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PROCEEDINGS OF SOUTHERN CONFERENCE ON ENVIRONMENTAL RADIATION PROTECTION FROM NUCLEAR POWER PLANTS, APRIL 21-22, 1971

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Radiation Programs

Technical Reports

OFFICE OF RADIATION PROGRAMS
ENVIRONMENTAL PROTECTION AGENCY

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ORP/SID 72-4	Proceedings of Southern Conference on Environmental Radiation Protection from Nuclear Power Plants
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SURVEILLANCE AND INSPECTION DIVISION

SEPTEMBER 1972

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Radiation Programs
Washington, D.C. 20460

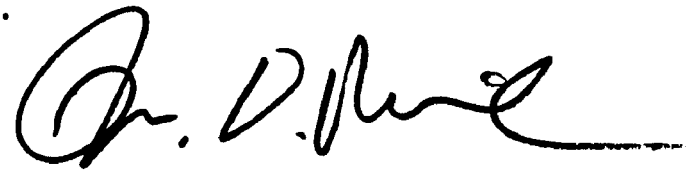
FOREWORD

The Office of Radiation Programs carries out a national program designed to evaluate the exposure of man to ionizing and nonionizing radiation, and to promote development of controls necessary to protect the public health and safety and assure environmental quality.

Within the Office of Radiation Programs, the Surveillance and Inspection Division conducts programs relating to sources and levels of environmental radioactivity and the resulting population radiation dose. Reports of the findings are published in the monthly publication, Radiation Data and Reports, appropriate scientific journals, and Division technical reports.

The technical reports of the Surveillance and Inspection Division allow comprehensive and rapid publishing of the results of intramural and contract projects. The reports are distributed to State and local radiological health programs, Office of Radiation Programs technical and advisory committees, universities, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested groups and individuals. These reports are also included in the collections of the Library of Congress and the National Technical Information Service.

Readers of these reports are encouraged to inform the Office of Radiation Programs of any omissions or errors. Comments or requests for further information are also invited.



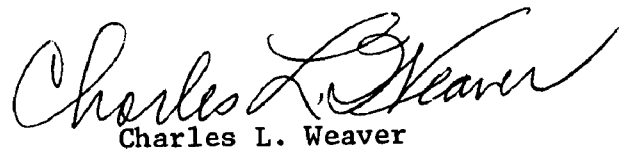
W. D. Rowe
Deputy Assistant Administrator
for Radiation Programs

PREFACE

The Southern Conference on Environmental Protection from Nuclear Power Plants was convened in St. Petersburg, Florida, on April 21-22, 1971, to discuss potential health hazards associated with nuclear power plants. Specifically, the purpose of the conference was to present techniques used to identify and monitor radionuclides contained in liquid and gaseous effluents produced by operating nuclear power plants. A second purpose was to specify pathways through which radioactive materials released by the nuclear power industry may reach the population. Such information assists in determining the radiation dose that may be contributed to the national population by the nuclear power industry.

The conference was sponsored jointly by the Environmental Protection Agency and the Florida Division of Health with the cooperation of the Florida Power Corporation. Participants listed in the Appendix came from Federal and State governmental agencies, universities, the utility industry, and from other companies having an interest in the nuclear power industry.

This report is a compilation of the papers presented at the conference and the deliberations following their delivery. Additional information of this type is sought on a continuing basis and the interest and comments of individuals concerned with various aspects of radiation protection of man and his environment are solicited.



Charles L. Weaver
Acting Director
Surveillance and Inspection Division

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MAN AND HIS ENVIRONMENTAL RESPONSIBILITIES

Dr. Joseph A. Lieberman*
Acting Commissioner, Radiation Office
Environmental Protection Agency

In recent years, demands to act upon the condition of our physical environment have intensified to such a point that 1970 became "The Year of the Environment." A growing public concern for the state of our environment has resulted in a great outpouring of demands for prompt national action at every level of government. In my mind, this manifest public concern is a reaction somewhat overdue. Over the years, it has become increasingly clear that we must know more about our total environmental system--the land that grows our food, the water we drink, and the air we breathe. I am pleased, then, to be here in the fine environment of Florida in April to discuss my concept of man and his environmental responsibilities.

The use of technology in American Society has expanded for decades to such an extent that, for many, the "American Way" now includes acceptance of the equation that "technology equals progress." Guidelines such as the Gross National Product have often been used as the only indicators of "progress" in our society. We have now reached a point, however, where we can no longer afford to simply automatically apply technological innovations to solve our immediate

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* Present Position, Chairman, EPA Energy Policy Committee

problems without first assessing the direct and indirect effects the application may have on the environment. One of the key roles of the Environmental Protection Agency, for example, will be to initiate a more orderly system of performing technology assessments. And we're going to have to decide in favor of the environment if the choice ever comes down to that--but it need not! I believe that we can achieve a quality environment, and at the same time enjoy a high level of material progress.

How we go about doing that depends on a lot of different things. For one, it depends on whether we are successful in developing a new environmental ethic in this country. And the core of this ethic must be a profound respect for life--in all of its forms. Man, of course, is included, but man cannot survive on this planet alone.

All life depends on certain cycles of energy and material conversion, powered ultimately by radiation from the sun: the oxygen-carbon cycle, the water cycle, and many others. All living things take part in, and affect, these natural cycles, but today man's activities are affecting them on a massive scale. And we cannot limit our concern only to the effects of our activities to this generation. Our environmental ethic must include recognition that others will follow us here--and perhaps we should temper our use of resources so that we leave as our inheritance sufficient quantities for them to use.

So in meeting the legitimate needs and desires of our present society, in reaching the high level of material progress that we hope to reach for our people, we must recognize that we have no greater cause--we have no greater duty--but to enhance and to protect the environment so that we ourselves and future generations will be able to enjoy living on this earth. That is the thrust of "man's environmental responsibilities"--and that is the core of the mission of the Environmental Protection Agency.

The Environmental Protection Agency was established December 2, 1970. On that same day Mr. William D. Ruckelshaus was confirmed as Administrator of EPA by unanimous vote of the Senate. The principal functions of the Agency include: (1) the establishment and enforcement of environmental protection standards consistent with national environmental goals; (2) the conduct of research on the effects of pollution and on methods and equipment for controlling it; (3) the collection of surveillance and monitoring data, and the use of this information in strengthening environmental protection programs and recommending policy changes. One of our principal roles is also to assist other groups which have environmental responsibilities through grants and technical assistance.

We will also be working with the Council on Environmental Quality in developing and recommending to the President new policies for the protection of the environment. Six offices have been established to assist the Administrator in carrying out these functions: the Water

Quality, Air Pollution Control, Pesticides, Solid Waste Management, Noise Abatement and Control, and Radiation Offices.

I am the Acting Commissioner of the Radiation Office, whose mission is to conduct a program designed to protect man and the environment from adverse effects of exposure to both ionizing and non-ionizing environmental radiation. Our responsibilities are aligned with the major functions of the Agency, and are carried out by four operating Divisions. The Division of Surveillance and Inspection will have the job of providing information on radiation levels in the environment through the assimilation of these data from all sources. The Division of Technology Assessment will carry out the requirements of the National Environmental Policy Act through the review of environmental impact statements, and will provide an evaluation of developing technology through analysis and special studies. The Division of Research will provide basic supporting information for all Radiation Office activities, including studies on the biological effects of radiation. The Division of Criteria and Standards has the job of developing environmental radiation protection standards, functions formerly within the Federal Radiation Council and the Atomic Energy Commission. Two of our Division Directors, Mr. Chuck Weaver and Mr. Dave Harward, are scheduled on the program of this conference.

Nuclear Power and the Environment

It is clear that the national concern over the state of our environment and the concurrent expansion of nuclear power generating capacity in the United States have placed great responsibilities on industry and on both State and Federal agencies charged with environmental protection. We must seek to achieve a rational balance between an adequate supply of electric power and a quality environment. Dr. Edward E. David, Jr., Director of the President's Office of Science and Technology reminded us of this responsibility quite candidly in the 1970 report, "Electric Power and the Environment." Dr. David said the following, and I quote:

> "The growing controversy over the siting of electric power facilities--both nuclear and fossil-fueled--makes it imperative that we take action to improve the role of government in establishing a balance between the need for power and the need to preserve our environment. The power shortages experienced this summer remind us that we live in an age of energy. The demand for electricity continues to grow at a rapid rate but concerned citizens are increasingly objecting to the construction of new capacity and associated transmission lines because the facilities may pollute the surrounding environment. Legislation to implement the basic recommendations to

alleviate the concerns contained in this report will be proposed by the Administration early in the next Congress."

With the endorsement of the President, the National Power Plant Siting Act of 1971 has been introduced in the Congress. The purpose of this bill is to provide for establishment within each State or region a single agency with responsibility for assuring that environmental concerns are properly considered in the certification of specific power plant sites and transmission line routes. Enactment of this Presidential proposal would constitute a landmark in this environmental decade.

Another significant milestone was the passage of the National Environmental Policy Act of 1969. All Federal agencies are now required to consider explicitly the environmental implications of their actions. The other Federal agencies with expertise in environmental matters are required to review these actions, and State and local agencies and the public can review the environmental implications of a Federal project before the project is undertaken. In essence, this legislation provides at least part of the mechanism to apply a preventative rather than a curative approach to the conduct of activities having a potential impact on our environment. While I believe there is some "shaking down" to do in connection with the implementation of this legislation, and future candid evaluation

of its effectiveness will obviously be in order, I also believe it is sound in concept.

Draft environmental impact statements for the construction or operation of nuclear power plants are prepared by the Atomic Energy Commission. The draft impact statements and environmental reports written by utility companies are sent to Federal agencies having special expertise or regulatory authority relative to potential environmental effects of operating these facilities. The Environmental Protection Agency submits specific comments on the statements to the Commission. Our comments, along with those of other Federal agencies, are incorporated into a final environmental statement which is submitted to the President's Council on Environmental Quality, and made public. We, as a matter of course, send copies of our reviews of the impact of nuclear power plants to appropriate State agencies.

Our technical review activities for nuclear facilities are significant, we believe, because not only are they based on technical information developed by an unbiased technically competent agency but also because they now play a vital role in judging the environmental impact as required by the National Environmental Policy Act. This established review procedure for Federally conducted or controlled actions has become an important mechanism by which the Environmental Protection Agency provides information and influences these actions. Evaluations of nuclear facilities consider the effect of the operation of the facility on population dose and how best to assess and judge

this effect, the environmental effects of operating the facility, the suitability of the site, and the design of the facility relative to reducing radioactive waste discharges to the lowest practicable levels.

Public Concern

Radiological questions have been among those raised by the public about nuclear power during the past year. These have included the adequacy of the radiation standards used by the Atomic Energy Commission in their regulatory program, and the long-term effects of extremely low level radioactive discharges to the environment from nuclear power plants. Some State authorities have proposed the adoption of their own set of discharge limits for nuclear power plants which are more restrictive than those established by the Atomic Energy Commission; other States find themselves in a dilemma of whether or not to follow suit. These and other related factors have created a significant national controversy concerning the use of nuclear power.

There are probably many reasons why the controversy is taking place. In retrospect, it appears that perhaps some of the public relations problems the nuclear power industry is now facing may have been lessened if appropriate information from operating nuclear power plants had been made available at an early date and more extensively to the health and scientific community for interpretation to the public in terms of radiation dose to people.

In any case, it was not until the results of the Radiation Office field studies at operating nuclear power stations became available that our own technical staff could begin to make realistic judgments on some of the radiation exposure implications of routine nuclear plant discharges. Up to that time, our evaluations of nuclear reactors were largely dependent upon the analysis of safety reports and limited published data as the principal mechanism for reaching conclusions regarding population exposure.

The concept of radiation dose to people--and its relation to an estimate of risk--sometimes appears to be a missing element in the public's demand to protect and preserve the quality of the environment. The principle of keeping discharges of radioactivity to the environment to the lowest practicable levels is obviously an appropriate goal, however, there is unfortunately sometimes an interchange of words so that "practical" is equated with "possible," a substantial difference. In each instance, there should be a thorough analysis of the actual benefit gained in terms of dose reduction to the people and this compared with the risks involved. The evaluation of risks should not be limited to radiation but, from the public interest standpoint, should also include other considerations. One such consideration that obviously occurs to me would be the public health and welfare implications should loss of the plant's capability to produce electric power occur because discharge limitations cause the plant to be shut down.

In an ultimate sense, of course, the solution of benefit-risk equation is a societal decision or function. Our job is to assure that to the maximum extent possible proper inputs are provided to the development of the equation.

This is the type of question that must be answered in the future and it will be necessary for environmental and health agencies to produce independent dose assessments made on a professional and technical basis that can be utilized in ascertaining compliance with environmental radiation standards and, as deemed required, risk assessments. The data from our field studies at operating nuclear power plants thus far have shown that radiation exposures to the public have been minimal to the extent that they are, as best, difficult to measure quantitatively and often too low to be measured at all. This excellent record must be continued for all future plants. As new technology and procedures in waste treatment methodology are developed, further reductions even in these low radiation doses should be made where reasonable and practicable. However, the public health need to further reduce radiation doses from nearly immeasurable levels must be rationally evaluated in terms of overall public health considerations and appropriate allocation of resources.

What are some of the issues with regard to nuclear power plants? In our opinion, the issue is not whether nuclear power plants are within the current standards, because all present plants are operating within these standards and there is no reason why future plants

cannot be operated well within these standards. A key issue, it seems to me, is that the public and the critics want honest answers to the questions of what is going to happen to the environment if a nuclear power plant is built, of how well we understand this effect and what is being done to minimize it, and how we will assess the effects and take protective action if any adverse effects are observed. As many of you know, many of us now in the Environmental Protection Agency have been dealing with the public information--nuclear power question for a long time. We, I believe, are in the position of being able to work this problem from a middle-ground and hopefully from an unbiased perspective.

Radiation Standards and Information

One of our most important responsibilities in the coming months will be to establish environmental radiation standards to protect man and the environment and to ascertain that environmental contamination levels are kept as low as practicable. I would like to make it clear that we do not have responsibility for licensing nuclear reactors--that has remained with the Atomic Energy Commission--but it seems to me there is little question that we can exert considerable influence on the design, construction, and operation of nuclear power plants through the environmental standards we establish. We have underway a major review of all existing Federal radiation protection criteria, standards, guidelines, and policies. Until this review is completed, we will be developing at least an interim EPA position with respect to

environmental radiation standards and guidance levels--based on current knowledge, experience, and technology.

Our basic policy for radiation standards is that no man-made environmental radiation exposure should be allowed without a reasonably demonstrated benefit. In establishing environmental standards relative to this policy, the EPA is going to look to inputs from the scientific community and the public. We do not pretend to be omniscient, and we do not intend to make these kinds of decisions behind closed doors without appropriate involvement of the scientific community and the public. We are, as Administrator Ruckelshaus has said, "an advocate of the environment," but we recognize that we have a responsibility to be fair.

The manner in which we in the Environmental Protection Agency carry out our functions is extremely important. Obviously we must seek the facts regarding radiological contamination of the environment with independence and objectivity; and we must present these facts the same way. There is a basic necessity for continuing studies on which we will be able to make judgments on the environmental impact of the nuclear power industry in order to provide information both to the public and to the scientific community. We must refrain from acting defensively to critics of "technology equals progress," but must provide the facts necessary to resolve issues. I assure you that one of the major goals of the Radiation Office will be to maintain both integrity and credibility in these areas. I believe that we are going

to adequately meet this challenge in order to assure that environmental problems will be resolved in the public interest.

It is also the responsibility of those who operate nuclear power facilities to continue to recognize that one of their key roles is to make factual data related to the environmental effects of operating their facilities available to both the public and the scientific community. We must all be responsive to these needs. The Radiation Office is currently developing a system for the routine publication of environmental radiation and radioactive materials discharge data in "Radiological Health Data and Reports." Surveillance activities are being expanded to provide information on population exposure from nuclear power operations on a regional and nationwide basis. I earnestly solicit the cooperation of all of you, both States and industry representatives, to ensure that all operational and environmental data from nuclear facilities are made publicly available through this mechanism. I sincerely believe that this will be in the public interest and to our collective mutual benefit.

Conclusion

In conclusion, we in the Radiation Office believe that an important environmental responsibility is for the appropriate State agencies and power companies to establish a working relationship during the planning stage of a nuclear power plant. An interchange of information must be forthcoming in order that each other's position may be clearly understood. A working relationship that incorporates

mutual trust and respect is a key element in establishing the basis for the effective conduct of environmental programs essential to the maintenance of the quality of the environment and the public health. Accomplishment of this relationship is, I believe, one of our most important environmental responsibilities and one we should all strive to meet.

PROBLEMS IN MEETING AEC REPORTING AND COMPLIANCE REQUIREMENTS

Billy H. Webster
Principal Radiation Control Engineer
Carolina Power and Light Company

I have been asked to discuss today problems in meeting AEC reporting and compliance requirements as related to the Carolina Power and Light Company H.B. Robinson plant.

For those of you who are not familiar with the plant, I would like to begin with a brief description of the plant and the site.

H.B. Robinson Unit Two is a Westinghouse pressurized water nuclear power plant rated at 2,200 megawatts thermal and is the first nuclear power plant to go into operation in the southeast. We have operated at 100 percent power for a short period of time.

The plant was built on the existing site of a 200 megawatt coal-fired unit which is designated as H.B. Robinson Unit One. Both units are located on the southwest shore of Lake Robinson about 4-1/2 miles west northwest of the town of Hartsville, South Carolina.

The plant site including Lake Robinson exceeds 5,000 acres; the exclusion distance and low population zone distance are 430 meters and 7,240 meters, respectively.

Lake Robinson was built by Carolina Power and Light Company as a cooling lake, and the company owns all of the land surrounding the lake, at least to the high water elevation. It is an onstream lake and subject to the water quality standards as set by the State of South Carolina. The lake is about 4,000 feet wide at the plant site

and about 7-1/2 miles long at its maximum water elevation; it covers about 2,200 acres.

Condenser cooling water is taken from the lake at a point near the dam and discharged through a canal about 4 miles from the plant site. In effect most of the lake is used as a cooling pond for the two generating units.

In January when I was asked to discuss this subject, I thought we would have had considerable operating experience prior to this meeting. However, as mentioned before, due to numerous operating problems at the plant, most of which have been associated with the secondary side of the plant, our operating experience to date has been somewhat limited.

I know of no real problems we have encountered in meeting the AEC reporting requirements. By this I mean we have had no problems with the AEC and compliance in regard to the information we have supplied them. Collecting and compiling this information has been quite difficult at times and this is what I plan to discuss today. I would like to go over briefly our reporting requirements, and show how we have either met these requirements or plan to meet them. Also, I would like to review briefly the new AEC reporting requirements, how they differ from our present requirements, and some of the associated problems we might expect to encounter.

I would like to look first at the liquid releases from the plant. The following seven items are the reporting requirements as listed in our technical specifications.

1) Total curie activity released exclusive of tritium,

2) total curie activity of tritium discharged,

3) total volume of liquid waste discharged,

4) total volume of dilution water used,

5) the average concentration of the outfall at the discharge canal,

6) maximum concentration of release for any consecutive 24 hours during the reporting period, and

7) the MPC used, and the basis for this MPC.

In our particular case at the Robinson site, these reporting requirements do not have the same meaning that they might normally have. As I said before, Lake Robinson is a fairly large onstream lake containing about 31,000 acre feet of water, and is used essentially as a cooling pond for the two generating units.

Although the lake is an onstream lake, the normal flow in the stream and the outfall of the lake are small compared to the circulating water flow through the condensers. This means that our radioactive discharge limits are based on buildup in the lake rather than on concentrations in the discharge canal.

We have calculated that the residence time for water in the lake based on average stream flows for a 6-year period is about 64 days. However, our technical specification limits are based on a reference 3-month dry season when the average outflow from the lake was about 117 cubic feet per second and residence time for water in the lake was 137 days.

This in effect limits our discharge to the lake to a concentration in the discharge canal of 10 percent of the limit of 10 CFR 20. What we are actually saying is that on the average, water from the lake

passes through the condenser ten times.

Our technical specifications further state that this addition rate amounts to 26 mCi/day based on unidentified beta activity with an MPC of 1×10^{-7} μCi/cc.

In regard to how we meet these reporting requirements I will go through each of the seven items listed in the technical specifications and explain how we document these records.

We have designed our liquid release authorization to contain all the data required by the technical specifications and we summarize this daily on a monthly data sheet.

The first two items are the total curie activity released and the total curies of tritium released. Each tank of liquid waste to be released is analyzed in the laboratory for gross beta and tritium activity using a Packard liquid scintillation counter; the total activity in the tank is recorded on a liquid release authorization as well as a total volume in the tank. As the release is completed, the operator records the actual volume released as shown on a flow integrator in the discharge line (item three). He also records the number of circulating water pumps in operation during the release which gives us dilution water available during this period.

Item four is the total volume in gallons of dilution water used. As I stated before, we record on the liquid release authorization the number of circulating water pumps in service during the release. This gives us the total volume of water available during the actual release time. However, we interpret this requirement to mean the total volume of dilution water available during a 24-hour period. To obtain this

number, a running time meter has been installed on each of the circulating water pumps. This enables us to calculate the average circulating water flow for the day and the total volume of dilution water available.

The fifth item is the average concentration at the outfall of the discharge canal. We actually calculate this number two ways. First we calculate the average concentration during the release only, and then calculate the average concentration based on total circulating water flow for the day. The latter number is the one that we report. The concentration during the release is calculated for administrative purposes only to insure that we do not exceed limits in the canal at any time.

The sixth item is the time and date of the maximum concentration for any consecutive 24 hours during a reporting period. As I indicated before, all liquid released is summarized daily on a monthly basis so it is only a matter of determining the date of the maximum concentration from the summarized data. This number is based on total circulating water flow for the 24-hour period.

The seventh item is the MPC used and the basis for this MPC. To date we have only used the MPC for unidentified beta activity of 1×10^{-7} µCi/cc. We do, however, apply this limit to the lake rather than in the discharge canal. The corresponding limit in the discharge canal is 1×10^{-8} µCi/cc with three circulating water pumps running. However, the controlling limit I stated before is 26 mCi/day.

We think this satisfies record keeping and reporting requirements as far as liquid releases are concerned except for one other potential

point of release to the circulating water systems.

Our steam generating blowdown goes to a flash tank which then overflows into a line which discharges into the circulating water system. With steam generator leaks, this presents a possible release mechanism to the environment. The steam generating blowdown line has a radioactivity monitor which will isolate the blowdown lines as well as the tank discharge line before the MPC is reached in the discharge canal.

The monitor's sensitivity is not, however, high enough to record low-level releases. We routinely make radioactive analyses of the secondary system water. If we begin to see significant radioactivity in the secondary system, we will then calculate the activity released based on blowdown flow and the activity. This will be summarized by day on our summary sheet. To date, we have not detected any radioactivity in the secondary system.

Our technical specifications are not as specific in regard to record keeping and reporting of gaseous waste. The following reporting and record keeping requirements are contained in the technical specifications.

The first is a total of the curie activity discharged. The second is the time and date of maximum activity released for any consecutive 24 hours during the reporting period. The third item is the MPC used if greater than 3×10^{-8} μCi/cc for noble and activation gases and 1.43×10^{-13} μCi/cc for halogens and particulates having a half-life greater than 8 days.

I should note here that this MPC for halogens and particulates

contains the 1/700 factor which the AEC has been inserting into the technical specifications recently.

Although item one does not specify which activities are to be recorded, we interpret this to mean activities are reported separately for activation and noble gases, halogens with a greater than 8-day half-life and for particulates with a greater than 8-day half-life.

I stated before that we have had some difficulty collecting data to meet reporting requirements and most of the difficulty concerns airborne releases to the environment owing to the fact that we have numerous vents where radioactivity may be released from the plant.

I would like to identify these possible release modes and explain how we acknowledge each of them.

The first is our main plant vent or stack. The main plant vent is used to exhaust all the reactor auxiliary building ventilation and in addition the containment building is purged through this vent.

In addition to the process radiation monitoring equipment furnished by Westinghouse, we have installed on the main plant vent a particulant and iodine sampler. This sampler along with the installed detector in the vent enables us to keep accurate records of releases through the main plant vent. Also, all gaseous wastes released from the gas decay tanks are released through this vent. We make laboratory analyses of decay tanks prior to their release and maintain these records in the same manner as described for the liquid releases.

The second release location is the condenser air ejector exhaust. The condenser air ejector exhausts through a radiation monitor directly to the atmosphere. When the alarm level is reached this vent

is automatically diverted to the plant vent and the releases would be monitored as described before. This monitor is set to an alarm when the concentration equal to 1/10 MPC is reached. In addition, we can make fairly accurate estimates of activities here from secondary system liquid analyses.

The third possible source of release is from the steam generating blowdown vents. I previously mentioned the steam generating blowdown system in regard to the liquid releases. The blowdown tank has an 18-inch vent line which vents directly to the atmosphere. The blowdown liquid enters the tank at essentially primary temperature and pressure.

Due to the large vent line in the blowdown tank, the tank is maintained at about atmospheric pressure. We have calculated that when the water enters the blowdown tank, the liquid flashes and about 30 percent by weight is vented to the atmosphere as steam. Again, we must rely on laboratory analyses of secondary system activity and calculate the activity released to the atmosphere through this vent.

The fourth place where releases to the atmosphere can occur is from our fuel handling building. We actually have two separate ventilation exhaust systems in our fuel handling building. One system services the gas decay tank area and the hot machine shop area. The other system services the new and spent fuel storage areas. Each of these systems contains a radioactive gas monitor which is set to alarm at 10 percent of the annual average release limits.

When an alarm is reached, that vent is automatically shut down. We will depend on periodic sampling to determine halogen and/or

particulate activities. The systems have not presented a problem to date since we have not had any radioactive material in these areas.

I would like to mention one other technical specification requirement which has presented a problem. This is the radiochemical analysis of the primary coolant. Our technical specifications defines a radiochemical analysis as follows:

"A radiochemical analysis shall consist of the quantitative measurement of each radionuclide with half-life greater than 30 minutes making up at least 95 percent of the total activity of the primary coolant."

To date our primary coolant activities have been relatively low and have been primarily activation and corrosion products which have been difficult to identify. We have been unable to completely satisfy this requirement.

I should explain this. We run analysis for every isotope we can think of, but when we add up all of the isotopes that we have identified, we end up with about 75 percent of the total activity. We never do get the 95 percent. We feel, however, that when we have had more operating experience which will increase the fission product activity in the coolant, that this requirement can be met. Or maybe we will get closer to 95 percent anyway.

The radiochemical analysis also related to our technical specification limit for primary coolant activity is 50 divided by $\bar{E}$, where $\bar{E}$ represents the average beta and gamma energy per disintegration.

This, I think fairly well documents how we are handling radioactive discharges from the plant.

The other side of the monitor program is the radiological environmental monitoring program. I do not plan to go into the details of our environmental monitoring program except to say that our environmental monitoring program is contained in our technical specifications.

I had intended to briefly describe a special radiological monitoring program being carried out by the Environmental Protection Agency on Lake Robinson, but I see from the agenda that this program will be a specific topic for tomorrow.

To date there are probably as many different approaches to environmental monitoring as there are nuclear facilities. There have been no standards or firm guidelines for establishing an acceptable program. It is my observation that the AEC has taken the approach that each applicant should design his own program to suit his particular site and operating philosophy.

The AEC does review these programs to determine if they are adequate, but with no attempt to standardize programs, analytical analyses, or reports. This approach, however, is changing. I will discuss that a little later. We have already heard some discussion of this approach this morning.

I would like now to discuss briefly the new AEC proposed uniform monitoring and reporting standards. The first, monitoring effluent releases; the second, monitoring environmental radiation levels; and the third, reporting the results of these monitoring programs.

I have reviewed the AEC draft Safety Guide for "Monitoring and Reporting of Effluents and Environmental Levels" and my comments will be related to this draft Safety Guide.

The Safety Guide contains guidelines for environmental monitoring programs; the location, frequency and types of samples to be taken; analyses to be performed; programs for recording of data; and the format and frequency of making reports to the Commission.

It appears now that the AEC is going to be very explicit in regard to what samples will be taken, the analysis that will be run, and the manner in which these results will be reported.

One of the major differences is that the proposed requirements will require the licensee to identify all radionuclides associated with the radioactive releases and report these releases by isotope rather than by gross activity.

The monitoring guide further states that this identification of principal radionuclides shall account for more than 90 percent of the gross activity present. It then specifies which nuclides should be identified in each of the categories; gaseous, iodine, particulate, and liquid effluents.

I am not going to go into the details of the requirements of the Safety Guide, but I would like to summarize just a few of those requirements. As far as the atmospheric releases are concerned, the licensee will be required to maintain hourly records during releases of release rates and meteorological conditions. In addition, there are requirements for isotopic analyses and analysis for tritium at varying frequencies, depending on release rates and plant conditions. There are similar requirements in regard to iodine and particulate releases as well as for liquid releases.

I am not a radiochemist, but I do have some feeling for the

amount of additional laboratory work necessary to meet these requirements. In fact, at the low levels normally associated with these releases, I am not sure that the requirement can be met. I do know that we do not have the equipment or manpower available at the Robinson plant to comply completely with the Safety Guide. I should throw in a little explanation here. We have staffed and equipped our laboratory to perform process analyses, and at the low levels we are talking about and the isotopic identification, I don't think this can be done in the same laboratory with process samples.

As I indicated earlier, the Commission has not previously given any definite requirements for environmental monitoring programs.

This draft guide does contain, however, explicit guides in regard to the types of samples to be taken, location of sampling points, frequency of sampling, isotopic analyses to be performed and details of reporting requirements. The guide actually identifies two levels of environmental monitoring, the first level would apply with estimated exposures of less than 3 percent of those that might result from annual continuous exposure to Part 20, Appendix B, Table II concentrations with an increase in the monitoring frequency above these levels.

I am presently doing a comparison with our present environmental monitoring program and what it might cost to comply with the requirements of this Safety Guide. Based on prices of analytical analyses furnished by our contractor, the cost of the program for the Robinson plant would increase by a factor of about six.

DISCUSSION:

MR. LIONEL LEWIS: Bill, what does the word, "guide," mean?

MR. WEBSTER: If you read the words in the draft safety guide, there is frequent use of the word "should," however, I interpret this to mean "shall." Once these requirements are a part of the technical specifications then they mean shall.

MR. KAHLSON: When you discussed your computations on effluent, could you tell us how you are doing it? Is it automated or manual?

MR. WEBSTER: It is manual. We go in the laboratory and do the laboratory analyses and calculate all releases manually.

MR. KAHLSON: Are there any people doing this on an automated basis?

MR. WEBSTER: To my knowledge, no. There very well could be. Equipment is being automated and I assume that you probably could get monitoring equipment that would feed into a computer that would spit out anything you want it to. But we are not equipped to do that.

MR. KAHLSON: Bill, if that equipment were available, would you prefer to have it automated?

MR. WEBSTER: Well, I think you would have to know what the price of that equipment was before you could really make a judgment. My personal preference would be yes, I would prefer to have it automated.

DR. GOLDMAN: There are some plants that are incorporating automated tabulations of releases and analysis and this is being done usually with an inplant on line computer--a data logger. The output of a

spectrometer, for example, is analyzed by the plant's data logger and those results combined with information on pump operation which are already part of the data logger input.

I don't know that it is being done, but it is planned in several of the new plants that are coming along.

EVALUATION OF ENVIRONMENTAL FACTORS AFFECTING POPULATION EXPOSURE

Mr. John F. Honstead*
Mr. Thomas H. Essig,
Radiological Physics Battelle
Northwest Laboratory

What I am going to be presenting here today isn't all my work, but represents the work of a lot of people over a rather long time and I would like to recognize the efforts of many other people in all of this. Also, I would like to point out that the work we have done at Hanford in environmental evaluations is not at all applicable to anyone else's problem and I am not going to prescribe a model all of you should adopt.

Perhaps many of you have considered environmental models in detail, but I hope that you can step back and recognize some of the logic that went into the model that we followed and possibly use this logic and apply it to some particular problems that you may be faced with.

Neither the radionuclides that were of interest to us at Hanford nor the environment we had to evaluate is duplicated anywhere else and obviously in our evaluation, problems are not directly applicable to anyone else's.

Deceased - August 1971

Everybody has complained that they can't measure radioactivity. We had the problem of evaluating the environment of a nuclear facility in which there was radioactivity present in measurable amounts. At least it was present in measurable amounts until the last production reactor was retired in February 1971. So, what I am talking about, then, is a little bit ancient history.

To start off with, let's talk about what we are using for a "yardstick" in our evaluations. We are evaluating the dose received by individuals in the population around the plant, that received by an average of the population and comparing these doses with dose standards, as shown in Figure 1.

When radioactivity is released into an aquatic environment, you can expect something such as is shown in Figure 2 to happen. At time zero, the radioactivity will be all in the water and all of the organisms present are essentially free of radioactivity. As time moves on, radioactivity will find itself in the sediments and in the organisms and no longer in the water. You have to know something about this transfer from water into organisms and the fact that it changes. A very important consideration in our case is the species of fish present. The relationship between the concentration that you find in a fish or other organism and in the water itself is called a concentration factor. These factors differ among various species of fish and radionuclides.

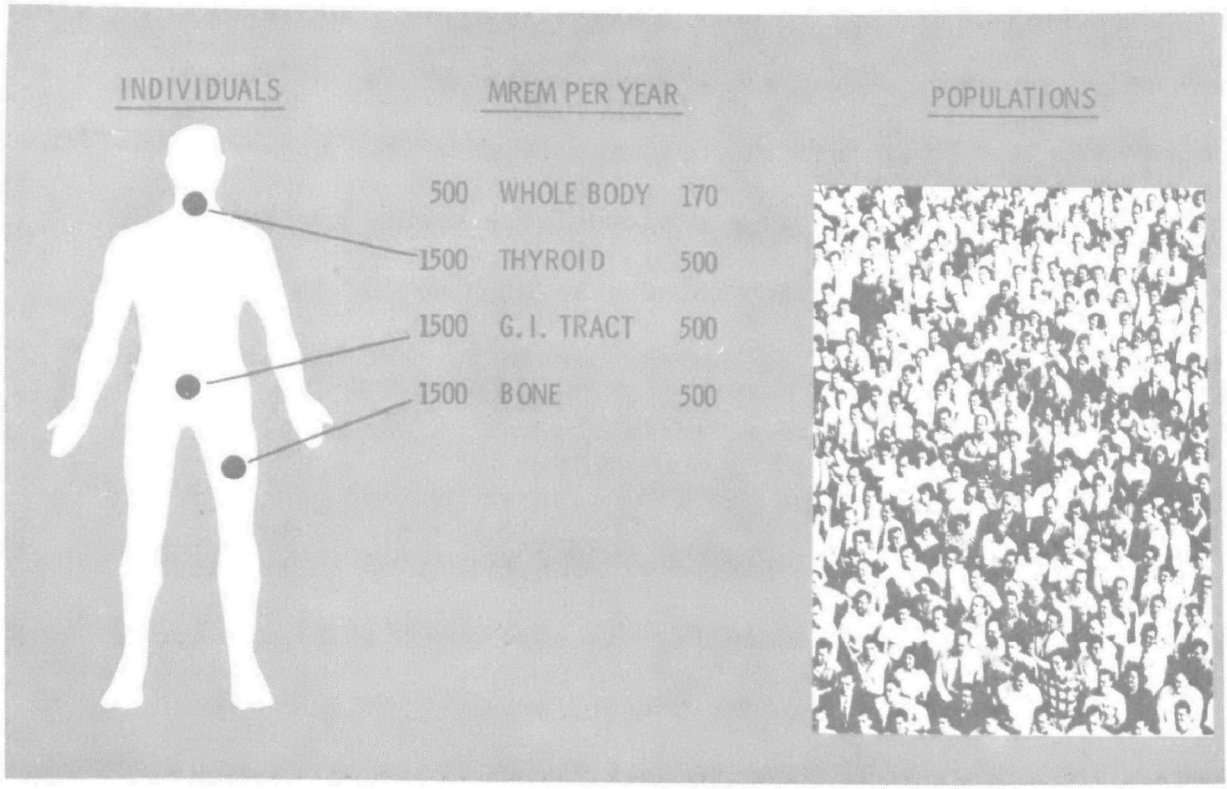


Figure 1. Exposure Limits for the Public.

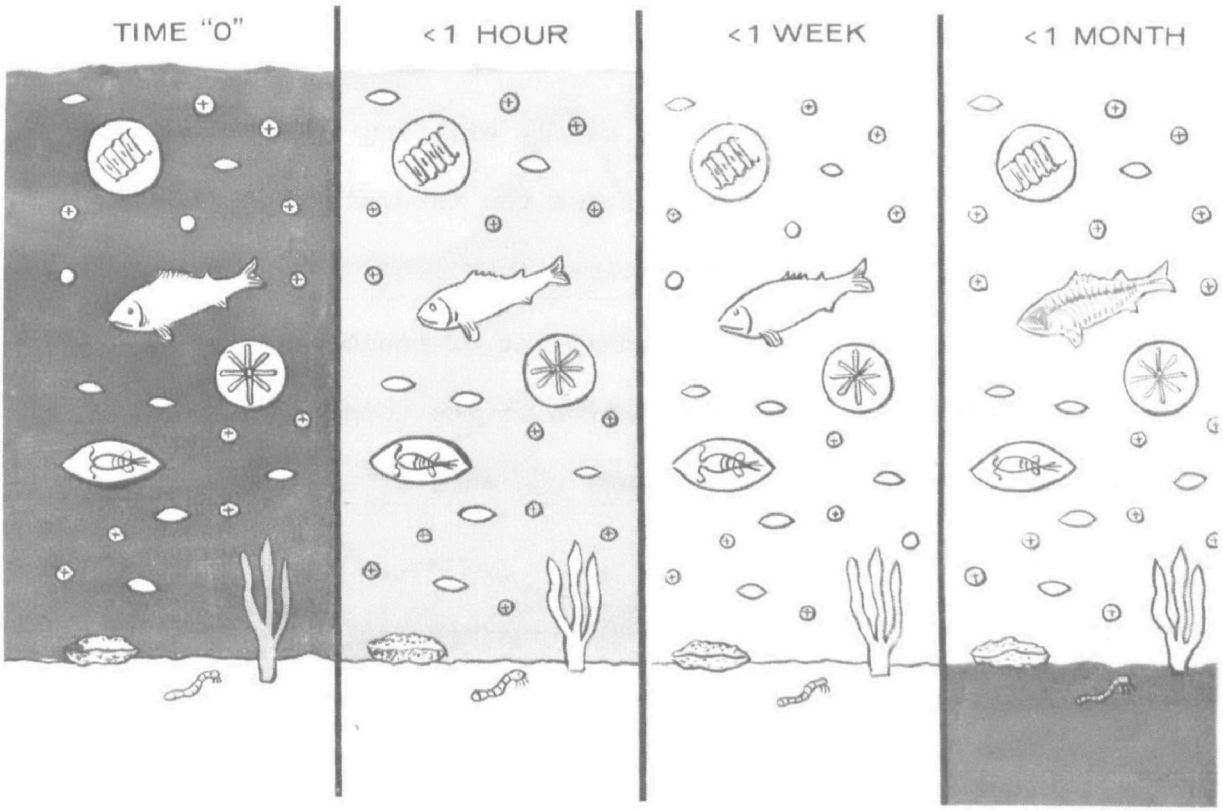


Figure 2. Fate of Phosphorus-32 in Water.

The radionuclides that we have studied is ^{65}Zn. We found concentration factors ranging all the way up to 10^5 for different organisms from the water into the organism (Figure 3). So, even though the concentrations of some radionuclides aren't measurable in water, if you have concentration factors as high as 10^5 in an environmental medium, they may well become measurable in that medium.

Another important consideration is the role of seasonal effects. The Columbia River temperature and flow rate at Hanford change according to a pattern such as shown in Figure 4. The effect of these natural variables on the concentration in fish is also shown in Figure 4.

Let's talk for a minute about the different ways in which man is exposed to radioactivity. To begin with, let us introduce some radioactivity into an environment, as shown in Figure 5. We are concerned about man living in the environment and we have to worry about dose to man. We have to worry about the external dose that he receives from this radioactivity as a result of simply existing in the environment where the radioactivity is present and the internal dose that results from radioactivity being introduced into many dietary pathways.

The complicated transition from an amount of radioactivity measured in an environment to a calculation of the total dose is shown in Figure 6. This total represents the sums of all internal and external exposure pathways.

When we are evaluating the impact of radioactivity on the environs, we need to have answers to several questions, e.g., what kinds, quantities,

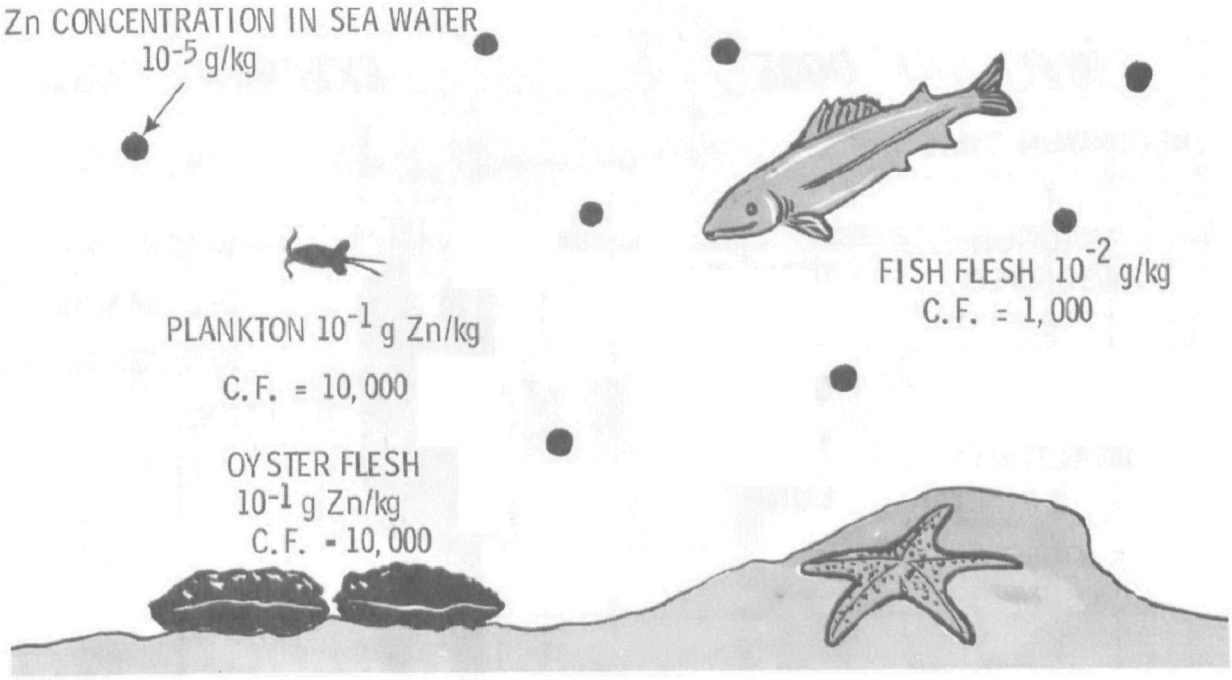


Figure 3. Concentration Factors for Zinc and Sea Water to Organisms.

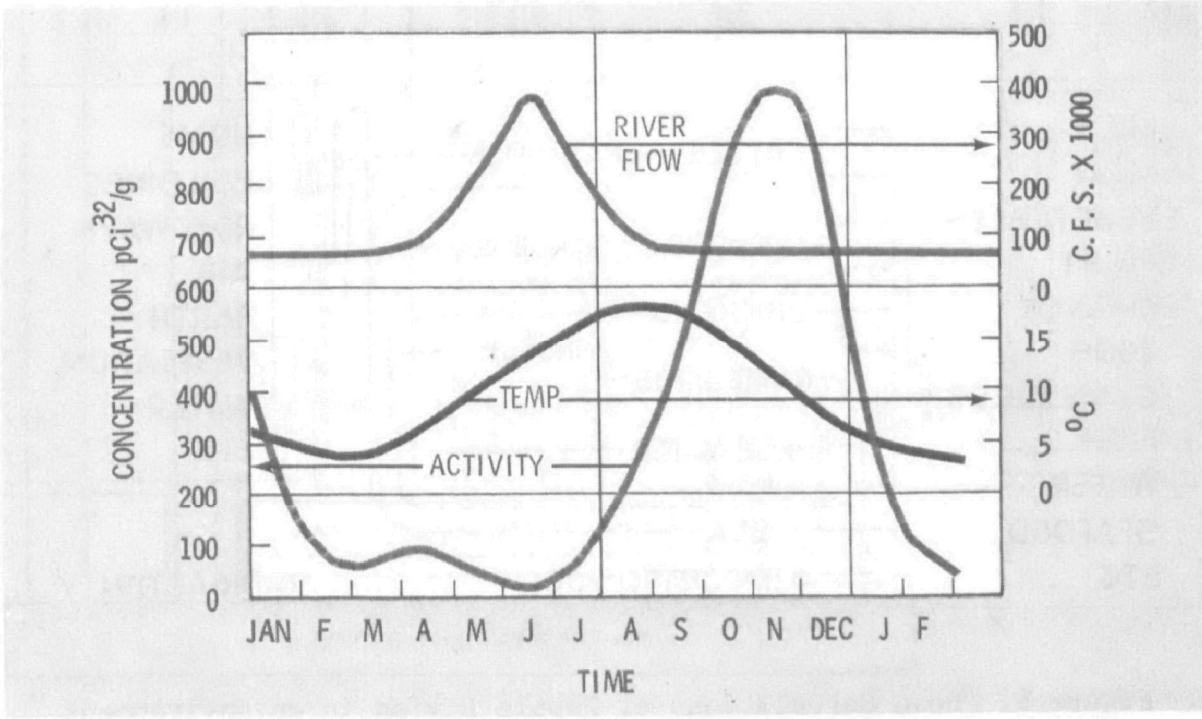


Figure 4. Seasonal Variation in Phosphorus-32 Concentration of Columbia River Fish.

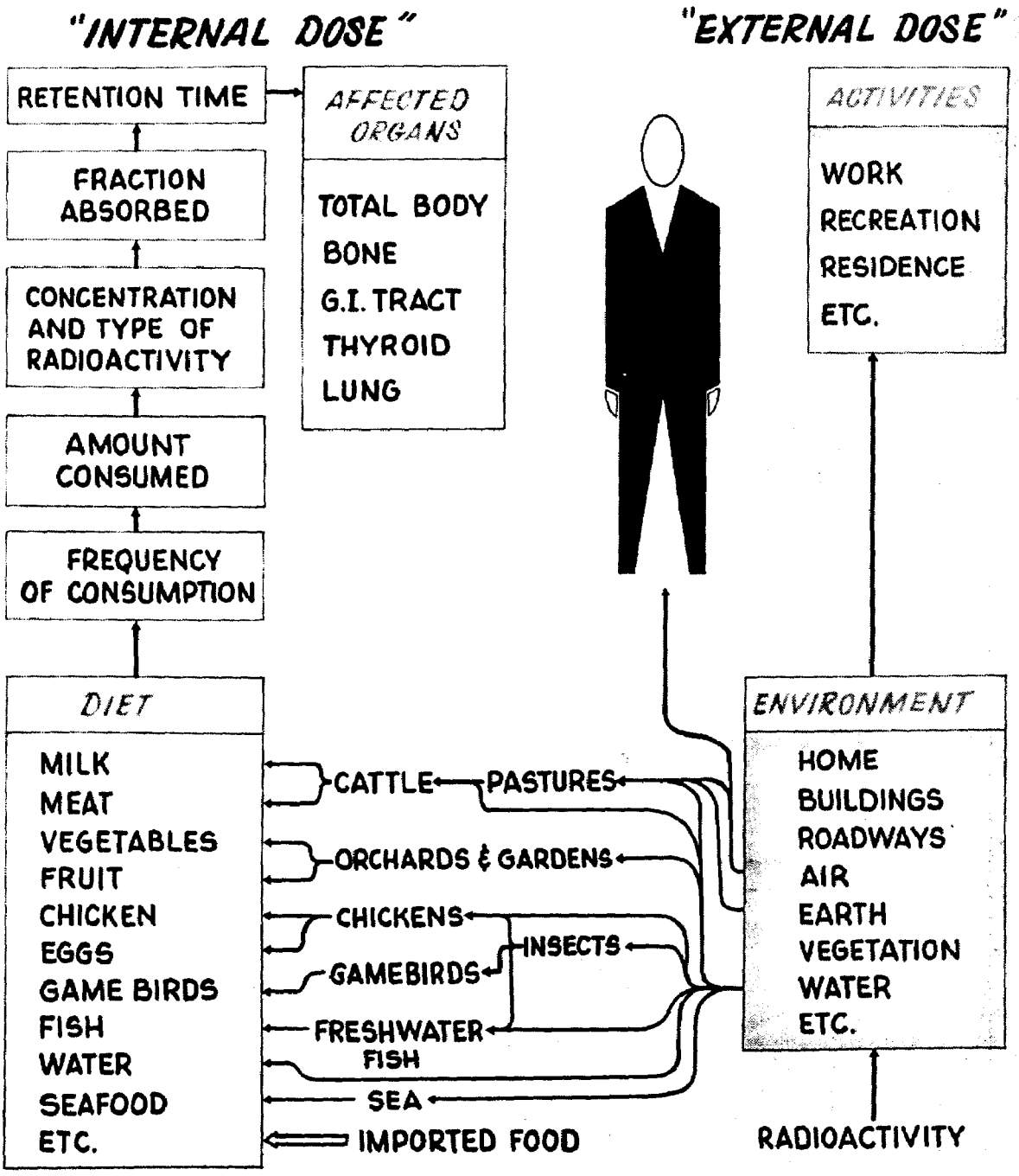


Figure 5. Dose Calculations of People Living in an Environment Containing Trace Amounts of Radioactivity.

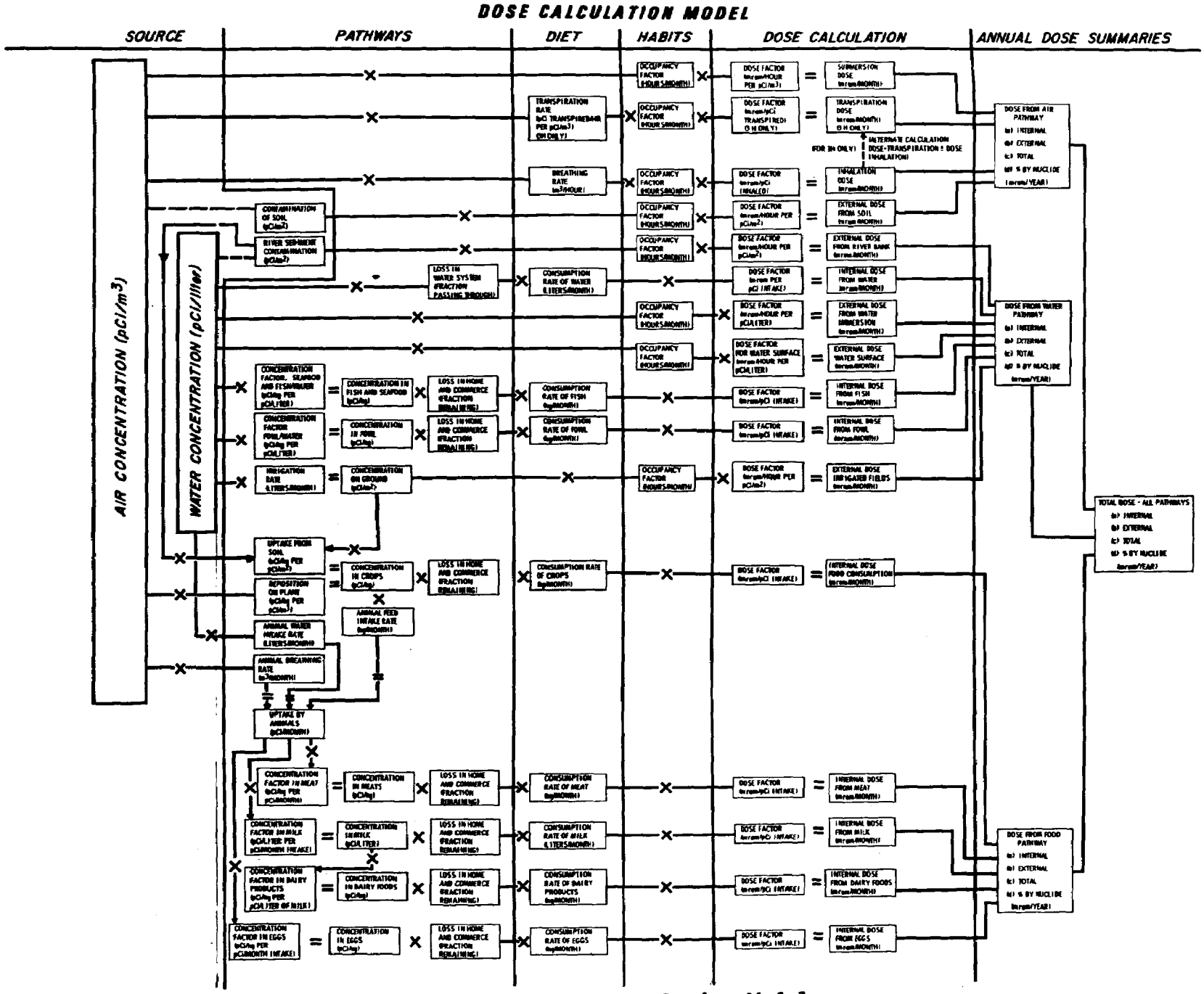


Figure 6. Dose Calculation Model.

and concentrations of radioactivity are present; at what rates are particular foods and beverages consumed by people living in the environment; also, what fraction of that radioactivity is absorbed and how long it is retained in the person's body.

Finally, we can come up with doses for various organs resulting from a particular body burden of radionuclides as a result of this particular set of pathways. We can then add that to the external dose which results from the activities that a person undertakes.

To estimate the external dose a person receives, we have to know how frequently he goes swimming in the river if there is radioactivity in the river. Also, we need to know how many periods of the year he spent fishing or how many times he digs clams by the beach. Activities such as these in the environment determine his external dose.

There have been numerous examples of exposure pathways that have been studied. The one shown in Figure 7 has been studied rather extensively at Hanford. We have found that a release rate of about 50 curies of ^{32}P per day to the river results in a concentration in the flesh of fish of about 250 picocuries per gram. We have had to know something about how many fish are caught and eaten by people so that we can then calculate (not measure) the resulting dose to bone or other tissues as a result of this particular pathway.

Another example of an exposure pathway that has been extensively examined is found at the Bradwell Power Station in England (Figure 8). It has to do with zinc-65 released into estuaries. For the organisms

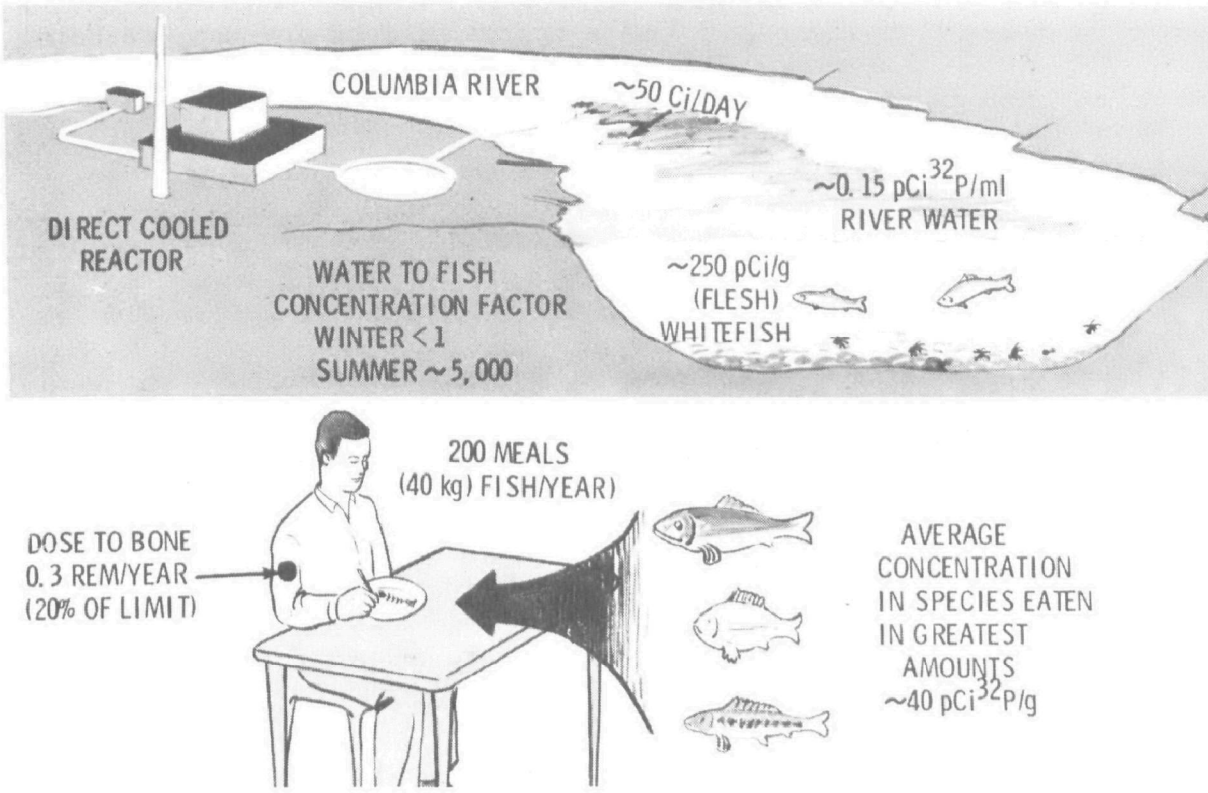


Figure 7. The Phosphorus-32 Exposure Pathway at Hanford, Washington.

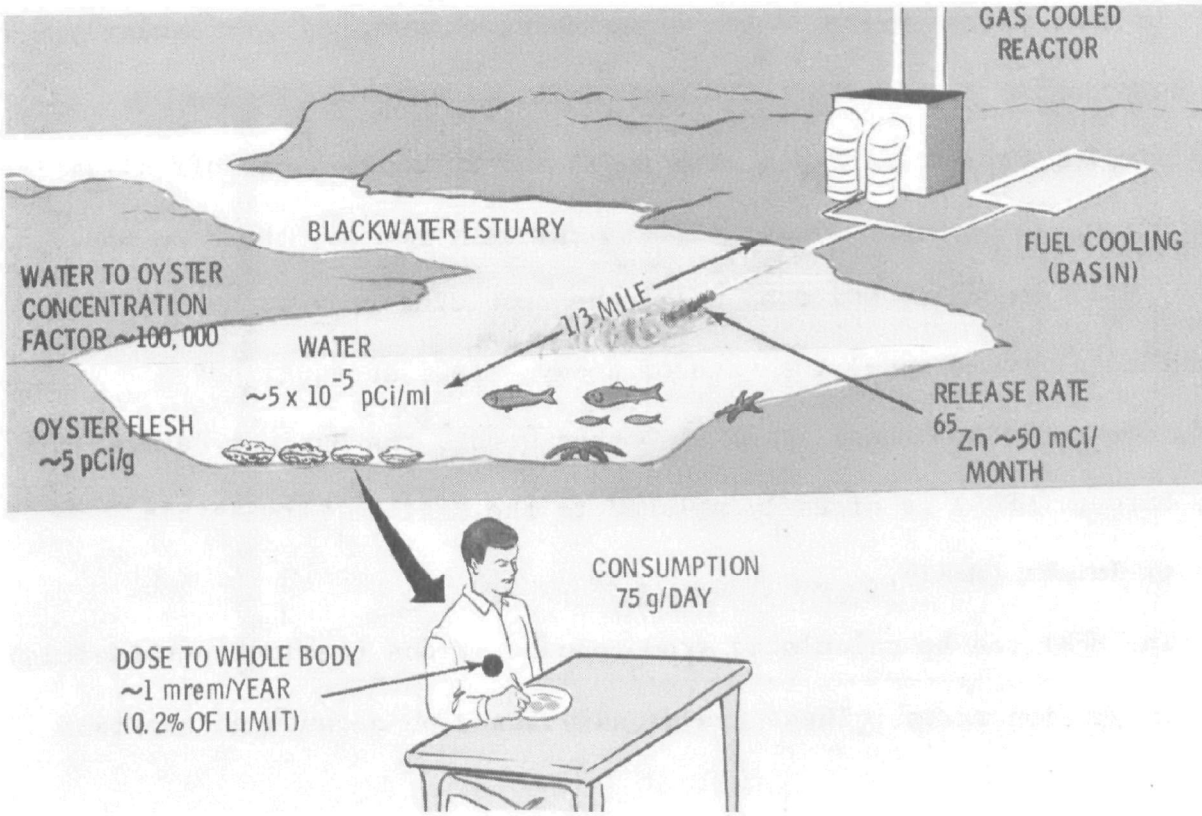


Figure 8. The Zinc-65 Exposure Pathway at Bradwell Power Station, U.K.

that may be taken from the estuary as a source of food for man, we need to know how much is eaten by man and absorbed by his tissues. Then, an estimation of the body burden as well as the dose that results to various organs therefrom as the result of this experience can be made.

There are several things that one has to know about people and the radioactivity that may be present in their body. You have to know the effective half-life such as for ^{65}Zn. If a person were to consume a quantity such as shown in Figure 9, 90 percent (according to ICRP) would not be absorbed at all. It would pass through the person's body right away. The remaining 10 percent would be absorbed and would be excreted with an effective half-life of 194 days. Many months later, we ould find a rather low body burden, as shown in Figure 9.

If this person were, on the other hand, consuming ^{65}Zn regularly, the body burden would accumulate with time, as shown in Figure 10. Very simply, you would have a meal today and it would decay off slightly. By continuing this consumption pattern for many months, the ^{65}Zn body burden will gradually build up until the resulting body burden of this radionuclide would equal the rate of decay, i.e., an equilibrium condition would be established. In other words, the Maximum Permissible Body Burden (MPBB) is directly related to the Maximum Permissible Rate of Intake (MPRI).

The MPRI can be calculated from concentrations (maximum permissible) and consumption rates. These are usually based on an assumed constant

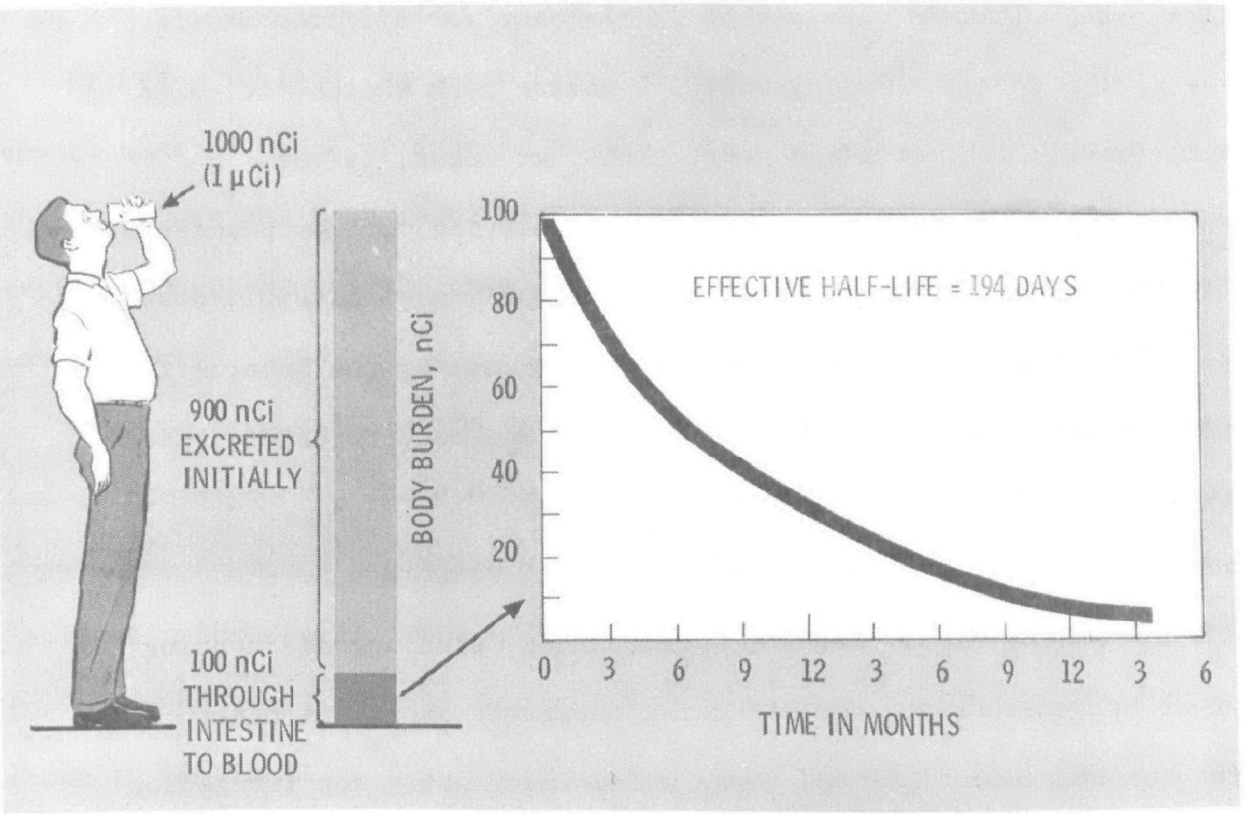


Figure 9. Fate of Zinc-65 in the Body.

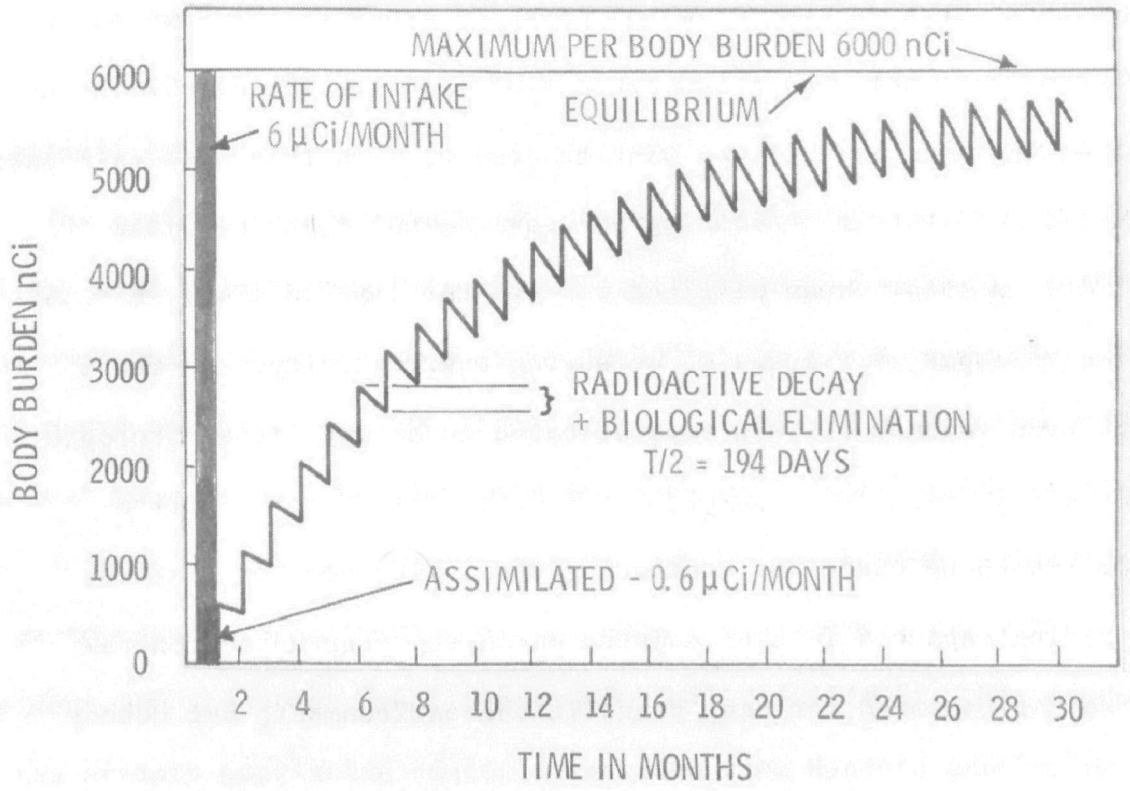


Figure 10. Accumulation of Zinc-65 with Sustained Intake.

metabolism rate. That is, the method is the same for all food stuffs. If you are going to eat ^{65}Zn, it wouldn't matter much whether it comes from game, birds, fish, or clams, etc. This, at least, is the assumption made by the ICRP and others in calculating maximum permissible rates of intake so that you can end up with a maximum permissible dose or risk. These parameters have been defined for use by the International Commission on Radiological Protection (ICRP). The body burden is based on an assumed dose rate to a given tissue.

The external exposure on the other hand, is sometimes more difficult to come by. For example, water skiing, fishing, and boating habits must be considered. Hunters using the river shore and other areas for hunting game birds and those using river water for irrigation and as a drinking water supply must also be considered. All of these can contribute both to internal and external dose. A study of the environment in terms of habits of the people and sources of food for the people living in the environment is a must if you want to come up with this dose calculation.

At Hanford, we started monitoring our environment when the plant was first built in 1944. When we first went on the line in 1944, we had only electroscopes as a means of measuring radioactivity. In those days, no one even dreamed of such sophisticated techniques as an isotopic analysis.

In 1958, we found ourselves monitoring the environment of Hanford, collecting filing cabinets full of numbers which represented concentrations that we had measured for many years in the environment, but nobody

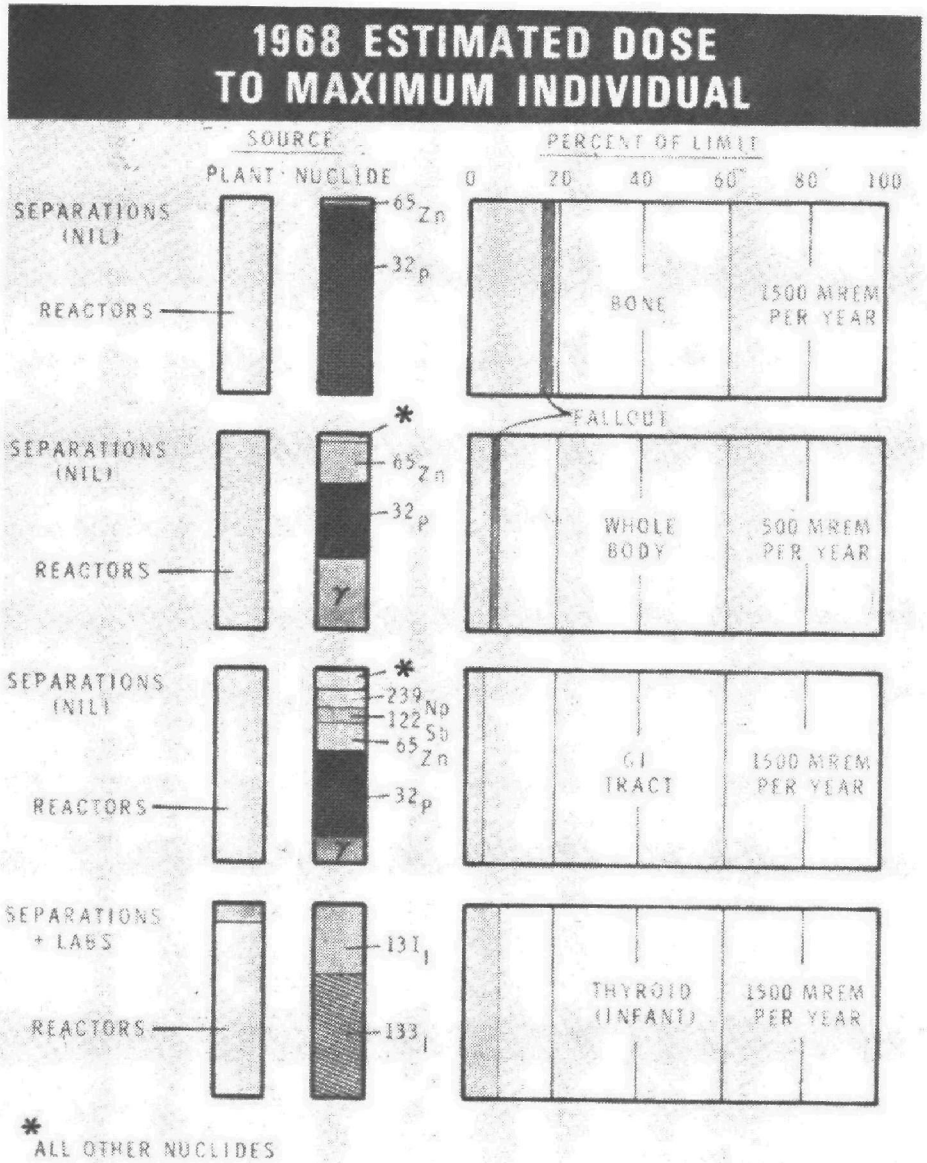
knew how to comprehensively evaluate the data.

Starting in 1958, we began this process of evaluating Hanford's environment in terms of dose to people. We did this because we decided that dose was the most meaningful end product, and that what we were trying to protect was the people and the organisms that lived in our environment.

We have been calculating environmental radiation doses at Hanford for thirteen years. These dose estimates have been made for two population segments - a Maximum Individual and an Average Richland Resident. The actual doses estimated for these two population segments for a recent year, as well as the primary sources of these doses, are shown in Figure 11.

As is shown in this figure, reactor effluents are the principal source of radiation doses in the Hanford environs, although the separations areas and fallout from nuclear weapons testing contribute to a small extent.

The maximum individual is not someone we can go out and identify and say meet Mr. Maximum Individual. He is our hypothetical guy who does everything in a maximum way to maximize the dose. He spends the most hours on the river shoreline fishing, he eats the most fish and the most game birds. He also eats the most meat from local farms and the most vegetables from gardens irrigated with Columbia River water and so on to result in maximizing every pathway. The Average Richland Resident, on the other hand, represents real individuals. He resides in the primary population center downstream from Hanford and has no



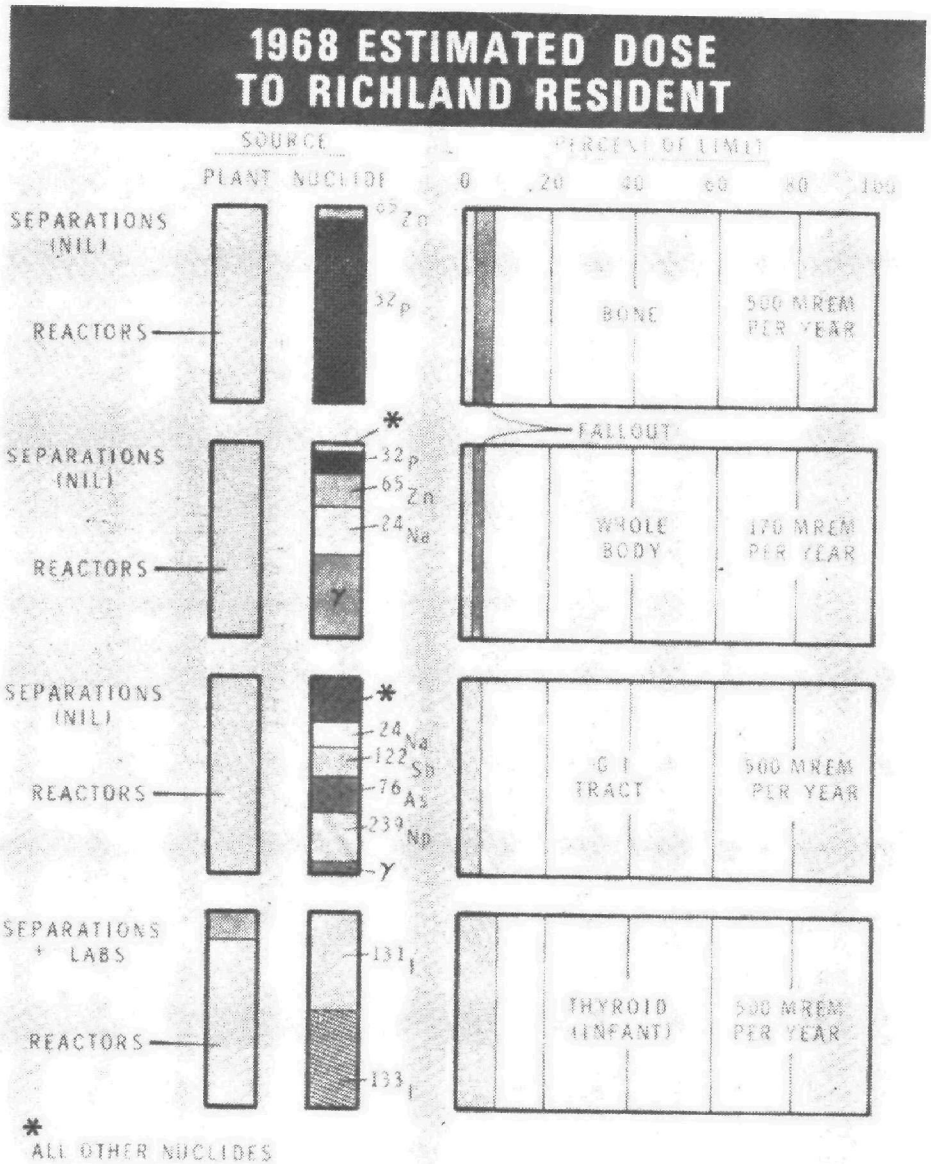


Figure 11. Dose Estimates for Maximum Individual and to Average Richland Resident.

unusual dietary or living habits.

We have made at Hanford what we call surveys of population groups. Now, a population survey is simply an effort conducted by us to obtain, from a certain population group, some of the "blanks" that we need to complete in the logic process that I have been describing to you to calculate doses.

We go to specific groups that have a specific kind of information to contribute. We have used our own employees over the last ten to eleven years to obtain much of the needed information. We wanted to find out how many of them eat fish caught in the Columbia River, how many of them eat game birds and seafood, and how many of them eat locally produced beef and drink locally produced milk. We also wanted to define their water consumption, as well as any other dietary habits. All of this information was collected as a part of the routine whole-body count for these people.

We also have a mobile whole-body counter with which we can go out and measure radioactivity in school children. About fifty-five hundred such measurements were made on elementary school children throughout the Tri-City, Richland, Pasco, and Kennewick area. A similar survey was conducted with a small group of teenagers.

Another survey involved specific studies of the fishing habits of local fisherman because fish happens to be a very important pathway in our dose calculation. One such study had to do with just how much fishing is done on the river. This was based on the statistical model and took us a full year to accomplish. We moved our truck out to the

riverbank and selected people who derive a large part of their diet from the Columbia River in the form of fish. Eighty-five individuals participated in the study.

We have also studied farm populations where Columbia River water was being used for irrigation and residents of seafood-producing areas along the Pacific coast. Still another study involved a definition of serving sizes (an important parameter for dose calculations) for a sample of the Richland population. You can see, from what I have just described, that many special population surveys have been conducted at Hanford in support of environmental dose calculations.

I am not proposing that each of you should necessarily repeat these studies for your own plant's environs. This is the kind of thing, however, that we found was needed in order to improve our estimates of dose. It was knowledge such as this that we were lacking. The fisherman's surveys involved a statistical model of time and space. We chose twenty-one areas along the river and divided the year up into four-hour periods and we hired a man to spend a full year sampling the times, spaces, populations that we had randomly chosen.

We learned, for example, what kind of fish they caught and how many. Our statistical model permitted us to take our sample and extrapolate it to the whole population. It resulted in some calculations of the fishing pressure of the whole population of the tri-city area as a result of knowing something about the fishing habits.

The diet questionaire we asked our adult employees to fill out

BATTELLE NORTHWEST
RICHLAND, WASHINGTON

THE INFLUENCE OF DIET ON RADIOACTIVITY IN PEOPLE

THIS QUESTIONNAIRE IS TO OBTAIN DIET INFORMATION TO SUPPLEMENT YOUR WHOLE-BODY COUNTING RESULTS. THE DATA ARE OF REAL SCIENTIFIC VALUE TO HELP US UNDERSTAND THE WAY PEOPLE TAKE UP RADIOACTIVITY FROM THEIR FOOD, AND HOW LONG IT IS RETAINED IN THEIR BODIES. WE CAN DO THIS BY RELATING THE MINUTE AMOUNTS OF RADIOACTIVITY MEASURED BY THE WHOLE-BODY COUNTER TO INDIVIDUAL DIETS. WHEN A LARGE NUMBER OF THESE RELATIONSHIPS ARE OBTAINED WE CAN DETERMINE SIGNIFICANT AVERAGES. EVEN THOUGH IT IS NOT POSSIBLE TO PROVIDE PRECISE ANSWERS, WE APPRECIATE YOUR GIVING THE BEST ESTIMATES YOU CAN TO THE FOLLOWING QUESTIONS. TRY TO AVERAGE YOUR DIET THROUGHOUT THE YEAR WITHOUT BEING UNDULY INFLUENCED BY RECENT SEASONAL FACTORS. IT MAY HELP YOU TO UNDERSTAND THE QUESTIONS IF YOU REMEMBER THAT WE SIMPLY WANT TO FIND OUT YOUR AVERAGE CONSUMPTION RATE OF CERTAIN FOODSTUFFS AND WHERE THESE FOODS WERE PRODUCED.

NAME	SOC. SEC. NO.	DATE
HOME ADDRESS	PAYROLL NO.	OCCUPATION

AGE	HEIGHT	WEIGHT	SEX ☐M ☐F	EMPLOYED BY	BLDG.	AREA

1 RESIDENCE HISTORY

I HAVE LIVED IN MY PRESENT COMMUNITY FOR _____ YEARS.

BEFORE THAT I LIVED IN _____ CITY

FOR _____ YEARS.

2 DRINKING WATER

WHAT IS THE SOURCE OF DRINKING WATER IN YOUR HOME?
☐WELL ☐MUNICIPAL SYSTEM

HOW MANY GLASSES OF WATER DO YOU DRINK PER DAY?
_____ GLASSES

ON A WORK DAY HOW MUCH OF THIS WATER DO YOU DRINK WHILE AT WORK?
☐LITTLE ☐SOME ☐MOST OF IT

3 OTHER LIQUIDS

HOW MANY CUPS OF BEVERAGE MADE FROM TAP WATER (COFFEE, TEA, SOUP, KOOL-AID, ETC.) DO YOU DRINK PER DAY?
_____ CUPS

HOW MUCH OTHER LIQUID DO YOU DRINK (BOTTLED SOFT DRINKS, JUICE, BEER, ETC.)?
_____ GLASSES

4 MILK

HOW MANY GLASSES OF FRESH MILK DO YOU DRINK PER DAY?
_____ GLASSES

WHAT IS THE SOURCE OF YOUR FRESH MILK?
☐COMMERCIAL ☐LOCAL FARMS

WHICH BRAND OF COMMERCIAL MILK DO YOU USUALLY DRINK?
_____
(DO NOT INCLUDE CANNED OR POWDERED MILK)

5 MEAT

FOR HOW MANY MEALS A WEEK DO YOU EAT FRESH MEAT (OTHER THAN CANNED OR CURED)?
(DO NOT INCLUDE PREPARED MEATS SUCH AS WEINERS, LUNCH MEAT, AND TV DINNERS)
_____ MEALS

HOW MUCH OF THIS FRESH MEAT IS BEEF? ☐NONE ☐LITTLE ☐MOST ☐ALL OF IT

WHERE DO YOU OBTAIN YOUR FRESH BEEF? ☐MEAT MARKET ☐LOCAL FARMS

6 FRESH VEGETABLES

FOR HOW MANY MEALS A WEEK DO YOU EAT FRESH VEGETABLES (OTHER THAN CANNED OR COMMERCIALLY FROZEN? _____ MEALS

FRESH FRUIT? _____ TIMES

WHERE DO YOU OBTAIN MOST OF YOUR FRESH VEGETABLES?
☐GROCERY ☐LOCAL FARMS

WHERE DO YOU OBTAIN MOST OF YOUR FRESH FRUIT?
☐GROCERY ☐LOCAL FARMS

7 SEAFOOD

ABOUT HOW MANY TIMES A YEAR DO YOU EAT THE FOLLOWING SEAFOODS?

FRESH OYSTERS _____ TIMES

FRESH CRAB _____ TIMES

FRESH CLAMS _____ TIMES

(DO NOT INCLUDE FISH OR CANNED OR COMMERCIALLY FROZEN SEAFOOD. INCLUDE ONLY THAT FROM NEARBY PACIFIC SOURCES.)

8 GAME BIRDS

HOW MANY TIMES A YEAR DO YOU EAT THE FOLLOWING GAME BIRDS?

DUCK _____ TIMES

GOOSE _____ TIMES

PHEASANT _____ TIMES

QUAIL _____ TIMES

CHUKKAR OR GROUSE _____ TIMES

9 COLUMBIA RIVER FISH

HOW MANY TIMES A YEAR DO YOU EAT FISH CAUGHT IN THE COLUMBIA RIVER BELOW HANFORD (OTHER THAN COMMERCIAL FISH?)
ABOUT _____ TIMES

WHAT KINDS OF FISH WERE THEY?

	MOST	SOME	NONE		MOST	SOME	NONE
SALMON				STEELHEAD			
STURGEON				WHITEFISH			
BASS				CRAPPIE			
TROUT				PERCH			
CATFISH				OTHER			

FOR SECTION USE ONLY

IDENTIFICATION CODE _____

A	B	C	D	E	F	G	H

NA-24 _____
ZN-65 _____
CS-137 _____
K-40 _____
_____
_____

10 OTHER QUESTIONS

WHEN WAS THE LAST TIME YOU ATE SEAFOOD (OTHER THAN FISH) AS THE PRINCIPAL PART OF A MEAL? _____

WHICH SEAFOOD WAS IT? _____

WHEN WAS THE LAST TIME YOU ATE FISH FROM THE COLUMBIA RIVER? _____

WHEN YOU OBTAIN SEA FOOD OR LOCAL FISH DO YOU USUALLY PRESERVE IT BY FREEZING? ☐YES ☐NO SMOKING? ☐YES ☐NO CANNING? ☐YES ☐NO

BB-1200-109 (10-65) AEC-BLOO RICHLAND, WASH.

Figure 12. Questionnaire Used in Conjunction With Whole-Body Counting.

when they came in to get a whole-body count is shown in Figure 12. Figure 13 is a picture of a man getting a whole-body count. As a result of this whole-body counting program, we were able to obtain body burden measurements and relate them to the consumption of particular foods and beverages. In Figure 14, ^{65}Zn body burdens and drinking water concentrations are shown for Richland residents. This example is shown because drinking water happened to be one of the major sources of this particular radionuclide. We were able to determine that at the time the city of Richland started using the Columbia River for a source of drinking water. Of course, there were other sources of ^{65}Zn in the diets of Richland residents, but you can see the buildup as a result of the drinking water source.

The mobile body counter we have taken around to various Tri-City schools is shown in Figure 15. The kids really respond to this kind of a program. The whole body counter has a large sodium-iodide crystal, under which the children move on a traveling bed during the whole-body count (Figure 16). With the large, sensitive crystal in our whole body counter we can easily measure the body burdens of radionuclides of fallout and Hanford origin and all natural radioactivity such as ^{40}K.

Each child fills out a diet questionnaire which they hand in to us prior to their whole-body count (Figure 17). At the end, they get a little certificate saying that they have participated in the study. We have obtained, as a result, distributions of consumption levels of various foods and beverages which we have used in making dose calcula-

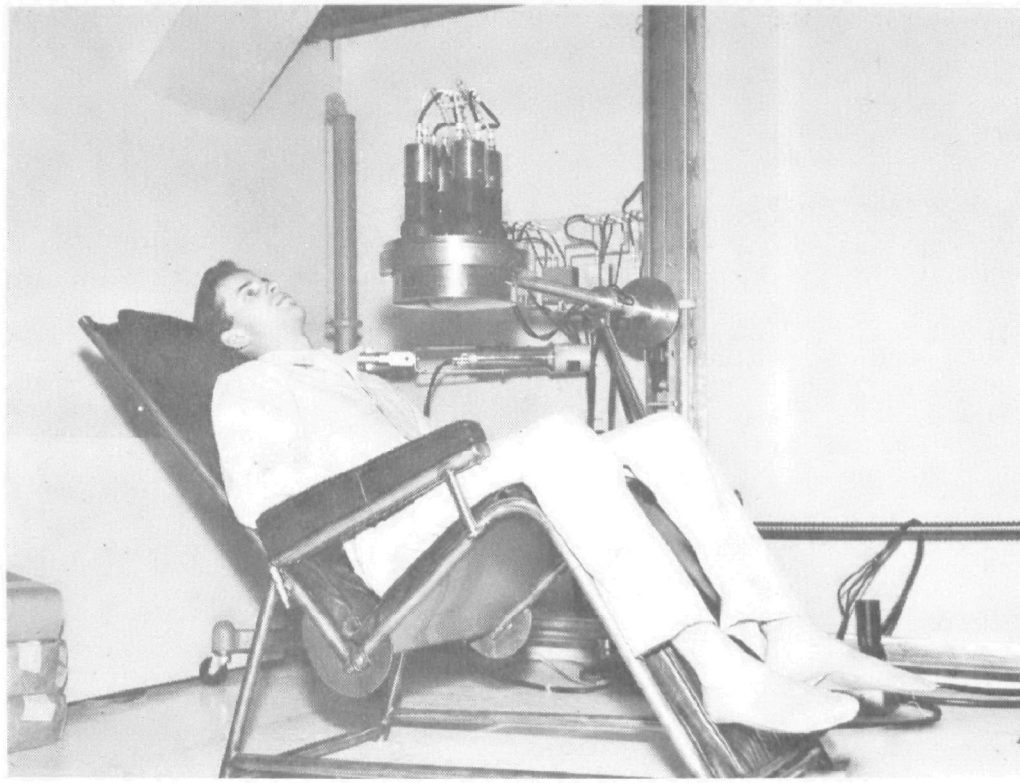


Figure 13. Whole-Body Counter.

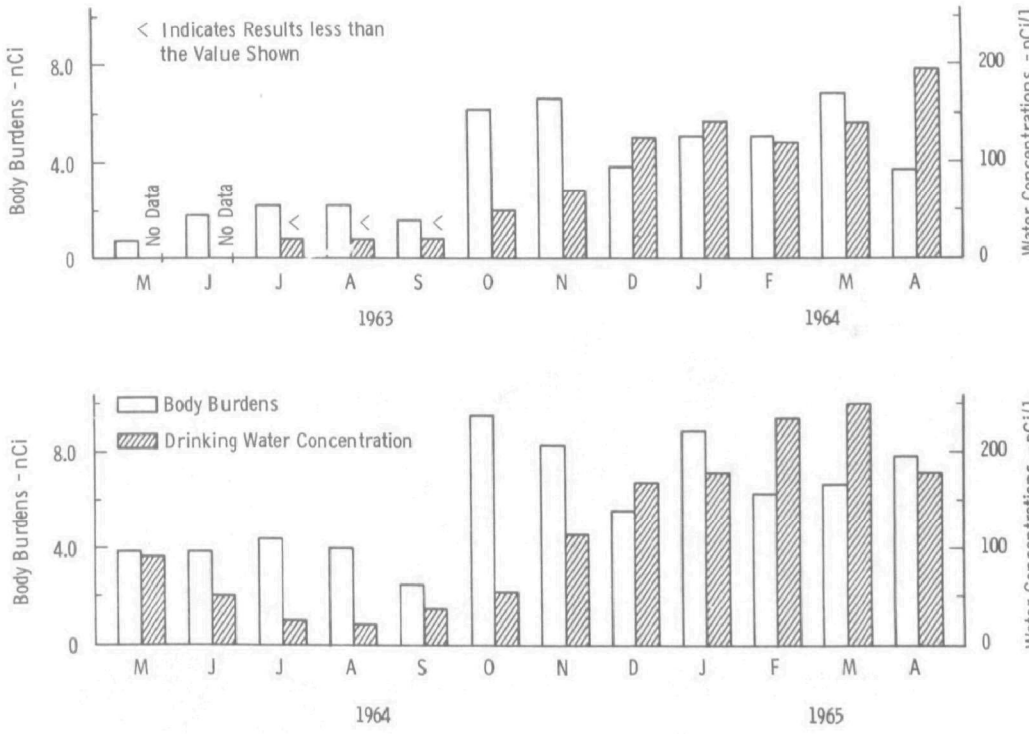


Figure 14. Average Zinc-65 Body Burdens and Drinking Water Concentrations in Richland, Washington Residents.

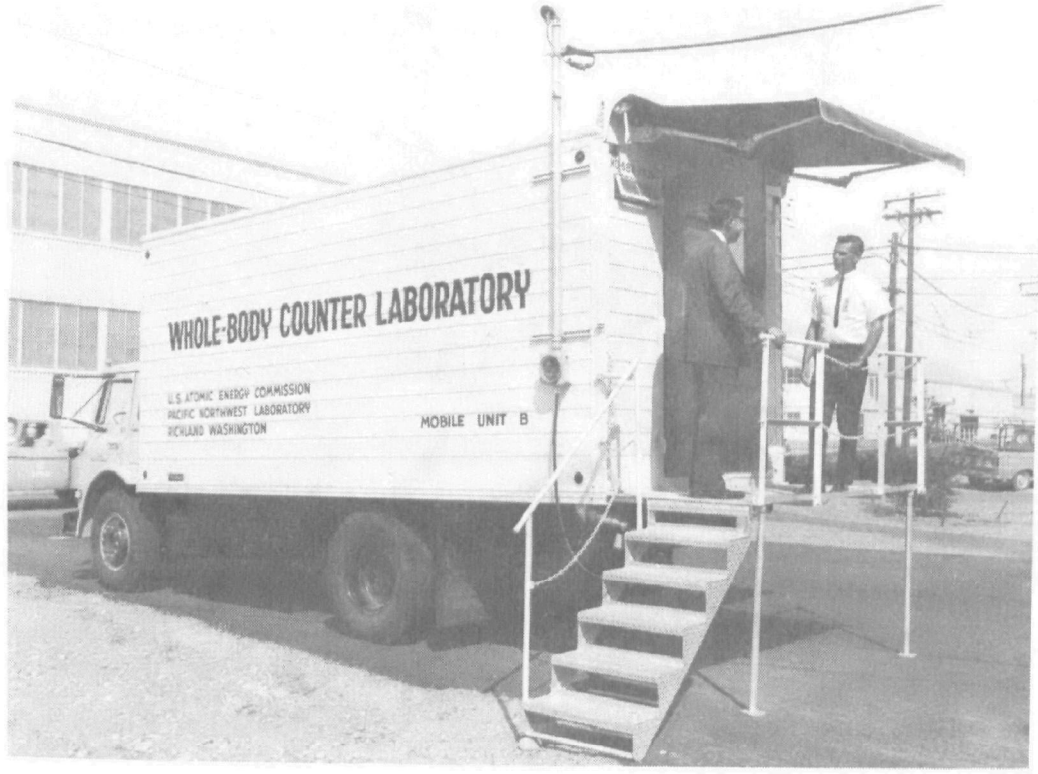


Figure 15. Mobile Whole-Body Counter Used for School Children.

Figure 16. Interior of Mobile Whole-Body Counter.

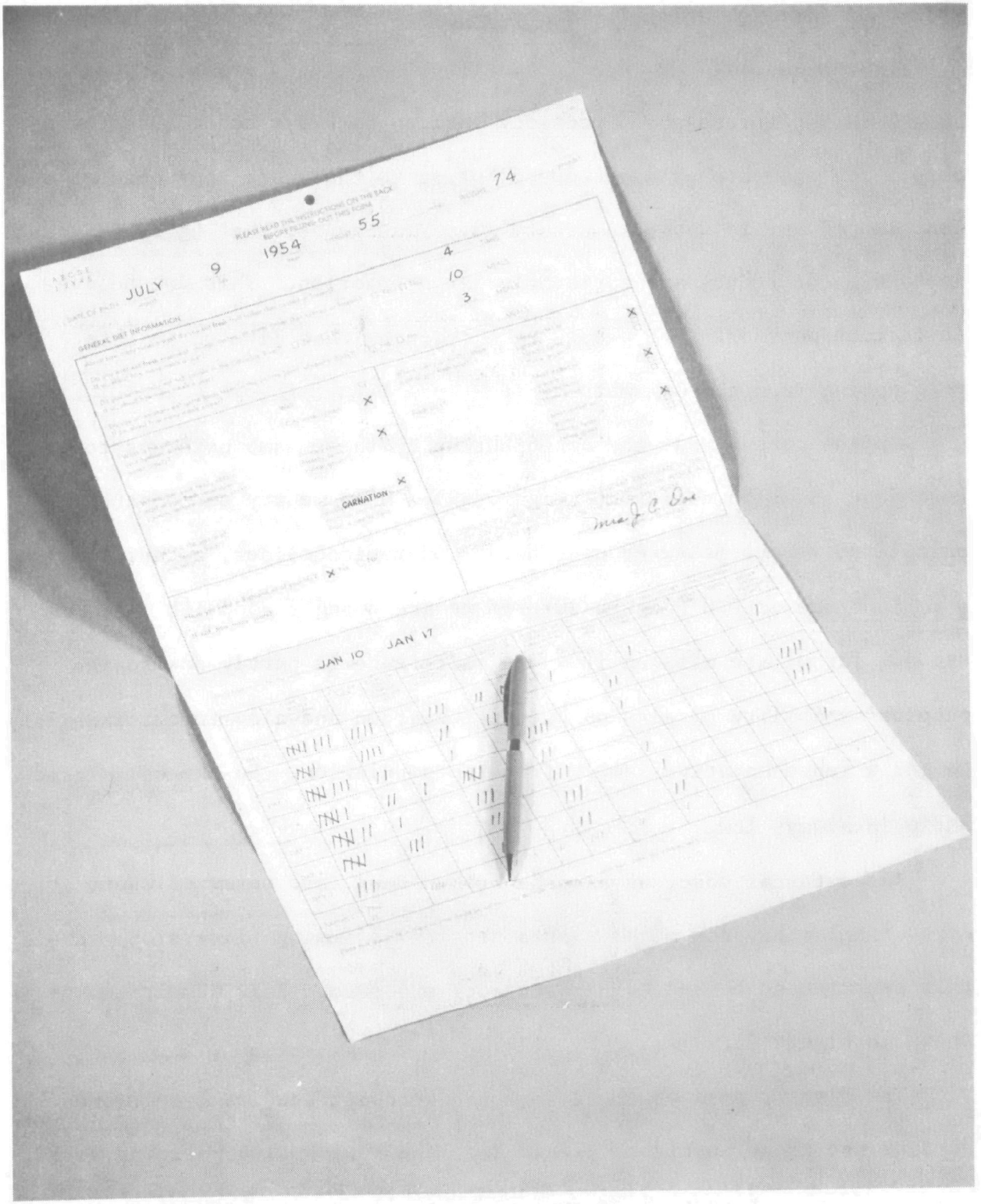


Figure 17. Questionnaire Used in Conjunction With Mobile Whole-Body Counter.

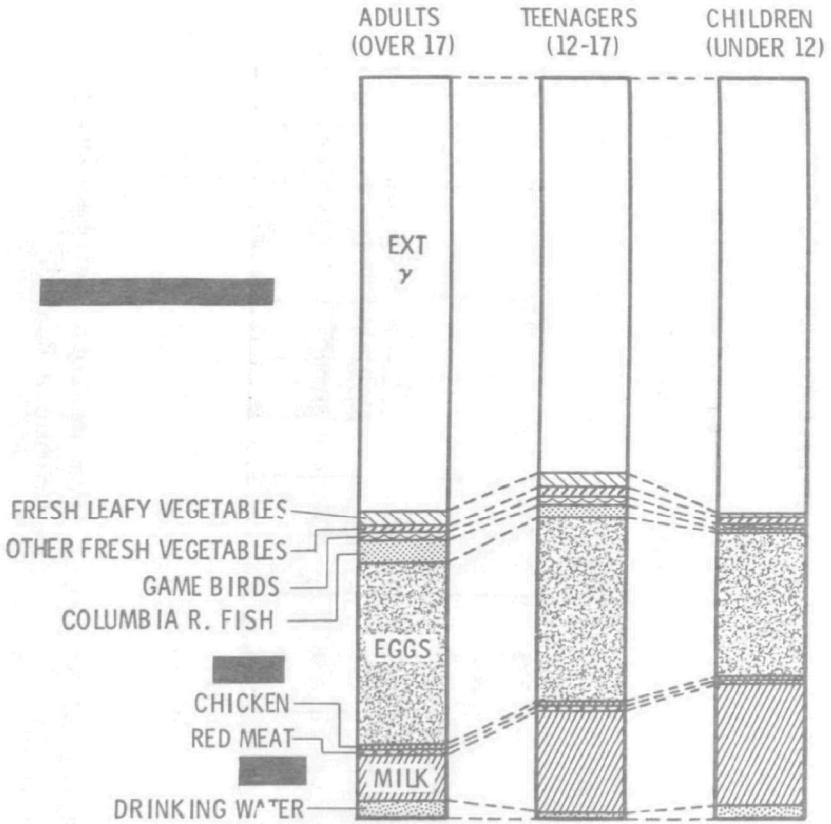
tions for children as well.

In the case of the rural population I mentioned earlier, we are able here to express what fractions various pathways contribute to the dose. The exposure pathways contributing to the whole body dose as a function of age is shown in Figure 18. You can see that eggs, for instance, contribute a surprisingly large fraction. This, we belive, is because many of these people have chickens that live on insects originating from the Columbia River.

On the other hand, the contribution by these same pathways to the bone dose is quite different (Figure 19). When we try to compare the calculated versus measured body burden of radionuclides, we should find a ratio close to 1.0 (Figure 20), if we are doing a good job. You can see how far we are missing it. The difference is partly due to the peoples' inability to give us diet information and also to our inability to get a representative sample from the population. So the calculated ratio is always low.

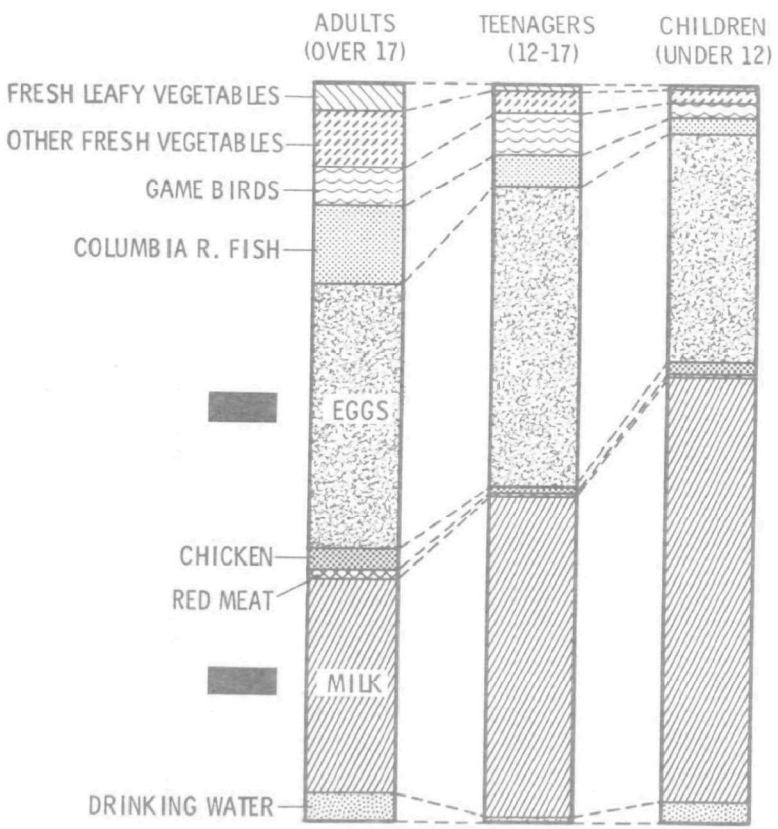
The external dose can also be broken down into terms of where it comes from, i.e., how much is obtained from swimming (immersion) versus that contributed by shoreline (surface) exposure. This comparison is shown in Figure 21.

The dietary data obtained from the seacoast studies I mentioned earlier are shown in Figure 22 and 23. The consumption patterns were quite different because Rockaway was primarily a crab producing area and Ilwaco was an oyster producer. We used these data to calculate the



	ADULTS (OVER 17)	TEENAGERS (12-17)	CHILDREN (UNDER 12)
NUMBER OF PERSC.	166	83	92
AVERAGE PERCENT OF PERMISSIBLE DOSE (170 mRem/YEAR)	1.20	1.59	2.91
MAXIMUM INDIVIDUAL PERCENT OF PERMISSIBLE DOSE (500 mRem/YEAR)	1.14	2.07	2.57

Figure 18. Sources of Environmental Whole-Body Dose from Hanford Rural Population - 1969.



	ADULTS (OVER 17)	TEENAGERS (12-17)	CHILDREN (UNDER 12)
NUMBER OF PERSONS	166	83	92
AVERAGE PERCENT OF PERMISSIBLE DOSE (500 mRem/YEAR)	1.11	1.71	2.52
MAXIMUM INDIVIDUAL PERCENT OF PERMISSIBLE DOSE (1500 mRem/YEAR)	2.19	3.83	3.79

Figure 19. Sources of Environmental Bone Dose from Hanford Rural Population - 1969.

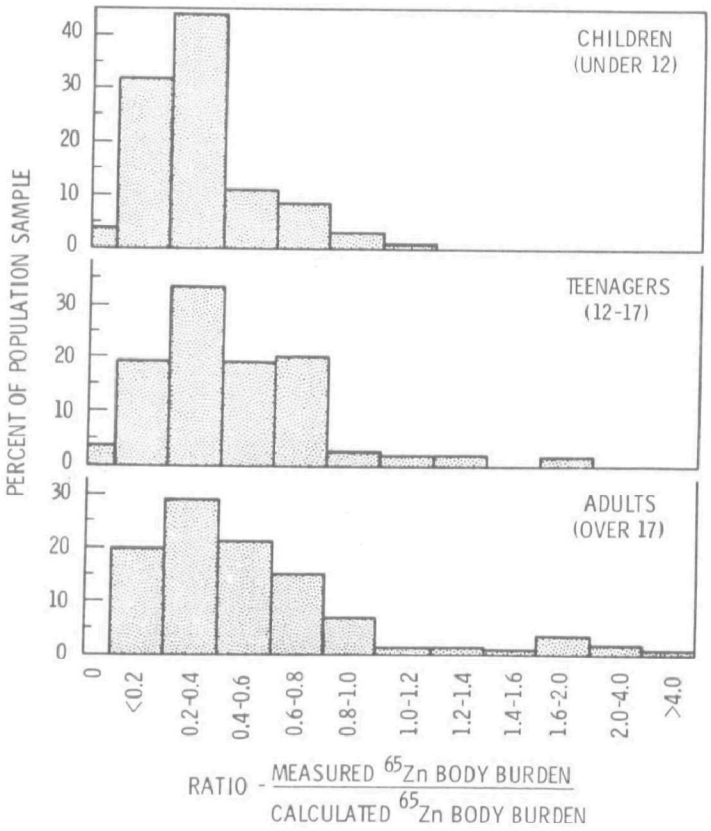


Figure 20. Comparison of Measured and Calculated Zinc-65 Body Burdens - Rural Population Survey.

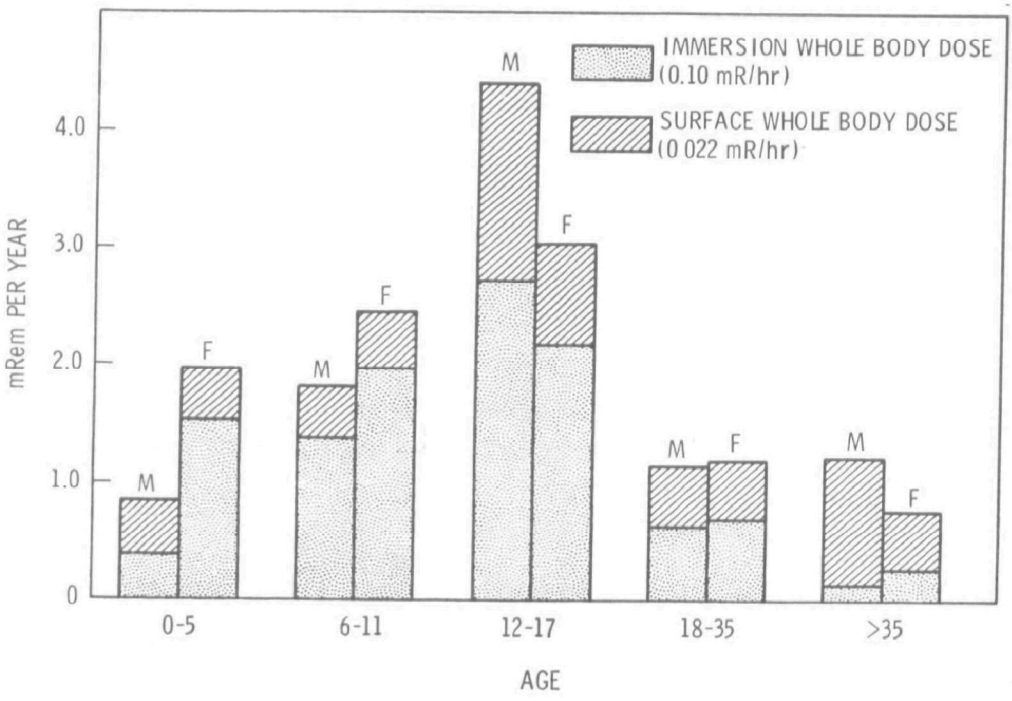


Figure 21. External Exposure from Hanford Radioactivity from Recreational Use of the Columbia River.

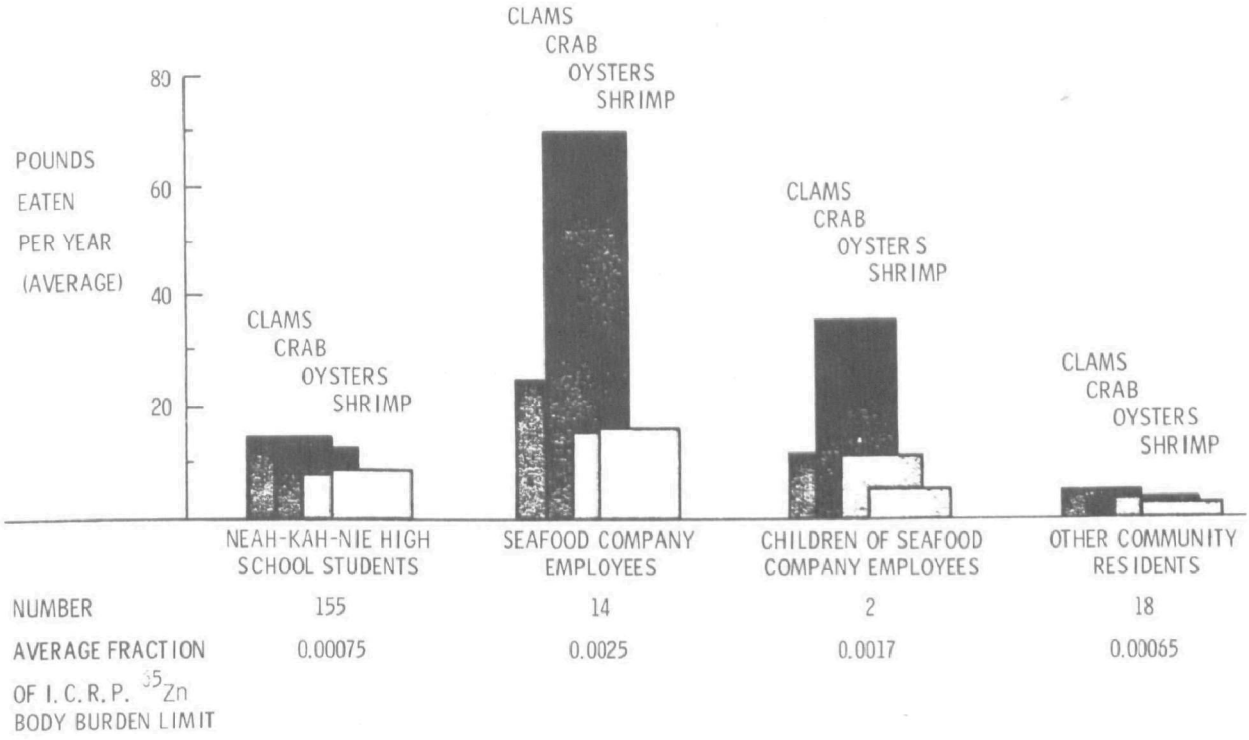


Figure 22. Dietary Data Obtained from Rockaway, Tillamook County, Oregon - 1970.

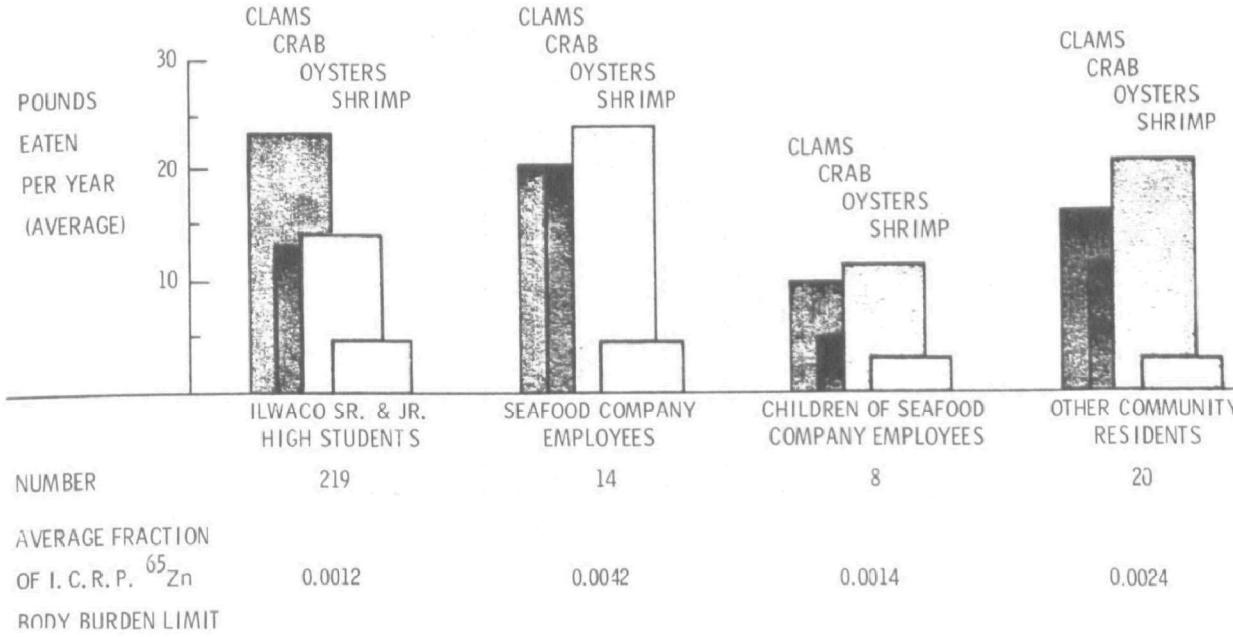


Figure 23. Dietary Data Obtained from Ilwaco, Pacific County, Washington - 1970.

fractional uptake of ^{65}Zn from four different kinds of seafood and we found that apparently ^{65}Zn isn't absorbed at a constant fraction of ten percent, as suggested by the ICRP. We found that from oysters, for instance, only about one percent was absorbed, while from shrimp as high as twenty-two percent was being absorbed. The difference is largely, I think, due to the natural Zinc content of the different food stuffs. We need more studies of this kind, however, in order to be sure.

In conclusion, I would like to show you an animal which can digest all of the basic data we have been gathering in our environmental studies and give us environmental dose. Such an animal is the computer program diagrammed in Figure 24. The doses this program calculates are, of course, only as good as the basic data which we have generated to feed to the program.

DISCUSSION:

SPEAKER: Did the maximum individual drink the water coming out of the plant effluent? You mentioned who ate the most fish, but did he also drink the water coming out of the plant? We talked sometime about calculating dose to a man that drank the water coming out of the discharge canal.

MR. HONSTEAD: He drank water from a community that was using the Columbia as its source of water.

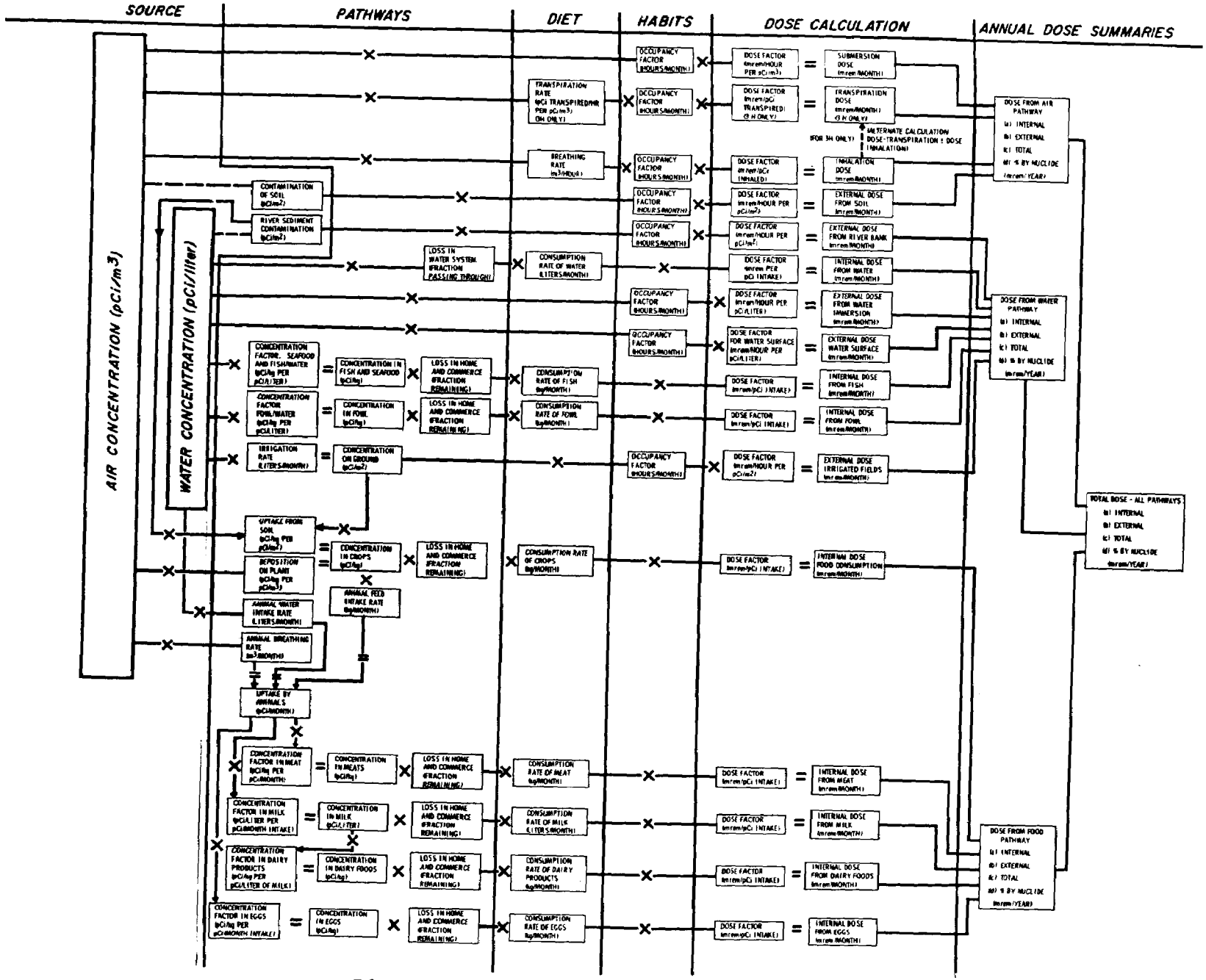


Figure 24. Dose Calculation Model.

SPEAKER: So your maximum individual did not take the fence post approach?

MR. HONSTEAD: That's right. It was where water was being drunk. Our plant is a big area and there is no communities that close to the reactor.

SPEAKER: What sort of nuclides do you measure and in what levels recently in your whole blood count?

MR. HONSTEAD: The only Hanford radionuclide that we have recently been measuring in our body count measure is ^{65}Zn. We can measure one nanocurie fairly readily. If it gets below one nanocurie, we can tell that it is there, but our calibration is not sufficiently adequate to be sure of it. But one nanocurie is fairly evident. This would be a very small peak compared to the natural potassium anywhere in a person's body.

We used to be able to occasionally measure ^{131}I and ^{24}Na in rare individuals, not in everybody. These are the only Hanford generated nuclides that I have ever detected except for a small amount of ^{60}Co, in employees but not the general public.

MR. PROUF: I am Dr. Prouf from Middle South Utilities. Could you give me a rough estimate of the annual budget for this type of program?

MR. HONSTEAD: This is a hard question to answer, because we are talking about parts of several programs. This data has been collected over a period of about seven years. It isn't something that was done all in one year.

The program does not pay for any of the concentration data for instance. One scientist and one technician were required to run the whole body counter survey. So eventually what it is going to cost to do this would be an amortization of that piece of equipment plus those two peoples' salaries. That was the size of this program. There was a small additional charge for computer services, because we were using the computer to formalize our output. That is, the analyzer output data was fed into the computer. I am afraid I can't break it down any finer than that. The whole body counter can be pretty expensive. It costs on the order of several tens of thousands of dollars to put together.

REGION IV RADIATION OFFICE ACTIVITIES RELATED TO THE NATIONAL RADIOLOGICAL DATA MANAGEMENT PROJECT

Mr. Douglas H. Keefer
Region IV Representative
Environmental Protection Agency

As the concluding speaker in this particular session, I would, first of all, like to tie together what you heard this morning relative to environmental radiation data. You heard Dr. Beck speak about AEC's interest in the State data relative to the limit and compliance responsibility of AEC, and you heard Dr. Martin discuss the dose assessment interest and responsibilities of the Office of Radiation Programs. Breaking down the responsibilities and activities a little further, the Office of Radiation Programs has a staff under the direction of Dr. Paul Tompkins, who is working specifically in the area of evaluating dose assessment. The collection of data for this evaluation of dose is the responsibility of the Division of Surveillance and Inspection. This division is in the process of developing a National Environmental Radiation Monitoring Program (NERMP). The program, which is currently being refined, will present the approach which the Office of Radiation Programs will be using to collect environmental radiation data throughout the country.

My particular project in Atlanta, which is being referred to as the State Radiological Data Management Program, is designed as a pilot study for the development of NERMP. State health departments and other new State environmental agencies which have been created

for the purpose of looking at environmental problems, will be preparing radiological data of specific interest to us. These data are the source of intelligence for the NERMP. The sole purpose of this particular project in Region IV is to assist in developing techniques for the preparation and management of these data so it can be better utilized by both State and Federal agencies, but more specifically by the State agencies themselves in meeting their own program objectives.

The Region IV Radiation Data Management Project actually was started in Florida in 1964, when I was assigned to Orlando as Technical Director of the Florida Radiological Laboratory. A specific project in this assignment was to develop a basic program called, "A State Radiological Data Processing System for Environmental Radiological Analysis," for use by all State agencies. This was completed and made available to several States within the Region, and Florida has been utilizing this particular approach until just recently when their increased environmental responsibility required them to be more extensive in their investigations. Other regional States have drawn from this approach to develop their own systems.

Last summer, the eight Region IV States, which are all agreement States, requested of the HEW Regional Representative that they be given some assistance in managing their radiation data which they had been collecting over the last 8 or 10 years. This is not just environmental data, but also data from medical X-ray surveys and radioactive material inspections. This resulted in my assignment to

Atlanta for this particular project and enabled me to continue my relationship with Florida while expanding the approach on a broader base to provide assistance to the other States within the Region.

Since September, Florida has increased environmental surveillance activity relative to the Crystal River Station, Turkey Point facility, and Hutchinson Island site. This extensive program of environmental analysis around these particular plants has generated a considerable quantity of data, placing greater emphasis and need on improved data management.

I have been assisting Mr. Wallace Johnson, who is directing the environmental activities in Florida, in the development of a data management system which would assist them in meeting the responsibility they have to the people of Florida, the power companies, AEC, and EPA.

Mr. Johnson will go into greater detail tomorrow concerning the advancements Florida has made in this direction. The other States within the Region and also outside the Region have observed Florida in their activities and have benefitted by their experiences.

Therefore, you can see that one of the primary functions of this regional project has been the interaction between the States enabling another State confronted with surveillance responsibilities around a particular nuclear facility to expedite their program development.

In my course of travels throughout the Region, I have reviewed and made recommendations to each of the State health departments or State environmental agencies relating to the development of their

laboratory and environmental programs. In meeting with these people throughout the Region, I have had the opportunity to evaluate their needs, relative to the increasing nuclear activities within the States, including the pending site selections and construction of various nuclear facilities, and the resources that these States have to meet specific environmental surveillance data requirements. In doing so, I have tried to assist them in such a way that they will be prepared for these responsibilities, both in handling the quantity of data being prepared but also being able to assure that these data are being prepared in a quality manner.

I have encouraged each of these States to relate as closely as they possibly can to the regional radiation office, Eastern Environmental Radiation Laboratory in Montgomery, and the Western Environmental Research Laboratory in Las Vegas.

These EPA laboratories have, through their activities for many years, been maintaining quality control activities, and one point that I think cannot be overemphasized is that as these data are being acquired for purposes of dose assessment, every effort should be maintained to keep these data as high quality as possible. We know that there is great difficult in calculating dose assessments and, therefore, every effort that can be maintained to minimize data error would increase the credibility of the dose value when it is ultimately obtained.

Specific attention is being given by this regional project to South Carolina which is at the present time planning or has planned for the construction of a considerable number of nuclear facilities, not just power plants, but fuel reprocessing plants and fuel fabrication plants. As part of our responsibility within the Region, I plan to provide them with as much assistance in the near future as I possibly can. We have recently held a Data Radiation Data Management Symposium in Mobile, specifically for the Region States. One of the primary purposes was the interaction of the activities of these States within the areas of data management.

A good example of this interaction was Florida's need for a Least Squares Gamma Spectrum Analysis Computation Program last year. This program is operational at the TVA Environmental Laboratory in Muscle Shoals, and therefore, readily available for use by other environmental programs.

Dr. Oppold's staff provided me with the program, and in turn I made it available to Florida. The Florida Data Center staff discovered that this program was not compatible with their present equipment system and in turn gave permission through the administrative structure of Florida for the Radiation Laboratory in Orlando to obtain the use of a minicomputer for the calculation of this type of analysis.

The use of Least Squares Analysis should be considered by everyone in the environmental field. It has several additional advantages over other techniques, one of which is that it enables you to compute confidence limits on your reported value. This is a

tremendous help since the promulgation of the errors involved in determining these limits in the case of a multinuclide analysis can be very complicated.

The National Environmental Radiation Monitoring Program's acquisition of data for the purpose of dose assessment calculation will be requesting data from both State and nuclear facilities programs. Confidence limits on all data will be required to enable the determination to be made that the quality of data is credible. The acquisition of confidence limits is dependent upon the computation capability of each State and each nuclear facility to provide these values and be able to show that these are reliable. How can we approach the credibility of dose assessment values if we do not start by accumulating the best quality values when the individual environmental analysis is predefined. We have to start with quality because we are going to find out that the promulgation of errors is fantastic. I emphasize this because the Office of Radiation Programs is interested in obtaining these values, thereby enabling an estimate of confidence to be made on dose values.

I am working primarily with the State programs at the present time; however, I am sure nuclear facilities requesting assistance from the regional radiation office relevant to data management and EPA request for data would be provided consultation.

On a broader scope than just Region IV State radiological data management, I recently conducted a survey of all the States in the country attempting to obtain an inventory of the current ADP equipment

which is available to the States. Also included was a brief cursory look at their environmental program activities and also to their X-ray data management. I inquired into the use of optical scanning equipment in both the environmental and X-ray fields.

It might be interesting to note that one of the major problems associated with getting intelligence from the field--in this case, we are talking about environmental laboratory analysis data--is obtaining data in a manageable form. In many States, this has become quite a problem. Radiological health, I am sorry to say, in many States is a very low priority program. You find that you are waiting for every other program in the health department to receive service. This may seem to be a very small problem, but when a man has to wait 3 or 4 weeks just to get a stack of cards punched, it seriously delays his program. In one State, they train their key punch operators on the radiation data forms. Well, right there you begin to realize that radiation does not have top billing. It is very important to be able to have a system that will take radiation intelligence, quality intelligence, and put it in a manageable form so that the agency can evaluate this data in light of their own program objectives, to meet their own responsibilities.

The collection of data for data sake is something which has been done for years. If you ask a question relative to a particular piece of data and you say "why have you collected it," the reply is usually, "well, we have always collected it." This does not hold true anymore.

You have got to clean the files, see what is worthwhile, and if it is not, it should not be collected any longer. If it is worthwhile data, you should be able to utilize it toward your program objectives.

As many of you are aware, these are hard times financially, particularly at the State level, and great is the need to justify our radiation program's expenditure of public funds. You cannot count bodies in the environmental field, thank goodness. The only thing you have got to turn to or draw from is the radiation data bank which you have developed. This data bank has go to be clean, manageable, and it has got to be of quality. What I am emphasizing is the need to develop radiation management information systems to provide you with this capability.

The Region IV Environmental Radiation Branch stands ready to assist any radiation program in better management of its data. Please let us know if we can assist you in responding to EPA's National Monitoring Program requests or any other data application.

WASTE MANAGEMENT

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Power Generation Division
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Introduction

Waste management is defined as the handling and control of wastes. It is based on law, shaped by experience, and limited by cost. This paper deals with waste management in a light-water reactor and describes new equipment designed to further reduce the already low waste discharges from a nuclear steam system (NSS).

The waste handling systems currently used with an NSS provide controlled handling and disposal of radioactive liquid, gas, and solid wastes. The equipment in these systems collects and discharges waste liquid and gas under controlled conditions to meet the limits of Title 10, Code of Federal Regulations, Part 20 (10 CFR 20). In fact, these systems discharge only a small fraction of the amount allowed in 10 CFR 20. Operating experience in 1969 shows that out of 13 operating plants, eight released less than 0.1% of the limit, three released less than 1%, one released 3.6%, and one released 31%.

B&W now offers a waste retention system consisting of the standard waste disposal system plus add-on components to further reduce environmental discharges. The add-on components are designed for maximum recycling of materials within the plant and for purification

of waste gas. Solid wastes are concentrated in special drums, which also serve as shipping containers. This arrangement reduces the number of drums as well as the time required to package solid wastes. Thus, B&W's waste retention system will restrict NSS waste discharges to "as low as practicable."

Discharge Limits

The U.S. Government's limits for radioactive waste discharges are listed in 10 CFR 20. These values were previously set by the Federal Radiation Council (FRC) until the newly formed Environmental Protection Agency (EPA) took this responsibility on December 2, 1970. The basis for these limits is that the concentration of radionuclides in air or water will not result in doses greater than one-tenth of the occupational dose limit.

Liquid discharges for an NSS are set to maintain concentrations below 10 CFR 20 values as measured at the point at which the liquid stream leaves the plant's boundary and enters an unrestricted area. Limits on gaseous releases are individually set for each plant on the following basis: calculation of the release rate, which at the point of highest radiation level averaged over a year, would result in exposure to an individual equal to FRC radiation protection guide limit of 500 mRem if the individual stood at the site boundary for the entire year.

Sources

Under normal operating conditions, the sources of radioactive wastes are fission products and activated corrosion products. Fission

products in the reactor coolant result from uranium contamination on fuel cladding surfaces and from fuel pin defects. The NSS is designed to operate normally with up to 1% fuel defects. The corrosion of NSS surfaces exposed to primary coolant causes some corrosion products to be dispersed into the reactor coolant. These corrosion products then pass through the reactor core and are irradiated to form activated corrosion products. The portion that is not dissolved tends to settle in low-flow areas and produce undesirable high-radiation areas. Activated corrosion products that are dissolved in the coolant are removed by purification demineralizers, and solids are removed by purification filters. One reactor coolant volume is processed through the demineralizers and filters daily. Further activity is removed during normal feed and bleed operations which are performed to change the concentration of boric acid in the primary coolant. One typical plant operation that produces radioactive wastes is as follows:

Waste Generation from Chemical Shim and Maneuvering--Power level changes produce xenon transients which are then compensated by changing the concentration of boric acid in the reactor coolant. This change is accomplished by diluting (deborating) or concentrating (borating) the reactor coolant. As the concentration of boric acid is decreased during core life to compensate for fuel depletion, the amount of water that the makeup and purification system must process increases because the change in boric acid concentration for a given transient is constant. The makeup and purification process water requirements also increase

as the magnitude of power level changes increases. Both of these points are illustrated in Figure 1.

Borated reactor coolant letdown to the makeup and purification system results in liquid, solid, and gas waste. Boric acid is separated from the reactor coolant by evaporation or ion exchange. Either process produces solid wastes. As the borated reactor coolant is depressurized, waste gas is released from solution. This gas must then be processed for ultimate disposal. Thus, the total quantity of process waste over one fuel cycle is a function of the number of power level changes. By reducing the magnitude and limiting the number of changes late in life, waste generation can be minimized.

Operating Experience

Experience has shown that proper waste management and reasonable safety precautions lead to low environmental discharges. Three boiling water reactors (BWR) and five pressurized water reactors (PWR) have been selected to illustrate this point (Table 1).

The PWRs using boric acid in the reactor coolant have higher environmental discharges of tritium than do comparable BWRs. Table 2 compares BWR-PWR tritium discharges. At present there are no economical tritium separation methods.

BWRs do not have a secondary system between the reactor and the turbine as PWRs do. Without this secondary system, radioactive gases dissolved in the primary coolant are continuously discharged from the condenser air ejectors to the environment via the gaseous waste system. Consequently, gaseous releases from BWRs are much larger

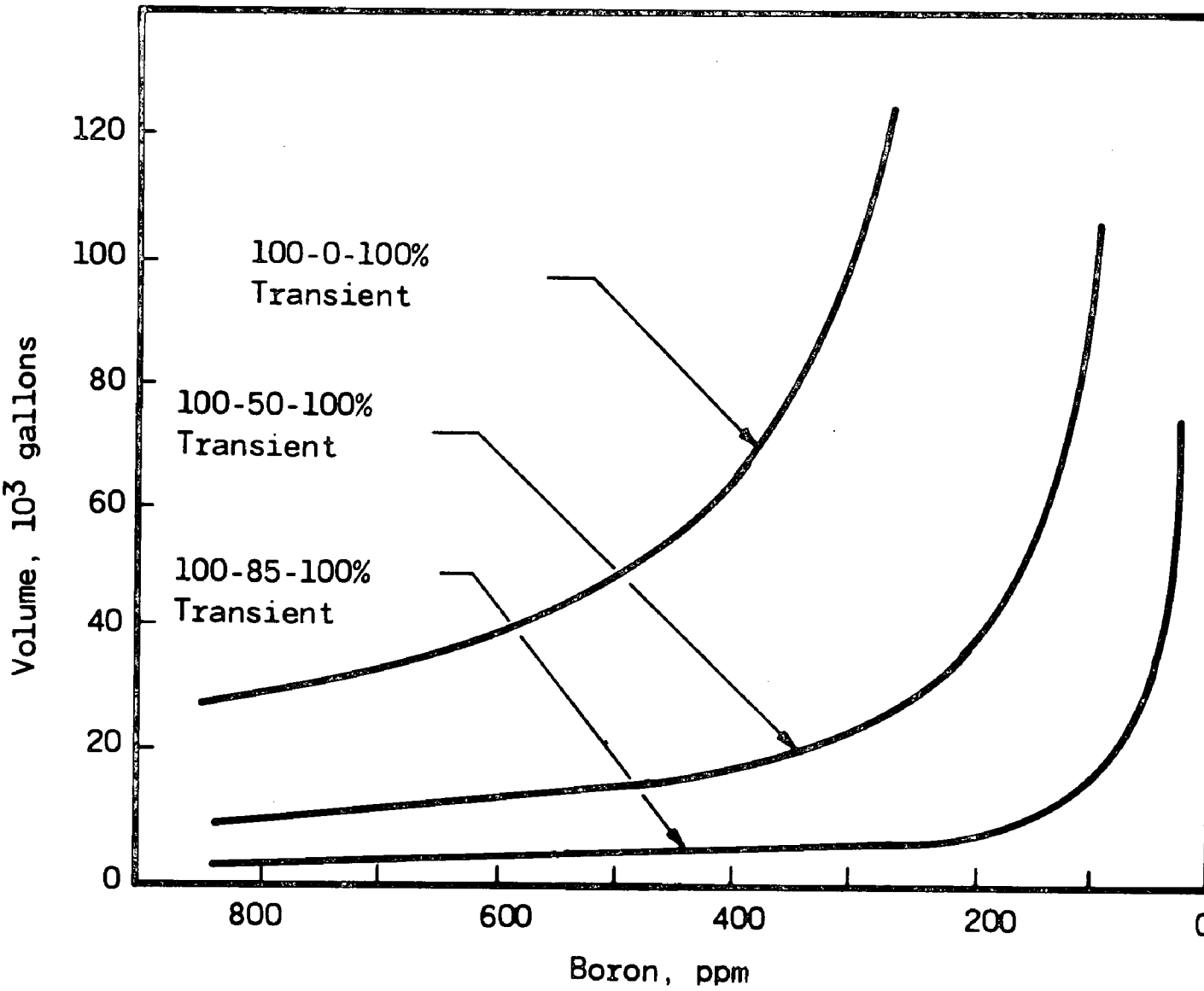

Figure 1. Chemical Shim Volume and Flow Requirements for Power Transients over One Fuel Cycle - 1000 MWe Plant.

TABLE 1

GENERAL INFORMATION FOR COMPARISON FACILITIES

Facility	Power Level Net, MWe	Stack Exhaust Rate, cfm	Condenser Water for Dilution Flow Rate, gpm
PWRs			
Shipping-port	90	9,000	114,000
Yankee	175	15,000	138,000
Indian Point-1	265	280,000	300,000
San Onofre	430	40,000	350,000
Connecticut Yankee	573	70,000	372,000
BWRs			
Dresden-1	200	45,000	166,000
Big Rock Point	71	30,000	50,000
Humboldt Bay	68	12,000	100,000

TABLE 2.
1968-1969 AVERAGE TRITIUM DISCHARGE IN LIQUID WASTES

Reactor	Curies	% of Limit
Pressurized Water Reactors		
Shippingport	30.13	0.005
Yankee	1456.00	0.145
Indian Point-1	577.25	0.057
San Onofre	2925.00	0.155
Connecticut Yankee	2387.00	0.160
Boiling Water Reactors		
Dresden-1	4.45	0.002
Big Rock Point	31.00	0.011
Humboldt Bay	86.50	0.001

than releases from PWRs. Gaseous discharges from operating plants are given in Table 3.

Based on these data, liquid waste discharges do not seem to be related to the type of reactor or the power level. The amount of liquid waste generated depends largely on the integrity of the fuel cladding and the corrosion of the reactor coolant system's surfaces. Table 4 lists liquid waste discharges for the two types of plants.

Off-Site Disposal

The AEC has the regulatory responsibility for controlling, handling, and disposing of radioactive waste material. A land burial site may be established only on land owned by the government (federal or state). The AEC also has authority to enter into agreements with individual states to transfer its regulatory responsibility for the disposal of radioactive wastes within a state. The AEC has entered into 22 such agreements. Two commercial radioactive waste disposal companies are in operation in the United States; their five commercial burial sites are shown in Figure 2 .

The cost of waste management is increasing because of the increasing number of nuclear plants and the more stringent disposal requirements. The cost for NSS waste burial is about $1/cu ft except for resin, which is about $50/cu ft. Figure 3 shows the cumulative quantities of NSS waste buried since 1962. It is estimated that the annual volume will reach 6 million cubic feet by 1980.

TABLE 3. ANNUAL GASEOUS WASTE DISCHARGED

Reactor	Curies	% of Limit
Pressurized Water Reactors		
Shippingport	0.058	0.143
Yankee	4.57	0.068
Indian Point-1	109.40	0.003
San Onofre	89.60	0.016
Connecticut Yankee	64.58	0.340
Boiling Water Reactors		
Dresden-1	395,266	1.16
Big Rock Point	191,826	1.11
Humboldt Bay	389,241	24.60

TABLE 4. ANNUAL LIQUID WASTE DISCHARGED, GROSS LESS TRITIUM

Reactor	Curies	% of Limit
Pressurized Water Reactors		
Shippingport	0.158	0.70
Yankee	0.019	0.047
Indian Point-1	21.74	17.50
San Onofre	3.31	5.60
Connecticut Yankee	5.37	2.25
Boiling Water Reactors		
Dresden-1	5.22	15.10
Big Rock Point	5.75	31.60
Humboldt Bay	1.84	1.04

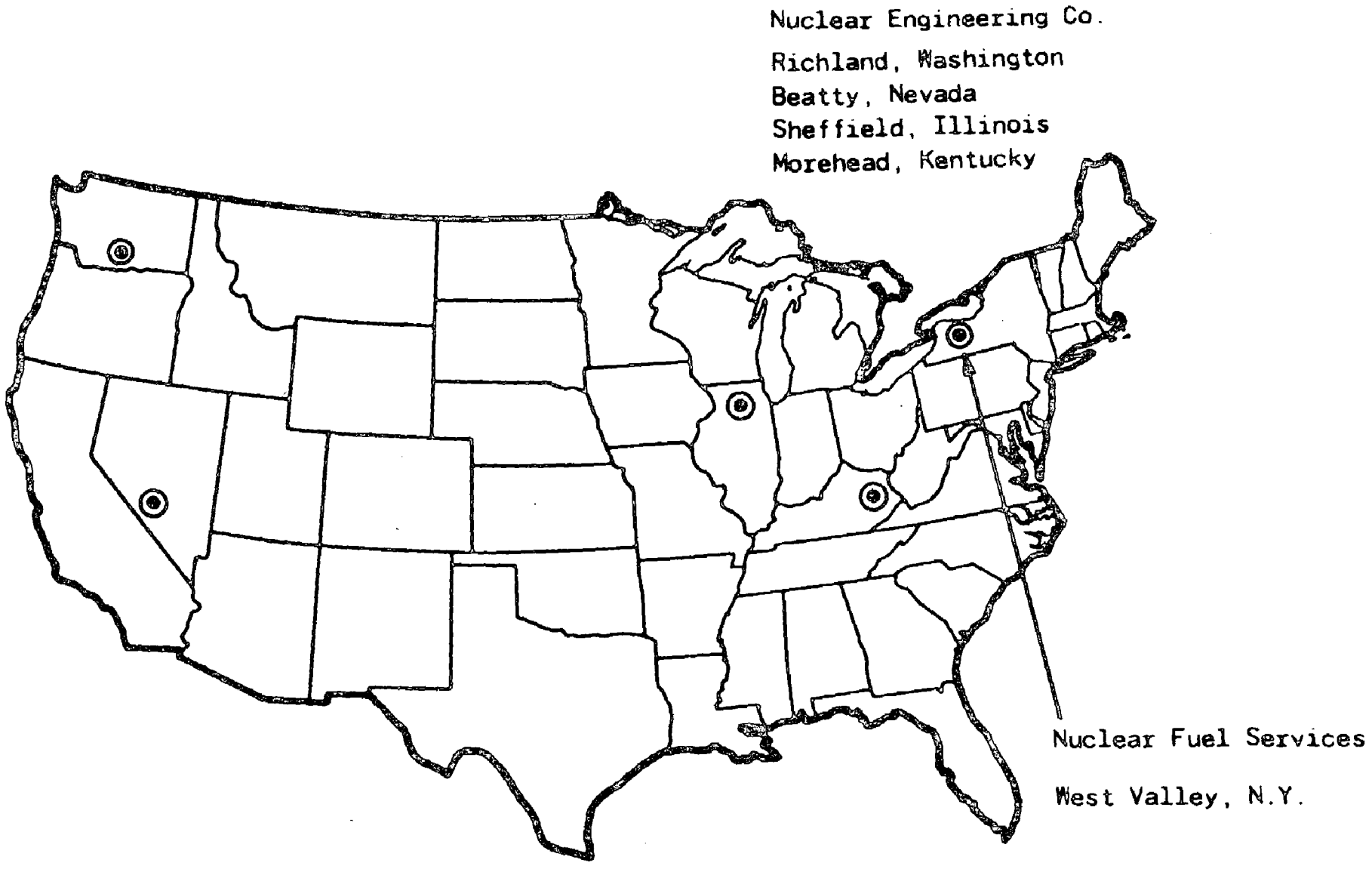

Figure 2. Commercial Waste Burial Sites.

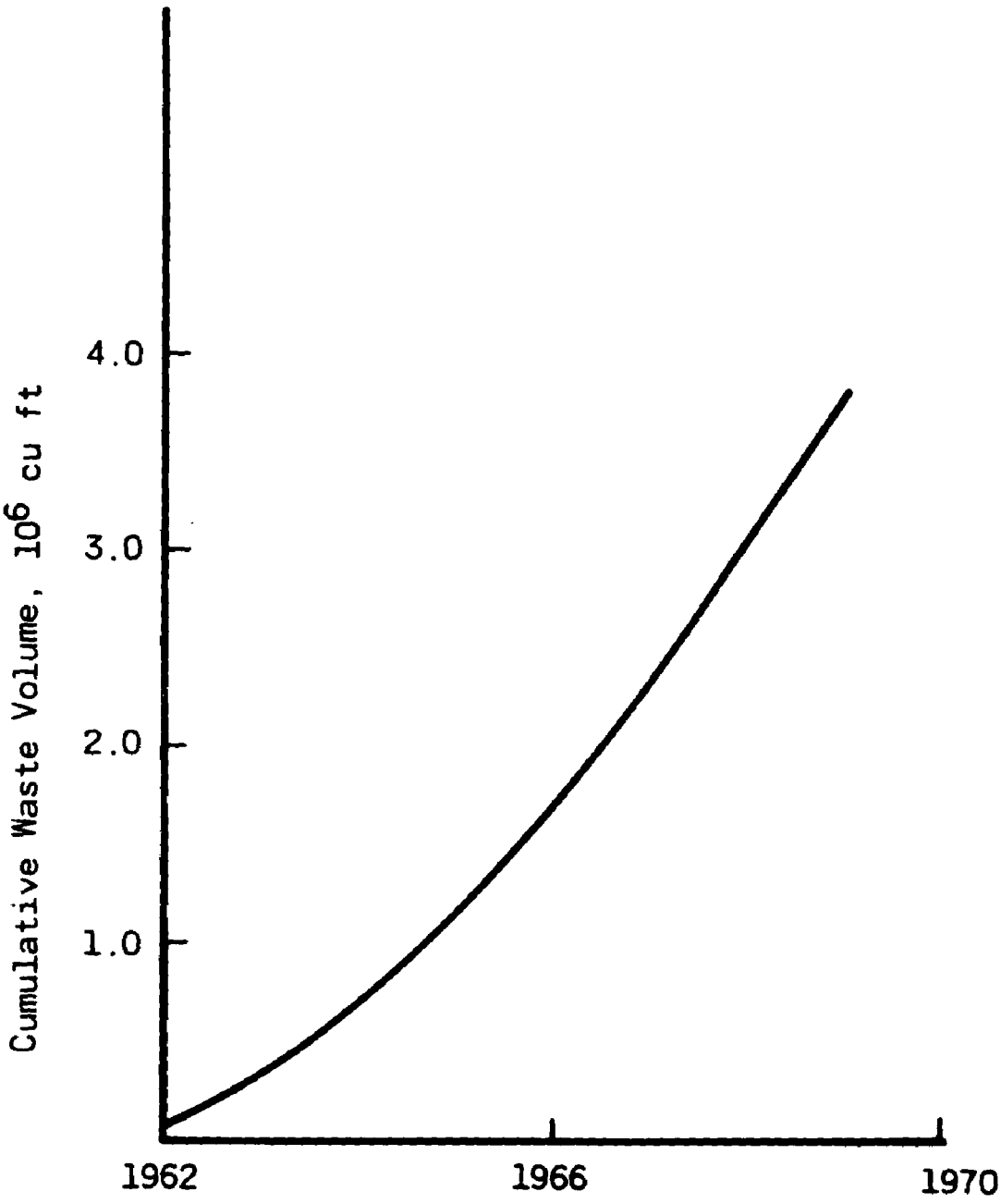

Figure 3. NSS Waste Burial Quantities.

The Atomic Energy Commission is studying methods for the disposal of gaseous krypton-85. One proposal suggests storage in pressurized gas cylinders located in salt mines. This method is estimated to cost about $2000 per fuel cycle for a 1000-MWe plant. This is burial cost only and does not include the cost of separating krypton from other waste gases.

Tritium-water separation equipment has not been developed for use in the nuclear industry, but it may be on the market soon. Such equipment will probably be a multistage device similar to that used to separate heavy water from ordinary water. The current cost of heavy water is about $425 per gallon. Although no cost figure for tritium-water separation is given here, it is obvious that the cost will be extremely high.

Additional restrictions will further increase the cost of NSS waste systems. For example, if we had to eliminate the NSS containment purge during refueling, a new generation of equipment would be required.

B&W Waste Retention System

This system comprises the standard waste disposal system plus add-on components designed to restrict environmental discharges to "as low as practicable." The equipment is designed to process wastes due to plant operation with 1% failed fuel.

Solid Waste--

Solid wastes accumulate from spent resins, evaporator bottoms, plastic bags, paper, etc. A conventional waste compactor is used to

drum low-activity waste such as plastic, paper, and the like. The unique drumming device shown in Figure 4 is used to process spent resins and evaporator bottoms. After being automatically loaded into drums containing an internal filter, the waste is filtered by gravity. The drums are automatically refilled, as water passes through them, until the filter contains a cakelike mass of solid waste. The top of the drum is then sealed, and the package is ready for shipping. Thus, the drum serves as a collection tank and as a shipping container, and handling and shipping operations are minimized.

The drumming station operates automatically and utilizes a series of drums that are classified according to the radioactivity level of the contents. The probability of spillage occurring during loading is not nearly so great as with the cement-vermiculate technique. Portable shielding around the drums further protects operating personnel from exposure.

Liquid Waste--

Liquid wastes are collected from operations such as coolant sampling, sluicing and regeneration of resins, backflushing filters, primary coolant leakage, and equipment decontamination. To lower its activity, liquid waste is collected and processed through standard filters, evaporators, and demineralizers. The resultant water is recycled for reuse.

Gaseous Waste--

Figure 5 gives a block diagram of the gaseous waste tanks. Gaseous wastes are collected in two separate vent headers--one nitrogen rich

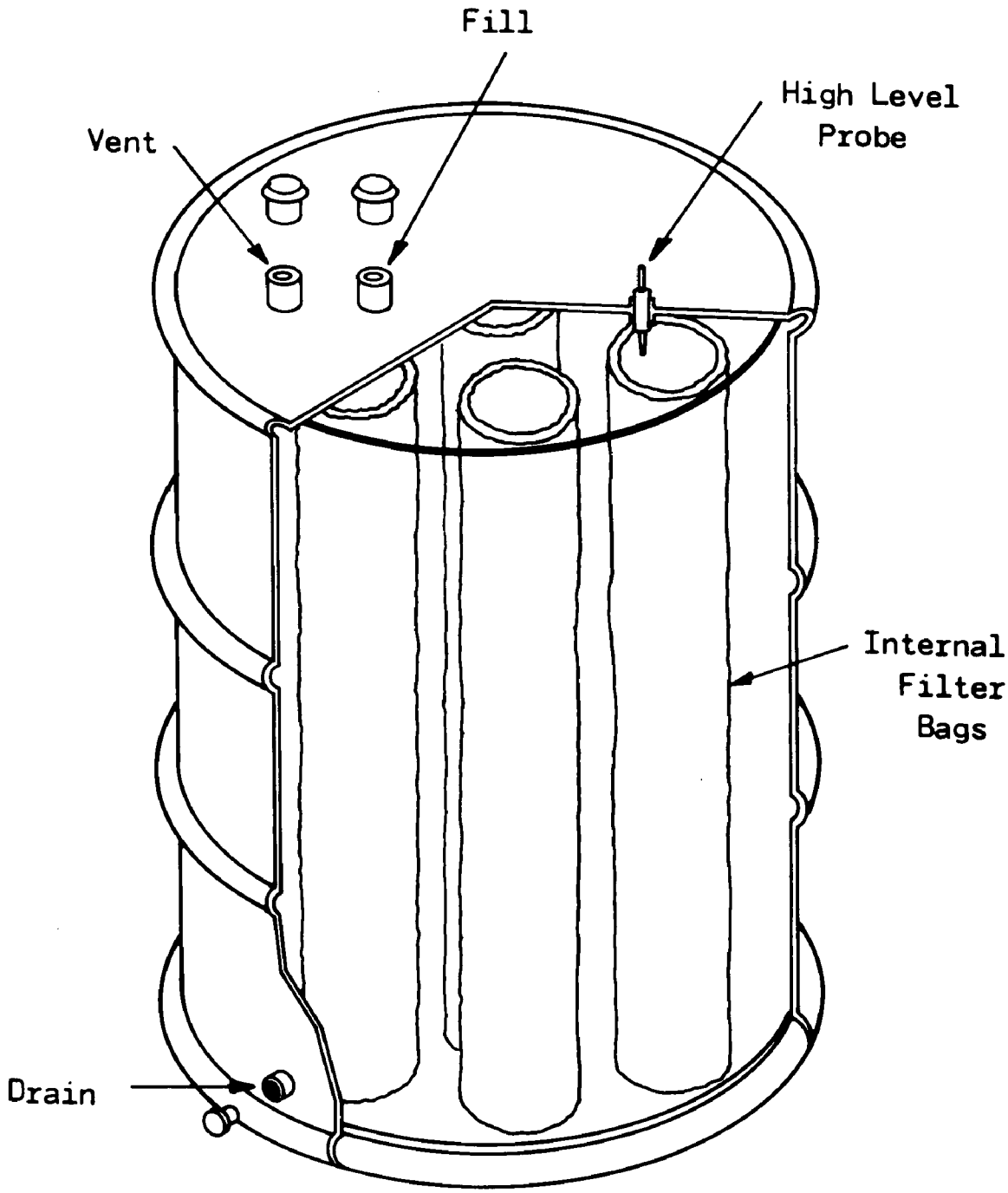

Figure 4. Solid Waste Drum which Serves as a Collection Container and Shipping Container.

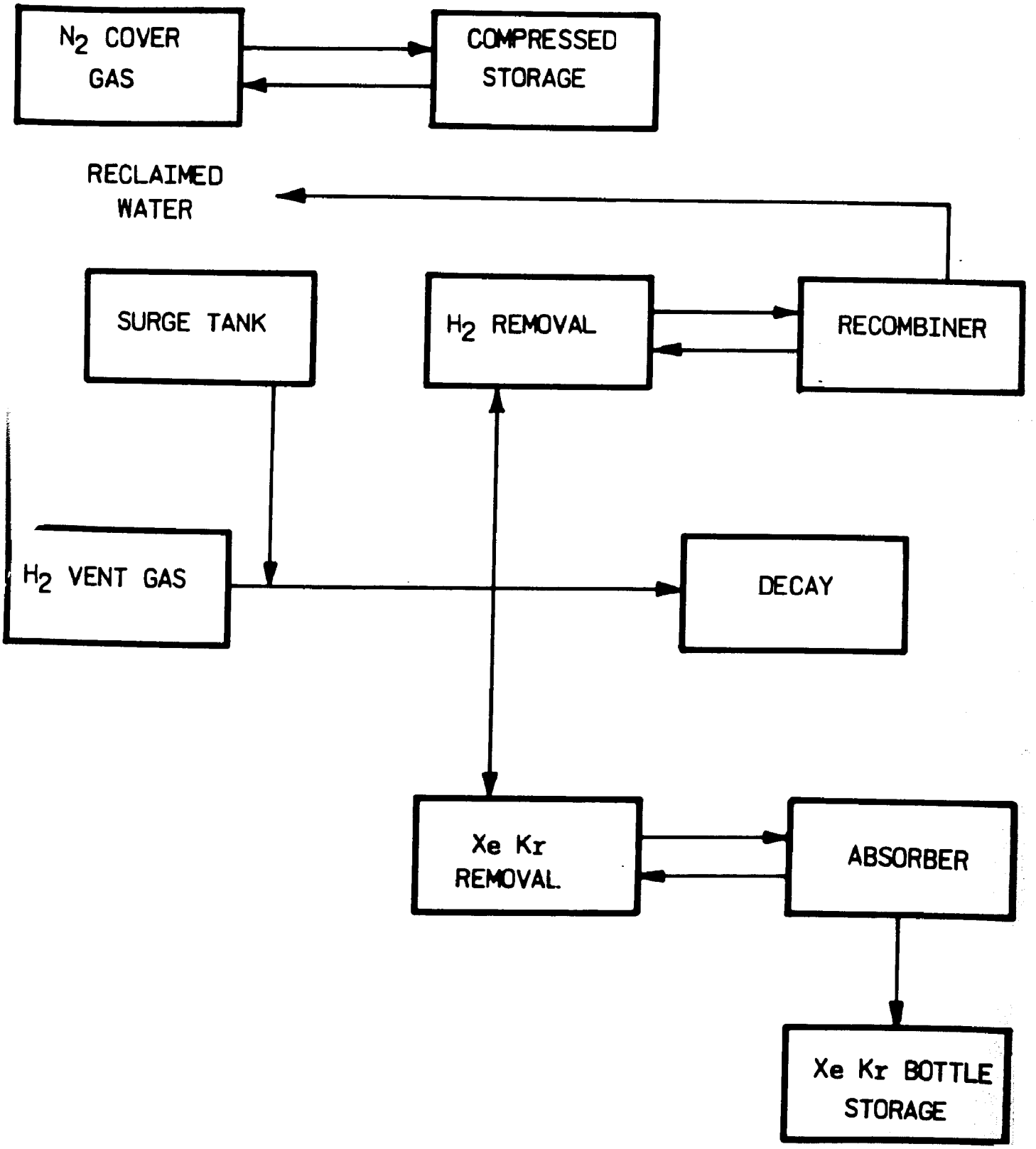

Figure 5. Waste Retention System - Gas

and the other hydrogen rich. The nitrogen vent header collects cover gas from the liquid storage tanks, and the gas is recycled as required. Thus, the nitrogen-rich vent gas is recycled in a closed system to minimize the generation of waste gas.

The hydrogen vent header collects hydrogen-rich waste gas from depressurized reactor coolant. The header feeds into a compressor and surge tank, where the hydrogen gas is temporarily stored. After a sufficient quantity has been collected, the hydrogen gas is transferred to a decay tank, which contains enough nitrogen to dilute the hydrogen to about 3%. The decay tank is then valved to the hydrogen recombiner and recycled to remove hydrogen. This equipment uses a catalyst to chemically combine hydrogen and oxygen to form water, which is recycled to liquid storage for plant use. This process is repeated until the xenon-krypton concentration in the decay tank warrants processing with the xenon-krypton absorber. The contents of the decay tank may be allowed to decay further, or they may be promptly directed to the xenon-krypton absorber shown in Figure 6. The absorber removes xenon and krypton from the waste gas by contacting it counter-currently with Refrigerant-12 in the absorber column. The xenon-krypton rich Refrigerant-12 is then directed to a fractionating column, while the xenon-krypton lean gas is returned to the decay tank. In the fractionating column, the Refrigerant-12 is heated to drive off the xenon and krypton for storage. The Refrigerant-12 is then returned to the absorber column and the cycle is repeated.

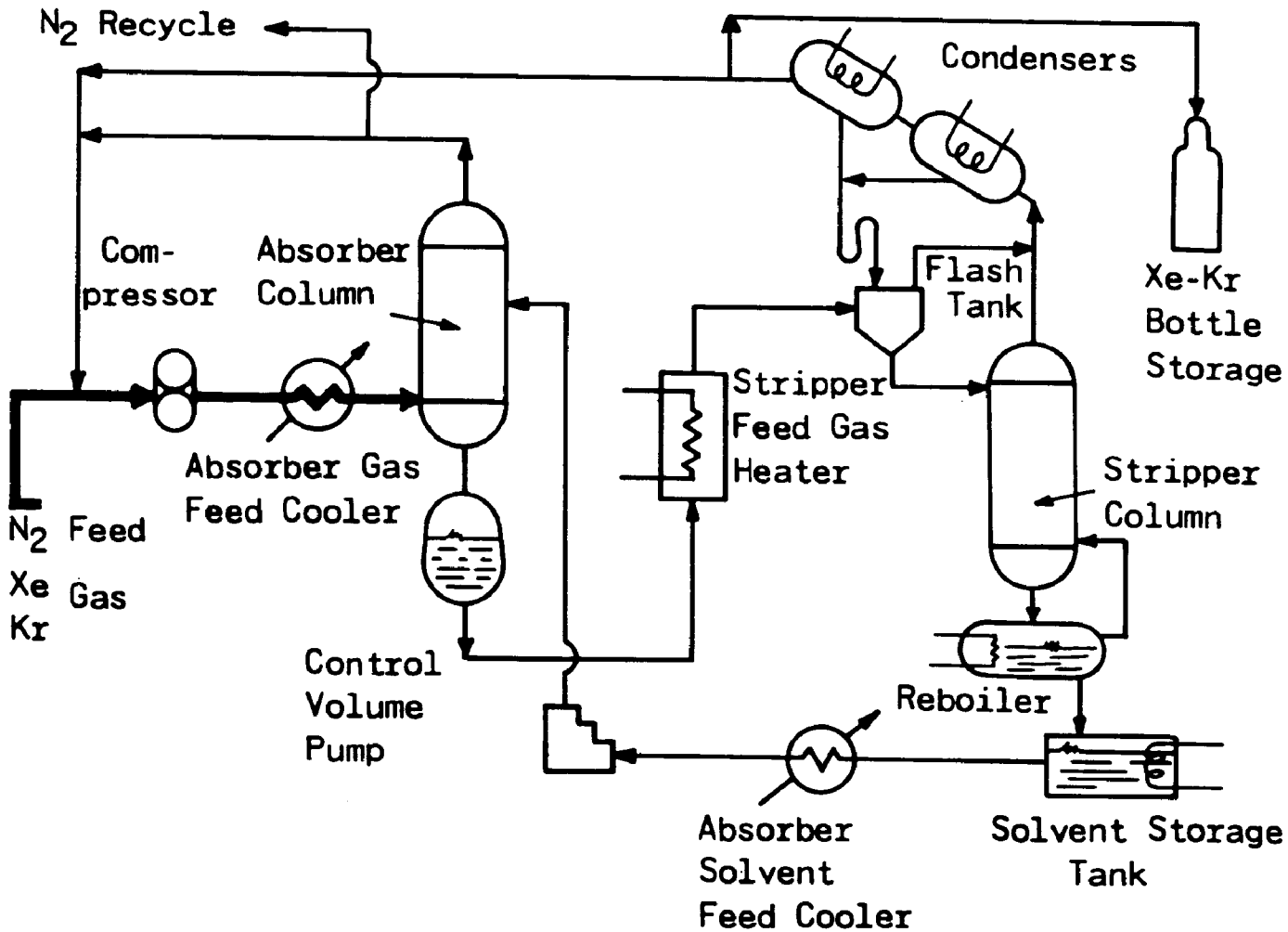

Figure 6. Xenon Krypton Absorber.

The hydrogen vent header gas treatment equipment may be used to process the nitrogen vent header gas.

Problem Isotopes

Of the many isotopes produced in a light-water reactor, only two may be considered as problem isotopes: Both krypton-85 and tritium have long half-lives and are difficult to separate from waste streams. They create problems mainly in fuel reprocessing plants rather than in power plants because both are fission products that largely remain within the fuel.

Even without failed fuel, krypton-85 exists in the primary coolant. This fission product is produced from "tramp uranium" left on the surface of fuel pins during manufacture. The level of krypton-85 activity in the primary coolant from this source is about 0.003% of the level expected with 1% failed fuel. One fuel pin is equivalent to about 0.003% of the total number of fuel pins and would thus produce about the same degree of primary coolant activity as the tramp uranium would. Krypton-85 is separated from waste gas using the xenon-krypton absorber and is then stored in gas cylinders. Less than one cylinder of storage capacity is required per year if the xenon-krypton absorber is used.

It has been estimated that the amount of krypton-85 in the earth's atmosphere will reach the 10 CFR 20 limit of 3×10^{-7} $\mu Ci/cm^3$ by the year 2050 assuming the following:

1. Essentially all electricity (50 billion kWe) is produced by nuclear power plants.

2. All the krypton-85 is released and diluted in only one-fourth of the earth's total atmosphere.

This amount of krypton-85 would result in a dose of 7 mRem to the whole body, 500 mRem to the surface of the body, and 300 mRem to the skin. The dose of 7 mRem may be compared to the whole body dose limit of 500 mRem/year given in 10 CFR 20.

This information is presented neither to justify nor to disqualify the need for krypton-85 separation equipment, but to provide a "worst case" result. Note that more than 99% of the krypton-85 discharged will be from fuel processing plants, while less than 1% will be from nuclear power plants. The xenon-krypton absorber will be readily adaptable to fuel processing plants as well as to nuclear power plants.

Tritium in the primary coolant is produced from ternary fission and neutron irradiation of boron-10, lithium-6, and deuterium. The major source of tritium in the reactor coolant of a PWR is boron-10 in the soluble poison, boric acid. Since tritium cannot be readily separated from water, it tends to concentrate in the reactor coolant. The concentration becomes a problem when the level of tritium in the containment air (from water vapor) approaches the 10 CFR 20 limits; tritium in the reactor coolant must then be diluted. Figure 7 shows the increase of tritium in the containment building for various values of fuel cladding leakage. Assuming a 1% leakage of tritium from fuel cladding, the reactor coolant would have to be diluted once or twice during the lifetime of the NSS.

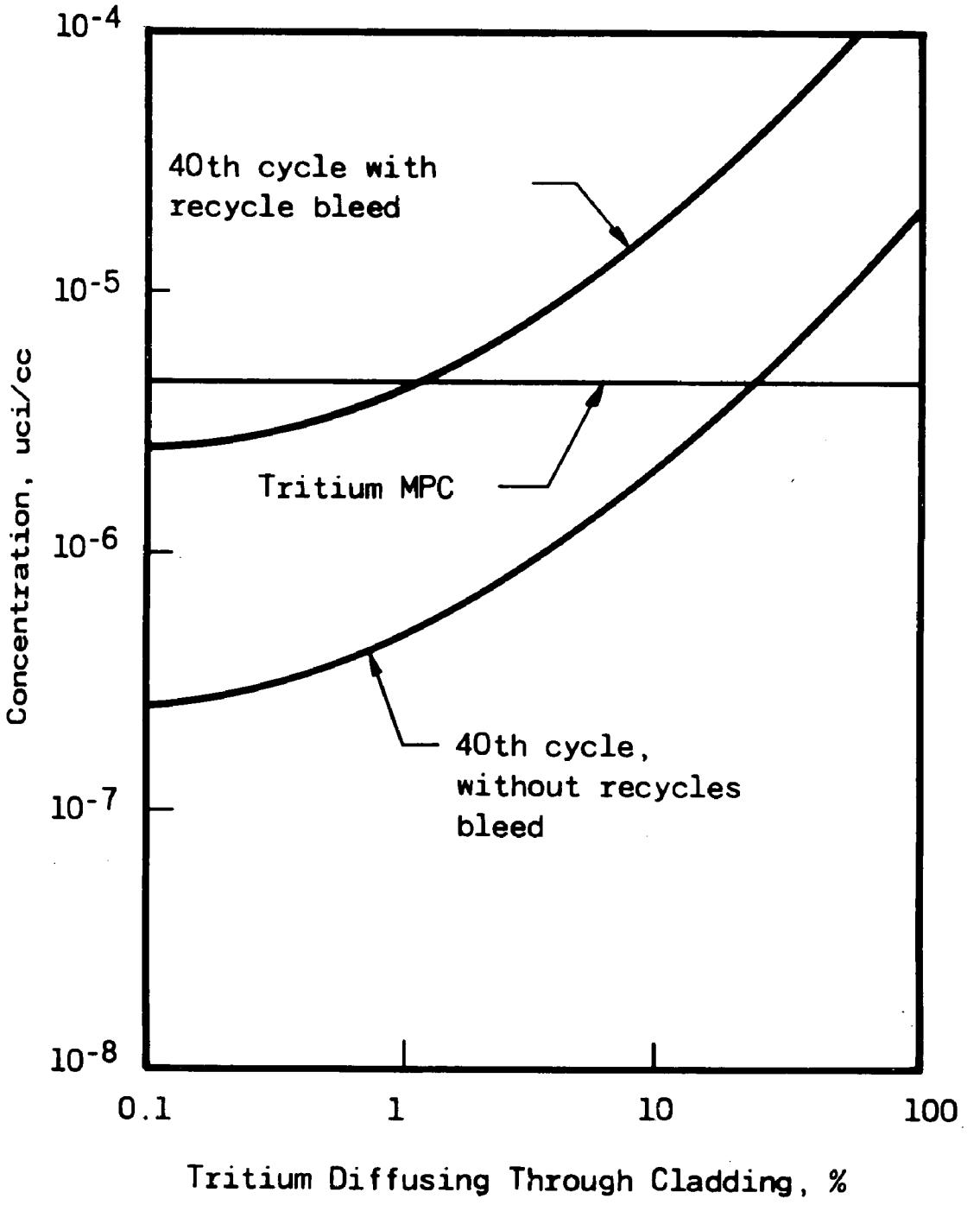

Figure 7. Tritium Concentration in Containment Air.

We must then consider the possibility of increasing the risk of exposure to the operating staff during refueling. Much work has been done to assess the biological effects of tritium; the biological concentration of tritium, the concentration of tritium in the protein-building blocks of the DNA molecule, and the concentration of tritium in the food chain have been studied. The results indicate that these factors do not significantly increase the dose that might be expected from a given concentration of tritium in the environment.

Assuming that refueling takes about 20 days and that the tritium in the refueling water is at the maximum level, an operator could expect to receive about 1% of the annual dose limit during refueling.

It has been estimated that the probable dose to the population from tritium produced by nuclear reactors will be about 0.001 mRem/year in the year 2000; the comparable dose produced from weapons testing will be 0.1 mRem/year. These values may be compared with the current whole-body dose limit of 500 mRem/year.

PWR NUCLEAR POWER PLANT SYSTEMS FOR REDUCING RADIOACTIVE RELEASES

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Introduction

In practice, releases of radioactive products from nuclear power plants to the environment have been carefully controlled and well below plant design levels. This paper describes further system improvements in the control of radioactive products in Pressurized Water Reactor designs. These designs are based on the philosophy of concentration and long-term storage, as opposed to dilution and release to the environment. This advanced Pressurized Water Reactor design represents an integrated systems approach to the control of reactor effluents within the plant and the eventual processing of plant effluents. The Pressurized Water Reactor is uniquely qualified to achieve a substantial minimization of releases of radioactivity to the environment.

The fissioning process which provides the heat in nuclear reactors also produces radioactive byproducts which are confined and controlled to ensure the safety of plant personnel and the general public. From the beginning of the nuclear power industry, great emphasis has been placed on plant design features and plant operating procedures affecting radioactive releases to the environment.

Such releases are also the subject of federal regulations. The basic philosophy governing radioactive releases is derived from national and international guidelines set by the Federal Radiation Council, the National Council on Radiation Protection and Measurements, and the International Commission on Radiological Protection. Definitive requirements are set by the Code of Federal Regulations of the United States Atomic Energy Commission which establishes both the limits on radioactive releases and the objective that every reasonable effort be made to keep releases of radioactivity "as low as practicable." It is the joint responsibility of the nuclear plant designer and the plant operator to not only assure control of radioactive releases to the environment to within permissible levels but to endeavor to maintain actual releases significantly below such levels.

Reactor operating experience in the United States has been outstanding. Actual releases to the environment from reactors have only been a fraction of the permissible levels set by federal regulations. The United States Public Health Service, for example, carried out extensive long term studies of the environs of three power reactors, including the Pressurized Water Reactor of the Yankee Atomic Power Station at Rowe, Massachusetts. This report concludes that after 10 years of operation, no evidence can be found that operation of the plant has increased the exposure of the surrounding population above that received from natural sources. In fact, the entire industry has an exceptional safety record. There have been no instances of a

radiation casualty of any member of the public or any plant worker due to operation of a commercial nuclear power plant. This record has been established while producing billions of kilowatt-hours of electricity and while accumulating over 75 reactor-years of commercial operation. No other industry in history, beginning from scratch, has chalked up such an impressive record.

System Concept

Industry has not stood on this record but has continued to monitor reactor experience and to innovate improvements. Last year Westinghouse announced the development of an improved system for reducing radioactive releases from Pressurized Water Reactor Nuclear Power Plants. This system has variously been referred to as the "minimum release" plant, the "essential zero release" plant and the "environmental assurance system." But regardless of the name, the concept of the new system represents a basic change to waste management philosophy applied to nuclear power plants. Where here-to-fore all nuclear power plants, both pressurized and boiling water reactors, handled liquid and gaseous radioactive wastes on a dilution and dispersion basis, the new system processes liquid and gaseous radioactive wastes on a concentration and storage basis.

During normal operation of a Pressurized Water Reactor Plant with this new system, there is essentially no intentional release of radioactivity to the environment. With the new system, radioactive wastes are concentrated into manageable quantities and retained within closed plant systems for extended periods of time. The system has the potential

for retention of radioactive liquids and gases within the plant over the entire operating life of the plant.

The key features of the new design are a basic change in the method of handling boric acid and changes to the waste liquid and waste gas processing systems to achieve recycle of radioactive liquids and gases within the plant. Boron concentration changes in the reactor coolant are effected by using a new development called boron thermal regeneration. Thermal regeneration refers to the use of ion exchange resins to either retain or release borate ions as a function of temperature. Thermal regeneration ion exchangers in effect act as a sponge to soak up or release borate ions.

The new Waste Gas System is designed to concentrate and store radioactive gases. The system also includes a new feature which maintains a significantly low level of dissolved gases in the Reactor Coolant System than in previous designs. These functions are performed by use of hydrogen as a carrier medium for the small quantities of radioactive gases.

The Waste Liquid System is designed to process and recycle radioactive liquids back into the plant systems. Since in previous designs liquid wastes were to be ultimately diluted and discharged, they were usually collectively gathered. Utilizing experience from operating plants, liquid wastes are now collected on a strictly segregated basis by radioactive and non-radioactive sources. In this manner, tritium can be retained and stored within the plant on a long term basis.

This waste management philosophy and the processes for handling radioactive liquids and gases are tabulated in outline form on Table 1.

Boron Thermal Regeneration

In the Pressurized Water Reactor, any activation products or fission products, which may be released in the event of clad defects, are initially retained within the Reactor Coolant System. Ionic and particulate activities are removed in the Chemical and Volume Control System, which processes a side stream from the Reactor Coolant System by demineralization and provides for the addition of hydrogen to the reactor coolant for corrosion inhibition.

The reactivity of the core with long term burnup and load follow variations is controlled by changing the boron concentration in the Reactor Coolant System. Reactor coolant discharged from the Reactor Coolant and Chemical and Volume Control Systems is processed and recovered by the Boron Recycle System. This sub-system consists of holdup tanks, demineralizers, and an evaporator which separates and concentrates the boric acid from the reactor coolant stream. The distillate and concentrates from the evaporator are reused in the Reactor Coolant System to change the coolant boric acid concentration. The inter-relationship of these systems is shown schematically on Figure 1.

A principle development in the new design is the incorporation of boron thermal regeneration, wherein the boron changes in the reactor coolant required by load follow operations are achieved by the use of ion exchangers.

TABLE 1

WASTE MANAGEMENT PHILOSOPHY AND PROGRESS

	Previous Design	New Design
Radioactive Gases		
During Normal Operation	Separated from coolant by evaporation, heldup for decay, diluted and released to environment.	No intentional release to environment. Retained with systems. Concentrated and long term storage.
Containment Purge for Refueling	Diluted and released to environment.	Same process but activity less because of lower coolant activity.
Radioactive Liquids		
Tritiated Liquids	Intentional dilution and release to environment.	Operating experience demonstrates lower tritium in coolant with Zircaloy cores. Segregated drains and recycle. Long term storage feasible.
Solids	Waste ion exchange resins, filters and waste evaporator concentrates shipped offsite.	Additional waste resins from boron thermal regeneration shipped offsite.

This system is based on the fundamental property of ion exchange resins that ionic capacity varies with temperature and that the process is reversible. The system is capable of handling boron changes associated with load follow cycles comparable to those previously accommodated by large evaporators.

Figure 2 is a plot of boron concentration versus resin capacity for the operating temperature range of the system, 50°F and 140°F. In

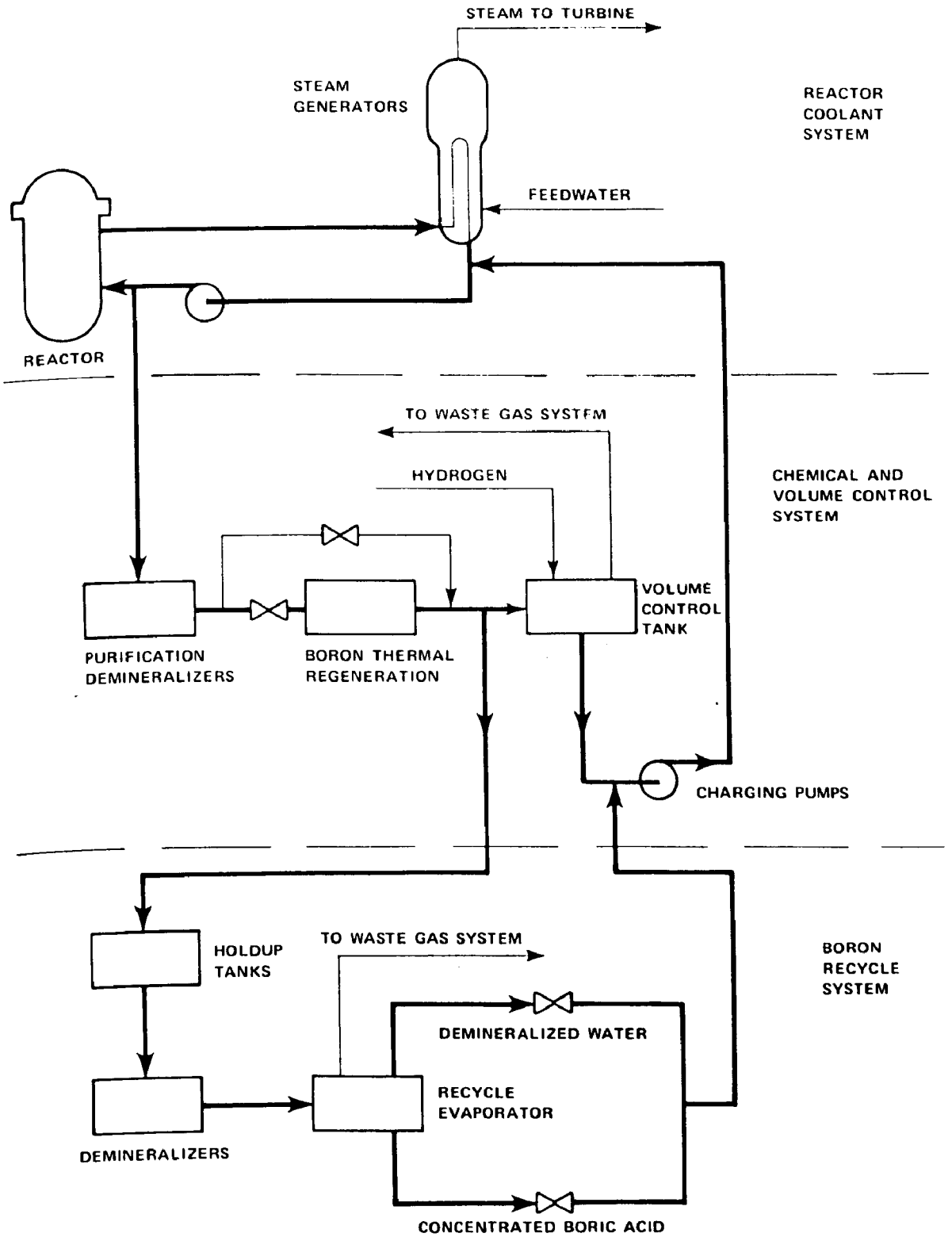

Figure 1. PWR Schematic Flow Diagram.

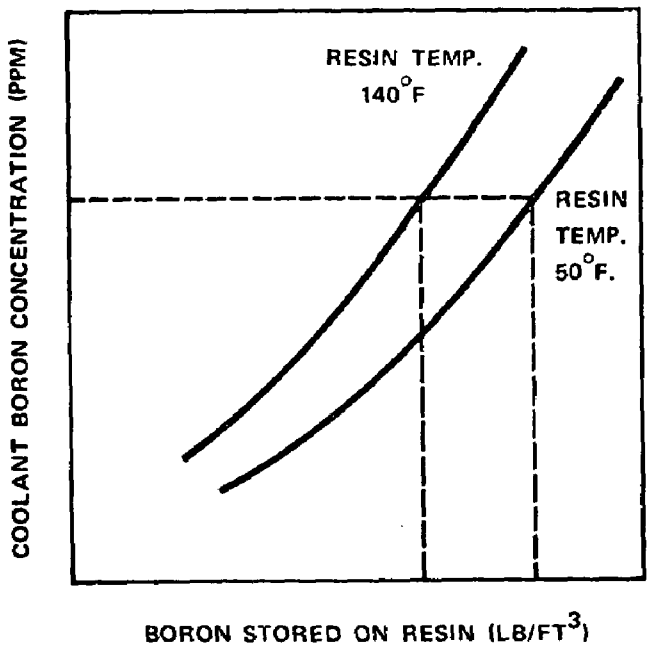

Figure 2. Thermal Regeneration. Boron Concentration versus Resin Capacity.

the operation of these ion exchangers the resins are essentially saturated with boron and the difference in capacity at these temperatures provides the boron increment for control of the load follow transients.

With respect to the plant process systems, the boron thermal regeneration equipment is provided as an in-line function within the Chemical and Volume Control System processing train. When boron changes are desired in the Reactor Coolant System, the letdown flow is routed through the boron thermal regeneration equipment. During base load operation, thermal regeneration is bypassed.

Figure 3 shows a process flow schematic of the boron thermal regeneration equipment. This equipment consists of a series of three heat exchangers to control the temperature of the letdown stream going to the ion exchangers to either 140°F for the boron release cycle and 50°F for storage. A chiller unit is provided to cool the fluid to 50°F through one of the heat exchangers for the boron storage cycle. Operation of the system is simple and straightforward.

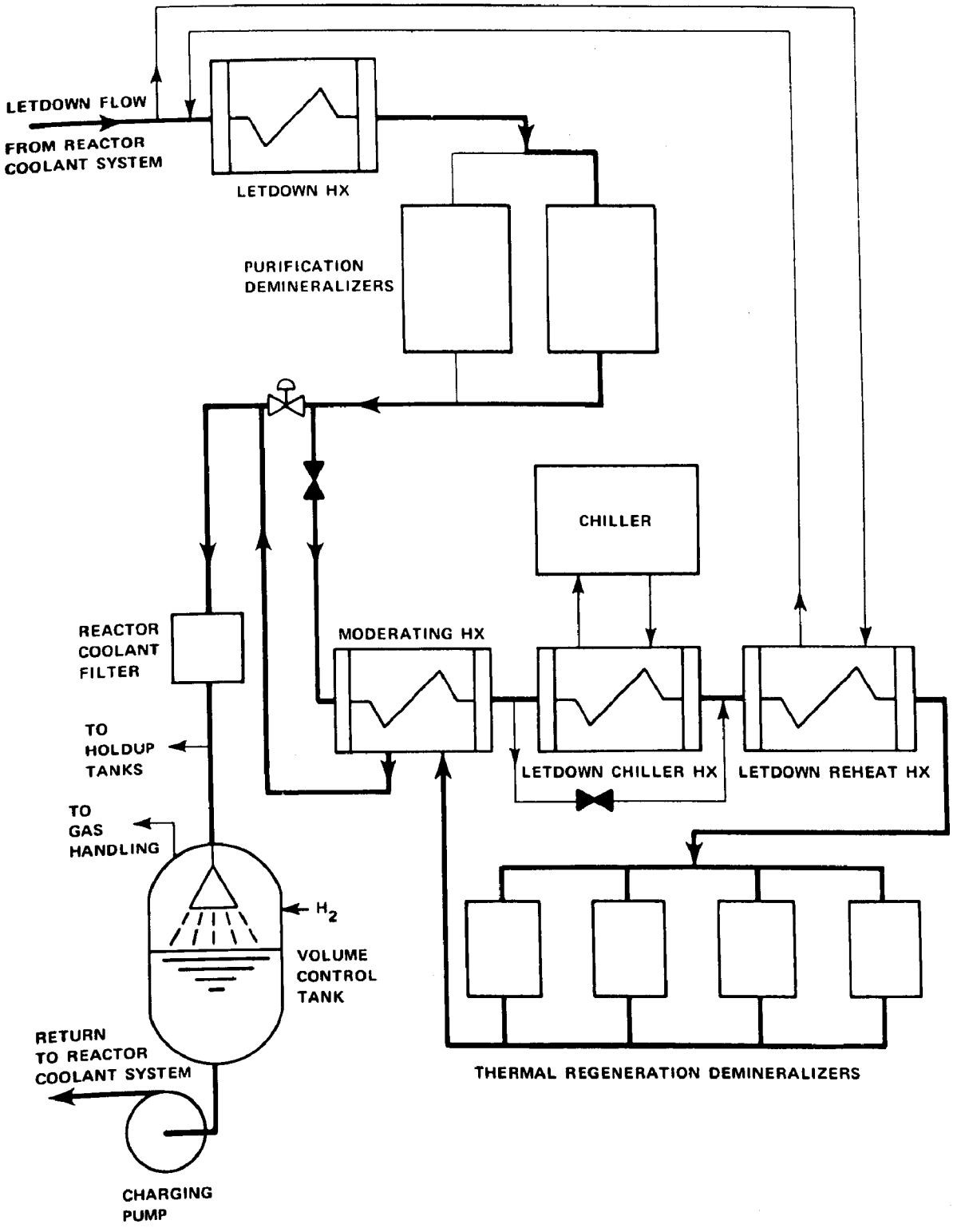

Figure 3. Chemical and Volume Control System, Boron Thermal Regeneration.

As indicated on Table 1, thermal regeneration does increase the amount of waste resins shipped offsite. For an 1100 MWe plant, approximately 25 additional 55 gallon drums of waste resins will be generated per fuel cycle.

What advantages have accrued from adoption of this system? First, there is a substantial reduction in the amount of coolant which must be processed by the Boron Recycle System. The Boron Recycle System, fundamentally, only needs to process those liquids associated with long term fuel depletion. The amount of liquid to be processed in the Boron Recycle System has been reduced by a factor of 10 over previous designs which utilized evaporators only. The resulting reduced requirements on evaporator capacity and tankage is apparent.

Waste Gas System

The second major addition to the plant systems has been the incorporation of an additional function to the Waste Gas System. Since the fission product gases are retained within the Chemical and Volume Control System, it is possible to provide for more efficient and continuous removal of fission gases from the reactor coolant. Fission product gases accumulate in the volume control tank. A continuous purge of hydrogen into the tank results in transport of the fission product gases from the tank to the Waste Gas System. This system, shown schematically on Figure 4, consists of a recombiner, compressors, and gas decay tanks provided to accumulate the fission product gases. The hydrogen purge is used as a carrier gas and is

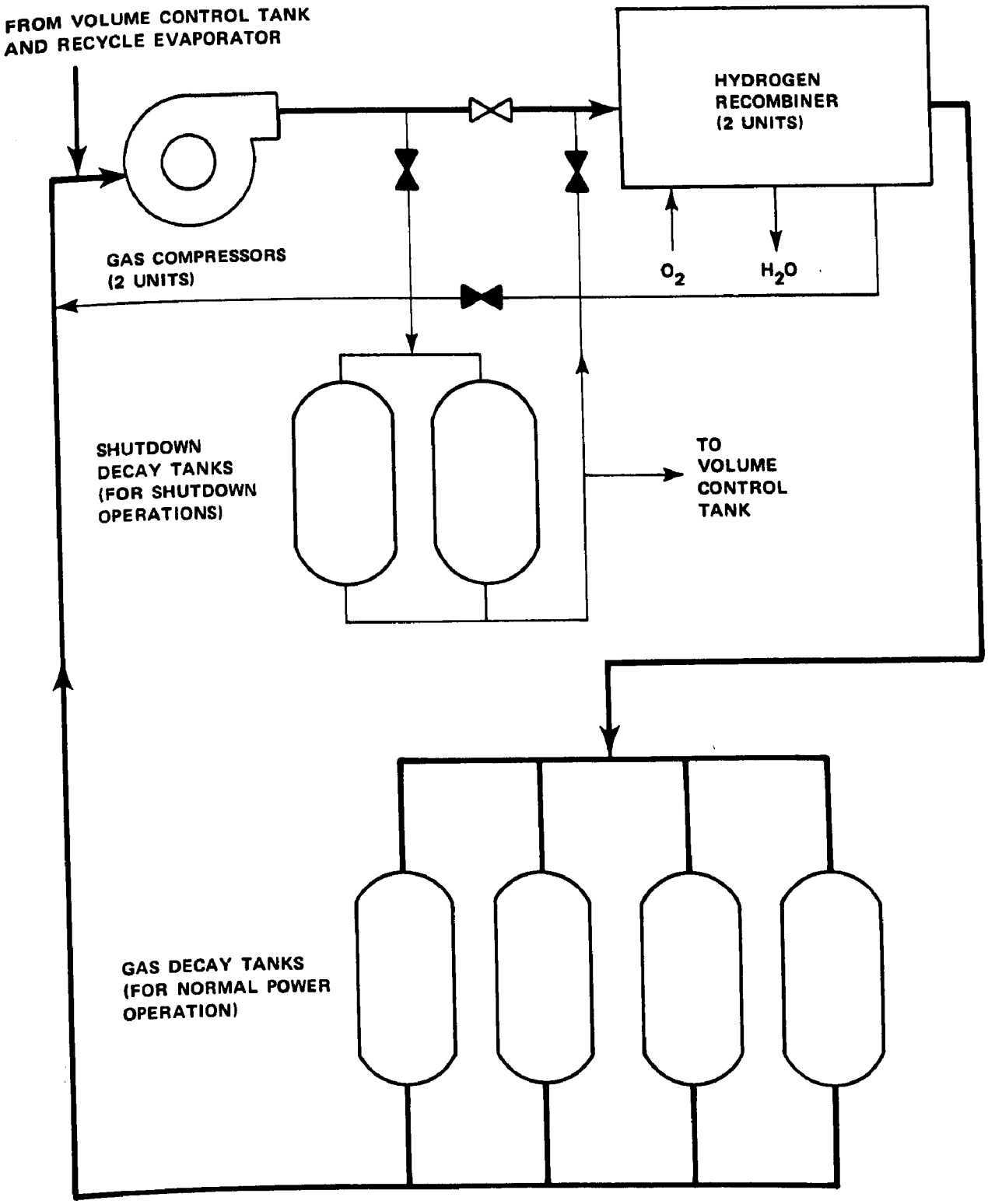

Figure 4. Waste Gas System.

removed by the recombiner within the Waste Gas System resulting in only a small volume of fission product gases requiring storage. The gas decay tanks are filled with nitrogen at essentially atmospheric pressure. The nitrogen is circulated through the system and provides the diluent for the hydrogen which is burned in the recombiner.

With operation of this system, it is possible to collect virtually all of the Kr-85 released to the reactor coolant and to achieve a reduction by a factor of approximately 7 in the fission product gas inventory in the Reactor Coolant System. Provisions are made also to collect any residual gases stripped out of solution by the Boron Recycle System evaporators. This general reduction in reactor coolant activity substantially reduces the effect of any leakage from the plant.

The system has been provided with sufficient tankage to accumulate all the gases released to the reactor coolant with the very conservative assumption that the plant operates with a 1 percent failed fuel level throughout 40 years of plant operation. Rather than provide means for shipping these gases offsite for disposal during the operation of the plant, Westinghouse recommends that these gases be continuously stored for the life of the plant since the volumetric quantity of gases is so small.

The bulk of the activity in the gas decay tanks is Xe-133 with a decay half life of 5.3 days. The total gas inventory in the plant is predominately Xe-133 during power operation of the plant with defective fuel. If all the gases are stored for 40 years and it is assumed that

the plant operated with defective fuel during every cycle, the amount of Kr-85 present at the end of this time will be approximately equal to the Xe-133 present during any fuel cycle with 1% fuel defects. Therefore, the total gaseous activity if stored for 40 years will be less than twice that present during any fuel cycle with 1% fuel defects.

The question is often raised as to whether storage of this gaseous activity constitutes an additional hazard to the plant operator? The answer to this question is negative on two counts. First, the amount of activity stored with the new design is of the same order of magnitude as with previous designs. Secondly, and more important, the amount of activity within the reactor coolant and in the plant process systems is appreciably less than with previous designs.

Liquid Waste System

With respect to the Liquid Waste System, the various plant process streams and collection drains are segregated to maintain separation of tritiated and highly radioactive fluids from non-tritiated water. The process systems and equipment and building drains are designed to insure that as much as possible of all tritiated liquids are recycled. A general process diagram is shown on Figure 5 and indicates these various process streams. The principle methods of removing any activity present is still conventional evaporation, filtration and ion exchanger.

The major impetus to this strict liquid segregation philosophy has been the very high tritium retention experienced with Zircaloy cores.

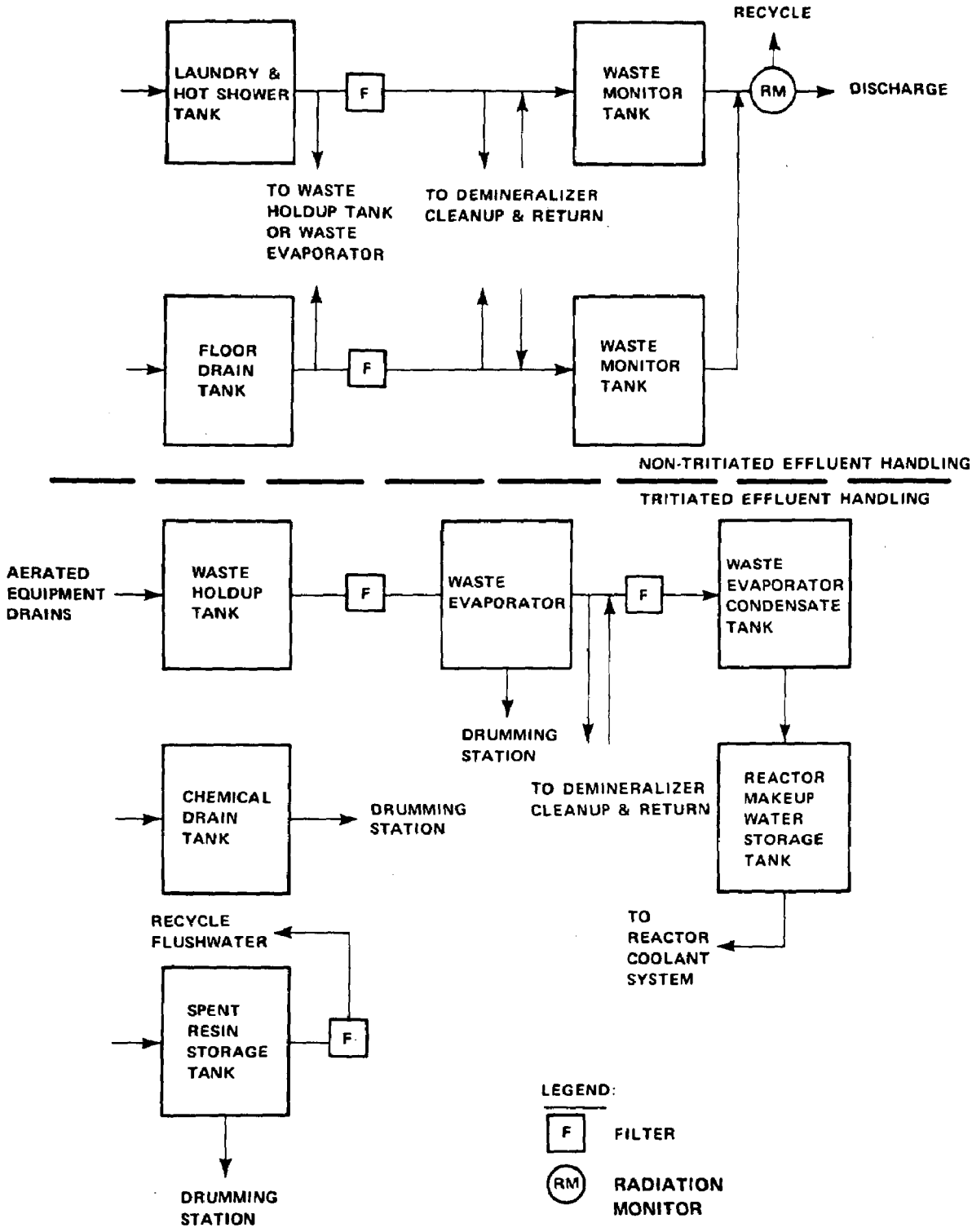

Figure 5. Waste Liquid System.

With lower quantities of tritium released to the reactor coolant, long term storage of tritiated liquids is feasible. The only discharges from the Liquid Waste System are those liquids with very low activity for which additional processing is impractical. These effluents are diluted with plant condenser cooling water prior to discharge. Ultimate disposal of the radioactivity collected in the waste evaporators, spent resins and filters is drummed for shipping offsite.

Conclusions

The systems described have been developed as part of a continuing program to improve nuclear power plant operation based on operating experience and the current emphasis on environmental considerations. The new systems can significantly reduce already acceptable radioactive releases to the environment from Pressurized Water Reactor Plants.

REGULATORY EXPERIENCE AND PROJECTIONS FOR FUTURE DESIGN CRITERIA

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Recent Experience

Nuclear power reactors and their associated waste treatment systems are designed so that actual emissions of radioactive materials in aqueous and gaseous effluents are at small percentages of the limits identified in 10 CFR Part 20 at the locations where these are released to the unrestricted environment. Beyond these locations dilution in the water bodies and the atmosphere occur so that persons located at larger distances are exposed to levels very much lower than those already low levels which exist at the plant boundaries. Recent experience with these releases to the environment will be discussed.

LIQUID EFFLUENTS

A summary of the releases in liquid effluents for 13 operating nuclear power plants for the calendar year 1969 are shown in Table 1. The upper limits for concentrations in liquid effluents at the discharge point are given in Appendix B of 10 CFR 20. The concentration limit for any one nuclide must take into account the other radionuclides that may be present. This of course requires that the concentrations of each of the nuclides present be determined. The licensee has had the option of foregoing these analyses if he uses a more restrictive limit based on the assumption that all the unidentified radionuclides

TABLE 1. RELEASES OF RADIOACTIVITY FROM POWER REACTORS IN LIQUID EFFLUENTS, 1969

	Mixed Fission & Corrosion Products			Tritium	
Facility	Released (Ci)	Concentration Limit 1/ (10^{-7} μCi/ml)	Percent of Limit 2/	Released (Ci)	Percent of MPC 3/
DRESDEN 1	9.5	1	22	~ 6	<0.001
SAN ONOFRE	8	1	14	3500	0.2
HUMBOLDT BAY	1.5	1	8.7	<5	<0.001
NINE MILE POINT	0.9	1	8.2	1	<0.001
BIG ROCK	12	22	5.6	28	0.01
OYSTER CREEK	0.48	1	4.1	5	0.001
SAXTON	0.01	1	2.5	<1	0.008
INDIAN POINT 1	28	37	1.5	1100	0.07
CONN. YANKEE	12	12	1.4	5200	0.24
GINNA	0.02	1	0.4	<1	<0.001
LA CROSSE	8.5	300	0.11	~ 25	0.003
YANKEE	0.019	1	0.07	1200	0.14
PEACH BOTTOM	<0.001	1	0.002	40	0.031

FOOTNOTES FOR TABLE 1

1/ Facility licenses require that the release of radioactive liquids in plant effluents be in accordance with 10 CFR Part 20, "Standards for Protection Against Radiation." For mixtures of radionuclides in the effluent, Part 20 provides two alternatives for determining permissible concentration limits. If the identity and concentration of each nuclide is known, Appendix B, Note 1, prescribes a formula for calculating the limiting value. Note 3 prescribes a method for selecting one of a series of values if it can be shown that certain radionuclides are not present in the mixture. The values calculated or selected by licensees may vary from year to year.

2/ One of the limits specifically mentioned in Note 3.c. of Part 20 is 1×10^{-7} μCi/ml, which is sufficiently restrictive that it can be used for any mixture of fission and corrosion products in water from any nuclear power reactor without any identification of the radioisotopic composition of the mixture. Typical isotopic compositions of radioactivity in water from power reactors are such that limits higher by two orders of magnitude or more are expected to be available to the licensee if he wishes to support them with adequate radioisotopic analyses. The percent of limit given in this column generally represents upper bounds to the value that would be applicable on the basis of a complete analysis of the composition.

3/ The maximum permissible concentration of tritium in water is 3×10^{-3} μCi/ml.

in the mixture have the same concentration limit as does the most restrictive radionuclide which has not been determined to be absent from the mixture. The limit of 10^{-7} μCi/ml used by most licensees suits this requirement. Typical radionuclide mixtures which have been identified in power reactor effluents would have a gross activity limit for drinking water of perhaps a factor of 100 or more larger than the 10^{-7} μCi/ml value. The new requirements for analysis of monitoring samples given in the recent amendments to 10 CFR Part 50 will allow more realistic estimates of potential offsite exposures from liquid effluents. Rough assessments of these exposures based on the relative quantities of the following radionuclides (e.g., Cs-134, Cs-137, I-131, I-133, Sr-89, Sr-90, BaLa-140, Co-58, Co-60, Mn-54, Mn-56, and Cr-51) which have been identified and their approximate reconcentration factors in salt and fresh water organisms, indicate that an individual could eat 150 grams of fish, shellfish and crustaceans each day and obtain his whole drinking water supply (if fresh water is involved) without exceeding the exposure limits of 10 CFR 20 even if the gross concentration in the water was 10^{-7}μCi/ml.

GASEOUS EFFLUENTS

External exposure from gaseous releases is due almost entirely to isotopes of the noble gases of xenon and krypton. In deriving the release rate limits, "annual average site meteorology" based on site data is determined and a total dilution factor is derived from the meteorology, topography, stack air flow and elevation and site boundary

distance. The limiting release rate is derived so that the annual average exposure rate at the site boundary or at the point of maximum ground level exposure offsite (whichever is more restrictive) is no more than 500 millirems per year from external radiation. This means that if the reactor were releasing radioactive gases at the limit, an individual present outdoors on the site boundary or other point of highest exposure rate offsite 24 hours a day, 365 days a year is not likely to receive an external whole body exposure in excess of 500 millirems per year.

Nuclear power reactor waste treatment systems are designed to limit releases of radioactivity in effluents to small percentages of AEC limits. It is not expected that actual releases will approach the upper limits during normal operations. A summary of the releases in gaseous effluents for 1969 and their relationship to the release limits which are identified in the manner just described are shown in Table 2. Eight of the plants released less than 0.1 percent of the limit; three released 1 percent or less; one released 3.6 percent; and one released 31 percent.

It is of interest to examine estimates of the annual average radiation dose that the population living in the vicinity of nuclear power plants receive from the emissions of noble gases identified in the table.

Values of the dose from zero altitude releases of beta-emitting isotopes typical of pressurized water reactors (PWR) and 100-meter stack releases of gamma-emitting isotopes typical of boiling water reactors (BWR) normalized for a dose rate limit of 500 millirems per

TABLE 2. RELEASES OF RADIOACTIVITY FROM POWER REACTORS IN GASEOUS EFFLUENTS - 1969

Facility	Noble and Activation Gases			Halogens and Particulates		
	Curies		Percentage of Permissible	Curies		Percentage of Permissible
	Released	Permissible 1/		Released	Permissible 2/	
DRESDEN 1	800,000	22,000,000	3.6	0.26	85	0.3
SAN ONOFRE	260	567,000	0.045	<0.0001	0.8	<0.001
HUMBOLDT BAY	490,000	1,560,000	31	0.65	5.6	12
NINE MILE POINT	55	25,800,000	<0.001	<0.001	63	<0.001
BIG ROCK	200,000	31,000,000	0.65	0.2	38	0.53
OYSTER CREEK	7,000	9,450,000	0.075	0.003	126	0.002
SAXTON	1	3,750	0.035	<0.0001	10	<0.001
INDIAN POINT 1	600	5,360,000	0.01	0.025	7.6	0.33
CONN. YANKEE	190	18,900	1	0.001	0.27	0.37
GINNA	<1	360,000	<0.001	<0.0001	1.7	<0.001
LA CROSSE	480	480,000	0.1	<0.063	1.6	<4
YANKEE	4	6,600	0.062	<0.0001	0.03	0.01
PEACH BOTTOM	72	189,000	0.038	<0.0006	0.12	<0.5

FOOTNOTES FOR TABLE 2

1/ Where the technical specifications express a release limit in terms of a constant factor time the 10 CFR Part 20 concentration limits, the MPC used is 3×10^{-8} μCi/cc. This MPC is based on typical noble mixture releases with less than two hours holdup. (For a holdup longer than two hours the MPC is larger).

2/ Where the technical specifications do not state an annual limit for the iodines and particulates, values of 1×10^{-10} μCi/cc and 3×10^{-11} μCi/cc, respectively, were used. These MPC's are based on the most restrictive isotopes normally found--I-131 and Sr-90. The annual limit was reduced by a factor of 700 to account for reconcentration.

year at a site boundary distance of 500 meters (.31 miles) are shown in Figure 1. The dose rates shown are for outdoors. Gamma dose rates indoors would be less, perhaps by a factor of two, depending on the shielding properties of the building. The dose rates become smaller with increasing distance from the source. At a distance of 15 miles the theoretical dose rates for the example are about 2.5 millirems per year for a BWR and about 1 millirem per year for a PWR. At distances beyond 30 miles and 20 miles, respectively, the dose rates are less than 1 millirem per year.

The estimated average annual doses to the populations living in the vicinity of these power plants are functions of the population distribution with respect to the wind direction frequency distributions and the distance from the emitting point from the site boundary where the controlling dose rate of 500 millirems per year exists (dose rates at other locations on the site boundary would be equal to or less than 500 millirems per year). Using realistic population distributions and wind frequencies for the 13 different power reactor sites along with an average mix of meteorological conditions, the average annual dose rate at the site boundary and for the whole population included within circles with radii of 4 and 50 miles of these plants have been calculated and are shown in Table 3 for the emissions identified in Table 2.

The average exposures to the total population living within a radius of 4 miles of these plants were about 1 millirem and for those within 50 miles the average is about one-one hundredth (0.01) of 1 millirem.

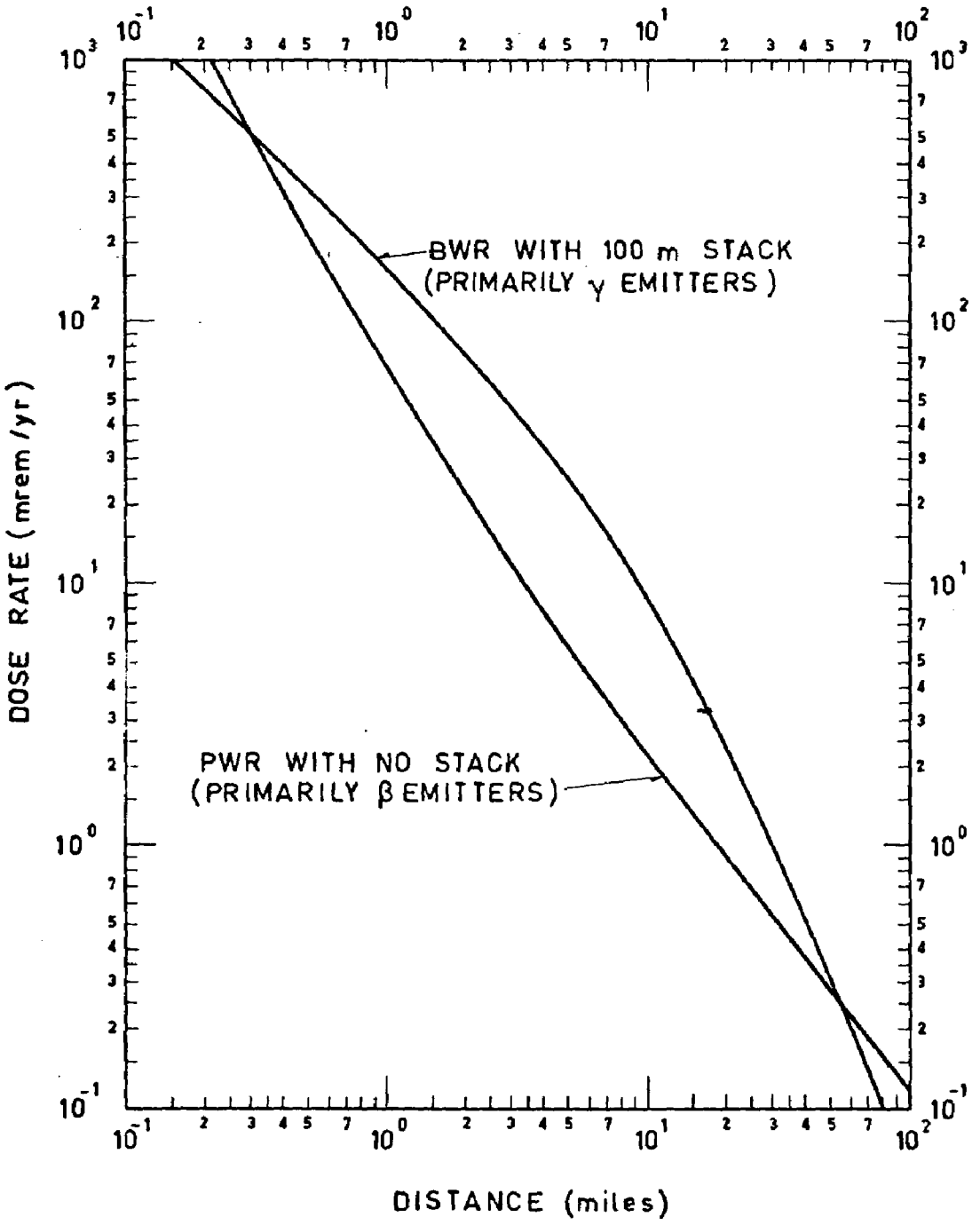


Figure 1. Dose Rates as a Function of Distance for a BWR and a PWR Normalized to give 500 mrem/year at 0.31 Mile.

TABLE 3. CALCULATED ANNUAL RADIATION EXPOSURES TO UNSHIELDED INDIVIDUALS AND POPULATIONS IN THE VICINITY OF NUCLEAR POWER PLANTS BASED ON GASEOUS EMISSIONS FOR 1969

Reactor Site	Type	Max. at Boundary	Within Circle of 4-Mile Radius			Within Circle of 50-Mile Radius		
		D_b (mrem)	P_4 (units)	D_4 (man rem)	$\bar{D}_4$ (mrem)	P_{50} (thousands)	D_{50} (man rem)	$\bar{D}_{50}$ (mrem)
DRESDEN	BWR	18	2,577	11	4.26	5,715	360	.063
HUMBOLDT BAY	BWR	155	18,940	68.5	3.69	101	107	1.06
NINE MILE PT.	BWR	.005	1,310	.001	.0008	533	.012	.000023
BIG ROCK	BWR	3.25	1,430	.570	.4	100	3.64	.036
OYSTER CREEK	BWR	.375	3,619	.082	.023	1,158	.606	.00052
SAN ONOFRE	PWR	.23	5,470	.047	.0095	2,696	1.02	.00037
SAXTON	PWR	.030	3,774	.015	.0041	837	.05	.00006
INDIAN PT.	PWR	.055	38,740	.130	.0035	13,324	1.94	.000145
CONN YANKEE	PWR	5	5,062	1.150	.227	2,682	15.56	.0058
GINNA	PWR	.005	5,001	.0011	.00022	953	.0077	.000008
LA CROSSE	PWR	.5	934	.042	.045	328	.301	.00092
YANKEE ROWE	PWR	.11	1,180	.0217	.0184	1,209	.70	.00059
PEACH BOTTOM	HTGR	.19	3,343	.048	.0143	4,405	1.79	.00041
ALL (Total or average)		14.1	88,380	81.61	.924	33,841	492.6	.0145
ALL except Humboldt Bay (Total or average)		2.33	69,440	13.11	.189	33,740	385.6	.0115

RADIOIODINE AND PARTICULATE AIR RELEASES

To control exposures from airborne radioactive materials that may enter terrestrial food chains, the calculations of stack release limits for halogens (primarily radioiodines), and particulates with a half-life greater than 8 days include a reduction factor of 700 applied to Part 20 air concentrations. These materials are released in such small amounts that they contribute very little to external exposure or to exposure by inhalation of the materials in the air. Although this factor of 700 was derived for iodine-131 in milk, it is applied as a measure of conservatism to all radionuclides in particulate form with a half-life greater the 8 days. The release rate for iodine-131 is sufficiently conservative that an individual could receive his entire milk supply from cows grazing near the point of highest iodine deposition. The radiation exposure to the thyroid of such an individual would be less than 1.5 rems per year. Experience has shown that actual releases of iodine from power reactors have been less than a few percent of limits. Environmental monitoring programs around power reactors have shown no measurable exposures to the public from iodine-131 or particulates.

Projections for the Near Future

Dr. Beck has discussed the recent changes to 10 CFR Parts 20 and 50 which incorporate the requirement that exposures be kept as low as practicable and identified design objectives for equipment to be installed to maintain control over gaseous and liquid effluents. The changes also incorporated operating, monitoring and reporting requirements. The Statement of Considerations which accompanied the amendments

as published in the Federal Register noted that a substantial number of comments were received following the initial publication which suggested that the AEC develop more definitive criteria for keeping releases as low as practicable and indicated that discussions with the nuclear power industry and other competent groups would be initiated to achieve this goal.

During the month of January 1971, members of the Commission's staff held discussions with representatives of six reactor suppliers, conservation and environmental organizations, architect-engineers and consultants, and nuclear power utilities. During February, there were meetings with officials of State health organizations. These meetings were generally structured around a list of questions prepared in advance and sent to the attendees.

The discussions brought out that, while not unanimous, a large majority of those attending favored some more definitive criteria and that the criteria should be based on some kind of performance requirement and not on a requirement for specific kinds of equipment. The opinions were more divergent in discussing the form that the performance requirement should take. Some favored release quantities and concentrations at the release point and others preferred limitations based on doses to individuals and groups of individuals located offsite, while a subjective majority of others preferred that the specification be identified as quantities and concentrations but that they be based on the site dependent variables such as meteorology, boundary distances, and

dilution in water streams. It was noted that some present leakage paths currently not routinely monitored which now amount to a few tenths of a percent of the total release could become relatively more important if the main release streams are substantially reduced. It was also brought out that systems which require in-plant storage of waste may increase the in-plant exposures so that the desired minimization of total population exposure may have some built in limitations.

At the present time the Commission staff is considering numerical guidance as more definitive criteria and it is to be expected that at some not too distant date these will be presented for comment by the industry and the public either as guides or as new amendments to 10 CFR Part 50.

Projections for the More Distant Future

The Commission expects to continue to evaluate the releases of radioactive materials by the nuclear power industry and as an aid in this evaluation, the Commission through the Division of Reactor Development and Technology is supporting a study by WADCO at Richland, Washington, to develop a computer model which will enable the AEC to estimate potential dose commitments to individuals and population groups caused by radioactivity additions to the environment from nuclear power reactors and fuel reprocessing plants. This computer program is being applied initially to the upper Mississippi River Basin for the nuclear facilities which may be in that region by the year 2000. The model is sufficiently flexible so that the effect of changing input

parameters such as radionuclide release rates, site locations and numbers of facilities can be studied.

The program includes models for the transport of radionuclides through air and water routes, living pattern models, exposure pathways and dose calculation. At the present time the individual models have all been operated and some modifications are being made to make the models compatible with the computers available to the AEC. Tests are being run to determine the sensitivity of the program to the input data so that the unimportant provisions may be modified or eliminated to simplify the overall program.

It is expected that the program can be extended to other areas of the country by the addition of special features to cover bays, estuaries, large lakes, and sea coast areas.

WHAT THE FUTURE HOLDS FOR NUCLEAR POWER

Ernest B. Tremmel, Director
Division of Industrial Participation
U.S. Atomic Energy Commission

Tonight I am going to show a series of slides on the nuclear industry. I have taken out all the slides on how good nuclear energy is for the environment, because we have experts here who will tell you that, I am sure. I am going to tell you what the future looks like for power in general and a little bit about the nuclear industry that is in existence today.

The AEC has had a very significant role in bringing the nuclear industry into being. In addition to its primary function of developing and producing nuclear weapons, Congress gave it responsibility for developing peaceful uses within the framework of our free enterprise system (Figure 1). One of my jobs has been to help get this into private industry in this country.

I also thought we ought to take just a brief look at how the Commission is made up. It is made up of five Commissioners, appointed by the President, who direct the two principal activities of the Commission.

The first is under a General Manager who runs our research and development activities and our weapons program. The second is under a Director of Regulation who has responsibility for licensing the commercial (or peaceful) uses of atomic energy (Figure 2). This has been one of the areas in which the AEC has been criticized, because we

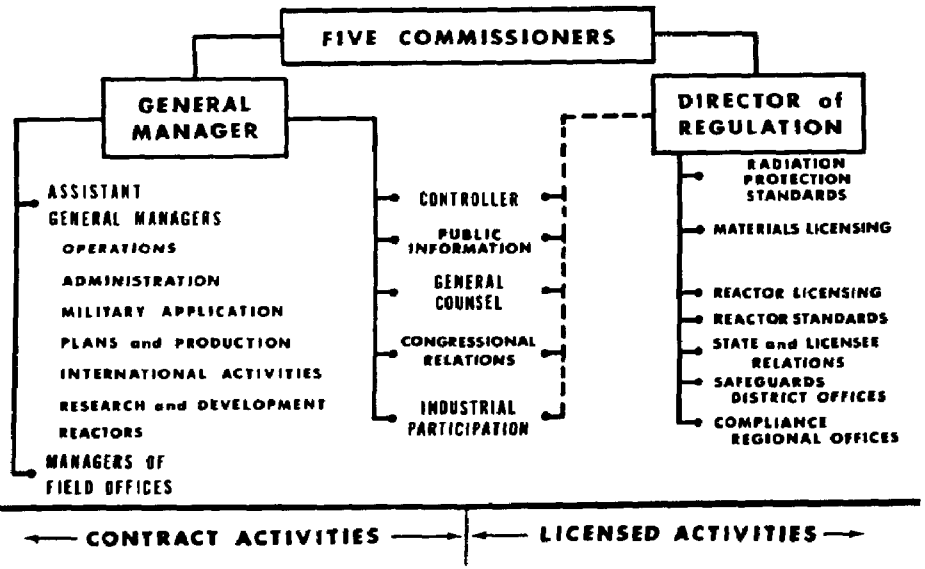
① ATOMIC ENERGY ACT OF 1954

SECTION 1. DECLARATION - . . . . IT IS . . . .
THE POLICY OF THE UNITED STATES THAT -

. . . . SUBJECT AT ALL TIMES TO THE PARAMOUNT OBJECTIVE OF MAKING THE MAXIMUM CONTRIBUTION TO THE COMMON DEFENSE AND SECURITY . . . .

THE DEVELOPMENT, USE, AND CONTROL OF ATOMIC ENERGY SHALL BE DIRECTED SO AS TO PROMOTE WORLD PEACE, IMPROVE THE GENERAL WELFARE, INCREASE THE STANDARD OF LIVING, AND STRENGTHEN FREE COMPETITION IN PRIVATE ENTERPRISE.

② ☆ UNITED STATES ☆ ATOMIC ENERGY COMMISSION



③ AEC OPERATING BUDGET

FISCAL YEAR 1971

		Millions
RAW MATERIALS		$ 18
SPECIAL NUCLEAR MATERIALS		349
WEAPONS		842
REACTOR DEVELOPMENT		432
Civilian Power	$142	
Naval Reactors	132	
Space	76	
Safety & Other	82	
PHYSICAL RESEARCH		274
BIOLOGY & MEDICINE		88
ISOTOPES DEVELOPMENT		6
EXPLOSIVES (PLOWSHARE)		8
OTHER (INCLUDING ADMINISTRATION)		177
TOTAL -		$2,194

④ AEC OPERATING COSTS

(Millions of Dollars)

	R&D Peaceful Uses	Materials	Defense	Other	Total
1960	$ 405	$ 1,448	$ 685	$ 81	$ 2,619
1961	456	1,369	705	82	2,613
1962	552	1,226	827	91	2,696
1963	650	1,130	843	90	2,713
1964	765	963	919	93	2,739
1965	770	832	874	94	2,570
1966	781	750	822	87	2,440
1967	833	683	842	88	2,446
1968	862	632	907	106	2,507
1969	834	596	1,026	110	2,566

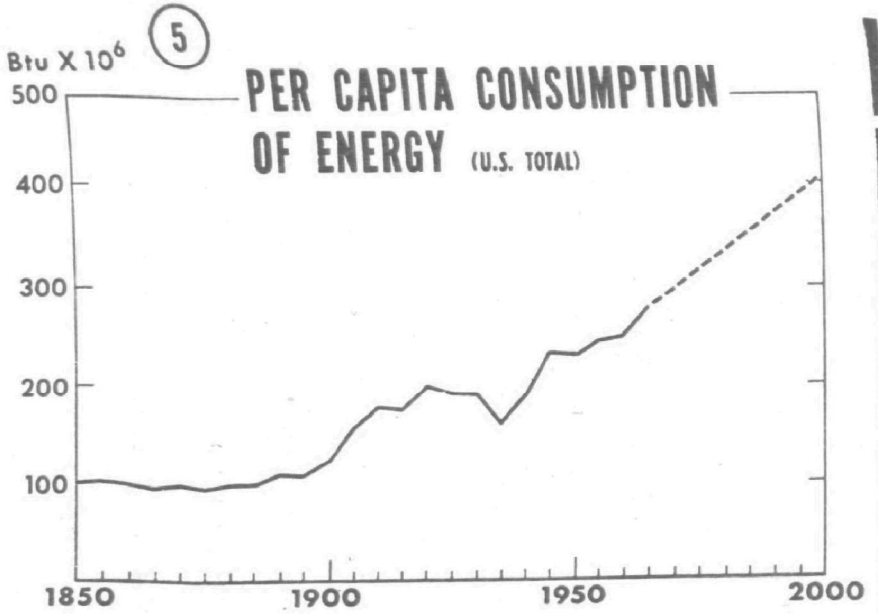
are accused of both developing nuclear applications and licensing them under the same Commission.

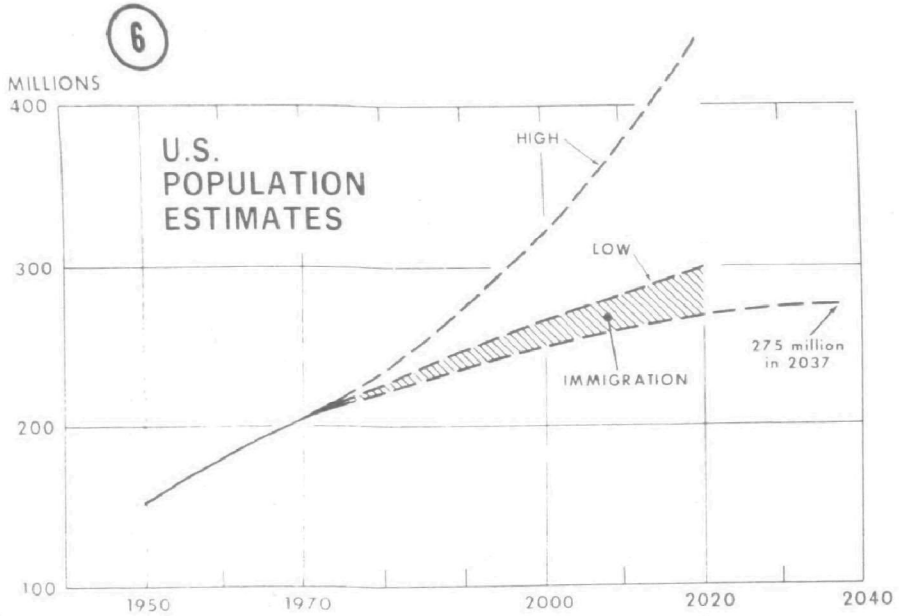
Referring to our budget (Figures 3 and 4), you will note that almost half our funds are being spent for peaceful uses. You can see from the slides that defense gets a big portion of the budget, but that the amount devoted to peaceful uses such as biology and medicine, isotopes, peaceful explosives, and reactors has been increasing over the past several years.

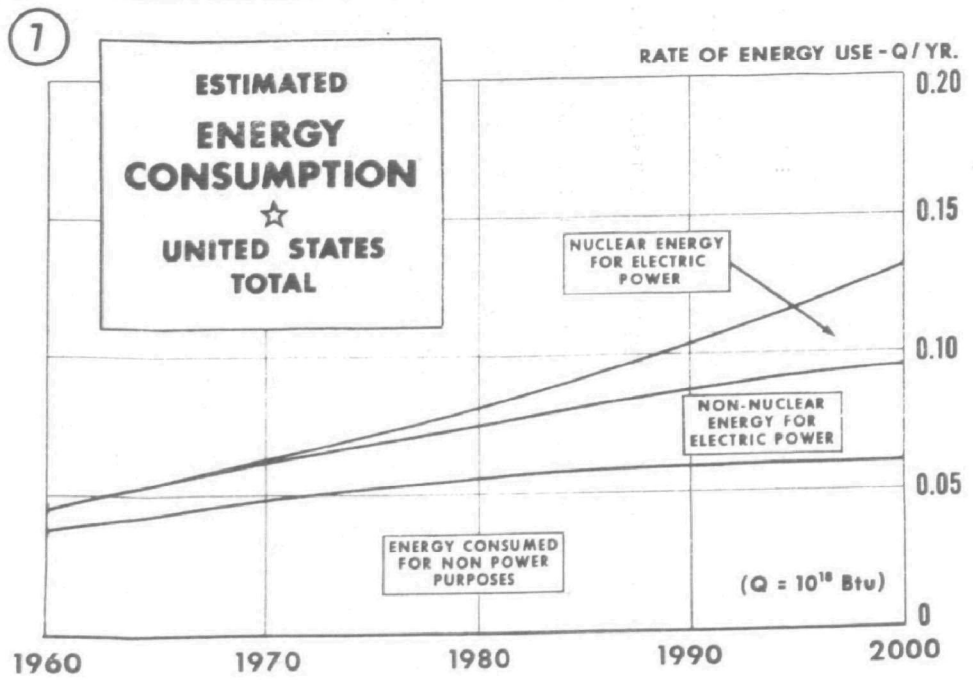
I am going to devote most of my talk today to nuclear power for civilian purposes, because this is the area of peaceful uses of atomic energy that is receiving the most attention. But before I do, I want to talk a little bit about why we need nuclear power and, of course, it goes back to the basic need of man for energy.

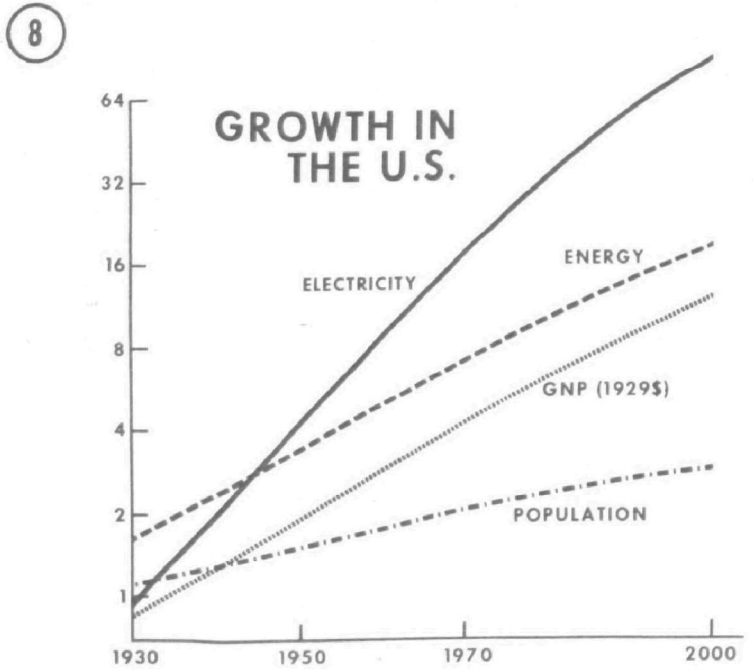
Figure 5 shows how each of us are asking for more and more. Figure 6 is interesting because it shows what would happen to our population if we decided to limit every woman in this country to two children and we stopped all immigration. We would have the lower line and our population would level out somewhere around the year 2040. You can see that we have a built-in growth in our population, and we really can't do too much to stop it for some time to come.

Figure 7 shows a projection for total energy use in the United States. You can see how rapidly energy needs for electric generation are rising, and you can imagine how rapidly it would continue to rise if we carried this projection beyond the end of this century. I think it is also interesting that with only 6 percent of the world's population, we


5
Btu X 10^6
PER CAPITA CONSUMPTION OF ENERGY (U.S. TOTAL)
500
400
300
200
100
1850
1900
1950
2000


6
MILLIONS
U.S. POPULATION ESTIMATES
HIGH
LOW
IMMIGRATION
275 million in 2037
400
300
200
100
1950
1970
2000
2020
2040


7
ESTIMATED ENERGY CONSUMPTION ☆ UNITED STATES TOTAL
RATE OF ENERGY USE - Q / YR.
NUCLEAR ENERGY FOR ELECTRIC POWER
NON-NUCLEAR ENERGY FOR ELECTRIC POWER
ENERGY CONSUMED FOR NON POWER PURPOSES
(Q = 10^18 Btu)
0.20
0.15
0.10
0.05
0
1960
1970
1980
1990
2000


8
GROWTH IN THE U.S.
ELECTRICITY
ENERGY
GNP (1929$)
POPULATION
64
32
16
8
4
2
1
1930
1950
1970
2000

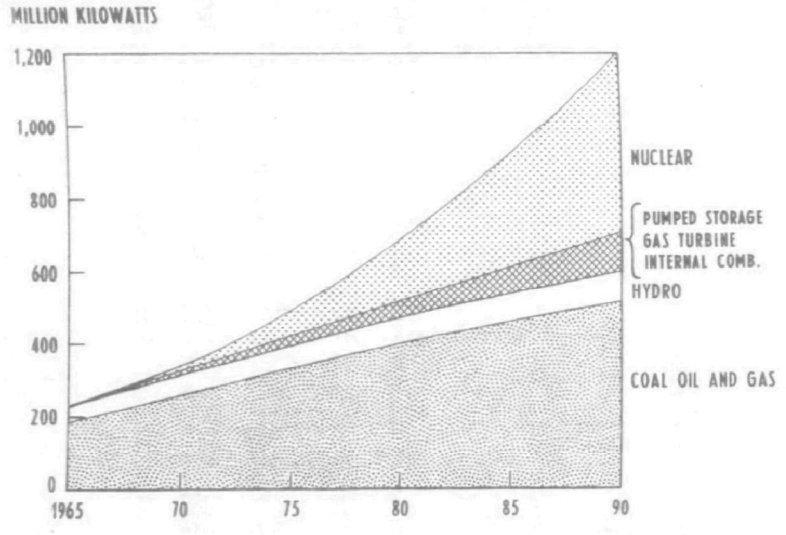
use 36 percent of all the electricity generated throughout the world.

Figure 8 compares growth rates for population, GNP, energy and electricity, and you can see that demand for electricity is growing much faster. This probably results, at least in part, from the unit price of electricity remaining steady over the past 30 or 40 years, while the price of other items has gone up. I would like to think that this stems from the fine job that our American utilities have done, along with the competitive system in our country.

Now, let's take a look at the projections through 1990. What kind of fuel is going to supply this demand for electric energy? You will see that as we get out to 1990, nuclear power is expected to be supplying about half of the capacity in the country (Figure 9). Figure 10 shows projected use of fossil fuels over the next 10 years in more detail. Use of oil and gas is not expected to increase much more. But as we see in the forecast, demand for coal will continue to rise.

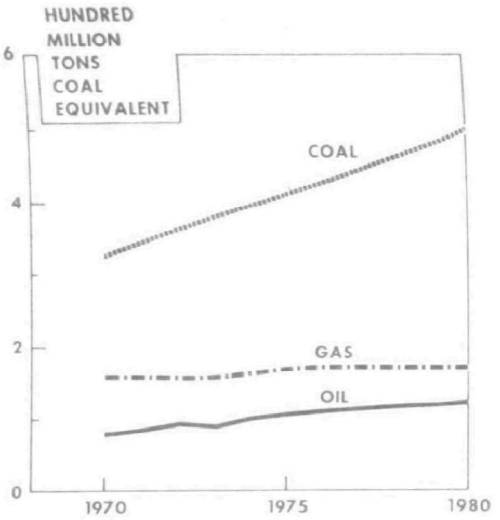
What has happened to the United States is that orders for nuclear power plants have increased pretty fast over the last 5 years (Figure 11). We call this the surge to nuclear power. Actually, the Commission didn't even anticipate that we would be moving into nuclear power plants this fast. Back in 1965 we were starting to sell some nuclear plants, but in 1966 and 1967 orders really picked up. In 1967 we hit a real peak of 31 plants in one year and that is what we call the real "surge to nuclear power." Orders fell off in 1968 and in 1969, but then they picked up again in 1970, and this year (1971) looks like a good year. Nine

9 ELECTRIC GENERATING CAPACITY IN THE UNITED STATES

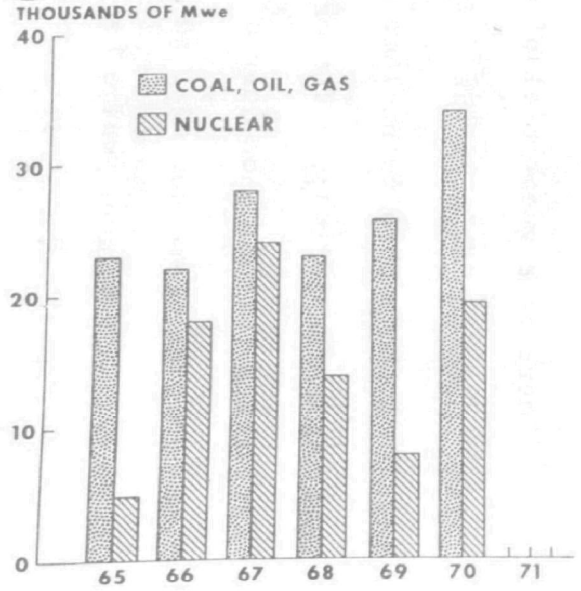


10 ELECTRIC UTILITY FOSSIL FUEL USE

KEYSTONE FORECAST



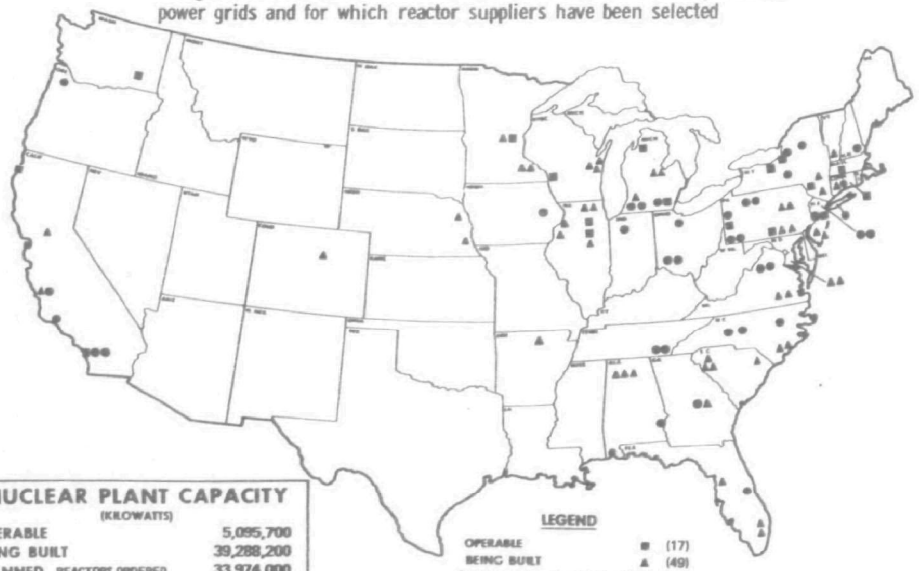
11 ORDERS FOR STEAM SUPPLY SYSTEMS



SOURCE: EEI

12 NUCLEAR POWER PLANTS IN THE UNITED STATES

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected



*7 more plants have been announced for which reactors have not yet been ordered.

NUCLEAR PLANT CAPACITY
(KILOWATTS)

OPERABLE		5,095,700
BEING BUILT		39,288,200
PLANNED	REACTORS ORDERED	33,974,000
	REACTORS NOT ORDERED	6,800,000
	TOTAL	85,157,900

ELECTRIC UTILITY CAPACITY BY CONVENTIONAL MEANS AS OF JAN. 31, 1970: 329,318,247 KILOWATTS

plants have been contracted for by the utilities already, and we know a good many more that will be ordered this year.

Now, as far as supplying these plants, one of the things we watch in the Commission is what kind of industry we have created, and we try to encourage a competitive situation. There are now four light water reactor suppliers very actively competing and a fifth supplier is now entering the market with a gas cooled reactor.

As of this year, we have granted about 16 operating licenses. Twenty more are in process. And there are about 53 construction permits in effect and about 23 more in process.

As for the number of plants operating, Figure 12 shows where they are are and where additional units are under construction or on order.

Figure 13 shows the most recent projection of nuclear capacity expected to be in operation in the United States. This shows about 150,000 megawatts of capacity by the end of calander year 1980 and 300,000 MW by the end of 1985.

We are optimistic that there will be more than sufficient orders placed by electric utilities to meet this projection.

There is a great deal of concern, however, on bringing these plants into operation on schedule. There have been delays. But people are now learning how to build nuclear plants and are allowing more time for the construction activity. The only reason that I see for not meeting this projection would be because of licensing delays due to holdups that fossil plants are not exposed to. Utilities can still build fossil plants and not have public hearings.

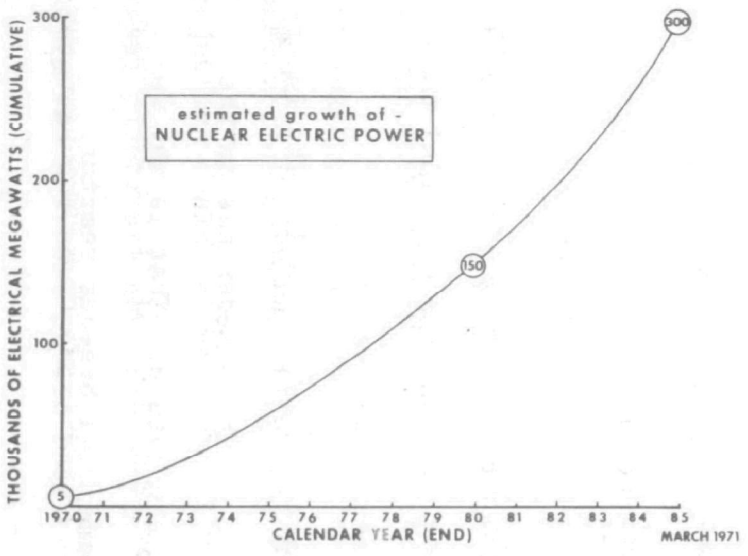
Now, actually I am kind of proud of the United States and again, I like to think it is because of the free enterprise system. We have left the rest of the world behind on nuclear power plants for capacity. This is shown a little better on Figure 14. Actually the British like to tell me that they are generating a lot more nuclear kilowatts than us. But you will see that our country will soon leave the rest of the world behind on nuclear generation.

Figure 15 shows what the possible break-even point could be for nuclear power in comparison with fossil fuels. This is for plants that would come into operation in 1975. If these figures are correct, and we believe they are, it is more economical by far to build a nuclear plant. Also, with the necessity of burning low-sulphur fuels, we are finding all around the country that the cost of fossil fuel is going up very rapidly. In fact to a point where we think that utilities will be buying nothing but nuclear plants for base-load operation before long.

So the outlook is very promising right now for nuclear power plants. Looking to the future, we have reactors of advanced design--the gas-cooled reactor--and, beyond that, the liquid metal cooled fast breeder reactor (LMFBR) which now has the highest priority in the Commission's research and development program. The LMFBR, since it generates more fuel than it burns will greatly reduce our requirements for uranium.

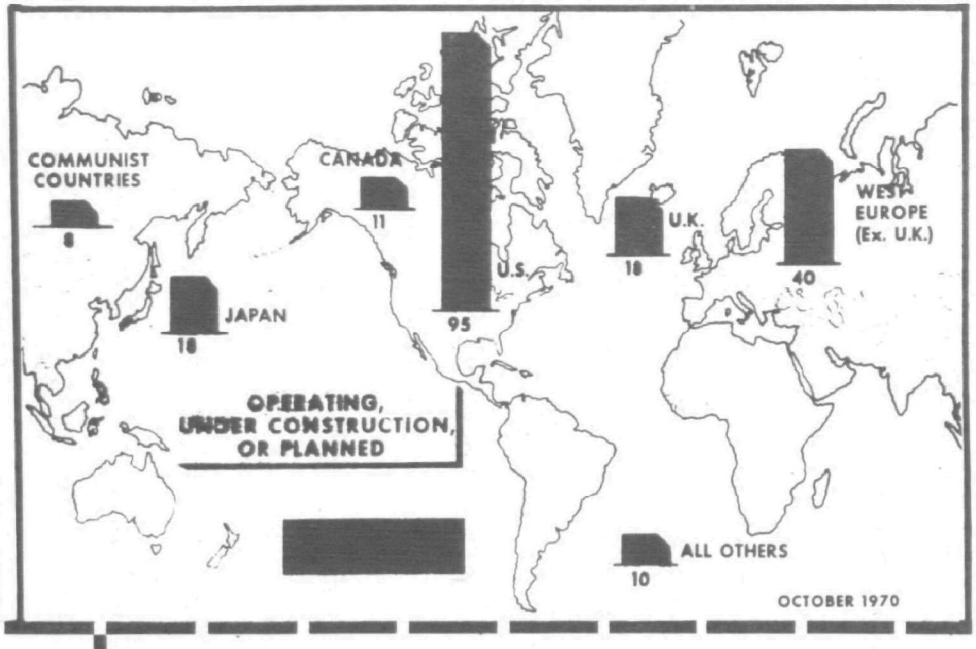
Figure 16 shows what the breeder reactor means to fuel. The important thing here is the effect introduction of the breeder has on the amount of uranium required many years in the future. That is why we consider it so important to develop a commercial breeder reactor.

13



14

NUCLEAR ELECTRIC GENERATING CAPACITY
MILLION KILOWATTS



15

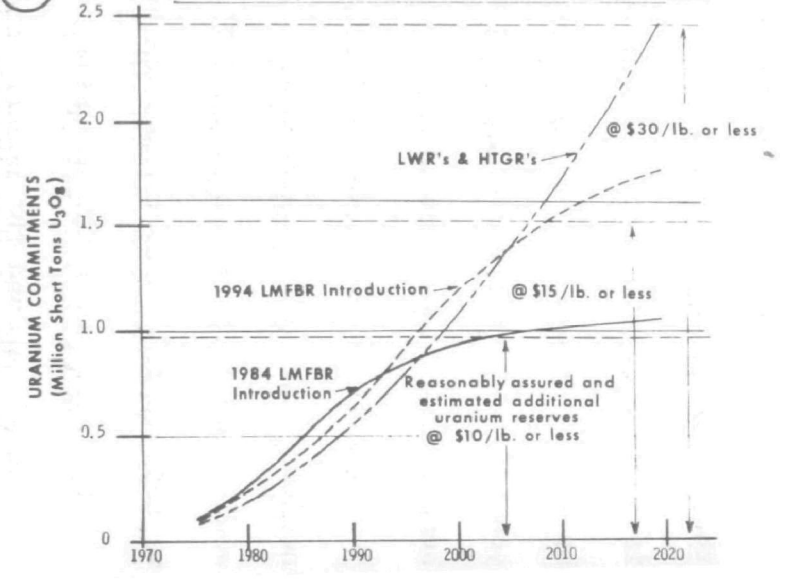
ELECTRIC POWER-
COST COMPARISONS

FUEL	PLANT SIZE Mwe	AVG. PLANT COST $/KW	BREAK EVEN FUEL COST ¢/MILLION BTU
GAS	600	95-120	45-50
OIL	600	140-180	30-40
COAL	1,000	180-210	25-35
NUCLEAR	1,100	230-260	16

OCTOBER 1970

16

EFFECT OF LMFBR INTRODUCTION ON URANIUM COMMITMENTS



There are three companies working on it now. At this time the AEC and the Edison Electric Institute have been working to raise money to build the first demonstration plant.

Looking even further into the future we see the possibility of demonstrating a fusion power reactor toward the end of this century with a commercial plant following early in the next century. Figure 17 illustrates the rapidity with which we are using up our economically recoverable energy sources, and points up the importance of fusion power to our future well-being.

Now, I want to show you why American industry is so interested in nuclear power: the dollars that are involved get quite large. Figure 18 shows projected expenditures for nuclear electric power plants out to 1985 where the annual figure is $10.6 billion. The nuclear steam supply systems alone for these plants are shown in Figure 19 which indicates 1985 expenditures at close to one and one-half billion dollars.

Figures 20 and 21 show projected expenditures for fuel for nuclear power plants and the distribution of these costs to the various parts of the fuel cycle.

Summing this all up, cumulative expenditures through 1985 for plant construction are projected at $100 billion and for the fuel cycle at $23 billion (Figure 22).

The next few charts provide some insight on the nuclear fuel cycle and the industries involved. The first area is uranium, and Figure 23 shows projected requirements over the next ten years in comparison with past deliveries. Uranium concentrate as it comes from the mills has to

17

ENERGY RESERVES

AVAILABLE FOR ECONOMIC PRODUCTION OF ELECTRIC POWER

GAS and OIL ..... 30 YEARS

COAL ..... 80 YEARS

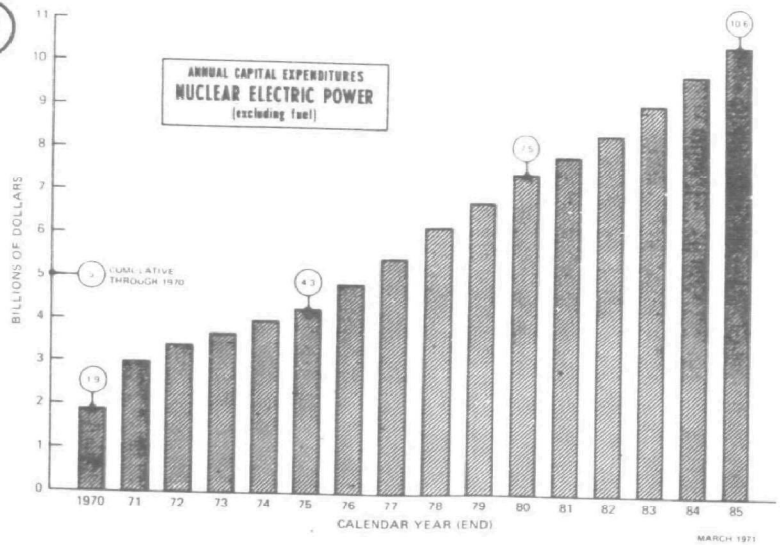
URANIUM & THORIUM

- IN WATER REACTORS ..... 40 YEARS
- IN BREEDER REACTORS ... 1,000 YEARS

TRITIUM

- IN FUSION REACTORS ..... MILLIONS of YEARS

18



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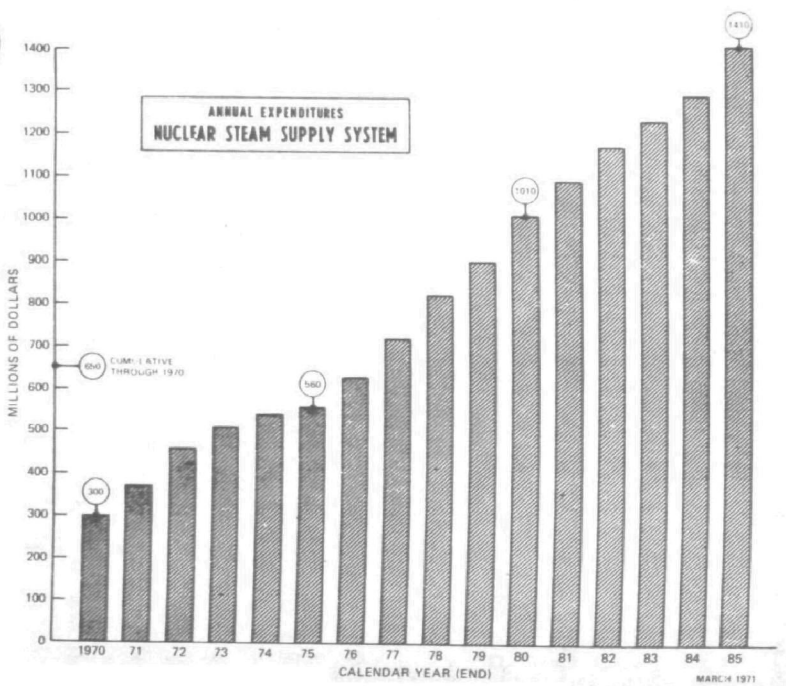

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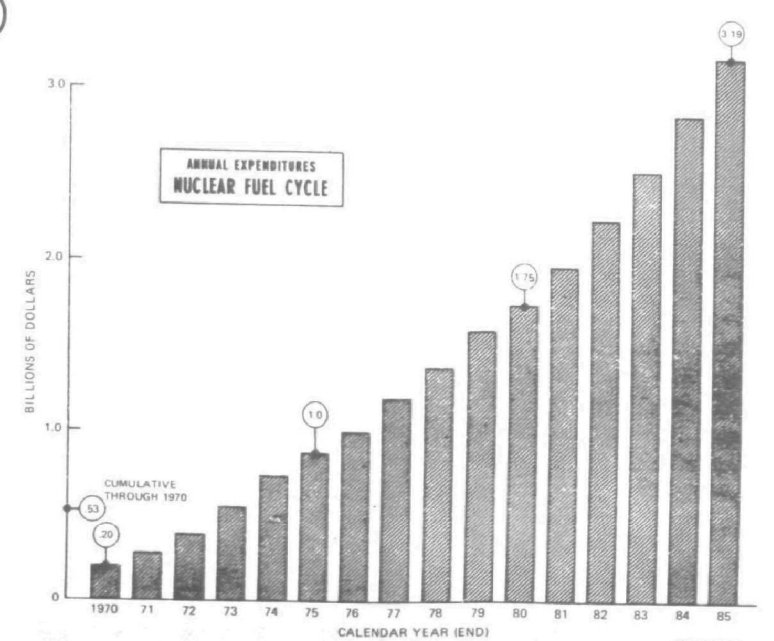
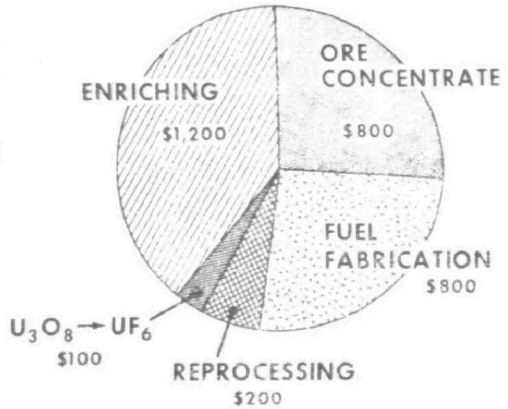


(21) NUCLEAR ELECTRIC POWER

FUEL CYCLE COSTS (MILLIONS)

1985

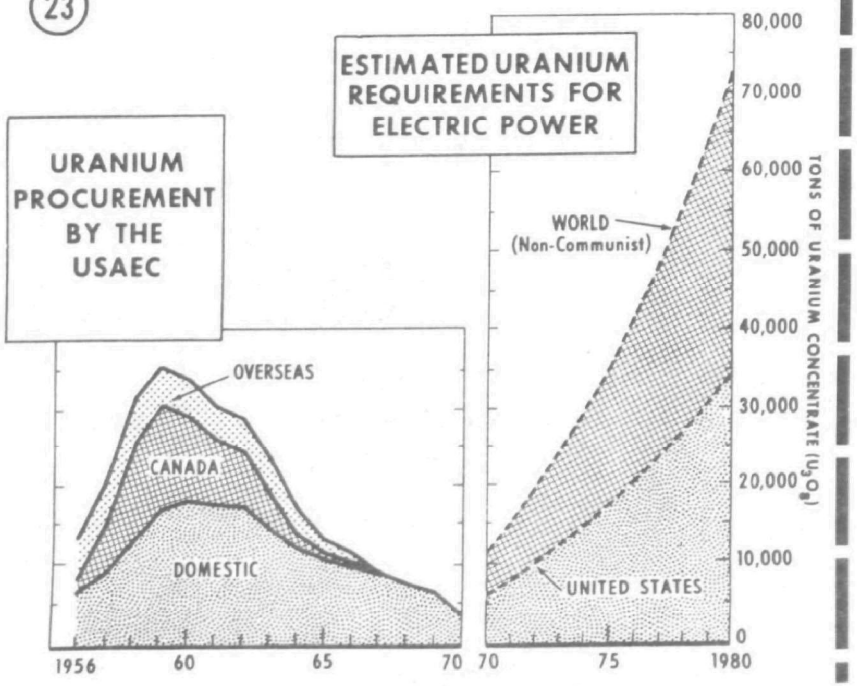


(22) NUCLEAR ELECTRIC POWER

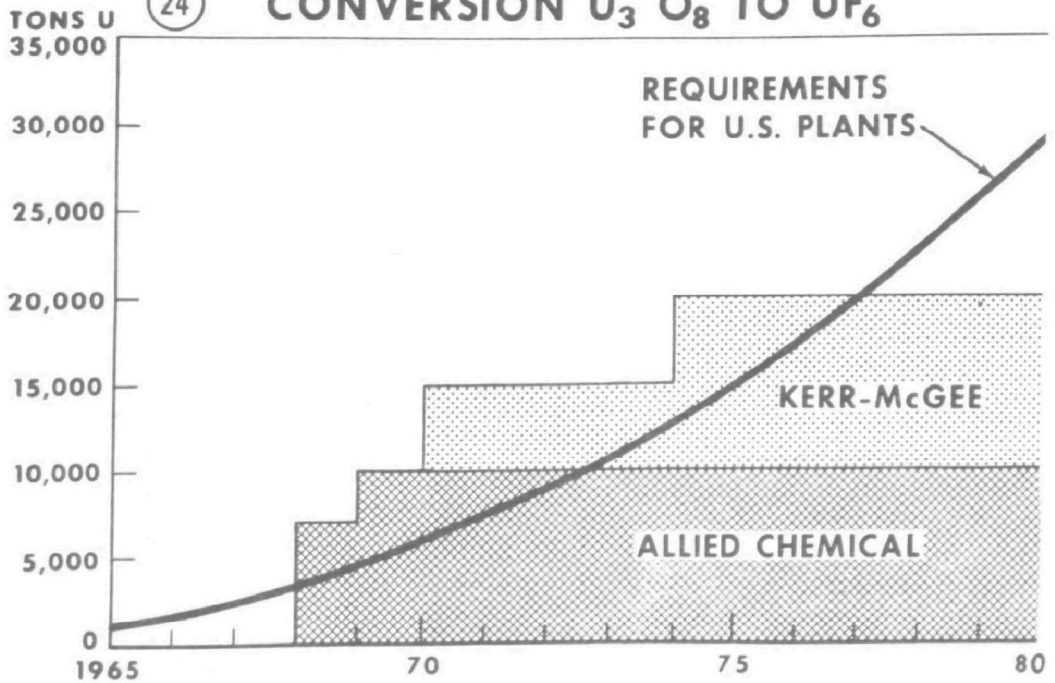
CUMULATIVE EXPENDITURES THROUGH 1985

- PLANT CONSTRUCTION $100 BILLION
- FUEL CYCLE COSTS $23 BILLION

(23)



(24) CONVERSION U_3O_8 TO UF_6



be converted to a gas, and Figure 24 shows the market for this conversion step. You can see that we have more capacity here already than we really need.

Now, the big question in Washington today in the nuclear business is when are we going to transfer the last fuel cycle step remaining in the Government to private industry, and that is the enrichment of natural uranium in the uranium-235 isotope. This is all done now in Government-owned enriching plants.

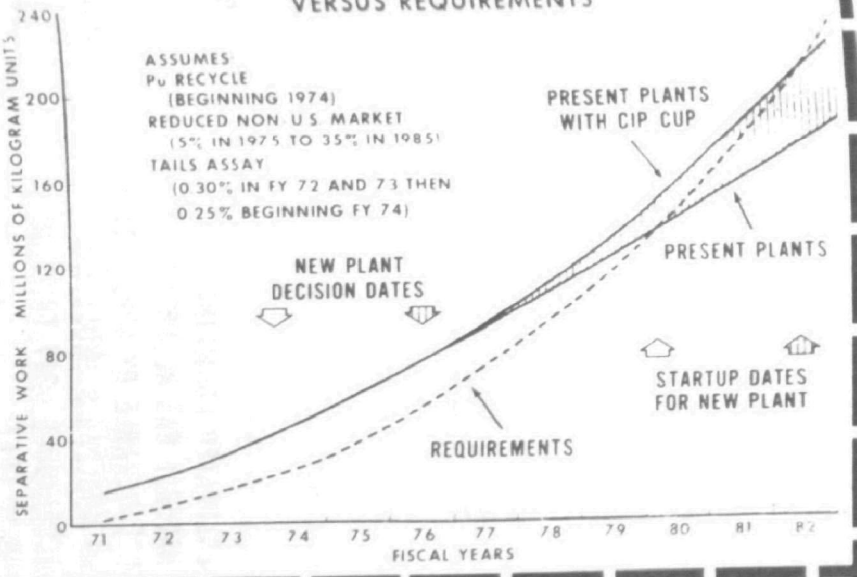
Figure 25 shows the requirements for enriching (or the separation of uranium isotopes) and the capability that exists in the AEC plants. At some time in the near future we are going to have to build new enriching plants to meet our needs. We are expecting that the new plants will be built, owned and operated by private industry. This will mean an investment of $10 to $20 billion by private industry (including power plants to supply the electricity required).

Figures 26 and 27 show requirements for fuel fabrication and fuel reprocessing. We feel we have been pretty successful in creating a competitive industry for these steps.

The final step in the fuel cycle is the disposal of radioactive wastes. I mention this only because it fits into the subject of your conference. The AEC has announced a policy of solidifying liquid waste and storing it only at a federal repository. We don't view this as a particularly difficult problem. The only comment I want to make here is that, based on our estimates, we have more waste stored at Hanford, Washington today from our weapons program than we will have from all

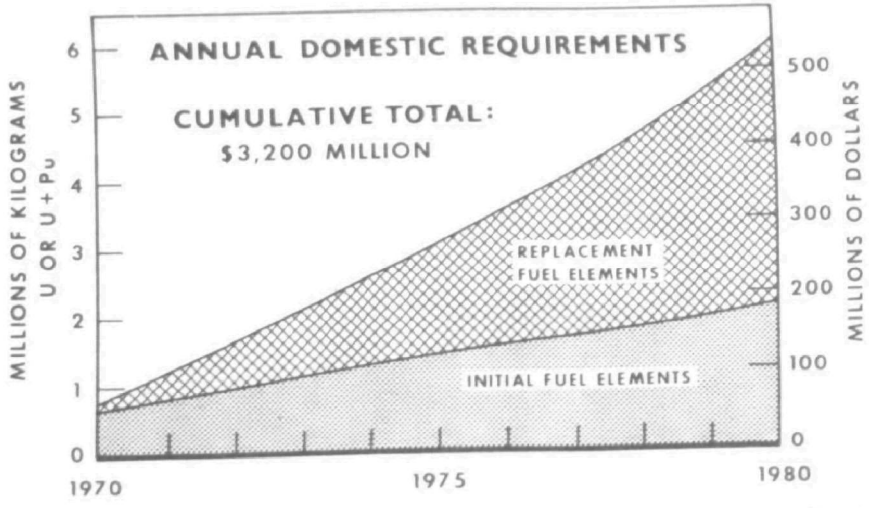
(25)

CUMULATIVE SEPARATIVE WORK AVAILABILITY VERSUS REQUIREMENTS



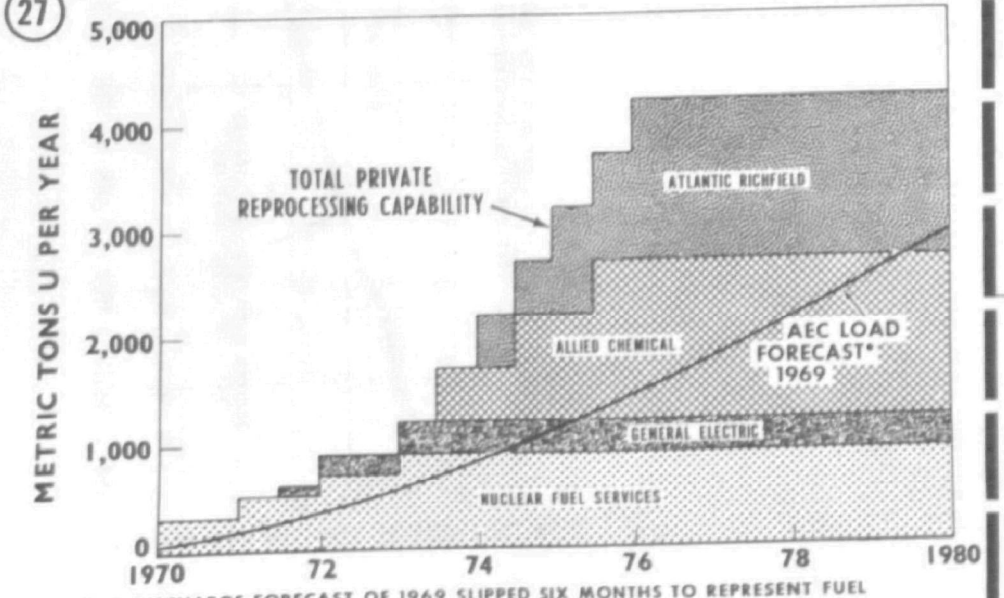
(26)

POWER REACTOR FUEL FABRICATION



(27)

FUEL REPROCESSING - CAPABILITY VERSUS LOAD

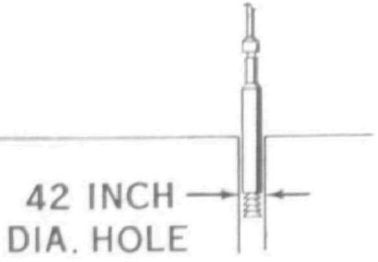


AEC DISCHARGE FORECAST OF 1969 SLIPPED SIX MONTHS TO REPRESENT FUEL AVAILABLE FOR REPROCESSING

10 KT EXCAVATION EXPLOSIVE

(28)

NUCLEAR



$350,000

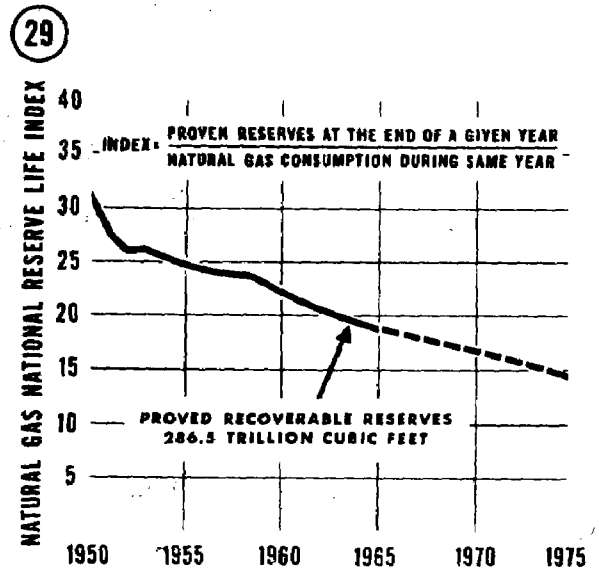
nuclear power plant fuel projected for reprocessing through the year 2000.

In addition to nuclear power, there are two other principal applications of nuclear energy to peaceful purposes: the use of nuclear explosives in our Plowshare program and the many uses of radioisotopes.

The reason people are interested in nuclear explosives is the large concentration of energy involved. Figure 28 indicates the advantages of nuclear explosives where a large detonation is needed.

One of the more interesting applications which has been receiving a lot of attention is called project Gasbuggy. It has been estimated that if this program is successful, our reserves of natural gas can be doubled or even tripled (Figure 29).

I will only mention radioisotopes because they do not fall within your subject tonight. They have literally thousands of uses--in medicine, in industry, in agriculture, as irradiators of materials, and for the generation of electric power in small unattended packages.



THE TERRESTRIAL RADIOLOGICAL MONITORING PROGRAMS AT DUKE POWER COMPANY'S OCONEE AND MCGUIRE NUCLEAR STATIONS

Lionel Lewis
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Duke Power Company

Introduction

Wondering what the original title meant in my invitation to speak, I decided to look up the word, terrestrial, in Webster's Dictionary. One meaning of terrestrial is, "of, or relating to the earth or its inhabitants"; another is "of, or relating to land as distinct from air or water". This didn't help to resolve the question since I could not separate the land from the air or the liquid waste from the earth's inhabitants. I finally assumed that I was supposed to talk about monitoring of the gaseous rather than liquid waste in the land environment at the Oconee Nuclear Station. However, I also want to talk about the McGuire Nuclear Station which is still in the proposal state, as well as the Oconee Nuclear Station which is currently under construction, since there are some significant aspects concerning the environmental programs for these stations that have developed over a period of a few years.

The Oconee Nuclear Station is located in the western part of South Carolina near Clemson. It is a multiple reactor station situated on a power lake and consists of three 886 MWe PWR units. (Figure 1)

The McGuire Nuclear Station (Figure 2) will be located about 17 miles northeast of Charlotte, North Carolina. It is also to be a multiple unit station located on a power lake and will consist of two 1180 MWe PWR units.

Figure 1. Architectural Drawing of Oconee Nuclear Power Station Showing Lakeside Setting and Adjacent Hydroelectric Plant.

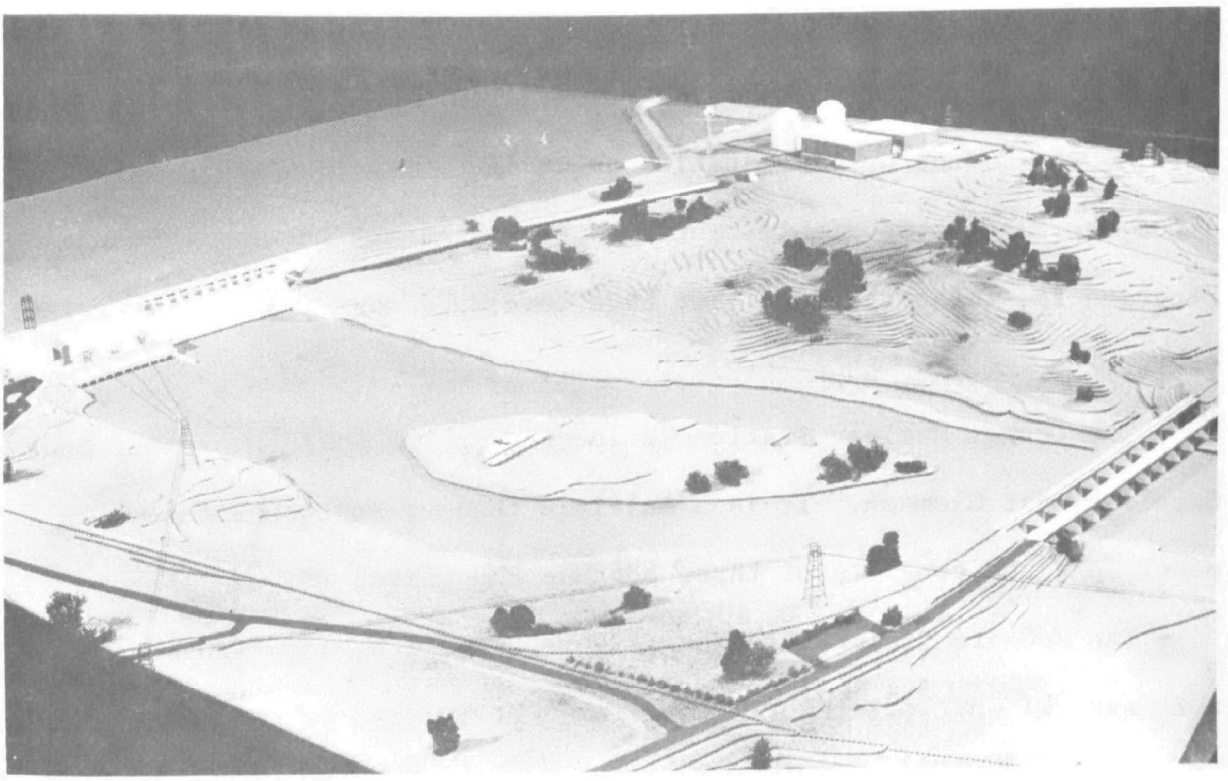

Figure 2. Model of Proposed McGuire Nuclear Power Station Showing Lakeside Setting and Adjacent Hydroelectric Plant.

Although both of these stations will normally release radioactivity at a very small fraction of permissible limits, with McGuire considerably less than Oconee (Table 1), the interest and concern these days about nuclear power and the environment have caused us to devote considerable attention to these programs. For example, in the McGuire PSAR we evaluated all of the critical environmental exposure pathways to man in order to estimate the maximum dose to an individual and to establish the sampling requirements for the Environmental Radioactivity Monitoring Program. The highest dose we obtained from this evaluation of exposure to liquid and gaseous waste effluents was a total of 0.22 millirem to the highest individual. This is about one/2300th of the Radiation Protection Guide for an individual and 1/770th of the Radiation Protection Guide for a suitable sample of the exposed population. An extensive study of an early boiling water type nuclear power reactor was made by the U.S. Public Health Service in 1968 using very sensitive instruments. This reactor discharged more than 800,000 curies of radioactivity in gaseous and liquid waste effluents in 1969 (compared with less than 927 curies total expected from McGuire). According to their report, no radioactivity attributable to the station was found in samples of rainwater, soil, cabbage, grass, corn husks, milk, deer, rabbit,

TABLE 1. COMPARISON OF GASEOUS WASTE RELEASES

Maximum Design Releases (1% failed fuel)
Oconee $\approx 10^6$ curies per year (mpc $\approx 10^7$)
McGuire $\approx 10^4$ curies per year (mpc $\approx 10^6$)
Normal Operation at Boundry
Oconee - 0.01% mpc, total for 3 units, 159 curies
McGuire - 0.02% mpc, total for 2 units, 89 curies

surface water, drinking water, or fish. However, they did state that traces of radioactivity far below acceptable limits were found in three other samples. The study concludes with the statement that, "on the basis of these measurements exposure to the surrounding population through consumption of food and water from radionuclides--was not measurable". For the McGuire Nuclear Station, it appears from the results of our evaluations that although the total amount of radioactivity released concentrations of activity and resulting doses that can be calculated, it is doubtful that these concentrations of radioactivity, so far below limits, can actually be measured beyond the Exclusion Area and differentiated from the normally existing background radiation. However, the interest and concerns these days about the extent of environmental monitoring programs at individual nuclear power stations seems all out of proportion to the amounts of radioactivity these modern plants will release. We shall, nevertheless, conduct the program and attempt to measure these trace amounts.

Environmental Monitoring Programs in General and Terrestrial Monitoring in Particular

An environmental monitoring program at a nuclear power station is an organized effort to sample and measure radiation and radioactivity in the vicinity of the station. This program is conducted for the purpose of determining the contributions to the existing environmental radiation and radioactivity levels that result from station operations. It is also performed in order to evaluate the significance of this contribution; particularly, as it effects the health and safety of the public, that is, the radiation dose received by man.

Monitoring programs are usually divided into preoperational and operational phases on the assumption that preoperational levels may provide a baseline to which operational levels can be compared. Such comparisons are complicated by additional fallout from nuclear weapons testing, seasonal and annual variations in residual fallout levels, variations in natural background and discharges of radioactive materials from other installations. However, preoperational monitoring does generally document the existing radioactivity levels and their variability. Also, the use of control locations well out of the influence of the plant can serve as a means of comparison for evaluating the plant's contribution to the environment during the operational phase. The outlines of the monitoring programs for the Oconee and McGuire Nuclear Stations are shown in Tables 2 and 3.

During the normal operation of a nuclear power plant, the only contribution of radioactive materials to the terrestrial environment will be due to the release of airborne radioactive wastes; that is, from controlled releases of radioactive gases and particulates. There will also be a very minor contribution to the radiation levels in the immediate area beyond the site fence due to direct radiation from operations conducted within the plant. The radioactive wastes released from the plant will usually be diluted and dispersed in the environment and will exist only in trace quantities beyond the Exclusion Area, in concentrations that should be many orders of magnitude below the permissible limits. The measurement of these extremely low levels

TABLE 2. OUTLINE OF ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAM

OCONEE NUCLEAR STATION

Terrestrial	Aquatic
1. Airborne particulates, rain, settled dust	1. Water lakes, streams, wells, water supplies including tritium
2. Radiation dose and dose rate	2. Lake bottom sediment
3. Vegetation (grass)	3. Vegetation, including plankton
4. Animals	4. Fish
5. Milk	

TABLE 3. OUTLINE OF ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAM

McGUIRE NUCLEAR STATION

Terrestrial	Aquatic
1. Airborne particulates, rain, settled dust	1. Water lakes, wells, water supplies including tritium
2. Radiation dose and dose rate	2. Lake bottom sediment
3. Vegetation and crops corn, beans, others	3. Aquatic vegetation, plankton, bottom organisms
4. Milk	4. Fish

of radioactivity in environmental samples requires very sensitive instruments, usually low background counters.

Since the plant's contribution to the terrestrial activity occurs mainly as a result of radioactive airborne waste releases, it follows that the most likely place where this activity should be found is in the air beyond the plant where this radioactivity is transported by the wind. Air particulate samples should be taken in prevailing wind directions, particularly near centers of population. Since most of the radioactivity discharged in the airborne waste effluent is gaseous activity, the measurement of dose and dose rate is a necessary and an important sample. Thermoluminescent dosimeters, (TLDs), are most effective for this purpose.

Samples of airborne particulates, rain and settled dust, and radiation dose and dose rate, are considered as primary measurements. The primary samples are of those things that may contribute a dose to man directly. These primary measurements must be correlated with information on plant radioactive waste releases, meteorological data, plant radiological controls and the installed effluent monitoring system instruments within the plant. Secondary samples are of those things that may contribute a dose to man indirectly. Samples of secondary importance on land include vegetation and milk. Sampling of local crops and animals may also be significant.

Some samples are collected continuously, others weekly, monthly, quarterly, or semi-annually, depending on their significance as primary or secondary samples. Airborne radioactivity (particulate and gaseous) being considered as of primary importance is often collected or measured continuously.

Just as it is important to measure the radioactivity contribution of the plant to the environment, it may be equally important to measure the contribution to the environment not due to the operation of the plant. For example, there may be legal or public relations value in the fact that your environmental monitoring program has detected fallout from a recent Chinese nuclear weapons test.

Criteria for the selection of various terrestrial samples at both the Oconee and the McGuire Nuclear Stations were generally as follows:

TYPE SAMPLE OR MEASUREMENT	CRITERIA FOR SELECTION OF SAMPLING LOCATIONS	COLLECTION FREQUENCY
1. Airborne Particulates Rain and Settled Dust	Comparison of on-site vs off-site locations at distances up to 10 miles near towns and populated areas; and in prevailing wind directions and control locations.	Monthly, sample collected continuously
2. Radiation Dose and Dose Rate	Comparison of on-site vs off-site locations near towns and populated areas at distances up to 10 miles and in prevailing wind directions; and control locations.	Dose: Quarterly Integrated total duplicate samples at each location Dose Rate: Quarterly Single Measurement
3. Terrestrial Vegetation and Crops	Comparison of upwind and downwind directions on-site, in nearby Low Population Zone and in control locations.	Quarterly Crops (in season)
4. Milk	From nearby farms in prevailing wind directions and from control locations.	Quarterly

5. Animals	Within Exclusion Area, nearby Low Population Zone and from control locations in accordance with recommendations of State Wildlife Agency.	Quarterly

Since comparison with preoperation levels has its problems, to aid in evaluating the effect of plant releases on the environment during the operating period, the plant's contribution of activity will be differentiated from existing environmental levels by comparing levels found in similar samples collected at the same time in different locations. This is done by collecting samples both within and beyond the Exclusion Area, upstream and downstream, and upwind and downwind, of the release point for the waste effluent from the station.

The analyses generally performed on environmental samples are:

1. Measurements of gross alpha and gross beta-gamma activity.
2. Identification of specific radionuclides (by use of gamma spectrometry or other means).
3. Measurement of specific radionuclides (such as iodine-131, strontium-90, cesium-137, and tritium).

The sensitivity of these analyses and the size of the samples taken at both Oconee and McGuire will permit absolute measurements of existing preoperational and operational levels to be made even though they may be far below permissible levels. Gross beta and gross alpha radioactivity is counted with a low background gas-flow proportional counter having nominal backgrounds of one count per minute for beta and 0.05 cpm for alpha. Environmental samples, for practical reasons, are usually

counted for a period of twenty minutes and results are expressed at the 90% confidence level. Under these conditions, the minimum detectable activity is approximately 3.6 pCi for beta and 2.4 pCi for alpha radiation. The sensitivity of the radiation dose measurements (gross gamma) is at least 10 mR for a three-month integrated dose and about 0.01 mR per hour for the dose rate measurements.

Sample Collection, Equipment, and Procedures

Rain and settled dust samples are collected in buckets that are held approximately five feet above the ground by pole supports. The samples are processed by filtering the entire sample and counting the filter paper and by evaporating and counting an aliquot of the filtrate, adding the results together after correction to final volume, and expressing the results in nanocuries per meter squared. If at the end of the one-month collection period, the rain water has evaporated, distilled water is added to take up the settled dust and residual activity in the bucket. Dose and dose rate measurements are made by means of duplicate thermoluminescent dosimeters which are wrapped in a protective covering of polyethylene and held in a small wooden box three feet above ground. Dose rate can be determined by dividing by the number of hours the TLD's were in the field. Dose rate measurements are also made by means of a calibrated geiger or scintillation counter held at three feet above ground level. Air particulate samples are collected on a four-inch filter paper at a flow rate of approximately 2 cubic feet per minute operating one hour "on" and three hours "off" over a period of

one month. By means of this off/on sampling during the preoperational monitoring period the samplers have been used for more than two years without maintenance.

Additional Details About the Oconee Terrestrial Monitoring Program

The sampling stations were established in the Oconee environs at the end of 1968, and a laboratory for the analysis and counting of the samples was also established at that time. The laboratory equipment includes a low background gas flow proportional counter for measuring gross alpha and gross beta radioactivity and a 400 channel gamma scintillation spectrometer (multi-channel analyzer). In addition, some samples are sent to commercial laboratories for analysis of specific radionuclides.

The full scale environmental sampling program was begun in January 1969. Thus, at least two years of preoperational monitoring data will be obtained prior to the operation of Unit 1.

The preoperational environmental radioactivity program for Oconee has been discussed with the South Carolina State Board of Health, Division of Radiological Health, and the South Carolina Pollution Control Authority. The U.S. Government Fish and Wildlife Service has also been advised of the program through their district office in Atlanta, Georgia. In addition, the program was discussed with the South Carolina Wildlife Resources Department. This latter department is cooperating with Duke Power Company in regard to the collection of fish and animal samples. They have made recommendations as to what specimens should be collected

and are supplying fish samples from the Hartwell Reservoir and Lake Keowee. They have also issued a special research permit to Duke Power Company for the collection of animal samples.

The results of the environmental radioactivity monitoring program to date are comparable to those reported from throughout the country by what is now the Environmental Protection Agency in their "Radiological Health Data and Reports" document. It is of interest also to note that radium daughter products have been observed, as a result of gamma analysis, to exist in considerable amounts in deep well water. Further investigation has shown that this condition seems to be peculiar to the Piedmont area of the Carolinas.

The Environmental Radioactivity Monitoring Program will continue during the operating period.

Prior to the initial operation of Unit 1, two additional air monitoring stations beyond that listed in the preoperational program will be established within the Exclusion Area at locations where the highest ground level concentrations of radioactivity are expected to exist based on site meteorological studies. Additional thermoluminescent dosimeters will be used to measure radiation dose at various locations along the Restricted Area fence, in the Unrestricted Area of the station, throughout the construction area for Units 2 and 3 and at significant locations along the Exclusion Area boundary.

The environmental radioactivity monitoring program for the Oconee Nuclear Station is conducted by the station Health Physics Supervisor, with some assistance from the Chemist. The program was established

and is directed and reviewed by the Duke Power Company System Health Physicist; that is, by me.

Results of the Oconee Environmental Radioactivity Monitoring Program will be made available to the State of South Carolina and to the Federal agencies mentioned previously who have a direct interest and concern in these matters.

It is expected that the results of the Environmental Radioactivity Monitoring Program for the Oconee Nuclear Station will demonstrate the effectiveness of plant control over radioactive waste disposal operations and of compliance with Federal and State regulations for the disposal of these materials. The detailed descriptions of the preoperational and operational environmental radioactivity monitoring program for Oconee are presented in Tables 4 and 5.

Additional Information Concerning the McGuire Terrestrial Monitoring Program

In the McGuire PSAR, we were asked, in addition, to evaluate possible critical exposure pathways to man. Although the amounts of radioactivity added to the environment from station operation are minimal and as low as practicable based upon the latest available technology, possible critical exposure pathways to man have been evaluated in order to estimate the dose to the maximum individual and to establish the sampling requirements for the Environmental Radioactivity Monitoring Program.

TABLE 4. OCONEE PREOPERATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAM

CODE	
Monthly - M	Frequency
Quarterly - Q	
Annually - A	
Type of Sample - (A) thru (M)	

Code No.	Location	H_2O Well - Residence (A)	H_2O Finished - Water Supply (B)	H_2O Raw - Water Supply (C)	H_2O Surface - River, Lakes (D)	Rain, Settled Dust - Fallout (E)	Air - Particulate (F)	Vegetation - Terrestrial (G)	Vegetation - Aquatic (H)	Bottom Sediment Water Supply & Lakes (I)	Radiation Dose & Rate TLD & Film, Instrument (J)	Animals (3) 1 Mile Radius (K)	Fish (3) Lakes (L)	Milk - Local Dairies (M)
000	Site: Visitors Center					M	M	Q			Q			
000.3	1st Bridge North of Site on New 183 Connecting Canal				M+A				Q	Q				
000.4	2nd Bridge North of Site on New 183				M									
000.5	1 Mile Radius of Site - Specify N, S, E, W											Q		
000.6	Keowee Lake												Q	
000.7	@ Bridge on 183 Existing				M					Q				
000.8	Residence within Exclusion Area	Q												
000.9														
000.10														
001	Salem: Vol. Fire Dept. Lot										Q			
001.3	4.5 Mi. N.E. of Salem on Hwy. 11 @ Bridge (Cedar Creek)				A									
001.4	8.0 Mi. E. of Salem @ Bridge (Crow Creek)				A									
001.5														
001.6														
002	Walhalla: Branch Rd. Sub Station					M					Q			
002.1	7.5 Miles West of Site on Hwy. 183													Q
002.2														
003	Keowee: High School Hwy. 16 (Opposite Side)										Q			
003.1														
003.2														
004	Seneca: Oconee Memorial Hospital										Q			
004.1	Water Supply, Lake Keowee Intake, (When Completed)		M	M						Q				
004.2														
005	Newry: Abandoned High School on S. C. 130							Q			Q			
005.1	Spill Dam (L.R. & Keowee Spill)				M					Q				
005.3	Hwy. 27 at Bridge				M					Q				
005.4	3.75 Mi. W. of Newry on Keowee Hwy. @ Bridge (Cain Creek)				A									
005.5	3.25 Mi. N.W. of Newry on Keowee Hwy. @ Bridge (Crooked Creek)				A									
005.6														
005.7														
006	Clemson: Meteorology Plot					M	M	Q			Q			
006.1	Water Supply		M	M										
006.2	Intake Hartwell Reservoir K-3				M+A				Q	Q				
006.3														
006.4														
006.5														
007	Central, S. C.: Joint Sub Station Hwy. 93										Q			
007.1														
007.2														
008	Liberty, S. C.: Branch Office Yard										Q			
008.1														
008.2														

TABLE 4 (cont'd). OCONEE PREOPERATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAM

CODE
Monthly - M — Frequency
Quarterly - Q
Annually - A
Type of Sample - (A) thru (M)

Code No.	Location	H_2O Well - Residence (A)	H_2O Finished - Water Supply (B)	H_2O Raw - Water Supply (C)	H_2O Surface - River, Lakes (D)	Rain, Settled Dust - Fallout (E)	Air - Particulate (F)	Vegetation - Terrestrial (G)	Vegetation - Aquatic (H)	Bottom Sediment Water Supply & Lakes (I)	Radiation Dose & Rate TLD, Film, Instrument (J)	Animals (3) 1 Mile Radius (K)	Fish (3) Lakes (L)	Milk - Local Dairies (M)
009	Six Mile, S. C.: Microwave Tower Hwy. 137										Q			
009.1														
009.2														
010	Pickens, S. C.: Branch Office Yard					M					Q			
010.1														
010.2														
011	Floating Station: Subject to Change with Conditions										Q			
011.1														
011.2														
012	Anderson, S. C.: Water Supply		M	M						Q				
012.1														
012.2														
013	Hartwell Reservoir: 5.8 Mi. South of Keowee Dam												Q	
013.1														
013.2														

Note: 1. 000.3 and 006.2 will be sent to outside services for analysis for ^{3}H and ^{90}Sr (2 gals. each location).
2. Fish speciments will be collected alternately from Lake Keowee and Hartwell.
3. 001.3, 001.4, 005.4, and 005.5 will be collected once per year during rainy season.

Note: Location numbers that appear in Table 2-2 which are not shown above are results of special investigations at the general location indicated.

TABLE 5. OCONEE OPERATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAM

Code of Collection Frequency

Monthly M
Quarterly Q
Annual A

			TYPE OF SAMPLE													
									6.							6.
			H_2O Finished - Water Supply	H_2O Raw - Water Supply	H_2O Surface - River, Lakes	Rain, Settled Dust - Fallout	Air - Particulate	Vegetation - Terrestrial	Vegetation - Aquatic and/or Plankton, Bottom Organisms, Crustaceans	Bottom Sediment Water Supply & Lakes	Radiation Dose & Rate TLD and Instrument	Animals (3) 1 Mile Radius	Fish (3) Lakes	Milk - Local Dairies and Nearby Farms
	000	Site: Visitors Center, Station #1				M	M	Q			Q			
	000.1	Station #2				M		Q			Q			
	000.2	Station #3				M		Q			Q			
	000.3	Bridge N of Site on New 183 Connecting Canal			M									
6. |	000.4	Near Liquid Effluent Release Point (closest point where found downstream)							Q	Q				
6. |	000.5	1 Mile Radius of Site (Including Lake Keowee, upstream of release point)			A*				Q			Q	A***.	
	000.6	Lake Keowee Cooling Water Discharge			M					Q				
	000.7	@ Bridge on 183 Existing			M					Q				
	000.9	Site Fence, Various Locations									Q			
	000.10	Exclusion Area, Various Locations									Q			
	001	Salem: Volunteer Fire Dept. Lot									Q			
	002	Walhalla: Branch Road Sub Station				M					Q			
	002.1	7.5 Miles West of Site on Hwy 183												Q
6. |	002.2	Nearby farms in prevailing wind directions												Q
	003	Keowee: High School Hwy. 16						Q			Q			
	004	Seneca: Oconee Memorial Hospital									Q			
	004.1	Water Supply, Lake Keowee Intake	M	M										
	005	Newry: Former High School on S. C. 130									Q			
	005.3	Hwy. 27 at Bridge			M				Q	Q				
	006	Clemson: Meteorology Plot				M	M	Q			Q			
	006.1	Water Supply	M	M										
6. |	006.2	Intake Hartwell Reservoir K-3								Q				
	007	Central, S. C.: Joint Sub Station Hwy. 93									Q			
	008	Liberty, S. C.: Branch Office Yard									Q			
	009	Six Mile, S. C.: Microwave Tower Hwy. 137									Q			
	010	Pickens, S. C.: Branch Office Yard				M					Q			
	011	Miscellaneous: Location, Samples and Frequency vary				As Required								
	012	Anderson, S. C.: Water Supply	M	M										
6. |	013	Hartwell Reservoir: South of Keowee Dam as close to liquid effluent release point as they can be obtained.			A*								Q	

COLLECTION FREQUENCY

Notes:
1. Fish and animals will be collected in cooperation with the South Carolina Wildlife Resources Department.
6. | 2. Fish specimens will be collected from Lakes, Keowee and Hartwell, subjected to gamma analysis and analyzed for specific radionuclides found, as well as gross beta minus K-40, strontium-90 and cesium-137.
* 3. Lakes Keowee and Hartwell will be sampled annually for tritium analysis by outside service. (000.5, 013)
** 4. Collection depends on availability
6. \|*** 5. Lake Keowee which is above the liquid effluent release point is considered as a control.

These pathways included:

1. Whole body dose from gaseous waste disposal (direct atmospheric exposure).
2. Drinking water from that portion of the lake receiving the radioactive liquid waste releases or from wells directly associated with this portion of the lake.
3. Swimming, boating, fishing, or walking along the shore of lake within this same area.
4. Eating fish from within this portion of the lake.
5. Consuming milk and other dairy products from locations affected by gaseous waste disposal.
6. Eating foods (crops, animals) grown in areas or on feeds affected by waste effluents.

Evaluation of Items 1 and 2 above show the resulting annual dose estimates from these gaseous and liquid waste releases to be:

	Dose Estimates (millirem per year, whole body)	
	Normally Expected Operation	Maximum Design Figure
Gaseous Waste Releases	0.11	10.00
Liquid Waste Releases	0.11	0.18
Total	0.22	10.18

Evaluation of these other critical pathways results in doses so low as to be meaningless such as, an immersion dose of 0.0005 mRem per year, from swimming 24 hours/day, 365 days/year in the liquid waste effluent;

or the fact that you will have to eat many thousands of pounds of fish each day, every day, to achieve the permissible population dose (Radiation Protection Guide); or the fact that we will normally add only 8 mCi of corrosion product radioactivity other than tritium to a lake that in 1970 contained background activity in excess of 6300 mCi. Under abnormal conditions of 1% failed fuel in both units, we will add a maximum of 700 mCi of corrosion product and fission product activity to the lake. The tritium dose will be about twice the background tritium dose from drinking the lake water right now, before the plant is even constructed; that is, the tritium dose will be about 0.06 mRem/year.

Conclusion

The Oconee and McGuire Nuclear Stations will utilize the latest available technology and will operate in compliance with regulations requiring reactor operators to reduce waste to as low a level as practicable. Radioactivity in the environment should, therefore, be several orders of magnitude below permissible concentrations, and should, correspondingly, result in doses that are several orders of magnitude below permissible population limits, for you HEW and EPA people, (Radiation Protection Guides). It may be argued, as a result of this, that there is no technical reason for environmental monitoring around these plants, other than to demonstrate compliance with regulations.

We fully expect to find negative results in environmental samples collected in the vicinity of the Oconee and McGuire Nuclear Station. We hope that this will serve to demonstrate that the radiological effects on man and his environment from releases of gaseous and liquid waste from these stations will be so low as to be essentially nothing.

Discussion

SPEAKER: What kind of thermoluminescent system are you planning to use?

MR. LEWIS: The Harshaw one hundred on an Eberline Reader.

SPEAKER: Can you describe the level of meteorological support required to initiate and carry out this program?

MR. LEWIS: We had conducted on-site meteorological studies as a part of the initial licensing of the plant and we have a tower with meteorological instruments at various heights. We will have this in operation during the operating period and read-outs of wind speed and direction information and so forth available in the control room in support of possible use by operators for waste disposal operations and for emergency purposes.

SPEAKER: You just have a single tower at the site, is that correct?

MR. LEWIS: There will be one tower constructed that will read out in the control room during the operations; but we have taken measurements from many places on the site. We ran smoke tests; it was quite an elaborate program.

SPEAKER: Which are the controlled areas?

MR. LEWIS: In the case of Oconee Nuclear Station, the exclusion area boundary is a one mile radius from the plant. In the case of McGuire Nuclear Station, we have a half mile exclusion area boundary.

Of course, the plant itself has a fence around it and we more or less consider the sections of the plant like the reactor buildings and

the auxiliary building to be the restricted area within a small inner fence. What would be the unrestricted area of the plant would be the administrative offices and the turbine building and essentially the same thing for McGuire.

SPEAKER: You mentioned that you were going to take some control locations way off site to see the natural background.

MR. LEWIS: You try to get a control location so that you can ask is this material coming from our plant? If you find it upwind and downwind, you may have some doubts that you released it.

That is one way of comparing these; upstream and downstream, and upwind and downwind. But you try to find some locations that are so far removed from this plant that they may be considered a part of the area but unlikely to be influenced by the plant.

Savannah River Plant has located some sampling stations at least twenty-five miles away, possibly even further, that they call control locations. I am not quite sure that they are. I think one time at Parr Nuclear Station we found tritium attributed to them and Parr was more than a hundred miles away.

I hope SRP people are not here right now. But this was a very rare occasion. We were not operating at the time. But for the most part I think they consider stations twenty-five miles away from them to be control locations. We might find one fifteen miles away that is quite suitable.

SPEAKER: I wonder if you are finding higher alpha activity or beta activity in the area; alpha activities in populated areas higher than those you are finding near your site?

MR. LEWIS: I don't know if I understood. Why would you expect this?

SPEAKER: Well, I think it is being found in several of these type of surveys that you are doing, that the alpha activities in cities, for example, is higher than the alpha activity in air.

MR. LEWIS: I haven't made this correlation, but it might exist.

SPEAKER: Do you do a background correction from TLD's, do you attribute all you see on the dosimeter to the actual exposure, or do you have some shielded?

MR. LEWIS: Well, if you are measuring background, it is hard to subtract background from it. So we have to take the absolute reading as the background.

SPEAKER: What air filters are you using?

MR. LEWIS: We use HV70 filter paper, eighteen gauge.

SPEAKER: Is the rain and dust fall sample a combination pot collection?

MR. LEWIS: Yes.

SPEAKER: Are you filtering that then and analyzing the two separations?

MR. LEWIS: Yes, and adding them together.

SPEAKER: Are you filtering that with membrane?

MR. LEWIS: Millipore filter paper, about forty-five microns.

SPEAKER: Can you give an approximate annual cost for each of these programs?

MR. LEWIS: I don't know if I can or not. We use health physicists and health physics technicians part time. I devote time to evaluating results and the cost of equipment in setting up laboratories, I don't know. Do you want me to take a stab at it?

SPEAKER: Yes.

MR. LEWIS: Ten, fifteen thousand dollars.

SPEAKER: I noticed from some of the discussions yesterday that we didn't get around to the business of standards or devising some sort of a guide for surveillance programs. It was alluded to in the morning. But it may be appropriate here to ask the question if you, from your experience, find value in having somebody like the Radiation Office develop an environmental surveillance guide for use in setting up these programs, or are they too individual in nature? That is, is each station unique by itself? If you had a guide, would it be so general that it would not be of any value?

On the basis of your own experience, would you find it to be of value in developing your environmental monitoring program?

MR. LEWIS: Well, I used what was made available by the Public Health Service and other organizations as a guide in setting up the program.

First of all, I wanted to input as many groups as possible who had legitimate interests in this regard. I suspect the guide would be

appropriate in that at least it would represent what people have to do, such as what the AEC might be thinking at the present time. I was trying to emphasize in my talk that the plant is releasing so little that it is extremely difficult to detect it, let alone for it to be at environmentally significant levels from these modern plants.

I was also trying to show that the later plant, McGuire, which is really a minimum release plant has additional requirements tacked on it. Since there is some concern, we had to evaluate all the critical exposure pathways and so forth. But yet you can't help getting the impression from those who want additional samples analyzed, that they equate this plant with a large federal contractor activity; like with Hanford, the Savannah River Plant, or some such facility. Of course it is nothing when you compare the activity that is released.

MR. STAGNER: Florida Power Corporation. We cannot assume the responsibility of a guideline. There are many people, though, who say you should do this. They want a piece of the action. They want a piece of the money. If you were to publish such a guide, it would be by priority which would be followed through with the food chains, the eco-systems from beginning to end and then if another point is raised by communications with you it could be touched. You would give us a service, a greater service, in doing this.

MR. LEWIS: On the Oconee program the AEC and other federal agencies read it and want additional samples collected. One time we were told to collect crayfish within five hundred feet of the release point. This release point is associated with the hydroelectric station.

I think crayfish would be pretty strong and unusual to hold on when a hydroplant lets go. So I called this back to the AEC and later they said, "Well, get the crayfish as far back as they can hold on." Well, since we have state people assisting us, we put on scuba gear and went down and looked for these crayfish. We spent two hours looking and gave up. So our only alternative--that is, we thought of this as an alternative--was to import crayfish from the Louisiana Bayous and tether them in the water, pull them out for sampling purposes and have them analyzed to satisfy the requirement.

I am telling you this story in the hopes that people setting standards will require realistic samples. Perhaps there is more politics involved here than concern for the environment.

Today they expect us to prove negative results in a lot of samples and it is important to show this; there is that aspect. But today I am trying to leave an impression about releases from these two modern plants, and I assume many other people here are putting up plants with not much activity released during the year, certainly far below limits. Programs required of us should reflect this aspect.

SPEAKER: I assume that the State agencies in the vicinity have at these two stations, background monitoring stations that overlap yours to some extent, is that correct?

MR. LEWIS: Yes, that is correct. At least they will have some sampling stations. The State of South Carolina has recently been sharing TLD's with us. They are putting their out with ours and we mail them back to them. They are also taking water samples with us immediately downstream of our effluent release point.

SPEAKER: It is difficult to arrive at a good background radiation level value and I am wondering if you had any problems with disagreement between the data obtained by the State and your efforts.

MR. LEWIS: Well, sometimes this disagreement and the data can be resolved by looking at the methods.

Our airborne dust radioactivity sample differs from HEW in the method of analyses. I think they measure theirs with a geiger counter against the filter face and so you would find a lot more of the shorter lived activity.

They obtain results of the order of 1 pCi/m^3 and we show 0.01 to 0.1 pCi/m^3. This is because of differences in the methods, but once you resolve this they are in agreement.

SPEAKER: This probably is one area where standards would help; to have some consistent way of taking samples and analyzing them so when EPA gets on the statistics they can do something meaningful with them, rather than comparing your 0.01 with somebody else's 1.0.

MR. LEWIS: Well, I like this method of measuring only the longer lived activity. We collect it on a highly efficient filter paper.

SPEAKER: I am not criticizing their way or your way of doing it. But just saying possibly it would be of value to have some consistent way of doing it.

MR. LEWIS: That is true and I think this was discussed at various times yesterday. That is, standardizing the methods and procedures and so forth.

SPEAKER: You mentioned earlier the Dresden report. The study was made, it was published, and it just sort of lays there? Is that report of value to you?

MR. LEWIS: I think it was important to us to show in our environmental report a comparison between Dresden releases of eight hundred thousand curies with the eighty-nine curies which we will discharge.

Nevertheless the amount of radioactivity in the environment was almost meaningless at Dresden and should be many order of magnitude below meaningless at Charlotte.

I was concerned yesterday about the papers that set requirements for a certain accuracy on the samples. As I mentioned, in order to get the work done, a man collects all the samples and prepares them in a lab and ends up with a large number of samples to count in a given working time. We have just standardized on twenty minutes. We put samples in an automatic counter and allow twenty minutes per sample just for expediency. Of course, with higher activity samples you get a greater accuracy and with the lower level samples the accuracy is poor. I was somewhat concerned about this in regard to accuracy and precision. They would have to count low activity samples for an awfully long time in order to get high accuracy. But if someone sets accuracy as a requirement, they should take this aspect into consideration, that is, reject samples below a certain significance.

MR. HANNON: Bill Hannon, from N.C. State. I would remind ourselves that for years the government, States, and other agencies have been flying themselves into all sorts of programs. I am reminded for example of the old Radiation Effects Program. They spent a half billion dollars on it.

Now, the reason it was defunct is the fact that it ended up with no sampling, no reporting, no standardization. I think Dick's remarks, even though we referred to them yesterday as standards, are procedures of sampling reporting, and comparison is extremely important even though we are reporting less than nothing.

Unless this gets into the guide, we are just blowing our whistles for nothing. I have had trouble with this in my own activation analysis work. Water resources people are trying to get some kind of standard collection procedure they say. I don't give a damn how it is. Just be sure it is standard so that I can compare with HEW and water collection agency and things like this. We have to get this part settled.

MR. LEWIS: I find myself more or less in agreement with you. But what I was saying is possibly a sample containing less than say one percent of permissible concentrations in an environmental sample can be just reported to low accuracy.

MR. HANNON: I meant the collection. You have to start at the source. I was asked the other day to run some analyses on collections for air filters. I said fine. You just want the answer, right? Yes, we don't care how it was done if you see what I am driving at. That guy was spending money for us to give him an answer and I am putting my name on there that it is what it is.

They said well, they would put their name on it. Well, I am not going to sign it, because he didn't do anything about the sampling and yet he is going to use that to tell someone else that he didn't have mercury or something else in his water.

MR. LEWIS: The AEC mentioned the magic number in their draft guide of three percent of the concentration limit. I can see expressing a number close to that, or above it, to whatever accuracy you want. But if the sample count is close to zero, I don't think you should have to count it sufficiently long to put the accuracy figure into the answer.

MR. HANNON: Now, I get back to collecting. Where do you get water? Two or three levels across the stream? Do you mix it? How do you control the HP?

MR. LEWIS: But if you write too strict a standard, you are going to end up like we did with the crayfish.

MR. HANNON: If you are going to collect it then you have got a standard.

MR. LEWIS: If you have to collect crayfish, they have got to be there.

MR. HANNON: What I am getting at is how do you collect the water, air, and other materials that we are bringing in here and establishing a base line hopefully for the future. You have got to have some basis for standards.

MR. LEWIS: In a sense, this paper and discussion is a plea for getting all of these factors and aspects into any sort of guide that is developed.

MR. HANNON: Yes.

MR. WHIPPLE: University of Michigan. With regard to subjects for guides, let me call the release and discharge into the atmosphere, that would be the legal limit at one. I would ask that those who consider forming guides to give some thought to when releases become one

one-thousandth, one one-millionth, one-billionth of one. Then perhaps it is proper to consider spending this ten or twenty thousand dollars a year in some more useful way then collecting zeros.

MR. LEWIS: Precisely.

MR. COLLINS: Massachusetts. I would like to lend my support to the need for standardization to the sample media. I don't care where we go. It is essentially the same media. I think it is critically needed. This way we can minimize.

Now, I would agree with what the last gentleman said. Since the direction EPA is taking leads to looking for the infinite result, what we have to do is set up an amount of environmental sampling in order to prove our point.

I would also suggest that you look at other contaminants now. Concerning the station in Massachusetts, there is a great concern for the lobster which up there is considered something sacred. Since we found mercury in the water, it sort of deemphasized the impact of radiation in lobster.

MR. LEWIS: I hope that wasn't a question.

MR. STAGNER: I hope this will tie into your discussion. Under part 140 of standard 10, there are some surface levels mentioned, and this has been a radiological paradox for a number of years. But we are vitally interested in case we have a locality in which there is off-site radioactivity. What are going to be the standards that are going to be used? How do you measure this? If it requires several different standards or criteria, we would like to know that because there are several legal and decontamination implications.

MR. HILLEY: As you know, the AEC, I think it was back in December, put out a draft of a guide for environmental and effluent monitoring. I don't think it came across very clearly just what this cut-off level was. I hope that by the time the guide is put out in final form, that the intent will be clear.

The intent is to require more extensive environmental monitoring when you exceed range 1 of FRC and this three percent is an attempt, and I don't think they succeeded, to equate 10 CFR 20 values with this range 1 of FRC.

FRC says if you get range 1 or below, you don't--you have to do a confirmatory surveillance. Above range 1 you do more extensive monitoring, and at range 3, I think, you take remedial action.

The intent of that guide was to say that below range 1 you don't do very much. Above range 1 you go into quite an extensive program. You are saying that if you measure three percent of 10 CFR 20 values you have got to do an extensive monitoring program and that is not the intent.

MR. LEWIS: I was talking about accuracy of results and the means in which they are expressed, the plus or minus value. I say if they are below a level of concern, perhaps they don't need to be expressed to the sixth decimal place, like zero to the sixth decimal place. Perhaps they can be expressed zero to the first or second decimal place.

On samples which have more significance, they should be counted to the accuracies required.

MR. HILLEY: Okay. For example, you apparently in your FSAR have calculated .0005 mRem. That I think would constitute this minimal kind of monitoring. So that there is an attempt being made to do what you say.

AQUATIC RADIOLOGICAL MONITORING
BROWNS FERRY NUCLEAR PLANT

Gilbert F. Stone
Assistant to the Director of Environmental
Research and Development
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Introduction

I am happy to be here today to speak to this Symposium on the Aquatic Radiological Monitoring Program for the Browns Ferry Nuclear Plant. By way of general remarks, I should like to acquaint you with some of the general features of the plant, and since the concern of this paper is aquatic radiological monitoring, I will go into the Browns Ferry Nuclear Plant liquid waste processing and handling systems in some detail.

The Browns Ferry Nuclear Plant (Figure 1), being constructed by the Tennessee Valley Authority (Figure 2), is located on an 840-acre site in Limestone County, Alabama, bounded on the west and south by Wheeler Reservoir. The site is 10 miles southwest of Athens, Alabama, and 10 miles northwest of Decatur, Alabama. The plant (Figures 3 and 4) will consist of three boiling water reactors; each unit is rated at 3,293 MWt and 1,098 MWe. The first unit is tentatively scheduled to be placed in commercial operation in April 1972.

TVA began preoperational environmental monitoring at the Browns Ferry Nuclear Plant site in the spring of 1968, some two years before the first unit was scheduled to go into operation. The program has the

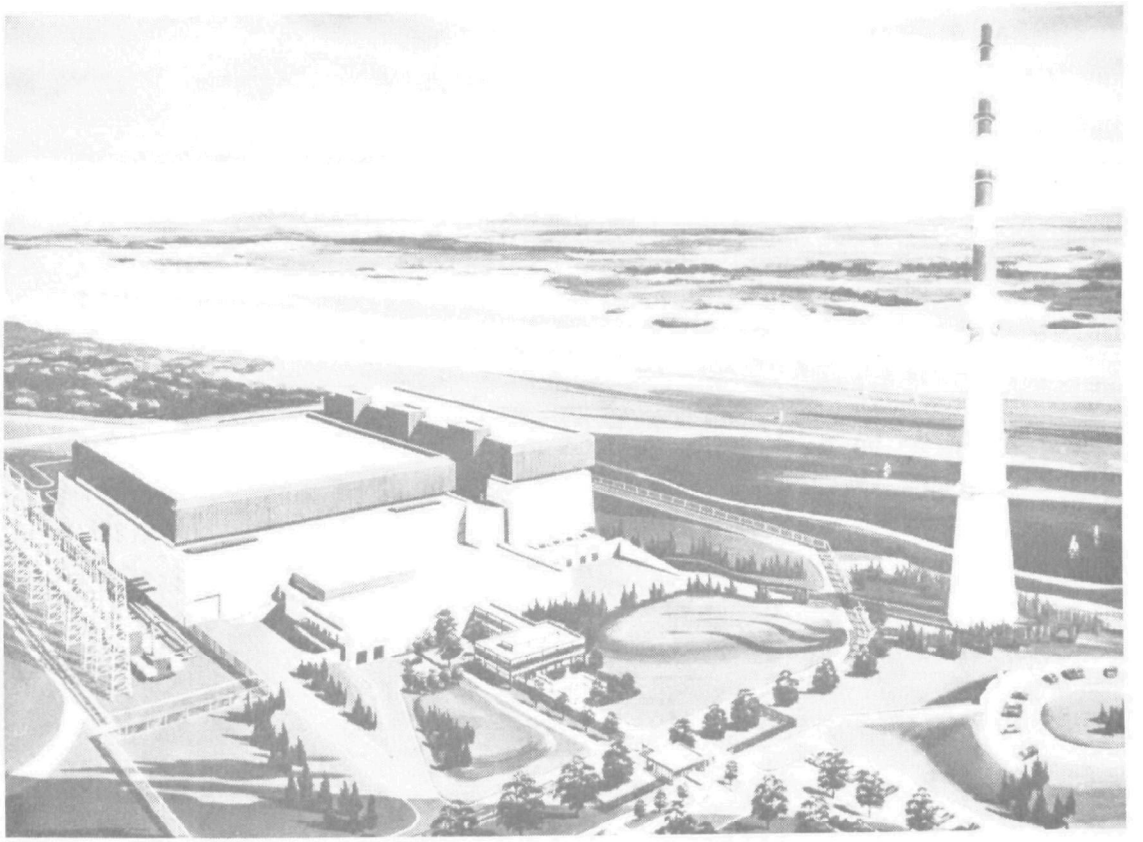


Figure 1. Architectural Drawing of Browns Ferry Nuclear Plant.

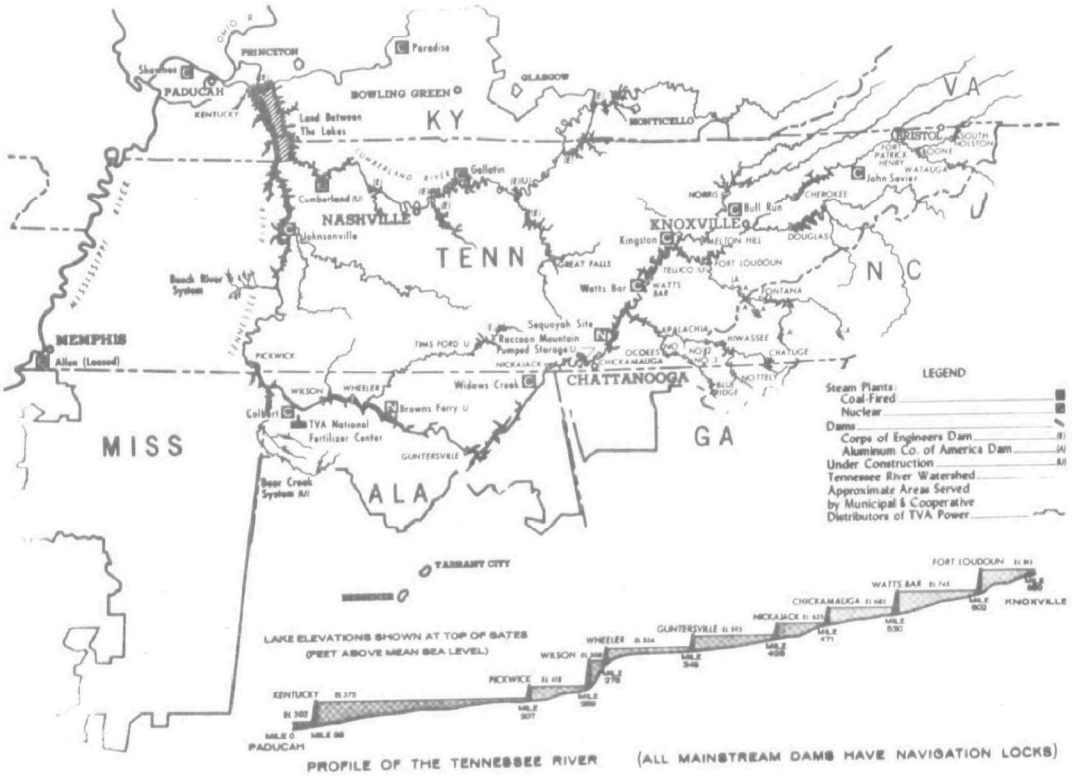


Figure 2. Tennessee Valley Region.

Figure 3. Browns Ferry Nuclear Plant Under Construction.

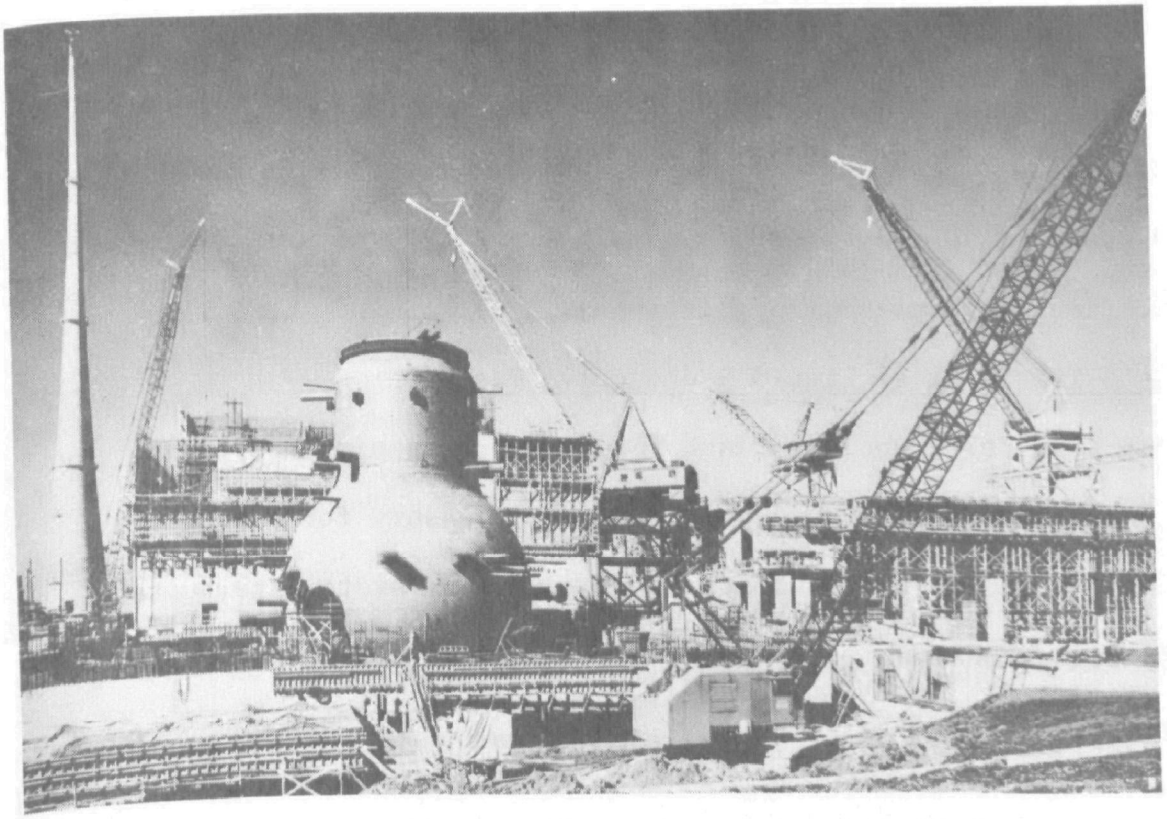


Figure 4. Browns Ferry Nuclear Plant Under Construction.

objective of establishing a baseline of data on the distribution of natural and manmade radioactivity in the environment near the plant site, so that when the plant becomes operational, it will then be possible to determine what contribution, if any, the plant is making to the environment.

Field staffs in the Division of Environmental Research and Development and the Division of Forestry, Fisheries, and Wildlife Development carry out the sampling and analysis program. All the radiochemical and instrumental analyses are conducted in a central laboratory at Muscle Shoals, Alabama, about 45 miles from the Browns Ferry plant. Alpha and beta analyses are performed on a Beckman Low Beta II low background proportional counter. A Nuclear Data Model 2200 multichannel system with 512 channels and two 4" x 5" NaI crystals is used to analyze the samples for specific gamma-emitting isotopes. Data are coded and punched on IBM cards or automatically printed on paper tape for computer processing specific to the analysis conducted. An IBM 360 Model 50 computer is used to solve multimatrix problems associated with identification of gamma-emitting isotopes.

Sources and Treatment of Liquid Radioactive Wastes

The Browns Ferry Nuclear Plant (Figure 5) uses single-cycle Boiling Water Reactors to produce the steam necessary for electrical generation. Clean-up requirements for the primary system are quite demanding and extensive liquid waste treatment and clean-up systems are provided.

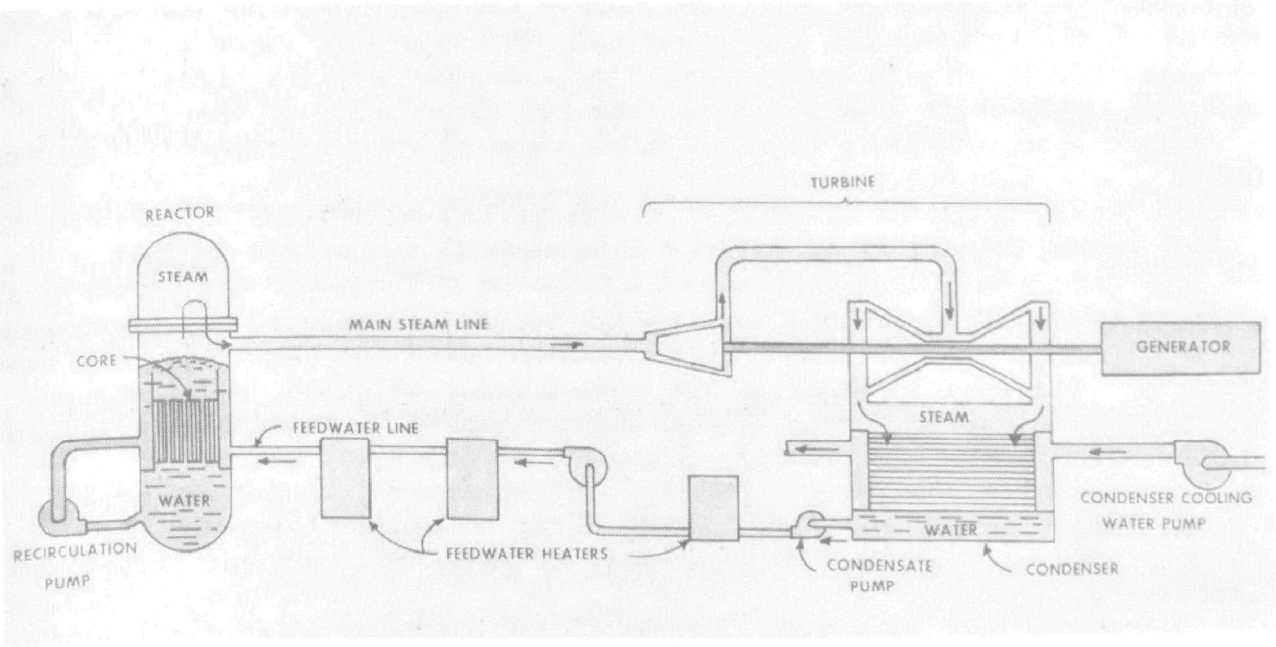


Figure 5. Simplified Steam Cycle Used in Browns Ferry Nuclear Plant.

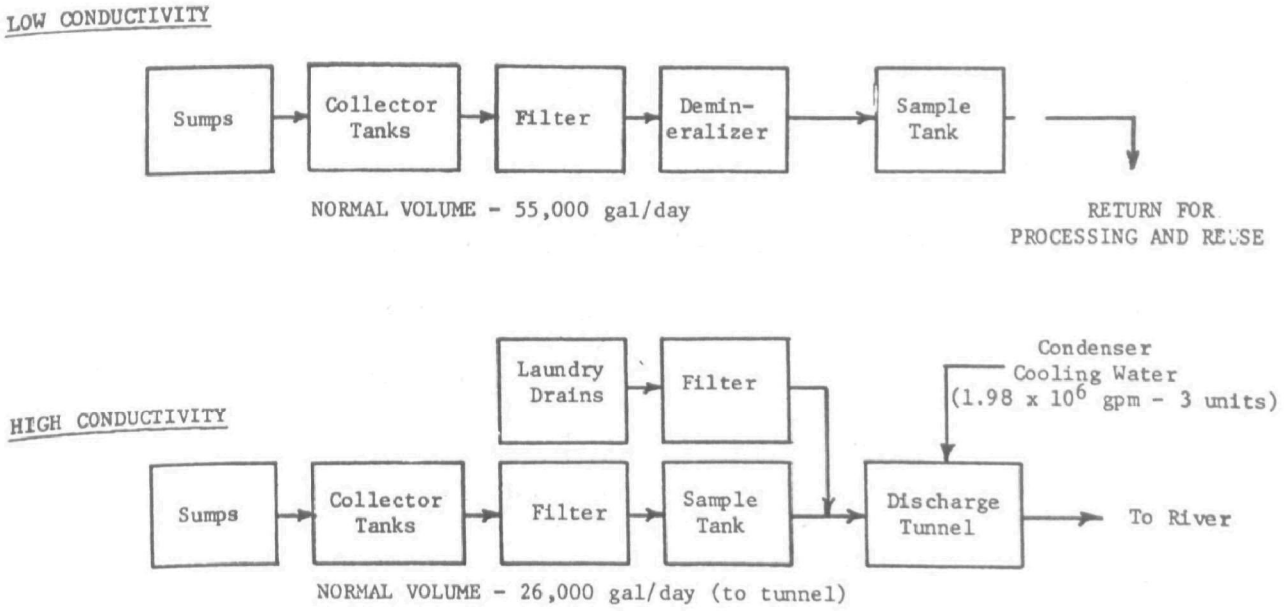


Figure 6. Scheme for Radioactive Liquid Waste Processing - Browns Ferry Nuclear Plant.

The Liquid Radwaste System collects, processes, stores, and disposes of all radioactive liquid wastes. The system is sized to handle the radioactive liquid wastes from all three units of the plant.

The system (Figure 6) is divided into several subsystems so that the liquid wastes from various sources can be kept segregated and processed separately. The liquid radwastes are classified, collected, and treated as either high purity, low purity, chemical, or detergent wastes. The terms "high" purity and "low" purity refer to conductivity and not radioactivity.

The high purity (low conductivity) wastes are processed by filtration and ion exchange through the waste filter and waste demineralizer. After processing, the waste is pumped to a waste sample tank where it is sampled and then, if satisfactory for reuse, transferred to the condensate storage tank as makeup water.

If the analysis of the sample reveals water of high conductivity ($>1\mu$mho/cm) or high radioactivity concentration ($>10^{-3}\mu$Ci/cc), it is returned to the system for additional processing. These wastes may be released to the discharge canal if allowable discharge canal concentrations are not exceeded.

Low purity (high conductivity) liquid wastes are collected in the floor drain collector tank.

These wastes generally have low concentrations of radioactive impurities; therefore, processing consists of filtration and subsequent transfer to the floor drain sample tank for sampling and analysis. If

the analysis indicates that the concentration of radioactive contaminants is sufficiently low, the sample tank batch is transferred to the circulating water as necessary to meet plant effluent discharge requirements of 10 CFR 20. Because no radium-226 or radium-228 of plant origin will be present, and because the potential concentration of iodine-129 is very low, the canal discharge concentration limit for otherwise unidentified mixture of radioisotopes is 10^{-7} μCi/ml above background.

Some tritium is present in the effluent. However, the concentration expected in the plant effluent is less than 10^{-8} μCi/ml. The MPC for tritium in drinking water is 3×10^{-3} μCi/ml; therefore, the plant contribution to the tritium background in natural waters is negligible.

Estimated concentrations of the radioactivity in the liquid wastes discharged from the radwaste facility to the discharge canal during normal operation are expected to be quite low. These liquid wastes are released at a rate to give an unidentified isotope concentration of not more than 10^{-7} μCi/ml in the discharge canal during the period of the discharge. Since the discharge is on a batch basis into a large volume-flow of condenser cooling water (1.98×10^{6} gpm), the daily average concentration in the canal is correspondingly less. The discharge from the canal to the environs, therefore, is considerably less than the maximum permissible concentration for a mixture with unidentified radioisotopes, that is, 10^{-7} μCi/ml. Mixing in Wheeler Reservoir provides additional dilution.

The concentrations of the radioisotopes which are the major contributors to the radioactivity in the canal after dilution to 10^{-7} μCi/ml are shown in the next slide (Table 1). From these data it can be seen that the concentration of each discharged isotope is considerably less than the maximum permissible concentration for that radisisotope.

TVA is currently evaluating extended radwaste systems for Browns Ferry, including gas recombiners and added holdup capability for gaseous releases, and an evaporator for liquid wastes.

Reservoir Monitoring System

The Browns Ferry Nuclear Plant Reservoir Monitoring System was designed to accomodate collection and analysis of selected aquatic samples for both gross radioactivity content and for specific radionuclides that are expected to be present in the condenser cooling water discharge. The overall reservoir monitoring system is designed to assess both radiological and thermal effects of the plant, but I shall limit my remarks to only the radiological aspects of the monitoring program.

Types of Samples Collected for Radiological Analysis

Five types of samples are collected quarterly along nine cross sections in Wheeler Reservoir--at Tennessee River miles 277.98, 283.94, 288.78, 291.76, 293.70, 295.87, 299.00, 301.06, and 307.52, as shown in Figure 7. Samples collected include fish and plankton from three of these cross sections and bottom fauna and sediment from four cross sections. The locations of these cross sections conform to sediment ranges on the reservoir bottom. Station 307.52 is located 13.5 miles

TABLE 1. NORMAL ISOTOPIC CONCENTRATIONS IN DISCHARGE CANAL BROWNS FERRY NUCLEAR PLANT

Radioisotopes	Canal Concentration (μCi/ml)	MPC (μCi/ml)
^{56}Mn	2.0×10^{-8}	1×10^{-4}
^{24}Na	1.0×10^{-8}	3×10^{-5}
^{187}W	1.8×10^{-8}	6×10^{-5}
^{51}Cr	0.4×10^{-8}	2×10^{-3}
^{58}Co	4.2×10^{-8}	9×10^{-5}
^{60}Co	0.4×10^{-8}	3×10^{-5}
Other	0.2×10^{-8}	-
	1.0×10^{-7}	2×10^{-5} (Actual MPC)

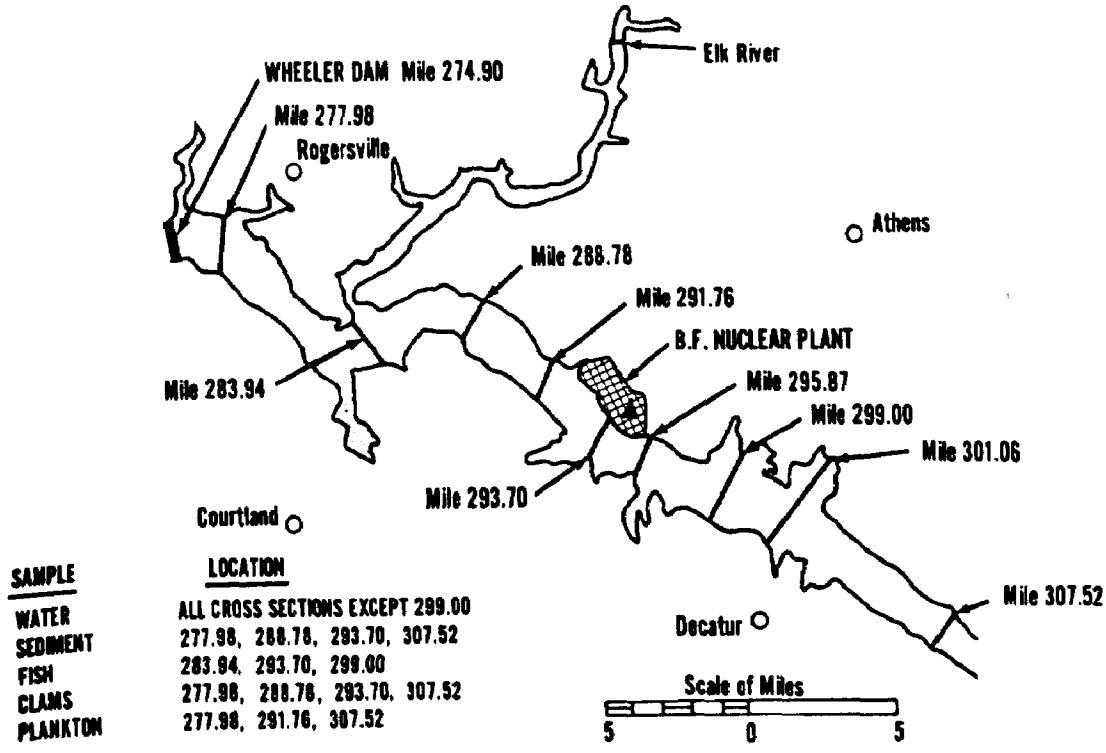


Figure 7. Reservoir Monitoring Network.

upstream from the plant diffuser outfall and was selected as a control station.

Radiological Analyses

(Water)--From eight of the nine cross sections, 24 water samples are collected quarterly for determination of gross beta and gamma activity in suspended and dissolved solids. Water samples are also collected monthly at the point of plant discharge to the Tennessee River and at a point on the Elk River.

(Fish)--Radiological monitoring of fish is accomplished by analyzing three composite samples from collections at each of three sampling stations--miles 283.94, 293.70, and 299.00. One sample is composited from the flesh of six white crappie, 8 inches or longer, one from the flesh of six smallmouth buffalo, 14 inches or longer; and one from six whole smallmouth buffalo, 14 inches or longer. These are collected quarterly and analyzed for gamma and gross beta activity. The ^{89}Sr and ^{90}Sr concentrations are determined on the whole fish and flesh of buffalo only, which are as nearly equal in size as possible. The composite samples contain approximately the same quantity of flesh from each of the six fish. For each composite a subsample of at least 50 to 100 grams (wet weight) of material is drawn for counting.

(Plankton)--Net plankton (all phytoplankton and zooplankton caught with a 100 μ mesh net) is collected for radiological analyses at two depths at each of three stations by horizontal tows with a 1/2-meter net. At least 50 grams (wet weight) of material is necessary for

analytical accuracy. Collection of this amount is practical only during the period April to September (spring and summer quarters) because of seasonal variability in plankton abundance. Samples are analyzed for gamma and gross beta activity and ^{89}Sr and ^{90}Sr content.

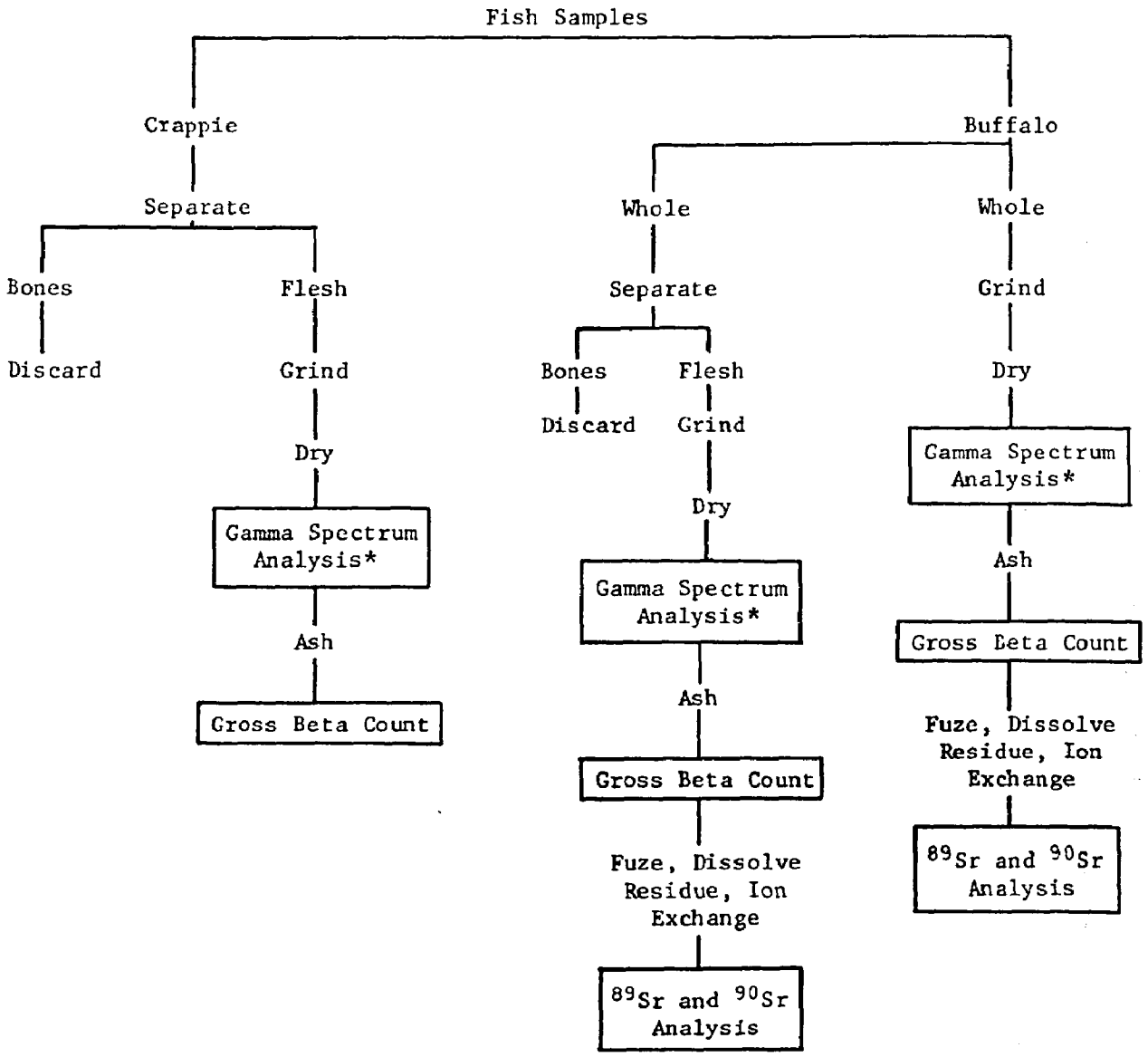
(Sediment)--Sediment samples are collected from Ekman dredge hauls made for bottom fauna. Gamma and gross beta radioactivity and ^{89}Sr and ^{90}Sr content are determined quarterly in a composite sample collected from each of two points in the cross section at four stations.

(Bottom Fauna)--Asiatic clams are collected at quarterly intervals from two points in the cross section at four stations and the flesh is analyzed for gamma and gross beta activity. The ^{89}Sr and ^{90}Sr contents are determine on the shells only. A 50-gram (wet weight) sample provides sufficient activity for counting.

At this point you may be interested in some of the steps involved in processing and analyzing samples--I have chosen one type of sample, fish, as shown in Figure 8. After the best efforts of streamlining the various laboratory steps, using computerized data handling, etc., this part of the monitoring program is still timeconsuming, as indicated on the flow chart.

Typical Data - January-June 1970

The next two Tables, 2 and 3, show a summary of typical pre-operational monitoring data for two types of samples analyzed--fish and bottom sediment. You will note that both types of samples are analyzed for ten isotopes by gamma scan and for ^{89}Sr and ^{90}Sr. The ten isotopes



*The following nuclides will be included in this analysis:

^{60}Co, ^{137}Cs, ^{144}Ce, ^{65}Zn, ^{95}Zr-^{95}Nb, ^{140}Ba-^{140}La, ^{106}Ru, ^{131}I, ^{40}K

Figure 8. Radiochemical Analysis on Fish Samples.

TABLE 2. SUMMARY DATA ON FISH SAMPLES - BROWNS FERRY NUCLEAR PLANT, JANUARY - JUNE 1970

Species	Number of Samples	Specific Radionuclides (pCi/gm)											
		^{137}Cs	$^{103,106}Ru$	$^{141,144}Ce$	^{40}K	^{95}Zr-Nb	^{65}Zn	^{140}Ba-La	^{54}Mn	^{131}I	^{60}Co	^{89}Sr	^{90}Sr
Smallmouth Buffalo (flesh)	6	0.1	0.1	ND	9.3	ND	0.1	ND	ND	ND	ND	1.9	1.8
Smallmouth Buffalo (whole)	6	0.1	0.1	ND	4.6	ND	ND	0.1	ND	ND	0.1	3.3	0.9
White Crappie (flesh)	6	0.2	ND	ND	9.3	ND	ND	ND	ND	ND	ND	ND	ND

ND - Less than sensitivity of analysis.

TABLE 3. SUMMARY DATA ON BOTTOM SEDIMENT - BROWNS FERRY NUCLEAR PLANT, JANUARY - JUNE 1970

Number of Samples	Specific Radionuclides (pCi/gm, average)											
	^{40}K	^{60}Co	^{137}Cs	$^{103,106}Ru$	^{54}Mn	$^{141,144}Ce$	^{95}Zr-Nb	^{140}Ba-La	^{131}I	^{65}Zn	^{89}Sr	^{90}Sr
8	12.1	0.3	1.7	0.8	0.1	0.4	0.1	0.1	ND	ND	2.4	0.1

ND - Less than sensitivity of analysis.

chosen for gamma spectrum analysis are representative of isotopes that could be present in the liquid waste effluent from the plant. Data from the spectral analysis of the ten isotopes are treated by a ten-element matrix, using the ALPHA II program developed at ORNL, and run on TVA's IBM 360 computer in Chattanooga.

Quality Control

When planning and carrying out a comprehensive environmental monitoring program, it is important to consider means for continuous checks on the quality of laboratory procedures and analyses. Very early in the Browns Ferry Nuclear Plant program, we set up a quality control system for both intra-laboratory and inter-laboratory checks. In regard to the former one of the things we do is to make a simple statistical check on the day-to-day variance of our own laboratory counting equipment. An allowable error band is set up and daily checks of counting equipment are made and plotted within this band (Figure 9). If a given instrument shows results that consistently fall close to or outside the permissible limits, corrective steps can be quickly instituted. The other quality control system involves the routine exchange of samples with the Southeastern Radiological Health Laboratory[1] and the Alabama Department of Public Health radiological laboratory in Montgomery. Split samples are analyzed by each of the participating laboratories and the results are compared at frequent intervals. In the comparisons thus far, variance of results of the three laboratories has been generally within limits of acceptable error. However, a check

[1]Redesignated Eastern Environmental Radiation Laboratory

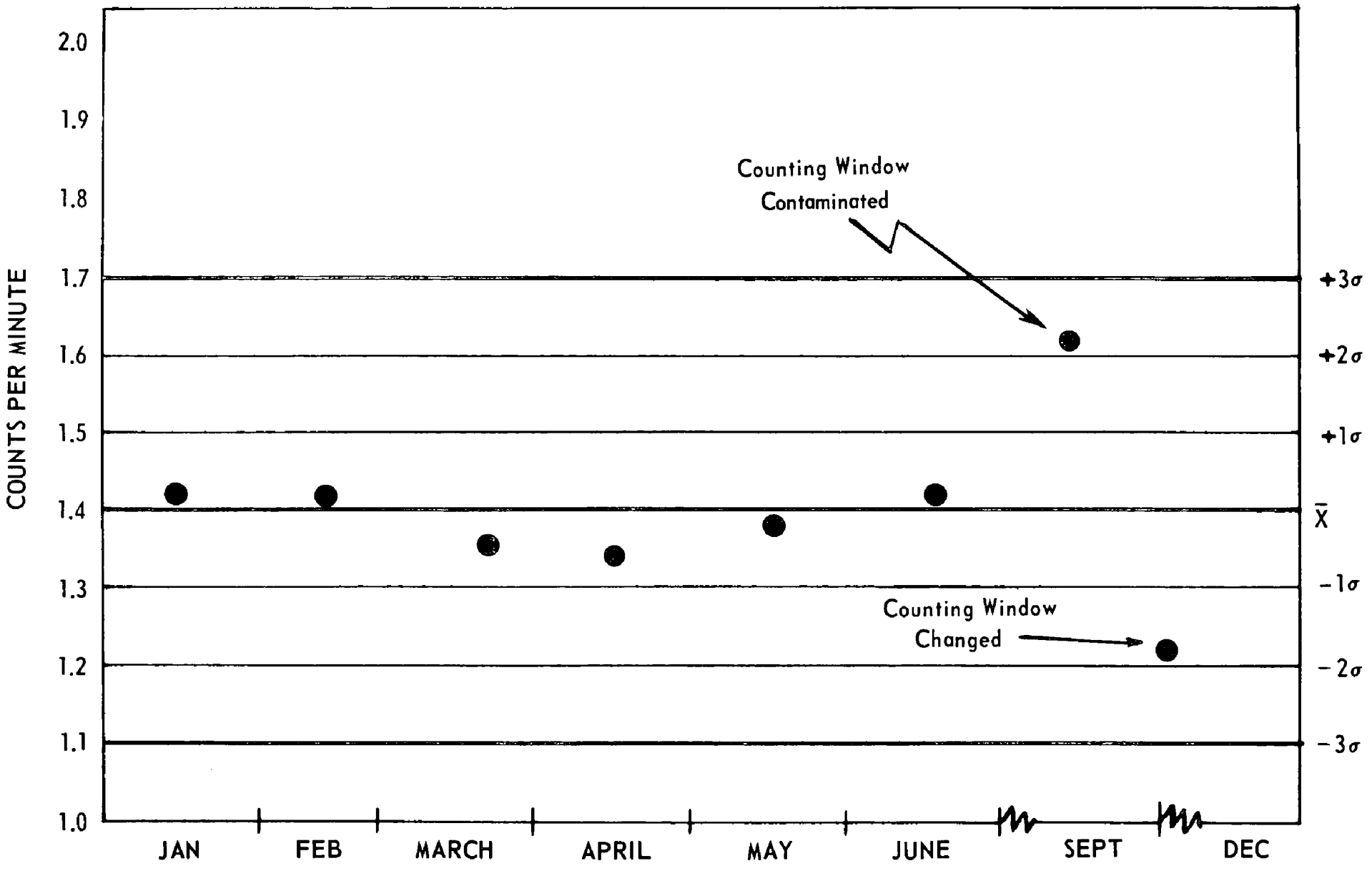


Figure 9. Laboratory Quality Control of Low Beta II Counter.

made recently showed our laboratory at Muscle Shoals reporting consistently higher numbers than the other labs. This may be due to the very low levels of activity present in some of the samples, so SERHL has prepared samples spiked with higher activity for intercomparison. If results are still questionable, steps will be taken to find where the variance is and to correct it.

Costs of the Browns Ferry Aquatic Monitoring Program

Finally, let me touch briefly on one aspect about which I am sure some of you are already curious--how much does a program like this cost? For fiscal year 1970, the second full year of the Browns Ferry monitoring program, the collection and preliminary processing of reservoir samples prior to analysis cost about $20,000 and the actual laboratory analyses, data processing, and reporting about $60,000. If additional allowances are made for central staff support, the total estimated costs for the reservoir phase of our radiological monitoring program amounts to about $100,000 per year. This may sound prohibitively expensive to some of you but please bear in mind that a rather large number of samples ($\sim$ 400/yr.) are involved and an equally large number ($\sim$ 4000) of analyses are performed. So the average cost per analysis is not too great. Even so, we believe the type of environmental monitoring program being carried out for the Browns Ferry Nuclear Plant is justified perhaps more so today than ever, and we feel certain that preoperational data of the type now being obtained in Wheeler Reservoir will prove invaluable when full operation of the plant gets under way next year.

AN ECOLOGICAL APPROACH TO MARINE RADIOLOGICAL MONITORING AT THE FLORIDA POWER CORPORATION CRYSTAL RIVER NUCLEAR PLANT

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Richard W. Englehart, Department of Nuclear Engineering
John F. Gamble, Department of Environmental Engineering

University of Florida
Gainesville, Florida

This report deals with only the marine aspects of a larger monitoring project which also includes fresh water sampling, terrestrial sampling, and air sampling. This study was begun in August 1970.

The Florida Power Corporation plant for which this study is being done is located approximately 2 miles north of the Crystal River and approximately 3 miles south of the Withlacoochee River on the northwest coast of Florida (see Figure 1). The principal characteristics of the region will be described shortly.

The objectives of the marine radiological monitoring program are as follows:

1. To gather baseline information on the preoperational levels of radionuclides existing in the marine environment.

2. To assess the major food chains which could be involved in directing radionuclides into organisms consumed by man.

3. To provide a monitoring program which can be continued after commencement of plant operation in order to measure any possible effect of the power plant on the marine environment in terms of

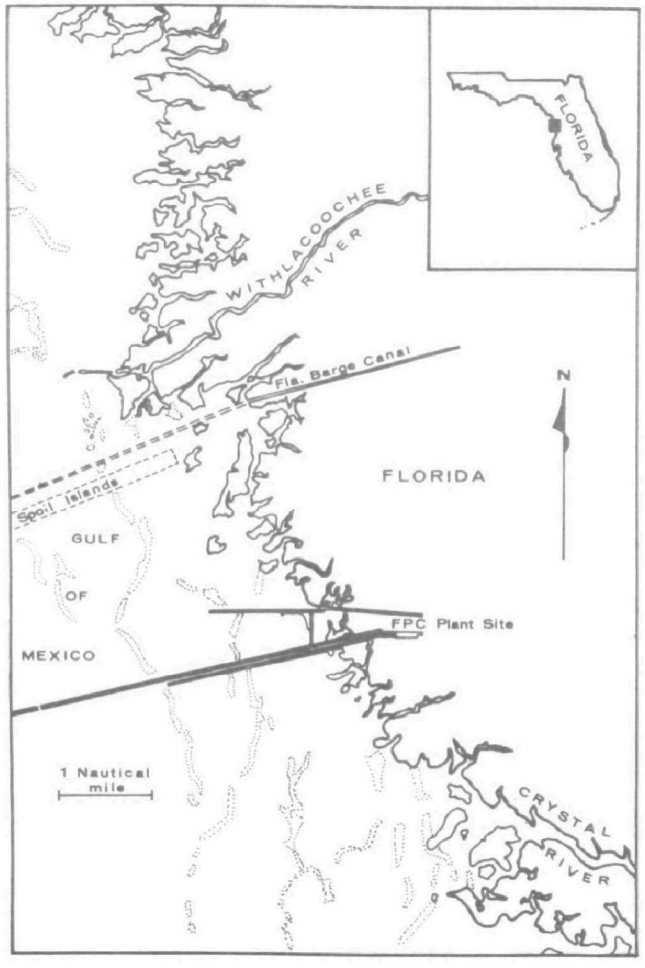


Figure 1. Location of the Florida Power Corporation Nuclear Plant on the Northwest Coast of Florida.

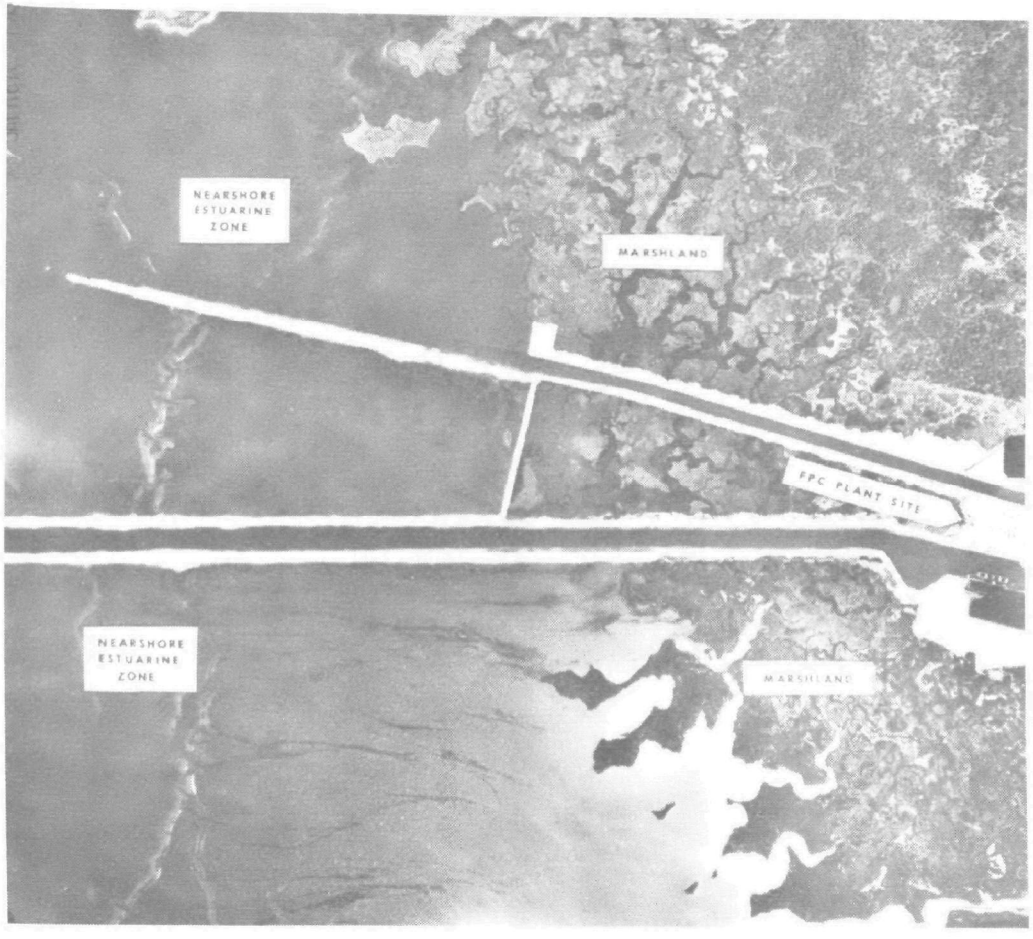


Figure 2. Coastal Habitats Present in Vicinity of Florida Power Corporation Nuclear Plant.

increased levels of radionuclides in organisms.

4. To provide estimates of the future levels of critical radionuclides which are likely to appear in marine organisms consumed by man as a consequence of wastes discharged by the nuclear plant.

ECOLOGY OF THE AREA

The marine monitoring program is focused upon two intimately related types of coastal habitats:

1. the tidal marshland habitat

2. the nearshore estuarine zone which is immediately Gulfward of the marshland habitat.

The separation of the two habitats is somewhat arbitrary but is nevertheless useful to the context of this study (see Fig. 2).

Marshland Habitat

Marshlands associated with estuaries have been described by authorities to be "among the most productive natural ecosystems in the world". Coastal marshes have been shown to produce up to 10 tons of plant material per acre per year. The rate of production of organic material in marshlands is comparable to the rate of production obtained from intensely cultivated crops such as rice and sugar cane. Much of the organic production in the marshland habitat near the Crystal River site occurs in the form of marsh grasses and mangroves. The leaves and other living parts of these plants are not eaten directly by many marine animals. Nevertheless, this plant material

serves as a primary food base for a great many of the organisms which inhabit both the marshland and the adjacent nearshore waters. This apparent inconsistency can be explained as follows. Plant material from marsh grass and mangroves is deposited at a relatively constant rate into the shallow waters of the marshland. These leaves, stems, etc., are attacked by bacteria, fungi, protozoa, and other microbial forms. Gradually the plant material is broken down into an ever increasing number of smaller and smaller organic particles called detritus particles. Each detritus particle supports a dense assemblage of microbial forms. It is this detritus with its protein-rich assemblage of microorganisms that is fed upon extensively by a diverse array of the fishes and invertebrates which grow and develop in the inshore waters. Thus, detritus assumes a major role in many of the most important food chains of the marshland and nearshore waters--a characteristic which distinguishes many of the food chains found here from most of the more common ones encountered in terrestrial habitats or in the open sea.

Nearshore Estuarine Zone

The nearshore estuarine zone is immediately Gulfward of the marshland habitat and is markedly influenced by it. The nearshore estuarine zone, like the marshland habitat, is characterized by its high productivity. Much of the productivity here is accountable to dense stands of submerged sea grasses and attached algal forms. Some marine animals living here eat this plant material directly. However, an even greater

amount of this plant material, like that in the marshland habitat, is introduced into food chains in the form of small detritus particles with their protein-rich assemblages of microorganisms.

Nursery Areas

The marshland habitat and the nearshore estuarine zone have another extremely important attribute in common. They both serve as vital nursery areas for an impressive array of marine finfish and shellfish. Authorities tell us that upwards of 70% of the species of fish and shellfish which are harvested annually in coastal fisheries are estuarine-dependent species. By estuarine-dependent, we mean that each of these species is obligated to spend at least a portion of its life cycle in the shallow, productive confines of the estuarine zone or the adjacent marshland habitat. For some of these species, i.e., the oyster, the entire life cycle is spent in an estuarine area. For even a greater number of these valuable species, the estuarine-dependent stages of their life cycles are the early juvenile stages. Many of these species, such as the mullet, crab, shrimp, redfish, and others go offshore as adults to spawn. However, the larvae which hatch offshore move instinctively back into the shallow, productive confines of the inshore habitats to feed, find shelter, and prepare themselves for the rigors of their adult lives. The expression "nursery area" which is used to describe the productive inshore waters is an expression depicting the dependence upon these areas that is shown by the immature juvenile stages of a large number of species.

Summary Statement Concerning Ecology of the Area

This description of the ecology of the habitats of concern can best be summarized by pointing out that their major characteristics are such as to magnify their importance and uniqueness in radionuclide uptake. The total uptake of radionuclides will be increased in these estuarine habitats because of their high productivity and because of the large numbers of organisms which are present. This is because the total uptake of radionuclides by organisms is proportional to the combined (or total) mass of the organisms which are present and to the amount of new biological material which is being manufactured. On both counts, marshland and nearshore estuarine areas rank exceptionally high.

Design of Preoperational Surveillance

Having completed a brief description of the characteristics of the habitats associated with the Crystal River site, we can consider the design of the preoperational surveillance of the marine environment which is being conducted. Two important questions arise:

1. What areas should be sampled and how often?

2. What organisms should be sampled from each area and why?

Areas Being Sampled

Three areas were selected for sampling in order that the following type of coverage was provided (see Fig. 3):

1. Control area (Area A) - not affected by liquid wastes released by power station into discharge canal.

2. Critical area (Area B) - site of convergence of discharge canal with nearshore estuarine zone and marshland habitat.

3. Potentially affected area (Area C) - site to the north of discharge canal in direction of principal inshore water movement.

Each sampling area (Areas A, B, and C) consists of two components: a nearshore component and a marshland component (see Fig. 3). Separate samples are taken on a quarterly basis from both the nearshore and the marshland component of each sampling area. Each sampling area is large in size because of the necessity of collecting an array of organisms. Quarterly sampling permits the detection of any inherent seasonal changes in the levels of presently occurring radionuclides which may

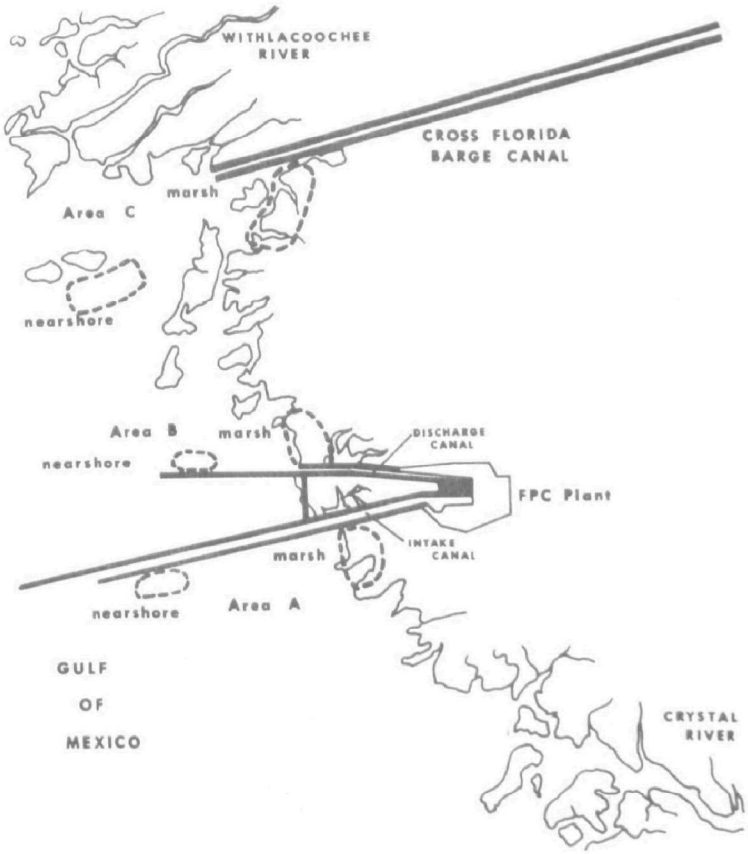


Figure 3. Locations of Sampling Areas in Vicinity of Florida Power Corporation Nuclear Plant. Each sampling area is shown to consist of both a nearshore component and a marshland component.

accompany changes in sea water composition, rainfall and land drainage, migration of species and other factors. It is felt that the areas selected for this preoperational study are logical areas for continued sampling after the nuclear power station commences operation.

Organisms Being Sampled

It would be nice to sample all of the species of organisms present but this is not practical, i.e., 125 species of fish and several times that number of invertebrate species are known to inhabit the area.

We have emphasized two things in our selection of organisms:

1. Commercially important inshore and marshland species, i.e., species consumed by man.

2. Major dietary items of these species.

Since it is not practical to sample on a quarterly basis all of the species consumed by man in the area, we have made certain that our samples of such organisms include a representative spectrum of the principal "feeding" types; i.e., filter feeders or planktivores, detritus feeders, predators on invertebrates, predators on fish, scavengers with mixed diets. By paying attention to feeding types and major dietary items consumed by our sampled species, we have a program which should be capable of detecting the causes of increased levels of radionuclides in consumer species which are due to passage of materials through food chains.

A list of the samples of organisms consumed by man which are included in our sampling program is given below:

Samples from Nearshore Sites (A, B, and C)	Samples from Marshland Sites (A, B, and C)
Oysters	Oysters
Blue Crabs	Blue Crabs
Mullet	Mullet
Spotted Seatrout	Spot
Redfish	
Pinfish	
Pink Shrimp	

The above commercial species represent our "core" items; i.e., we try and sample them from all areas each quarter. We complement this list of consumer species whenever possible with other species consumed by man when they are available. For example, during the winter quarter there was a mass migration of many species of fish into the heated discharge canal. This migration was accompanied by intensive fishing activity by sport fishermen. Because of these two factors, we augmented our samples from Area B by including 6 additional species of fish which were abundant at this time.

Major Dietary Items of Commercial "Core" Species

Decisions as to which food chain items should be sampled on a quarterly basis came from an awareness of the food habitats of the organisms of concern. Figure 4 presents a summary of what is known concerning the diets of these species. The Figure shows several conspicuously important dietary items: detritus, crustaceans (crabs and shrimp), plankton, mollusks, silversides, pinfish, mullet, and sea grass. The Figure also points out that several of the important food

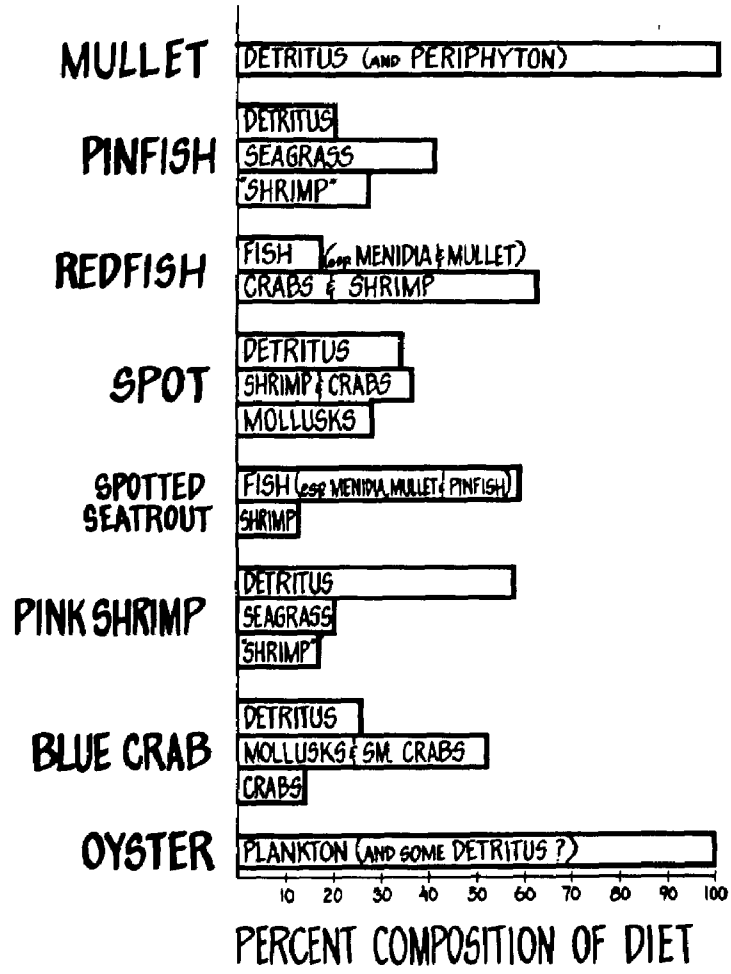
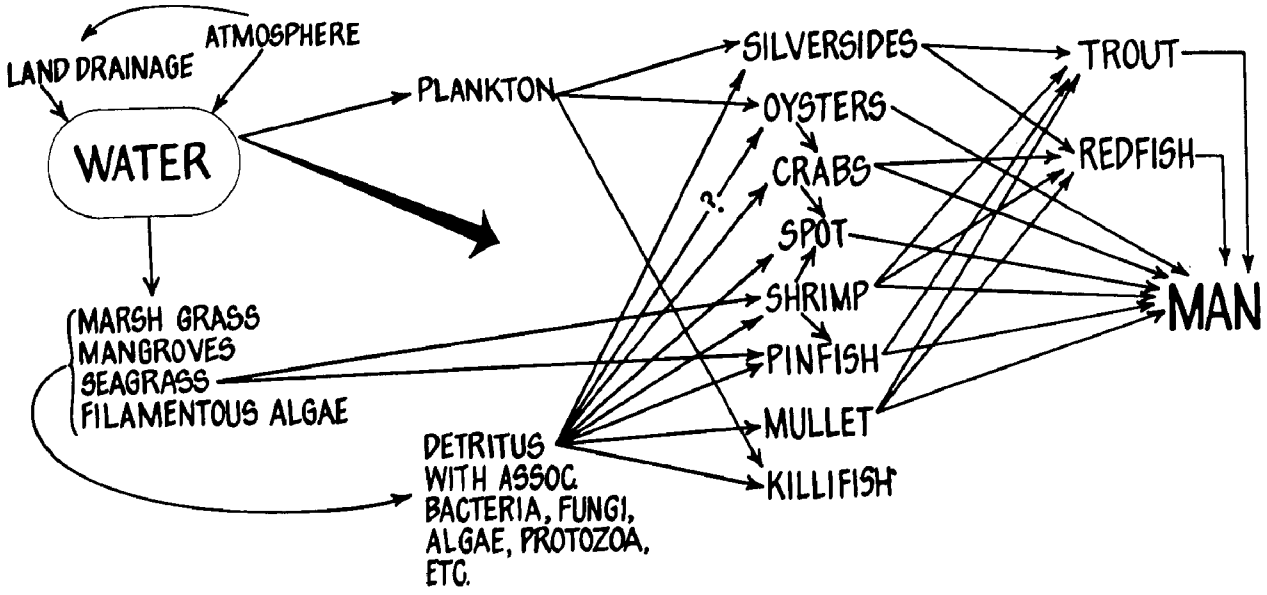


Figure 4. Food Habits of Commercial "Core" Species Being Sampled in Vicinity of Florida Power Corporation Nuclear Plant.

chain items are organisms which we already included in our list of commercial "core" items.

Figure 5 shows our entire sampling regime for each area (A, B, and C). The individual components shown in the Figure are integrated into major food chains which lead to man. All samples are frozen shortly after collection and returned to the University of Florida for measurement of individual gamma emitters by gamma scan analysis.

The values shown previously in Figure 4 for percent composition of diet permit us to put approximate values on all of the arrows indicated in Figure 5 and thereby calculate the approximate magnitudes of



PATHWAYS OF NUCLIDES TO MAN VIA FOODCHAINS

Figure 5. Samples Being Taken from Sampling Areas in Vicinity of Florida Power Corporation Nuclear Plant. All samples are shown as components of food chains which may lead to man.

SPOTTED SEATROUT

I. Growth Rate–

Year 1: 0 → 185g.
Year 2: 185g. → 465g.

II. Approx. amount of food necessary to support growth rate (10% conversion effic.)

Year 1: 185g. x 10 = 1850g. Year 2: (465–185g.) x 10 = 2800g.

III.

% Composition of Diet		Grams of each Dietary Item Consumed/year Year 1	Year 2
Shrimp	13%	240	364
Fish	79%	1460	2210

Figure 6. Estimates of Growth Rate, Food Requirement, and Food Habit of Spotted Seatrout.

all of the dietary inputs which are indicated. An example of this is given in Figure 6 for the spotted seatrout. We have similar data for all other organisms included in our collecting program and for many other species in the area but these data will not be presented at this time.

The data shown previously in Figure 4 on the food habits of commercial species were obtained primarily from the literature for the adults and sub-adults of these species. Very little data are available on the food habits of the juvenile stages of these species. We are currently conducting detailed quantitative studies on the food habits of juvenile fishes in the area so that we will have data on the entire spectrum of dietary inputs from time of arrival in the estuarine zone until time of harvest by man.

Stable Element Analyses and Predictions of Future Levels of Radionuclides in Marine Organisms

To augment our ecological food-chain approach to preoperational surveillance, we are initiating stable element analyses of estuarine water, sediment, and a group of marine organisms consumed by man. These organisms, and the water and sediment, will come from the same sampling areas described earlier. The elements being analyzed are Co, Cr, Fe, Mn, Sr, Cs, Zn, Mo, and Cu. These analyses are being done for the following reasons:

1. Radionuclide concentration factors for marine animals as published in the literature are defined as the ratio of the radio-

nuclide concentration in the organisms to the radionuclide concentration in the ambient water. Our use of published concentration factors requires that the following assumptions be made:

A. The existence in the water of a relatively large and constant pool of the analogous stable nuclide in the same physico-chemical state as the radionuclide.

B. That isotopes of the same element in the same physico-chemical form behave identically in biological systems; i.e., have similar biological availabilities.

We do not feel justified in making assumption A (above) without first taking some measurements. This is because the condenser cooling water into which the radionuclides will be discharged is an admixture of sea water with varying amounts of freshwater from the Crystal River and adjacent areas. This admixture will vary with the season (i.e., dry or wet). Hence, the composition of this water, and its variation, must be measured. More will be said about physico-chemical forms later.

2. If the estuarine water is considerably different in chemical composition than "world average" sea water, then it will be necessary to measure concentration factors of elements for the important marine animals living in this particular area.

Given the information on the elemental composition of the sea water and the organisms, the concentration factors in the organisms, and the average rates of discharge of radionuclides, we feel that we

will almost be in a position to calculate the total levels of the various radionuclides which are likely to occur in marine organisms after the nuclear plant begins operation. I qualify the statement with an "almost" and will clarify that in a moment after we consider the following:

1. If the chemical forms of the radionuclides and the analogous stable nuclides are the same in sea water, it is generally held that the degree to which a marine organism can concentrate the radionuclide is determined by the degree to which the same organism can concentrate the stable nuclide of the element; i.e., given the concentration factor for an element in an organism, and the specific activity of that element in the water, one can calculate the amount of that radionuclide which is likely to appear in the organism. This is based on the generally held assumption that specific activity is not altered in food chains when the initial chemical states of radionuclides and analogous stable nuclides are the same in the water.

2. The uncertainty:

A. If discharged radionuclides are in different physico-chemical forms than their analogous stable nuclides in sea water, then our predictions may be in error, i.e., some physico-chemical forms may be absorbed more readily by organisms or absorbed more readily by detritus particles. Either of these factors, and there may be others, could increase the biological availability of discharged radionuclides. Consider the following and maybe someone here can give us some help.

B. Most of the radionuclides which are to be discharged into sea water are reportedly in the form of oxides. Almost none of the analogous stable nuclides exist as oxides in sea water.

C. According to consultations with an inorganic chemist at the University of Florida, we have come up with the following information on these oxides -- please comment on this if you have information to the contrary.

1) For some of the oxides released, i.e., Rb, Sr, Cs, Ba, Co, and I, there will be an almost instantaneous conversion to the ionized form in sea water. This will result in these nuclides becoming a part of the ion pool characteristic of their analogous stable nuclides in sea water. Subsequently, the predictive logic developed earlier should hold for these nuclides since their biological availability should be the same as the analogous stable nuclides of these elements.

2) Also, Cr should pose no particular problem since the released form should apparently be hexavalent CrO_4^{--} ion. This is a prevalent form of stable Cr in sea water.

3) For the remaining radionuclides to be discharged, Mo, La, Mn, Ce, Fe, and Zr, the behavior of the discharged oxides in sea water is uncertain. These oxides may be resistant to dissociation or may be involved in complexes which in either case, may not be a part of the common ion pool in sea water, i.e., their biological availabilities may be quite different from their analogous stable nuclides in sea water. If this is the case, then there is the real possibility that

the levels reached by these radionuclides in marine organisms might be considerably greater (or lesser) than the predictive logic developed earlier would forecast. An entirely hypothetical example of the difficulty here is shown in Figure 7. The Figure depicts a hypothetical oxide exhibiting a differential affinity for suspended detritus particles in which case detritus feeders and filters feeders are receiving a biased sample of the nuclides of the element in question. The situation depicted here results in a change in specific activity both immediately in detritus particles and subsequently in organisms eating detritus particles.

Hypothetical Example

1. Naturally occurring Sr in seawater:

Sr^{++}	95%
$SrSO_4$	4.6%
$Sr(HCO_3)_2$	0.4%

2. In the following, consider naturally occurring Sr as Sr
and
introduced radionuclides of Sr as Sr*O

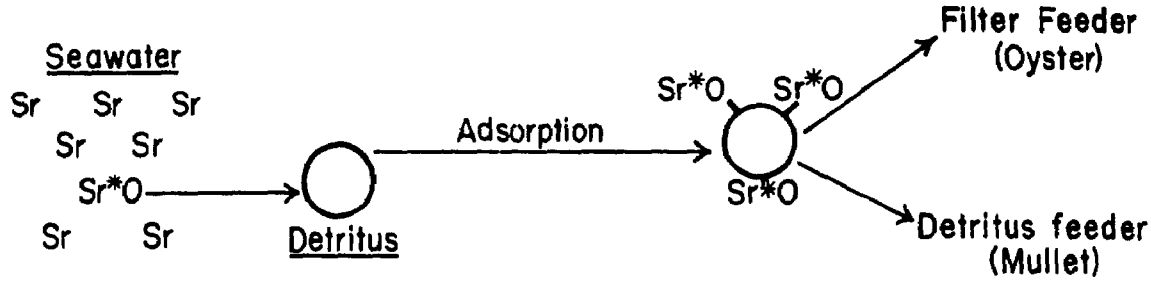


Figure 7. Hypothetical Example of Mechanism Whereby Specific Activity of an Element in Detritus Particles and in Detritus Consumers Could Become Different from Specific Activity of the Element in Sea Water.

Closing Statements

In summary, our preoperational surveillance program contains what we feel to be is an important extra dimension. This is explained as follows:

1. Data on stable element composition, concentration factors, and specific activities provide us with a means of predicting the levels of radionuclides which are likely to appear in marine organisms in the future.

2. In the event that postoperational analyses show that our predictions are in error, then we will be in a position to make an important contribution regarding the mild controversy which exists concerning the reliability of the "specific activity" approach. Our data on marine food chains leading to man will permit us to determine at which level(s) in our food chains the specific activity has actually changed. I am not suggesting that the latter will of necessity occur, but in the event that it does, we will have data from both preoperational and postoperational samples taken from the same areas which can be used to provide a reliable documentation of this troublesome phenomenon. Once documented, we can then explore the specific mechanisms which are responsible.

ACKNOWLEDGEMENTS

This research was supported by a contract to the University of Florida by Florida Power Corporation, St. Petersburg, Florida: "Environmental Surveillance for Radioactivity in the Vicinity of the Crystal River Nuclear Power Plant: An Ecological Approach", Dr. W. E. Bolch, Principal Investigator.

PANEL DISCUSSION

INTERRELATIONSHIPS OF FEDERAL, STATE, ACADEMIC AND INDUSTRIAL INTERESTS IN ENVIRONMENTAL STUDIES

NATIONWIDE REACTOR SURVEILLANCE PROGRAM

E. D. Harward, Acting Director
Division of Technology Assessment
Office of Radiation Programs, EPA

The growth of nuclear power in the United States will result in a substantial impact upon the radiological health programs of State health agencies over the next several years. Many State health departments which are now conducting programs relating to the public health aspects of nuclear power plants will be required to increase their activities as more new plants are built. In addition, many State health agencies will be facing the prospects of their first nuclear power plant and must make decisions regarding the extent of their program effort relative to these facilities.

In order to give you a brief summary of the magnitude of the problem that we face in carrying out our public health responsibilities in this area, I would like to briefly summarize some of the vital statistics relating to nuclear power growth. At present, 17 nuclear power plants are in operation. Forty-nine plants are now under construction, 37 additional plants are ordered with another 7 planned but not yet ordered. This total of 110 nuclear plants represents over 85 million kilowatts of electrical generating capacity. Approximately 100 of these plants are scheduled to be in operation by 1977. AEC estimates indicate that there may be approximately 150 million kilowatts produced by nuclear generation by 1980 and one billion kilowatts by the year 2000. These statistics indicate that many public health agencies will have a big job facing them.

One of the program areas where we in the Division of Environmental Radiation saw a need several years ago was in the compilation of waste discharge and environmental surveillance data from nuclear power sources in order to start to make judgments as to possible long-term environmental radioactivity trends and population exposure on a national basis. Such a project was initiated and because of the expected future volume of data, automatic data processing techniques were utilized.

In addition to the growth of nuclear power, the growing concern of the public as evidenced by articles in the press, in both scientific and non-scientific publications, and by public and congressional inquiries that we receive in quantity, have indicated a further need to increase our knowledge of nuclear power plant discharges and their possible exposure of people, both in the near and distant future. As a result, the Division of Environmental Radiation took the position that a more definitive program was needed to meet our public health responsibilities for:

1) Evaluating environmental levels of radiation resulting from this additional source of potential population exposure.

2) Detecting long-term radiological changes in the environment and interpreting any changes in terms of future population dose commitments.

In examining the problem that we faced, several things were evident. First and foremost, such an effort would require the cooperation of the States in a manner similar to our past cooperative efforts

in the radiological health area. Second, it would require substantial effort by the Bureau's area laboratories in providing training and specialized laboratory support. Third, the cooperation of the AEC and possibly their licensees would be required.

In view of the Bureau's current responsibilities for evaluating environmental levels of radioactivity. It is our belief that such a program should be undertaken and would be a logical function for the Bureau of Radiological Health to perform. We have therefore proposed that the Bureau establish such a cooperative Federal-State program, utilizing all available resources. Our plan would be to accomplish this program in an orderly manner as follows:

A. Work with States in the design of surveillance programs to assure uniform development of data that is adequate to estimate population exposure.

B. Provide for cooperative arrangements between the Bureau and the States for making data available to BRH and for providing laboratory assistance when needed to the States.

C. BRH would provide analytical quality control services to the States. (Operator surveillance data could be included where State has cross-checking system and can verify validity of the data.)

D. Bureau of Radiological Health would conduct special studies in cooperation with States, AEC and their licensees to provide information that might be required for interpretation of data.

E. Bureau of Radiological Health is examining present surveillance network operations to determine their applicability to the measurement of radioactivity resulting from nuclear facilities operation. In addition, SERHL will operate an expanded tritium surveillance network to factor in nuclear power growth.

F. Finally a compilation of the analyses and interpretation of data would be routinely published in Radiological Health Data and Reports.

Our ultimate objective, of course, is to have the data published where it can be made readily available to the public and the scientific community. We believe it to be extremely important for factual environmental radioactivity information on the operation of nuclear facilities to be made readily available to all interested parties.

We have had some preliminary discussions with the AEC regarding some of the aspects of this program and it was our wish that you be fully informed as this program develops. The draft project proposal sent to you recently represents our current thinking and we would greatly appreciate receiving your comments and constructive criticism.

Mr. Wallace B. Johnson
Health Physicist
Florida Division of Health

Gentlemen from the EPA, you are on the spot, so to speak. Many people came to this meeting hoping to hear some sort of definitive statement about EPA programs. We sympathize with reorganizational problems you are having.

But we await with bated breath some statements on the course of EPA.

Fortunately, I am at the State level and don't have to worry about problems like this. You heard the ten dollar version of the Crystal River surveillance program a little earlier. I could tell you about the ninety-eight cent version which is being conducted by the Florida Division of Health.

I think rather than do this, however, I am going to make just a few general remarks about our philosophy in Florida as relates to radiological surveillance.

As far back as 1966, we adopted as a stated philosophy our feeling that the primary obligation for radiological surveillance around nuclear power sites should properly belong to the States.

We still feel this way about it. We began surveillance efforts at Turkey Point in 1966. The Florida Power and Light Company developed a surveillance plan which was submitted with the PSAR. Although not parallel with the one we had operational there, they had remarkable similarities. It was our feeling when we look at these two plans together that duplicate programs did not appear to be in the best

interest of the company, of the State, of the taxpayers and of those who pay light bills and realize that eventually some of this cost gets into our light bills.

We, therefore, adopted a program under which the company actually has underwritten part of the cost of the surveillance.

The program has been conducted independently by the State Division of Health. We have had the usual conflicts of interest statements. In fact, to be perfectly candid, my first reaction to this proposal was exactly that. This program has been operating since 1969 and seems to be going along very well. To this particular company we represent essentially their total commitment for radiological surveillance to AEC.

Perhaps, in relation to the contention of conflict of interest, the Minnesota case has resolved some of these problems. Certainly the statements which we have had from AEC as to their position that the State in fact is not regulatory over the nuclear power plants seem to preclude a conflict of interest situation. We have also adopted this same general philosophy.

A second program in 1969 resulted in some support from what we call "the other company," Florida Power Corporation. The relationship here is not exactly the same as the relationship which exists with Florida Power and Light Company. You heard this morning of some very excellent and quite elaborate studies that are being done for Florida Power Corporation by another group. We do not object to this--we encourage it. But our goal--our attempt--from the beginning was

based on the development of a State system which would create in the State of Florida an integrated data base which would permit the State Division of Health to evaluate the impact of nuclear power on the total State of Florida rather than individual areas.

And I would like to close just by saying one or two words on the topic of a cooperative approach.

It seems to have become popular in this day and age to consider that industry and government, of necessity, are enemies; that they have goals which are far apart. We simply are not willing to acknowledge this.

We feel that, with the expertise which is available to industry in the State of Florida from the health agency and the university system, it just makes good dollars and common sense to approach the problem of industry's surveillance commitment by utilizing the existing available capability. This will permit a much better evaluation of the impact of nuclear power by the State agency and will give industry at least a minimal program for satisfaction of their legal requirements to AEC, and in the long run, will result in substantial savings to the people of Florida.

DISCUSSION

MR. McCALL: George McCall, Pinellas County Health Department. I address this to Wallace Johnson because I know it is something he is in and out about and I would like to hear his present thinking and that is, in view of our cesium problem or anomaly in Florida, showing

up even in our field mice or acorns and our holly berries and so forth as we saw this morning. Should there not be a rather studied question then as to whether or not the State of Florida needs to take another look at the release limits with the thought in mind that they may need to be reduced with respect to cesium?

MR. JOHNSON: George is perfectly aware that I have already made a recommendation in this respect to our staff, sitting on a committee on regulations. We do have a cesium anomaly. We do have a good bit of data that is piling up on this problem. We do not wish to get into conflict with the Atomic Energy Commission on the topic of limits. In all seriousness though, to answer the question, if I were asked today as I have been would I recommend a reduction of cesium limits in Florida, my answer would be yes. I think we should do this.

Mr. Robert L. Zimmerman
Radiological Safety Officer
Georgia Institute of Technology

I appreciate this chance to talk about the role of the university in the environmental crises as it relates to nuclear power operations. I believe it is something that, with limited exceptions, has not been touched upon in this meeting. I can speak only for Georgia Tech, but I believe that our posture in this matter is typical of many major State universities; however, we are more deeply involved in applied training programs than are similar institutions.

Obviously, when you consider the role of the university, you think of the mission of education. The public all too often thinks that education is the only mission of the university. That is not true. Although education is our primary responsibility, the Georgia Legislature and the legislatures of many other States requires that the university, especially a technological university such as Georgia Tech, be a resource to the State, the region, and the nation. If we are successful in achieving this goal, the university will attract new industry to the State, and improve the performance of existing industry. One of the most significant services which the university can offer is in the area of research and development. Industry frequently utilizes the university staff to conduct specific R&D tasks which are beyond the resources of the industrial organization.

The capability of a university to assist industry is dependent to a large extent upon the interests of the faculty. Georgia Tech has

built a faculty strong in knowledge of experience in the nuclear industry. Therefore, Georgia Tech has been among the leaders in assisting the nuclear power industry especially in the South. Many key employees in all phases of the industry have obtained the M.S. or Ph.D. in Nuclear Engineering at Georgia Tech. One of the strongest areas of speciality in the nuclear engineering curriculum is radiological health. Furthermore, the Schools of Physics and Nuclear Engineering have recently agreed on a combined program which will lead to the B.S. in Health Physics. Graduates will be prepared to enter industry immediately upon graduation and contribute meaningfully on the junior health physicist level.

Georgia Tech is now providing a unique series of training programs which utilize the skills of the faculty and staff, as well as the excellent nuclear facilities on the campus. The Georgia Tech Research Reactor, a one to five megawatt research reactor, is the center focus for much of the training. Special courses of study and practical experience are arranged to fit the needs of three main groups of utility employees designated to learn the following job skills: health physics supervisor, health physics technician, and reactor operator.

Individuals chosen to supervise health physics services have, as a minimum, a B.S. degree in science or engineering. Ideally, one would enroll in the M.S. level radiological health program which, assuming adequate prerequisites, would require the devotion of about one year of effort as a full time student. Then the trainee would be assigned

to work in the Office of Radiological Safety for about six months in order to gain practical experience in the field. To this, the trainee must be provided with an opportunity for significant practical experience in an operating nuclear power plant. In practice, utility companies may be unable to allot sufficient time for the full program of residence at Georgia Tech. In such cases, a modified program of six months to one year of a combination of reduced academic load and daily practical training in health physics has proved most efficient. Academic work is limited to one to two courses per academic quarter, which are carefully selected for applicability to future job assignments. The trainee devotes an average of four to six hours per day to observation and training with the health physics staff at the Georgia Tech Research Reactor. Here he learns and participates in all phases of an ongoing operational health physics program. His training is accelerated by his daily exposure to reactor conditions which may occur only once every 13 to 15 months in an operating power reactor. By the end of the period of residence, the trainee will be expected to perform most types of radiation safety surveys without immediate supervision, and be knowledgeable on most aspects of health physics management and governmental regulation.

Special programs have also been provided for groups of three to eight health physics technician trainees, usually from a single organization. A typical program, lasting for a period of about sixteen weeks, is tailored to the specific objectives of the sponsoring company,

and the backgrounds of the trainees. Instruction is on the practical level, and is intermingled with field experience at the reactor and related facilities. In addition, trainees are assigned specific routine technician duties, on a rotating basis, to accustom them to their future job activity. If required by the utility, training is also provided in plant chemistry techniques. Field trips to operating nuclear power plants are an integral part of the training.

The Reactor Operations staff of the Nuclear and Biological Sciences Division offers a comprehensive training program for utility employees designated to become licensed reactor operators as well as to those who will serve as reactor operations support personnel. Their training begins with the basic mathematics and technology which is prerequisite to the specific instruction necessary to pass the AEC licensing examination. The program concludes with assignment to the Nuclear Research Center for individual practice in the startup and shutdown of the GTRR.

The programs which I have described have been utilized by a number of utilities in the South. They are examples of the rather unique service concept of the university to the industrial community. I believe the applicability of the programs to the needs of the utility to be excellent.

While utility executives may intuitively trust the motivation of the university staff in serving the needs of the industry, they may fear that the instruction may be too theoretical or the continuity of the programs to be in question. We at Georgia Tech feel that such

detractions are overcome with the commitment of our top administrators to the continuity of the services.

The university is presently an important factor in nuclear power utilization. I believe it must become involved to an even greater extent in the future. Protection of the environment is inseparable from power generation in our current social climate. Therefore, I encourage industry to look to the university for a greater measure of assistance, and I recommend that universities consider increasing the services offered to industry.

Joel T. Rodgers
Nuclear Project Manager
Florida Power Corporation

We used to think that there were two ways to get into heaven in this industry. The one for nuclear plants was at 1717 H Street in Washington, D.C. with the by-pass gate in Bethesda. There was a way of getting there with fossil plants and that happened to be on Riverside Drive in Jacksonville. But this was shot down and they locked the gates when the environmental problems began. Then came the new agency called EPA, and I am not sure whether that is a gate to heaven or not, but you fellows are sure acting like it.

Now, we have really got a problem. So I am going to take just a couple of minutes here and read what I have written down here and then sit down because I think the utilities do have a valid case for their continuance in this business with an ability to protect the environment.

If anyone in this room thinks he can build a power plant, nuclear or fossil, without some allocation of resources permanently, then you are wrong. If you think Florida Power Corporation or Alabama Power or any other company can go out of the business of generating electricity, you are also wrong. This is because the same people that want a clean environment commissioned us to stay in business for the production of electricity.

I think this pretty well sets the stage for the quandary the utilities are in. I think we need rationale and must use intelligence in these matters. We also have a goal and it is Florida Power's goal and we are

operating this way, too, in an attempt to meet the electric generation and environmental needs. Our goal is to build power plants with a minimal impact on the environment.

Gentlemen, we must do this. We cannot continue to throw pollutants into the atmosphere, whether they are radiological or some other name. Gas. Smoke. Whatever you want to call it. We have got to do something about this. But complete irrational goals or imposition of standards on the utility industry at this particular time are going to shoot down research programs. It has got to shoot down intelligence and it may ultimately get us to the goal, but we may back into it. It doesn't really matter if you back into it or not, if you get there. But we can't go out of business. The utility industry is a law abiding business. It has its methods of operating which none of you may approve of or disapprove of doing anything with.

As far as the subject that we started out with here, the utilities do not have the scientific expertise to look into details of the ecology and the impact on it by our plants.

The outside business supporting the power plants, lack a broad capability although there do exist a few companies that are very capable in this area.

The Regulatory Agencies do contain a very good environmental capability, but they obviously need to perform in support of their own positions. There are, of course, exceptions to this rule such as is the case with our Florida Division of Health which is doing work as a matter of its public responsibility.

The State of Florida Department of Natural Resources which was also suffering from reorganization is doing the same thing in the area of thermal pollution for us.

Our greatest source of expertise for environmental understanding is in our universities. This source of experts is essentially untapped at this time and perhaps the reason is mutual lack of communication and perspective between it and the power industry. Industry sees the university as a bunch of little kids with pieces of string attached to their noses while the university sees industry as a money monger with no feeling for the environment or the public or anybody else. All we want you to do is sell electricity.

Well, both of us are wrong. I think that is true and I am happy to tell you that the ice is broken. They are finding it difficult going, but the environmental protection is growing. The complimenting capabilities of two truly responsible business organizations in the public interest, with direct benefit to students in the way of improved quality of their education is taking place, then the utility can attain true credibility through complete openness and honesty of our efforts in the environment. The great majority of the public will find such activity to be acceptable. Complete liaison with regulatory experts is essential to making this thing go.

I think we were the first utility to respond openly to the Fish and Wildlife Letter at the construction permit stage and agreed to do what was imposed on us at that time. In partial answer to the letter, we are holding semiannual coordination meetings with all the people

who are involved at the Crystal River nuclear facility environmental effort.

We have two of them to date. The concept is working beautifully and if you have ever tried to put that group of people in a room together and expect to come out with your hide you're fooling yourself. I wouldn't even agree to be the moderator. They were scared of us and each other, but why could't we talk to each other. They were all afraid the slides weren't any good. So we just talked a little bit about the program. The second one was absolutely phenomenal.

Now, there were some EPA people there. We don't open this to the press or the public for, I guess, obvious reasons in spite of the fact that having done it twice now I am sure that we could get away with it.

I think we will get out with our hide. I think you do have to understand the public has to know that what you are doing is in their interest and you have to have this complete honesty with each other.

We are very pleased that the University of Florida and South Florida go along with us and we are most proud of the association. We also have the two State agencies working with us on environmental research. We anticipate an even greater involvement in the State with the University of Miami and Florida State University. We want you to go home and take the trouble to see what your university can do to assist your company in protecting the environment.

We have had dealings with many universities; Cornell University, and North Carolina State University. The University of Florida, the

University of South Florida and the Georgia Tech Health Physics group is another area where we have worked. We have good relationship at all these universities. We don't put any restrictions on work that they are doing. We outline initially what the program is and then they take off. We are not operating in a vacuum and this, I think, is extremely important.

W. Emmett Bolch, Ph.D.
Associate Professor of Environmental Engineering
University of Florida

I would briefly like to cover two points, the first is the question of how, and why the university should be involved in environmental surveillance. The second point, is the question of how best can the university meet the needs of society, especially in terms of training the right kinds of people.

Maybe I should review briefly the history of our involvement with Florida Power Corporation. I had been teaching several courses in Radiological Health for a number of years and suddenly came to the realization that I was not in tune with some of the new concepts in environmental surveillance for radioactivity. For this reason, I set up a special seminar series in the Winter of 1969-70, and invited a number of experts who were currently dealing with the problem of environmental surveillance to come and talk to my students. In addition, we discussed all the current literature on environmental surveillance for radioactivity.

Our speakers included Wallace Johnson, State Board of Health, John Hancock, Florida Power Corporation, and a lot of other people from in and out of State. It was a very successful seminar series. I believe it is fair to say that John Hancock was impressed with our facilities and "up-to-dateness," and before dinner was over I had agreed to put in a proposal to perform the third party preoperational environmental surveillance for Florida Power at Crystal River.

A few months later the contract was signed. There was full agreement between the industry and the university that the investigators would be able to innovate and try new approaches to this problem of environmental surveillance. Of a special importance in our proposal was the application of ecological principles to the sampling and analysis. The university considered the contract a research contract and we could investigate new ways of approaching the subject. We would, of course, want to do things right and collect sufficient amounts of base line data to more than satisfy any regulatory requirements. I agree with what has been said at this conference about some necessity for standardizing procedures. There has been some talk out in the halls about having a special conference on this subject. I think that that would be a good idea. I am not sure exactly who should respond or where it should be, but we ought to give it some thought.

Let me get back to my first point. I think it is safe to say that the university does not want to be and shouldn't be in the business of routine environmental surveillance. That is a responsibility for somebody else. If there are problems that occur, we would like to look at these problems and find solutions, or we would like to investigate new ways to approach old problems. As Bob Zimmerman has said, "we do have a lot of expertise" at a university. When I first came into the academic world several years ago, the word, "interdisciplinary" was being thrown about quite a lot. A lot of paper organizations were tried, but many really didn't work. I truly believe that our interdisciplinary group is working. It is an exciting experience to see

a Nuclear Engineer and a Marine Biologist working together and learning from each other. The faculty members involved in such a project benefit greatly from the application of principles to a real problem. Some personal experience is a tremendous asset when you stand up before a group of students.

As an end result of the type of project the University of Florida is carrying on for Florida Power Corporation, the industry benefits from the expertise brought to bear upon the problem, the investigators benefit from the interaction with other faculty members and the industrial personnel, the teaching program benefits from the interjection of real problems, and, of course, finally, the students benefit both from the improved classroom teaching and from working on these projects as graduate assistants.

Let me briefly go into my second point. I am in a department that has the audacity to call itself Environmental Engineering. We supposedly cover water pollution, water treatment, radiological health, ecology, environmental biology, environmental chemistry, and solid waste.

Our most important product is, of course, students. We are in the business of trying to train the people that are going to be your employees. I would like to mention a few things that I see as trends. We are currently only a graduate department awarding only masters, and Ph.D.'s. In the last few years we have seen the ratio of masters to Ph.D.'s, change toward more masters candidates. What this means to the industrial and governmental people in this audience is that we are training more people to be hired in these organizations, and less

people to be hired by other educational institutions. How far should this trend go? We are meeting in a faculty retreat this weekend, and one of the subjects is going to be that, undergraduate education in Environmental Engineering.

I have mixed emotions about undertaking such a program. We need inputs from industry and government. Do you need this type of person? Do you need someone with a Bachelor of Science in Environmental Engineering? It is a rather difficult job to set up an undergraduate program, and we would like to know if it would be of service to you. We always appreciate comments, criticisms, and suggestions from the people that are going to hire our graduates. It is difficult to get this type of feedback. We have tried various procedures, including questionaires to our past graduates. In the last couple of weeks a Blue Ribbon Commission was formed to visit our department and tell us what type of individual needs to be trained.

I am told that there are several reasons why people go into teaching. One is for revenge, two is because they get a call similar to a preacher, and three is they like to have a captive audience just to ramble on whatever subject they want to. I probably fall into that third category here. My time is limited and I thank you for your attention and will welcome any questions.

G. K. Rhode

Representing

Atomic Industrial Forum

I am very pleased to represent the Atomic Industrial Forum today, because we wanted to make this group aware that we have a relatively new Ad Hoc Working Group on Radiation Protection which is presently working very actively on several projects, including environmental monitoring guidelines. Some of my remarks this afternoon will include ideas our group has been discussing; others represent my personal feelings regarding proper interrelationships.

There have been suggestions that industry--and particularly electric utilities--spend at least one percent of their income on research and development. Whether you agree or disagree with this figure, the question still remains, "Do environmental studies fall in this category at all?" or "Is basic research fundamentally a public agency responsibility?" Already the public has come to look upon some segments of our collective industry as representing something they call the "Establishment" and to view these entities with considerable suspicion. I think it will be necessary to consider this problem at the very top of the list as we plan for future environmental studies. I agree that universities will play a major role here. I also feel that a cooperative effort between the plant operator and public health agencies is necessary and desirable across the board. However, some division of responsibility is feasible. The plant

operator, for example, should take the lead in controlling and tracking emissions from his own facility, while public health agency responsibility takes over in areas such as interpretation of data for public health purposes, setting of standards, the undertaking of new research which might be needed, and assessing public exposure from all radiation sources. From an operator's standpoint, it makes little difference which agency takes the lead in monitoring our activities, but it would obviously not be desirable to see duplication of inspection efforts as Dr. Beck touched on.

It is clear that new nuclear plants will incorporate effluent cleanup systems which are likely to hold down emissions, most of the time, to levels that are extremely difficult if not impossible to distinguish in the natural environment. Therefore, the question of continuing full blown environmental monitoring programs, collecting a continuous string of zeros,--a question which has always been with us--now seems more pertinent than ever. Several of us at the Forum are convinced that graded surveillance programs, such as have been described by other speakers, are the appropriate answer.

I don't think it is particularly relevant which standard these graded programs are geared to; the standard could be a fraction of 10 CFR 20 dose limits as described by Dr. Beck; it could be more restrictive state standards, or perhaps the yardstick might be total man-rem exposure to large population groups. In any event, three

significant guidelines are applicable:

1) Continuing operation of a full scale environmental surveillance program below a distinguishable measurement threshold is not warranted.

2) Graded surveillance programs, which can be scaled up or down in accord with in-plant monitoring results, should be utilized.

3) These activities should be designed for easy assessment of exposures above normal background actually received by people--not necessarily fence posts!!

Utilitization of these graded environmental surveillance programs will place additional reliance on in-plant measurements of what is being released so that doses can be better predicted. In my opinion, the practices being conducted today in nuclear facilities are more than adequate for this purpose. However, anyone who has been accustomed to thinking that in-plant measurements are private domain will have to recognize that these data are also extremely important to public health and regulatory agencies. Here again, a cooperative system for data review will have to be worked out.

Joel touched on my last comment, but I think it is worth repeating. We do indeed have a problem, but it will do no good to overreact to environmental pressures and set up conditions none of us would welcome. I think the vast majority of the public expects us to determine a proper balance between all environmental considerations and will keep the pressure on us until we do just that. Frankly, our power needs are too urgent for us to get caught in the middle of any such controversy. The power industry has been accused on many occasions

of trying to foist nuclear plants on a completely unwilling public--presumably for reasons which no one has yet been able to define.

The fact of the matter is that nuclear plants are a tremendous added burden to our industry:

1) They have a much higher capital cost--at a time when we are finding it harder and harder to raise capital.

2) They require at least a two year longer construction period--making long-range planning more difficult and requiring an earlier financing program.

3) They have a most difficult regulatory climate which casts a heavy shadow on construction schedule plans and requiring continuous management attention from beginning to end.

One of the main reasons why we volunteer to take on these added burdens is because all of us are convinced that nuclear power is the "cleanest" way we know of today to produce electricity. But, how many times have utilities been forced to turn to other forms of generation because of nuclear roadblocks? Is this the balance the public <u>really</u> wants? I think not--and we must be very careful not to create a framework which forces industry in this direction.

NUCLEAR POWER AND A PROTECTED ENVIRONMENT

Dr. Morton I. Goldman, Vice President
Environmental Safeguards Division
NUS Corporation

I have been increasingly involved over the last several years in what have become known as confrontations with the so-called environmentalists, particularly with regard to nuclear power plants. Therefore, I welcomed the last minute invitation to come here, and to make a presentation on the future role of nuclear power in a protected environment. I say this because I see trends at the present time which lead me on occasion to doubt our ability to maintain a balanced perspective with regard to the role of nuclear generation of electricity in supplying the energy demands of our country. Unfortunately a good part of this trend has been aided and abetted by some public agencies who should know better.

I don't think it is necessary to go into the role of electric energy in maintaining and improving what some people call "the quality of life" or what others call "the standard of living." There is a debate at the moment as to whether our use of energy has or has not approached the conspicuous consumption stage and therefore resulted in an expenditure of resources that are out of proportion to the benefits.

This debate about national energy policy, both as to the source of the energy and its usage, is one that is continuing and I think, encompasses a fairly broad spectrum of society. However, the present

use of electricity constitutes only about ten percent of the total per capita usage of energy in the United States. It doesn't take too much of an examination of the environment and other energy usage to reach the conclusion, at least with regard to the environment, that electric energy may be the most beneficial of any of the other forms of energy usage at the present time.

This is a decidedly arguable thesis to some of my frequent opponents on the other side of the table. But there have been enough studies done on environmental effects of alternative energy usage to indicate that the generation of electric energy by central stations, particularly through use of nuclear fuel, provides by far the least environmental impact of any other available alternatives.

In trying to look at the future of nuclear power and its role in supplying our energy needs, I thought it might be of some interest, especially in view of my own recent exposures to the environmentalists, to examine this role in the light of the present debates with regard to nuclear plants. These debates usually encompass a number of topics. Although the specific details vary, the topics can be broadly characterized as those related to: first, low-level discharge from nuclear facilities; second, the ultimate disposal of high-level wastes; third, nuclear accidents and public health; and fourth, thermal effects. Each of these, brought up in different ways and with different variations, has been discussed on a number of occasions and in a wide variety of forums ranging from formal hearings to television debates.

I think unless we manage to resolve these debates in some reasonable manner, the promise of nuclear power will be sharply curtailed. Several States have "moratoria" legislation under consideration. Several utilities have rejected nuclear plants in favor of fossil alternatives largely on the basis of an unfavorable response from the public. I don't think these actions are necessarily in the direction of an improved environment.

The resolution of these debates may not necessarily be reached with many of our more vocal opponents. Some are obviously irreversibly committed. For example, Dr. Gofman testified under oath a few months ago in Maryland that one percent of the AEC standards are, and I quote, "grossly unsafe." I am quite sure we are not going to change his mind.

On the other hand, some of our opponents are not as unreasonable as they are misinformed. It is almost universally the case that the public is at the very least uninformed and (more usually) misinformed about any particular nuclear power plant proposal. Until we can inform and educate this latter group, that is, the partially informed, the present difficulties are going to escalate in many areas.

I propose to look at two of the areas of concern that I mentioned earlier; those of low-level wastes and thermal effects. I think that to some extent they share a very common emotional element.

The low-level waste discharge question is one upon which the attention of this meeting has largely been focused. The questions in this area are based on the broader inquiry into the validity of present radiation protection standards, particularly as they apply to licensed

nuclear facilities. I don't think that it is necessary for me to review the waste discharge values that you have seen on a number of occasions in the last few days, or the history of our present protection standards, or the degree of control that has been exercised both by industry and regulatory agencies over this potential problem.

Certainly, as has been said on several occasions here and on many occasions elsewhere, the history of licensed nuclear facilities is unmatched by any other human activity in the degree of care that has been exercised before rather than after a problem has arisen. One of the fairly widespread misunderstandings that I have found in dealings with the public and with some people in regulatory agencies relates to the application of these protection standards by the AEC to nuclear facilities and to the significance of the most recent changes in AEC regulations relating to waste discharges.

It is not unusual at all to find people who are firmly convinced that the AEC regulations permit regular exposure of individuals near nuclear facilities to the legal limit of five hundred mrem per year, and exposure of substantial populations to one hundred seventy mrem per year; and that the AEC considers only air and water concentrations and doesn't consider food chain reconcentration. It has been extremely difficult to convince some of these people that it is almost impossible to reach the maximum dose levels to individual members of the public. The only way to reach maximum dose levels is by a combination of extremely poor performance of both fuel and waste control systems.

Even under those circumstances one would have to be that delightful hypothetical individual who lives outdoors in his skin on the most unfavorable site boundary twenty-four hours a day, three hundred sixty-five days a year, and who also has a long enough neck to get his head down in the discharge canal to get his water and proteins from that source.

Furthermore, under no attainable conditions can a significant population be exposed, through nuclear plant operations, even to a small fraction of that appropriate limit without greatly exceeding the individual limits at the site boundary. A combination of both calculations and measurements (such as those that were presented yesterday for Carl Gamertsfelder by Charles Pelletier) have indicated that for the plants currently in operation there exist factors of difference between the site boundary exposures and population exposure within about fifty miles in the range of several hundred to several thousand, depending upon the site, considering both direct and indirect exposure routes, i.e., through the food chain.

In view of the fact that radioactive discharges from presently operating plants have ranged from a few tenths to a few percent of their licensed limits and that these plants were designed and built before the present regulations relating to "as low as practicable" were in effect, it is pertinent to ask what useful things have been accomplished. Certainly the surveys of Dresden and Yankee-Rowe did not indicate any perceptible change in population exposure as a result of operation of these plants.

That these regulatory changes have had some effect is unquestioned. They have made every potential intervenor and review board or agency instant experts as to how low "as low as practicable" really is. The modifications also have undoubtedly served to increase the gross national product by increasing the amount of hardware that can be sold to utilities for incorporation into power plants and by increasing the amount of paper necessary to design, license and operate the stations. What the regulatory changes probably will not do, except in a few instances, is to materially change the radiation burden borne by either plant neighbors or the population at large.

There are instances where the application of better management methods can have a significant effect on population doses. Leaving the nuclear power field for just a moment, there is a real need for substantial reductions in the huge population dose due to excessive and unnecessary use of medical X-rays. However, in the nuclear power area, there are instances where provisions for added systems can be of benefit. One of these is to augment the decay of gaseous radioactive effluents in the off-gas systems of the boiling water reactors. This also has the benefit to the operator of providing him with flexibility in operating with defective fuel elements which do show up from time to time.

A second less specific improvement as a result of the modification of regulations may well result from requiring the use of installed waste management equipment at nuclear plants. This has not always been the case. There are a number of plants that have waste treatment

systems that have never been used, except to be tested. This use can be expected to improve effluent quality.

A third instance of significant benefits to be derived from requiring improved waste management lies in the fuel reprocessing plant area, particularly in the control of noble gases and tritium. The control of noble gases, as we have heard, is technically feasible at these plants at present. The control of tritium is something that remains for the future.

Aside from these instances, I find it almost impossible to identify examples of significant public radiation dose reduction attained from the application of more stringent management of low-level discharges from nuclear facilities, and I submit it is that reduction of public radiation exposure which should be our objective in all of these activities. Nevertheless, we are seeing at the present time, a significant number of other systems being considered for incorporation in other plants as described in this meeting.

It is my own judgment that for the most part, although we will see relatively little difference if any resulting from incorporation of these various systems, we will see a significant increase in the average radiation exposure of the plant workers due to increased maintenance and handling requirements for these systems. Further, having had the momentary vision of a so-called "zero release" concept dangled before them, concerned citizens groups are hardly likely to settle for much less, not realizing that they are paying for a commodity, improved radiation protection, which they are not going to receive.

This situation will very probably continue until sometime in the future when either the public will become sufficiently well-informed about nuclear power and radiation that these fears will be dealt with more rationally, or we will reach a state of irrationality such that we begin to control where and in what structures people may live because of incremental natural radiation dose contributions. One day we may even reach the extreme point of controlling medical uses of radiation.

We need to recognize and to clearly state the relationship between those research-oriented activities directed at improving our existing knowledge of radioisotope transport and ultimate fate, and the existing regulation of human radiation exposure which is entirely adequate and done with sufficiently satisfactory accuracy to assure the public health and safety.

We don't need five decimal places to assure the public health and safety. As desirable as this additional research may be, we have to make very clear to the public that it is not necessary that we await all of these results before proceeding with nuclear power programs. With projected population exposures from nuclear power in the range of one tenth mrem per capita per year or less, I cannot accept the idea that we may have catastrophe awaiting us in the years to come from these radioactive wastes. Furthermore, considering that the cost of these perhaps unnecessary activities are being borne by the public, any honest individual might ask himself where these dollars can best be invested for a return in improved public health and welfare.

I would submit that the best return in improved health will not be from the three to five million dollars per station in additional waste systems as much as it would be in a municipal sewage treatment plant or in rebuilding slums for both of which the public is expected to pay.

The area of thermal effects is one that bears a number of similarities to the radiation area, and I thought it might be refreshing for a change to listen to someone else's problems. I think this is an area that also threatens the full realization of the future potential of nuclear power, and for that matter all benefits of electric generation.

Of course, the laws of thermodynamics were not really part of the Atomic Energy Act of 1954, as amended; Congress really doesn't have that much to do with steam cycle efficiency, and resulting waste heat rejection needs were defined quite a few decades before fission was discovered. However, it seems environmental thermal effect problems have largely been examined because of nuclear plants.

Now, it is a fact that cooling water in the light-water nuclear plants discharges more heat per kilowatt than in the most modern fossil plants. It is also a fact that nuclear plants are being built with larger unit capacity than fossil plants resulting in the requirement for more heat discharged from a given site. The combination of these two factors results in a thermal discharge and a <u>potential</u> for harm which is greater than has been usual in the past.

The problems of heat rejection, though, have not gone entirely unrecognized by the organizations that design and build these facilities. Heat rejection has always been a major consideration in siting and designing power plants. This may be made somewhat more important and somewhat more difficult to solve by the introduction of the light-water reactor plants, but in the present climate of insistence on instant environmental purity, the political responses to uninformed pressures produce in some instances "solutions" which will in my opinion result in net harm to the public.

These are number of examples of this kind of solution. Temperature limits significantly lower than the natural range of temperatures observed in the unaltered Bay water, have been established for unmixed discharge into the Chesapeake Bay. This may have the effect of requiring plant output at Calvert Cliffs to be reduced at precisely those times of the year when it will be needed by both myself and my neighbor, Mr. Ruckelshaus, to run our air conditioning systems directly off the P.J.M. system. But the difficult part to understand is that there is no net benefit to the biota in the area who have the freedom (and exercise it) to leave uncomfortably warm water for the season, so to speak.

A second example is the prohibition of once-through cooling at the Trojan site on the Columbia River, despite the fact that the Hanford plants on that river have added substantial heat loads in the past with no significant effect on the fishery resources on the

Columbia. The giant cooling tower under construction at that site may increase the frequency of fogs and precipitation in the area somewhat to the detriment of the human inhabitants, to say nothing of adding a substantial visual impact for those concerned with aesthetics. It is hard to hide a fifty-story structure covering the area of one and one half football fields.

The Illinois Water Pollution Control Board denied permission for the Dresden 3 unit to be operated this summer because the cooling lake under construction will not be completed until late in the year. Considering that fish are scarce, to say the least, in the Illinois River near Dresden largely because of the presence in the water of sewage and waste from Chicago, it seems to me to be a very poor trade off for the people served by Commonwealth Edison to be deprived of a badly needed eight hundred thousand kilowatts this summer for the benefit of almost non-existent fish.

A final example of official nonsense is the pending action by EPA in the matter of the Lake Michigan Enforcement Conference. Here, the Enforcement Conference heard testimony and, because there was so much of it, set up their own technical committee to evaluate all of the evidence that had been presented. The findings of the Conference's own technical committee was "that there has been no significant damage at large presently operating stations, that any effects at all are largely localized, and there is time to demonstrate the extent of more subtle effects before the lake is remotely endangered." EPA totally ignored these findings and the Conference was directed to

define limits which would require alternate heat rejection schemes for large power plants, i.e., requiring use of cooling towers in northern climates, perhaps the poorest overall choice for the people that can be imagined. These installations which are and would be required to operate through the winter will create, at the very least, highly adverse conditions of fog and precipitation during the fall and winter and, at the very worst, may on occasion result in injury or death from the creation of local icing conditions on adjacent highways. I expect, however, that the fervor for alternate heat rejection methods where there is no valid basis for their choice will continue until these units have been in operation, and the public has an opportunity to see what they have bought and paid for. At that time, I think there will be a reevaluation of the direction in which the scale should be balanced with perhaps the immediate human environment taking precedence again.

In summary, I would say that the role of nuclear power in maintaining and improving our environment can be a major one, but that its full potential is being threatened by the current wave of emotionalism which has found an all-too-ready home in some of our public agencies which should be leading, rather than following, the uninformed.

It is also true that there have been occasions when some representatives of the industry have been less than fully responsible in their actions. However, unless the scientific and engineering communities can effectively and honestly inform the public about the

balances and the trade-offs involved in these plans or decisions, the political and industrial responses are going to result in providing needed electric energy at a premium price with no net environmental gain.

We do need electrical energy, more of it than ever before, not only to continue to provide for the personal standard of living that we enjoy, but to provide the needed improvement to the environment itself, by producing the energy to run the pumps and the blowers and the process equipment that we need to clean up our presently really polluted water and air.

It is a fact, not a fancy, that nuclear power provides this energy with the least overall detriment to the environment. With these considerations in view, I would suggest that we would spend our time better talking less to each other and more to the public.

APPENDIX

Conference Participants

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