NEW LOW-LEVEL RADIOACTIVE WASTE STORAGE/DISPOSAL FACILITIES FOR THE SAVANNAH RIVER PLANT

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ABSTRACT

Within the next few years the Savannah River Plant will require new facilities for the disposal and/or storage of solid low-level radioactive waste. Six options have been developed which would meet the regulatory and site-specific requirements for such facilities.

INTRODUCTION

Low-level radioactive waste is generated in many forms, with a wide range of specific activities, radiation levels, and volumes. The Savannah River Plant currently generates about one million cubic feet of solid low-level radioactive waste each year. A disposal facility for the Savannah River Plant must be able to accommodate the many different kinds of waste generated at the site.

Near surface disposal is the practice presently employed at the Savannah River Plant for the disposal of low-level radioactive waste. This includes all of the disposal methods currently in routine operation as well as test demonstrations. These practices include shallow land burial, greater confinement disposal, waste classification, incineration, and compaction. In addition, methods employing above or below grade vaults are also considered forms of near surface disposal. Six options for the disposal and/or storage of wastes generated at the Savannah River Plant are presented below.

WASTE STORAGE AND DISPOSAL OPTIONS

Continue Present Operation

In this option, present disposal operations would be continued. Disposal operations that are presently being performed are:

- Low activity waste is differentiated from high activity waste by a bench mark radiation level, presently 300 mR/hour at 3 inches.
- Incineration of a fraction of the low activity waste (waste reading less than or equal to 1 mR/hour at 3"). The ash is disposed of in metal containers.
- Compaction of a fraction of the low activity waste in cardboard boxes. Compaction ratios of four or five to one can be achieved. The compacted waste boxes are placed into metal containers before disposal. A compactor to compress waste directly in large metal disposal boxes has been installed.
- Disposal of alpha activity waste at concentration levels of less than 10 nanocuries/gram as low level waste, as defined by DOE Order 5820.2, and disposal of alpha activity waste with concentrations of 10 to 100 nanocuries/gram by Greater Confinement Disposal (GCD).
- Disposal of low activity waste in metal containers by stacking the containers in an Engineered Low-Level Trench (ELLT) at about a 20-foot depth and covering the boxes with at least four feet of soil.
- Disposal of bulky low activity waste directly into 20-foot deep trenches.
- Disposal of the higher activity fraction of the waste either into Greater Confinement Disposal boreholes or directly into Intermediate Level Waste trenches.
- A Greater Confinement Disposal trench is being constructed for disposal of high activity waste that is too large to be disposed of into GCD boreholes.

Trench-use efficiency can be improved by providing larger trenches. These larger trenches are called Engineered Low-Level Trenches, or ELLT. A typical trench would be about 500 feet long and 170 feet wide at the top. Sides are sloped at a 45 degree angle. A ramp is provided for truck access. Waste boxes can be stacked such that the trench-use efficiency is 80% or greater.

The floor of the ELLT is covered with a layer of crusher-run stone. The floor is sloped about 1% to a corner of the excavation, such that rainwater is directed away from the emplaced boxes. Surface water intrusion is prevented by providing a protecting berm at the surface and by surface grading to drainage ditches.

In the GCD borehole demonstration at Savannah River, waste is emplaced in a 7-foot diameter, 20-foot high liner, with a total disposal volume of 770 cubic feet. The liner is a half-inch-thick water tight fiberglass cylinder with an integral bottom. The liner is placed on a one-foot-thick concrete pad in a 9-foot-diameter augured hole. The top of the base pad is 30 feet below grade and 10 feet above the expected high water table. The top of the waste placed in the liner will be at least 10 feet below grade. The liner is surrounded by a one-foot-thick annulus of grout. Grout is poured around all waste forms placed in the liner, to form a solid cement-waste matrix inside the liner. After all waste is emplaced in the liner, a one-foot thick layer of grout is poured on top of the top waste form.

A GCD trench is built with the same objectives as a GCD borehole. A typical GCD trench would have four concrete lined cells, each about 25 x 50 feet, and about 20 feet deep. The bottom of the cells would typically be 30 feet below the surface. Each cell would have a rain-tight cover. Waste would be emplaced in the cells about one foot from the walls, and this one-foot space would be filled with grout when the waste forms themselves were stabilized in place with grout. The GCD trench would be used for emplacement of high-activity waste forms too large to be emplaced in GCD boreholes.

This option would continue the present disposal of low-level solid radioactive waste by near surface disposal, or shallow land burial, as it is defined in DOE Order 5820.2.

Near Surface Disposal With Exceptions

In this option, near surface trench disposal of LLW would continue as described above, but with the following exceptions:

- High radiation level tritium-containing waste would be stored in an above ground vault, for example, while low radiation level tritium-containing waste would be stored in a storage building. This waste would be stored for ten half-lives, about 120 years, to allow for decay-in-place of the tritium. The storage method would be designed to allow for retrievability; storage would be dry and monitorable. At the end of the storage period, the waste would be disposed of as low-level waste. The intent here would be to not allow tritium waste to be in contact with soil until a large fraction of the activity has decayed.
- Waste containing long-lived activity, such as carbon-14 and iodine-129, and other waste whose chemical form would tend to enhance migration of radionuclides in soil would also be stored for treatment or for later disposal by other than near surface disposal.

Disposal and Storage by a Combination of Facilities

Designs for the combination of facilities will be matched to the different waste streams generated by the Savannah River Plant. Examples of typical operations are:

- Pretreatment

  Pretreatement of low activity waste by incineration or compaction, and stabilization would be encouraged. High activity waste which cannot be reduced in volume by incineration or compaction because of radiation levels would be stabilized to the extent possible, either by grout injection or containerization in a stable waste container.

- Engineered Disposal of High Activity Waste

  High activity waste is waste that emits high radiation levels. What constitutes high activity waste depends on the limits imposed upon personnel and upon the equipment available for handling the waste. A typical cut point between high and low activity waste would be a radiation level of 300 mR/hour at 3 inches from the waste form.

High activity waste would be disposed of in Greater Confinement Disposal boreholes or trenches, or in above or below grade concrete vaults. These disposal facilities would be provided with shielding materials to keep radiation exposure to acceptable working levels. The GCD or vault designs would provide for percolate water collection within the waste emplacement volume.

It is estimated that about five percent of the volume of SRP waste is waste that would be triggered into GCD or vault disposal, based either on the radiation level or the concentration of radionuclides in the waste.

- Engineered Storage of Special Waste Forms

  An engineered storage facility would provide for dry, monitorable, and retrievable storage for special waste forms such as waste containing tritium, and waste that contains long-lived radionuclides such as carbon-14 and iodine-129.

- Engineered Disposal of Low Activity Waste

  Low activity waste would be treated to reduce its volume and, to the extent possible, to stabilize it. The waste would be disposed of in an Above Grade Operation (AGO) facility or in above or below grade concrete vaults.

A typical design concept for an Above Grade Operation would consist of a sub-base composed of clay, an impermeable plastic membrane, a layer of sand to protect the membrane, a second plastic layer to maintain separability between the layer of sand and the final layer of gravel. The sub-base would be sloped to collect any water that appears while waste is being placed on the AGO and to collect percolate water after closure. If the closure is executed properly, no percolate water will be collected.

The cover of the AGO would consist of layers of sand, clay, an impermeable membrane, and soil. The cover membrane would be sealed to the impermeable membrane on the bottom of the AGO to form a sealed envelope around the stacked waste forms. All percolate water will be collected, monitored, and if contaminated, then stabilized.

An Above Grade Engineered Vault would consist of vault floor and walls formed of two-foot thick concrete. There could be two variations of the design: in the first the vault has no chambers. Equipment that is used to stack containers would therefore have free access to all parts of the vault. In the second variation chambers would be designed to allow the formation of concrete monoliths at convenient time intervals. All percolate water would be collected, monitored, and treated if necessary.

A Below Grade Engineered Vault would consist of an excavation lined on the bottom and sides with two feet of concrete, which could be either poured in forms, precast, or formed of shotcrete. The vault would be divided into chambers which would be designed to support a rain cover for each chamber. A complete percolate water collection system would be incorporated into the design. Percolate water could be collected, monitored, and treated if necessary.

The waste material may be treated in a number of ways before emplacement into vaults. Stabilized waste forms -- that is, waste forms that would resist subsidence -- could be placed in the vaults and grout poured directly around the forms. In another method that would prevent subsidence, the waste could be placed into concrete forms such as hexagons or cylinders, and these concrete waste forms would provide the desired degree of stabilization. Alternatively, the vault and cap could be designed to prevent subsidence without relying on the emplaced waste forms.

The intent of this option would be to provide a cost and environmentally effective combination of treatment, storage, and disposal methods for the SRP solid waste streams, that would decouple the waste from the groundwater and maintain low personnel exposure.

Engineered Storage of All Waste

In this option, LLW would be stored retrievably in structures with various degrees of shielding -- ranging from heavily shielded structures such as boreholes or vaults, to moderately shielded structures such as concrete bunkers, to lightly shielded structures such as a storage building on a concrete pad. The storage structures would be designed to be dry, and to have a percolate water collection system, and would be designed to last for 100 years or more. As the radiation levels in the waste decrease because of decay, waste would be moved from more heavily shielded structures to those with less shielding.

Waste reduction methods and volume reduction methods would be employed to the extent possible.

The storage method of operation is in use in Canada, where LLW is stored in cylindrical tile holes, concrete bunkers, heavily shielded quadracells, and a storage building. A search is proceeding in Canada for a geologic repository for ultimate disposal of the waste.

The objectives of the designs are to store low-level radioactive waste retrievably for the purpose of either decay-in-place for short-lived radionuclides or later retrieval for disposal in a geologic repository. A necessary preliminary segregation step is required for storage, which is segregation of the waste according to the radiation level of the waste forms. Waste would be separated into at least three categories according to radiation level -- low activity, intermediate activity, and high activity. The activity levels referred to below are those used at the Ontario Hydro facility at the Bruce Station (1).

Low Activity Storage Building

Waste with low levels of radiation -- radiation levels of less than about 1 mrad/hour at 3 inches -- would be stored in an above-ground concrete building. Design features of the storage building would include:

- Concrete walls 15 to 18 inches thick, and a concrete roof 6 to 10 inches thick. Great attention must be placed on roof design to make it water tight.
- A poured concrete floor of suitable load bearing capacity, with an internal drainage collection system that is capable of collecting and monitoring drainage from individual sections of the building.
- The size of the building must be such that it can store about a year's generation of the low activity waste. A typical building would be abut 150' long, 100' wide, and 30' high. Waste storage capacity is about 50% of the building volume, or 225,000 cubic feet.
- The building would have a smoke detection system, a fire extingishing system, forced air ventilation with filters, internal lighting, and racks for stacking waste packages. The racks would be positioned to allow stacking the waste forms with a loading vehicle similar to a fork-lift truck, and to allow visual inspection of the waste forms.
- The building would be designed as a modular structure to allow for easy expansion by connecting similar buildings to it.

Intermediate Activity Storage Facility

The intermediate activity storage facility would be designed to store waste with radiation levels greater than 1 mrad/hour at three inches but less than or equal to 100 mrad/hour. Remote handling of all waste forms will be required. Design of the storage facilities could be along several different lines. Typical examples would be:

- Cylindrical holes bored into the ground, with water-tight liners and covers. The waste is emplaced into the liners and can be grouted in place. When the waste is retrieved, the liner itself is removed and becomes the new waste form.
- Underground water-tight vaults, with concrete (or other) covers. The vaults are provided with a complete water collection and monitoring system. Waste forms are emplaced and removed from the vault by remote operation.
- Above ground water-tight vaults, with concrete (or other) covers. Waste is emplaced or removed remotely. The covers are shielded, sloped to provide runoff for precipitation, and provided with lifting lugs.

HIGH ACTIVITY STORAGE FACILITY

High activity storage facilities would be similar to the intermediate storage facilities, except that more shielding would be required. Waste placed in these facilities would have radiation levels in excess of 100 mrad/hour at three inches. Remote handling of all waste forms would be required. If the facility is placed above ground, the side wall shielding would have to be three or more feet thick. Covers would have to be at least three feet thick and made in two or more pieces to reduce the weight of each piece.

Engineered Disposal of All Waste

In this option an engineered structure would be built that would be similar to the LLW disposal facility designed and used by the French at the Centre de la Manche. Higher activity waste would be placed in concrete monolithic structures below grade, while lower activity waste would be volume reduced, stabilized, or placed in stable containers, and placed on top of the monoliths in an earth mounded tumulus.

Pretreatment of waste to the extent possible would be required. Both below and above ground structures would be provided with a percolate water collection system.

The above ground tumulus would require closure to reduce the amount of percolation water entering the mound. The entire structure would be designed to last for 300 years, or about 10 half lives of the waste emplaced in it. Long-lived radionuclides would be stored for geologic disposal, while waste containing tritium would be stored above grade for decay-in-place.

The following description of the engineered disposal facility closely parallels the description of the low-level radioactive waste disposal facility operated by France at the Centre de la Manche, near Cherbourg (2).

Prior to disposal the waste is segregated into three parts -- high, intermediate, and low activity waste. Also prior to disposal the low activity waste is stabilized by:

- Compacting drummed waste and placing the crushed drums into cylindrical concrete forms that are subsequently filled with grout and sealed, or

- Incineration and subsequent stabilization of the ash in cement, or

- Stabilizing boxed waste by injecting grout into the boxes in a way that makes the waste form stable in the event the metal box corrodes or fails.

In general, the three waste classes are disposed of in an earth-mounded concrete bunker disposal facility. In this concept, waste containers that do not provide adequate isolation of radionuclides are disposed of in subsurface units composed of concrete monoliths or bunkers. Packages of very low level activity waste, or waste whose container does provide adequate radionuclide isolation (concrete cylinders or compacted drummed waste) are stacked on top of the monoliths at surface level in what are called "tumuli". Once a disposal unit is filled with monoliths and tumuli it is covered with layers of clay and soil to look like an earth-mounded concrete bunker.

The disposal method begins with the excavation of a 3000 square meter disposal unit (32,300 square feet, or about 180' x 180'). A concrete pad is formed that has a complete drainage and water collection system. The water collection system will collect any water that may percolate through the disposal unit and take it to individual checkpoints where it can be monitored for activity. If there is an abnormally large amount of water, or if it contains radioactivity above background levels, this signals a failure in the disposal unit's cap. The cap failure can be located and repaired, and if the water is contaminated it is processed directly on site by stabilizing it in cement and disposing of it in the facility. Another water collection system completely surrounds the facility to divert surface runoff away from the disposal units. The water collection system is a critical part of the design of the entire disposal facility.

On top of the concrete pad formed in the excavation, disposal cells, or monoliths, are formed side by side, either by pouring concrete into reusable steel molds or by using prefabricated concrete panels lined with reinforcing steel. Waste packages are lowered into the monoliths by cranes a layer at a time and covered with grout. Reinforcing steel is placed on the last layer of packages and covered with concrete. Two meter (6.5') wide channels are formed between selected rows of monoliths for disposal of waste that requires remote handling (that is above a contact radiation level of about 200 mrad/hour). The remote handled waste is lowered into the channels by a shielded crane or by use of a shielding bell that surrounds the waste form. After the high activity waste is placed in the channel it is also covered with concrete.

The excavation, when filled, thus becomes a large, solid concrete monolith. To help prevent rainwater from entering the monoliths during the time they are being filled, a transportable cover is placed over the openings. This cover enables waste operations to take place on rainy days and decreases the amount of water that is collected and monitored during disposal operations.

When the subsurface disposal unit has been filled with individual monoliths, and when all of the channels have been filled with the high activity waste, the unit is covered with a reinforced concrete pad that is surrounded by another water collection system. Stabilized waste packages of low activity waste are arranged in stacks up to 20' high on top of the pad. Concrete cylinders are placed around the periphery of the pad to form a structural framework. Other waste forms are then placed inside the walls. When the pad surface area has been filled with waste forms, it is backfilled with gravel, clay or other material. It is then covered with a layer of impermeable clay and a layer of soil which is planted with local vegetation. These layers form a temporary closure, which will be altered when a permanent closure is accomplished.

The ratio of volume of waste to surface area used is about 3.3:1, or about 10,000 cubic meters of waste can be disposed of in a 3000 square meter area.

Vault Disposal of Untreated Waste

In this option all waste would be disposed of untreated in above or below grade concrete vaults. Vaults containing higher activity waste would have a percolate water collection system. The waste would be grouted in place in the vault cells. The intent of this operation would be to provide as simple as possible a disposal method that would not require pretreatment facilities, and yet would decouple the waste from the ground water.

Waste would be emplaced in the cells by an overhead gantry crane. The cells being filled with waste would have a removable rain cover to keep the waste dry until the cell would be filled. When waste has filled the cell a heavy metal screen would be placed over the waste while self-leveling grout would be poured around the waste to form a monolithic structure. The purpose of the screen would be to prevent waste from floating on the grout.

When a vault cell has been filled with grout, a layer of concrete one or more foot deep would be poured to form a temporary closure for the cell. When all cells in the vault have been filled, a permanent reinforced and sloped concrete roof would be placed over the cells.

The vaults containing higher activity waste would have a leachate collection system designed to collect and treat any water that percolates into the vault cells.

A typical vault volume would be about 1.5 million cubic feet, which would be sufficient to hold the million cubic feet of LLW generated at SRP each year and about one-half million cubic feet of grout used to stabilize the waste.

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REFERENCES

T. J. Carter and P. K. M. Rao, "Fifteen Years of Radioactive Waste Management at Ontario Hydro," **Proceedings of the Sixth Annual Participant's Information Meeting, DOW Low-/level Waste Management Program,** CONF-84-09115, p. 41, December 1984.

C. Hutchison and Y. Marque, "Low-Level Radioactive Waste Disposal in France: Past Experience and Future Plans," presented at A Decisionmaker's Forum: Low-Level Radioactive Waste Management: The Next 5 Years -- Transition to Stability or Continued Uncertainty, Isle of Palms, SC, June 1985.