherent in requiring one agency to wait upon action by another. It also avoids the problems and duplication of effort that would result from the Federal licensing agency attempting to apply and enforce standards established by another body which has been given legal jurisdiction over the matter.

I hope these comments are responsive to the questions raised in your letter of September 16, 1968. If we can provide further information, I hope you will let me know. We will be happy to supply it. We would also be pleased to have you, members of the subcommittee, or your staff visit with Dr. John Geyer and the other scientists at the Johns Hopkins University who have been conducting the cooling water discharge research project which I mentioned earlier. We believe that they have accumulated the most complete data on the effects of thermal effect on the ecology of water life that is available anywhere. They would be happy to share it with you.

Very truly yours,

EDWIN VENNARD,
Managing Director.

The following is a summary of environmental monitoring programs in progress for Northern States Power Co.:

I. Allen S. King (coal fired) generating plant unit No. 1:

Commercial operation May 1, 1968.

609 mw gross capacity.

Continuous waterflow, 290,000 gallons per minute.

Temperature rise across condenser—17.3° F.

Once-through helper cooling towers to limit continuous waterflow discharge temperature to 86° F maximum at entrance to St. Croix River.

Chimney height—785 feet above grade, 90 feet per second exit velocity.

99.0 percent efficient electrostatic precipitators.

Supercritical pressure cyclone boiler.

1. Environmental monitoring program:

A. Water monitoring program:

- (1) Chemical analyses.
- (2) Macro-invertebrate studies.
- (3) Algae studies.
- (4) Fish studies.
- (5) Temperatures.

B. Air monitoring program

- (1) SO₂ recorders.
- (2) Soiling index recorders.
- (3) Wind direction and velocity recorders.
- (4) Lead peroxide candles and dust jar combinations.
- (5) Vegetation study.
- (6) Paint panel study.
- (7) Temperatures.

The following reports on the studies are available from the Engineering Department, NSP Co., 414 Nicollet Mall, Minneapolis, Minn. 55401:

Environmental monitoring program outline—July 1, 1965.

First annual report (1966)—July 1, 1967.

Second annual report (1967)—June 1, 1968.

II. Monticello nuclear (boiling water) generating plant unit No. 1:

Commercial operation May 1, 1970.

569 megawatts electrical gross capability.

Continuous waterflow—290,000 gallons per minute.

Temperature rise across condenser—27° F.

Cooling towers for either once-through or closed cycle operation.

1. Preoperational radiological monitoring program: This program is being conducted by NSP with the help of the Minnesota State Board of Health in providing analytical services. This survey covers background monitoring of river water, fish, bottom sediments, water plants, air and milk. Data on this program can be obtained from NSP Engineering Department.

The following is a summary of programs in progress or recently completed by Northeast Utilities and its affiliated companies relating to water problems:

I. Connecticut Yankee Atomic Power Co., Haddam Neck, Conn.:

Commercial operation January 1, 1968. 490 megawatts electrical gross (stretch capability—590 megawatts electrical) cold water flow 372,000 gallons per minute. Temperature rise across condenser—18.4 to 22.4 F.

1. Connecticut River study—Dr. Daniel Merriman, director: A “thorough and comprehensive” study of the biological chemical and physical characteristics of the lower Connecticut River determining the effect of the Connecticut Yankee plant on the ecology of the river.

The following reports on the study are available from the Connecticut Water Resources Commission, State Office Building, Hartford, Conn.

Study outline, January 1965.

First semiannual report, July 1965.

Second semiannual report, April 1966.

Third semiannual report, October 1966.

Fourth semiannual report, April 1967.

Fifth semiannual report, October 1967.

Sixth semiannual report, April 1968.

2. Thermal distribution studies: Field surveys are in progress to determine the horizontal and vertical distribution of the condenser cooling water from the Connecticut Yankee Atomic Power Plant at Haddam Neck. Knowledge of the thermal distribution pattern is required to (1) assure that the water quality standards for the Connecticut River are maintained, (2) provide thermal information required by the biologists on the Connecticut River Study, and (3) to establish the accuracy of the predicted thermal distribution patterns for the plant.

In addition to direct measurement of surface and subsurface water temperatures, infrared and rodamine B dye tracer techniques are being used to determine the location of the plume under a variety of river and weather conditions. The major contractor on this work is Traveler's Research Center, Hartford, Conn. Information on the thermal survey work in progress is available from the Environmental Sciences & Services, Northeast Utilities Service Co.

3. Radiological monitoring program: As part of the preoperational and operational radiological monitoring surveys, river water, finned fish, bottom sediments, and shellfish are routinely sampled to deter-

mine levels of radioactivity. Data on this program is available through Environmental Sciences & Services, Northeast Utilities Service Co.

II. Millstone Nuclear Power Station—Unit 1, Waterford, Conn.: Commercial operation August 1969—550 megawatts electrical, cold water flow 420,000 gallons per minute, temperature rise across the condenser—21.3 F.

1. Preoperational hydrographic studies: Predicted thermal effluent patterns for Unit 1 based on rodamine B dye tracer studies by Prithard-Carpenter Associates and hydrographic analyses by Ebasco Services. Conclusions on ecological effects by Dr. Nelson Marshall, University of Rhode Island. For summary reports see Final Safety Analysis Report, MNPS-1, section II.

2. Ecological studies—Millstone Point: A continuing survey of key indicators of marine ecology in the Millstone Point area starting in May 1968 to determine the effect of thermal discharge from Millstone units I and II, Battelle Memorial Institute—Duxbury Laboratory. Information available through Environmental Sciences & Services, Northeast Utilities Service Co.

3. Preoperational radiological monitoring program: Radiological survey of Millstone area including sampling of shellfish, fish, marine flora, and sea water to establish existing levels of background radioactivity. This survey will be continued as an operational monitoring program after startup of unit I in 1969.

III. Montville Station—Unit 6: 400 Mw oil-fired addition to existing 200 Mw fossil plant on the Thames River above New London, Conn.

1. Thermal distribution survey: A survey during the summer of 1968 will be conducted to obtain information on thermal patterns from the existing plant for use as a basis for design of the circulating water discharge system for the plant addition.

The Northeast Utilities Service Co. has several ambient air quality surveys and related work in progress at the present time in connection with its air quality control program. Information on these programs is available if desired.

PROGRESS REPORT—HEATED WATER DISCHARGE RESEARCH PROJECT OF EEI

In December 1962, the EEI board of directors, on recommendation of the prime movers committee, authorized a research program on heated water discharge (EEI Project RP-49), to study the effects of temperature on water bodies from steam electric powerplant cooling water discharge.

The objective of the program, which was carried out at the Johns Hopkins University, under the direction of Dr. J. C. Geyer, chairman of the university's department of environmental engineering science, was to summarize a literature survey of the effects of elevated water temperatures on fresh water finfish and to study the physics of natural cooling processes in water bodies surrounding condenser cooling water discharges.

This work resulted in the publication of two reports, "Water Temperature and Aquatic Life" (EEI Publication No. 65-901), and "Heat Exchange in the Environment" (EEI Publication No. 65-902). A final

summary report on this phase of the program appeared in the August 1965 EEI Bulletin.

The first phase of this program pointed up the need for further investigation directed in particular at the evaluation of the physical parameters or rate constants which describe mixing within a water body and heat exchange to the atmosphere for the wide range of condenser intake and discharge situations which the power industry presently encounters. Accordingly, the EEI board in March 1965 authorized a second phase of this program to study the physical aspects of temperature distributions and heat dissipation in water bodies surrounding thermal powerplants. Under this phase of the work, a number of field sites have been instrumented and are providing meteorological, hydrologic, and water temperature data for study and analysis. This information will allow field evaluation of the coefficients of equations developed under the first phase of the program.

As phase 2 of the program progressed, the prime movers committee, in view of the increasing need for data in this area, recommended further expansion of the program to include supplementary biological research. The extension was authorized by the EEI board in September 1967, and additional work was initiated which includes a supplementary literature review of the effects of temperature on marine, estuarine, and fresh-water invertebrates, as well as to initiate biological research at some of the sites of the RP-49 project.

The physical fieldwork, now underway, is being carried out at 11 sites provided by electric utility companies, four of which are located on rivers, two on deep stratified lakes, two on shallow lakes or cooling ponds, and three on tidal, marine water bodies. State representation includes California, Delaware, Georgia, Illinois, Kentucky, Louisiana, Mississippi, North Carolina, Texas, and West Virginia. Daily maximum air temperatures exceeding 90° F. are common at four of these sites during the summer, while during winter four others commonly experience subfreezing weather.

The field sites cover a wide variety of withdrawal and discharge conditions, and a wide range in size of plant (125 to 1,500 megawatts), relative to size of water body. It is expected that the 11 sites under study should provide a good coverage of sites typically used by the power industry today, and will provide the basis for improved predictions of temperature distributions at future sites.

During the spring of 1966, detailed planning reports for each of these sites was submitted to the project steering committee, covering such aspects as descriptions of proposed sampling stations, recommendations for meteorological station instruments, details of proposed survey procedures, and draft data tabulation sheets.

The participating electric utility companies are cooperating in the program by purchasing, installing, and maintaining the required measuring instruments and for the collection and forwarding of data to the university for subsequent analysis. The project has benefited from willing cooperation afforded the university by utility company staff members assigned to the program. It is appropriate, also, for this report to include acknowledgment of the high level of investment in equipment, manpower, and skill on the part of each of the participating companies.

A considerable effort has been invested by the project's university staff to summarize the main features of the 11 field sites in a third

report to EEI, entitled "Field Sites and Survey Methods," which is now in final stages of preparation prior to publication later this year.

MAIN OBJECTIVES LISTED

Besides describing and comparing the physical features of the project's 11 field sites and their survey data collection techniques, the third report lists and discusses the main objectives of the physical studies which include—

(1) Evaluation of the surface heat exchange coefficient and equilibrium temperature from the field survey data for different periods of averaging.

(2) Correlation of the exchange coefficient and equilibrium temperature with meteorological and hydrographic variations such as windspeed, length of fetch, air temperature, relative humidity, and solar radiation.

(3) Evaluation of horizontal and vertical turbulent diffusion coefficients from the field data, and their correlations with hydrologic variations such as discharge wind and density-induced flows.

(4) Statistical analyses of field survey data to determine the most significant parameters for future measurement, and correlations between meteorological variations observed at the project's field sites with those at nearest U.S. Weather Bureau stations.

(5) Development of general techniques for temperature prediction at new sites, based on the correlations in the second, third, and fourth objectives above.

At the time of writing this progress report, considerable progress has been achieved toward objectives (1) and (4) above. These two objectives, together with objective (2), are expected to be fairly well completed during this year, and some significant progress is anticipated with objectives (3) and (5).

In addition to regular reports to the electric utility industry, some of the project's analytical results have already been summarized in technical papers for presentation at various institutional conferences.

In August 1967 a paper, entitled "Analyzing Steam Electric Power Plant Discharges," was presented at the National Symposium on Estuarine Pollution, sponsored by the American Society of Civil Engineers at Stanford University in California. This paper reported the development of a theoretical temperature distribution equation for an estuarine situation and compared predicted mean monthly temperatures using this equation with observed data in the vicinity of a steam electric powerplant located on a peninsula and discharging near the midpoint of a small narrow estuary.

DIURNAL TEMPERATURE VARIATIONS

A second paper, entitled "The Variation of Water Temperatures Due to Steam Electric Cooling Operations," was presented in New York at the Research Symposium of the Water Pollution Control Federation's annual conference in October 1967. This paper was concerned with diurnal temperature variations at one of the project's cooling pond sites, and proposed a method for differentiating between the effects caused by the wide-ranging diurnal load variations of the powerplant and the effects of natural heating and cooling due to meteorological conditions. The method provides a basis for predicting the

expected longitudinal decay of mean temperatures and diurnal amplitudes for cooling ponds in which vertical and lateral mixing predominate over longitudinal mixing, and when the diurnal cycle is repetitive.

TIME SERIES DATA ANALYSIS

At the first Mid-Atlantic industrial waste conference held at the University of Delaware in November 1967, a third paper entitled "Characteristics of Steam Electric Condenser Cooling Waters" was presented. The emphasis of this paper was in the field of time series data analysis, specifically on the use of frequency response techniques for detecting correlations between cyclic effects, such as seasonal, weekly, and daily tidal cycles and iteratively observed data such as water temperatures measured at regular intervals. The method is used to detect such correlations at one of the project's estuarine field sites.

Biological work which is being carried out under this program will include a second literature review dealing with the effects of heated effluents upon invertebrate organisms, both fresh water as well as estuarine. This annotated review should augment the earlier report, "Water Temperature and Aquatic Life" (EEI pub. No. 65-901), and is expected to be ready for publication during the summer of 1968.

FUTURE BIOLOGICAL WORK

Future biological work will include studies of the environmental factors that influence the effects of heated effluents upon various trophic levels (food chain), as well as upon particular life-cycle stages of specific organisms. Field studies are currently being initiated at some of the sites which are collecting physical and meteorological data. During these studies it is planned to develop sampling equipment and techniques which will facilitate the collection of representative biological data in the field on a routine basis. This work will provide supplemental biological data that will assist in filling in the gaps in the currently available knowledge on the ecological effects of thermal discharges.

This project is under the general supervision of a steering committee consisting of: J. W. Purssell, Boston Edison Co., chairman; A. C. Thies, Duke Power Co.; and W. J. Robinson, Potomac Electric Power Co. S. T. Powell, consulting engineer, has served as a consultant to the Johns Hopkins University and to Edison Electric Institute in this project.

FINAL REPORT ON FIRST PHASE OF COOLING WATER DISCHARGE RESEARCH PROJECT

The first phase of research on temperatures associated with condenser cooling water discharges from steam-electric powerplants sponsored by the institute has been completed.

This research began in March 1963 with a contract between EEI and the Institute of Cooperative Research of the Johns Hopkins University, Baltimore, Md. The work has been conducted by a project staff within the department of environmental engineering science of the university.

This work was begun as a result of recognition by the power industry that the competitive uses of waters for municipal, industrial, agricultural, and recreational purposes impose increasing importance on the need to understand the effects of all types of returned waters. The desire of the power industry is to maintain the maximum utility of rivers, lakes, and harbors for the widest general use through application of the best scientific and engineering principles which can be developed.

The objective of the first year and one-half of the work on the EEI cooling water project has been to summarize the effects of warm water on fish life and to study the physics of natural cooling processes in water bodies surrounding condenser cooling water discharges. This work has resulted in the preparation of two reports: "Water Temperatures and Aquatic Life" and "Heat Exchange in the Environment."

MANUAL ON AQUATIC LIFE

The study on "Water Temperatures and Aquatic Life" has been prepared in the form of a quick reference manual. It is a 100-page summary of existing information on the relationship between temperature and the biological response of fishes of all types. The material in this report has been gathered from over 225 technical publications from all branches of aquatic biology.

To make the manual generally useful when evaluating the effect of temperature changes, the pertinent technical literature has been arranged to describe conditions that may prevail in each 5 F temperature range. Within each temperature range the abstracted information has been divided into seven categories of effects of temperature on fish life and small bottom organisms that are important in the food economy of fish.

The seven categories chosen for classification are: (1) Effects of exposure, which includes information on the time-tolerance to changed temperature as well as data on normal reactions to natural temperatures common to the climate and season; (2) Compound stress effects, which describes changes produced by temperature in conjunction with other limiting conditions, such as food supply, dissolved oxygen, and chemical compounds; (3) Effects on feeding and growth; (4) Effects on reproduction and development; (5) Effects on movement and activity; (6) Adjustment to temperature, which includes reference to sharply altered temperatures and the mechanisms by which fish adjust themselves to the change; and (7) Environmental conditions, which reviews chemical and physical changes produced by temperature and related biological alterations in the aquatic system.

This manual is intended for use by engineers, managers, administrators, and others responsible for judging the possible effects on fish life that might result from plant operations. Copies of the manual, "Water Temperatures and the Aquatic Life," are available from EEI (publication No. 65-901) at \$2 per copy.

METHODS OF TEMPERATURE PREDICTION

The report on "Heat Exchange in the Environment" is a study of the physical principles relating to condenser cooling water discharges. This report is in the form of a textbook which covers the development

of the mathematical relationships between meteorological conditions, heat inputs, and water temperatures, and provides a systematic classification of cooling water discharges based upon the type of water body involved.

More than 110 technical articles pertaining to analytical procedures used by engineers and scientists for the study and prediction of water temperatures were reviewed during the course of this study. It was found that the many existing analytical methods could be reduced to a few basic equations which can be applied to the wide variety of condenser intake and discharge conditions. Many of the analytical methods developed are the result of original research conducted by The Johns Hopkins project staff during the course of the project.

Equations which can be applied to predict water temperatures are developed for cooling ponds, rivers and streams, and lakes and reservoirs. These equations are based on the spatial temperature distribution expected in each type of water body. The procedure of relating the exchange of heat with the atmosphere to the distribution of heat within a body of water is used in each case.

Included in the report are the results of a short-term temperature survey conducted during the course of the project which was designed to test instrumentation procedures and analytical techniques for evaluating physical parameters derived from the theoretical considerations. It was found from this survey that the most significant parameter, the exchange coefficient, varies widely throughout the day and that values computed on an average weekly basis do not provide sufficient detail to interpret temperature effects.

The 250-page text also covers the three types of temperature studies that the power industry can use in assessing cooling water discharge conditions, and discusses available meteorological and hydrographic instrumentation for conducting these studies. Copies of this report, "Heat Exchange in the Environment," are available from EEI (publication No. 65-902) at \$2.50 per copy.

FIELD STUDIES BEING PLANNED

The first phase of the cooling waters research has served as a basis for assessing the present state of engineering knowledge. It has been found that the physical parameters of rate constants which describe mixing within a water body and heat exchange to the atmosphere remain unevaluated for the wide range of condenser intake and discharge situations which the power industry presently encounters.

In order to continue this work, EEI has entered a new contract with The Johns Hopkins University for field studies to determine numerical values of the parameters and constants needed for prediction of water temperatures in the vicinity of thermal electric powerplants. This program calls for the establishment of at least six sites which represent a cross-section of climatic, hydrologic, and physical site conditions ranging from plants located on rivers and reservoirs to those on estuaries and embayments.

In this second phase, the planning of field studies for each site and design of instrumentation systems, methods of operation and data analysis, will be the responsibility of the research staff at Johns Hopkins. It is proposed that individual companies finance the purchase

and installation of necessary field equipment, and collect and forward data to the Johns Hopkins for analysis.

The research at Johns Hopkins has been directed by Dr. J. C. Geyer, chairman of the Department of Environmental Engineering Science. The physical report was prepared by Dr. J. E. Edinger and Dr. Geyer, and the biological report was prepared by Dr. C. E. Renn and Dr. C. B. Wurtz.

Coordination of the research between the project staff and EEI is maintained through a steering committee of the Cooling Water Task Force, under the EEI Prime Movers Committee. The steering committee is composed of W. J. Robinson, Potomac Electric Power Co.; A. C. Thies, Duke Power Co.; and J. W. Purssell, Boston Edison Co.

REPLY OF AMERICAN PUBLIC POWER ASSOCIATION

AMERICAN PUBLIC POWER ASSOCIATION,
Washington, D.C., October 18, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Senate Subcommittee on Air and Water Pollution, U.S.
Senate, Washington, D.C.*

DEAR SENATOR MUSKIE: In our letter of September 30, 1968, to you, we indicated that the American Public Power Association would canvas members of pertinent APPA committees to obtain their comments on the questions raised in your letter of September 16, 1968, regarding thermal pollution for inclusion in the record of the recent hearings by your subcommittee on this matter. We have done so, and the following is a compilation of the answers to our inquiry:

1. What should be the extent of the electric utility industry's responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities?

All respondents indicated a deep concern about potential long-term environmental hazards, but many were cautious about the degree of present knowledge that is available to properly assign responsibility. The particular geographical location and the relative size of the respondent's system were also moderating factors in the answers. Some of the specific comments included these:

"I don't believe we can rely on the utility industry to answer their own questions in determining the potential long-term environmental hazards when selecting plantsites or designing waste disposal facilities.

"The government regulatory agencies now have difficulty in counteracting claims made by the utilities, their highly paid staffs and consulting firms. They at present have a monopoly in the hiring of the few available biologists and environmental specialists that are both capable and experienced. It would seem that the best course would be to have the licensee pay a fee to an appropriate agency for studies and investigation on a crash basis to train an adequate staff of specialists in these areas. State and Government departments must certainly be handicapped because of the impossibility of finding or recruiting specialists in this area of need."—FRANK SAHLMAN, executive vice president, Northeast Public Power Association, Boston, Mass.

"The electric utilities selecting a powerplant site should be responsible for conducting a study and preparing a report of the environmental problems in the immediate area and outlining the proposed solutions to the same degree it is required to conduct studies and outline solutions for hydroelectric projects licensed by the Federal Power Commission with respect to game, fisheries, and recreation.

"In a broader sense the industry should participate in studies and research toward both developing standards and minimizing hazards."—R. W. GILLETTE, manager, Public Utility District, Grant County, Ephrata, Wash.

"* * * it is in our interest as utilities as well as the general public interest, for the utility industry to accept responsibility for design of waste facilities for powerplants that properly take into account long-term environmental hazards. Each utility should consider this a part of its individual utility responsibility carried out through its own planning and through support of joint research activities conducted by regional planning entities. Criteria established by the Federal Government as part of plant licensing procedure could provide the basic guide for this activity."—HOWARD C. ELMORE, assistant manager, Public Utility District No. 1 of Chelan County, Wenatchee, Wash.

"* * * the electric utilities should follow the dictates of the governing or regulating agency or agencies under whose direction the particular river, lake, or stream falls. In a complex river or lake system combined effects of a number of industrial users would require an all-encompassing study beyond the resources or understanding of an individual user. Such a study would be more appropriately handled by governmental agencies calling upon special technologies from numerous sources.

"In other words, the utilities should not be responsible for ecological studies, etc., necessary to determine standards and to foresee possible long-term environmental hazards. However, the electric utilities should be required to demonstrate conclusively that they can meet the standards set forth by the regulating agencies."—T. M. MORONG, assistant general manager and chief engineer, Salt River project, Phoenix, Ariz.

"The thermal pollution effects resulting from the selection of powerplant sites should be, and presumably are, a subject of consideration by all utilities. The extent of the electric utilities responsibility should be to fully support and meet regulations on thermal pollution consistent with a policy of obtaining maximum beneficial use of water."—EDGAR L. KANOUSE, general manager and chief engineer, Department of Water and Power, City of Los Angeles, Calif.

"With present technologies, there seems to be some environmental effect from every type of commercial electric generation. At the present time the tendency seems to be to ignore the air pollution arising out of the burning of conventional fuels and to assume that if the thermal pollution of water by atomic plants can be prevented, we have thereby carried out our obligations to humanity. This does not seem to me to be correct. If the Federal Government forces uneconomical cooling systems on nuclear electric generating plants, one result will be to cause greater air pollution by the use of conventional fuels, and in most cases there is apparently no Federal control over the construction of plants burning conventional fuels. At any rate, there must be new electric generating plants and minimizing environmental hazards will not necessarily be the result if more expensive cooling systems are forced on atomic plants.

"It would seem to me that all Americans have a responsibility to consider potential long-term environmental hazards in making decisions, but I would frankly doubt the desirability of having decisions regarding environmental hazards of powerplants left entirely to the electric utility industry. The pressures on electric utility officials are to provide as reliable and as economical sources of electricity as possible. I don't feel that those officials can or should be expected to weigh all of the

various public interests in determining sites for plants or in determining how much extra to spend for such things as cooling towers. It seems to me as though the public looks to the electric utility officials to obtain economical reliable sources of power and that they put on pressure for those items and that the public does not put pressure on electric utility officials with respect to, nor does it consider them the guardians of, the temperature of our natural waters. Therefore, it is my opinion that the American system of permitting the interplay of various economic and social forces with a public arbiter making decisions when those forces have irreconcilable conflicts is desirable in the field of thermal pollution, always keeping in mind that officials of utilities should recognize the need to protect the public against unwarranted pollution but should not be expected to meet that need solely on their own."—RICHARD D. WILSON of Wilson, Barlow & Watson, Lincoln, Nebr., counsel for Consumers Public Power District, Columbus, Nebr.

"I believe that it can be assumed that a rise in water temperature in our rivers and bays will alter the ecology of these waters. We have all witnessed the biological, chemical, and sedimentary pollution of our waters in such staggering proportions that we, as a society, will be required to expend billions of dollars in order to maintain a status quo. More billions will necessarily be spent to improve the presently deplorable condition of our waters.

"For this reason and this reason alone, we must face the problem headon and not say as has been the case with other forms of pollutants, that we will solve the problem when the conditions get out of hand. Certainly the electric industry should not be guilty of promulgating this plague upon our great natural resources. The electric utility industry should voluntarily design their generating facilities to preclude any deleterious effects of thermal pollution in all natural receiving bodies of water."—WILLIAM H. COCHRAN, Jr., general manager, Eastern Utilities Commission, Easton, Md.

"The electric utility industry has a direct responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities. It is expected that the utilities will meet all reasonable standards established for control of these items. It is likewise the responsibility of the State or other regulatory group to make sure that the standards required are reasonable and are necessary in order to accomplish the desired long-term environmental conditions. It is extremely important that the ultimate electric consumer is not burdened with large expenditures to comply with regulations which are not based on knowledge indicating the need for such regulations.

"Responsibility for insuring compliance with applicable water quality standards should be vested in the State since most States have recently adopted standards which are subject to the approval of the Federal Government."—J. WILEY BOWERS, executive director, Tennessee Valley Public Power Association.

"Senator Muskie's first question has the obvious answer that utilities must be concerned with the potential long-term environmental hazards resulting from thermal powerplants."—JOHN M. NELSON, superintendent of lighting, Seattle, Wash.

2. *What should be the extent of the responsibility of Federal agencies to insure compliance with applicable water quality standards when issuing a lease, license, or permit?*

"I understand there is no agency at present representing the community interest that has a clear-cut responsibility or the funds or the personnel of the right type to determine and insure compliance with applicable water quality or environmental standards. And furthermore, it is sometimes difficult to prejudge or ascertain the future long-term benefits.

"I believe: (a) The FPC takes a position it has no authority except in the case of a licensed plant; (b) the Atomic Energy Commission claims it has authority but not for the environmental aspects; (c) some agency responsibility is inferred in the Clean Water Act and given to the Secretary of the Interior but the authority is not clear cut and funds are not available.

"It would seem proper that the law be amended to be more specific and give authority and funds to some governmental office that could represent the public interest."—FRANK SAHLMAN, Northeast Public Power Association.

"A single Federal agency, possibly in the Department of the Interior, should be made responsible to approve the plans of an electric utility to insure compliance with all applicable environmental standards and specifically the Water Quality Act of 1965. Where State water quality standards are established in compliance with the Water Quality Act of 1965 the Federal agency should transfer the authority to the applicable State agency."—R. W. GILLETTE, PUD, Grant County.

"* * * there appears to be a need for some overall Federal jurisdiction to insure compliance with applicable water quality standards when issuing a lease, license, or permit. However, to minimize conflicts, delays, and blocking of justifiable plant construction, a single Federal Agency, perhaps the plant licensing agency, should have the power to make the final decision on compliance. From experience to date in the Northwest, in regard to nuclear plant siting, it appears evident that the Federal pollution control agency is attempting to require adherence to unreasonable and unnecessarily strict water quality standards with reference to water temperature increases from thermal plants. This is an example, we believe, of why the final decision on this and other environmental questions associated with thermal plants should rest with an agency that has the capability and responsibility of evaluating the overall public interest and not with an agency that is an advocate of a single or narrowly defined interest."—HOWARD C. ELMORE, PUD No. 1, Chelan County.

"* * * Federal agencies should be responsible for requiring utilities to submit adequate data in order to insure that compliance with applicable water quality standards have been met before issuing a construction permit and that they should enforce compliance after the plant is in operation.

"We do feel, though, that the governing agencies should conduct hearings for the purposes of demonstrating that the standards being imposed are reasonable, up to date, et cetera. Utilities should then be able to voice objections at such hearings if they are not satisfied that reasonableness has been demonstrated."—T. M. MORONG, Salt River project.

"We believe that the responsibility of Federal agencies would be satisfied when such agencies have specified that an applicant for a lease, license, or permit must meet the applicable provisions of the existing Federal Water Pollution Control Act, as amended." —EDGAR L. KANOUSE, Department of Water & Power, Los Angeles.

"I do feel that we need a central agency to which we can address ourselves on all the various facets of the thermal pollution questions but I am not prepared to voice an opinion at this time as to whether it should be Federal or State."—W. G. HULBERT, Jr., manager, Public Utility District No. 1, Snohomish County, Wash.

"The present Federal Water Pollution Control Act declares it to be the policy of Congress 'to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution.' (33 U.S.C.A. sec. 466). This Federal law also provides standards which are initially established by the States but subject to Federal approval (33 U.S.C.A. sec. 466g). This Federal law also provides methods of enforcement of these standards, initially by the States, but ultimately by the United States, if pollution is not otherwise abated. It is my opinion that this present law provides sufficient Federal control. There is still room under the present law for some rerecognition of the difference between the warm, muddy Missouri and a cool, clear stream in New England, and I would like to see the recognition of those local differences remain. It is true that the standards and enforcement procedures to prevent water pollution are currently in the formulative process under the present Federal legislation, but it is my opinion that these items now being formulated should be permitted an opportunity to work and to give recognition to local differences. The question posed by Senator Muskie seems to assume that the present standards and methods of control are inadequate and that perhaps various Federal agencies which issue licenses for electric generating plants should have the added responsibility of protecting against water pollution. In my opinion, there is already adequate Federal legislation to do that job, and adding additional roadblocks to obtaining leases, licenses, or permits will unnecessarily complicate and slow down desirable development of natural resources. This is not necessary in order to protect the public interest because of the present Federal and State regulations."—RICHARD D. WILSON, of Wilson, Barlow & Watson.

"* * * I would like to feel that strict regulations are not or should not be necessary, but I am certain that strict regulations and strict enforcement of these regulations are necessary.

"When we speak of thermal pollution of our waters we are, or at least I am, speaking of the effects that higher than normal water temperatures have upon our natural bodies of water. These bodies of water in most instances are interstate and the electrical energy generated at the powerplants flows between States and regions. It is inconceivable to me that any agency of government other than at the Federal level could effectively regulate and control the thermal pollution of our waters."—WILLIAM H. CORKRAN, JR., Easton Utilities Commission.

A number of the respondents were concerned about the difficulty of establishing and applying broad criteria. For instance, the Board of Public Works, Holland, Mich., reported:

"Lake Macatawa is connected with Lake Michigan and is the outlet for Black River and other small creeks.

"The powerplant is located at the entrance of Black River into Lake Macatawa, where flow conditions are not very great due to the fluctuation of the Lake Michigan level. Therefore, during certain hot spells in the summer, the water at our intake is at a higher temperature than that which water resources commission allow to be discharged back into the lake.

"During this time, fish avoid the area naturally even if we did not discharge back to the lake at about 10° rise. We are permitted to discharge into the lake so long as we do not raise the temperature 10° at 500 feet away from the discharge point, top being 85° F.

"I feel quite sure that our next expansion period will include a cooling tower for control of this situation. We would expect to be reasonable in the problem and meet required conditions provided they are reasonable also.

"It is my contention that each application should be handled on its own merits and not by one set of criteria for all cases.

"Our problem is small at present and appears not more than a 2-week period per year."—G. E. BELL, superintendent of utilities, Holland, Mich.

One respondent noted that "thermal pollution" is a complex subject which is "only now beginning to get the study it deserves," and urges caution in attempting to apply across-the-board solutions. The answer stated that:

"Clearly APPA must take a stand firmly with the Nation against water pollution. Clearly, this also includes thermal pollution. It is also clear that industry (including involved local government agencies who dispose into water courses or water bodies) will not police themselves on this matter and that for this reason overall standards and methods of enforcement must be established at the Federal level. But the knowledge to properly establish these standards as regards thermal pollution is not yet available. Nor when it becomes available does it appear that this knowledge will lead to a simple standard for universal application. In contrast, it is likely that the newly acquired information will require a stream-by-stream, river-by-river, bay-by-bay consideration with each case investigated separately. And when this is done, some so-called cases of potential thermal pollution may very well turn out to be thermal enrichment, much to the benefit instead of to the detriment of the local ecology and to the benefit of those who make use of the local ecology."—PAUL E. SHAAD, general manager and chief engineer, Sacramento Municipal Utility District, Sacramento, Calif.

"* * * compliance with standards should be delegated to the smallest unit of government having complete jurisdiction over the body of water concerned. For example, Lake Washington, east of Seattle, would be the responsibility of the King County unit of government. On the other hand, Puget Sound would involve at least all those counties bordering it and therefore should be the responsibility of the State water pollution control agency. There may be other situations in which two or more States are involved, in which case a regional or Federal agency would be required."—JOHN M. NELSON, Seattle, Wash.

"Thermal pollution is a matter of vital concern here in the Pacific Northwest because of the nuclear power generation era which will soon be with us.

"To date the pollution policy questions raised by Senator Muskie have not been answered to the satisfaction of all concerned here in the Northwest."—L. J. BAUER, general manager, Central Lincoln People's Utility District, Newport, Oreg.

The difficulty of untangling the electric utility's sometimes conflicting responsibilities is pointed out in the response by the city of Tacoma, Wash., as follows:

"We believe these two questions are necessarily intertwined. In the absence of knowledge regarding the effect of temperature, etc., on marine ecology, the utility must necessarily assume a certain amount of responsibility in the public's interest to choose sites which, as far as they are able to determine, minimizes this effect. At the same time, we believe the utility's main responsibility is that of providing electrical energy to meet the public's needs and that the fundamental responsibility of developing the knowledge necessary to develop reasonable rules to protect water quality must rest with the Federal Government. Undoubtedly, this will require considerable research and corresponding expense.

"The ever increasing power requirements require utilities to develop new sources of generation. The necessary procedures required in order to authorize the use of a site should consume only as much time as required to protect the public's interest. If independent research has to be carried out by each utility before this can be accomplished, it would appear that a great deal of overlapping effort would result."—R. M. BOYLES, department of public utilities, Tacoma, Wash.

This point is raised again by the head of a Wisconsin system who favors minimum Federal standards. He states:

"It is my opinion that water is a national and not a local or regional natural resource. I would, therefore, favor minimum Federal standards for pollution control assuming that there has been a reasonable opportunity for local and State participation.

"It appears to me that there have been as many statements that have overstated the case for thermal pollution as there have been those who would like to bury the problem. There is no question in my mind that a reasonable set of minimum standards taking into consideration local ecologies are not only desirable but necessary.

"Further, I do not feel that it is practical to assume that all States would have the necessary regulatory bodies or staffs to adequately determine the possible effect of thermal pollution from proposed generating or heat producing sources. I also realize that at time there will be a direct conflict of interest between the needs of the electric power industries to serve the Nation and also the need to preserve our natural resources. However, I believe that intelligent planning and good engineering can satisfy both of these points of view."—LOUIS H. WINNARD, general manager, Manitowoc Public Utilities, Manitowoc, Wis.

A note of caution is sounded by Carroll Oliver, manager of the city of Anchorage, Alaska, municipal light and power department, who is of the opinion that utilities should take the lead and that Federal agencies should have responsibility for enforcement as well as development of standards. However, he noted that, "recognition must be given to the fact that this program will be a long-term objective."

Many of the respondents have indicated the need for further knowledge on the subject. The administrator of the Alaska power admin-

istration, responding to the inquiry as a member of our power supply planning committee, pointed out that :

"This subject certainly opens an excellent chance for research and positive thinking if it isn't killed aborning by giving it a bad name.

"I certainly object personally to the term thermal pollution and I recognize that neither will all cases qualify for a name like thermal enrichment, thermal enhancement, thermal benefits, thermal recovery, or whatnot.

"A neutral name might be thermal effects.

"We need warmer water for irrigation.

"Municipal water supply in Alaska can be improved by tempering to get further above the freezing level.

"Many fish thrive in or prefer warmer water and will congregate at a utility steamplant condenser discharge channel.

"We waste a tremendous quantity of heat, far more than we use. We should join in research to recapture waste heat or improve efficiency or set up multiple-purpose plants such as the attempted combination of generation and desalinization.

"In responding to Senator Muskie's letter, it seems to me the questions are too narrow and are addressed to the symptoms instead of to the causes.

"The subject of wasted fossil fuels deserves a real study. The Nation little knows how little fuel ever reaches the point of use. Not the least of the consequences of the waste is air and water pollution but the real tragedy lies in the inefficiency."—Gus Norwood.

Many APPA members are not directly involved in questions related to thermal effects because they do not operate generating equipment. For instance, C. B. Johnson, general manager of the Electric Power Board of Chattanooga, Tenn., noted that: "We have had no experience with regard to thermal pollution of water, either with conventional or nuclear generating plants. We purchase all of our power requirements from TVA and have no generating facilities."

Several of our respondents indicate by their answers their concern with the problem but concluded that they simply do not have enough technical knowledge or personal experience to be able to make a substantive response to the questions.

I hope that your subcommittee will consider the opinions expressed by the respondents to our inquiry and will find them useful in resolving the policy issues that have been raised during your hearings.

Sincerely,

ALEX RADIN.

REPLY OF NATIONAL COAL ASSOCIATION

NATIONAL COAL ASSOCIATION,
Washington, D.C., October 18, 1968.

HON. EDMUND S. MUSKIE,
*U.S. Senate, Committee on Public Works,
Washington, D.C.*

DEAR SENATOR MUSKIE: The following statement is in response to your letter of September 16, 1968, requesting comments on the environmental factors, particularly thermal pollution, to be considered in siting powerplants.

The first question, which relates to the responsibilities of the electric utility industry in making such decisions, is best answered by utility spokesmen. I am advised by Mr. Grundy that they have been invited to respond.

We have some reservations about the second question which relates to the extent of responsibility of Federal agencies to insure compliance with applicable water quality standards when issuing a lease, license, or permit. Congress has already charged the Department of the Interior through the Federal Water Pollution Control Administration to investigate many of these activities. In addition, the Federal Power Commission, in recent decisions, has concerned itself with thermal pollution.

We do feel the need, in light of the fact that you are asking for solutions to long-term environmental hazards, to point out the necessity for expanded research. This area demands further research. Many such projects could have the multipurpose effect of solving not just one but many of the environmental problems we face today, for example, one which reduces thermal effects may also serve to reduce atmospheric contaminants.

We face a real need to develop new technology for conversion of heat into electricity. In the most modern powerplants, the basic process for producing electricity is little changed from 50 years ago. Fuel combustion, be it fossile or nuclear, produces steam which in turn causes a turbine to rotate and generate electricity. Although many improvements have been made in the process over the years, it appears that further refinements of the basic process are improbable. The conversion of only 40 percent of the fuel energy in the fuel into electricity appears to be a maximum with present technology. The ultimate achievements—improved efficiency and reduced environmental contamination—will only result from drastic fundamental changes in the process of producing electricity.

We believe that there are definite research opportunities for accomplishing these modifications in the power generation process. Initial investigations on such methods of power generation as magnetohydrodynamics, electrogasdynamics, fuel cells, and the conversion of coal

to a gas at the powerplant, with subsequent use of the gas to operate gas turbines rather than steam turbines, offer promise.

A comparison of improved efficiencies in electricity costs by existing and possible future methods of generation is shown in table I. The costs and efficiencies shown for plants of the future were taken from the published literature. All of these new approaches will increase the overall efficiency of converting the heat into electricity. In addition, many of the processes make possible a substantial reduction in thermal pollution as a result of the need for less cooling water. And a further benefit, possible in many new approaches because they operate under high pressures, is the opportunity for pollutant removal from lesser gas volumes and therefore at lower costs.

Such improvements in electrical generation technology will provide maximum benefit to society through the substantial reduction or nearly complete elimination of pollution, both atmospheric and thermal.

Attached to this statement is a copy of a recent publication published by Bituminous Coal Research, Inc., entitled "Electricity From Coal—a New Generation," which describes in detail the several processes discussed earlier.

We ask that both this statement and its attachments be made a part of the official record, and thank you for this opportunity to present our views on this most important subject.

Sincerely,

STEPHEN F. DUNN.

TABLE I.—COMPARISON OF VARIOUS METHODS OF ELECTRIC GENERATION

[500-1,000 mw. plant; capital 14 percent, capacity factor 0.8; coal at 24 cents per million Btu; nuclear fuel at \$8 per pound U₃O₈]

	Current plants		Possible future plants			
	Coal	Nuclear	MHD	EGD	Fuel cell	Gasifier turbine
Capital cost, dollars per kilowatt-hour.....	135	170	135	91	108	97
Efficiency, percent.....	39	33	50-55	50	60	41
Power cost, mills per kilowatt-hour.....	15.63	5.62	14.88	14.30	3.96	4.49

¹ Includes the equivalent of \$1 per ton of coal for SO₂ control.

[From Coal Research, summer, 1967]

ELECTRICITY FROM COAL—A NEW GENERATION

Total U.S. thermal generation of electric power in 1965 was 861.4 billion kilowatt-hours. The Federal Power Commission predicts that output will increase about 50 percent by 1970—and double again by 1980.

There are many other predictions in give-or-take range of the FPC's, but there is only one conclusion: by this decade's standards, almost unbelievable amounts of fuel will be needed for power generation in the next 15 years. And the end of power-demand growth is not in sight.

Another consensus—electric utilities will burn greatly increased ton-nages of coal to carry future powerloads. The utility coal burn this year is expected to reach about 281 million tons, continuing to supply more than half the Nation's power. By 1980 the utility figure could be 560 million tons, the U.S. Bureau of Mines says. And despite an expected drop in coal's percentage share of the utility fuel market as a

result of nuclear power growth, the Atomic Energy Commission sees a 1980 utility coal burn of about 450 million tons.

How high coal for power will actually go depends principally on two technological advances in electric generation—pollution abatement to meet clean-air regulations, and cost reductions to meet nuclear power competition.

Conventional coal-fired steam-electric generating plants have been refined to near peak efficiency. Experts confidently expect research to come up with a workable answer to the big current pollution problem—emission of sulfur oxides.

Meanwhile, however, research has also raised the curtain on a whole “new generation” of methods to produce power from coal—and these could shortcut both problems of pollution and operating costs. James R. Garvey, president of Bituminous Coal Research, Inc., summarized the principles and prospects of these new coal-based generation methods for the American Power Conference last April. The following evaluation is based on his remarks:

Improvements in the technology of converting coal to electric energy are needed, and they should be directed to providing maximum benefit to society as a whole. Basic objectives in development of better generation methods should include—

The substantial reduction or complete elimination of pollution, both stack and thermal:

The development of hardware to reduce capital investment in plant; and

Use of new energy-conversion principles to permit thermal generating plants to break out of the 35-plus percent efficiency straitjacket they now wear.

Opportunities for achieving some, or perhaps all, of these objectives are available now; all that remains is to expend the effort, and the dollars, to attain them. These “opportunities” include coal-based electric generation by fuel cells, electrogasdynamics, magnetohydrodynamics and the conversion of coal to gas for powering turbines.

FUEL CELLS * * * COMPACT EFFICIENCY

The direct production of electricity from a fuel and an oxidant, without first converting the chemical energy associated with the reaction to heat, has been the goal of scientists for more than 100 years. The device through which this electrochemical oxidation of a fuel would take place is termed a fuel cell. Its basic unit consists of an electrolyte and two electrodes—one electrode at which the fuel is oxidized and the other at which the oxidant is reduced. The electrolyte is selected to be compatible with the fuel and the electrode materials of construction. Depending on the fuel and the oxidant, the unit cell operating voltage ranges from 0.5 to 1.5 volts. The fuel cell power generation then must include a multiplicity of such units, along with associated equipment for heating or cooling the system, for product removal, for fuel preparation and for fuel storage.

The present applications of fuel cells are in aerospace and in the military. Prohibitive cost is but one item that has prevented their entry into commercial application. However, research sponsored by the Office of Coal Research is proceeding at a rapid pace to develop inexpensive,

reliable materials for fuel cell components, and commercial applications have been projected.

The attractiveness of fuel cells for commercial use is their inherent efficiency. With a potential conversion efficiency of 60 to 70 percent they out-perform present steam-turbine generators, which have a 40 percent cycle efficiency at best, and internal combustion engines with efficiencies of 15 to 40 percent. The absence of moving parts gives fuel cells a potential for almost maintenance-free operation. If efficient fuel cells using readily available, inexpensive fuels can be built with low-cost, reliable components and materials, their impact on the electric industry will be tremendous.

The heart of the coal-burning solid-electrolyte fuel cell system is the thin film battery, which represents the latest development and holds the greatest promise of any cell configuration considered. Economics and performance have dictated choice of this type of fuel cell assembly.

A continuous tube of porous substrate material is the foundation on which the battery is built and provides its mechanical strength. Spinels, alumina and calcia-stabilized zirconia show promise as substrate materials. The thin-film air electrode is deposited on the substrate, followed by successive deposition of a solid electrolyte and finally the fuel electrode. By use of masking during the film depositions, series-connected fuel cells are formed.

Of the possible air electrodes investigated, tin-doped indium oxide has shown greatest promise. The solid electrolyte consists of a ceramic, usually zirconium oxide, which has been doped with an oxide of another element, such as yttrium oxide, so that positions in its crystalline structure normally occupied by oxygen atoms are left vacant. Thus, the solid electrolyte is impervious to everything except oxygen atoms. Various materials have been investigated for possible use as fuel electrodes. Of these, cobalt doped with zirconium gives promising results, with performance approaching that of the much more expensive platinum electrode.

Project Fuel Cell, under contract by the Office of Coal Research, is still in the experimental stage and much work remains to be done before commercial application can be undertaken. Further research is needed to develop electrodes and electrolyte with desired optimum characteristics—low cost, reliability and long life. Polarization voltage of suitable electrodes must be within acceptable limits. The operating life of cell components must be established, bearing in mind that the ultimate goal is to attain a life approaching 20 years.

ELECTROGASDYNAMICS * * * POWER WITHOUT MOVING PARTS

Electrogasdynamics (EGD) is a technique for converting the pressure energy of a flowing gas directly into high-voltage electricity without moving mechanical parts. In principle, this offers the possibility of generating electricity at higher efficiency because higher temperature working fluids can be used.

In its simplest form the EGD power generator consists of a source of ions, usually a corona discharge, and a downstream collector of these ions. The mechanical force of the gas stream drives the ions downstream, where they are picked up by an electrode. Thus, the inside of the pipe through which the gas is rushing becomes part of an electric

circuit, ions being driven downstream from one terminal to the other and through the external circuit.

The resistance of the circuit causes an electric "field" to build up at the downstream terminal. The gas must drive the ions downstream against this opposing field. Thus the power in the circuit is the result of mechanical work done by the moving gas.

How can ions be pushed by a gas—or, conversely, how can a moving gas be impeded by ions? From a microscopic view, the opposing electric field due to the current through the external load exerts an electrostatic force on the ions in the gas, and these ions, in turn, transmit momentum and energy to the gas flow through collisions. In other words, the electrostatic force on the ions is transmitted undiminished to the gas and some of the gas kinetic energy is directly converted into electric energy.

In an EGD system as applied to power generation, air sucked into the EGD compressor at the inlet is seeded with fly ash from the electrostatic precipitator and is compressed to 15 to 30 atmospheres. In the combustion chamber, the air is mixed with pulverized coal and burned. The high-pressure combustion gas enters the EGD generator where it expands and where direct conversion to electric energy takes place. There are many stages in the conversion section through which the gas flows until it is near atmospheric pressure and near normal stack temperatures. The gas then flows into the electrostatic precipitator where the dust is removed and finally discharged to the atmosphere.

The primary advantage of an EGD coal-fired station is that it can operate at a higher efficiency and can be built at lower capital cost than a conventional station of the same size, thus resulting in cheaper electricity. A 50-percent increase in thermal efficiency over today's generation efficiency is possibly with an EGD station. Much of the expensive and bulky equipment of conventional coal-fired stations is eliminated. There are no boilers, no condensers, no forced air fans, and little requirement for cooling water. There is no need for inversion equipment or transformers because the output is high-voltage electricity ready for long-range transmission. Thus, the number of major components required is reduced, leading to a reduction in capital cost.

To remove any doubt of the feasibility of building coal-fired EGD powerplants, an attempt is being made to demonstrate, in a series of inexpensive table-top experiments, that EGD energy conversion can be done at high isentropic efficiency and at high power density with coal combustion gases. This is being done under a contract from the Office of Coal Research.

What is the significance of high isentropic efficiency and high power density in establishing feasibility? Isentropic efficiency is a measure of how closely the energy conversion process approaches the ideal; that is, no friction or heat losses. The isentropic efficiency of an ideal process is 100 percent; the isentropic efficiency of a set of turbine blades or compressor blades is 85 to 90 percent. The components of a gas turbine cycle must have an isentropic efficiency at least 70 percent to work at all. The present EGD experiments, for the sake of convenience, are being conducted in room-temperature air, seeded with fly ash. Better than 70 percent isentropic efficiency has already been achieved by optimizing the factors involved, which include electrode geometry, corona voltage, fly ash concentration, fly ash size, gas density and gas speed.

High power density means a more compact EGD generator and compressor. However, it is well known that high isentropic efficiency can be achieved only at the expense of high power density. In experiments to date, the power density is 5 by 10^5 watts/m³ at 70-percent isentropic efficiency.

Some engineering problems are anticipated in achieving the same high isentropic efficiencies and power densities as the temperature of the gases is increased, but no obstacles of a fundamental nature.

MHD PROMISE * * * AN EFFICIENCY BOOST

The promise of the magnetohydrodynamics (MHD) concept is more efficient conversion of primary fuels to electricity, with a related cut in air pollution. First, how does the magnetohydrodynamics generator work?

Fuel is burned in preheated or oxygen-enriched air under a pressure of 5 to 10 atmospheres. The combustion gas is expanded through a nozzle to high velocity and passed along a duct through a strong magnetic field acting at right angles to the axis of the duct. If the gas is electrically conducting, an electromotive force is induced in it and, if this voltage is connected to a load, energy is delivered directly from the gas to the electrical load. The passage of the electrical current through the magnetic field causes a drag on the gas, so the pressure at the magnetohydrodynamics generator inlet is higher than that at the outlet.

To be of use in a magnetohydrodynamics generator, the gas must be electrically conducting. If the gas flowing through the generator's magnetic field is hot enough, there will be sufficient free electrons to interact with the field to produce a net current flow through the device. However, very high temperatures are required (more than the 3,000° K. that ordinary combustion processes supply) to get sufficient ionization. Therefore, the hot gas is seeded with an easily ionizable substance such as potassium, which increases the conductivity of the gas. Even with seeding, the upper temperature limit should be as high as possible because the electrical conductivity varies extremely rapidly with temperatures; and the electrical conductivity determines the power density; that is, the electric power output per unit volume of duct. In addition, the upper temperature limit will determine the range of the working temperatures and hence the efficiency of the magnetohydrodynamics generator.

A 50- to 55-percent efficient commercial coal-burning magnetohydrodynamics plant would represent a 30-to-40-percent increase in efficiency compared with the most modern steamplant. Thus, burning less coal per unit of energy output means less sulfur will be discharged to the atmosphere. Then, too, the economic necessity for efficient recovery of the seed material will insure that the magnetohydrodynamics plant effluent is thoroughly cleaned of particulate matter.

There is also the possibility that various oxides of nitrogen will be produced in the MHD unit, thus further complicating the air pollution problem. Recovery of the fixed nitrogen as nitric acid might be economically self-supporting, however. In addition, the nitric oxide recovery equipment would also remove the sulfur and thus provide an air-pollution-free exhaust.

The higher efficiency of an MHD unit also means only 45 percent of the heat of combustion is ejected to the environment, instead of our present 60 to 70 percent. Thus, thermal pollution is reduced to approximately half that of a modern, conventional plant. This cut in the amount of heat rejected also leads to appreciable reductions in capital expenditures for such equipment as condensers and cooling towers.

At present, one company plans to build a 30-megawatt steam/MHD facility despite the many problems which still exist with regard to engineering a complete plant. A prototype plant of the size contemplated will point out further research projects. Subsequently, depending on experience, there will be research into new schemes and cycles to reduce the cost of the plant.

The proposed 30-megawatt MHD steamplant would duplicate, insofar as possible, all essential functions and characteristics—except size—of a projected large-scale plant.

GASIFICATION AND GAS TURBINES—NEAR-TERM ATTRACTIVENESS

Another approach to developing better methods for conversion of coal energy to electric energy involves coal gasification at the power station plus the use of an open gas-turbine cycle. Gas turbines have had limited application in power generation, being confined to topping of steam turbine plants. No coal-fired gas turbines are in use.

Recently, however, because of rapid advances in gas-turbine performance and the recognized need for control of sulfur pollution, several organizations have been reviewing gas-turbine possibilities. Essentially, the approach under consideration consists of onsite gasification of coal under pressure (30 atm.) in an entrained airblown gasifier, removal of hydrogen sulfide from the gas produced, and then combustion in a cycle in which a major portion of the generator driving energy is provided with gas turbines and a minor portion with steam turbines. Several studies, including one by Bituminous Coal Research, Inc., indicate the coal gasifier-gas turbine approach offers attractive near-term development opportunities. Much of the hardware required is already in an advanced stage of development. Larger gas turbine plants utilizing higher temperatures (up to 1,900° F.) are apparently going to be available in the near future. Gas cleanup methods have been developed and are in commercial use. And as a result of the several coal gasification research projects which have been underway for the past several years under Office of Coal Research sponsorship, this art is well advanced. Combining these technologies into the most effective powerplant design still remains to be done.

COMPARISON OF VARIOUS METHODS OF ELECTRIC GENERATION

[500–1000 mw. plant; capital 12.5 percent; capacity factor 0.8]

	Conventional with SO ₂ removal	MHD ¹	EGD ¹	Fuel Cell	Gasifier Turbine
Capital cost, dollars per kilowatt-hour...	123	120–150	91	108	97
Efficiency, percent.....	39	50–55	50	60	41
Power cost, mills per kilowatt-hour.....	4.64	4.05	3.21	3.15	3.85

¹Sulfur oxide pollution control not included. May add 0.5 to 0.6 mills per kilowatt-hour.

THE OUTLOOK

How do these four approaches to conversion of coal energy to electric energy fit the three objectives of pollution control, lower capital cost, and higher efficiency?

Insofar as air pollution control is concerned, the fuel cell and the gasifier-gas turbine seem to offer the best possibilities. In both instances, coal gasification is involved and sulfur can be removed prior to combustion, thereby reducing the volume of gas to be processed for cleanup as compared to what must be handled when cleanup is done after combustion. In MHD and EGD, the method of gas cleanup will be similar to that needed for current types of powerplants, but the higher efficiencies of the new methods of electricity generation may offset the cost of such gas cleanup.

Capital cost of the central station of the future will be a most important factor. As a comparative yardstick in discussion of such costs, we can use recent conventional plant estimates by Philip Sporn of American Electric Power Service Corp. He puts the cost of a conventional plant at \$112/kilowatt, but realistic evaluations must consider the possible added cost for sulfur dioxide control. Based on the limited information available, the added capital cost for such control may approximate \$11/kilowatt, bringing the capital cost of the conventional plant to \$123/kilowatt.

Capital costs for MHD appear to be on the high side according to most estimates, ranging from \$120 to \$150/kilowatt. EGD costs, based on very limited information as of this time, are estimated at \$91/kilowatt. A fuel-cell plant is estimated at \$108. BCR studies made in cooperation with the Bureau of Mines and a gas turbine manufacturer set the capital cost for gasification plus gas turbine plant at about \$97/kilowatt. The foregoing costs for the fuel cell and gasifier-gas turbine plants include the required sulfur recovery equipment, while the cost estimates for MHD and EGD do not.

The potential gains in efficiency vary for the several approaches. MHD and EGD will probably be in the 50 to 55 percent range. The fuel-cell plant will be of the order of 60 percent. The gasifier-gas turbine plant efficiency will, at 41 percent, be only slightly higher than that of the conventional plant.

Putting all the variables together and evaluating one approach against another, the cost of electricity is estimated in the accompanying table. The reliability of the estimates shown, of course, is a function of the state of hardware development for the various approaches.

OCR DEVELOPMENTS IN THE NEW POWER PICTURE

The U.S. Office of Coal Research stimulated development of new approaches to better, cleaner coal power through sponsored research on MHD, EGD, and the fuel cell. This is the way the prospects for commercialization shape up:

MHD—OCR is negotiating with the American Electric Power Service Corp. and Avco Corp. to build and operate a 30-megawatt experimental MHD plant. The total program is expected to cost in excess of \$27 million and be a cooperative government-industry project. The move was encouraged by a feasibility study by Westinghouse Electric Corp. under an OCR contract that put potential power cost from a

1,000-megawatt combined MHD-steamplant at 3.5 mills per kilowatt-hour, using coal at 20 cents per million British thermal units, and 3.1 mills/kilowatt-hours with coal at 15 cents per million British thermal units.

EGD—OCR's contract with Gourdine Systems, Inc., calls for testing the principle in several individual EGD ducts using the products of coal combustion. A coal-fired test rig, capable of burning up to 150 pounds of coal per hour at pressures up to 30 atmospheres, has been built by Foster Wheeler Corp. as a subcontractor. The first 6 months of operation should provide considerable information on construction materials, channel configurations, and overall feasibility—Fuel Cell. Westinghouse Electric Corp. demonstrated the technical feasibility of a coal-energized fuel cell in 1965. Under its OCR contract, the company last year concentrated on development of suitable low-cost fabrication methods to come up with an inexpensive, durable fuel cell battery. OCR has now authorized Westinghouse to start production of 100,000 tubular cells to be incorporated in alternate 100-kilowatt plants in a life-testing and efficiency demonstration. An independent consultant, Jackson & Moreland Division, United Engineers & Constructors, Inc., evaluated the fuel cell system for OCR and put potential power cost at 2.9 mills per kilowatt-hour from full-scale plants.

Gasifier-Turbine.—OCR is currently evaluating several research proposals for development of a combined gasifier and gas turbine cycle. One, submitted by BCR, calls specifically for development of an improved air-blown gasifier that BCR feels it is in a position to develop on the basis of research results from its coal gasification work sponsored by OCR. Most of the hardware needed for other parts of the proposed cycle are available; what is necessary now is to combine them into an integrated design and erect a test plant with a capacity of about 50 megawatts.

GASOLINE-FROM-COAL PILOT PLANT DEDICATED

The research drive to convert coal into competitively priced gasoline has reached a "significant phase," Secretary of the Interior Stewart L. Udall said at the dedication May 27 of the coal-to-gasoline pilot plant at Cresap, W. Va. The big-scale plant built by Consolidation Coal Co. under contract to the Office of Coal Research is "a giant step forward in our effort to properly use the coal with which our Nation has been blessed," Secretary Udall told the 300 Government and industry representatives who attended startup ceremonies at the plant.

Pilot plant operation should further reduce the potential gasoline manufacturing cost and provide all the data needed for design of a commercial plant by the early 1970's, Secretary Udall said. He added, "We can look forward to operation of a commercial plant by industry prior to 1975."

Consol President John Corcoran turned the \$5 million pilot plant over to OCR as a new research tool and said he was confident the vision of industry and government that conceived the gasoline project and built the plant will lead to "new horizons in the world of energy." Consol's research division will operate the plant, which was constructed by Dravo Corp.

George Fumich, Jr., OCR director, introduced distinguished guests at the dedication, including Senator Robert C. Byrd (Democrat, of West Virginia), West Virginia Gov. Hulett C. Smith, and Representative Arch Moore, Jr. (Republican, of West Virginia).

Senator Byrd was cited by Secretary Udall as a strong supporter of coal research who played an important role in helping to obtain funds for OCR's Project Gasoline. Senator Byrd told the dedication audience he believes coal research is "the key to the energy future of the United States." Despite successful laboratory development of coal liquefaction processes, the "idea of a commercial coal-to-gasoline industry lay dormant" until the coal industry presented its imaginative plan to OCR, he said.

Consol had already spent many research years developing its synthetic fuel process before OCR awarded it a \$10 million contract in August 1963, to speed its advance toward commercialization. The Cresap pilot plant, with a feed capacity of 1 ton of coal an hour for a liquid output of 60 barrels daily, is designed to confirm Consol's bench-scale information. Secretary Udall said a commercial coal conversion plant, with a minimum input of 10,000 tons a day, would produce at least \$63 million worth of high-quality gasoline annually, plus byproducts, from \$15 million worth of bituminous coal.

OCR has estimated commercial gasoline-from-coal costs in the range of 10 to 12 cents per gallon.

Consol's coal-to-gasoline process was described in Coal Research No. 24 Autumn 1966. Briefly, it consists of these steps. Coal is ground, dried, and partially dissolved in a solvent produced in the process itself. The dissolved coal, including the fraction most useful in producing the end product, is separated from the undissolved solids, including the ash. (The solid fraction removed can be a useful boiler fuel.)

The liquid fraction is combined with hydrogen to produce a refinery feedstock, which is processed by more or less standard petroleum refining methods to yield high-octane gasoline, fuel oil, and liquid petroleum gases.

GORDON CONFERENCE WILL REVIEW POLLUTION

The Gordon Research Conference on Coal Science July 3-7 at New Hampton, N.H., will include sessions on environmental pollution problems, in addition to a review of research processes for elimination from coal of such air contaminants as sulfur and nitrogen. BCR will be represented by Dr. R. A. Glenn, manager of the Chemical Division, and Erle Diehl, project scientist. Mr. Diehl will participate in a panel review of air pollution and coal, discussing "pollutants from coal-burning plants other than sulfur dioxide." Chairman of the session July 6 will be Harry Perry, director of coal research, U.S. Bureau of Mines.

Larry Cook, executive vice president of the Ohio Reclamation Association and chairman of the Coal Industry Advisory Committee to the Ohio River Valley Water Sanitation Commission, will speak at a panel on land and water pollution.

RECENT RESEARCH DEVELOPMENTS

Coal power topper.—Consolidated Controls Corp., Bethel, Conn., received a \$241,798 Office of Coal Research contract in April for development of a prototype thermionic electric generator suitable for operation in coal-fired steam-boiler plants. The device converts heat directly to electricity. Placed in a boiler furnace wall to absorb radiant heat, the "topper" generator may increase overall thermal efficiency of a generating plant from the present practical maximum of about 40 percent to 45 percent or more, OCR said.

Limestone wastes study.—The West Virginia University Coal Research Bureau will make a 2-year study of waste materials generated by addition of limestone to furnaces to control sulfur oxide emissions. Chemical and physical properties of the limestone-modified fly ash will be investigated with a view to upgrading the material to useful products. The Department of Health, Education, and Welfare will share cost of the study.

Sulfur-fly ash removal.—The U.S. Bureau of Mines has awarded a \$22,474 contract to Carnegie Institute of Technology to develop an economic system for simultaneous removal of sulfur compounds and fly ash from flue gases at coal-fired electric power stations. Project aim is finding a solid material to absorb sulfur compounds at reasonable temperatures and also attract fly ash.

SO₂ fate in air.—Bituminous Coal Research, Inc., is a cosponsor of a 3-year research program to determine what happens to sulfur dioxide after it leaves the stacks of industrial plants and power stations. The GCA Corp., Bedford, Mass., will do the research under a \$300,000 contract with the Department of Health, Education, and Welfare, BCR, the American Petroleum Institute, and the Edison Electric Institute. GCA will also seek to determine SO₂ reactions to sunlight and other chemicals in the atmosphere. Riley Stoker Corp. will act as consultant on powerplant technology and oversee installation of a small model boiler, and specially instrumented aircraft will sample plumes from industrial stacks in eastern Massachusetts.

Lignite for soil.—An organic soil conditioner made from weathered lignite will get extensive field testing by Pacific Power & Light Co. and FMC Corp.'s Niagara Chemical Division. The oxidized lignite comes from P.P. & L.'s coal properties near Glenrock, Wyo., and more than 54,000 pounds were distributed for tests on agricultural, recreational, and timberlands.

Coal for sewage.—A pilot plant designed by Rand Development Corp. to treat 3,000 to 10,000 gallons an hour of raw sewage with coal as a filter-adsorbent material is expected to go into operation in Cleveland, Ohio, this summer. The Office of Coal Research, project sponsor, said sewage treatment with coal works as well as, or better, than conventional secondary treatment. Treatment ratio is 5 to 6 tons of coal per million gallons of waste treated; a plant for a city of 500,000 people would use 145,000 tons of coal annually.

REPLY OF AMERICAN PETROLEUM INSTITUTE

AMERICAN PETROLEUM INSTITUTE,
Washington, D.C., October 28, 1968.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Air and Water Pollution, Committee on
Public Works, U.S. Senate, Washington, D.C.*

DEAR SENATOR MUSKIE: The American Petroleum Institute appreciates the opportunity to comment, briefly, on the matter of thermal pollution and its control. Since it is now general practice for any industry to evaluate possible environmental hazards in locating new installations, our comments will be limited to the question of the extent of Federal responsibility.

A mechanism for controlling water pollution of all kinds and from all sources already exists in the Water Quality Act of 1965. The act, as you know, provides for State responsibility and control, under supervision by the Department of the Interior. State standards for the quality of receiving waters—including temperature standards—must be approved by the Secretary of the Interior, and State plans for enforcing the standards must be satisfactory to the Secretary.

Since any installation discharging waste water or cooling water must now meet federally approved water pollution control standards, there is no need to write such requirements into the terms of any Federal license, lease, or permit granted for other purposes. Moreover, no other Federal agency should be permitted to modify State requirements approved by the Department of the Interior. This would be inconsistent with the spirit and letter of the Water Quality Act. Direct control of waste heat discharges, like other forms of water pollution, should continue to rest with the States, with the Department of the Interior as the sole Federal agency responsible for insuring that appropriate water quality standards are established and met.

The institute also believes that all industries and all installations should be treated on the same basis with respect to pollution control. There is no need to make an exception for power-generating plants, or to draw a distinction between powerplants run by nuclear energy and powerplants utilizing other sources of energy.

One further point: There is a need for more research on the effects of water temperature increases—both the adverse and helpful effects. If present criteria for these effects are found to be inadequate, State water quality standards ought to be modified accordingly, under the procedures spelled out in the Water Quality Act of 1965.

We hope these comments will be helpful in your further consideration of the problem of thermal pollution.

Sincerely,

P. N. GAMMELGARD,
*Vice President, Environmental Affairs, American Petroleum
Institute.*

REPLY OF COOLING TOWER INSTITUTE

COOLING TOWER INSTITUTE,
Houston, Tex., October 4, 1968.

HON. EDMUND S. MUSKIE,
*U.S. Senator,
Committee on Public Works,
Washington, D.C.*

DEAR SIR: In your letter of September 23, 1968, you asked for comments on two public policy questions concerning thermal pollution. We are pleased to submit the following statements:

(1) What should be the extent of the electric utilities industry's responsibility to consider potential long-term environmental hazards when selecting powerplant sites or designing waste disposal facilities?

The primary responsibility for the determination of potential long-term environmental hazards should rest with the electric utilities industry, with long-range studies being conducted on the environmental effect on thermal pollution. These studies should reflect conditions in a given area and relate to the elimination of a persistent thermal block to fish movement rather than to an arbitrary rise in water temperature. The electric utilities industry should consult with local and State water quality officials in the selection of plantsites and waste disposal facilities.

(2) What should be the extent of the responsibility of Federal agencies to insure compliance with applicable water quality standards when issuing a lease, license, or permit?

We believe that the primary responsibility for enforcing our water quality laws and the issuance of permits should rest with the State water quality agency in whose area the plant is being built and not with the Federal agency. Federal agencies already have a broad oversight over the States' water quality laws. For this reason, the Federal agency should act as an observer to make certain the State agency is enforcing water quality laws.

Thank you for considering the Cooling Tower Institute relative to these very important issues. Please let us know if we may be of further assistance.

Sincerely yours,

C. D. CARLSON,
CTI President, Dow Chemical.

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