

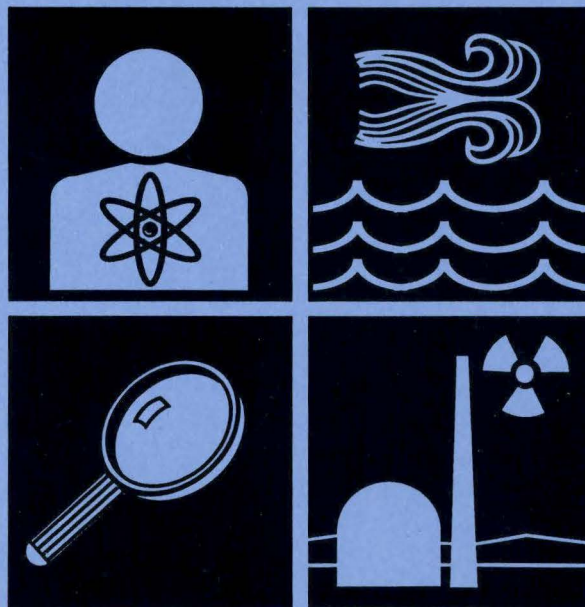
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Status of Technical Work

Hanford Environmental Dose Reconstruction Project

January 20 - 21, 1994

Technical Steering Panel Meeting



Battelle Staff
Pacific Northwest Laboratories

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Hanford Environmental Dose Reconstruction Project

Status of Technical Work

Dillard B. Shipler

**Presentation to
the HEDR Technical Steering Panel
January 21, 1994**

Battelle Pacific Northwest Laboratories

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Project and Technical Status

- BNW topics and speakers
- Status of technical work
- Status of budget and schedule

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BNW Topics and Speakers

- **HEDR Project Status**
 - DB Shipler
- **Feeding Regime Data and Dose Calculation Methodology**
 - DW Price/WT Farris
- **Validation Results**
 - DS Barth/BA Napier
- **Air Source Term Results**
 - CM Heeb
- **Columbia River source term results**
 - CM Heeb
- **Atmospheric Transport results**
 - JV Ramsdell
- **Columbia River Transport Results**
 - WH Walters
- **DESCARTES Results and CIDER Methodology**
 - PW Eslinger/WT Farris

Status of Technical Work

- **Code development and testing are finished**
- **Code validation is finished**
- **Sensitivity/uncertainty analyses are finished**
- **Air and river source terms are finished**
- **Air transport calculations are finished**
- **River transport calculations are finished**
- **Milk distribution systems are finished**
- **Vegetable distribution systems are finished**
- **Fish bioconcentration factors are finished**
- **All other data files are finished**

Status of Technical Work (continued)

- **Dose calculations for representative individuals are finished**
- **Dose calculations for HTDS individuals are in progress**
- **Phase I dose calculations for 7 Native American Tribes are finished**
- **Feeding regimes for backyard cows are being reevaluated by the TSP**
- **Final QA records are being processed**
- **Final task records are being processed**

Budget and Schedule Status

- **FY 1994 funds are in hand**
- **Sufficient funds remain to complete contract deliverables**
 - **Environmental monitoring data report- 2/28/94**
 - **Air pathways dose report- 3/17/94**
 - **River pathways dose report- 3/17/94**
 - **Other facilities source term report- 4/15/94**
 - **Project final report- 4/30/94**
 - **Records shipped to CDC- 2/28/95**

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Agenda

8:30	Introduction/HEDR Project Status	DB Shipler
8:45	Milk Cow Feeding Regime Data Used for Dose Calculations	WT Farris
9:15	Validation Results	BA Napier
10:45	Air Source Term Results	CM Heeb

Agenda (Cont)

11:15	Water Source Term Results	CM Heeb
1:00	RATCHET Results	JV Ramsdell
1:30	River Transport Results	WH Walters
2:00	DESCARTES and CIDER Results	PW Eslinger WT Farris

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Use of Milk Cow Feeding Regimes in Dose Calculations

W. T. Farris

Presentation to the HEDR Technical Steering Panel

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Battelle, Pacific Northwest Laboratories

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Air Pathway Dose Calculation Process

- **Determine timing and amount of radioactivity released**
- **Determine transport and deposition of radioactivity within HEDR domain**
- **Determine environmental transport of radioactivity and radioactivity concentrations in air, soil, and food stuffs**
- **Determine individual dose based upon individual data**

Preview Findings

- **Ingestion of fresh cow's milk is the most important exposure pathway.**
- **The type and amount of feed consumed by milk cows is important in estimating the radioactivity in milk.**

Development of Feeding Regimes

- **Four Phase I regimes were used for all milk cows (backyard and commercial).**
- **Phase I regimes were based upon input from dairy expert, farmers, extension agents, and dairy industry publications.**
- **Regimes were designed for ten counties.**
- **TSP wanted to develop additional regimes applicable to the entire HEDR domain.**
- **TSP held an expert workshop in September 1993.**

New Feeding Regimes

- **Major changes were the introduction of rain-fed regimes and different backyard versus commercial regimes.**
- **Eight new regimes were developed from the information provided by the experts and additional information from D. W. Price.**

Feeding Regimes

- **Backyard**

- Irrigated pasture
- Rain-fed pasture (Connell)
- Rain-fed pasture (Spokane)
- Stored feed

- **Commercial**

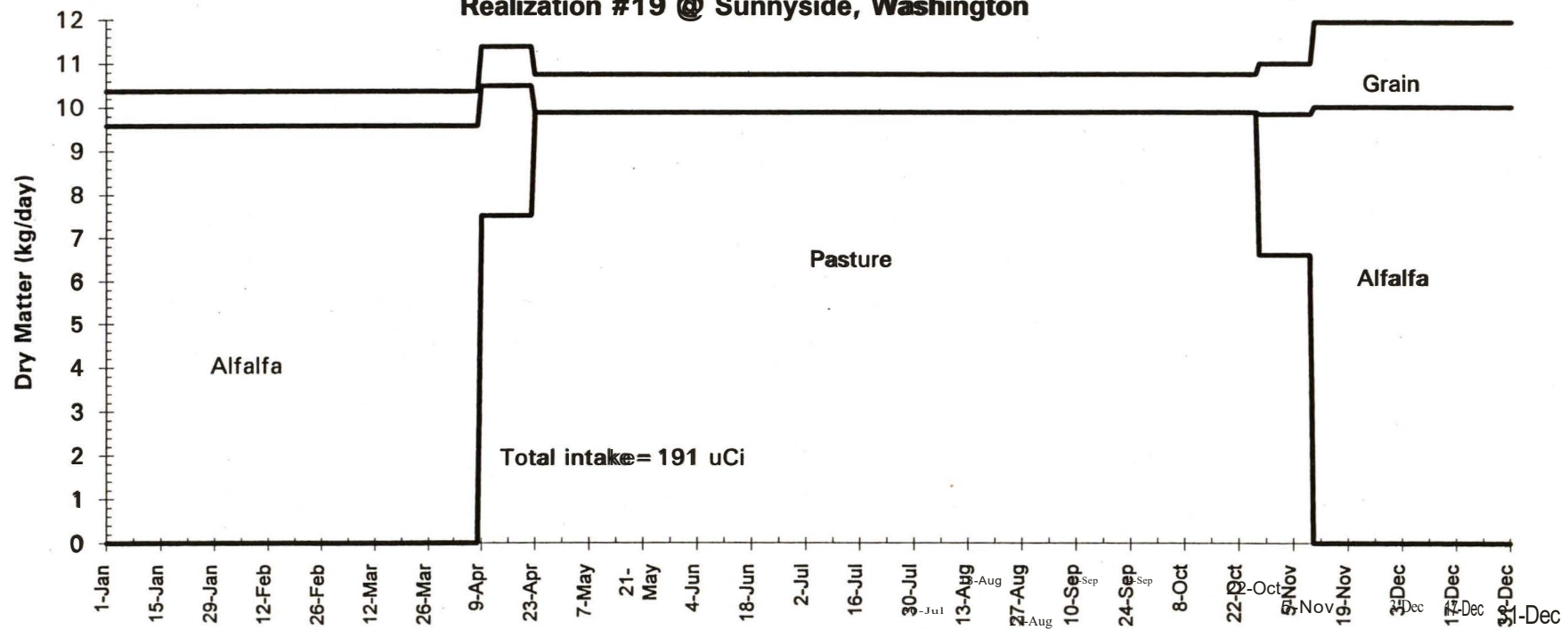
- Irrigated pasture
- Rain-fed pasture (Connell)
- Rain-fed pasture (Connell with wheat stubble)
- Rain-fed pasture (Spokane)

Characteristics of Feeding Regimes

- **The eight basic regimes are modified by the location within the HEDR domain to account for:**
 - **Seasonal differences**
 - **Spatial differences**
- **Variability in feed amounts and seasonal start-and-end dates are considered.**
- **881,600 feeding regimes are used in dose calculations.**

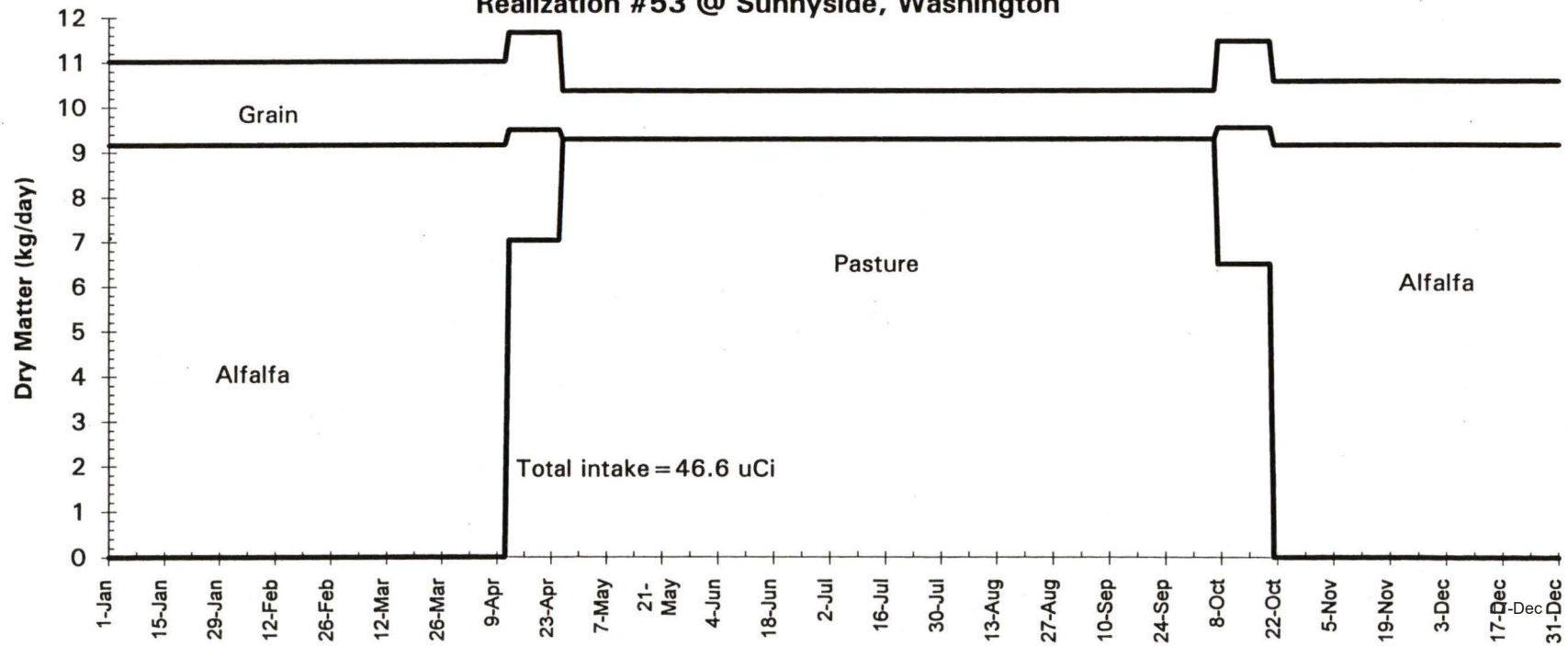
Backyard Cow (Irrigated Pasture Feeding Regime) 1945

Realization #19 @ Sunnyside, Washington



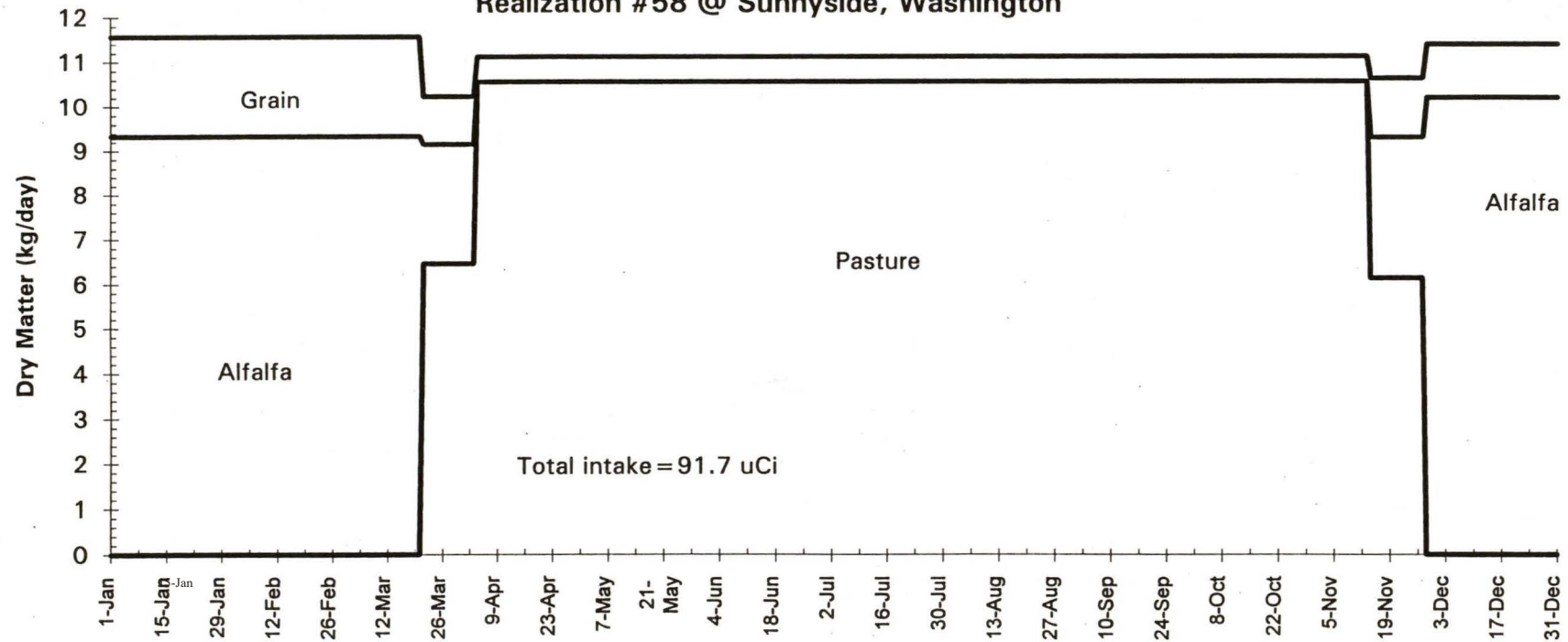
Backyard Cow (Irrigated Pasture Feeding Regime) 1945

Realization #53 @ Sunnyside, Washington

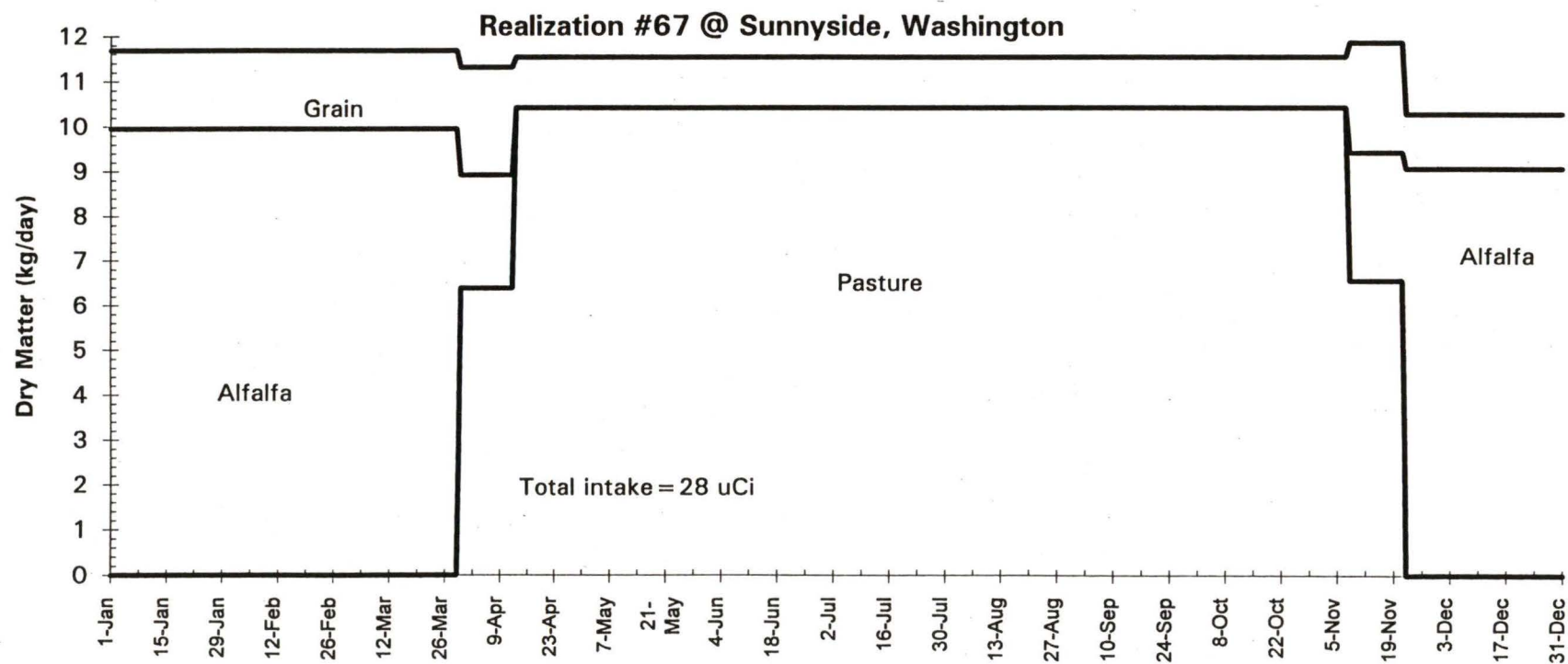


Backyard Cow (Irrigated Pasture Feeding Regime) 1945

Realization #58 @ Sunnyside, Washington



Backyard Cow (Irrigated Pasture Feeding Regime) 1945



Dose Calculations

- **Air Pathway dose report**
 - Representative individuals drinking milk from cows on pasture or stored-feed regimes
- **HTDS calculations**
 - Survey responses include specification of milk source and feeding regime
 - All four commercial regimes used to calculate commercial milk concentrations

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Validation of HEDR Models

B. A. Napier

Presentation to the HEDR Technical Steering Panel

January 21, 1994

Battelle, Pacific Northwest Laboratories

Topics

- **Brief summaries of cases investigated**
- **Changes since October highlighted**
- **Suitability of models for use**

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Cases Investigated

- **Reactor model burnup calculations**
- **Time-sequence vegetation contamination**
- **Dispersion/deposition footprint, April 13, 1946**
- **1949 Green Run**
- **PUREX release, September 1963**
- **Krypton-85 atmospheric dispersion**
- **Richland worker thyroid counts, 1945-1946**

Cases Investigated (Cont)

- **Columbia River hydraulics**
- **Columbia River water concentrations, 1967**
- **Columbia River resident fish concentrations, 1967**
- **Pacific coast oyster concentrations, 1967**
- **Richland whole-body counts, 1960-1971**

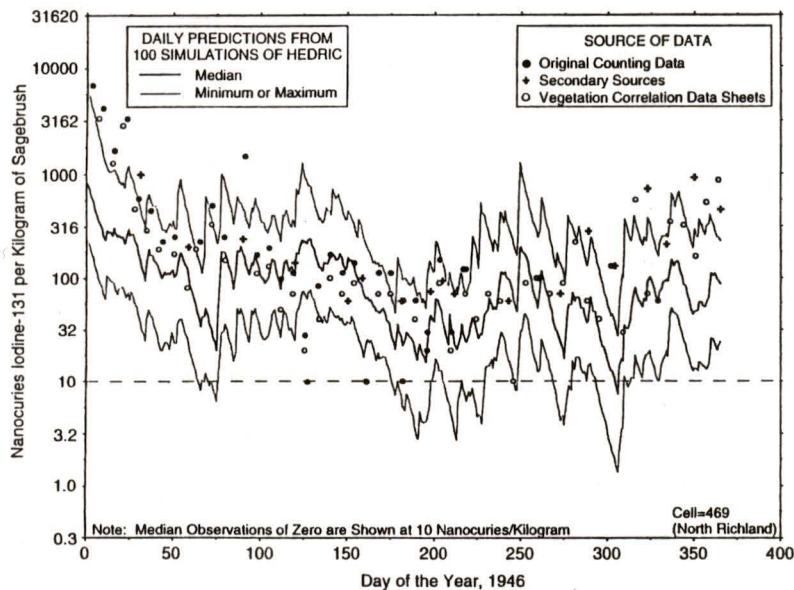
Reactor Model Burnup Calculations

- Compared the calculated burnup (MWd/t) of fuel at discharge to the Hanford P-Department records
- Found maximum discrepancies between calculated and measured burnups to be less than 15 percent
- Recommend no changes for reactor model

Time-Sequence Vegetation Contamination

- Compared the calculated time series of deposition on sagebrush to the measured values for 1946
 - North Richland
 - South Richland
 - Kennewick/Pasco
 - Benton City
- Found not all available data to be of similar quality
- Differentiated various sources at TSP suggestion

Comparison of Daily Predictions and Measurements of Iodine-131 Concentration in Sagebrush for North Richland, 1946



Time-Sequence Vegetation Contamination (Cont)

- Found order-of-magnitude agreement to be:
 - Within factors of 3 in grazing season months
 - Not as good during winter months
- Found apparent tendency to underpredict contamination
- When coupled with results of other evaluations, recommend no revisions to the models

Dispersion/Deposition Footprint, April 13, 1946

- Compared calculated deposition on sagebrush during the grazing season to available data
- Found data set less useful than hoped because of relatively few measurements
- Found most measurements to be very near historical level of detection
- Found results still show relative agreement

1949 Green Run

- Compared the calculated to the measured spatial distribution of iodine deposition on vegetation following the release of December 2-3, 1949
- Found first data from beyond Hanford Site boundary beginning December 5
- Found contamination of counting laboratory raised limit of detection

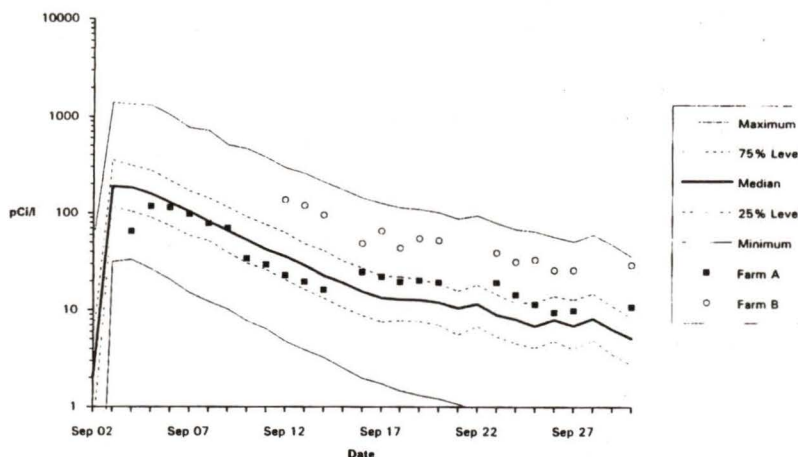
1949 Green Run (Cont)

- Found comparisons best for times corresponding to period of active transport and deposition
- Found some corrections had to be made for temporal mismatch - when this is done, 85 percent of measurements fall within ranges of predictions
- Found a minor miscalculation of the location of the plume after several days (average of 6 miles too far to the east)
- Recommend no changes for models

PUREX Release, September 1963

- Compared the calculated to the measured deposition of iodine on pasture grass at Horn Rapids
- Compared the calculated to the measured concentration of iodine in milk from individual family cows at Horn Rapids
- Compared the calculated to the measured thyroid burden/dose for children at Horn Rapids

Iodine-131 Concentration in Milk at Horn Rapids - September 1963



PUREX Release, September 1963 (Cont)

- Found deposition calculated on grass to be within the range measured
- Found uptake calculated for iodine in cow's milk to parallel the measured values and measurements to always be within the calculated range
- Found doses measured to the thyroids of two subjects to be in the middle of the range calculated
- Found component parts to be accurate with no evidence of compensating error
- Recommend no changes for models

Krypton-85 Atmospheric Dispersion

- **Compared the calculations to over 300 measurements of monthly averaged air concentration of krypton-85 from PUREX plant releases in the 1980s**

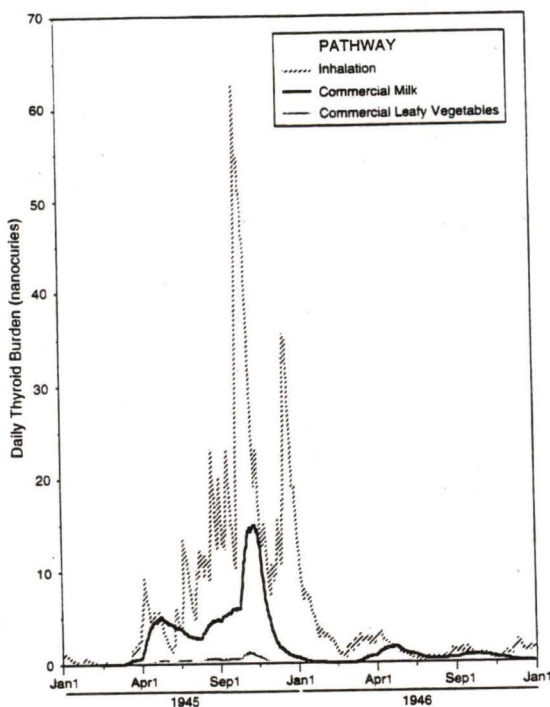
Krypton-85 Atmospheric Dispersion (Cont)

- **Found RATCHET has a median bias of about 25 percent when using all available meteorological data within the portion of the atmospheric transport domain covered by the measured data**
- **Found median bias to be about 38 percent when using only meteorological data equivalent to that available in the 1940s**
- **Found RATCHET to have an 80- to 85-percent probability of being within a factor of 3, depending on input data**
- **Recommend no changes for models**

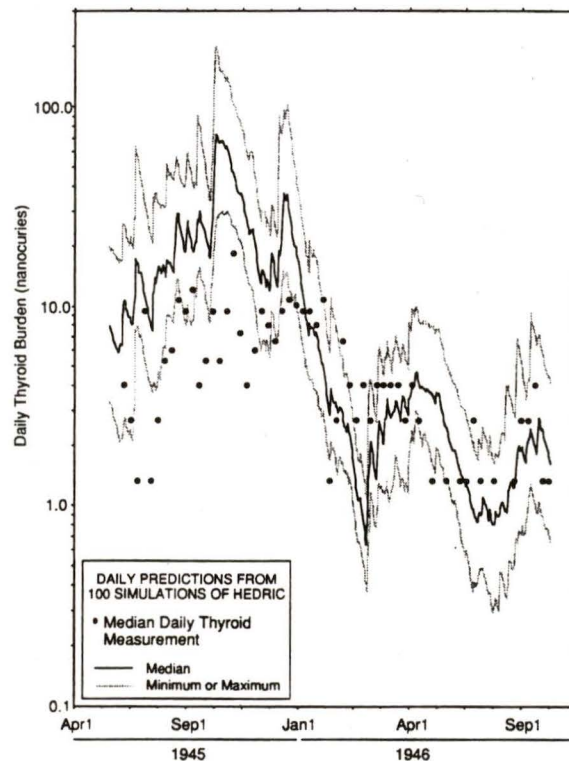
Richland Worker Thyroid Counts, 1945-1946

- Compared the measured thyroid burdens of iodine in Hanford workers (assumed to be adult males living in Richland) to values calculated using CIDER and the commercial milk and vegetable distribution models

Contribution of Inhalation, Commercial Milk and Leafy Vegetable Ingestion to Predicted Thyroid Burden of Iodine-131 in Adult Males in Richland for 1945-1946



Comparison of Predicted with Median Measurements of Daily Thyroid Burden from Inhalation, Commercial Milk and Leafy Vegetable Ingestion



Richland Worker Thyroid Counts, 1945-1946 (Cont)

- Found calculations show more variability than measurements. Because mean monthly measurements were used, averaging may tend to mask the variability.
- Found median calculations to be within factor of 4 or better of measurements
- Found results to support use of 1940s milk distribution model
- Recommend no changes for models

Columbia River Hydraulics

- **Compared the calculated to the measured values of discharge hydrograph and water-surface elevations. This ensures that discharge velocities and mass-balance calculations are correct and validates the dilution and travel time calculated by CHARIMA.**

Columbia River Hydraulics (Cont)

- **Found the computed and measured hydropeaks match to within a few hours for highly detailed hourly data and the water-surface peaks match to within 1 foot for all hours**
- **Found the calculated hydrograph to be closely coincident with the measured data for the annual time series hydrograph**
- **Recommend no changes for models**

Columbia River Water Concentrations, 1967

- Compared the calculated to the measured concentrations of chromium-51 in river water at several downstream locations. The year 1967 was emphasized in the validation report. Walters et al. (1994) address each year from 1960 through 1970.
- Found calculations of radionuclide concentration to be within factors of 2 for both composite and grab samples over long time periods and over numerous locations downstream
- Recommend no changes for models

Columbia River Resident Fish Concentrations, 1967

- Compared the calculated to the measured monthly average concentration of sodium-24, phosphorus-32, and zinc-65 in omnivorous, first- and second-order predatory fish

Columbia River Resident Fish Concentrations, 1967 (Cont)

- Found model tended to overpredict radionuclide concentrations in all types of fish at all locations, although there was a substantial variability between months
- Found some of the variability may be because of the selection of data sets: several were from areas near tributary streams where uncontaminated water may have influenced the uptake in fish
- Recommend no changes for model

Pacific Coast Oyster Concentrations, 1967

- Compared the annual average concentration of zinc-65 calculated for oysters to the measurements
- Found model calculation to be within 50 percent of the measurement for 1967
- Found use of the model would result in an overprediction of about 15 percent for the 1960s
- Used model only for years prior to 1959 when measurements are unavailable
- Recommend no changes for models

Richland Whole-Body Counts, 1960-1970

- Compared the calculated to the measured monthly average body burdens of sodium-24 and zinc-65 in adult male Richland residents
- Compared the calculated to the measured monthly body burden for an individual consuming a known amount of Columbia River whitefish

Richland Whole-Body Counts, 1960-1970 (Cont)

- Found the ratio of the calculation to the measurement to be 1.40 for sodium-24 and 1.39 for zinc-65. The CRD model calculations always fall within the range of the measurements.
- Found the calculations and measurements to be within a factor of 2 for the specific individual with known fish consumption. An overprediction for one period shifts the curves, but thereafter the dynamics are appropriate.
- Recommend no changes for models

Suitability of Models for HEDR Use

- **None of the tests indicated that the HEDR models were not valid.**
- **The comparisons provide a reasonable validation set for the needs of the project.**
- **No attempts to calibrate the models against the data sets were made.**
- **No changes to any codes or models are recommended.**

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HEDR Source Term Task

Cal Heeb

Presentation to the HEDR Technical Steering Panel

January 20 - 21, 1994

Battelle, Pacific Northwest Laboratories

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Completed Source Term Tasks

Releases to Air from Separations Plant

- Hourly releases: source file for Atmospheric Transport Model (RATCHET) 1944-1949
- PNWD-2222-HEDR, Monthly Releases 1944-1972
 - Iodine-131
 - Ruthenium-103, 106
 - Strontium-90
 - Cerium-144
 - Ruthenium-103
 - Plutonium-239

Completed Source Term Tasks

(cont'd)

Releases to the Columbia River from Single-Pass Reactor Operations 1944-1971

- **Monthly releases: source file for River Transport Model (CHARIMA)**
- **PNWD-2223-HEDR, Monthly Releases for**

Sodium-24	Chromium-51
Phosphorous-32	Manganese-56
Zinc-65	Gallium-72
Arsenic-76	Yttrium-90
Neptunium-239	Iodine-131
Scandium-46	Gross Beta

Remaining Source Term Task

Characterize releases from:

- **C Plant hot-semi-works**
- **Z Plant**
- **U Plant**
- **108 B tritium recovery operations**
- **Plutonium recycle test reactor PRTR (300 Area)**
- **Test Reactors: 305 Pile, HTLTR, PCTR, TRIGA**
- **PUREX Campaigns: N-fuel reprocessing**
- **thorium reprocessing, SEFOR, and PRTR fuel**
- **Possible releases from criticality accidents**
- **FFTF**

Monthly Air Releases from Separations Plants 1944-1972

- **Deterministic calculation:**
Monthly release = tons processed x Ci/ton x release factor
- **Tons dissolved by T, B, REDOX and PUREX**
- **Ci/ton:**
 - **ORIGEN2 calculations**
 - **Functions of burnup and specific power**

Monthly Air Releases from Separations Plants 1944-1972

Iodine 131

Release Factors 1944 - 1949

Pre-Scrubber Period	1944 - April 1948	90.5%
Water Scrubbers	May 1948 - Sept. 1948	28.5%
Sand Filters Added	Oct. 1948 - Nov. 1949	25.0%
Green Run	Dec. 1949	90.5%

Monthly Air Releases from Separations Plants 1944 - 1972

Iodine 131
(cont'd)

Silver Reactors	Jan. 1951	1%
	Feb. 1951	1%
	March 1951	2%
	April 1951	5%
	May 1951	13.2%
	June 1951	12.5%
	July 1951 - 1972	1.25%
REDOX generic release factor -		
Median Value 158 Observations		1.25%
PUREX generic release factor -		
Median Value 230 Observations		0.20%

Monthly Air Releases from Separations Plants 1944-1972

Iodine 131

Uncertainty Analysis

1944 - 1949 Monte Carlo method

1950 - 1972 monthly method

Median

Std. Dev.

Curies processed

• Tons dissolved	1.0	0.029
• Peaking factor	1.04	0.250
• Saturation	0.85	0.020
• Cooling time	1.14	0.31
• ORIGEN2 uncertainty	1.0	0.010

Monthly Air Releases from Separations Plants 1944 - 1972

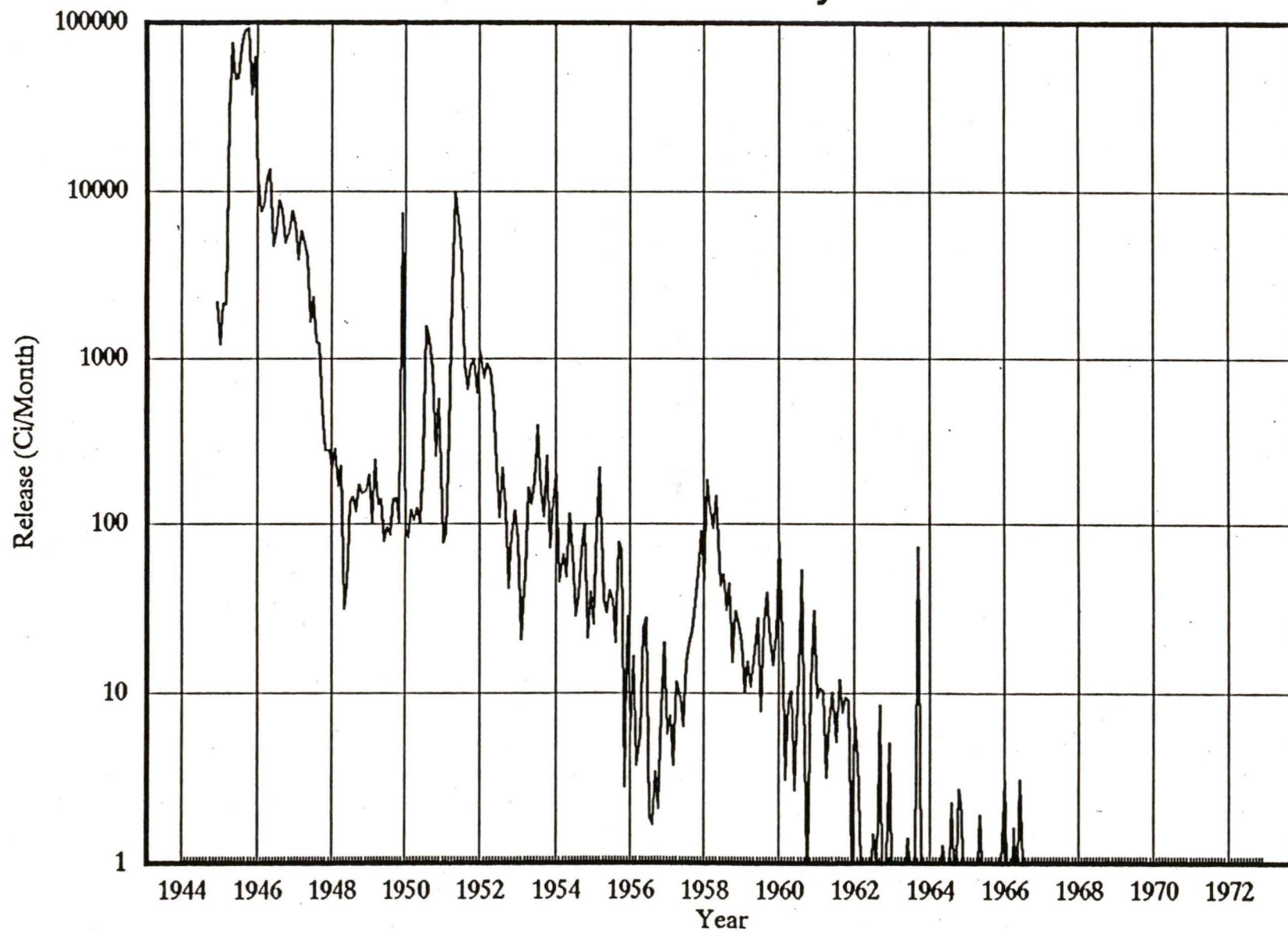
Iodine 131
(cont'd)

Uncertainty Analysis

Release Factor (lognormal)	<u>Mean</u>	<u>Standard Deviation</u>
•REDOX	-4.3	1.43
•PUREX	-6.3	0.624

95% confidence uncertainty multiplier 4.8

Iodine-131 Monthly Releases



Monthly Air Releases from Separations Plants 1944-1972

Ruthenium 103 and 106

Release Factors: REDOX

- Quarterly estimates provide data for the period of non-routine releases.

1951-1958	range	1.4×10^{-4} to 5.1×10^{-8}
	mean	7.5×10^{-6}

- Generic release factor based on 12 months in 1961
mean 0.75×10^{-7} standard deviation 1.1×10^{-7}

Monthly Air Releases from Separations Plants 1944-1972

**Ruthenium 103 and 106
(cont'd)**

Release Factors: PUREX

- **Release factor based on 12 months in 1961**

mean

0.75×10^{-7}

standard deviation

1.1×10^{-7}

- **Generic release factor used for all plants** **1.0×10^{-7}**

Release Factors: T and B Plant

prior to May 1948 (water scrubbers)

1.0×10^{-5}

Monthly Air Releases from Separations Plants 1944-1972

Ruthenium 103 and 106
(cont'd)

Uncertainty Analysis

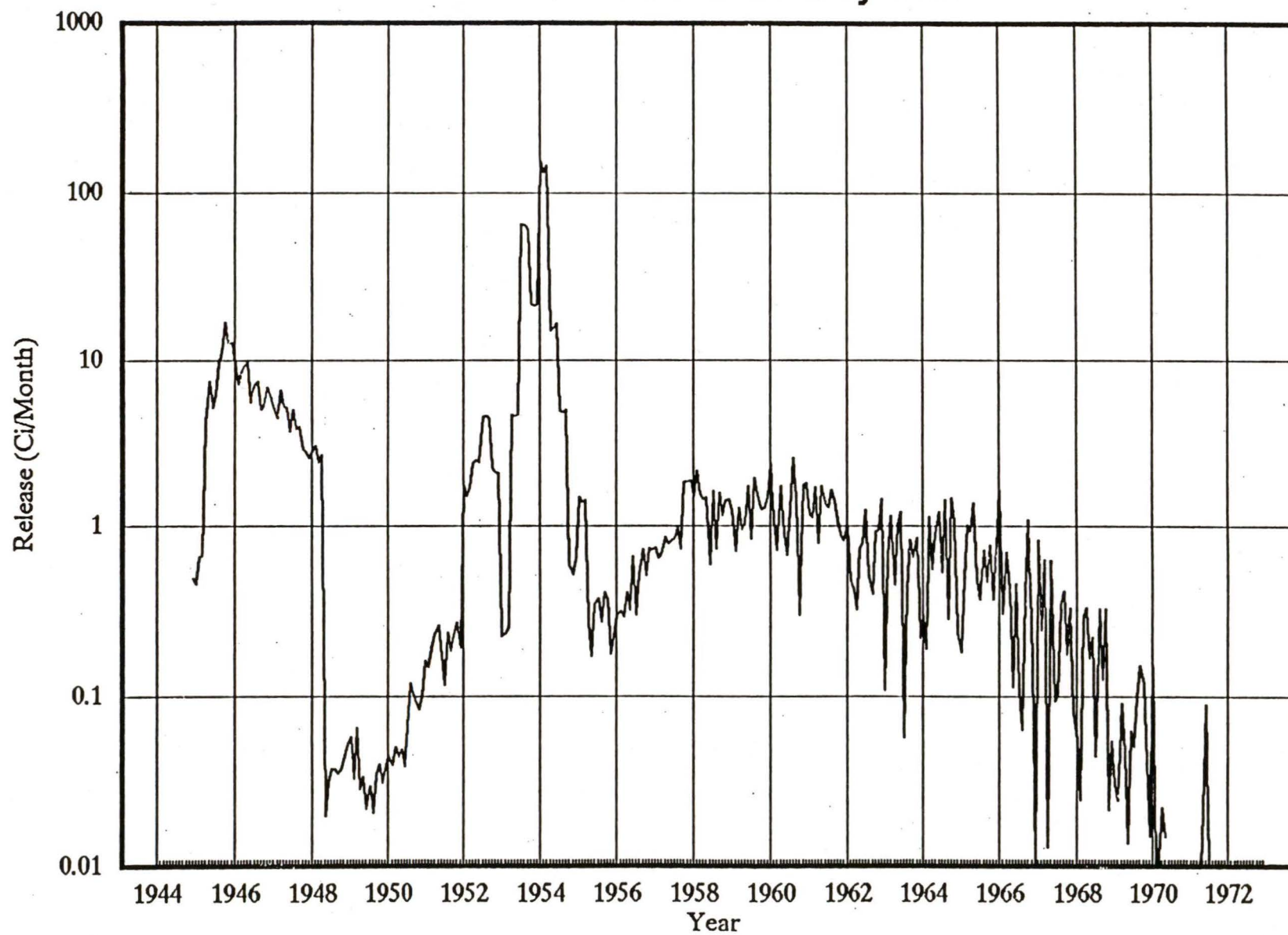
Curies Processed

	<u>Ru-103</u> <u>avg.</u>	<u>Std.</u> <u>Dev.</u>	<u>Ru-106</u> <u>avg.</u>	<u>Std.</u> <u>Dev.</u>
• Tons Dissolved	1.0	.029	1.0	.029
• ORIGEN2 Uncertainty	1.0	.010	1.0	.082

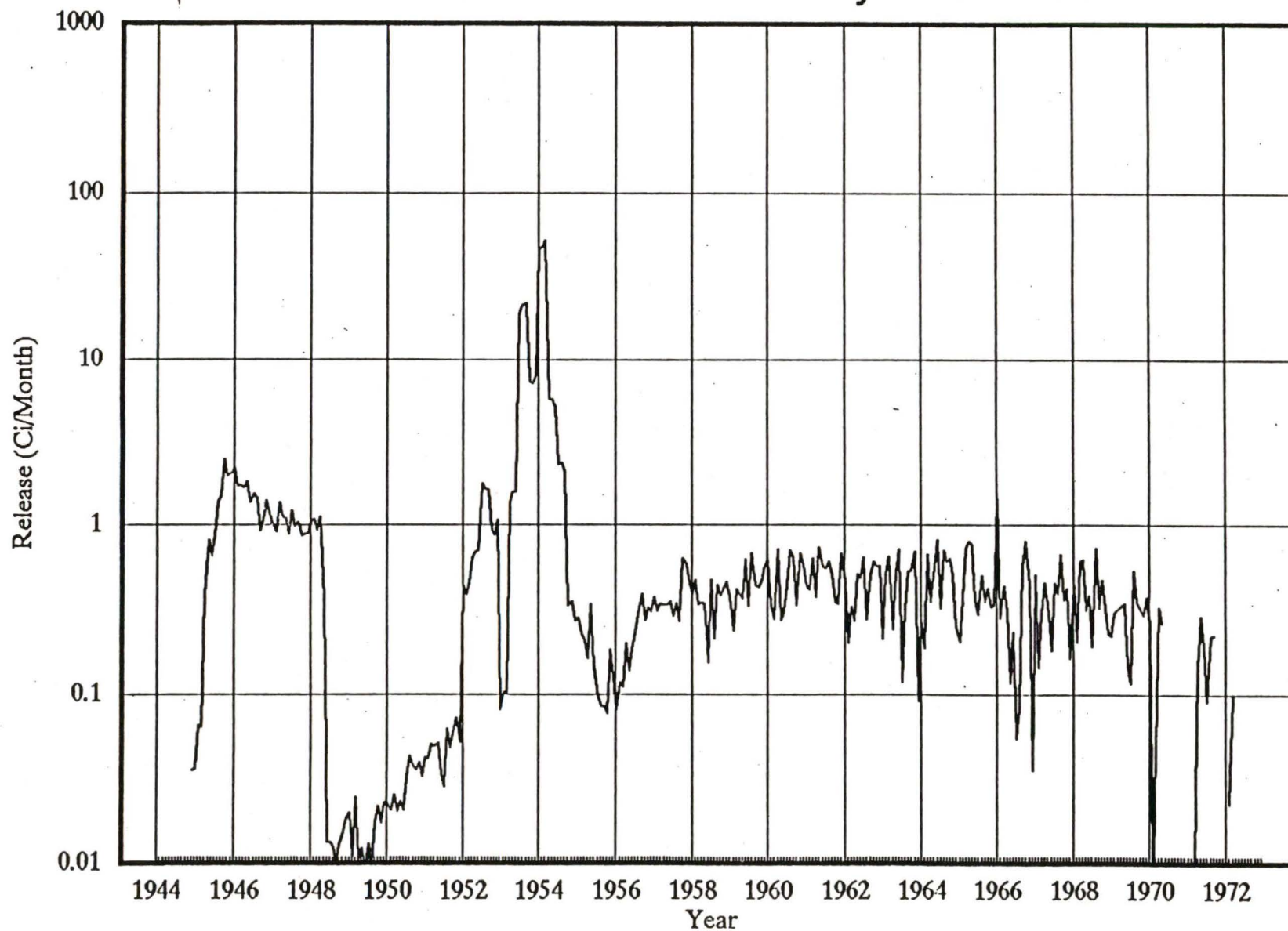
Release factor (lognormal)

	<u>Ln</u> <u>Mean</u>	<u>Standard</u> <u>Deviation</u>
REDOX	-16.6	0.813
PUREX	-16.2	0.933

Ruthenium-103 Monthly Releases



Ruthenium-106 Monthly Releases



Monthly Air Releases from Separations Plants 1944-1972

Cerium-144

Release Factor

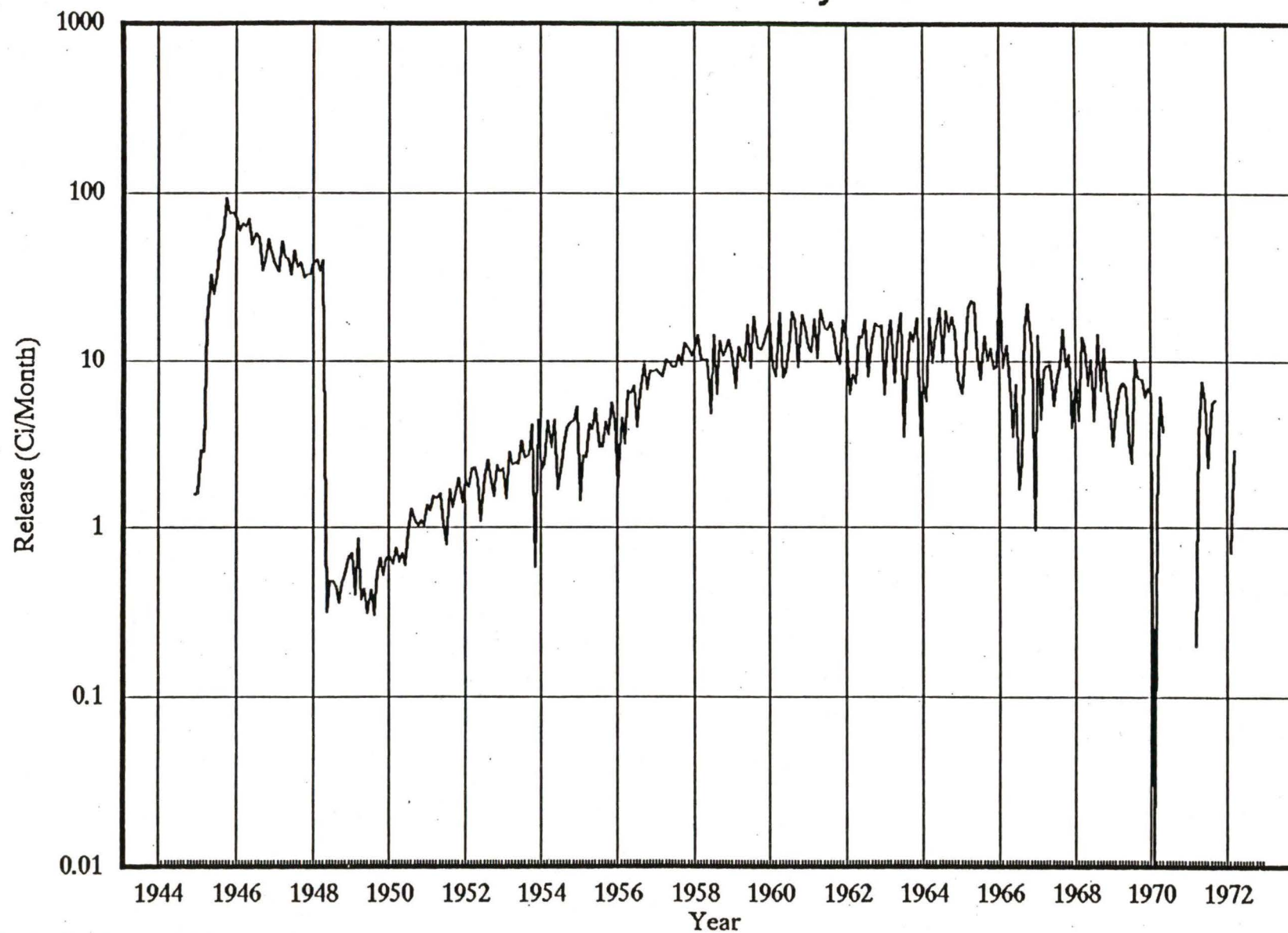
- Based on single observation, September 1958
at REDOX - applied to all plants 5.25×10^{-7}
- for T and B Plants prior to May 1948 5.25×10^{-5}

Uncertainty Analysis

Curies Processed	<u>Median/Mean</u>	<u>Std. Dev.</u>
Tons Dissolved	1.000	.029
ORIGEN2 Uncertainty	1.000	.010
Release factor	4.0×10^{-6}	2.3×10^{-6}

95% confidence uncertainty multiplier 2.8

Cerium-144 Monthly Releases



Monthly Air Releases from Separations Plants 1944-1972

Strontium-90

Release Factor

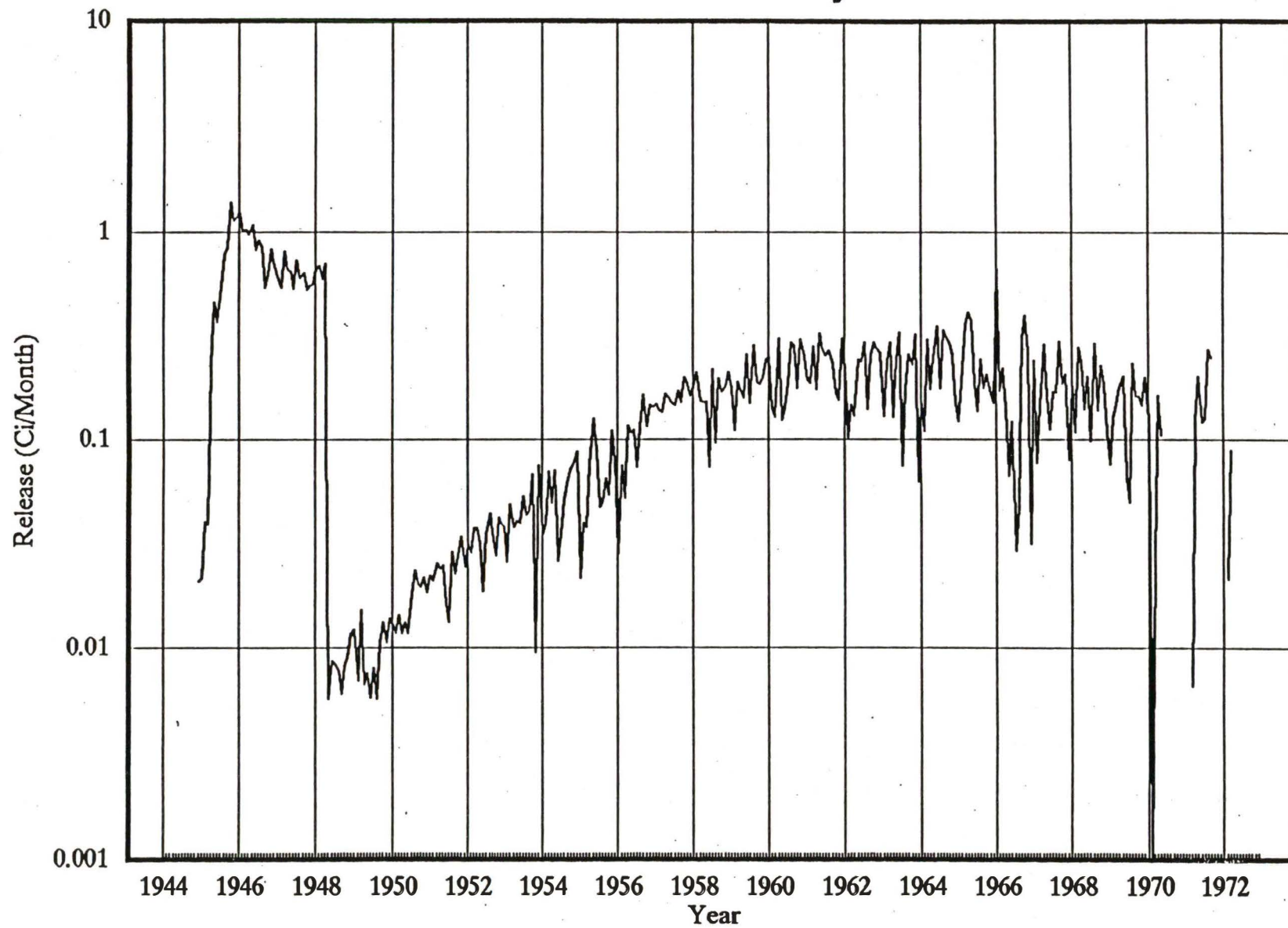
- Based single observation in 1957 1.9×10^{-7}
- For T and B Plants prior to May 1948 1.9×10^{-5}

Uncertainty Analysis

Curies Processed	<u>Median/Mean</u>	<u>Std. Dev.</u>
Tons Dissolved	1.0	.029
ORIGEN2 Uncertainty	1.0	.020
Release factor	9.6×10^{-7}	5.4×10^{-7}

95% confidence uncertainty multiplier 2.8

Strontium-90 Monthly Releases



Monthly Air Releases from Separations Plants 1944-1972

Plutonium-239

Release Factor - based on specific plant data

	Mean	Std.	
	<u>Ln (RF)</u>	<u>Dev.</u>	<u>Observations</u>
T and B	3.9×10^{-7}	3.0×10^{-7}	9
REDOX	1.5×10^{-7}	3.4×10^{-8}	3
PUREX	based on a monthly average of nine Pu-239 release measurements 2.0×10^{-9}		

Release Factors

	<u>RF</u>
T and B, 1944 through 1948	4×10^{-5}
T and B, May 1948 to 1972	4×10^{-7}
REDOX	2×10^{-7}
PUREX	2×10^{-9}

Monthly Air Releases from Separations Plants 1944-1972

Plutonium-239
(cont'd)

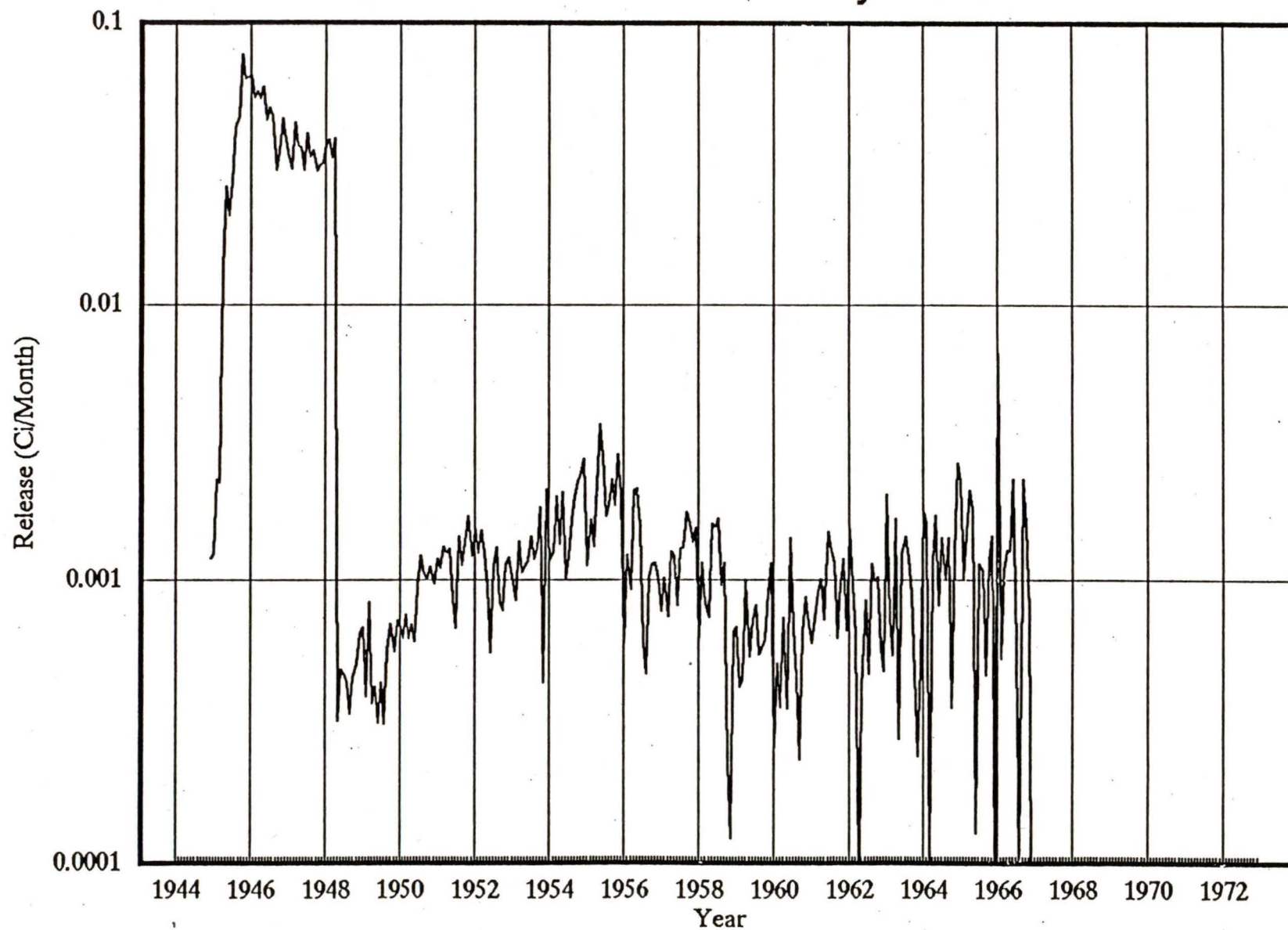
Uncertainty Analysis

Curies Processed	<u>Median/Mean</u>	<u>Std. Dev.</u>
Tons Dissolved	1.00	0.029
ORIGEN2 Uncertainty	1.00	0.050

Release Factor Uncertainty	Mean	Std.	
	<u>Ln (RF)</u>	<u>Dev.</u>	<u>Observations</u>
T and B	-15.06	0.89	9
REDOX	-15.76	0.25	3
PUREX	-21.69	1.919	9

95% confidence uncertainty multiplier 17.5

Plutonium-239 Monthly Releases



Reactor Air Releases

Tritium, Carbon-14, Argon-41

- **Graphite stack gas system**
 - **Composition He-CO₂ 0-100%**
 - **Recirculating with on-line silica gel gas dryers**
 - **H-3 source: He-3 + n H-3 + p (He-3 .00014%)**
 - **C-14 source: N-14 + n C-14 + p**
 - **Ar-41 source: Ar-40 + n Ar-41**
- **Reactor effluent water**
 - **Dissolved air in cooling water: C-14, Ar-41**
 - **Ternary fissioning of native uranium: H-3**
 - **Neutron capture on H-2**

Reactor Air Releases

**Tritium, Carbon-14, Argon-41
(cont'd)**

Reactor Graphite Stack

Tritium	1957 average from all 8 reactors - 1.4 Ci/day
Carbon-14	1957 average from all 8 reactors - 0.1 Ci/day
Argon-41	No estimates found

Reactor Effluent Water Vapor Releases

**Airborne activity of effluent system vents surveyed routinely.
No radionuclide-specific measurements were found.**

Air Releases

Conclusions

- **Confirmed that largest Iodine-131 releases were in the 1944-1947 period. Sufficient data existed to construct the most detailed source term for this period (STRM).**
- **Separations plants releases were provided for the complete single-pass reactor reprocessing history with 95% uncertainty factors from 2.8 to 17.9. Most were within a factor of 10.**
- **Reactor curie air releases of Tritium and Carbon-14 were relatively minor.**

Reactor Releases to the Columbia River 1944-1971

**STRRM - Source Term River Release Model
Monte Carlo Simulation of Monthly Releases**

Basic monthly release calculation

1. $C_i = 0.00545 \times A \times F \times D$

A = monthly average concentration (pCi/ml)

F = reactor flow rate (1000 GPM)

D = number of full power operating days in month

2. $C_i = C \times D$

C = average Ci/day

STRRM Water Releases

Data Quality Levels

<u>Level</u>	<u>Data</u>
1	One or more measurements exist for the month.
2	Ci/day is available
3	None of the above exists, but a regression exists which is applicable to this month
4	None of the above exists, use global average and uncertainty distribution

STRRM Water Releases

Relative Data Types

Approximate Percent Generated by Each Method

Level		Na-24	P-32	Zn-65	As-76	Np-239	Sc-46	Cr-51	Mn-56	Ga-72	Y-90	I-131	Gross Beta	Over All
1	pC/L	50	67	51	68	57	24	52	50	30	21	45	57	48
2	Ci/day	0	9	3	5	4	0	3	1	0	0	4	9	3
3	Regress	47	22	0	0	0	32	29	0	0	31	27	0	16
4	Global	3	2	46	27	39	44	16	49	70	48	24	34	33

STRMM Water Releases

Iodine-131 and Neptunium-239 from Fuel Failures

- **Fuel failure sources of I-131 and Np-239 are added to water activation calculations.**
- **Calculation:**
 - **Data file lists the burnup of each failure during the month.**
 - **This is the average burnup of all slugs in the tube.**
 - **Sampling a function of slug-position-dependent failures determine which slug failed for a given realization.**
 - **Burnup was determined from slug position and burnup function of the slug position.**
 - **Ci of I-131 and Np-239 determined from ORIGEN2.**
 - **Ci from each failure were added to monthly total.**

STRRM Water Releases

Slug Failure Function

- **Rupture Rate Equation**

$$RR = P^{3.3} T^{8.7} B^{5.0}$$

P = slug power

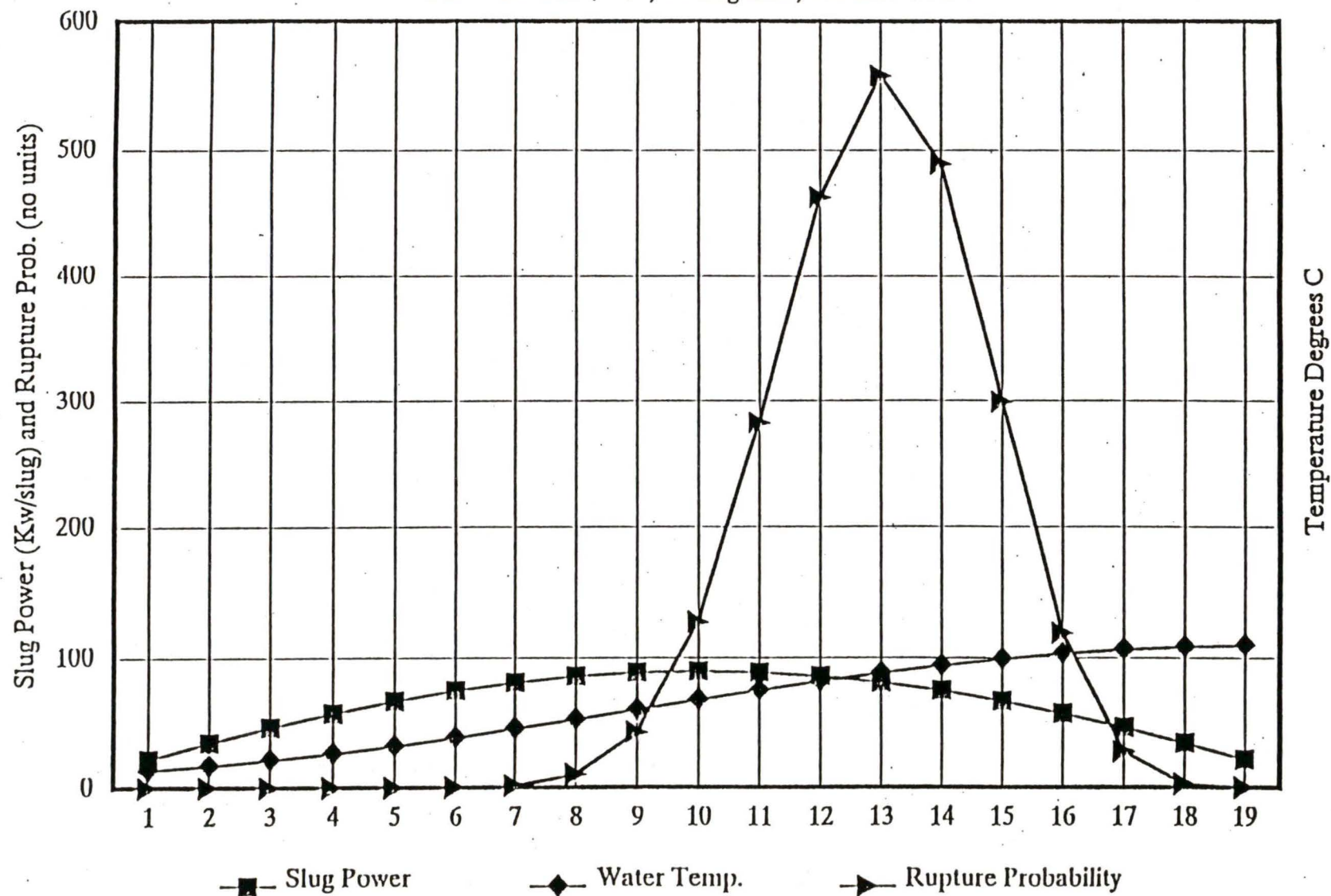
T = slug water temp

B = burnup

- **Front-to-rear slug power distribution (“chopped cosine”) used to calculate P, T, and B**
- **RR calculated as function of slug position**

Slug Power, Water Temperature and Rupture Potential

Power 1200 Kw/tube, 10 Deg Inlet, 110 Deg Outlet



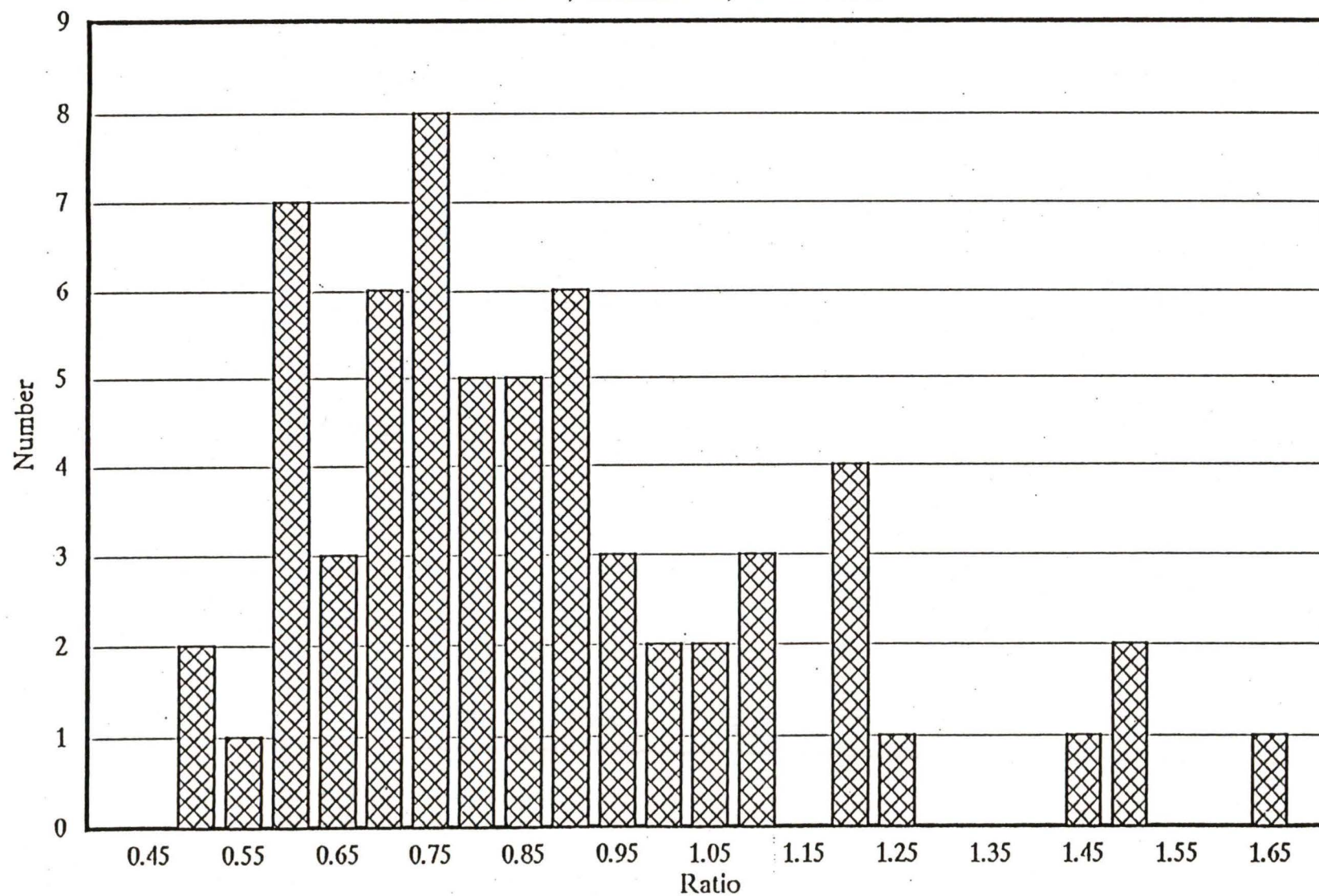
Reactor Releases to the Columbia River

STRRM-Modeled Uncertainty

- **Activity concentration measurement uncertainty**
- **Regression uncertainty**
- **Retention basin holdup time**
- **Reactor power measurement**
- **ORIGEN2 fits for fuel failure Iodine-131 and Neptunium-239**
- **Mass of Uranium dissolved per fuel failure**
- **Position of failure in process tube**
- **Burnup of failed fuel element**

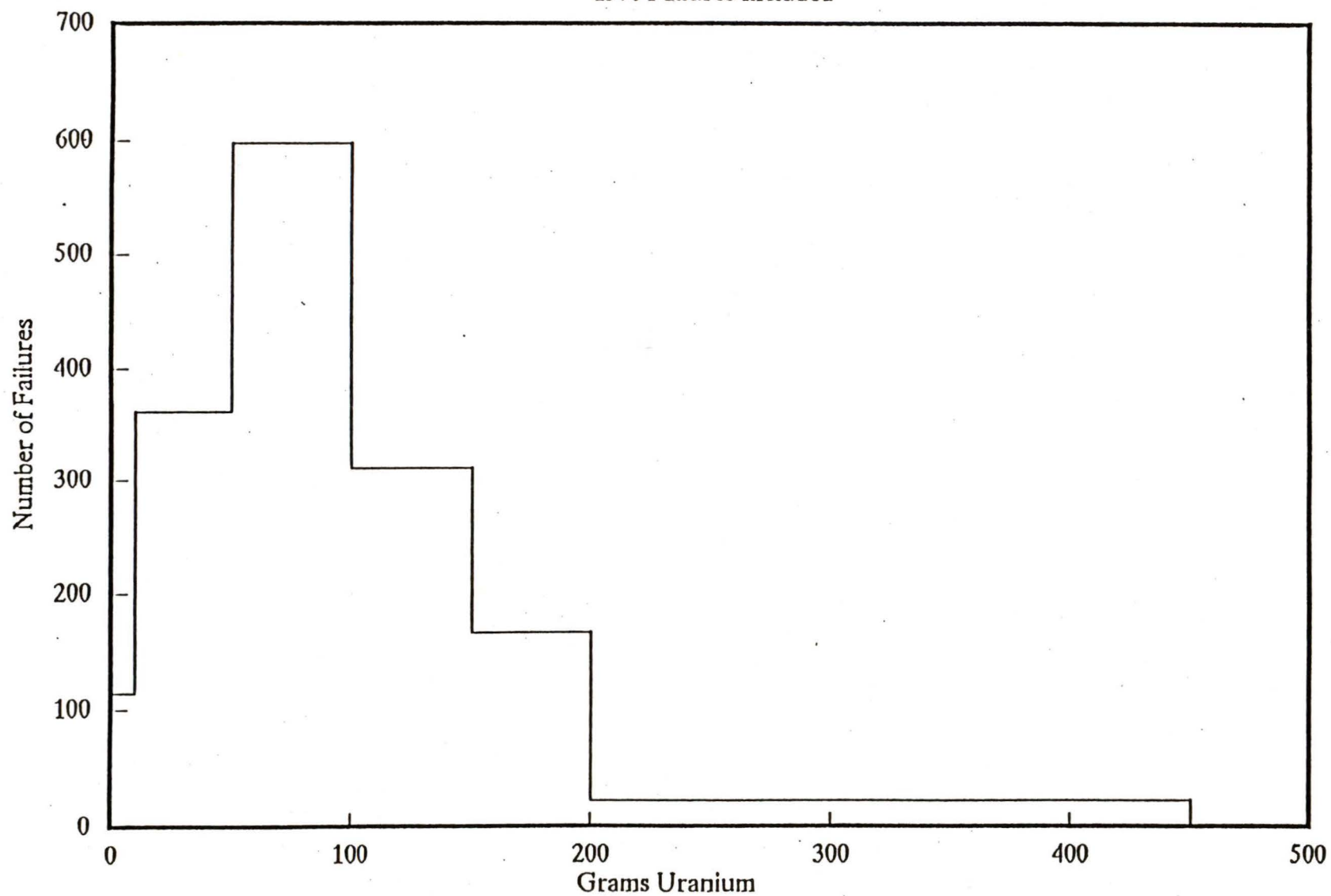
Ratio: Observed to Theoretical Holdup Time

Mean: .85, Median: .795, for 62 Observations



Distribution of Grams U Lost per Failure

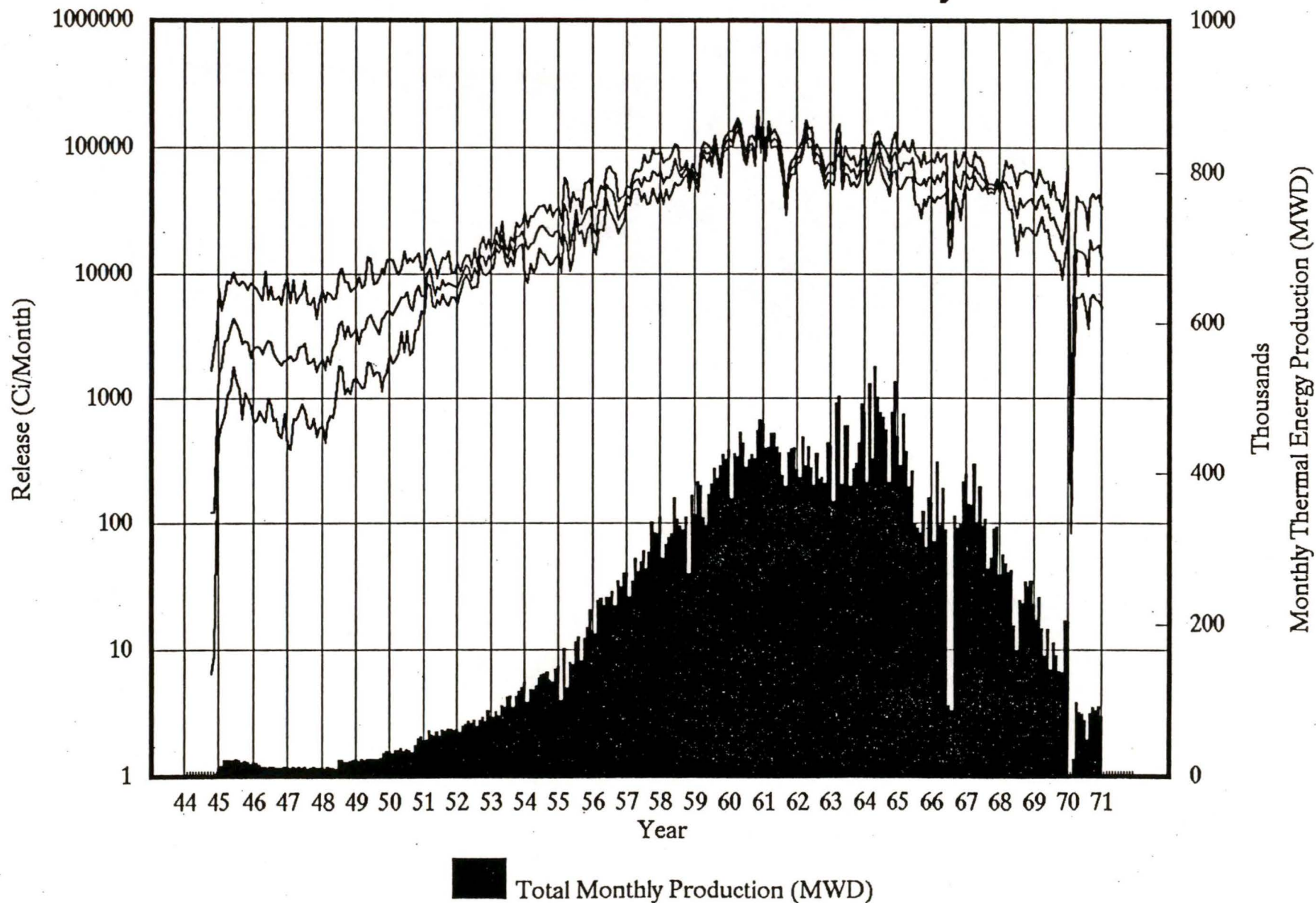
1570 Failures Included



Reactor Releases to the Columbia River

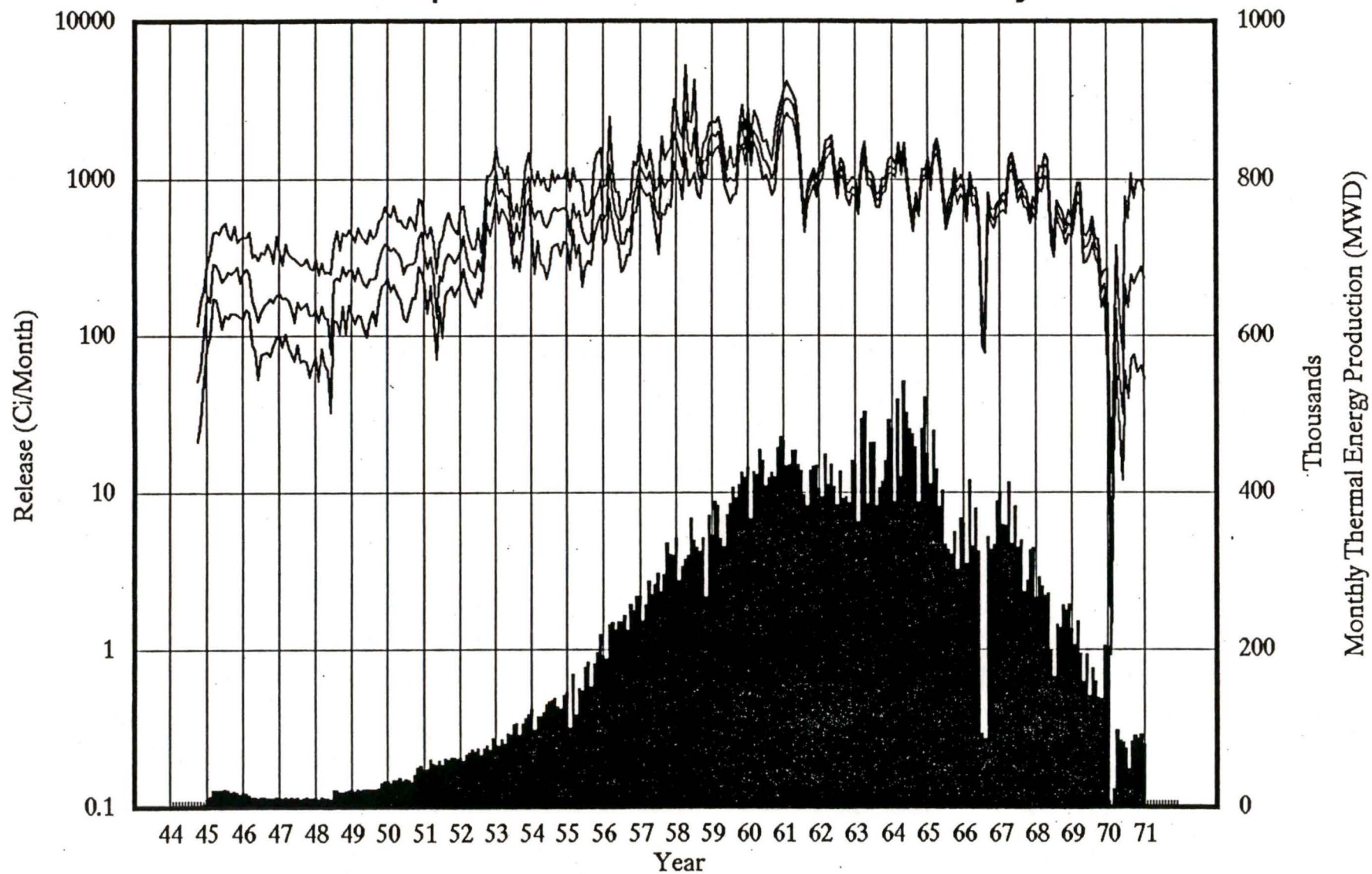
<u>Radionuclide</u>	<u>Half-Life</u>	<u>Ci</u>
Sodium-24	15 hr.	13,000,000
Phosphorus-32	14.3 day	230,000
Zinc-65	244 day	490,000
Arsenic-76	26.4 hr.	2,500,000
Neptunium-239	2.4 day	6,300,000
Scandium-46	83.8 day	120,000
Chromium-51	27.8 day	7,200,000
Manganese-56	2.5 hr.	80,000,000
Gallium-72	14 hr.	3,700,000
Yttrium-90	64 hr.	440,000
Iodine-131	8 day	48,000
Gross Beta - 4 hr. decay		66,300,000

Sodium-24 Release History



Upper Curves are minimum, median and maximum of 100 realizations

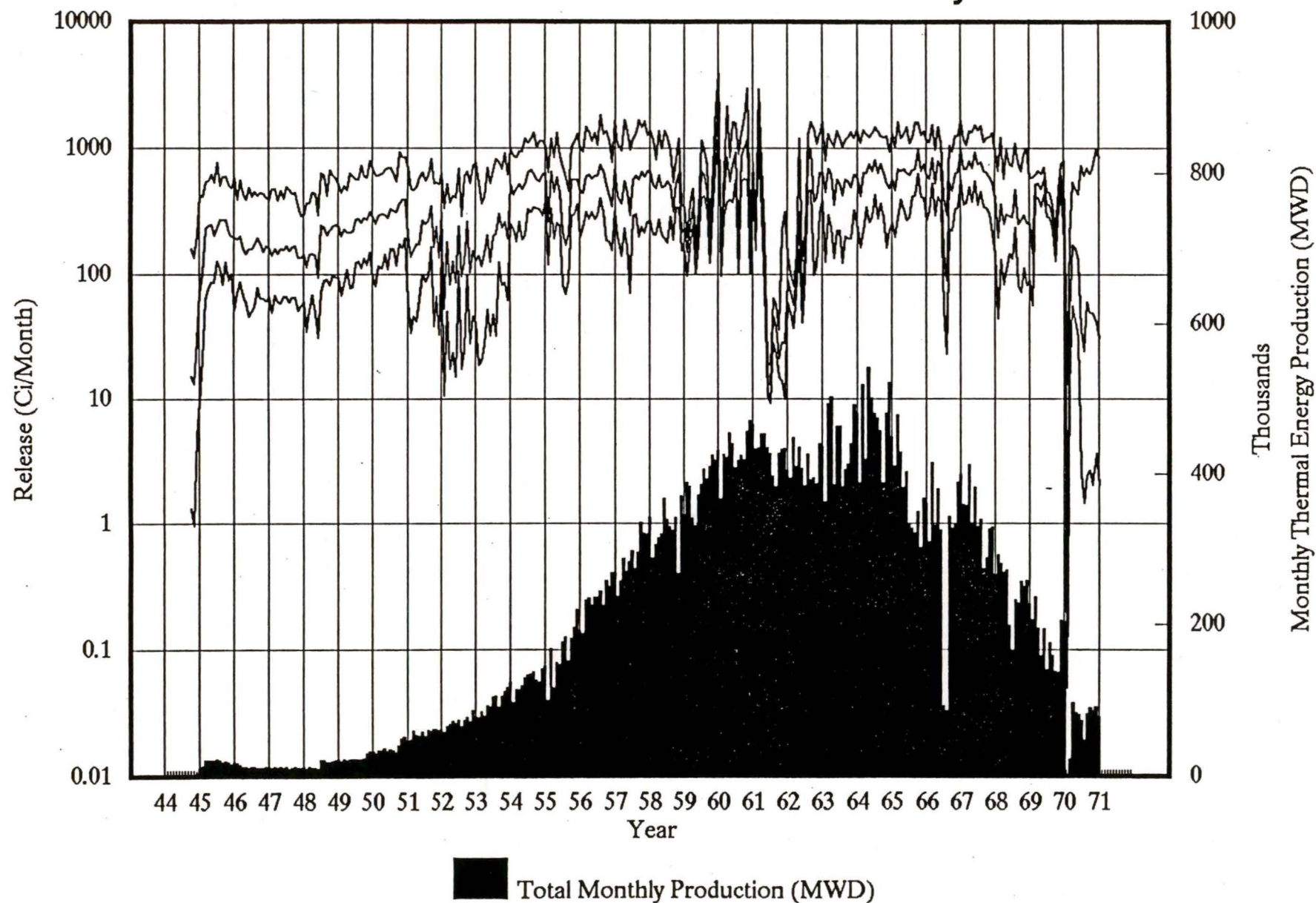
Phosphorus-32 Release History



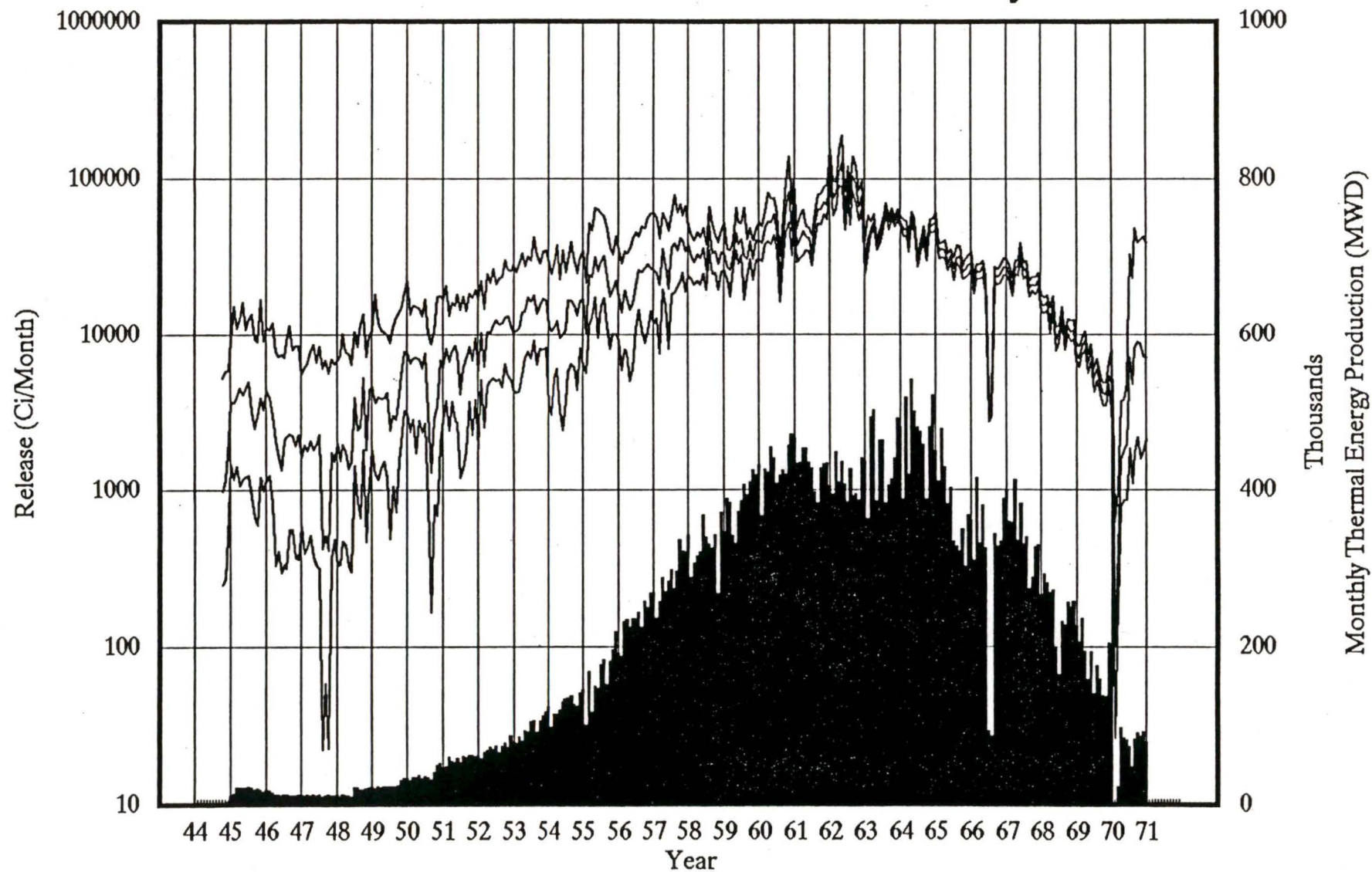
■ Total Monthly Production (MWD)

Upper curves are minimum, median and maximum of 100 realizations

Scandium-46 Release History



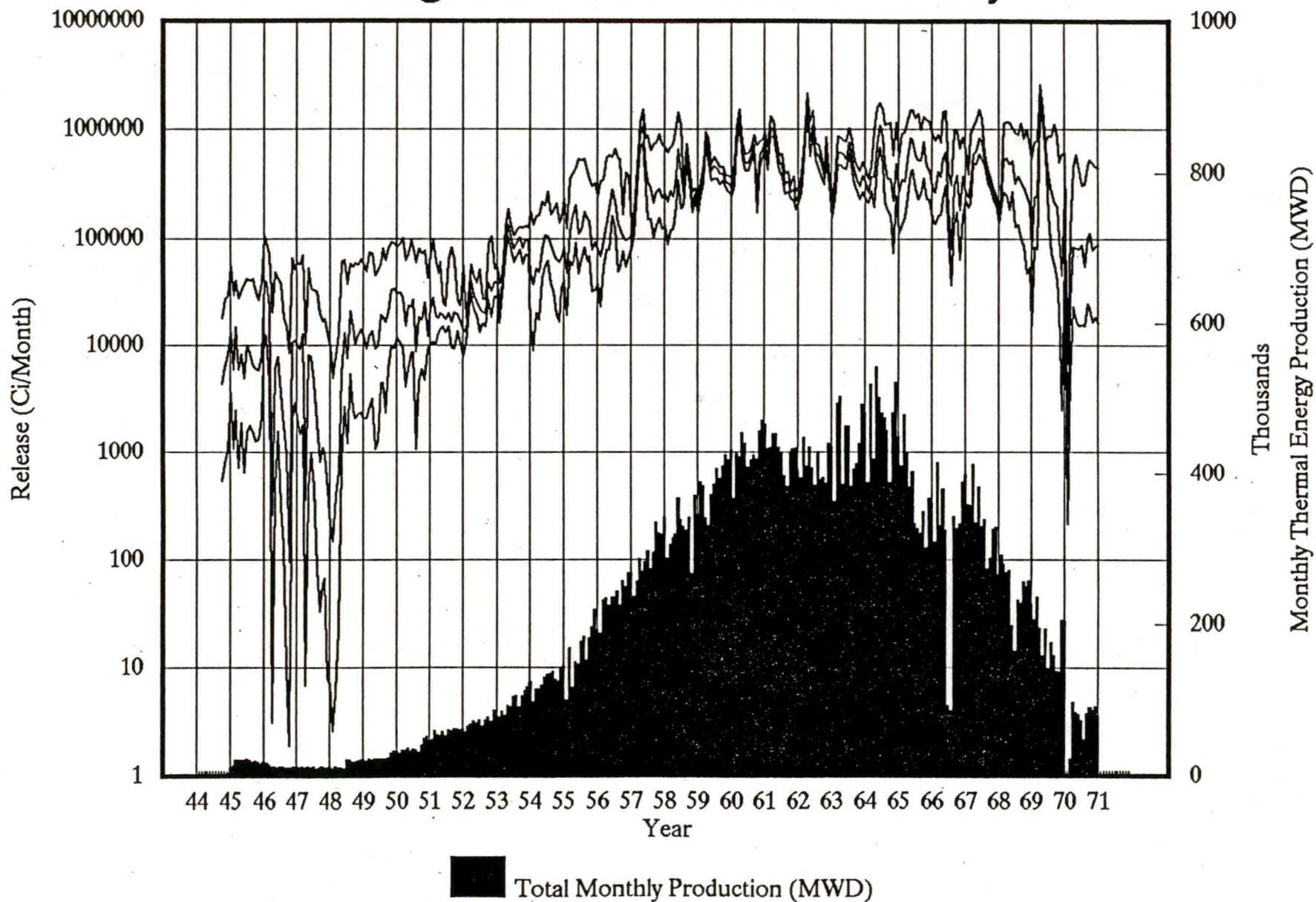
Chromium-51 Release History



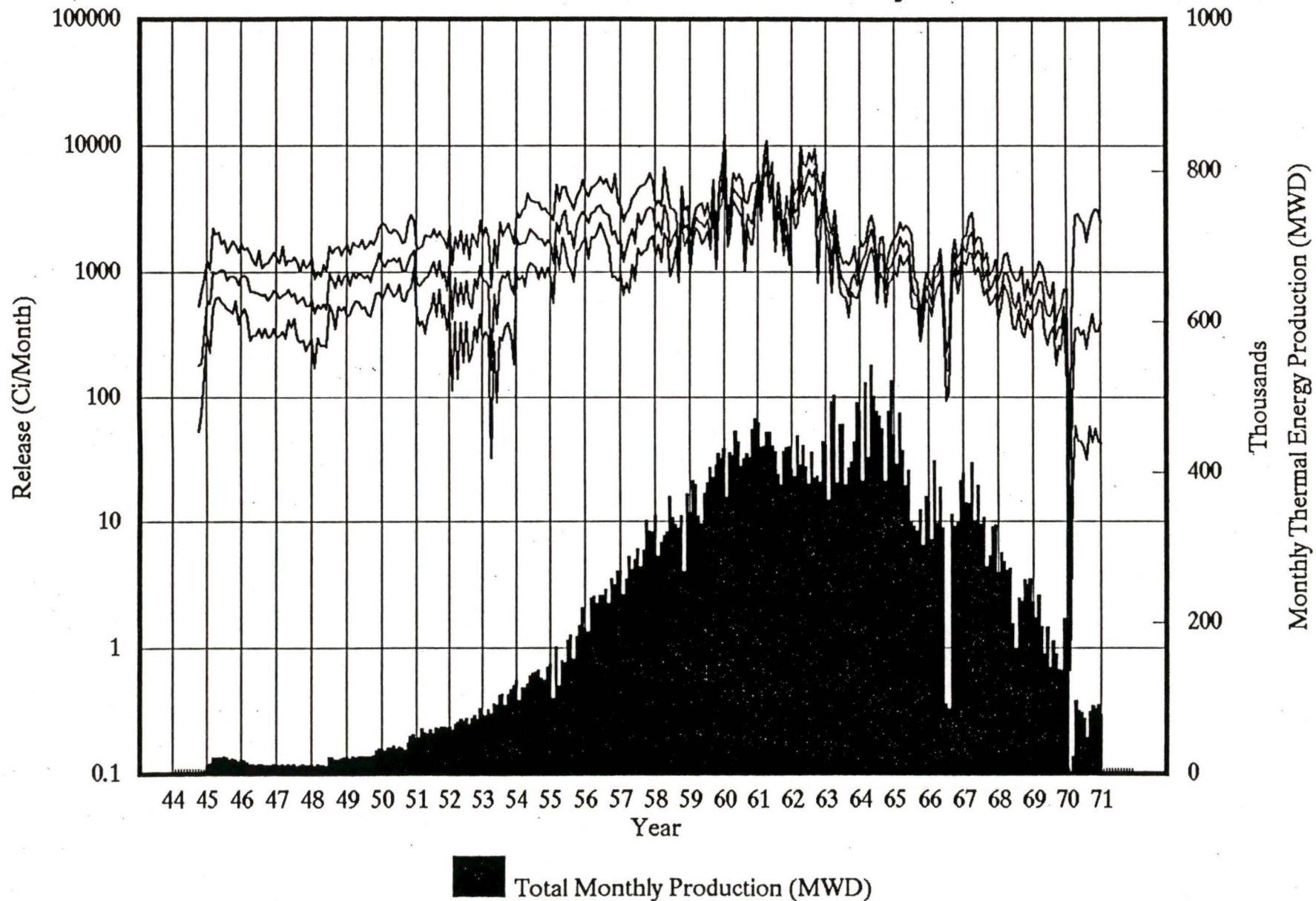
■ Total Monthly Production (MWD)

Upper curves are minimum, median and maximum of 100 realizations

Manganese-56 Release History

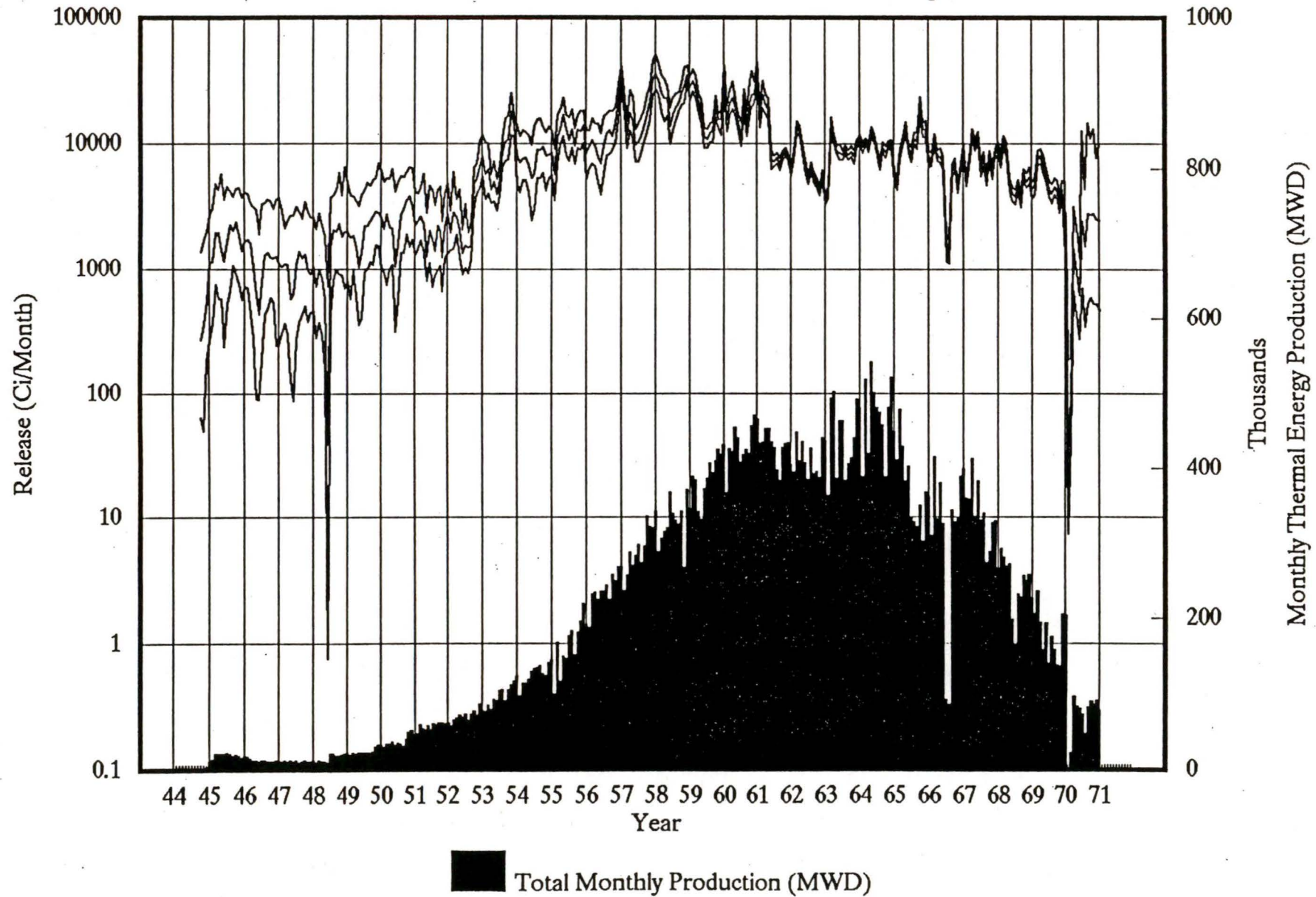


Zinc-65 Release History

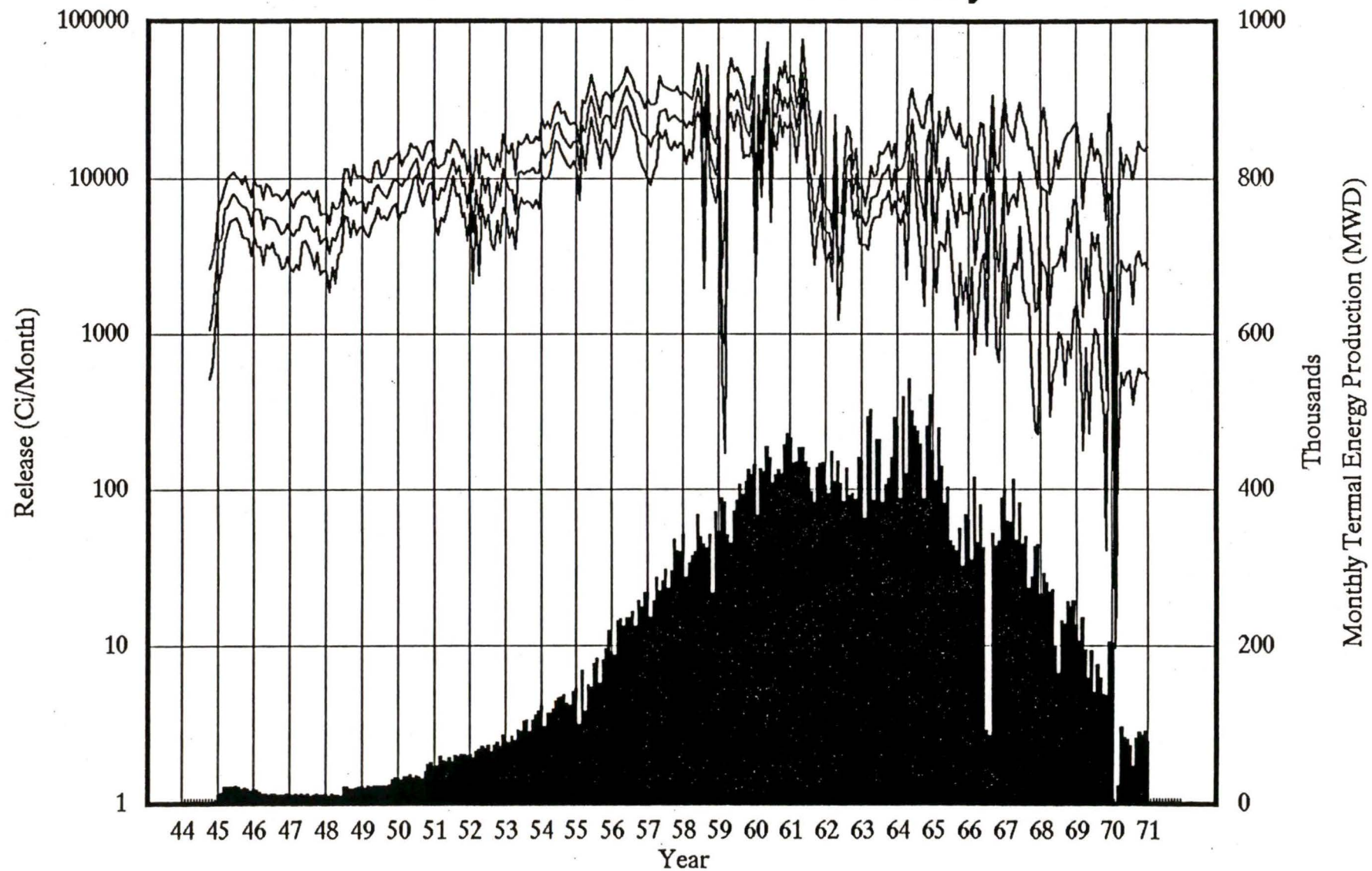


Upper curves are minimum, median and maximum of 100 realizations

Arsenic-76 Release History



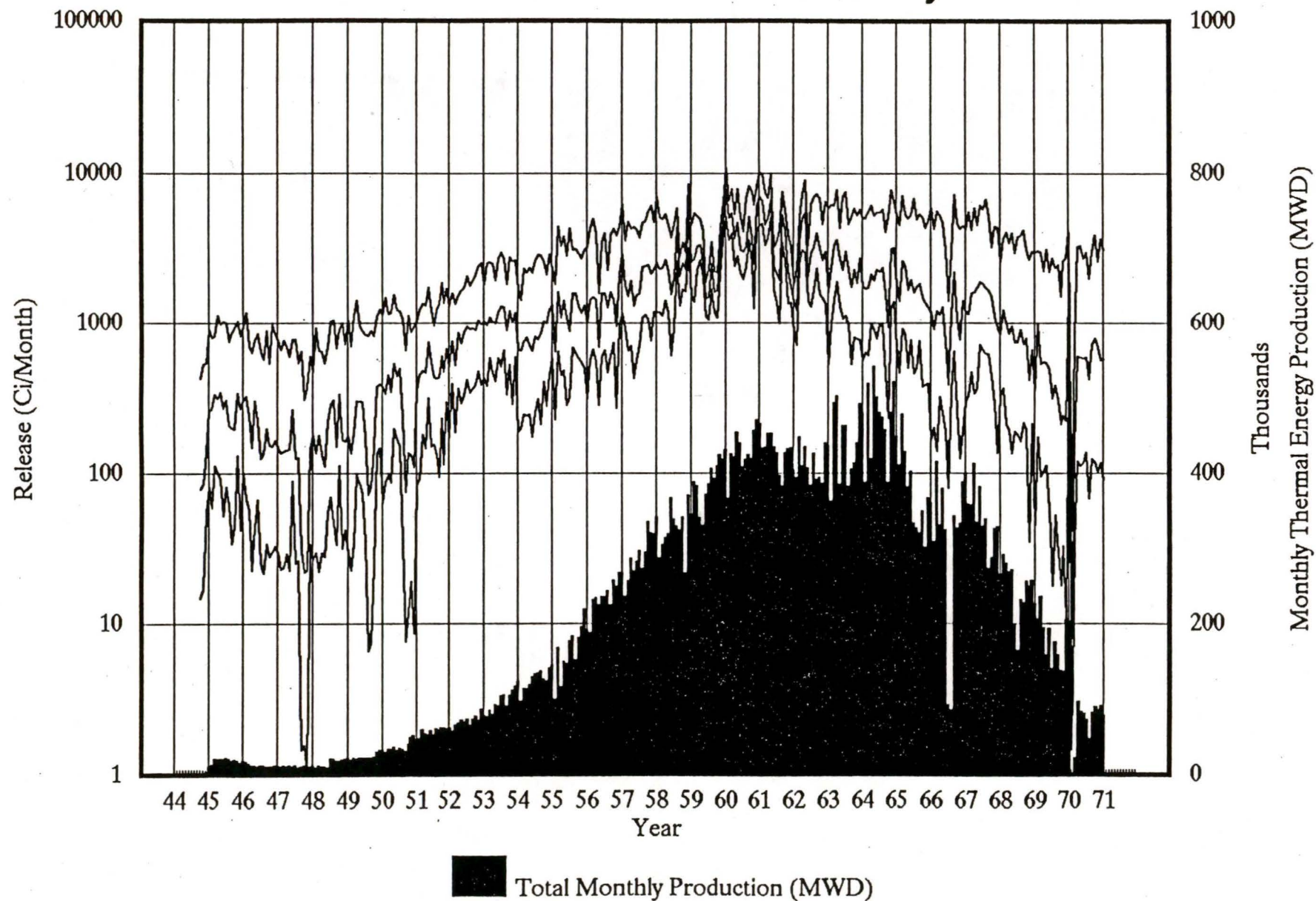
Gallium-72 Release History



■ Total Monthly Production (MWD)

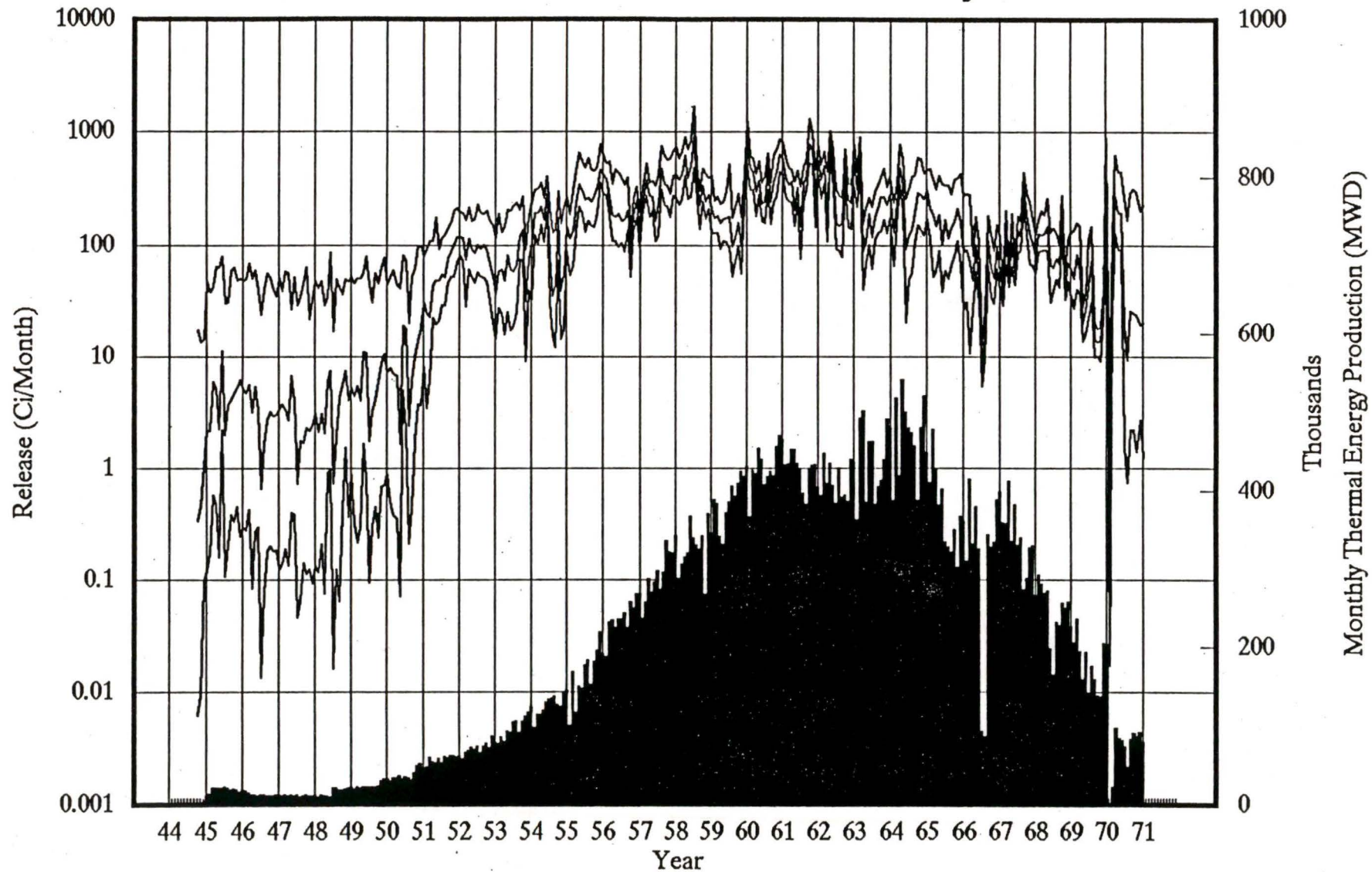
Upper curves are minimum, median and maximum of 100 realizations

Yttrium-90 Release History



Upper curves are minimum, median and maximum of 100 realizations

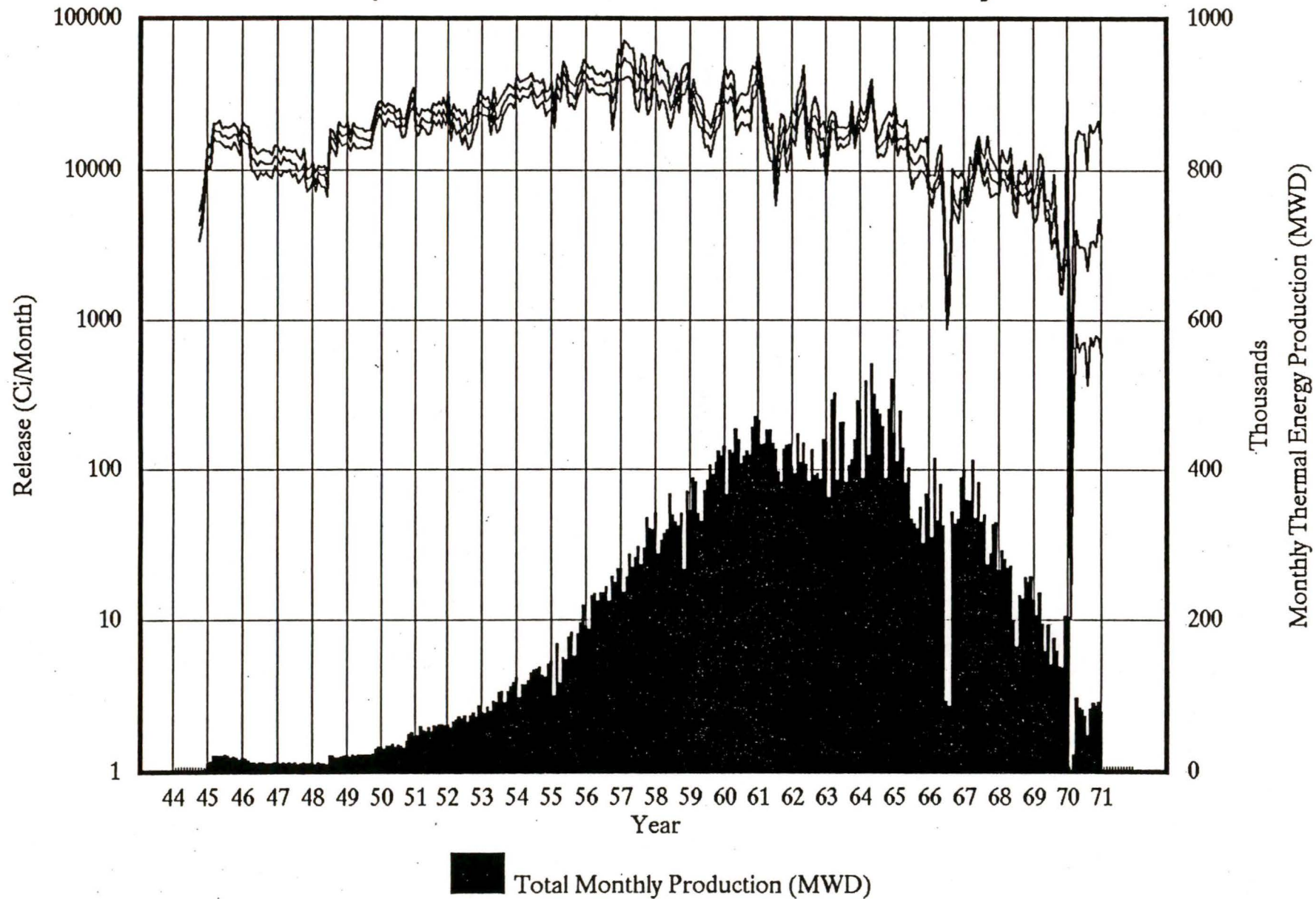
Iodine-131 Release History



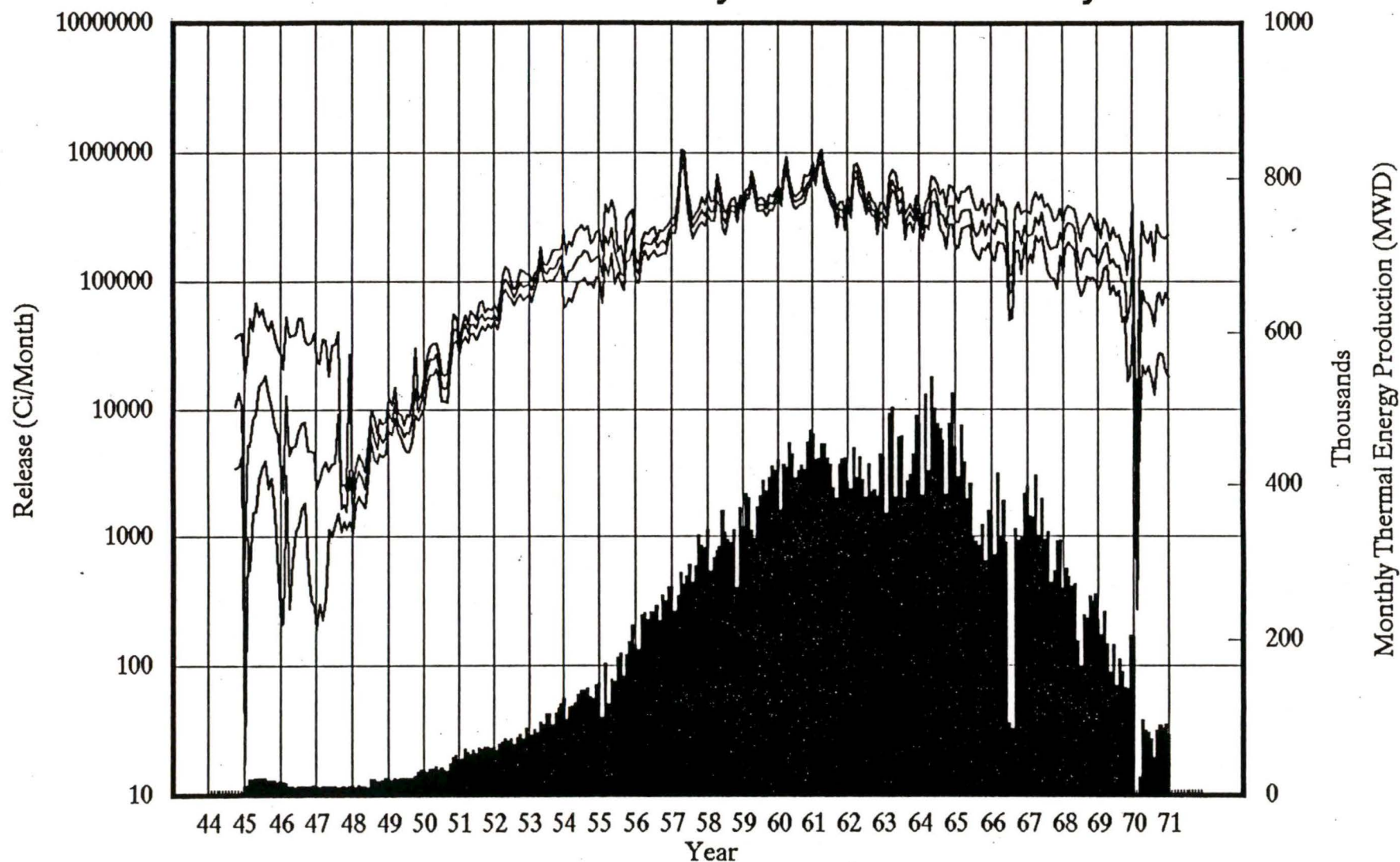
■ Total Monthly Production (MWD)

Upper curves are minimum, median, and maximum of 100 realizations

Neptunium-239 Release History



Gross Beta Activity Release History



■ Total Monthly Production (MWD)

Upper curves are minimum, median and maximum of 100 realizations

Note: Unlike the specific radionuclides, Beta activity is decayed four hours

Reactor Releases to the Columbia River

Conclusions

- **Complete source term provided**
- **Monte Carlo uncertainties estimated**
- **All known activity concentration measurements utilized**
- **Present estimate uncertainties cannot be significantly reduced**
- **Present estimates are an adequate source term for dose calculation**

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RATCHET

J.V. Ramsdell, Jr.

**Presented to the HEDR Technical Steering Panel
January 21, 1994
Battelle, Pacific Northwest Laboratories**

Topics

- **RATCHET Development Review**
 - Development Process
 - Data Quality Objectives
- **RATCHET Model Results**

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PreRATCHET Development

- **Early Modeling Discussions**
 - Options PNL-7198
- **MESOILT2**
 - Code Documentation PNL-7340
 - Phase I Results PNL-7199
- **Model Restructuring**
 - Phase I Model Evaluation PNL-7638, PNL7737
 - June 1990 Workshop
 - HEDRIC PNL-7993
 - CDC/NAS Review

RATCHET Development

- **RATCHET**
 - Working Group Meeting PNWD-1975
 - Initial RATCHET Document PNL-8003
 - Wind Field Modeling PNWD-2148
 - Interim Met. Database PNWD-2090
 - CDC Model Review
 - Testing and Verification

RATCHET Development, Continued

- Sensitivity /Uncertainty Plan	PNWD-2124
- Model Validation Plan	PNWD-2156
- Final Met. Database	PNWD-2200
- Final RATCHET Document	PNWD-2224
- Model Validation Report	PNWD-2221

External Reviewers

• F. A. Gifford	NOAA/ATDD
• R. P. Hosker	NOAA/ATDD
• C. J. Nappo	NOAA/ATDD
• D. Randerson	NOAA/NWSO
• W. B. Petersen	EPA/AMB
• W. B. Johnson	NCAR
• W. F. Dabberdt	NCAR
• W. S. Lewellen	ARAP

Data Quality Objectives-
Completeness, Representativeness, and Comparability

CDC Atmospheric Model Review Panel Conclusions:

- Approach in RATCHET is appropriate.
- Appropriate atmospheric processes are represented in RATCHET.
- Science in RATCHET is consistent with understanding and constraints.
- **NO BETTER CODE FOR THE HEDR PROJECT.**

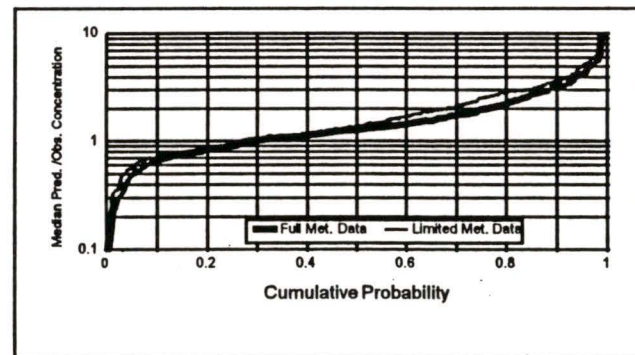
Data Quality Objectives-
Accuracy and Precision

- Model bias is less than a factor of 3.
- Uncertainties in the source term, meteorological data, and meteorological model parameters are characterized in RATCHET.

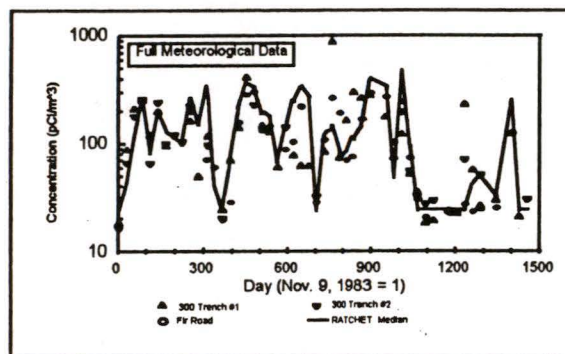
Topics

- RATCHET Development Review
- RATCHET Model Results
 - Monthly Krypton-85 Estimates
 - Iodine-131 Fate

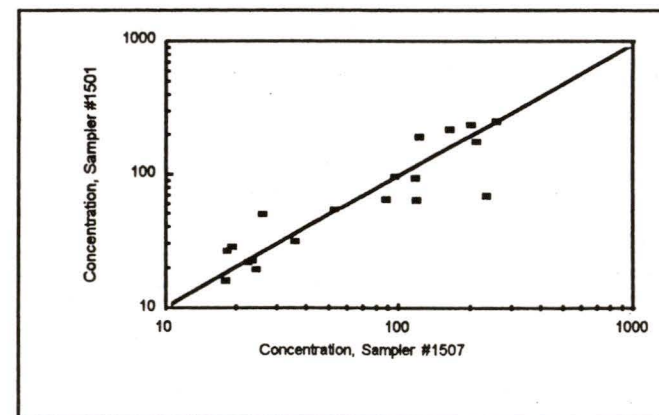
Comparison between Predicted and Observed Monthly-Average Krypton-85 Concentrations



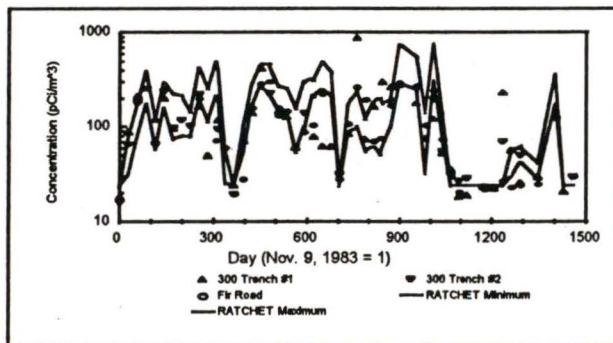
Krypton-85 Time Series at Node 17,23 (North Richland)



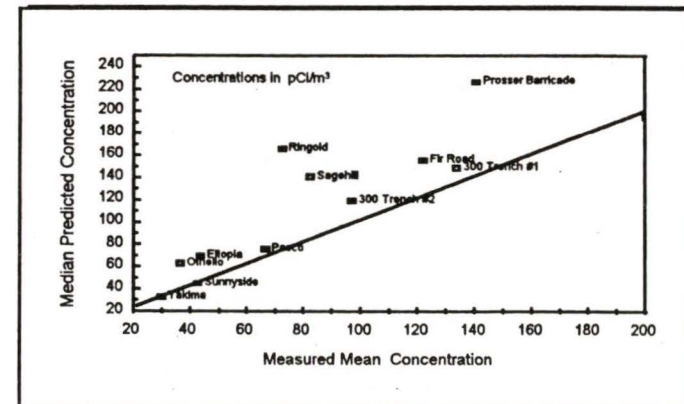
Comparison between Adjacent, Simultaneous Samples at the 300 Area Trench



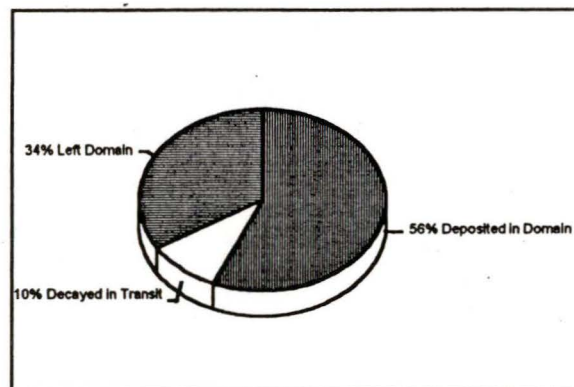
Krypton-85 Concentrations Compared with the Predicted Range at Node 17,23



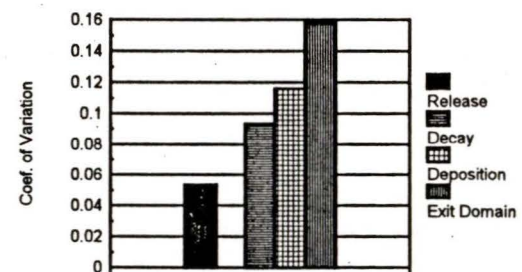
Comparison of Long-Term Predicted and Measured Krypton-85 Concentrations



**Iodine-131 Fate RATCHET Estimate for
December 1944 - December 1949**



Uncertainty In RATCHET Estimate of Iodine-131 Fate



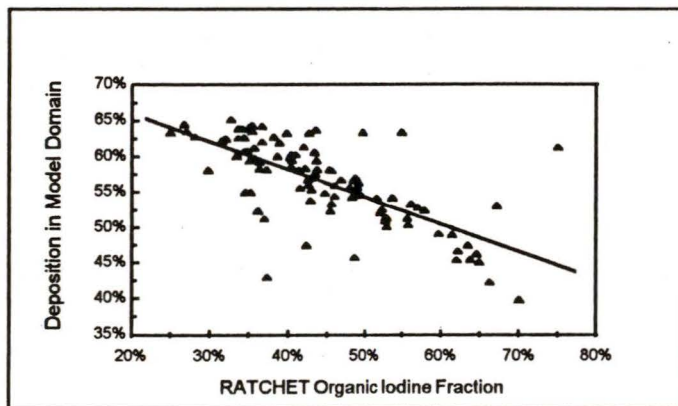
Conclusions

- **RATCHET Version 1.2 is an appropriate code for computing time-integrated air concentrations and surface contamination for use in estimating doses from Hanford releases.**
- **RATCHET provides acceptable estimate of time-integrated air concentrations and surface contamination for use in dose calculations.**

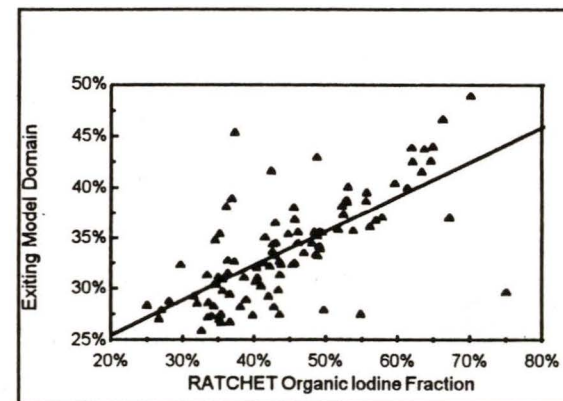
Conclusions, Continued

- **The uncertainty estimates for time-integrated air concentrations and surface contamination are acceptable.**
- **RATCHET provides a good estimate of the overall fate of the Iodine-131 released to the atmosphere from Hanford fuel-separations plants.**

**Variation of Total Deposition
with Organic Iodine Fraction**



**Variation of Iodine Exiting Model Domain
with Organic Iodine Fraction**



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River Transport Results

**W. H. Walters
M. C. Richmond
B. G. Gilmore**

**Presentation to the HEDR Technical Steering Panel
January 21, 1994
Battelle, Pacific Northwest Laboratories**

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Topics

- **Reasons for Modeling**
- **Model selection**
- **Computational scheme**
- **Model validation**
- **Testing for sediment effects**
- **Results**
- **Summary**

Reasons for Modeling

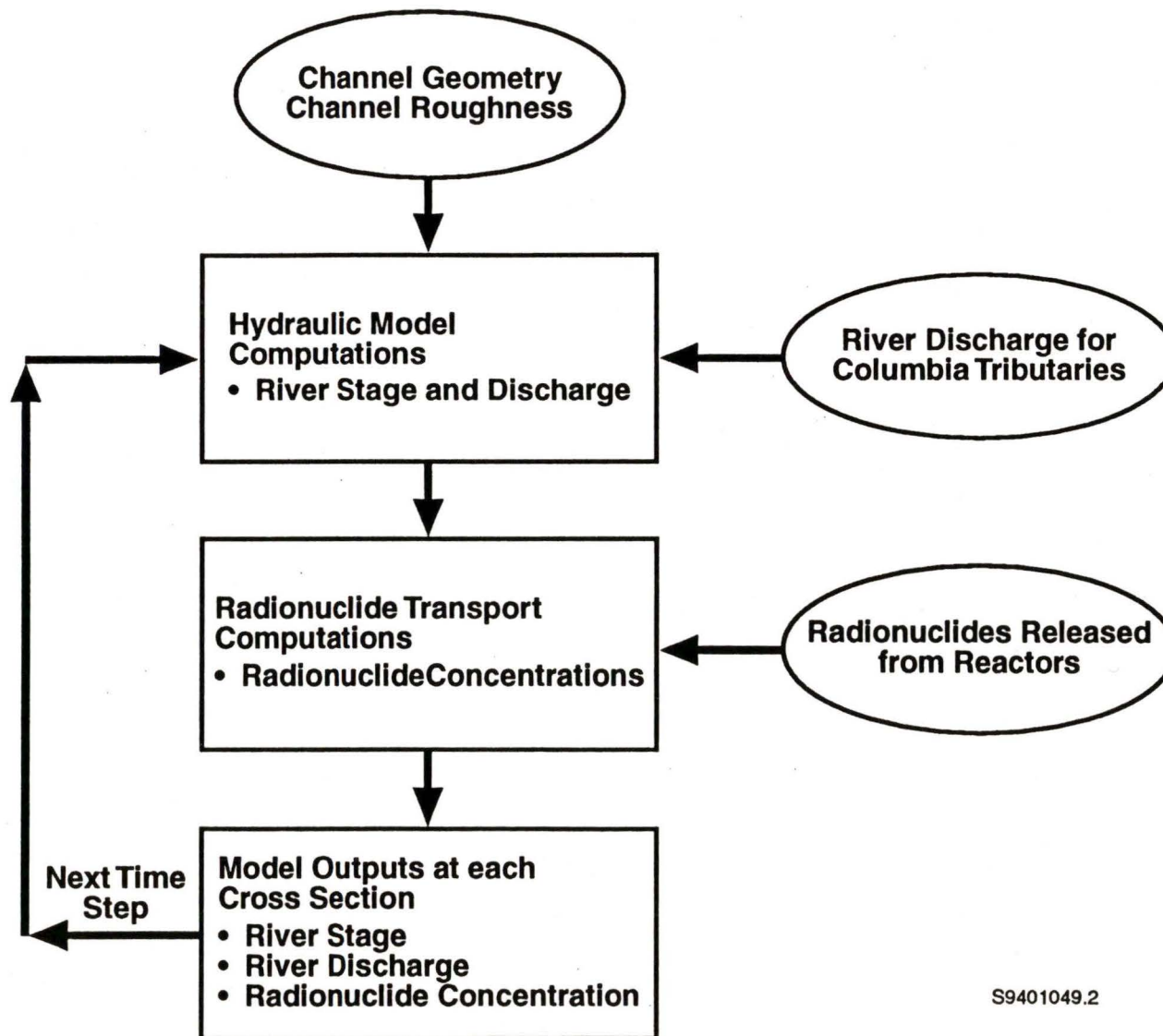
- **Lack of Monitoring Data**
- **Source term routing**

Model Selection

- **Reasons for using CHARIMA**
 - **Dams and open channels**
 - **Dilution and travel time**
 - **Output locations**
 - **Contaminant transport**

WSU-CHARIMA Model

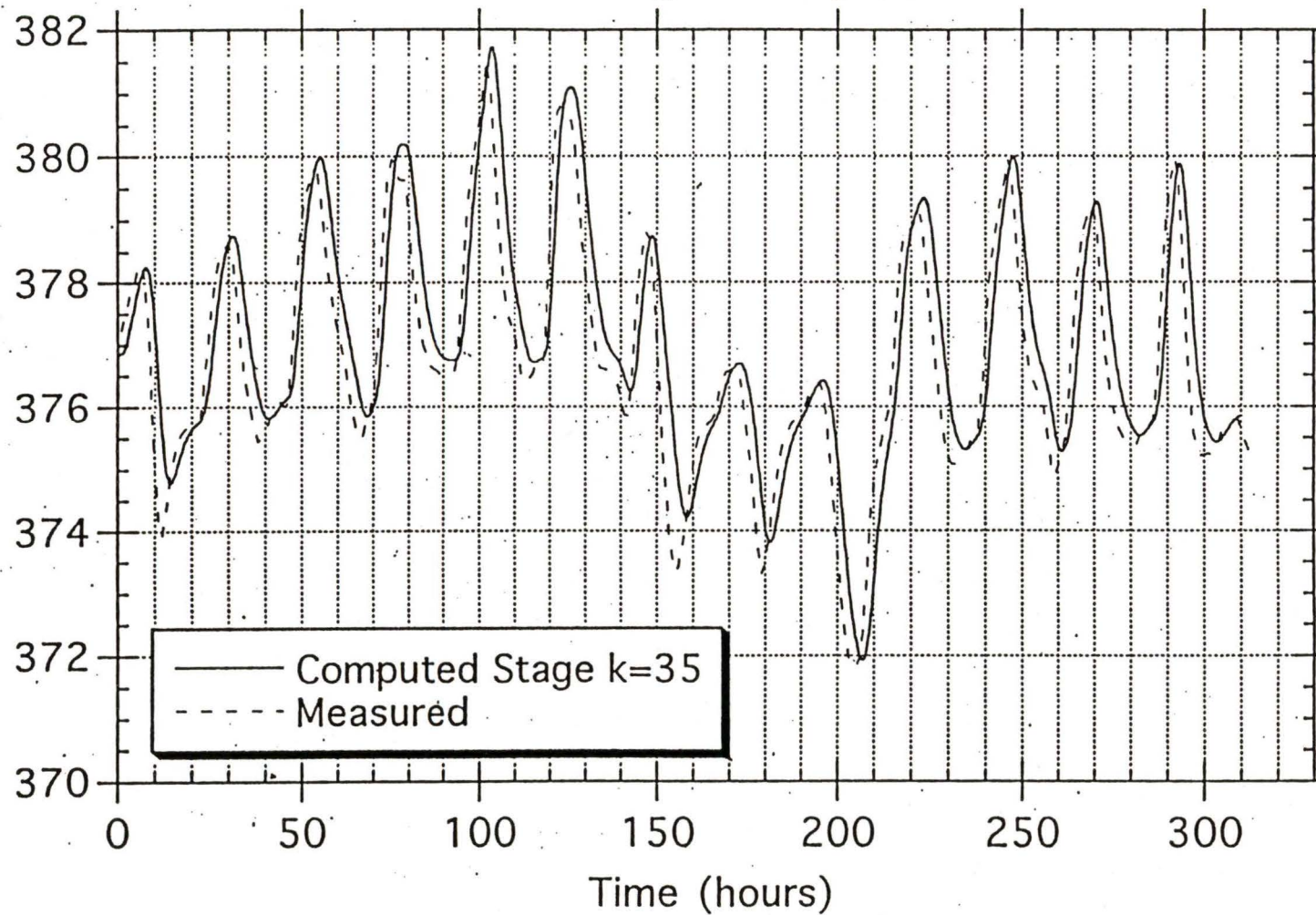
General Calculation Schematic



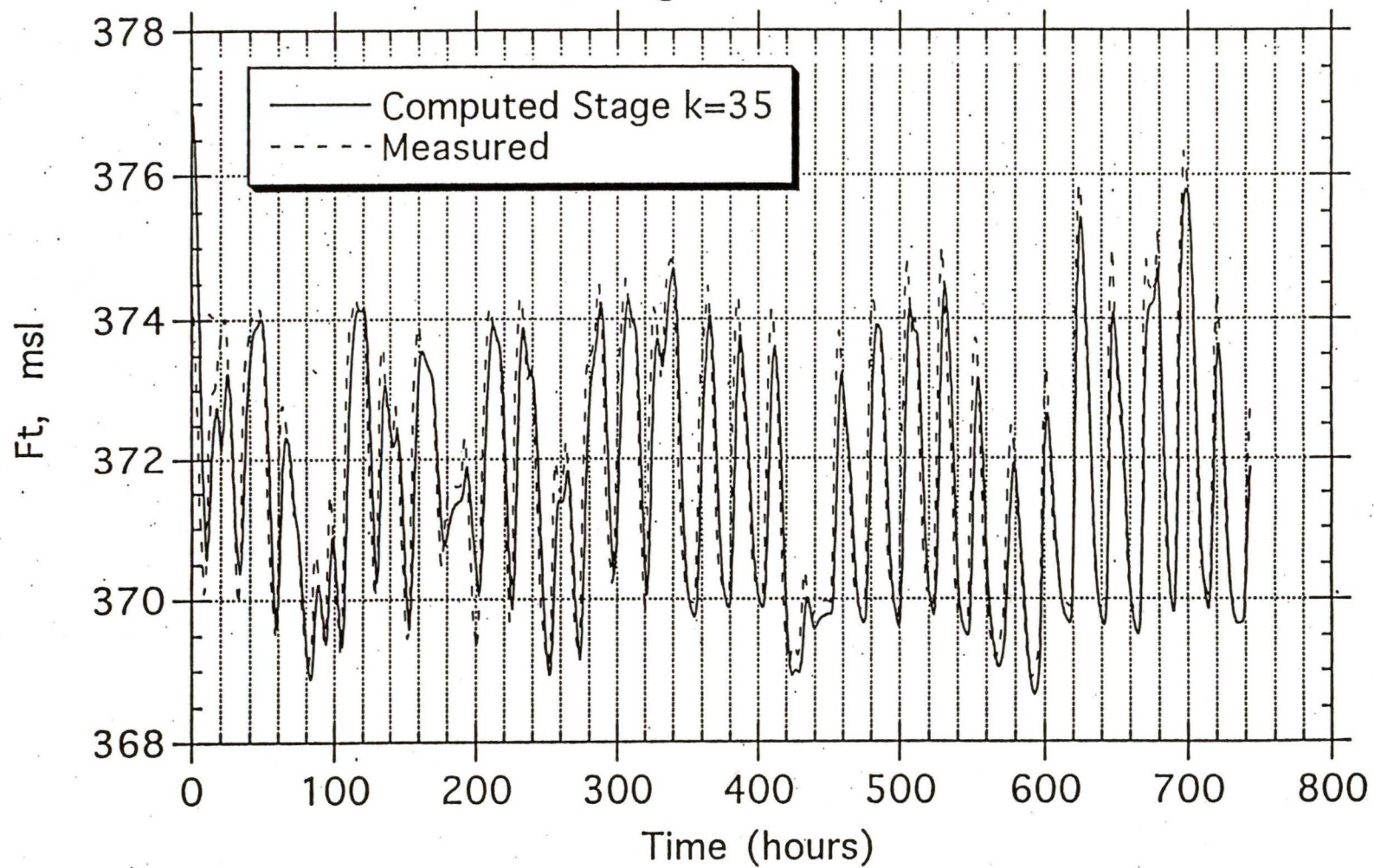
Model Validation

- **Columbia River hydraulics**
 - **Priest Rapids to 300 Area**
 - **300 Area to Portland**
- **Radionuclide transport**

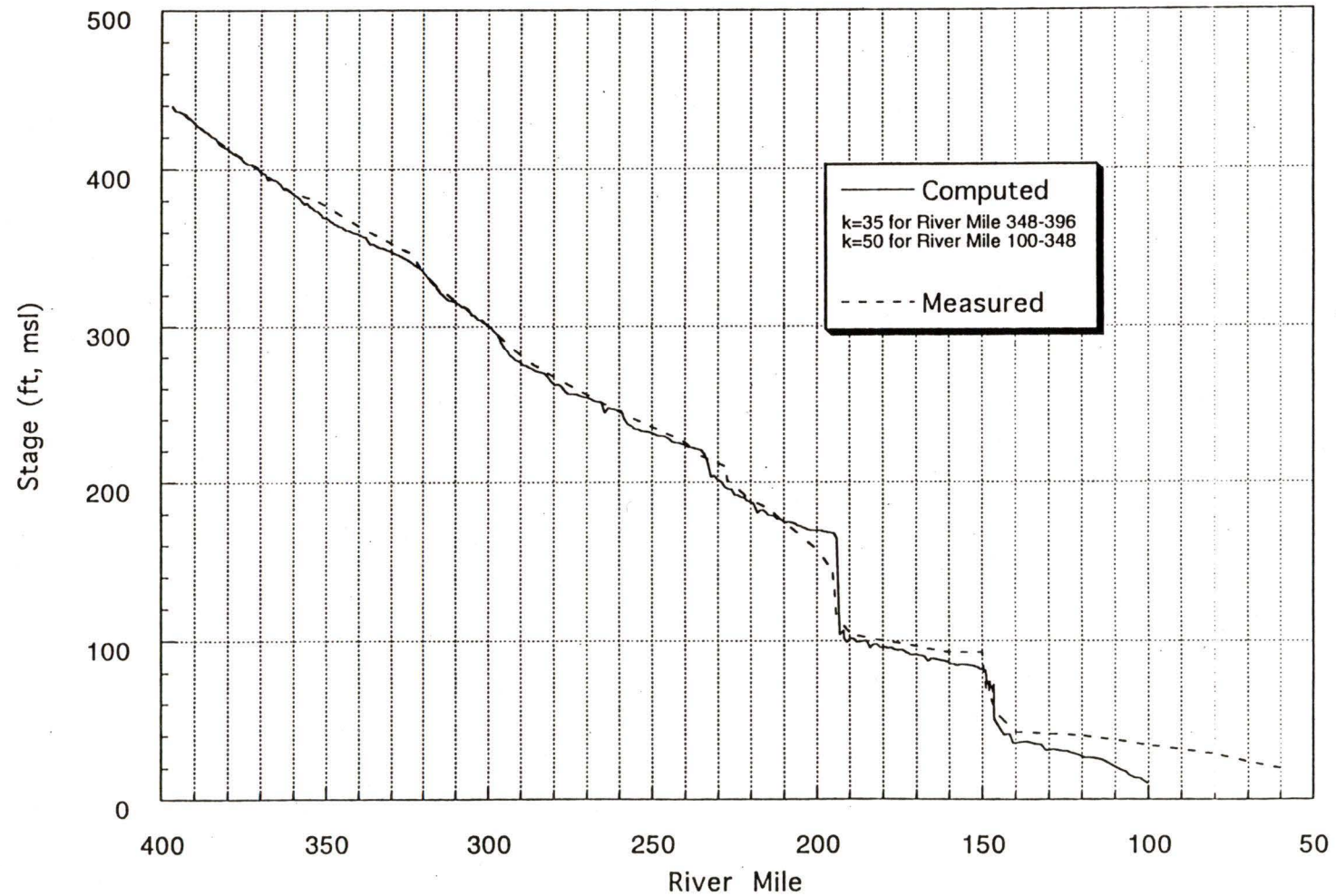
100H Gauge - May 1992



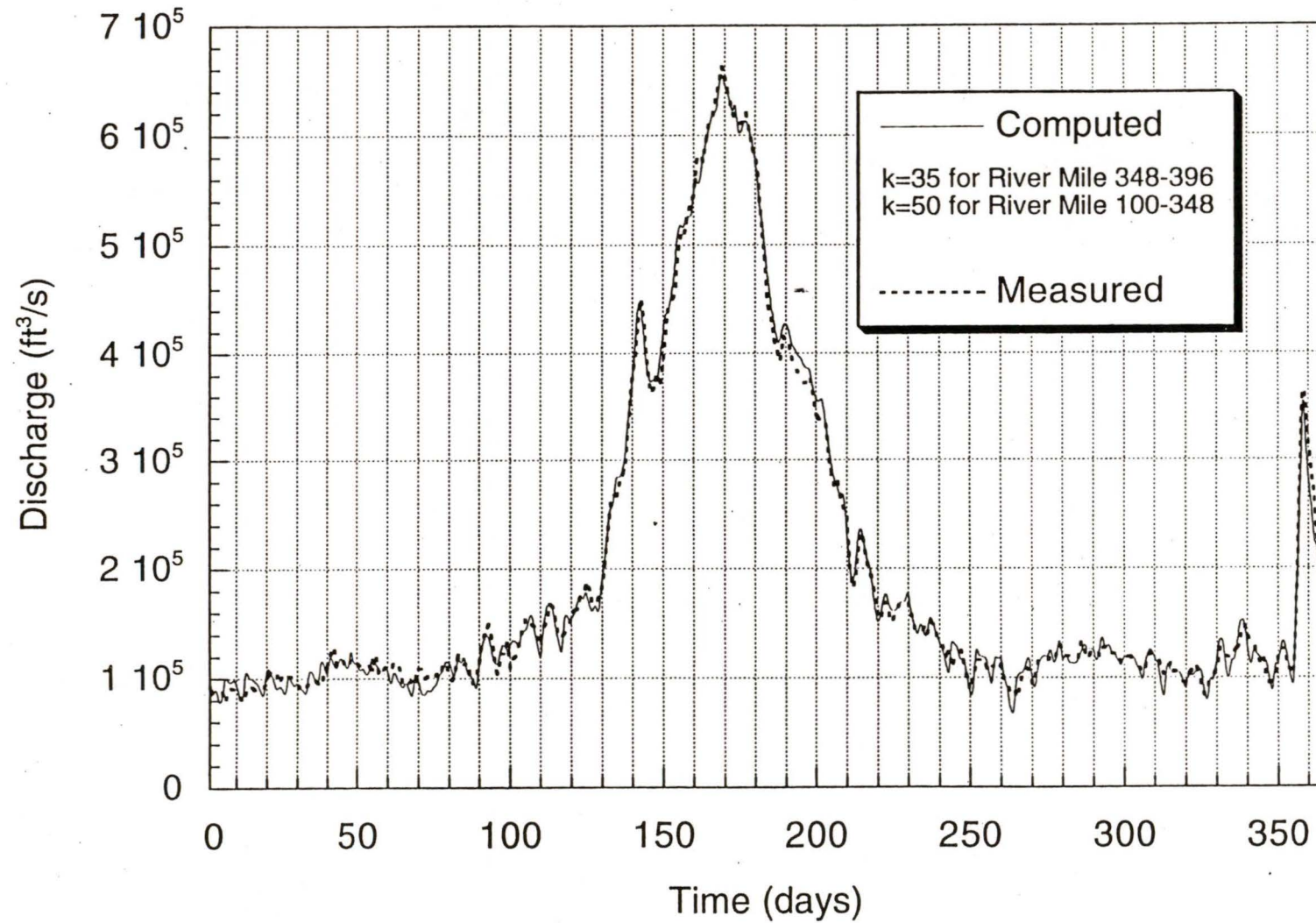
100H Gauge - October 1992



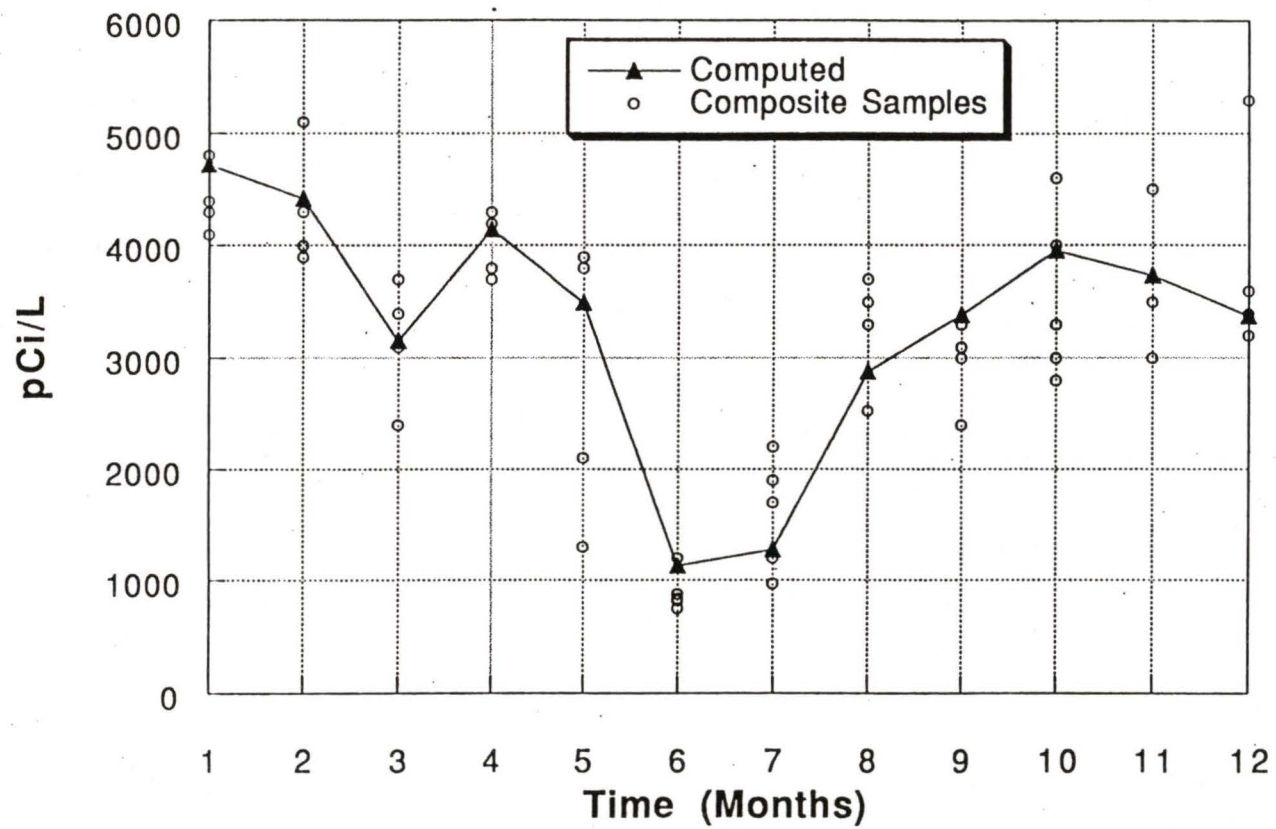
1894 Columbia River Flood



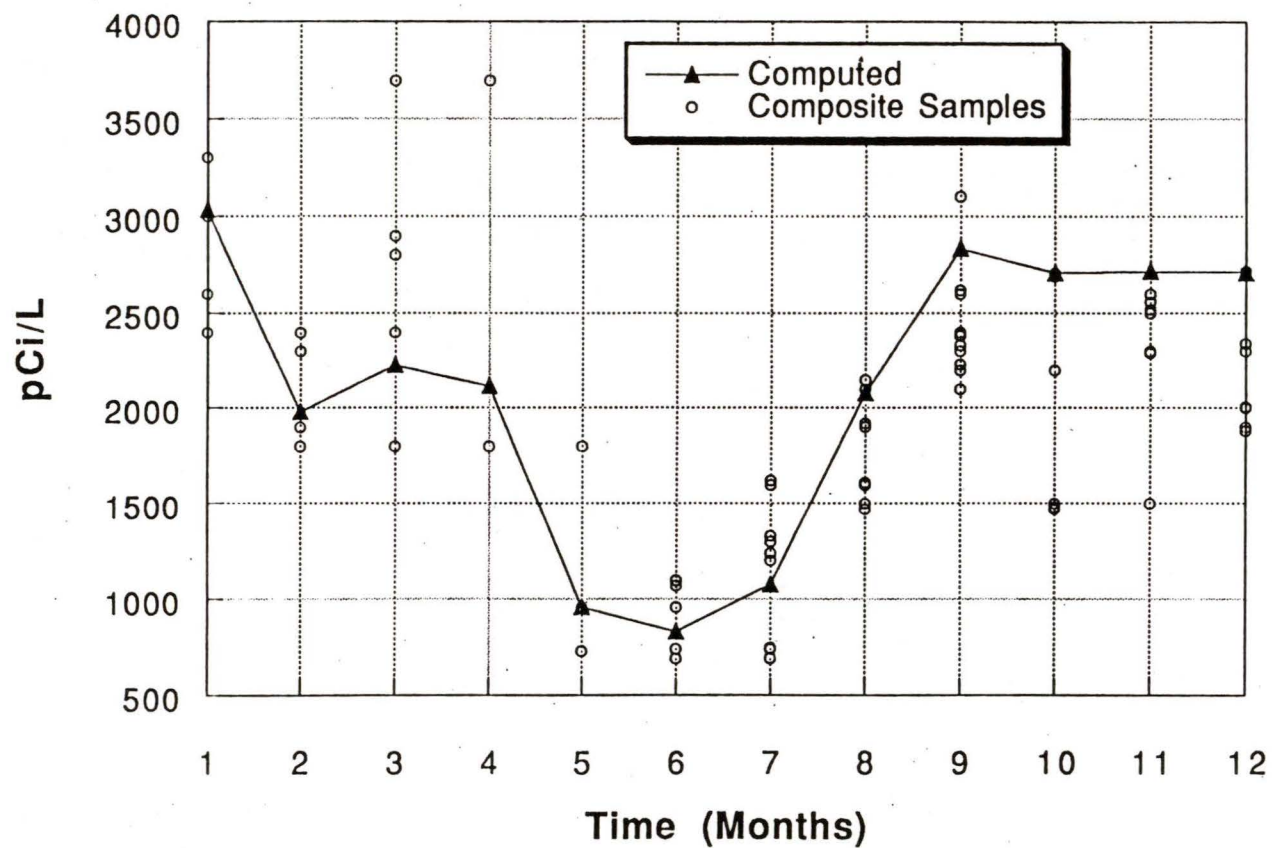
The Dalles - 1964



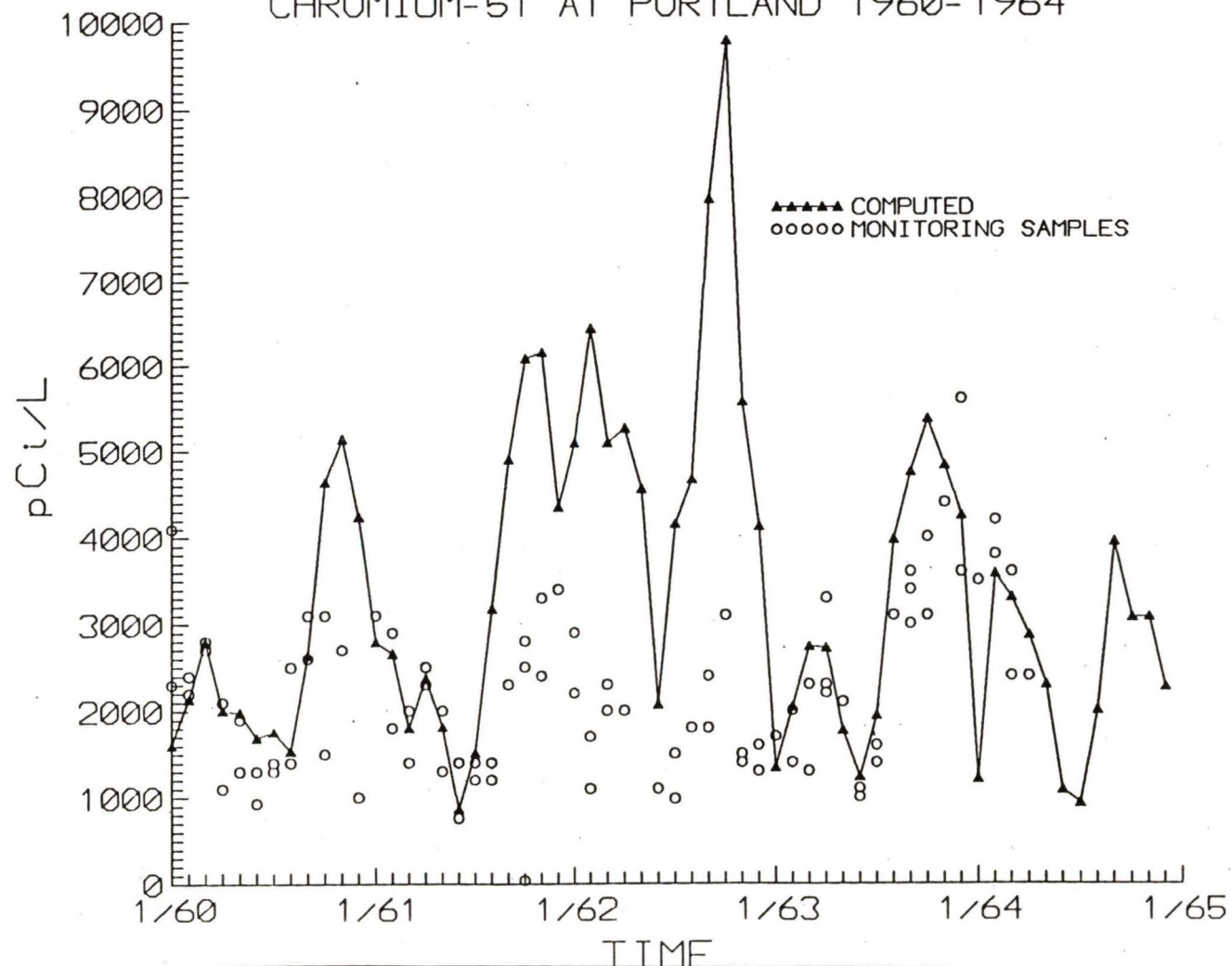
Chromium-51 at Richland 1967



Chromium-51 at The Dalles 1965



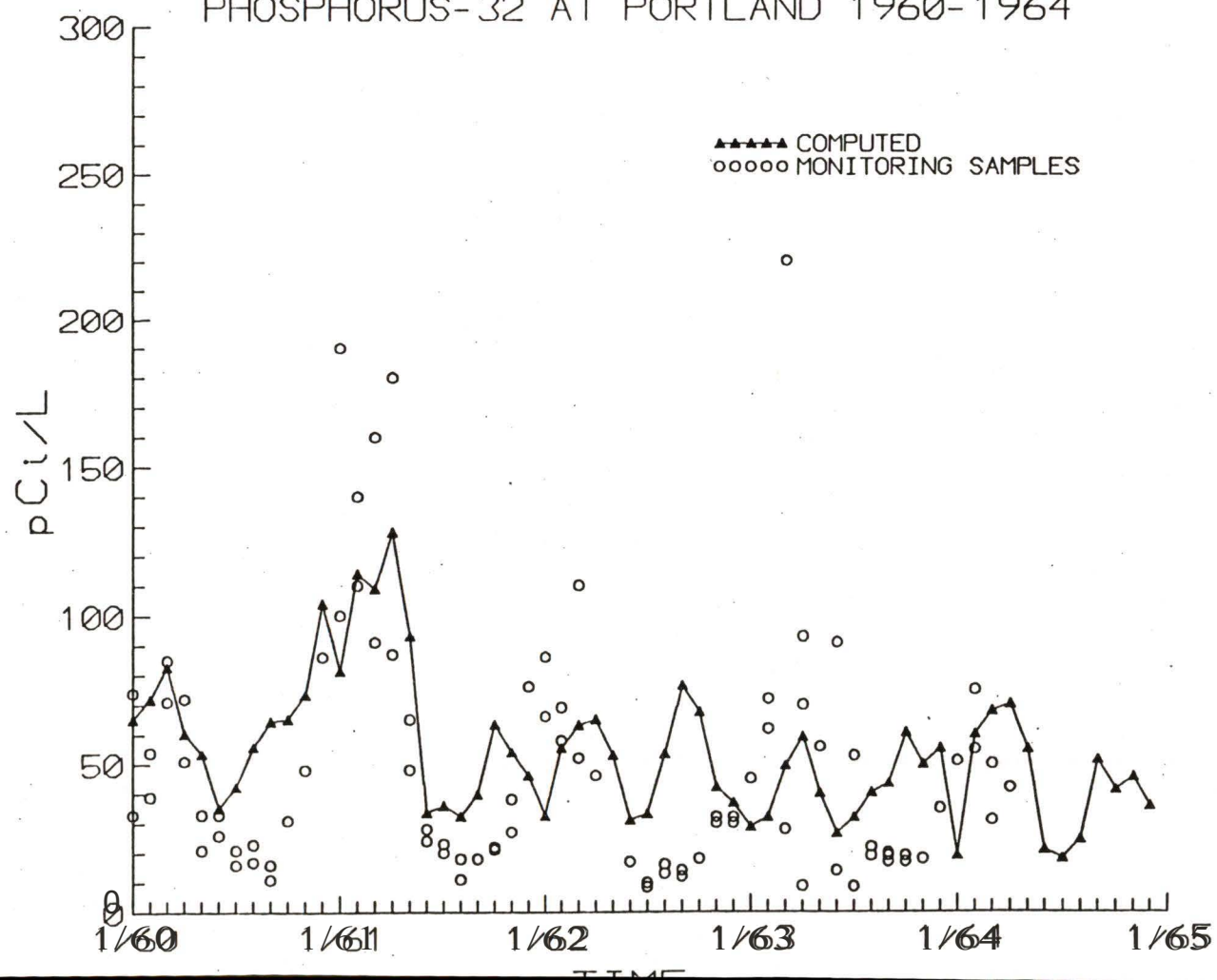
CHROMIUM-51 AT PORTLAND 1960-1964



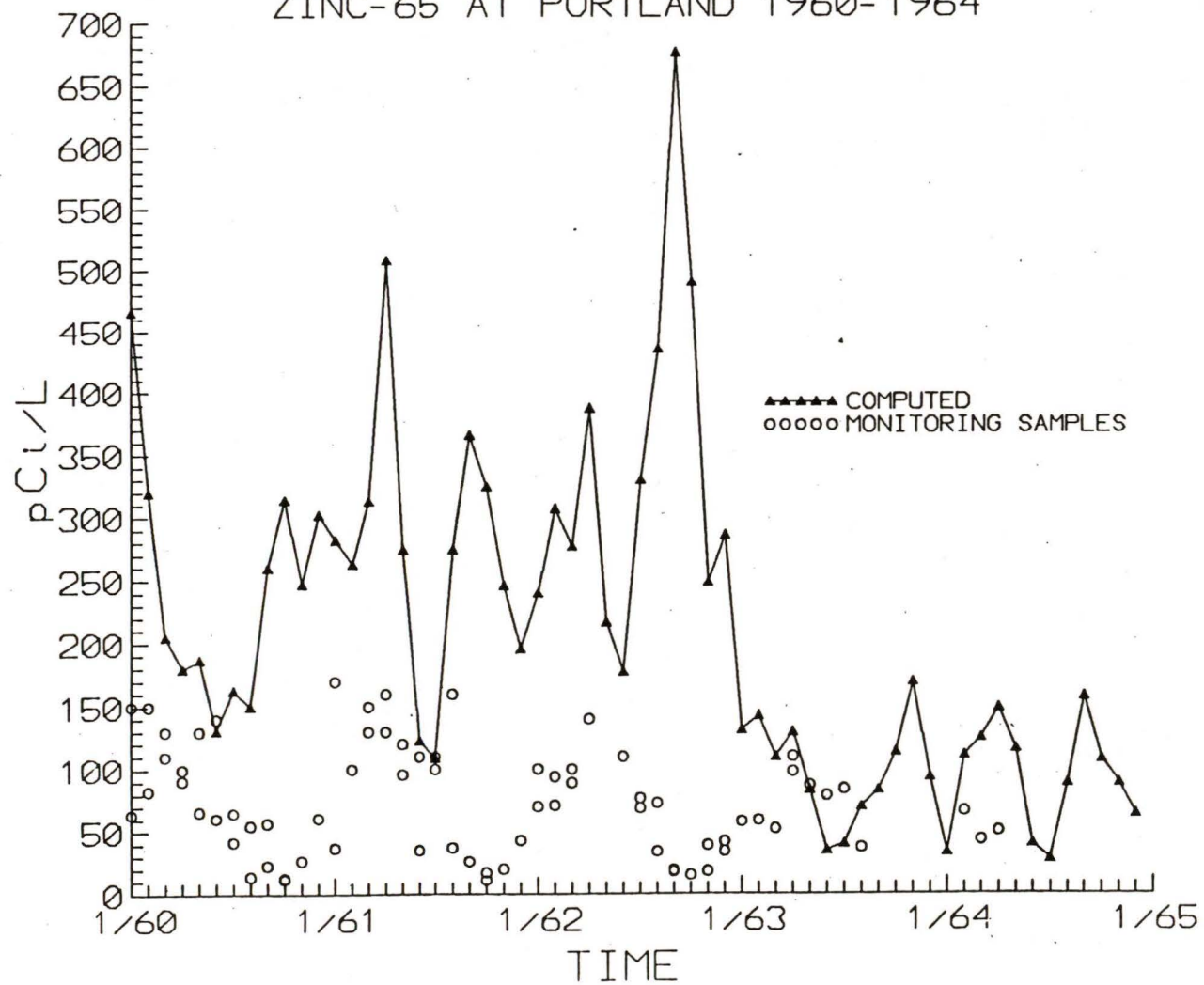
Evaluation of Sediment Effects

- **Sodium-24 and Arsenic-76**
 - Little effect to McNary Dam
 - No monitoring data below McNary
- **Phosphorus-32 and Neptunium-239**
 - Little effect to Portland
- **Zinc-65**
 - Effects mostly at Portland

PHOSPHORUS-32 AT PORTLAND 1960-1964



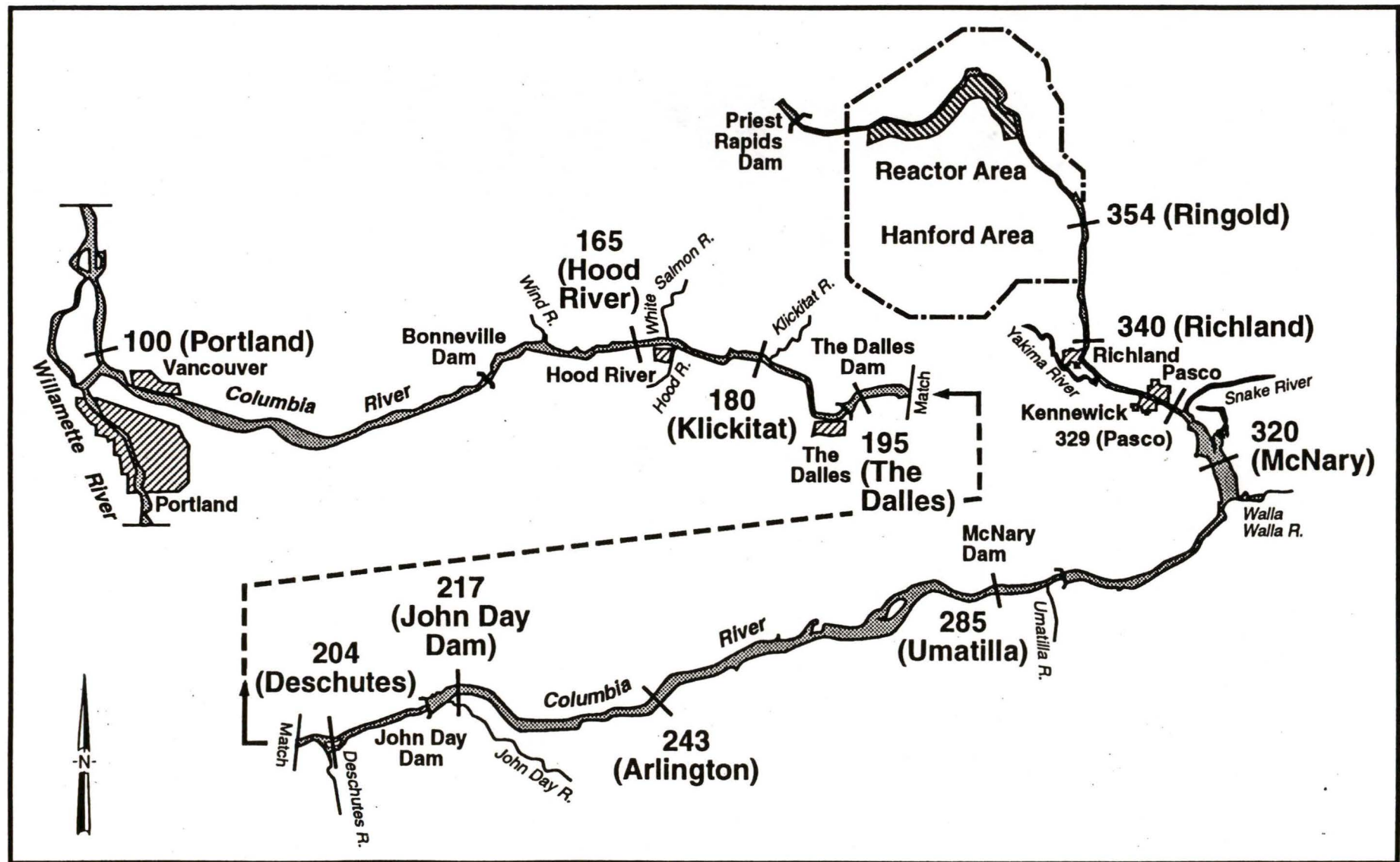
ZINC-65 AT PORTLAND 1960-1964



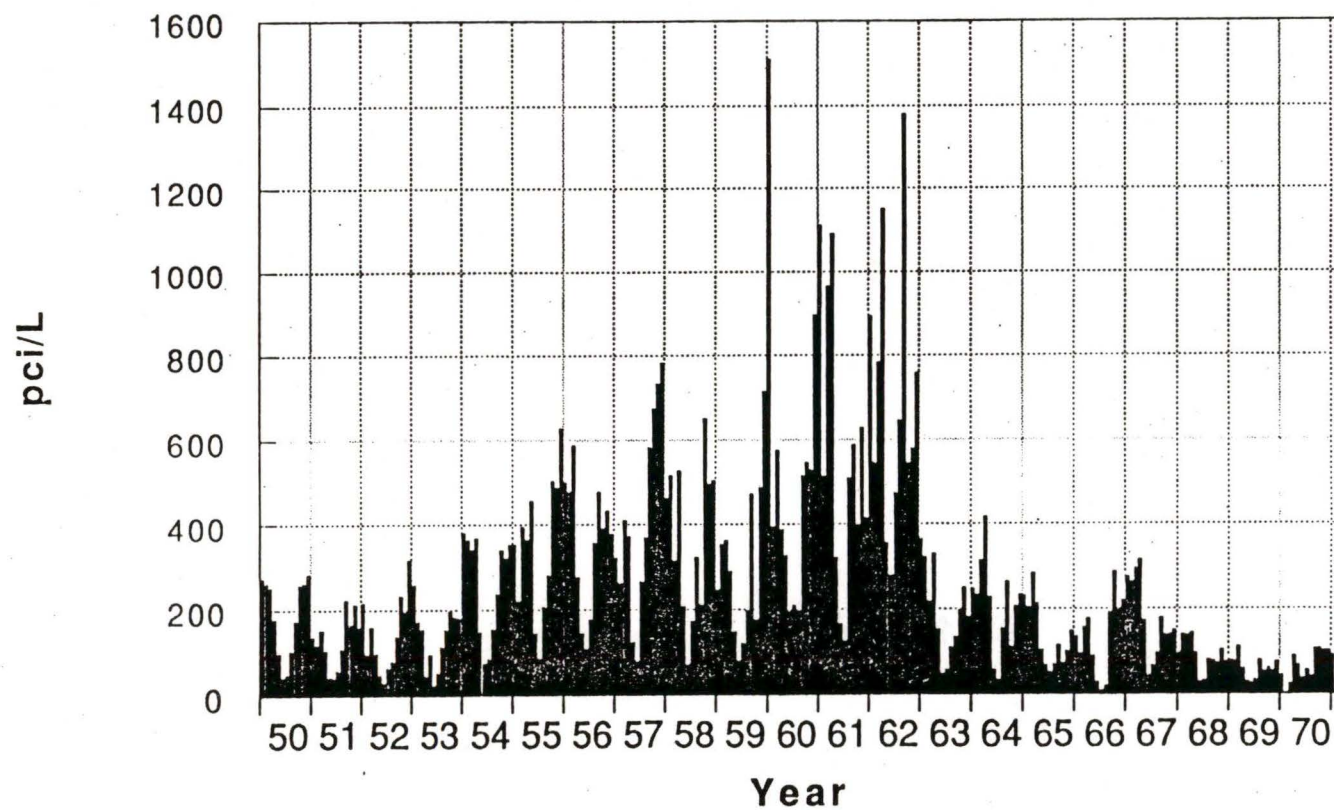
Results – Water Concentrations

- **Hanford to Bonneville Reservoir**
 - **Representative estimates**
- **Portland**
 - **Representative except for Zn-65**
- **Travel time effects (dams and decay)**
 - **Na-24; As-76; Np-239; strongly affected**
 - **P-32; Zn-65 hardly affected**

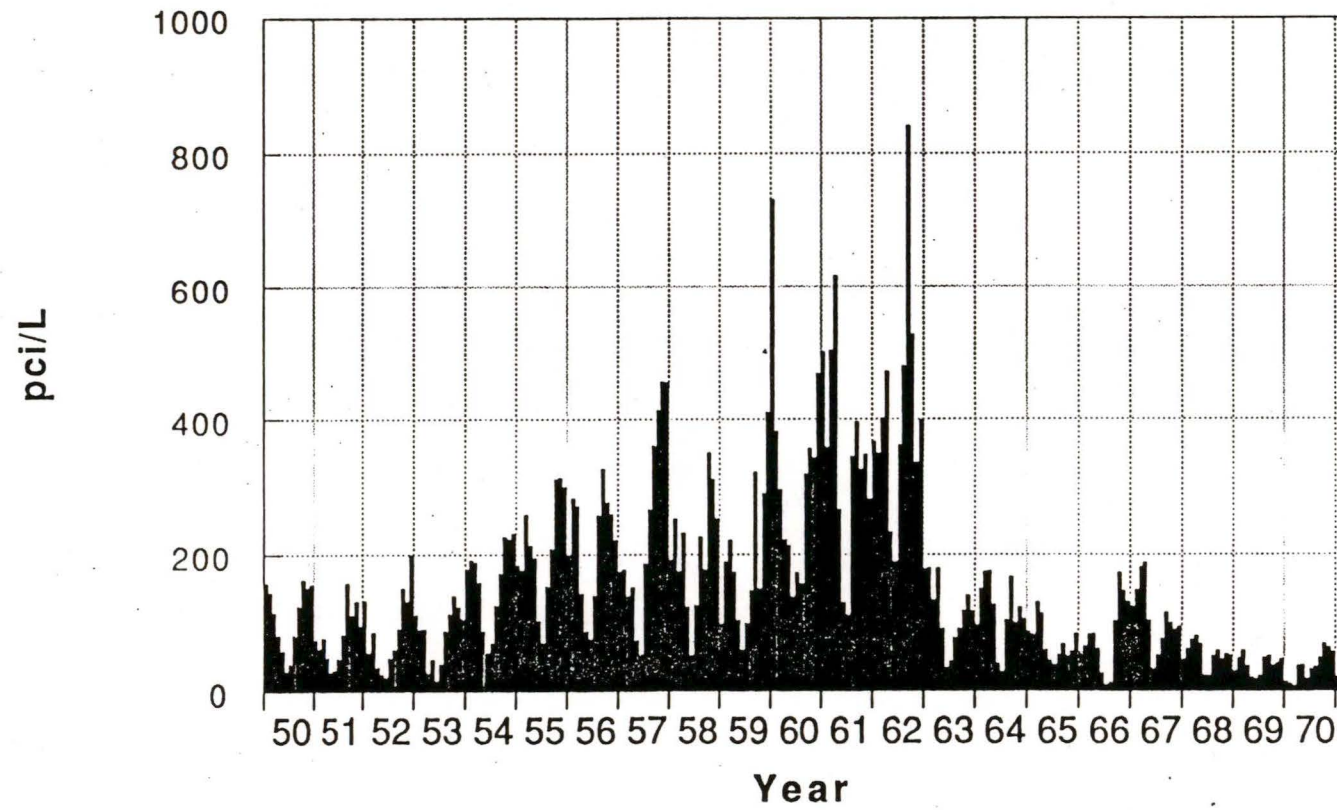
Location and River Mile of Computed Water Concentrations



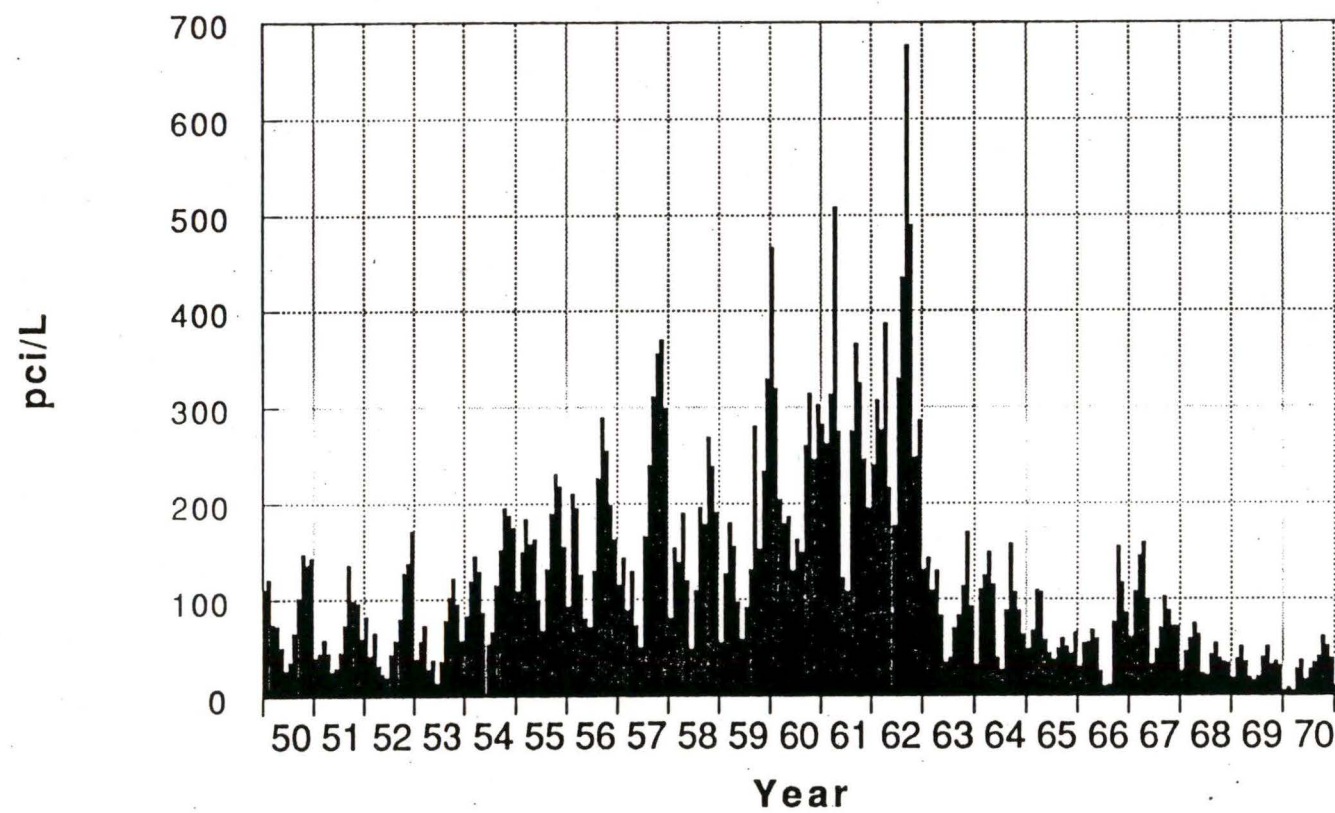
Zinc-65 at Richland



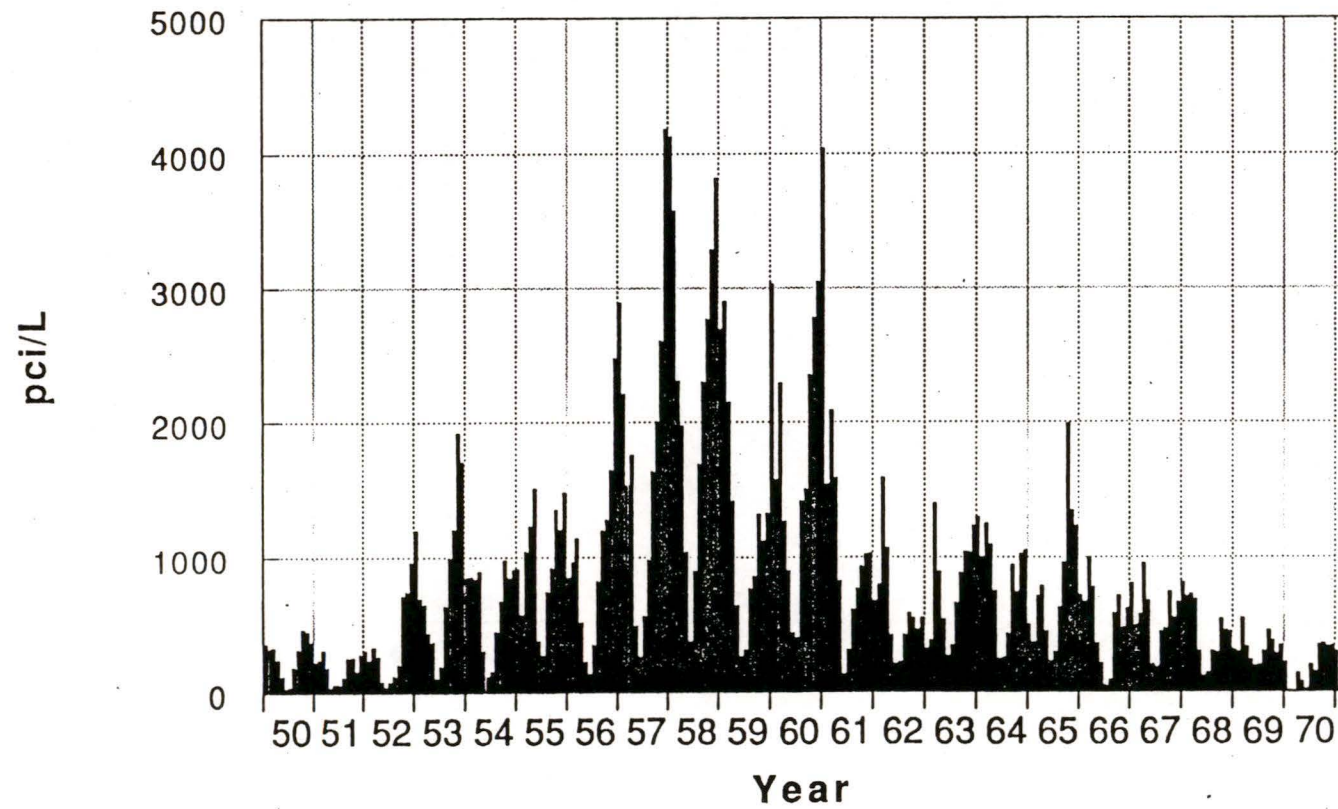
Zinc-65 at The Dalles



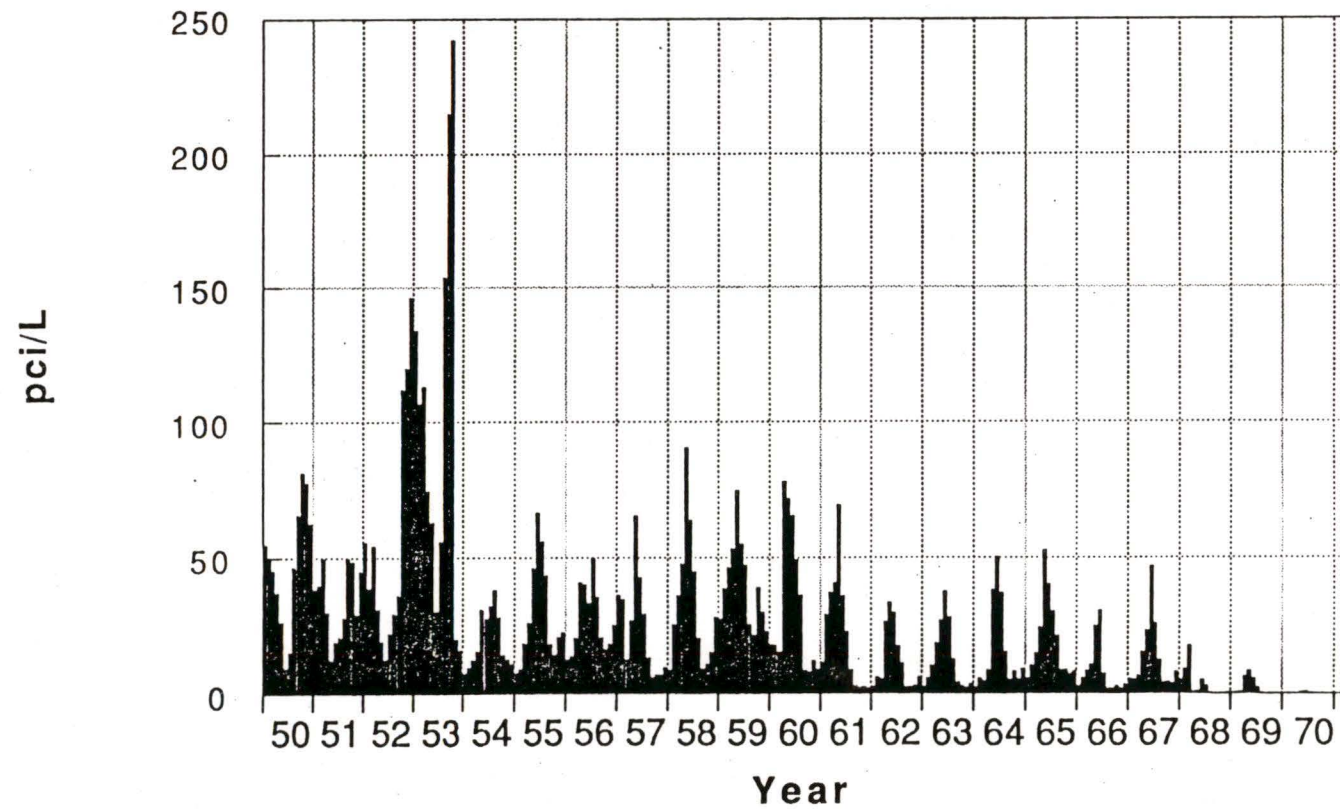
Zinc-65 at Portland



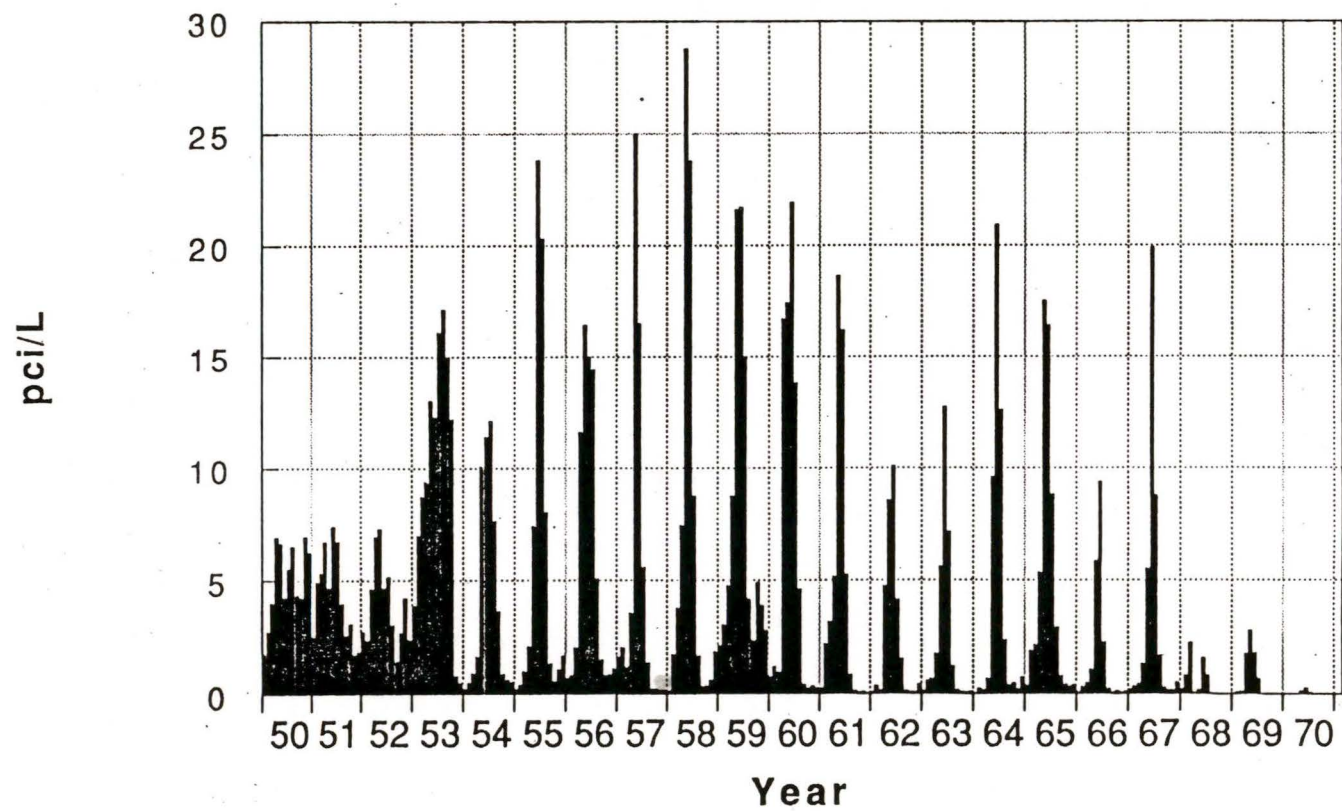
Arsenic-76 at Richland



Arsenic-76 at The Dalles



Arsenic-76 at Portland



Summary

- **Accurate hydraulic simulation**
- **Representative water concentrations**
 - **Sediment effects are minimal**
 - **Zinc-65 overestimated at Portland**
- **Impact of dams on concentrations**

AIR PATHWAY CODE STATUS

DESCARTES and CIDER Codes

**P. W. Eslinger
W. T. Farris**

**Presentation to the HEDR Technical Steering Panel
January 21, 1994
Battelle, Pacific Northwest Laboratories**

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Summary Status

All air pathway codes are:

- **Written**
- **Tested**
- **Operational**
- **Under configuration management**

**All work was performed under the controls
of the HEDR Quality Assurance Plan**

Code Description - Air Pathway

Major computational codes

- **DESCARTES** - Estimates concentrations in environmental media
- **CIDER** - Generates individual dose estimates

Major support codes

- **SHUFFLE** - Reformats daily air data from RATCHET
- **SHFMET** - Extends air data from 1944-1949 through 1957
- **AGGREGATE** - Integrates DESCARTES outputs for CIDER

Code Description - Air Pathway (Cont'd)

Environmental Accumulation Utility Codes

- ADIETP** - Builds libraries of animal diets
- FROSTP** - Builds libraries of frost dates
- RECIPE** - Builds commercial food distribution library files
- MLOOK** - Displays binary media files in ASCII format

Individual Dose Utility Codes

- ORGFAC** - Builds library of random dose conversion factors
- LIFFAC** - Builds library of lifestyle related random factors
- FOOFAC** - Builds library of food consumption random factors
- ENVFAC** - Builds library of environmental random factors
- EXPAND** - Summarizes CIDER output file for reports and plots

Air Pathway Code Execution Times

Environmental accumulation production runs took 12.5 days

Started: 1:45 pm Monday, October 25

Finished: 1:20 am Sunday, November 7

Production run:

- **100 realizations**
- **1102 nodes**
- **1944 through 1957**

Dose map production runs took 3.5 days

19 reference individuals

12 supporting cases

3 seconds (average) to calculate annual doses for reference individuals

Environmental Accumulation Production Run-Time Detail

SHUFFLE

9 hours

SHFMET

1 day, 12 hours

DESCARTES

3 days, 19 hours for all plant products

2 days, 17 hours for cow's milk

2 days, 11 hours for beef, goat milk, poultry, eggs

AGGREGATE

11 hours

DESCARTES Data Size

Input Data (Mbytes)

4,280	Daily air data 1944-1957
7	Animal diet libraries
26	Frost date libraries
2	Animal feeding season libraries
26	Commercial milk libraries
2	Commercial leafy vegetables libraries
4,343	Total

Output Data (Mbytes)

1,835	Concentrations by media
7	Stochastic data
13	Report files
1,855	Total

CIDER Data Size

Input Data (Mbytes)

11	Concentrations for creameries
995	Concentrations for other media
<1	Stochastic variable libraries
1	Human reference diet
1007	Total

Output Data (Mbytes) for Dose Report Runs

540	Dose maps (19 reference individuals)
331	Scaling factors for dose maps
871	Total

Calculations for a Real Individual

Input Data (Mbytes)

11	Concentrations for creameries
995	Concentrations for other media
<1	Stochastic variable libraries
1	Human reference diet
<1	Scenario file
1007	Total

Output data for thyroid dose, all pathways

Kbytes	Time period	Text Pages
25	1 year	4
175	14 years (1944-1957)	30

Calculation time

Approximately 3.5 minutes for 1944-1957

DESCARTES Output

Used in Dose Calculations

Dose Calculations

- **Individual specific information**
 - **Location**
 - **Consumption rate**
 - **Lifestyle**
- **19 different types of media concentrations**

Plant Media

- **Leafy vegetables (2 types)**
- **Other vegetables**
- **Fruit**
- **Grains**

Animal Media

- **Backyard goat milk**
- **Commercial cow milk**
- **Creamery cow milk**
- **Backyard cow milk (4 types)**
- **Eggs**
- **Beef/pork**
- **Poultry**

Other Media

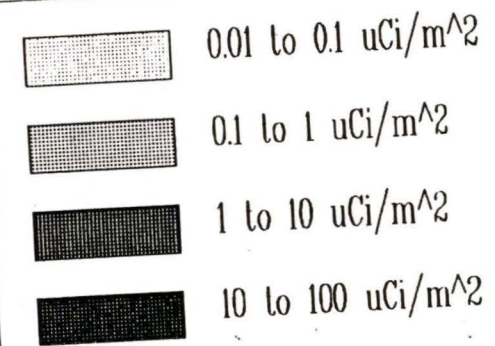
- **Air**
- **Air deposition**
- **Upper soil**
- **Root zone soil**

Media Maps

- **Cumulative deposition**
- **Pasture grass**
- **Milk from cows on fresh pasture**
- **Milk from cows fed stored feed**
- **Commercial milk**
- **Leafy vegetables**
- **Commercial leafy vegetables**

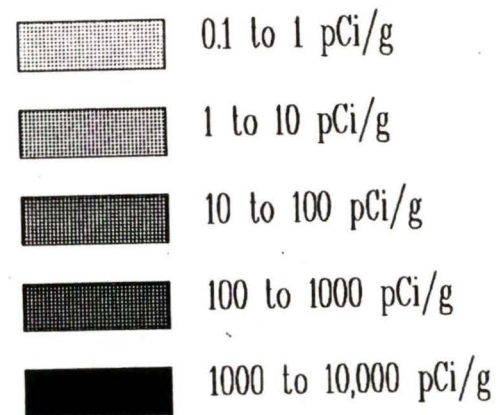
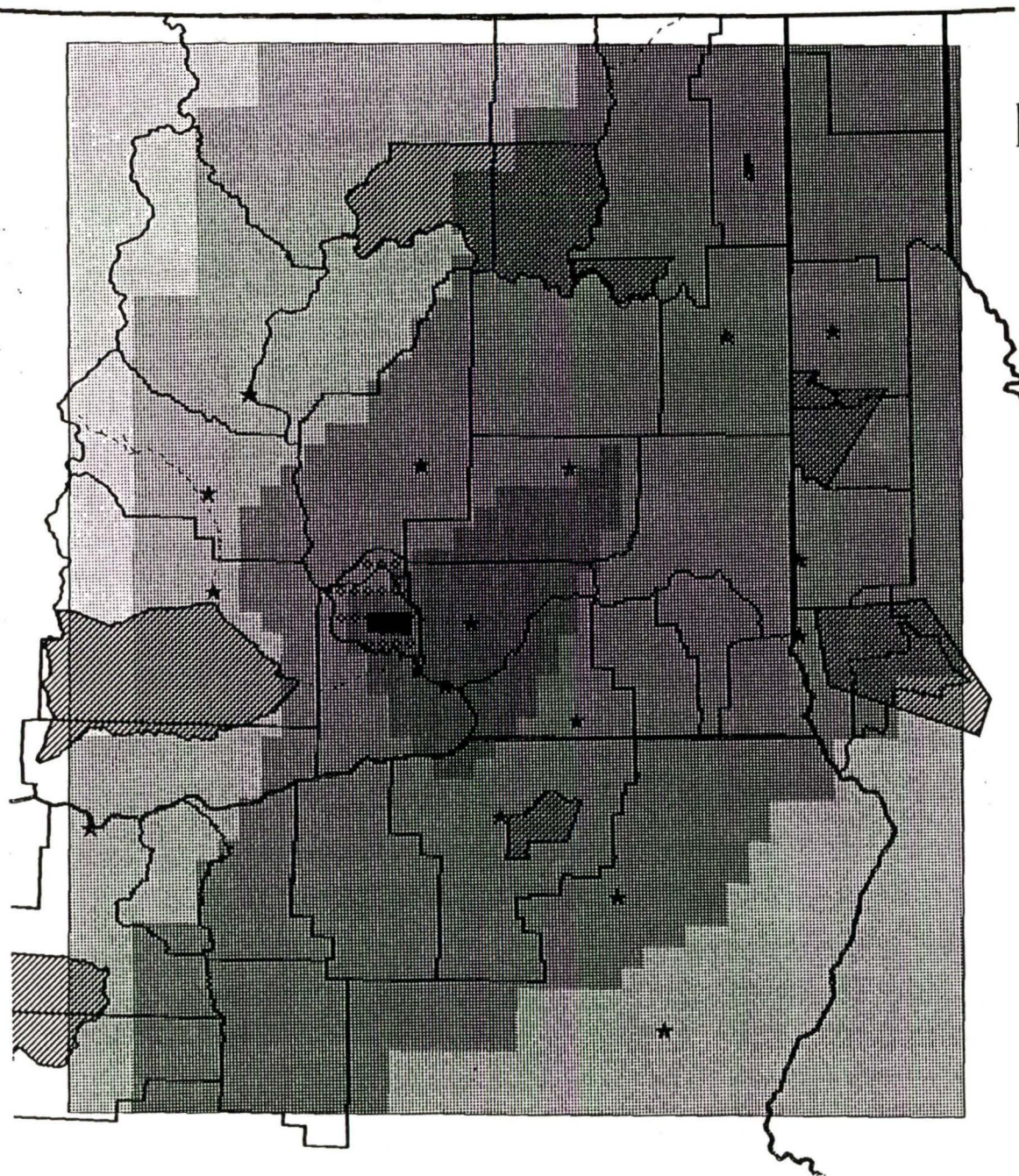
1945 TOTAL DEPOSITION (UNDECAYED)

August 1945



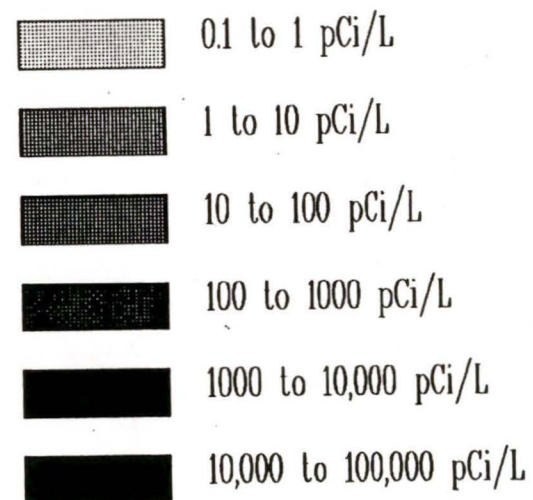
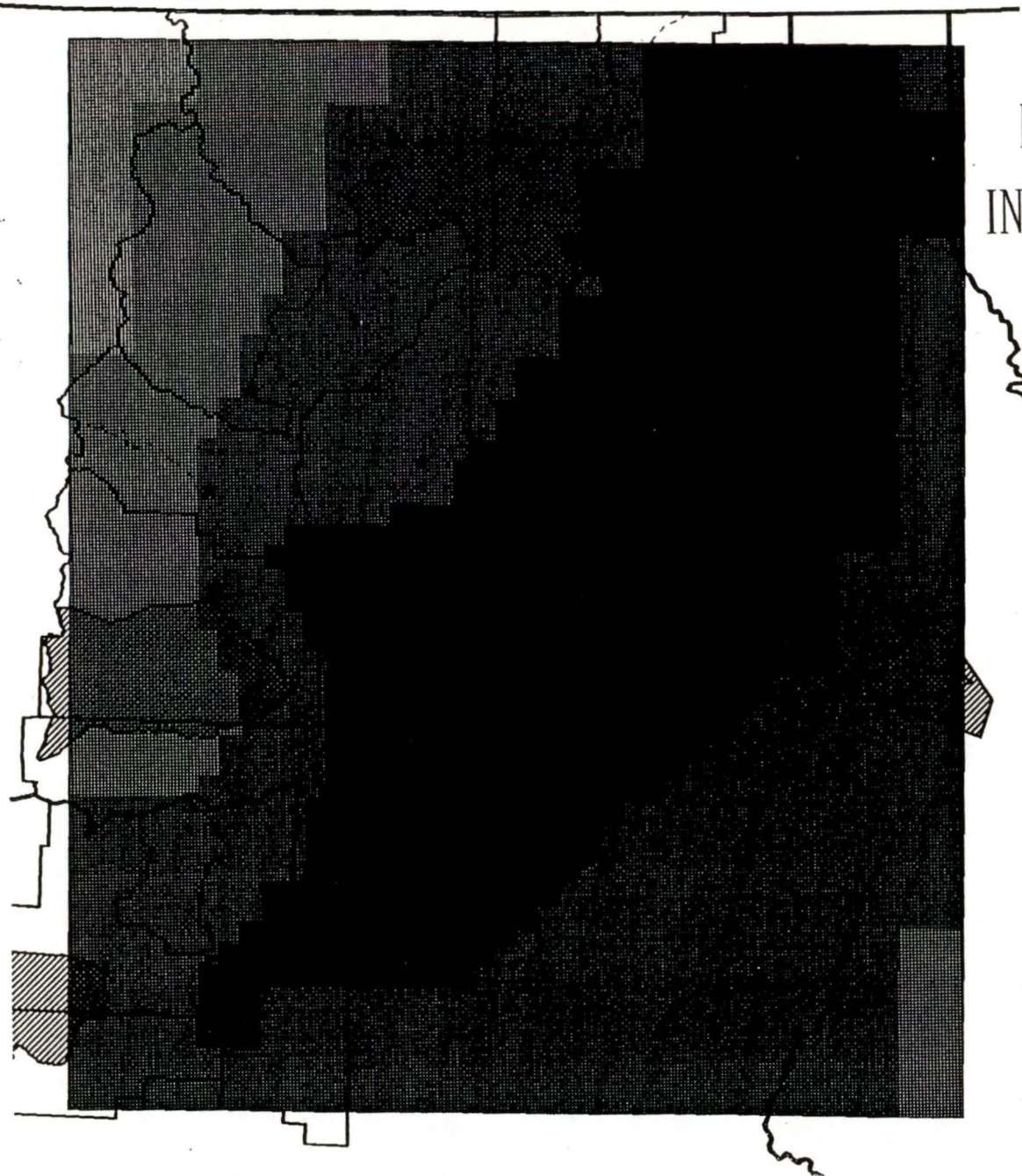
MEDIAN I-131 CONCENTRATIONS IN PASTURE GRASS

August 1945



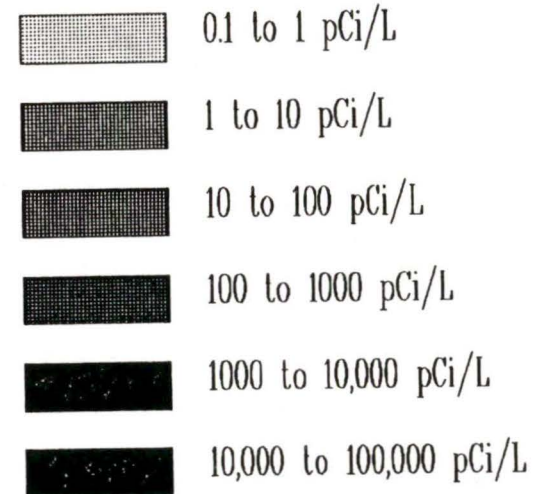
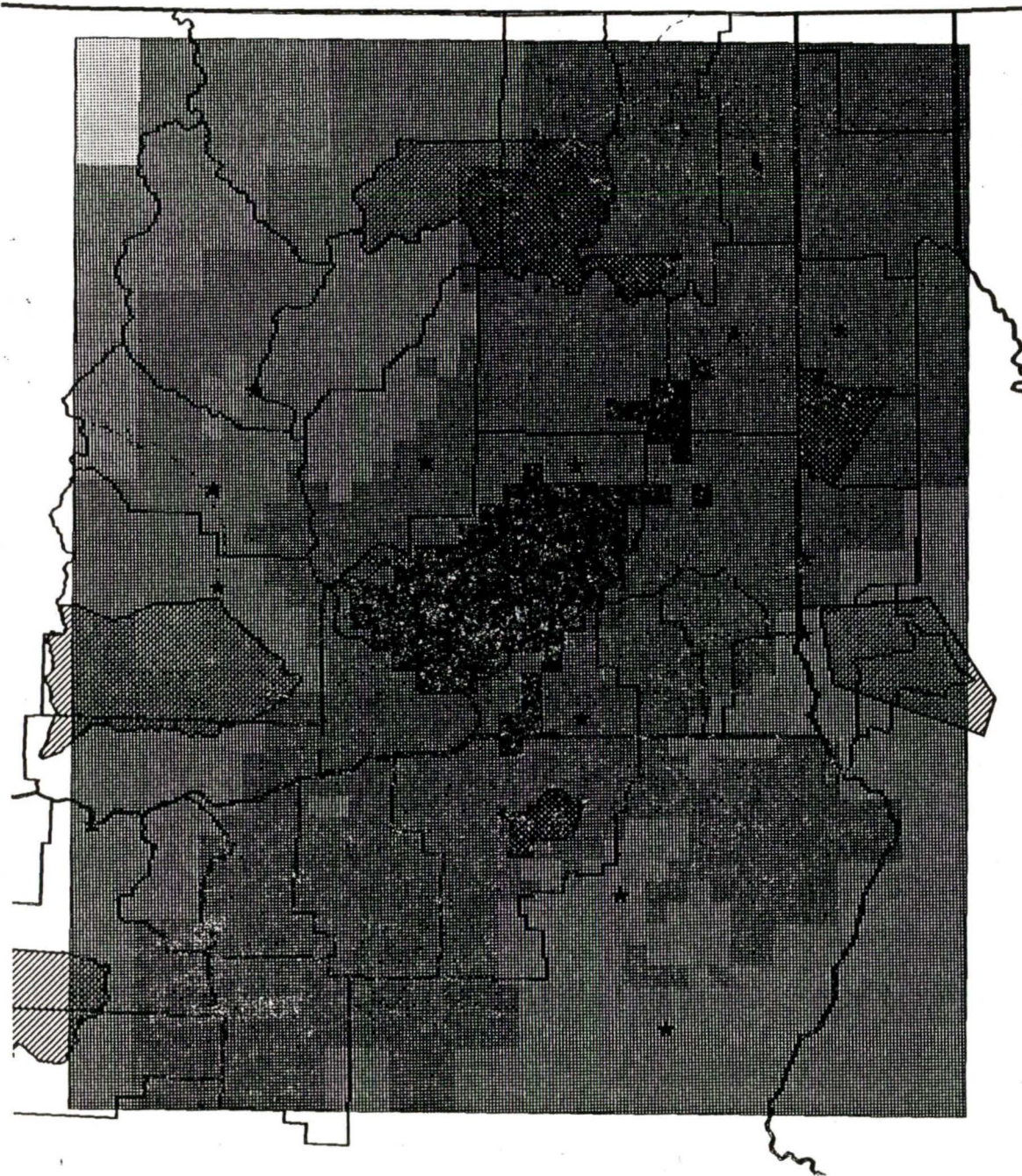
MEDIAN I-131 CONCENTRATIONS IN MILK FROM IRRIGATED PASTURE

August 1945



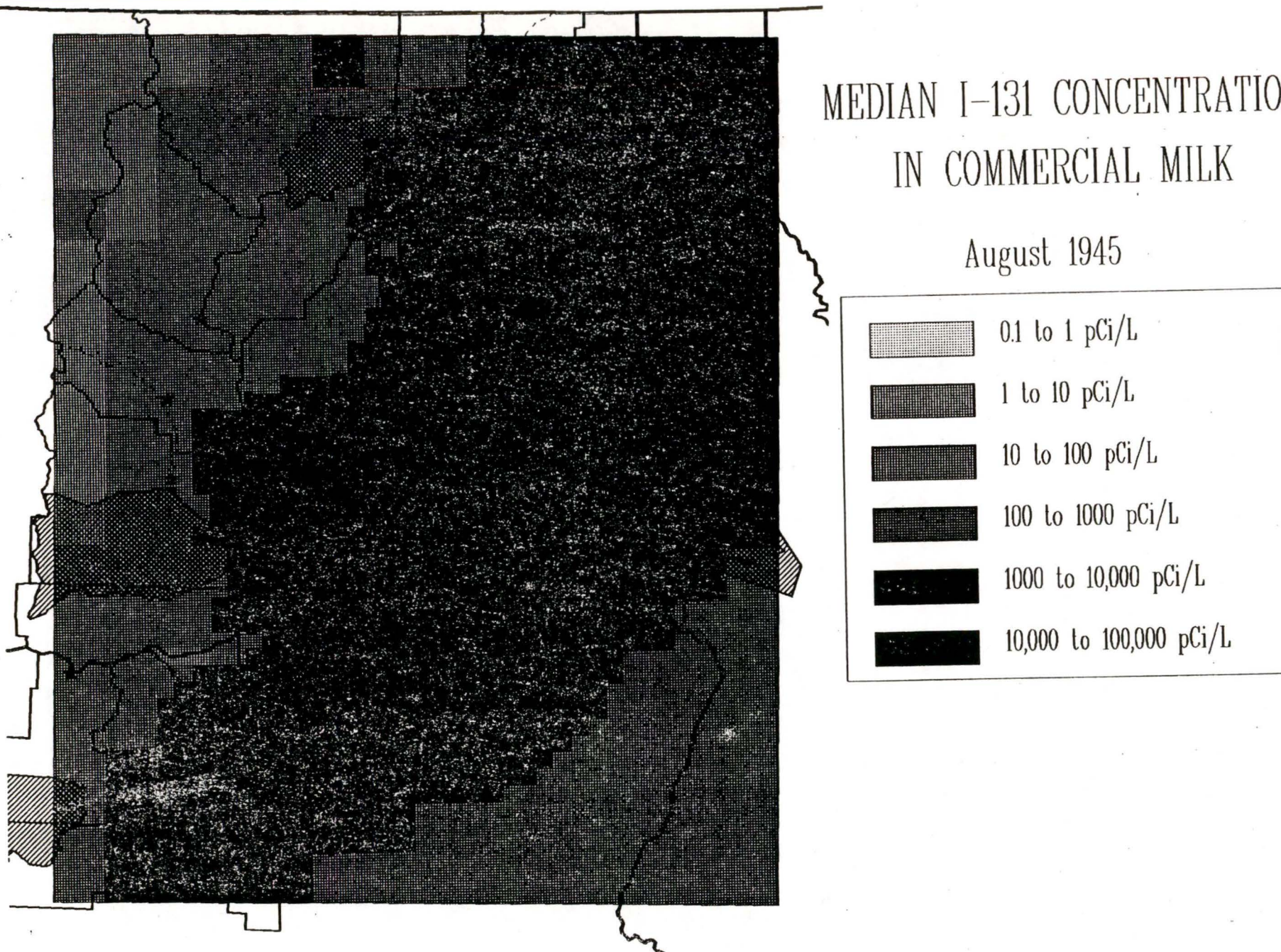
MEDIAN I-131 CONCENTRATIONS IN MILK FROM STORED FEED

August 1945



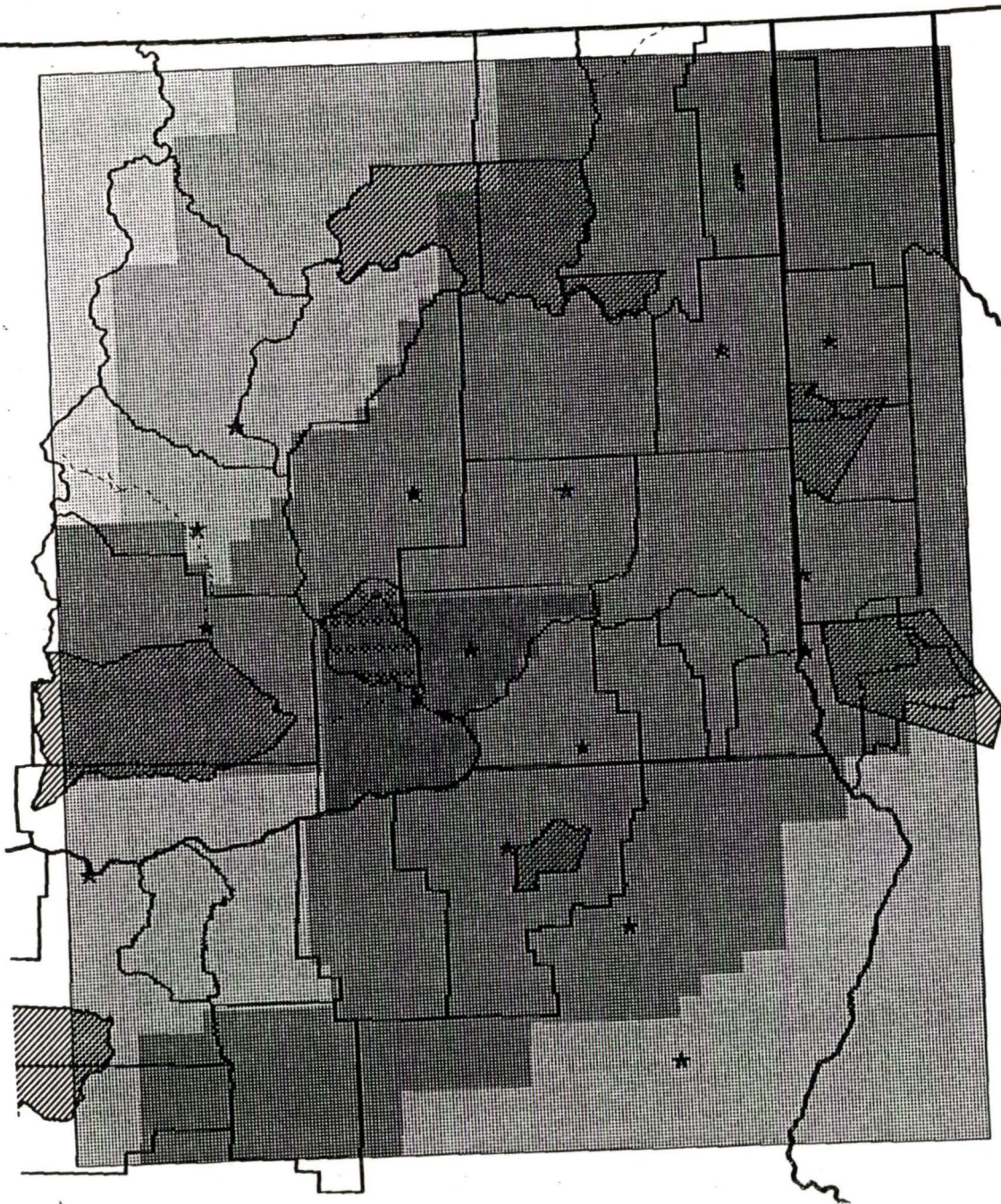
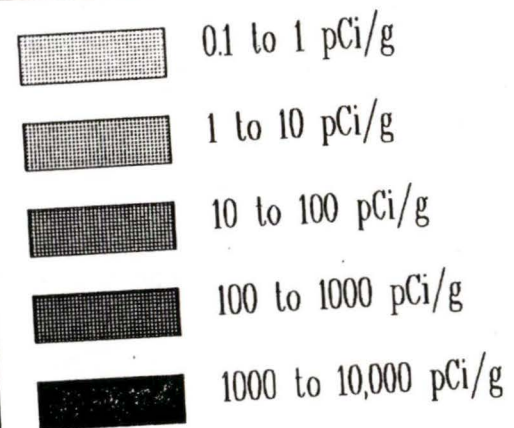
MEDIAN I-131 CONCENTRATIONS IN COMMERCIAL MILK

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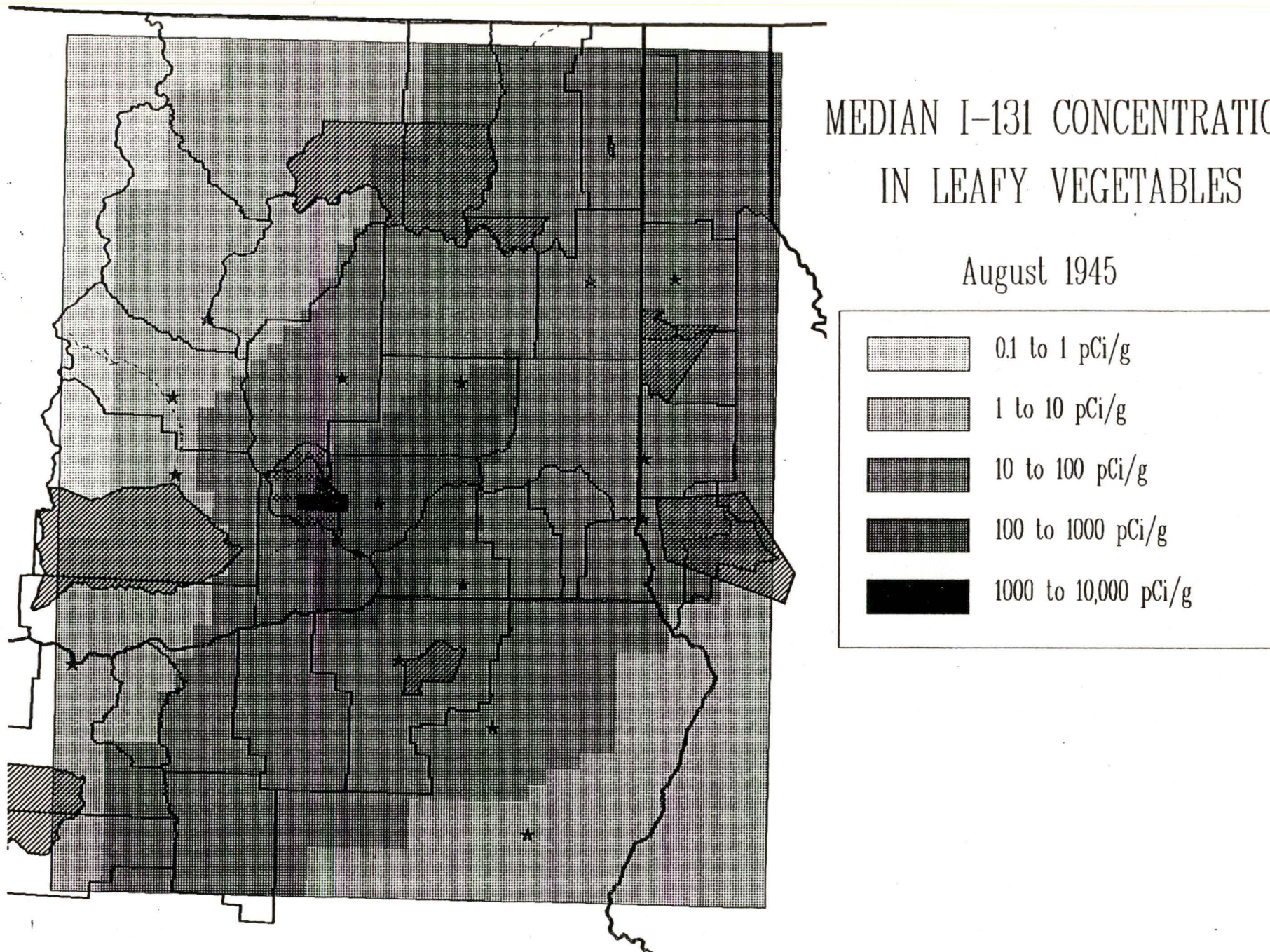
MEDIAN I-131 CONCENTRATION IN COMMERCIAL LEAFY VEGETATIONS

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MEDIAN I-131 CONCENTRATIONS IN LEAFY VEGETABLES

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