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REPORT TO THE
JOINT COMMITTEE ON ATOMIC ENERGY

This document consists of 67 pages
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Observations Concerning The Management Of High-level Radioactive Waste Material B-164052

Atomic Energy Commission

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

May 29, 1968

B-164052

Dear Mr. Chairman:

The General Accounting Office has made a review of selected aspects of high-level radioactive waste management activities of the Atomic Energy Commission. The report on the results of our review, which contains Secret Restricted Data, is being furnished to the Joint Committee on Atomic Energy, Congress of the United States, in accordance with a January 26, 1968, request of the Executive Director.

Our observations concerning the management of high-level radioactive waste material were discussed with the Commission and it advised us that certain actions would be taken which, if properly implemented, should strengthen the Commission's overall administration of its radioactive waste management program. Our principal observations and conclusions are summarized on pages 9 through 16 of the report.

As agreed to by the Executive Director of your Committee, we are making copies of this report available to the Commission. The Commission's comments have been incorporated in the report. We plan to make no further distribution of this report unless your approval has been obtained or public announcement has been made by you concerning the contents of the report.

Sincerely yours,

Frank H. Weitzel

Acting Comptroller General
of the United States

The Honorable John O. Pastore, Chairman
Joint Committee on Atomic Energy
Congress of the United States

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OBSERVATIONS CONCERNING THE MANAGEMENT OF HIGH-LEVEL RADIOACTIVE WASTE MATERIAL BY THE ATOMIC ENERGY COMMISSION

INTRODUCTION

The General Accounting Office has made a review of selected aspects of high-level radioactive waste management activities of the Atomic Energy Commission (AEC). Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), the Accounting and Auditing Act of 1950 (31 U.S.C. 67), and the Atomic Energy Act of 1954 (42 U.S.C. 2206). The report is being furnished to the Joint Committee on Atomic Energy (JCAE) in compliance with a January 26, 1968 request of the Executive Director.

The radioactive waste management program, as discussed in this report, is related to the actions taken by AEC and its prime contractors to assure that radioactive waste effluents from AEC's chemical-processing plants will not constitute a hazard to life forms. Our review was directed toward an examination of AEC and contractor management of these high-level radioactive wastes because of their concentration of long-lived isotopes and the need to assure their containment for extended periods of time. We did not examine in detail the planned management of high-level wastes expected to be generated by the expanding civilian nuclear power industry, or the technology which is being developed by AEC for the treatment and long-term storage of these waste materials.

As part of our examination, we reviewed applicable legislative history and AEC's policies and procedures. We also obtained the views of various AEC and contractor employees who were knowledgeable of, and responsible for, activities relating to the management of high-level wastes. At AEC Headquarters, we obtained information on the radioactive waste research and development projects conducted by AEC laboratories.

BACKGROUND

Radioactive wastes are created wherever radioactive materials are processed. By far the greatest source of wastes is the nuclear fuel cycle: the mining, milling, and preparation of fuel for reactors and weapons produce wastes containing natural radioisotopes; and fuel irradiation and subsequent processing produce wastes rich in fission products. Additional wastes are produced by irradiation of nonfuel materials in and around reactors.

Radiation cannot be detected by the senses (except in massive doses); its effects are often cumulative and may not be evident for some time; and it can damage both an individual and, by impairing his reproductive cells, future generations of his descendants. Unless properly controlled, the radioactive material can be hazardous. The nature of radioactivity also makes it possible to detect its presence with certainty and accuracy.

Radioisotopes are immune to outside influence; each isotope decays at its own particular rate regardless of temperature, pressure, or chemical environment. Allowing radioisotopes to decay naturally is the only known practical means of eliminating the radioisotopes. All processing and storing of radioactive wastes must therefore be considered as an intermediate step leading finally to disposal by decay.

Radioactive wastes may be divided into three separate categories: low-level, intermediate-level, and high-level. Although delineations of the categories is arbitrary and is dependent on operating parameters, an AEC document defines these categories as follows:

a. Low-level wastes have a radioactive content sufficiently low to permit discharge to the environment with reasonable dilution or after relatively simple processing. These wastes have no more than about 1,000 times the concentrations considered safe for direct release. In liquid form low-level wastes contain less than a microcurie[1] of radioactivity per gallon.

b. Intermediate-level wastes have too high a concentration to permit release after simple dilution, yet they are produced in relatively large volumes. The radioactivity of these wastes is up to one thousand times higher than that of low-level wastes and in a liquid form they may contain up to a curie of radioactivity per gallon. Intermediate wastes are disposed of through treatment, such as filtration or ion exchange, or are buried in the ground.

c. High-level liquid wastes cannot be released to the environment because of their high radioactivity concentration (as much as 10,000 curies per gallon).

AEC estimates that the high-level liquid wastes will retain hazardous concentrations of radionuclides for several thousands of years. According to the AEC, these wastes pose the most severe potential health hazard and a most complex technical problem in radioactive waste management.

Fission products, which are radioactive fragments from the fission of uranium and plutonium, produced during the irradiation of nuclear fuels in atomic reactors, are the principal source of radioactivity in the high-level waste considered in this report. Chemically processing these irradiated fuel elements to recover the valuable radionuclear products, formed during the irradiation, and the unfissioned fuel material results in the generation of a concentrated high-level aqueous waste solution containing the bulk of the fission products and other unrecovered radioisotopes. These waste solutions are stored in underground tanks. Some of these waste solutions have such a concentrated fission product content as to generate sufficient radiodecay heat to self-boil in storage unless the heat is removed by cooling.

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1 A microcurie is one millionth of a curie. A curie is a measure of the number of atoms undergoing radioactive disintegration per unit time and is 37 billion disintegrations per second or the rate of decay in one gram of natural radium.

During the first decade after generation, both the short-lived and long-lived fission products in the waste generate substantial amounts of heat in storage. After that time, only the long-lived fission products--strontium and cesium--present waste management problems from the standpoint of dissipating the generated heat. These long-lived fission products continue to produce substantial amounts of heat for a number of years and require hundreds of years to decay to activity levels which could be released without hazard to the biosphere. Other radioisotopes such as plutonium and americium, although not relatively significant heat emitters, require thousands of years to decay to activity levels suitable for release.

High-level wastes are generated at three AEC locations from the operation of chemical processing facilities to recover uranium, plutonium, and special nuclear products from irradiated fuel elements. These locations are the National Reactor Testing Station, the Hanford Plant, and the Savannah River Plant.

The National Reactor Testing Station was established in 1949 as a facility where AEC could build, test, and operate various types of nuclear reactors, allied plants, and equipment with adequate isolation for safety purposes. The Station is administered by AEC's Idaho Operations Office (Idaho) from offices in Idaho Falls, Idaho.

At the Hanford Plant, established in 1943 for the weapons programs, AEC has manufactured plutonium and other special nuclear materials, fabricated plutonium weapons components, and performed other atomic energy related activities. The plant is administered by the AEC's Richland Operations Office (Richland) located at Richland, Washington.

The basic facilities at the Savannah River Plant were completed in 1955 primarily for the production of nuclear materials to be used in connection with the weapons programs. The plant is administered by AEC's Savannah River Operations Office (Savannah), located in South Carolina.

Since the initiation of its activities to December 31, 1967, AEC has generated about 127 million gallons of high-level liquid wastes. At December 31, 1967, AEC had accumulated about 93 million gallons of high-level wastes in underground storage tanks at the three locations with the largest portion being stored at Richland. The use of evaporating facilities at Richland and Savannah and a waste calcining facility at Idaho has resulted in the reduction in the volume of high-level liquid wastes stored in tanks.

Tank storage of high-level liquid wastes has been used by AEC to confine and isolate the waste from biological life. Tank storage was the only reliable technology available at the time the plants were established. However, tank storage of liquid wastes requires continual surveillance and can only be considered an interim solution because the release of contamination to the environment can be avoided only so long as the tanks retain their integrity. At present, no valid basis exists for predicting accurately the service life of existing tanks. While AEC and its production contractors believe that with suitable surveillance, emergency spare tankage, and replacing tanks, tank storage of liquid wastes would continue to provide safe confinement for the short-term, they do not consider it a satisfactory method for long-term storage and believe that other alternatives should be developed.

To provide further protection against the possibility of inadvertent release of radioactivity to the environment, AEC has initiated actions at the three sites to develop and implement improved methods for the safe long-term storage of radioactive wastes. Idaho presently has a waste calcining facility which converts the liquid waste to a solid granular form for storage in bins. Richland is separating long-lived fission products from the waste and temporarily storing these radioisotopes in the separating facility with the intent of providing long-term storage as solids in high-integrity containers. The remaining radioactive wastes are to be evaporated to salt cakes for storage in the tanks. Savannah is doing research and development work on long-term storage of the wastes in bedrock formations below the Savannah River Plant site.

In addition to the specific responsibilities of the three AEC field offices for managing the high-level wastes generated at their respective sites, responsibilities relating to various aspects of high-level waste management are vested in several of AEC's organizational units.

The Division of Production (DP) develops and directs programs for the production and processing of feed, special nuclear, and other special materials and for associated process development. In conjunction with this function, DP coordinates programs for high-level waste management and long-term storage of radioactive waste from AEC's chemical processing operations which are under its jurisdiction, located at Idaho, Richland, and Savannah.

The Division of Operational Safety has the responsibility and authority to develop radiation protection standards and to appraise and evaluate the performance of AEC Field Offices in the protection of health, safety, and property.

The Division of Reactor Development and Technology (DRDT) is assigned to conduct research and development programs relating to the safety of reactors. Included in this assignment is the planning and technical direction of research and development on processes for the treatment and storage of high-level radioactive waste resulting or expected to result from chemical processing operations in connection with the nuclear power industry.

The Division of Materials Licensing under the Director of Regulation is responsible for licensing facilities for reprocessing irradiated source and special nuclear material, and therefore is concerned with the adequacy of waste management activities at such facilities. However, since AEC facilities are not subject to licensing by this Division, it is not responsible for evaluating the management of AEC's radioactive waste material.

The principal management officials of the Atomic Energy Commission responsible for administration of activities discussed in this report are listed in appendix I.

SUMMARY OF OBSERVATIONS AND CONCLUSIONS

In general, AEC considers a method for storage of high-level wastes to be long-term in nature when the inherent characteristics of the waste and the storage environment, with surveillance, are believed to assure continuing isolation of the wastes from the biosphere. With regard to wastes generated by AEC production facilities, each of the field offices involved has considered various alternative methods for providing solutions to the safe long-term storage of its wastes and has reached at least tentative conclusions as to the preferred method to be followed. It is generally recognized among experts in the field of waste management that because there is no single problem with a single solution, management of radioactive wastes can vary widely depending on the specific nature, concentration, and quantity of radioactive materials involved, and on the specific environment in which it must be considered.

Since 1959, when the JCAE held hearings on the subject of radioactive waste storage, AEC has made considerable progress in developing solutions to its long-range waste storage problems. At the time of our review, AEC had undertaken certain techniques at its sites which AEC considers to be the bases for long-term storage actions. In order to reduce the hazards associated with wastes in their liquid form,AEC has installed and is operating a calcining facility at the Idaho site, and has installed a waste fractionization operation for strontium and cesium and plans an encapsulation operation for these isotopes at the Richland site. AEC has also undertaken an in-tank solidification process at the Richland site to convert other liquid wastes to a solid form. Savannah is investigating the transfer of its tanked wastes to caverns mined in the bedrock, deep under the site. AEC believes that surveillance of the storage sites will be required under each of the long-term storage approaches set forth for Idaho, Richland, and Savannah.

At Idaho, solid wastes created by the calcining operation are being stored in stainless steel bins in underground concrete vaults. At Richland, we were informed that AEC plans, by means of the in-tank solidification process, to store in existing underground tanks about 59 million gallons of high-level wastes evaporated to solid form. AEC has not yet selected from candidate processes the manner in which the strontium and cesium, which are isolated by the waste fractionization process, will be solidified, encapsulated and stored for the long-term.

Each of the foregoing modes would have some degree of permanency in that AEC, at this time, does not plan further moving of the wastes once the long-term storage actions have been taken.

Approximately 93 million gallons of radioactive waste material were being stored in underground tanks at the three AEC sites at the time of our review. The greatest quantity of waste material (74 million gallons) was being stored at Richland and problems related to tank integrity have occurred at this location. Between 1958 and 1965, leaks were detected in 10 of the 149 underground storage tanks at Richland which did not have provision for secondary containment. An estimated 227,400 gallons of high-level waste have leaked to the ground. According to AEC measurements, the wastes were sorbed in the soil within about 10 feet below the tanks and about 200 feet above the ground water.

At Savannah, where about 17 million gallons are stored, leakage has occurred in four tanks containing high-level waste, but in only one instance did the waste material enter the ground by escaping the secondary containment. According to AEC, the tank leakage in this instance exceeded the capacity of the secondary containment for a brief period until pumping equipment could be installed to return the leaked wastes to the tank. AEC stated that its measurements indicated that no more than 700 gallons escaped the secondary containment, and that extensive soil corings and pumping of the ground water showed contamination levels equivalent to only a few gallons of waste. AEC believes that the difference, if any, was retained in the concrete structure surrounding the tank or in the soil immediately beneath the tank.

At Idaho, where about 1.6 million gallons are stored, our review of AEC records disclosed no evidence of significant problems or incidents regarding the storage of radioactive wastes in underground tanks.

AEC has not established a standard criterion as to the reserve storage capacity necessary to provide safe operation of tank storage facilities. In the absence of such standards, each of the locations has established its own informal practice as to the amount of reserve capacity to be provided. We were informed by AEC that generally the practice has been that at least either one spare tank or the equivalent of one spare tank for each tank area be available at all times.

As to commercial fuel processing facilities, there is one location, Nuclear Fuel Services, Inc. (NFS), West Valley, New York, where high-level radioactive wastes are being accumulated in tanks. NFS has an agreement with the State of New York to accept the long-term surveillance of the NFS storage tanks in the event that NFS should cease to operate. The agreement provides that NFS must maintain at least one spare carbon steel tank for each three such tanks in use and one spare stainless steel tank for each five such tanks in use. Thus, the only commercial firm currently accumulating high-level radioactive wastes is required to maintain a reserve capacity substantially in excess of that required under the informal practices established at the three AEC locations. Because of the technical judgment involved in this area, we are not in a position to comment on whether the requirement imposed on NFS is reasonable.

With respect to wastes produced within its complex, AEC advised us that it will reassess the situation and consider the development of standard criteria for reserve storage capacity for liquid wastes. At this time, AEC believes that such criteria would have to be developed on the basis of the conditions prevailing at each specific location.

At the time of our review, Richland was faced with a potentially serious situation with respect to the condition of its existing tanks. The operating contractor has estimated that the expected life of the 20 Richland tanks equipped to accommodate self-boiling wastes is probably no more than 20 years or could be as little as 10 to 15 years. Eleven of the 20 tanks have been in service for 10 years or more. Further, recent studies have cast doubt upon the wisdom of reusing such tanks after they have been emptied, regardless of their age. In this regard, it appears that in the last half of 1969, Richland may be confronted with a situation of having only used tanks available as spare tanks for high-level self-boiling waste storage.

The AEC recognizes that these unforeseen developments at Richland are not a satisfactory situation and has established priority for Richland waste management activities including the start of construction of two tanks in fiscal year 1968. AEC plans to budget for four additional tanks in fiscal year 1970.

Certain of the tanks at Savannah, designed to contain wastes not requiring auxiliary cooling, are similar in design to those at Richland in that they do not have provision for secondary containment. The Richland tanks have leaked without any apparent detriment to the environment because of the nature of the soil and because the water table at that site is well below the tanks. The situation at Savannah, however, would be more serious in the event of leakage because the tanks are set in the water table and leakage could be expected to eventually migrate into the ground water.

AEC advised us that the Savannah tanks in question do have leak detection channels in the concrete bottom adjacent to the steel liner and that if a leak were to develop and the liquid accumulated in the channels, waste could be pumped from these channels while the contents of the tank were being transferred to reserve storage space. AEC also stated that at the same time measures could be taken to control the flow of ground water so as to confine any material seeping through the concrete to the immediate vicinity of the failed tank. AEC added that as the Savannah program for the concentration of the waste by evaporation continues, the likelihood of a leak in these tanks diminishes since remaining salts will tend to plug any fissures that may develop.

At Savannah, four tanks and related facilities are currently under construction at an estimated cost of about $7.7 million, and there are plans to construct eight more by the early 1970's at an estimated cost of about $10.5 million.

We believe that considering (1) the volume of existing high-level wastes, (2) the reported condition of existing tanks, (3) the increased quantities that can reasonably be expected to be generated in the future, and (4) the potential additional costs of temporary storage to accommodate such wastes, AEC needs to devote more vigorous attention to advancing the technology required to permit long-term storage at the Richland and Savannah sites. The solidification and encapsulation processes for strontium and cesium and the bedrock approach which are currently being considered as long-range solutions to the storage problems at Richland and Savannah, respectively, have not been fully developed. The processes involved have been under study for 7 or more years.

In our opinion, AEC must devote vigorous management attention to the resolution of its waste management problems and must, if authorized by the Congress, commit on a priority basis the financial resources required to provide for long-term storage of its wastes. AEC has estimated that, at Richland, about $95 million in capital and operating funds will be required to process the accumulated and current wastes until about 1974 when waste processing and operations are expected to be on a current basis. For the Savannah site, AEC has estimated that about $62 million in capital and operating funds will be required to process the accumulated and current wastes to about 1978 when waste processing and operations are expected to be on a current basis. AEC has estimated that at Idaho, about $11 million in capital and operating funds would be required to process the accumulated wastes.

We believe that the effectiveness of AEC's organizational structure to provide the needed emphasis to solve the waste management problems, both short- and long-range, should be examined. In this connection, consideration should be given to the desirability of vesting responsibility for policy making and overseeing the waste management program in a single AEC office at a level sufficiently high so that it can efficiently and economically coordinate the program and assume the authority necessary to make decisions concerning long-term storage methods, with all of the implications which such decisions encompass.

AEC advised us that it fully appreciates the necessity for management of radioactive wastes by a method or methods which provide adequate protection to man and his biosphere against the hazards of radioactivity. AEC stated that it has recognized for many years that, while storage of liquid radioactive wastes in underground tanks did provide safe confinement for the short-term the need to replace tanks periodically and the ever-present possibility of failure of tank integrity made highly important the development, and adoption when perfected, of technology which would provide a more satisfactory method for the long-term storage of these wastes. To this end, it has devoted research and development effort, not only in relation to the management of wastes at its own sites, but also as a basis for the future management of wastes from the commercial nuclear power industry.

AEC stated that considerable progress has been made in the area of waste management but also pointed out that all of its efforts have not proceeded as rapidly as originally hoped because of (1) the extremely difficult technical problems encountered, (2) fundamental differences in technical judgments both within and outside the AEC as to the acceptability of particular approaches, which have required additional development to provide the necessary assurances, and (3) certain interrelationships in some instances with other activities having different objectives.

We were also advised that AEC considers waste management to be a high priority program and agrees that resolution of its waste management problems requires vigorous management attention and a priority commitment of financial resources at a rate consistent with the development of technology. In addition to the comprehensive in-house studies and the arrangements with the National Academy of Sciences (NAS) for advisory services discussed below, the General Manager has initiated a review of AEC's organizational structure for the discharge of its waste management responsibilities. This review will be accomplished promptly and will give specific consideration to our suggestion regarding the desirability of having responsibility for policy making and overseeing the waste management program placed in a single AEC office.

In March 1968, AEC approved a proposal by NAS to establish a committee to provide advisory services to AEC concerning long-range radioactive waste management plans and programs for the expanding nuclear power industry. Concurrently DP is selecting consultants to make detailed evaluations of the waste management programs at both Savannah and Richland.

AEC is also conducting an internal study of the long-range considerations involved in the siting of chemical processing plants and related waste management facilities, particularly those for high activity wastes. Its purpose is also to explore the need and to provide the bases for an AEC regulatory and licensing policy on siting, which would, while fully meeting the requirements imposed by considerations of public health and safety, present a minimum impediment to the growth of economic nuclear power.

Because of our concern as to whether these studies would be closely coordinated, with appropriate central direction, we discussed with AEC the possibility of undertaking an integrated, in-depth review of its waste management problems. One of the factors which concerned us was that in evaluating the management of chemical processing wastes, each group would have to rely on a common base of data as the source of evaluation and would seem to have at least somewhat similar objectives.

AEC agreed that there is commonality in the technology with which each group is concerned; however, AEC pointed out that the specific objectives of each of these activities are different and that it did not believe that they would be effectively accomplished by a single committee approach. The important thing is to resolve the waste management problems, both short-and long-range, effectively and economically on a priority basis, consistent with the development of technology. AEC informed us that particular attention will be given by the General Manager to the conduct of these activities so that they will be conducted with a minimum of duplication of effort and will be coordinated at both the operating and policy levels.

EFFORTS TO PROVIDE LONG-TERM SOLUTIONS TO THE PROBLEM OF STORING HIGH-LEVEL RADIOACTIVE WASTES

JCAE HEARINGS ON RADIOACTIVE WASTE MANAGEMENT

During late January and early February 1959 the Special Subcommittee on Radiation of the JCAE held public hearings on "Industrial Radioactive Waste Disposal." It was the intent of the hearings to emphasize the technical aspects of the waste-disposal problems and to determine whether the present scale of research and development was adequate to meet the coming needs. The hearings covered in detail the nature of wastes, waste-management operations, the various research and development programs, estimates of the future magnitude and economics of waste disposal, and concluded with a discussion of the activities of various Federal, State, and international agencies in the regulation of disposal of wastes.

In its report, the JCAE presented a summary and its conclusions on the status of waste management activities. Among the matters cited by the JCAE were the following observations.

> "The final disposal of high-level wastes associated with the chemical reprocessing of irradiated nuclear fuels represents an aspect of the problem that, while safely contained for the present and immediate future, has not yet been solved in a practical, long-term, engineering sense at the present time. The practice today is to reduce high-level wastes in volume, if possible, and to contain or hold them in tanks. It was the consensus that tank storage is not an ultimate solution in itself but that temporary (2 to 10 years) tank storage will be an integral part of any ultimate system. Although apparently feasible solutions to the problem of ultimate disposal of high-level waste are in various stages of development, at least several years of pilot plant, prototype, and field-scale testing will be required before engineering practicality can be demonstrated.

* * * * *

"Suggestions for final disposal of high-level wastes include--

(a) Conversion to solids by one of several methods;
(b) Storage of solids in selected geological strata with major emphasis on salt beds;
(c) Disposal of liquids into geological strata--either deep wells or salt beds;
(d) Disposal of liquids or solids into the sea.

Although a number of possibilities were described during the hearings, the conversion to solids and storage of these in salt formations seemed to be the most favored at this time. The least favored was disposal of high-level wastes in the sea.

* * * * *

"Although a substantial, coordinated waste-disposal research and development program exists, it is essential that it must be vigorously pursued on an expanded basis in order to (a) achieve better understanding of the behavior of radioactive materials in the environment; (b) anticipate the informational requirements in this field for an expanding nuclear energy industry; and (c) develop safe, practical systems for handling presently unsolved problems within a reasonable period of time. Because of the nature of the overall problem many aspects of the research and development must of necessity be long-range."

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<u>ORGANIZATION AND MANAGEMENT OF RESEARCH AND DEVELOPMENT ACTIVITIES</u>

Research as to the various methods and techniques that may be utilized to accomplish the long-term storage of high-level wastes has been carried out for a number of years within the AEC complex. Efforts in this area have been funded by DRDT and DP. The interests of DRDT have been directed basically towards long-range research and development of waste management concepts that will be applicable to the nuclear industry. DP, which has the responsibility for all high-level wastes generated by AEC production operations, has been more concerned with resolving the pressing short-and long-term waste management problems for the increasing volumes of wastes accumulating from these operations, including process changes to reduce waste generation rates. AEC field offices having chemical processing functions are basically responsible for the day-to-day management activities associated with high-level wastes stored at the various sites.

With regard to wastes generated by AEC production facilities, each of the field offices involved has considered various alternative methods for providing solutions to the long-term storage of its wastes and has reached at least tentative conclusions as to the preferred method to be followed. It is generally recognized among experts in the field of waste management that because there is no single problem with a single solution, management of radioactive wastes can vary widely depending on the specific nature, concentration, and quantity of radioactive materials involved, and on the specific environment in which it must be considered.

AEC provided us with estimates of research and development expenditures incurred and proposed for high-level waste treatment and storage. In general, this information shows that for the fiscal years 1959 through 1968, estimated expenditures incurred by DRDT have been higher than those estimated to have been incurred by DP, about $32 million and $12 million, respectively. The latter amount is exclusive of additional costs which cannot be readily identified. Part of the early effort was directed toward solving DRDT's then existing operational responsibilities for waste management at Idaho. DRDT estimates of expenditures for fiscal years 1969 through 1973 indicate that the Waste Solidification Engineering Prototype program, coupled with storage in salt structures, is being explored as a method to be used to solve the nuclear industry's long-range waste storage needs. AEC advised us that results of DRDT efforts are available to DP and other AEC groups, as well as non-AEC groups.

DP's sponsored identifiable research and development work for high-level waste management reached a peak in fiscal year 1964 ($2.3 million) and has since declined to a level of about $1.3 million in fiscal year 1968. DP's principal investment of effort has been in the areas of calcination at Idaho and waste fractionization and in-tank solidification at Richland. Relatively smaller expenditures have been made by DP to explore the bedrock concept which it now believes to be the solution to the long-term storage problem at the Savannah site. DP's estimates of expenditures for fiscal years 1968 through 1973 showed that its principal efforts will be directed toward demonstrating the feasibility of the bedrock concept.

Thus, at this point in time, it appears that the basic approaches which have been or are to be funded to resolve AEC's storage problems are (1) calcination, (2) waste fractionization, in-tank solidification, and encapsulation, and (3) bedrock. With respect to the use of salt structures for the storage of its radioactive wastes, AEC has no present plans to store its high-level wastes in this manner, even if the program is proven to be feasible, because the proposed approaches appear to be adequate and additional expenses do not seem necessary at this time. Following is a description of the status of the approaches intended to provide solutions to the long-term storage of the high-level wastes generated by AEC's production facilities.

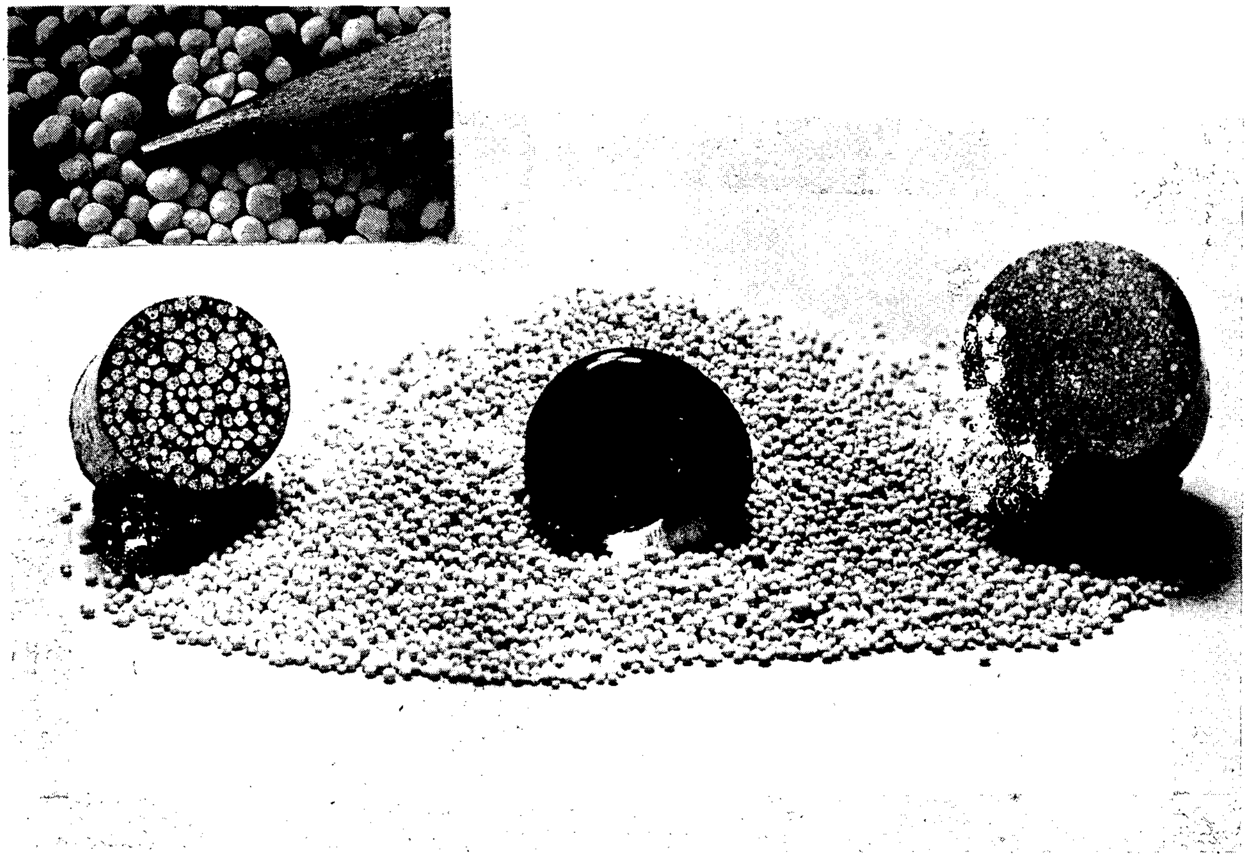
<u>CALCINATION</u>

Calcination involves the solidification of radioactive wastes by the use of techniques involving high-temperature heating and fluidizing with air, following which the solidified granular product is stored underground in steel and concrete vaults. Unless some new technology is developed, AEC considers this approach to be a suitable long-range method of storage for radioactive wastes at Idaho. The first project for calcining wastes was originated in 1956 when the Argonne National Laboratory began research to develop a calcining process. This effort was followed by the design and construction of the waste calcining facility at Idaho, which began in September 1958, and was funded by DRDT. In total, over $6 million was spent in research and development on the facility and about $5.6 million was spent for design and construction. The facility was completed in June 1962.

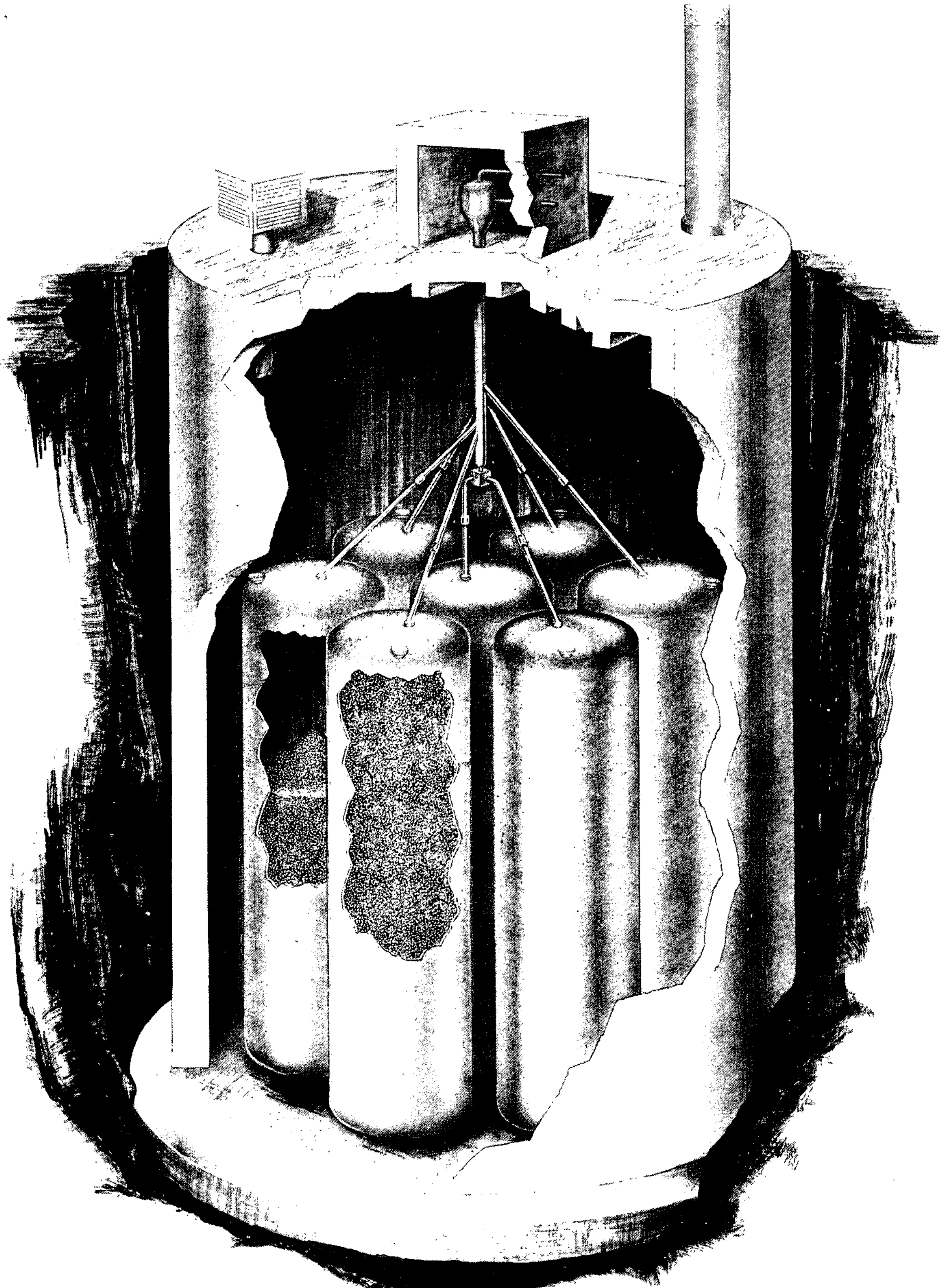
Pictures of the calciner product in granular form and of the underground facility used at Idaho for storage of calcined wastes are shown on succeeding pages.

The facility was designed as a demonstration unit and was not considered economical for use as a general solution to AEC's long-term waste management problems. We were advised that inasmuch as the basic plant investment had already been made, the costs to operate the facility were considered to be an attractive alternative to the method of storing wastes in liquid form in stainless steel tanks, which method was then being used at the Idaho site. Accordingly, DP assumed responsibility for the facility in February 1963 and spent about $500,000 for modifications and equipment which led to its successful operation.

The facility for processing Idaho's radioactive wastes began operation in December 1963, and continued until the initially constructed 7,800 cubic feet of storage space was filled in October 1964. During this period about 510,000 gallons of waste were calcined. Additional vault storage capacity of 30,000 cubic feet was completed in April 1966, and operation of the facility resumed immediately thereafter. By the end of fiscal year 1967, an additional 580,000 gallons of waste had been calcined, reducing its volume to about 6,900 cubic feet of solids. In the aggregate, Idaho had available 37,800 cubic feet of space for storage which was provided at a cost of about $2 million.



A pile of calciner product and three matrix materials that have been tested for containing the product: aluminum, left; glass, center; and sulfur, right. The granular solid product is compared with a pencil point in the inset picture.



Underground facility for permanent storage of calcined wastes in granular form.

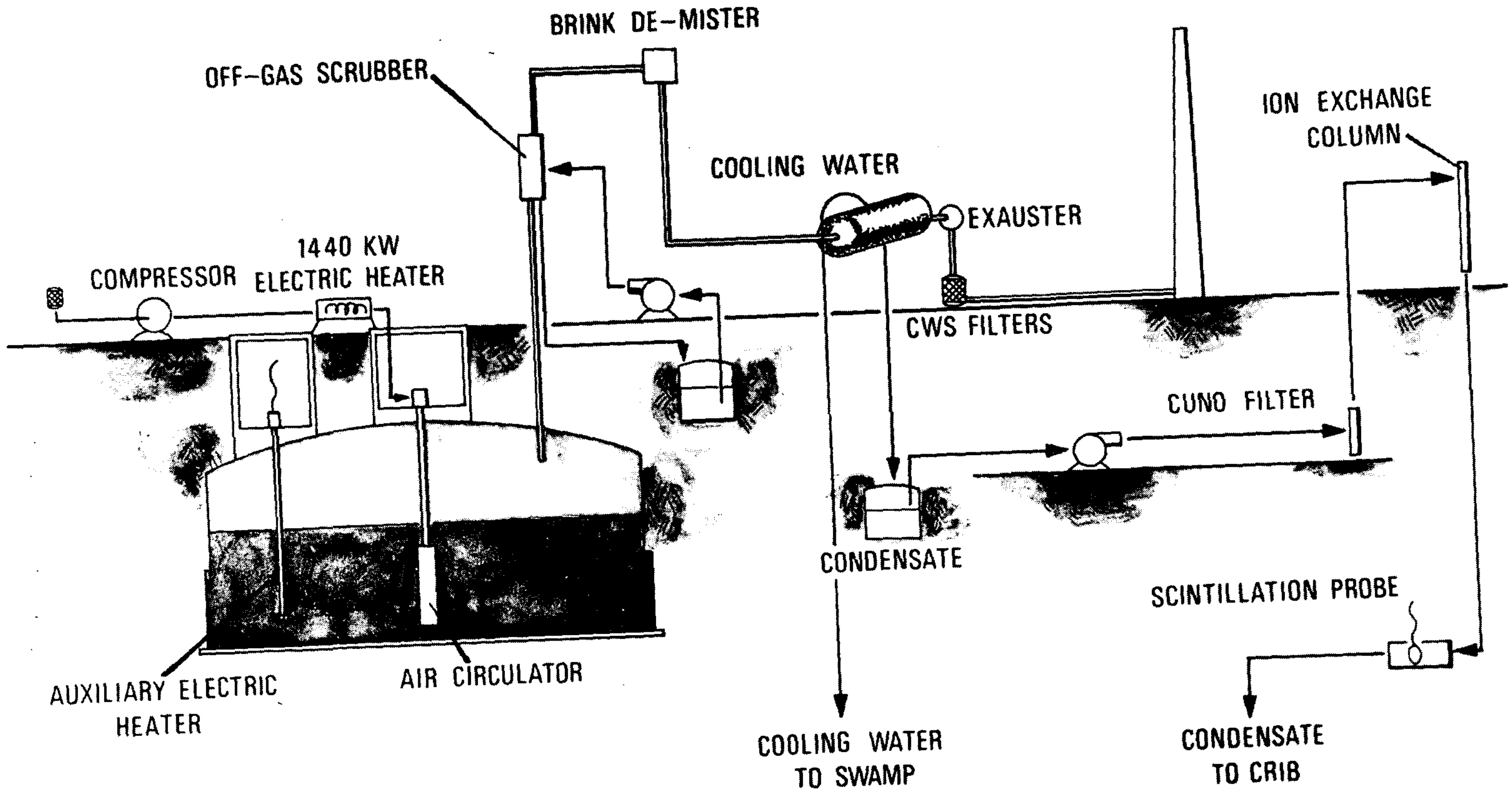


DIAGRAM OF IN-TANK
SOLIDIFICATION PROCESS
AT RICHLAND

Idaho's plans for operation of the facility showed that additional storage space for the solid waste will be needed in the near future. In this regard, AEC has included a request for $2.1 million in the fiscal year 1969 budget to permit the construction of an additional 30,000 cubic feet of calcine storage.

AEC estimates that, assuming a continued successful calcining operation, the accumulated waste stored in the existing tanks could be solidified in three years of calcining facility operation which would require about $9 million in operating funds in addition to the $2.1 million in construction funds to provide additional storage space.

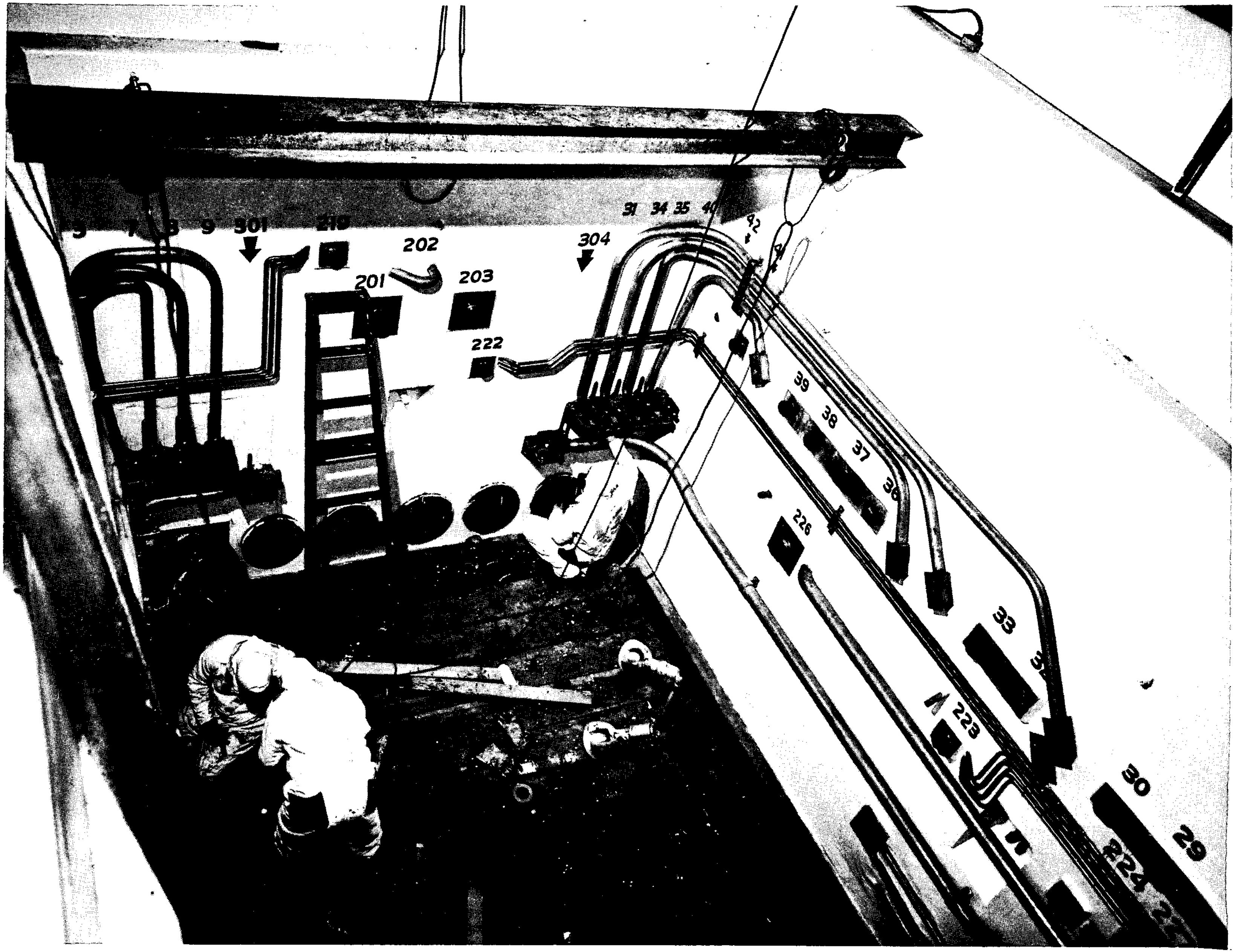
FRACTIONIZATION, IN-TANK SOLIDIFICATION, AND ENCAPSULATION

In 1962, AEC decided to develop fractionization, in-tank solidification, and encapsulation processes as means of storing self-boiling, high-level wastes at Richland. These processes involve the separating or fractionizing of the self-boiling wastes into three parts--one containing short-lived and intermediate-lived radioactive materials, the other two containing long-lived radioisotopes. The shorter lived wastes would then be stored in the same type of self-boiling waste tank currently being used. After the fission products had sufficiently decayed, this waste would be transferred to the non-boiling tanks and solidified as a salt cake in these tanks (in-tank solidification is discussed in succeeding paragraphs). Regarding the waste containing long-lived radioisotopes--essentially strontium and cesium--AEC planned to immobilize and package these radioisotopes in high integrity containers and store them on-site.

A diagram illustrating the in-tank solidification process, as well as pictures and a diagram of the building used for waste fractionization, are shown on succeeding pages.

OUTSIDE VIEW OF BUILDING USED FOR
INSTALLATION OF FRACTIONIZATION EQUIPMENT

INSIDE VIEW OF BUILDING USED FOR
INSTALLATION OF FRACTIONIZATION EQUIPMENT



INSIDE VIEW OF INDIVIDUAL CELL
USED FOR INSTALLATION OF WASTE FRACTIONIZATION EQUIPMENT

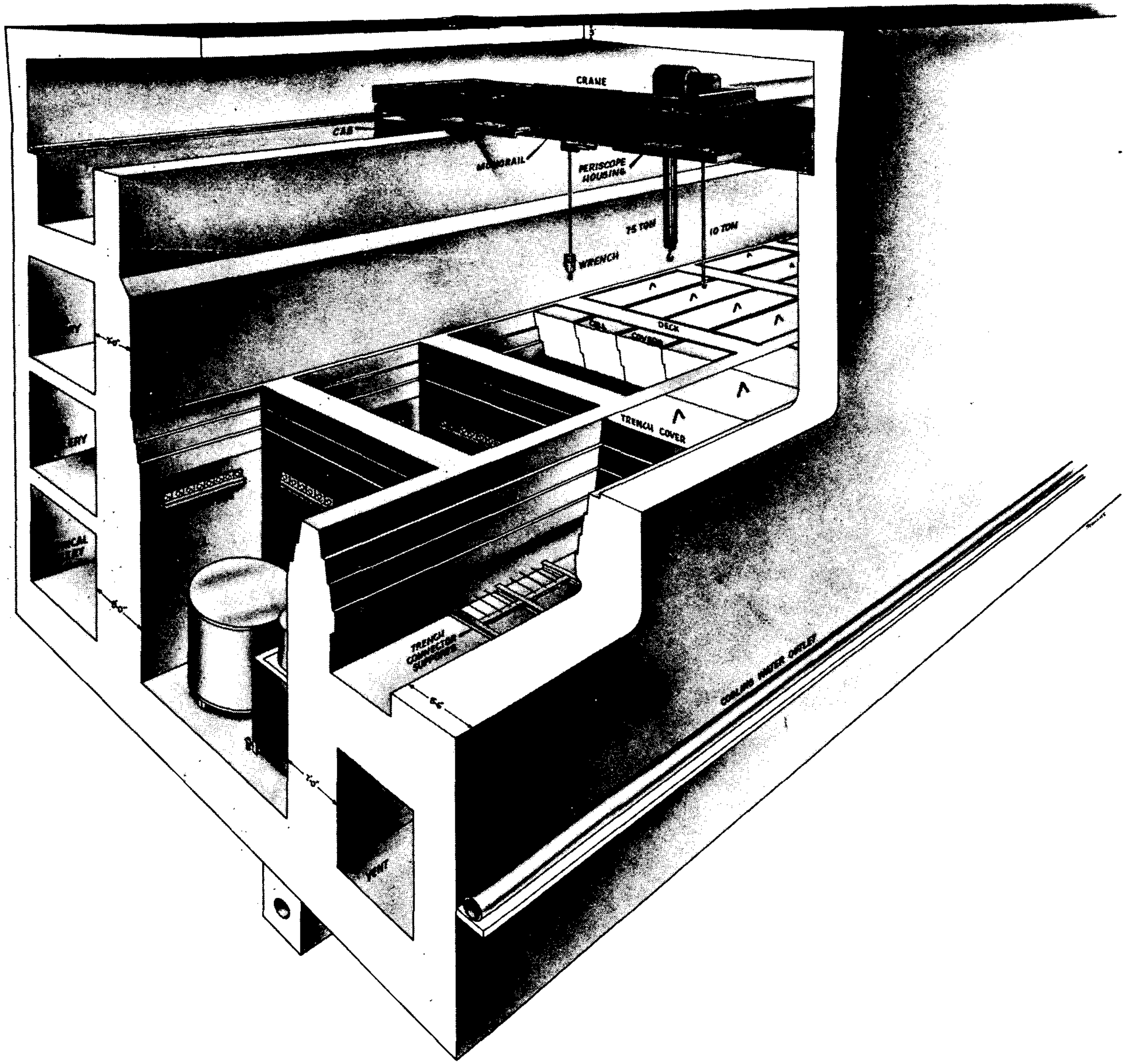


DIAGRAM OF BUILDING USED FOR
INSTALLATION OF FRACTIONIZATION EQUIPMENT

On the basis of a 1962 analysis of alternatives, fractionization, in-tank solidification, and encapsulation of self-boiling waste were recommended by the operating contractor over both continued in-tank storage and a calcination process which had previously been contemplated. As compared to tank storage, the added cost of fractionization and encapsulation was considered to be fully justified by the improved safety of better containment integrity and the benefits of fission product recovery capability. The calcination process was more costly than fractionization and encapsulation and did not offer offsetting advantages to justify the added costs.

Most of the facilities for fractionizing the wastes have been installed at Richland. AEC currently estimates that about $12.5 million has been or will be spent for constructing facilities in connection with the fractionization process. To reduce costs, facilities for the recovery of cesium from newly generated waste were not initially installed, and the underground tank storage of this long-lived isotope must be continued for at least three years before it can be processed in the waste fractionization facility. We were advised that the capability for current recovery of cesium from newly generated wastes is planned for installation during fiscal year 1969 at an estimated cost of $250,000.

We were advised that AEC plans to fractionize the 15 million gallons of self-boiling wastes currently stored in tanks plus all self-boiling wastes to be generated in the future. The remaining 59 million gallons of accumulated non-boiling wastes, as well as future generated non-boiling wastes will be solidified in existing tanks and stored therein indefinitely. In this latter process (in-tank solidification), wastes with a fission product content sufficiently low to produce only minor heating are evaporated within an underground storage tank to the point that solidification occurs on cooling. This approach is predicated on the premise that the tanks and their contents can be suitably prevented from commingling with ground waters for hundreds of years.

In 1965, AEC contracted with a firm, which subsequently became the chemical separations operating contractor at Richland, to construct a Fission Product Conversion and Encapsulation (FPCE) plant as a private undertaking with the intent to market the encapsulated isotopes. Plans for the FPCE plant were dropped early in 1967 when the contract was terminated for mutual benefit, largely because a firm market for encapsulated fission products had not developed. As a result of the termination of the contract, Richland requested the chemical processing operations contractor to reevaluate the waste management program in view of current needs and technologies, and to recommend either continuation or realignment of the program.

In August 1967 the contractor recommended continuation of the fractionization, in-tank solidification, and encapsulation program. Other alternative methods of storage of the waste material were also considered by the contractor but were estimated to be more costly than the fractionization, in-tank solidification, and encapsulation processes. To proceed with this program the contractor, in a planning document dated January 15, 1968, proposed plans for construction of encapsulation and waste container storage facilities to be funded in fiscal year 1970, at a cost of about $6 million. Richland, however, has recommended as part of its 5-year projection to DP that the proposed facilities be deferred until fiscal year 1971 in order to permit better project planning.

AEC advised us that 25 percent of the approximately 59 million gallons of non-boiling wastes currently stored in tanks at Richland are now in solid form. The contractor's planning document indicated that processing of the accumulated and current wastes could be completed by fiscal year 1974. AEC estimated that the operating cost of fractionizing the wastes, packaging cesium and strontium, and solidifying wastes in tanks through fiscal year 1974 would be about $69 million. Additional capital funds required for the same period were estimated at about $26 million.

At the time of our review, we were advised that AEC had not decided on the specific method to be used for solidifying and encapsulating the long-lived isotopes. We were advised that DP believes that there may be some greater flexibility achieved for the long-range program if a different method of solidifying and packaging cesium and strontium can be developed, and that further research and development work is justified to explore this possibility.

STORAGE IN BEDROCK

Savannah has a relatively large inventory of high-level radioactive liquid wastes. It has been estimated that a total storage requirement of approximately 40 million gallons may be needed by 1975. Underlying the plant site, at a depth of approximately 1,000 feet, is dense, crystalline bedrock. A concept for long-term storage has been developed for Savannah to store aged high-level wastes in chambers mined out of the crystalline bedrock.

Diagrams of the proposed bedrock storage vault for radioactive waste and of the geologic and topographic feature of the Savannah site where bedrock storage is proposed are shown on succeeding pages.

An exploratory drilling program was conducted at Savannah during 1961-1963 to determine the hydraulic and physical characteristics of the underlying

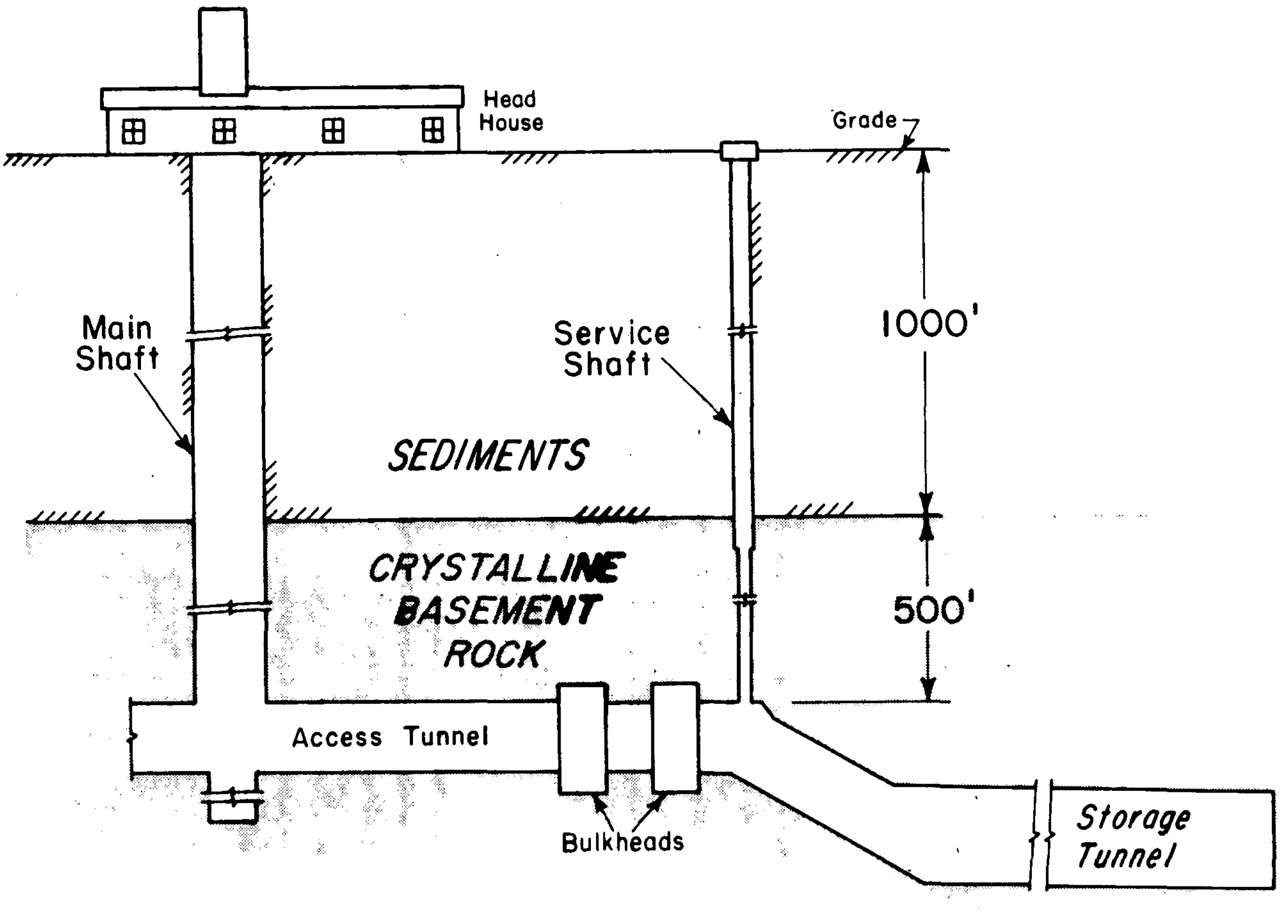
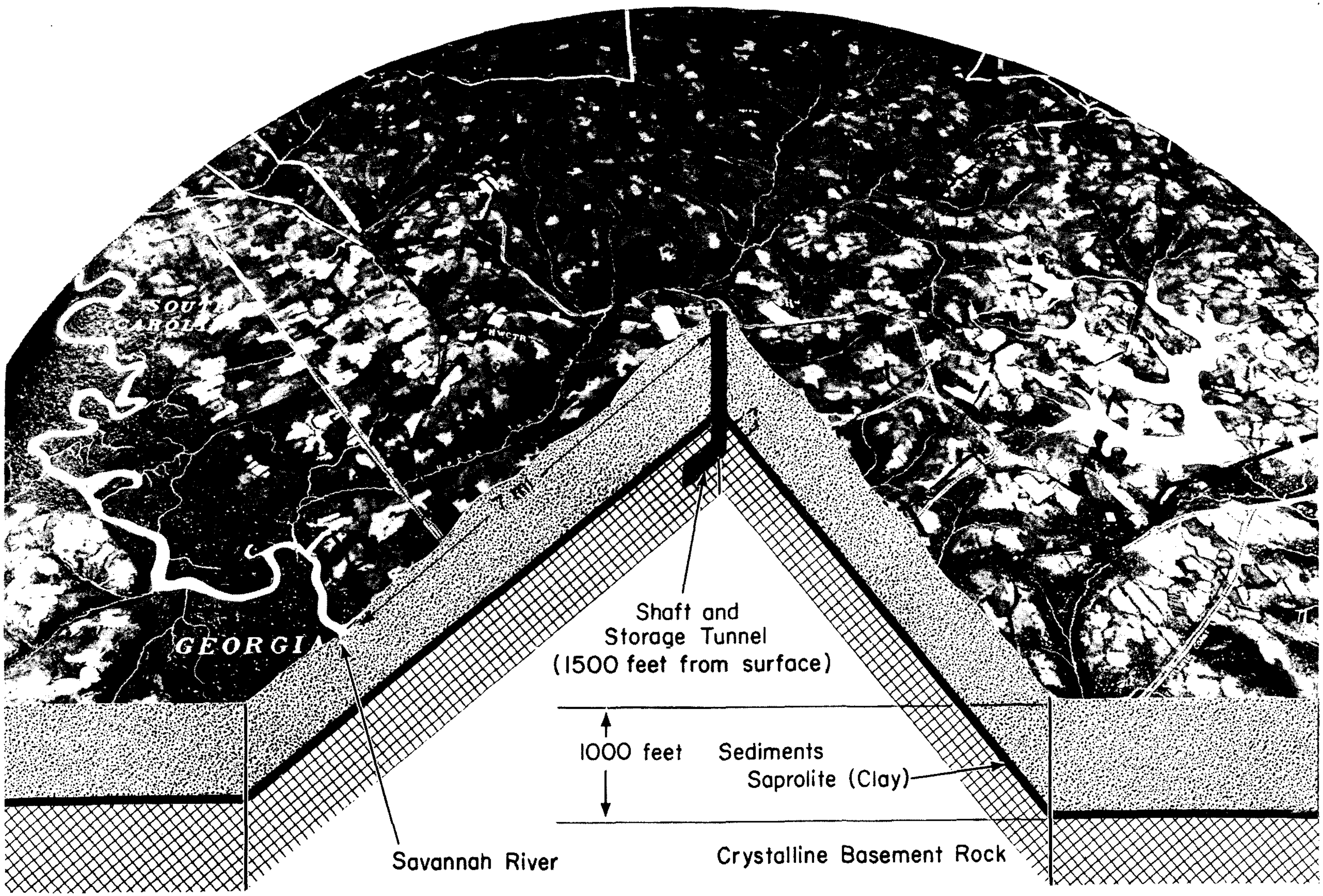


DIAGRAM OF PROPOSED BED ROCK STORAGE VAULT FOR RADIOACTIVE WASTES



GEOLOGIC AND TOPOGRAPHIC FEATURE
OF SAVANNAH RIVER PLANT SITE
WHERE BEDROCK STORAGE IS PROPOSED

strata as well as the compatibility of the rock with the waste to be stored. According to AEC, an extensive field and laboratory testing program served as a basis for a detailed safety analysis of the concept. Three principal mechanisms were evaluated independently to establish their resistance to the migration of waste. These were (1) movement of the wastes from the storage chamber through the adjacent sound rock, (2) movement of the wastes through a layer of saprolite clay overlying the rock, and (3) movement of the wastes through the overlying aquifier.

It was reported that the safety evaluation determined that any one of the three barriers alone would be sufficient to isolate the waste from man's environment and additional factors of safety would be provided by the barriers' being in series.

There are two approaches to bulk storage of the liquid wastes in underground caverns at Savannah: (1) hold the waste in tanks, as at present, until the short-lived fission products have decayed, and then transfer the waste to the caverns or (2) move the waste to the caverns soon after its generation. Principal study has been given to the first approach which would greatly reduce the problems associated with heat from waste being stored underground.

In 1963, Savannah requested that \$12.5 million be budgeted to provide bedrock storage facilities to be completed by June 30, 1967. In 1965, Savannah proposed that \$11 million be budgeted for the same facilities, to be completed by June 30, 1970. We were advised that these requests were not approved by DP due to the need for additional technical data to support the project.

The majority of a committee of the Earth Sciences Division of the National Academy of Sciences, in a report issued in 1966, expressed strong reservations concerning the bedrock concept of waste storage and recommended that investigations toward bedrock storage at Savannah be discontinued. A minority of this committee recommended the continuing collection of hydrologic information to substantiate the safety of the concept. We were advised that AEC believed that the views of the minority were technically sound and that continuation of the program was justified.

In 1967, Savannah proposed that $6 million be budgeted to dig a shaft in the bedrock to obtain additional information on the storage concept. The proposal stated that if, after digging the shaft, the project still appeared feasible, an additional $10 million would be requested for digging the chamber needed to store the waste. The requested funds were not approved by AEC Headquarters.

Through fiscal year 1967, AEC had spent about $1.5 million in studying the bedrock storage concept. We were advised that AEC currently plans to request $1.3 million to design the bedrock project in fiscal year 1970. We were also advised that if the project still appears feasible, AEC plans to request construction funds of approximately $4.7 million and $10 million in the fiscal year 1971 and 1972 budgets, respectively. In the meantime, as discussed in a succeeding section of this report, Savannah is continuing with tank construction until the bedrock project is operational.

According to DP, bedrock storage constitutes for the Savannah site a potentially safe, practical, and economical arrangement from the standpoint of providing a solution to its long-range waste storage problem. In this regard, Savannah's efforts are almost entirely geared to advancing the development of this concept. Savannah believes that if, for reasons not presently apparent, bedrock storage does not prove acceptable, methods for calcination, incorporation into phosphate glass, transportation to a more acceptable location, or similar techniques under development at other AEC sites could be applied at Savannah. Each of these alternatives is extremely expensive compared to the bedrock concept, and, on the basis of preliminary studies, DP believes these alternatives could involve expenditures on the order of \$100-\$500 million.

COMMENTS CONCERNING INTERIM STORAGE OF HIGH-LEVEL RADIOACTIVE WASTE MATERIAL IN UNDERGROUND TANKS

The following tabulation shows the quantities of radioactive waste material stored in underground tanks at the three AEC sites at December 31, 1967. Descriptive data concerning individual tank farms is presented in Appendix II.

Site	Year plant operation started	No. of storage tanks	Amount of wastes accumulated in tanks (gallons)
Richland	1944	149	74,000,000
Savannah	1955	24	17,000,000
Idaho	1953	15	1,600,000
	TOTAL		92,600,000

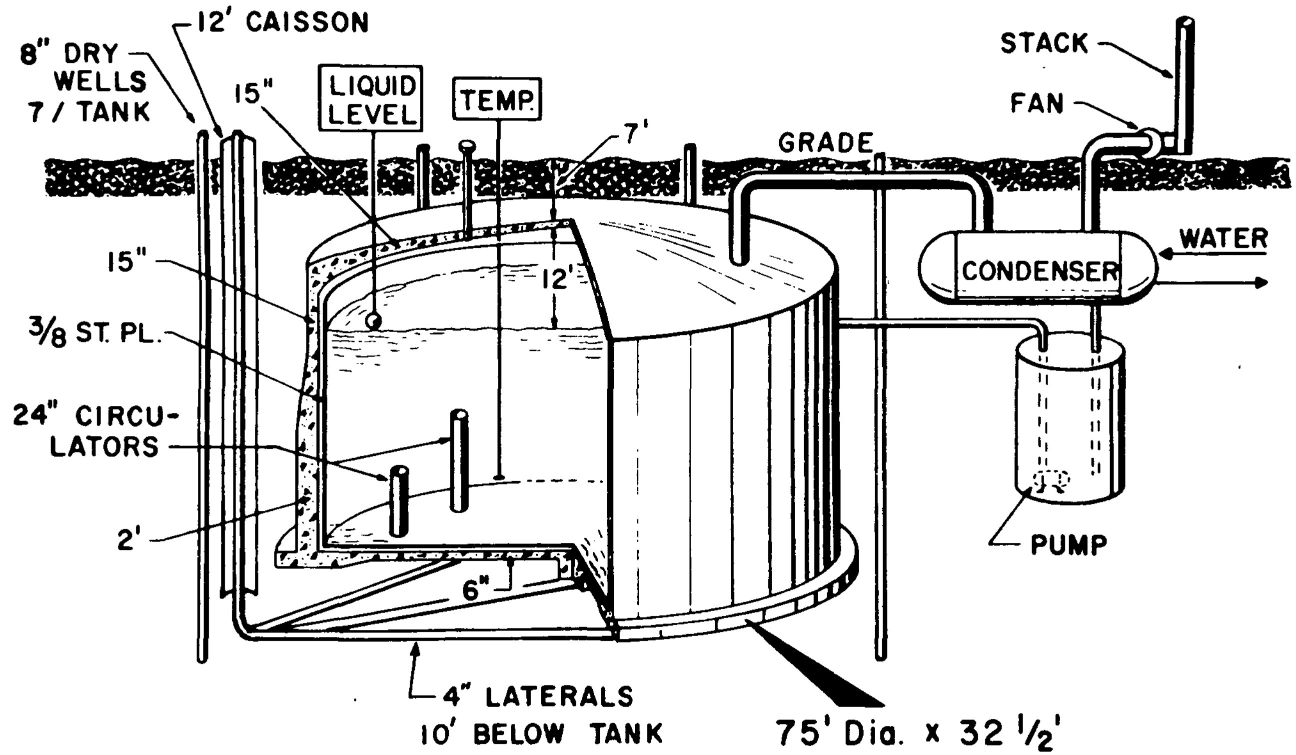
RICHLAND OPERATIONS OFFICE

Since the startup of plant operations in 1944, chemical processing wastes from the separation plants have been stored as alkaline slurries in underground tanks. The wastes contain varying amounts of fission products depending upon the age and particular process in use at the time of generation.

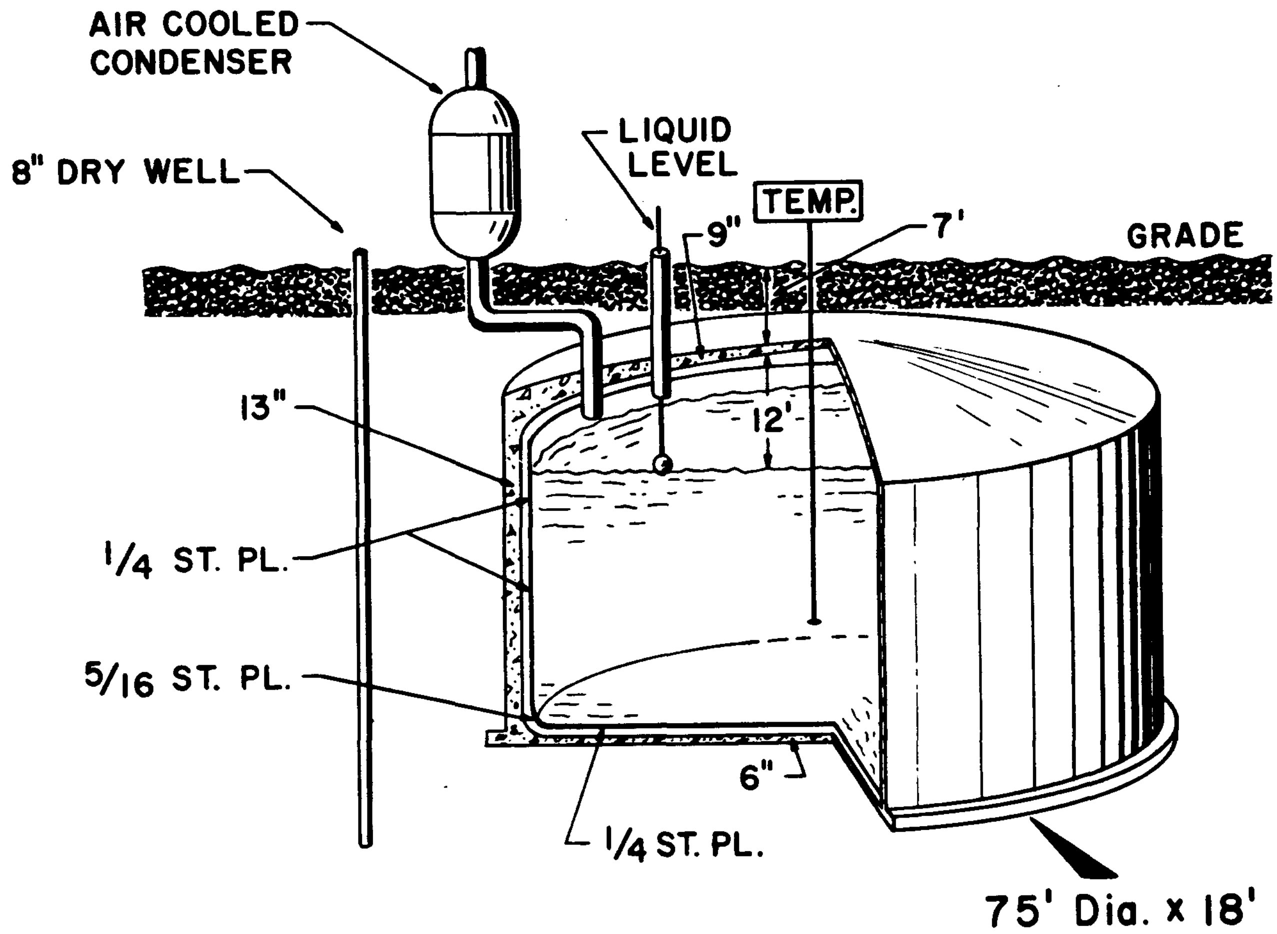
The complex of waste storage tanks includes 149 underground tanks, having capacities ranging from 54,500 to 1 million gallons. Except for four tanks built in the 1963-1964 time period, the tanks were constructed before 1956, and over 100 of them were built before 1950. AEC's investment in these tanks is about $41 million and they were built at an average cost of about 44 cents per gallon of installed capacity.

An evaluation is being made by AEC of the expected useful lives of the tanks because of estimates by the operating contractor that the expected life of self-boiling waste tanks is probably no more than 20 years or could be as little as 10 to 15 years. Of the 20 tanks equipped to handle self-boiling wastes at Richland, 11 have been in service 10 years or more.

In the aggregate, the 149 tanks provided an installed capacity of about 94 million gallons. At December 31, 1967, AEC records show that net useful storage capacity of these tanks, after allowing for leaking tanks and other



STORAGE TANK FOR SELF-BOILING WASTES AT RICHLAND



STORAGE TANK FOR NON-BOILING
WASTES AT RICHLAND

conditions which reduce storage capacity, was about 82 million gallons. AEC records show that at the same date, about 74 million gallons were being stored, all of which is considered to be high-level waste.

Two basic tank designs have been used in construction the storage tanks at Richland. The design of the tanks intended to store self-boiling and non-boiling wastes, respectively, are shown on succeeding pages.

The tanks consist of a carbon steel liner encased in thick reinforced concrete, up to 2 feet thick in places. The top of each tank may be as much as 10 feet beneath the ground level. The tanks are equipped with external condensers for removal of radioactive-decay heat and with monitoring facilities for leak detection.

Initially, the concentration of heat producing fission products per gallon of waste was not so great as to cause the wastes to self-boil; therefore, it was not considered necessary to design the tanks to hold boiling wastes. Later processing methods allowed for greater concentration of the heat producing fission products per gallon of waste to the extent that the waste would self-boil. Therefore, 20 tanks were equipped in a manner to permit storage of self-boiling wastes by adding provisions for liquid circulation, vapor condensation and return, and additional leak detection.

<u>Leakage of high-level wastes from tanks</u>

Of the 149 underground storage tanks at Richland, leaks have been detected in 10 tanks, with an estimated leakage of 227,400 gallons of high-level waste to the ground. Six of these tanks have been retired from service because of tank leakage resulting from stress corrosion or mechanical stress. With respect to the remaining four tanks, AEC has concluded that the leaks self-sealed and the tanks are now in use. Information obtained from AEC records relating to the tanks where leaks have been detected follows:

Richland storage tanks in which leaks have been detected

Tank number	Year constructed	Leak detected	Type of tank	Estimated leakage (gallons)	Tank retired
113-SX	1954	Aug. 1958	self-boiling	35,000	yes
106-TY	1952	Aug. 1959	non-boiling	20,000	yes
101-U	1944	Nov. 1959	non-boiling	30,000	yes
104-U	1944	Aug. 1960	non-boiling	55,000	yes
105-TY	1952	Sept.1960	non-boiling	35,000	yes
105-A	1955	Nov. 1963	self-boiling	very small	no
115-SX	1954	Dec. 1963	self-boiling	50,000	yes
107-SX	1954	Mar. 1964	self-boiling	very small	no
108-SX	1954	Aug. 1964	self-boiling	2,400	no
109-SX	1954	Jan. 1965	self-boiling	very small	no

AEC records showed that, in each case, measurements indicated that the leakage had been held in the soil at elevations no lower than 10 feet below the tank bottom. AEC records show that the tanks are situated about 200 feet above the water table.

Reserve storage space

Richland officials advised us that it was Richland's general practice to have the equivalent of at least one spare self-boiling waste storage tank available for each self-boiling tank area in case of tank failures. In addition, we were advised that Richland's general practice is to have the equivalent of at least two spare non-boiling waste tanks as spare capacity. We were further advised, however, that there is no formal AEC safety standard relating to reserve storage capacity requirements for high-level wastes.

In April 1959 the prime operating contractor requested that funds be made available to construct four new self-boiling, high-level waste storage tanks to be completed by August 1963 at which time filling of the last available self-boiling tank was scheduled to commence. This request was not included in Richland's fiscal year 1961 budget submission because, according to Richland officials, other funds were available to construct the tanks if needed. We were advised that the tanks were subsequently determined to be unnecessary because a tank fill criteria change allowed increased utilization of existing storage capacity. This change in criteria, according to Richland, was a "routine technical evaluation of the permissible capacity" of these tanks, and continued a historical pattern of stepwise increases in tank loading based on "cautious extrapolation of previous experience."

In March 1961 the contractor again requested that funds be made available to construct new self-boiling, high-level waste storage tanks to be available by April 1964, which then represented the revised forecast date for commencing filling of the last available self-boiling tank. A request for four tanks was included in the fiscal year 1963 budget submission and was authorized by Public Law 87-701, approved September 26, 1962.

In January 1963, before construction had started on the newly authorized tanks, the prime operating contractor began filling the last available self-boiling, high-level waste storage tank. Richland officials advised us that the earlier filling of the last available tank became necessary because attempts in 1961 to apply the increased tank fill criteria to tanks containing self-boiling aged waste caused unanticipated temperature control problems in the tanks. Construction of the new tanks was delayed until July 1963 because of a disagreement between AEC's operating contractor and Richland over the desirable tank design. Construction was completed in January 1965 and the new tanks began receiving waste in February 1965.

Between January 1963 and January 1965, an empty reserve self-boiling, high-level waste storage tank was not available at Richland. During this period, events occurred which created certain operational risks that, in our opinion, would have been minimized had reserve capacity been available to meet the emergency situation.

In November 1963, low-level radiation was detected outside of the tank which began receiving waste in January 1963. In a report on a later review of the problems encountered with this tank, it was stated that when the leak was detected, emptying the tank was not considered because spare tankage for self-boiling wastes was not available. AEC advised us as follows with respect to the problems encountered with this tank:

> "Normally tanks are partially filled with water before receiving wastes and liquid level is held relatively constant by boiling off water at a rate that compensates for the volume of wastes added. A few months before the external activity was detected, the liquid level had been raised incrementally to a level above a horizontal seam in the upper wall of the tank liner. Since it was possible that a stress corrosion crack had developed in that seam, the liquid level was lowered below the seam, by self-boiling. The intensity of the low-level radiation outside the tank declined gradually, and it was concluded that the problem of the leak was solved. Accordingly, the addition of wastes was continued, when the salt concentration reached a predetermined level, and the liquid level was allowed to rise. The radioactivity below the tank was monitored continually and continued to decline. In October 1964, the liquid level rose above the suspect seam with no evidence of leaking, thus confirming earlier observation that concentrated salt solution will plug small leaks. In December 1964, waste additions were terminated. The contents in this tank, which had been in use about 2 years, exceeded the capacity estimate for new tanks for the same size by about ten percent, and exceeded the amount added to any previously filled self-boiling tank by about 22 percent. This increased loading was needed to maintain continuity of production and was permitted only after careful and continued evaluation of the behavior of the self-boiling wastes and the radioactivity outside the tank."

In January 1965, a sudden steam release occurred in the tank, which release was believed to be more intense than any previous similar incident, causing the ground in the vicinity of the tank to tremble and minor damage to the tank instrumentation. Another very small leak was noted in March 1965. According to AEC, this leak was also carefully observed and apparently self-sealed in about two weeks.

From the time the tank was filled in December 1964, until the present, it appears that there has been an increased risk of contaminating the environment with highly radioactive material. According to AEC, while facilities have been available for emptying the tank, the risks involved in transferring the self-boiling materials to other tanks were believed to be much greater than those incurred by allowing the radioactivity to decay in place. Richland officials advised us that, because the heat of radioactive decay had declined substantially, they are now in the process of moving the radioactive materials to another tank.

It appears that in the last half of 1969, Richland may be confronted with the situation of having only used tanks available as spare tanks for high-level, self-boiling waste storage. AEC's December 1, 1967, forecast shows that the last new self-boiling high-level waste storage tank will start receiving waste during the last half of 1969. While Richland plans to have some currently filled tanks emptied by that time, recent studies have cast doubt on the reusability of these tanks.

The increased incidence of tank failures was given considerable attention in the chemical processing operation contractor's 1967 reevaluation report on the waste management program. In the summary and conclusion section of the report it was stated that major incentives now exist to take prompt steps to immobilize the radioisotopes currently stored in underground tanks. This section of the report also stated that 10 of Richland's 149 tanks have leaked and that structural stress and corrosion are almost certain to be present in 14 of the tanks now containing self-boiling wastes.

Related excerpts from the report include:

" * * * Current analyses by the Illinois Institute of Technology[1] have revealed that the * * *[self-boiling tank structures] are being stressed well beyond accepted design limits.

*   *   *   *   *

" * * * While the tank structure is not stressed to the point that collapse is imminent, the concrete is certainly cracked and is not likely to be capable of containing liquid. While corrosion of the reinforcing steel at the cracks is not considered likely, the possibility cannot be ruled out. <u>The wisdom of re-using these tanks after emptying them is debatable."</u> (Underscoring supplied.)

Richland officials advised us that existing self-boiling tanks could be used in an emergency, although with an increase in risk but that special precautions would be taken prior to reuse. Richland officials advised us further that new tanks for receiving high-level waste cannot be made available before the latter part of fiscal year 1970.

<u>Plans for new storage tanks</u>

Because of the decreased availability of storage space by failure of existing tanks and indications of possible additional failures, Richland submitted a request for the funding of four tanks in the fiscal year 1968 budget.

In justifying this request, Richland stated:

"While plans to continue operation without new tanks are being pursued vigorously, there is no assurance that the need for new waste storage tanks can be forestalled. The failure during the next several years of one self-boiling * * * waste tank or delay in starting of the waste fractionization facility * * * could require immediate start of construction of additional tanks. Consequently the provision of funds for replacement tanks is necessary to meet the exigency which may occur."

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1 Illinois Institute of Technology was hired by Richland on a consulting basis to determine the condition of Richland's storage tanks.

The proposal was included in AEC's budget and funds totaling $2.5 million were authorized as Project 68-1-b by Public Law 90-56, dated July 26, 1967, for the construction of 4 million gallons of underground storage capacity for high-level self-boiling wastes. The proposed tanks were to be similar in design to those previously constructed at Richland.

In October 1967, after reviewing the status of the proposed construction project, Richland advised AEC Headquarters that the tanks could not be constructed as originally proposed and provide adequate safety to the public. The problems involved were subsequently summarized in a DP document as follows:

> "Recent structural analyses of the Hanford tanks for the highly radioactive self-boiling waste have raised doubts concerning their present integrity and indicated considerable risk involving their planned reuse. This, and the continuing generation of high-level waste at Hanford, make it imperative that new tanks be constructed as soon as possible. Project 68-1-b was authorized for this purpose.
>
> "The structural analyses also pointed out that tanks similar to the current tanks, as originally contemplated for Project 68-1-b, should not be built. The design changes necessary for acceptable tanks make it impossible to comply with the authorized scope of the project within the allowable funds, viz., provide 4 million gallons of waste storage for $3.125 million."

Richland proposed a new tank design similar to that used at Savannah. The cost for four such tanks was estimated at $5 million and for two tanks, $3.125 million. Because of the change in scope of the proposed project, DP recommended that AEC Headquarters inform the JCAE of the situation and request approval for the change.

In suggesting this action, DP stated:

> "Hanford's self-boiling waste tanks' failure rate has not been encouraging. Since 1958, six have indicated leaks, five of these since 1963. Two of these six leakers remain in use since they appear to be dormant and, outside of the two spare available tanks needed for currently generated waste, there are no other tanks to transfer their contents. Although one of the currently filled tanks should be emptied during CY 1968 and another one in CY 1969, as pointed out, the possibility of reusing them is uncertain.

"In order to assure safe confinement of the highly radioactive wastes and continuity of the Hanford operations, RL strongly recommends that four tanks of approximately one-million gallons capacity each be built as soon as possible. The construction of fewer tanks could seriously jeopardize Hanford's capability to cope with the old (current) tanks which could fail actively during the next several years. Furthermore, if reuse of any of the current tanks involves questionable risks, more tanks may be required. The status of the current tanks is to be under continuous evaluation as they are emptied, and waste management procedures will be reviewed from time to time to minimize the need for additional new tanks.

"The impact of the foregoing developments since authorization of the FY 1968 project for waste tanks at Hanford did not become apparent until recently. It obviously would be contrary to the best interests of the AEC and the Government to continue with the project as authorized. * * *"

On February 13, 1968, AEC provided the Chairman, JCAE, with certain information concerning the existing tank situation and proposed that AEC proceed with the construction of at least two tanks of improved design which would provide the number of gallons (1.5 to 2 million) of storage capacity that can be obtained with the authorized project limitation. AEC records show that the JCAE has approved this proposal.

AEC also advised the JCAE that Richland was initiating tests and inspections, to the extent feasible, to judge the actual structural status of its existing self-boiling waste tanks. AEC stated that Richland planned to evaluate the long-range waste storage requirements in light of the information so obtained and its production planning, and that the JCAE would be advised of the situation as soon as the evaluation was completed.

SAVANNAH RIVER OPERATIONS OFFICE

Since the startup of plant operations in 1955, chemical processing wastes from the separation plants have been stored as alkaline slurries in underground tanks. These wastes contain varying amounts of fission products depending upon the age and particular process in use at the time of generation.

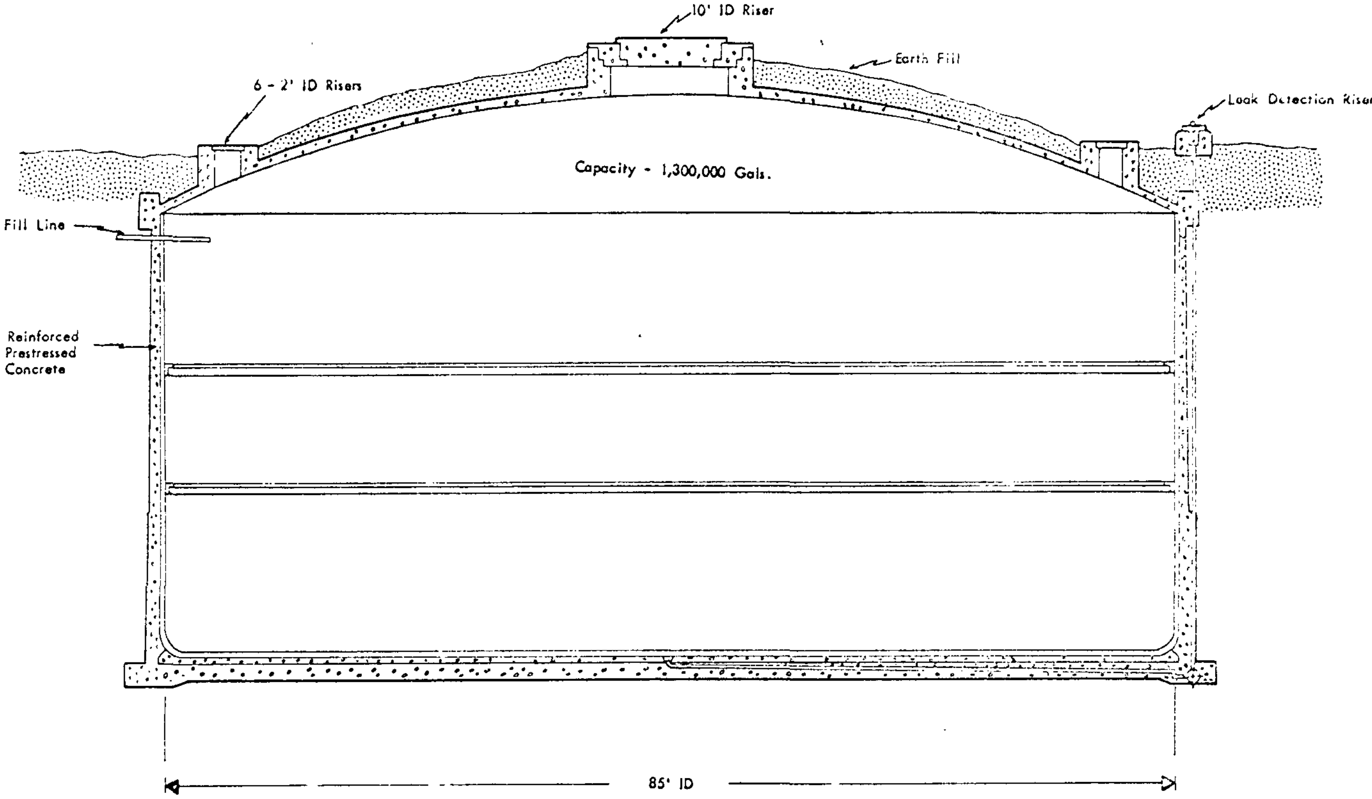
The complex of waste storage tanks includes 24 underground tanks having capacities ranging from 750,000 to 1.3 million gallons. Sixteen tanks were constructed in the 1954-1955 time period; the remaining tanks were built in increments of four tanks each during 1959 and 1963. AEC's investment in these tanks is about $23.7 million, and they were built at an average cost of about 99 cents per gallon of installed capacity.

In the aggregate, the 24 tanks provide an installed capacity of about 24 million gallons. At December 31, 1967, AEC records show that net useful storage capacity of these tanks, after allowing for leaking tanks and other conditions which reduce storage capacity, was about 23 million gallons and that about 17 million gallons were being stored.

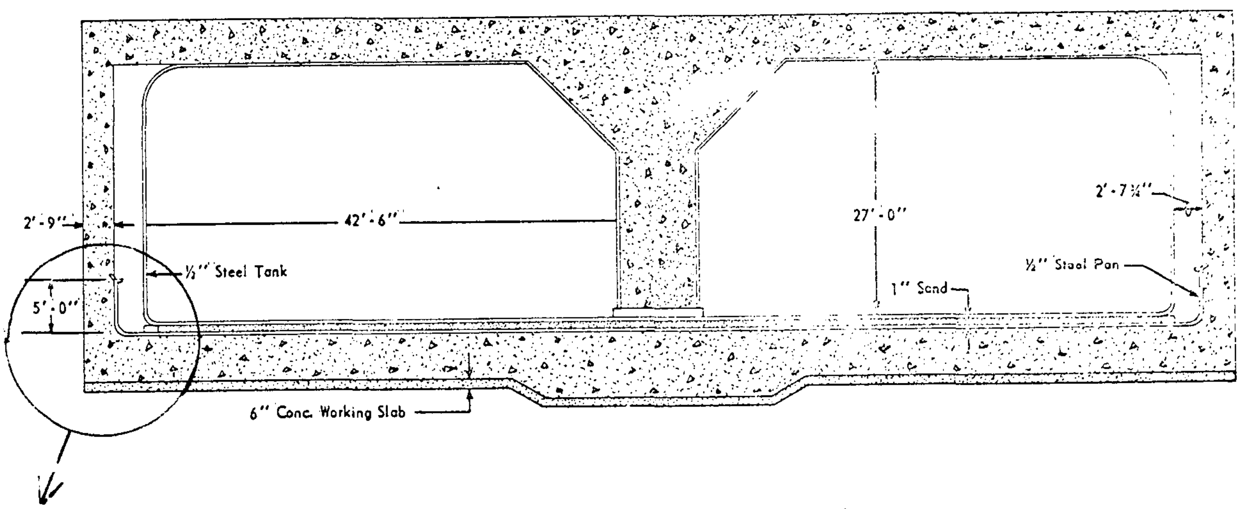
The waste tanks at Savannah are located in two tank farms, each containing 12 tanks. Savannah has 16 tanks equipped with cooling coils'; and 8 tanks without cooling coils, which are used to store aged waste.

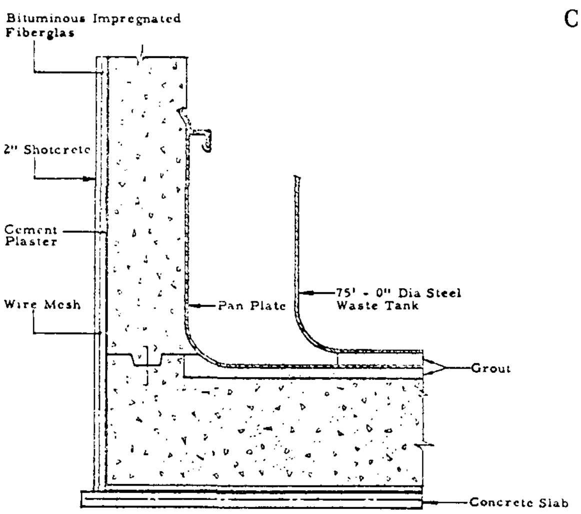
The tanks consist of a carbon steel liner encased in a thick reinforced concrete vault. The tanks are equipped with external condensers for removal of radioactive-decay heat and with monitoring facilities for leak detection. Sketches and pictures of the cooled and uncooled tanks are presented on succeeding pages.

For the 16 cooled tanks, the bottom portion of the vaults are lined with carbon steel to provide a saucer beneath the primary tank. There is a space between the tank and vault wall which, together with the steel



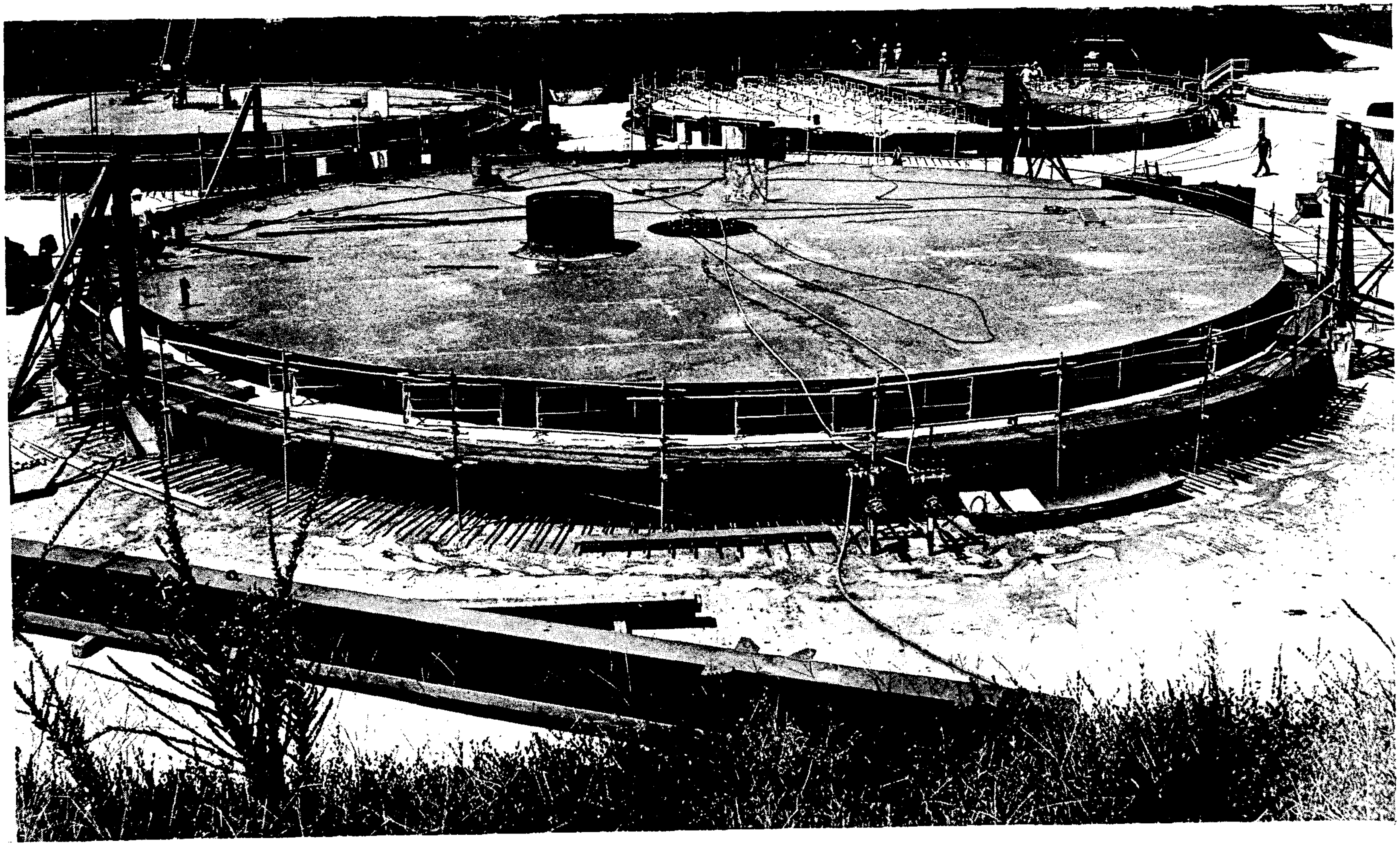
AN UNCOOLED WASTE STORAGE TANK AT SAVANNAH





DETAIL

CROSS SECTION OF A COOLED WASTE
STORAGE TANK AT SAVANNAH



SAVANNAH RIVER STORAGE TANKS UNDER CONSTRUCTION–
BOTTOM PORTION OF TANK SHOWN

saucer, provides a means of leak detection and permits the retention and recovery of liquid that may escape the tank. The useful life of the carbon steel tanks is estimated by AEC at 20 to 40 years; the first tanks constructed at the site are now 14 years old.

Savannah has an interfarm transfer line under construction which upon completion will permit movement of waste between the two farms, a distance of about 2.5 miles. At the time of our review, the estimated completion date for this system was May 1968. We were advised by Savannah officials that the transfer line will provide more flexibility in operations and make more storage space available in the event of an emergency at one farm.

Leakage of high-level wastes from tanks

Between October 1957 and November 1960, Savannah experienced problems involving slow leaks in 4 of the 16 high-level cooled waste storage tanks that were initially constructed. AEC records showed that for three of the tanks, wastes that escaped from the primary tank were contained in the secondary container, or annular space, that was designed into the tank configuration initially.

The operating contractor's investigation of these incidents showed that radioactive material escaped from the secondary container of the fourth leaking tank into the adjacent soil. According to AEC, the tank leakage, in this instance, exceeded the capacity of the secondary containment for a brief period until pumping equipment could be installed to return leakage to the tank. AEC stated that its measurements indicated that not more than 700 gallons escaped the secondary containment, but extensive soil corings and pumping of the ground water showed contamination levels equivalent to only a few gallons of waste. AEC believes that the difference, if any, was retained in the concrete structure or in the soil immediately beneath the tanks.

Tests were conducted to determine the reasons why the four tanks developed leaks. While the results of these tests apparently were not conclusive, indications were that stress-corrosion of the carbon steel tank body contributed significantly to these failures. AEC records show that during the past few years three of the leaking tanks have been refilled to normal levels, the leaks apparently having self-sealed. A Savannah contractor official stated that Savannah plans to continue normal use of these tanks, but with increased surveillance of the tanks' exterior walls. At the time of our review, only restricted usage could be made of the fourth tank.

With respect to the uncooled high-level waste tanks at Savannah, our review of AEC records disclosed no evidence that leakage occurred. It is important that leakage not occur from these tanks because the design of the tanks conforms to the design of the Richland tanks, in that they do not have secondary containment in the form of an annular saucer. The Richland tanks have leaked without any apparent detriment to the environment because of the nature of the soil and the water table situation at that site. The situation at Savannah, however, would be more serious in the event of leakage because the tanks are set in the water table and leakage could be expected to eventually migrate into the ground water. This matter is of concern because, according to AEC, there is not enough experience with the service life of existing storage tanks to reach experienced conclusions.

Reserve storage space

Savannah officials could not provide us with written criteria relative to reserve storage requirements for high-level radioactive waste. An operating contractor official advised us that the general practice was adopted of maintaining in the chemical processing areas equivalent reserve capacity equal to at least the largest cooled storage tank in each area. We are not in a position to determine whether this practice provides the desirable degree of safety. At the time of our review, Savannah reports showed that all completed tanks were being used and available reserve storage capacity in total was consistent with its stated general practice.

Plans for new storage tanks

Savannah has four cooled tanks under construction which will provide an additional storage capacity of 5.2 million gallons. These tanks and related facilities, estimated to cost $7.7 million, are planned for completion in April 1969. AEC has included in its fiscal year 1969 budget a proposal to construct four additional uncooled tanks, estimated to cost $3.5 million, which are planned for completion in fiscal year 1971. Also, the operating contractor's records show that four additional cooled tanks, estimated to cost $7 million, will be needed in the early 1970's.

IDAHO OPERATIONS OFFICE

Since the chemical processing plant began operation in 1953, chemical processing wastes at Idaho have been stored in an effluent acidic form in underground tanks. These wastes contain varying amounts of fission products depending upon the age, type of fuel element, and particular process in use at the time the waste was generated.

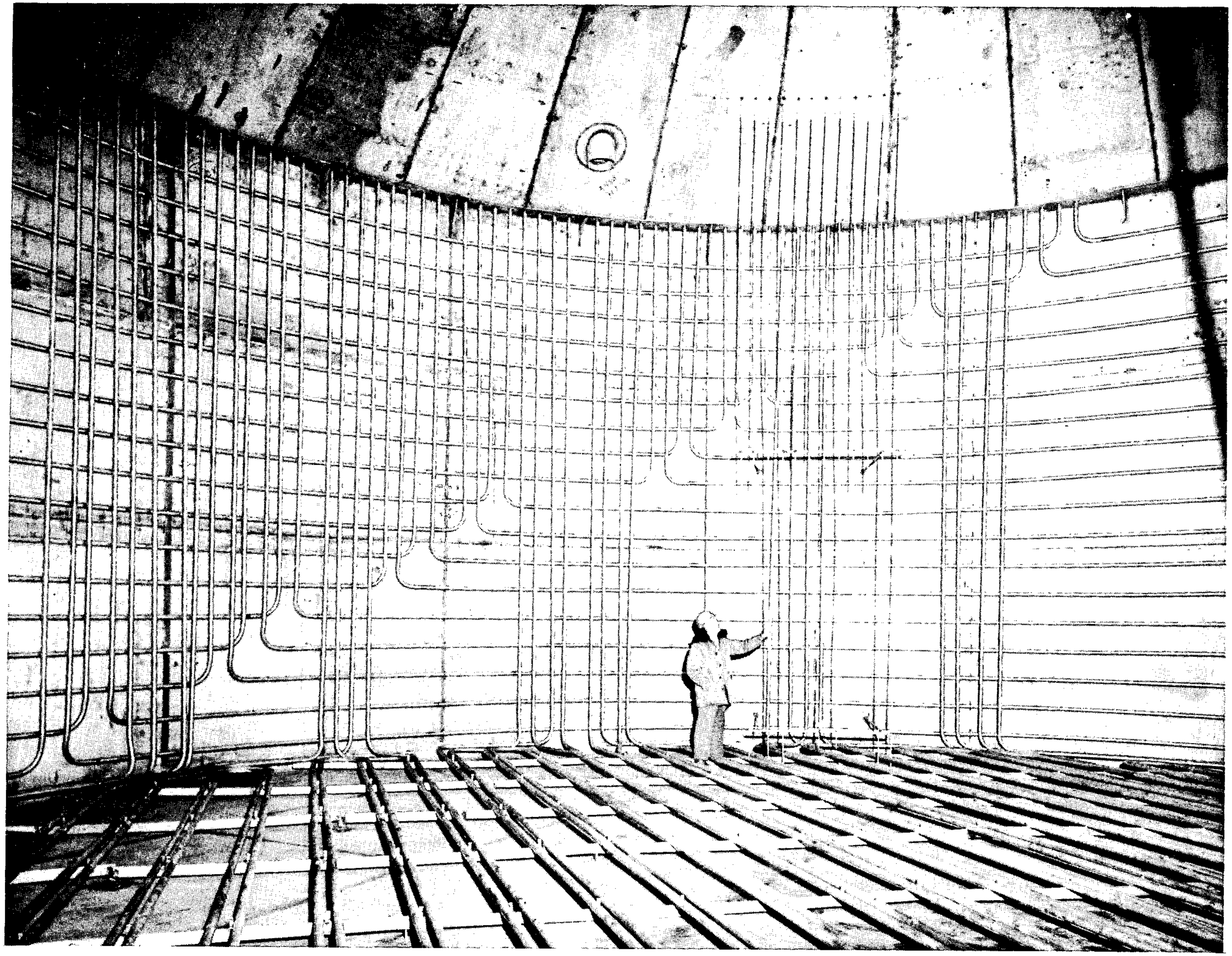
There are 15 underground waste storage tanks at Idaho having capacities ranging from 30,000 to 318,000 gallons. The first two tanks were completed in 1952 and the last two were completed in 1965. AEC's investment in these tanks is about $11.4 million and they were built at an average cost of about $3.31 per gallon of installed capacity.

In the aggregate, the 15 tanks provide an installed capacity of about 3.5 million gallons. We were advised that Idaho reserves 12 percent of tank space for liquid expansion, thereby reducing the available storage capacity to about 3 million gallons. AEC records show that at the time of our review, about 1.6 million gallons were being stored in the tanks.

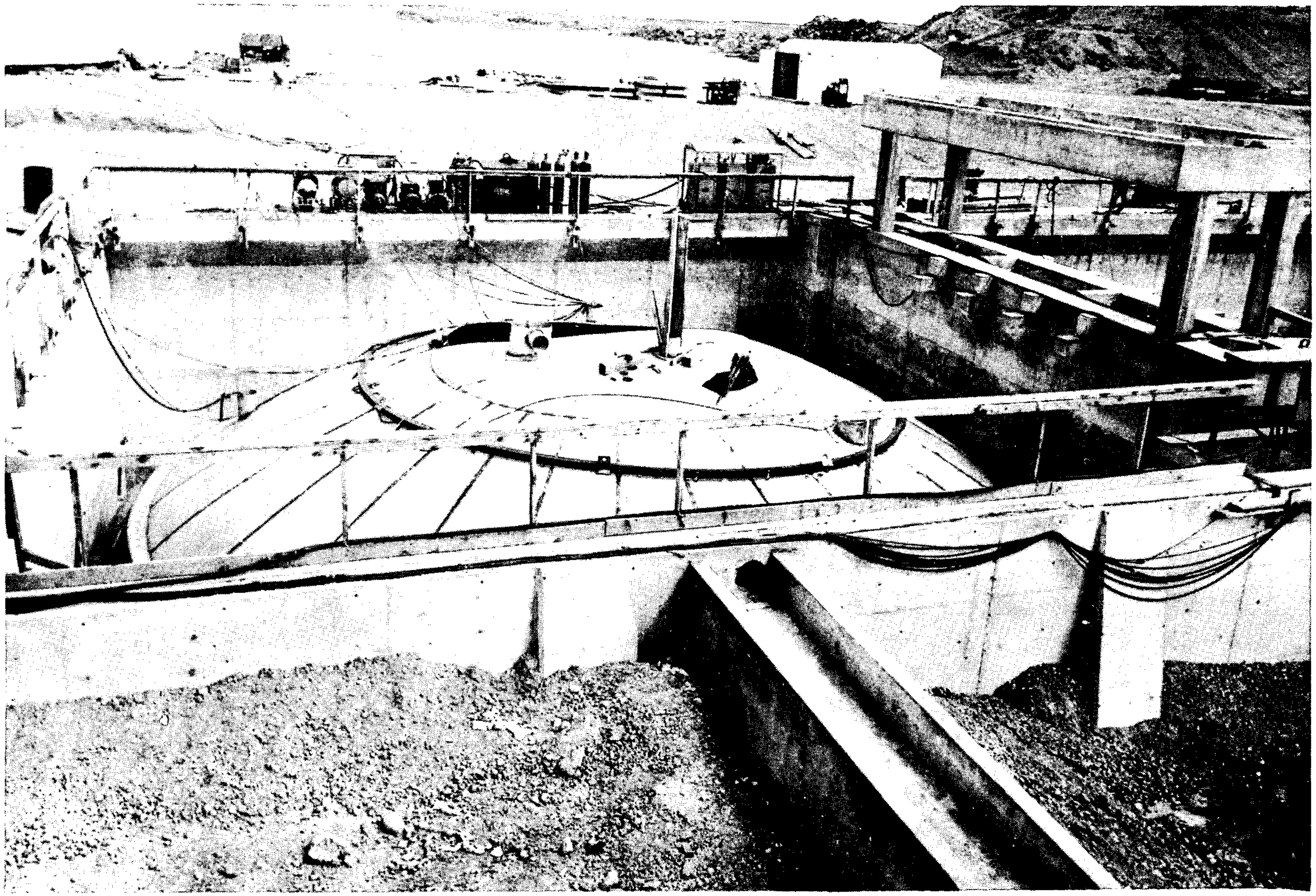
The 300,000-gallon type of tank used at Idaho is a completely enclosed stainless steel tank within a concrete vault which provides a means of containing and is equipped to detect tank leakage, if it occurs. The design of this type of tank, with cooling coils which lower the temperature inside the tank, is shown on a succeeding page. Three of the tanks do not contain cooling coils.

Idaho also has four 30,000-gallon cooled, stainless steel tanks which are buried on concrete drain pads with a liquid collecting sump. These tanks are considered only as short-term waste storage and holding tanks.

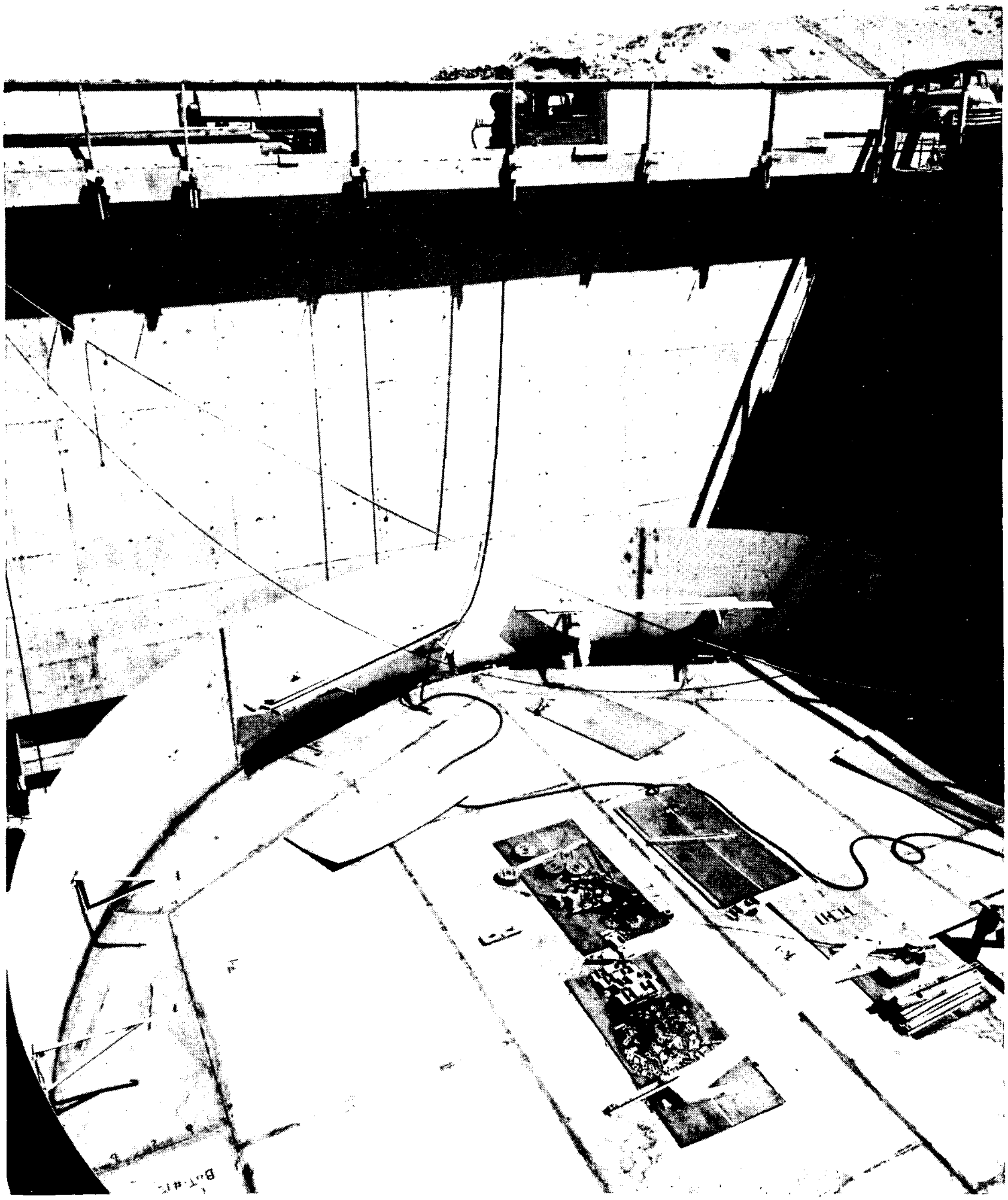
Idaho considers the integrity of the stainless steel tanks to be very high, with the useful life estimated from 50 to 150 years, depending



INSIDE VIEW OF IDAHO COOLED WASTE TANK



IDAHO WASTE TANK UNDER CONSTRUCTION—
TOP OF TANK VISIBLE



IDAHO WASTE TANK UNDER CONSTRUCTION–
BOTTOM PORTION

upon the types of waste stored. AEC's records show that in 1957 a study made of the cost of storing Idaho's acidic wastes in stainless steel tanks versus storing neutralized wastes in carbon steel tanks indicated that although tank cost per gallon was more for stainless steel tanks, this cost differential was offset by avoiding the extra expense of neutralizing the waste and the additional volume of waste resulting from neutralization.

Our review of AEC records disclosed no evidence of significant problems or incidents regarding the storage of radioactive wastes in underground tanks at Idaho. On two occasions waste was inadverently siphoned from a tank into the surrounding vault area but, because of the protective vault, the waste was not released into the environment. AEC records show that in both instances the waste was pumped back into the tank.

Idaho officials advised us that it has been their unwritten policy to maintain a spare 300,000 gallon tank and a spare 30,000 gallon tank for use in the event of a tank failure. However, the capability to transfer waste between the 300,000 gallon tanks was not installed until May 1959, about 7 years after the chemical processing plant began operation. Further, the transfer capability was not installed in the 30,000 gallon tanks until October 1961. Therefore, in the event of a tank failure prior to the installation of these systems, emergency means would have been required to accomplish the transfer.

At the time of our review, Idaho had about 1.6 million gallons of high-level wastes in underground tanks, thereby using about 52 percent of the available storage capacity for waste solutions. We were advised that the unused capacity is the result of (1) Idaho's policy of maintaining as spare tanks for use in the event of tank failure, one 300,000 gallon and one 30,000 gallon tank, and (2) the solidification of about 1.1 million gallons of liquid wastes in the waste calcining facility. This facility is discussed in a previous section of this report.

An Idaho official advised us that there is no need for additional liquid storage facilities at Idaho because future wastes, as well as those now stored in underground tanks, are expected to be calcined. This view is apparently based on the assumption that use of the calcining facility will continue indefinitely.

PRINCIPAL MANAGEMENT OFFICIALS

OF THE

ATOMIC ENERGY COMMISSION

RESPONSIBLE FOR ADMINISTRATION OF ACTIVITIES

DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
CHAIRMAN:		
Glenn T. Seaborg	Mar. 1961	Present
John A. McCone	July 1958	Jan. 1961
Lewis L. Strauss	July 1953	June 1958
GENERAL MANAGER:		
R. E. Hollingsworth	Aug. 1964	Present
A. R. Luedecke	Dec. 1958	July 1964
Paul F. Foster	July 1958	Nov. 1958
Kenneth E. Fields	May 1955	June 1958
ASSISTANT GENERAL MANAGER FOR PLANS AND PRODUCTION (note a):		
George F. Quinn	Aug. 1961	Present
Edward J. Bloch	Sept. 1959	Aug. 1961
Vacant	Sept. 1957	Sept. 1959
D. F. Shaw	June 1955	Sept. 1957
ASSISTANT GENERAL MANAGER FOR REACTORS (note b):		
George M. Kavanagh	Jan. 1966	Present
John A. Swartout	Dec. 1964	Dec. 1965
ASSISTANT GENERAL MANAGER FOR RESEARCH AND DEVELOPMENT (note c):		
Spofford G. English	Aug. 1961	Present
Alfonso Tammaro	Apr. 1954	Aug. 1961
DIRECTOR, DIVISION OF PRODUCTION:		
Frank P. Baranowski	Oct. 1961	Present
George F. Quinn	Sept. 1959	Aug. 1961
Edward J. Bloch	Mar. 1954	Sept. 1959

	Tenure of office From	To
DIRECTOR, DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY (note d):		
Milton Shaw	Dec. 1964	Present
Frank K. Pittman	Oct. 1958	Dec. 1964
W. Kenneth Davis	Feb. 1955	July 1958
FIELD OFFICE MANAGERS:		
IDAHO OPERATIONS OFFICE:		
William L. Ginkel	Nov. 1963	Present
Hugo N. Eskildson, Jr.	Jan. 1962	Nov. 1963
Allan C. Johnson	May 1954	Jan. 1962
RICHLAND OPERATIONS OFFICE:		
Donald G. Williams	July 1965	Present
J. E. Travis	Aug. 1955	July 1965
SAVANNAH RIVER OPERATIONS OFFICE:		
Nathaniel Stetson	Dec. 1965	Present
Robert C. Blair	Feb. 1955	Dec. 1965

[a] The title of Assistant General Manager for Plans and Production was established in August 1961. Formerly, the title of this position was Assistant General Manager for Manufacturing.

[b] The title of Assistant General Manager for Reactors was established in December 1964. Formerly, the duties and responsibilities of this position were carried out by the Assistant General Manager for Research and Development.

[c] The title of Assistant General Manager for Research and Development was established in August 1961. Formerly, the title of this position was Assistant General Manager for Research and Industrial Development.

[d] The title of Director, Division of Reactor Development and Technology was established in December 1964. Formerly, the title of this position was Director, Division of Reactor Development

DESCRIPTIVE DATA CONCERNING RADIOACTIVE WASTE STORAGE TANKS

APPENDIX 11
Page 1

Carbon steel waste storage tanks at Richland

Tank farm	Number of tanks	Capacity per tank (gallons)	Capacity per farm (gallons)	Year constructed	Cost per farm	Cost per gallon
T	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	$3,087,000	$0.469
U	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	2,969,000	0.451
B	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	3,019,000	0.459
C	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	2,938,000	0.447
BX	12	530,000	6,360,000	1946-47	2,208,000	0.347
TX	18	758,000	13,644,000	1947-48	5,859,000	0.429
BY	12	758,000	9,096,000	1948-49	2,651,000	0.291
S	12	758,000	9,096,000	1950-51	3,961,000	0.435
TY	6	758,000	4,548,000	1951-52	1,846,000	0.406
SX	15	1,000,000	15,000,000	1953-54	3,983,000	0.266
A	6	1,000,000	6,000,000	1954-55	5,865,000	0.978
AX	4	1,000,000	4,000,000	1963-64	2,577,000	0.644
	149		94,056,000		$40,963,000	0.436

Carbon steel waste storage tanks at Savannah

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In use

Farm	Number of tanks	Type	Capacity per tank (gallons)	Capacity per farm (gallons)	Year constructed	Cost per farm	Cost per gallon
F	8	cooled	750,000	6,000,000	1954	$8,626,271	$1.438
H	8	cooled	750,000(4) 1,070,000(4)	7,280,000	1955	9,862,251	1.355
F	4	un-cooled	1,330,000	5,320,000	1959	2,573,367	0.484
H	4	un-cooled	1,330,000	5,320,000	1963	2,595,725	0.488
	24			23,920,000		$23,657,614	$0.989

Under construction

Farm	Number of tanks	Type	Capacity per tank (gallons)	Capacity per farm (gallons)	Year constructed	Estimated cost	Cost per gallon
H	4	cooled	1,300,000	5,200,000	--	$ 7,700,000	$1.481

Stainless steel waste storage tanks at Idaho

Tanks per installation	Type	Capacity per tank (gallons)	Capacity per installation (gallons)	Year constructed	Cost per installation	Cost per gallon
2	1 cooled 1 uncooled	318,000	636,000	1952	$1,614,596	$2.539
4	cooled	30,000	120,000	1955	1,645,929	13.716
3	2 cooled 1 uncooled	300,000	900,000	1955	2,608,175	2.898
2	1 cooled 1 uncooled	300,000	600,000	1958	1,813,373	3.022
2	cooled	300,000	600,000	1959	1,908,727	3.181
2	cooled	300,000	600,000	1965	1,847,954	3.080
15			3,456,000		$11,438,754	3.310