INTEGRATED WASTE MANAGEMENT PLAN FOR THE SAVANNAH RIVER PLANT

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ABSTRACT

The Savannah River Plant will begin operation of several new waste disposal and treatment facilities during the next five years which will affect all waste streams generated on site. These will include a new solid low-level radioactive waste disposal facility, a hazardous/mixed waste disposal facility, and a low-level liquid waste solidification process. Existing waste sites will be closed in a technically and environmentally sound manner. Facility designs and closure plans are based on site-specific performance assessments and data from comprehensive monitoring systems. In addition, significant technical effort is directed toward waste volume reduction. These programs include compaction, incineration, waste avoidance, and clean waste segregation. These are elements of an integrated waste management plan that was developed to insure not only an effective, coordinated transition to these new facilities but to significantly enhance the overall site environmental management program.

INTRODUCTION

Low-level radioactive waste management at the Savannah River Plant (SRP) must provide for the disposal of a wide variety of solid and liquid wastes. The goal is to provide compliance with all applicable regulations. An integrated waste management plan has been developed which identifies current and planned waste streams and considers both new and existing facilities for treatment and disposal of these wastes. The general objectives of the plan are fourfold: 1) minimize generation and maximize recycle of waste material to the extent practical, 2) segregate wastes into classes having similar characteristics and requiring similar disposal methods, 3) reduce waste volumes using appropriate treatment methods and provide stabilized waste forms when required, and 4) package, store, and dispose of all wastes in engineered facilities. The purpose of this report is to outline programs developed to meet these objectives at the Savannah River Plant.

Regulatory Requirements

Comprehensive guidelines for management of radioactive wastes at DOE sites are provided in the recently issued DOE Order 5820.2A(1). Chapter III of the Order presents policies for overall management of DOE low-level wastes to protect the health and safety of the public, preserve the environment of the waste management facilities, and ensure no legacy requiring remedial action after site operations have ceased. The wastes should be managed using combinations of waste reduction, segregation, treatment, and disposal practices for maximum cost effectiveness. Site-specific performance assessments must be performed to demonstrate that waste management practices will meet the criteria set forth in the Order. Disposal of wastes that also contain hazardous components (mixed waste) must conform to requirements of the Resource Conservation and Recovery Act (RCRA) as well as the DOE order.

Performance objectives specified in DOE Order 5820.2A require that external exposures and concentrations of radioactive materials released to the environment in surface water, groundwater, air, soil, plants, and animals do not result in a committed dose equivalent exceeding 25 mrem/yr to any member of the public, or 100 mrem/yr continuous exposure or 500 mrem for a single exposure to an inadvertent intruder. Groundwater must meet Federal, State and local requirements. This means meeting the proposed EPA drinking water standards for radionuclides of 4 mrem/yr(2) at the disposal facility boundary. Site specific performance assessments are required to demonstrate compliance with these objectives, to support the overall combination of waste management practices used, and to design the monitoring system used to evaluate performance.

SRP Waste Management Plan

The SRP plan for management of low-level radioactive and mixed waste accommodates a broad range of waste streams and disposal strategies. Waste categorized generally as low and intermediate activity solid wastes and mixed radioactive and hazardous wastes are managed first through intermediate storage, followed by treatment facilities and subsequent final disposal in appropriate landfills, vaults or off-site facilities. Typical examples of radioactive and mixed waste requiring disposal include contaminated equipment, reactor hardware and resins, spent lithium-aluminum targets, contaminated oil, scintillation fluid, mercury from gas pumps, cadmium from control rods and neutron shields, and incidental waste from laboratory and production operations .

Current and planned programs for treatment and disposal of radioactive and mixed wastes are outlined in this paper. Plans for closure of waste disposal facilities are described as well. Discussion of the alpha radioactive waste is limited to that part containing less than 100 nCi/g of alpha activity and thus is defined as low-level waste. Plans for SRP TRU and high-level waste are presented elsewhere. More detailed information may be found in an Environmental Impact Statement covering waste management activities issued in 1987(3).

EXISTING DISPOSAL FACILITIES

Shallow Land Burial

In past and current practices, low-level radioactive solids have been disposed of by shallow land burial. Two sites designated the "old" and "new" burial grounds have been utilized for shallow land burial at SRP. The two facilities are adjacent and together occupy 196 acres. From 1952 to 1986, these facilities have received 430,000 cubic meters of low-level waste, containing more than 10,000,000 curies of activity (currently decayed to 3,000,000 curies).

Beta-gamma wastes of low(<300, mR/hr at 3 inches) and intermediate (>300 mR/hr at 3 inches) levels, and alpha wastes were buried in separate trenches.

Until 1965 the alpha waste was contained in plastic bags and packaged in cardboard boxes and was buried. Between 1965 and 1974 the alpha wastes were segregated by activity level; waste containing less than 0.1 curies per package were disposed of by shallow land burial, the remainder was considered TRU waste and was retrievably stored inside concrete culverts placed in trenches. Currently alpha wastes containing less than 100 nCi/g are handled as low-level waste. TRU wastes are stored at grade on monitored concrete pads.

Greater Confinement Disposal

An improved form of near-surface disposal is Greater Confinement Disposal (GCD), which uses both natural and engineered barriers to provide a greater degree of waste isolation than does shallow land burial. The GCD concept uses deeper burial to minimize water, root, animal and future human intrusion, stabilized waste forms to prevent subsidence and low permeability caps to limit water infiltration. GCD is intended for disposal of the higher activity fraction of low-level waste.

Two types of GCD facilities are in use at SRP; boreholes and trenches. The borehole design features a 7-foot diameter, 20-foot deep cylindrical cavity with a 1/2 inch thick fiberglass liner. The liner is stabilized by a one foot thick layer of concrete on the outside. Grout is poured around all waste on the inside, and a one foot thick concrete layer is placed over the waste. Twenty boreholes have been constructed at SRP to date.

The GCD trench facility provides four concrete lined cells, each 75 by 50 feet and 20 feet deep situated 30 feet below ground surface. The cells are fitted with a rain-tight cover which is removed during waste emplacement. Void space between waste packages is filled with grout. Total waste volume provided in one GCD trench is 100,000 cubic feet, which is about two years generation of GCD type waste.

PERFORMANCE ASSESSMENTS

The performance of the shallow land burial sites is monitored by a series of groundwater wells situated around the perimeters of the sites. The wells penetrate 40 to 50 feet below the surface and are screened in the water table. Well waters are routinely analyzed for gross alpha, gross nonvolatile beta, tritium, and other radionuclides and hazardous chemicals in an prescribed program agreed upon with the South Carolina Department of Health and Environmental Control.

The monitoring results indicate that with the exception of tritium radionuclides have not migrated in significant quantities to the groundwater. With the exception of a few anomalous wells, only trace levels of alpha and nonvolatile beta activities are detected after 30 years of operation. Tritium, in contrast, is readily released from the waste and is present as a plume in the groundwater which contains 1-2% of the buried waste inventory. Maximum concentrations of tritium in the monitoring wells range up to about 1,000,000 pCi/L and average about 90,000 pCi/L, which is the same as the proposed drinking water limit. The drinking water limit serves as a reference only, since control of site access eliminates the use of the water as a drinking water source. Small quantities of tritium have migrated about 1,000 feet downgradient to outcrop at an annual rate of about 0.6% of the groundwater plume inventory.

Nonradioactive but chemically hazardous species monitored in the groundwater wells include mercury, lead, and cadmium. Analyses from 1988 show mercury concentrations to be less than 0.23 ppb, compared with the drinking water limit of 2.0 ppb. Maximum measured levels for lead was 45 ppb compared to drinking water limits of 50 ppb. Cadmium was not found above detection limits. Preliminary studies indicate that several organic substances related to the waste oil, spent solvents and scintillation fluids disposed in the burial ground may also be present in the monitoring well waters.

Closure Requirements

Closure requirements for SRP waste disposal facilities are based on predictions of long-term exposures to radioactive and hazardous wastes released from the facilities under various closure options. The limiting pathway for shallow land disposal sites in humid climates is generally found to be associated with infiltrating rain water that carries the waste constituents into the groundwater system. Closure caps that effectively limit infiltrating rain water are therefore an essential element for closure. Satisfactory performance is achieved by designs that limit concentrations of materials in groundwaters to less than those permitted by EPA standards.

Releases of radionuclides from SRP burial grounds have been modeled for two waste fractions, including (1) a minor highly-mobile component that reaches the groundwater prior to closure, and (2) a major component with slower transport. Only the slower contaminants, which reach peak groundwater concentrations after closure is completed, depend upon the closure option considered. The results of the modeling for the slower contaminants indicate that highly effective caps are required to ensure long-term performance of the SRP shallow land burial sites.

A few of the highly mobile radionuclides, most notably tritium, as well as the hazardous materials including lead, cadmium and mercury, are predicted to be leached from the burial grounds into underlying groundwaters in concentrations exceeding drinking water limits over the near term. Comparison with well monitoring data shows that only tritium has been observed in significant quantities to date. In the longer term U-238 and Np-237 are calculated to exceed drinking water standards; however, modeling results also show that an effective closure cap coupled with access restrictions during the 100 year institutional control period will maintain the site within regulatory guidelines.

Closure plans have been developed for both SRP shallow land burial sites based on the water transport modeling. For the old burial ground a program of waste removal, stabilization, capping and monitoring is planned.

Retrievably stored TRU wastes will be exhumed. Grid wells will be closed and empty solvent tanks will be stabilized in place by filling with grout. A closure cap consisting of native soil, low-permeability clay, a gravel drainage layer, and top soil will be emplaced on the site. A series of new monitoring wells will be installed around the site to verify satisfactory post-closure performance.

The new burial ground will be closed in a similar manner, except that dynamic compaction will be employed to minimize potential subsidence of this more recently utilized site. Dynamic compaction is achieved by dropping a large weight from a height of 30-40 feet on the waste trenches in order to reduce the void space.

NEW DISPOSAL FACILITIES

New Low-Level Waste Disposal Facility

A new solid waste disposal facility incorporating state of the art containment features is being designed to replace the existing shallow land burial trenches. The new facility features below-grade vaults to provide the protection of groundwater required by the new DOE order. Low-level wastes will be classified into four types: 1) tritium-contaminated waste, 2) long-lived (30 year half-life) beta-gamma waste, 3) other low-activity waste, and 4) higher activity waste. The tritium waste will be stored for at least 120 years to permit decay to innocuous levels before final disposal. The long-lived waste will be placed in monitored storage until a final disposal method, such as deep geologic disposal, is developed. The remaining low-level wastes will be disposed of in below-grade vaults differing only in the degree of intruder protection.

The below grade vaults will subdivided into cells to provide structural support and operational flexibility, and will be designed specifically for wastes that are not self-supporting. They will be constructed of concrete comprised of equal proportions of Portland cement and Grade 120 slag. The slag cement has been demonstrated to be capable of retarding migration of reducible waste species such as U^{+6} and Tc^{+7}.

Final closure of the vaults will proceed as each vault or adjacent group of vaults is filled. A concrete top designed to shed rain water and withstand closure stresses will be emplaced on the vault. A cap consisting of native soil backfill, clay, gravel, and vegetative cover layers will be installed. Groundwater monitoring wells will be installed at the facility perimeter.

For waste requiring interim storage prior to final disposal, two types of facilities are provided. Tritium wastes will be placed in above grade vaults. Final closure of the tritium storage vaults will begin after a 120 year decay period by covering the vault with earthen material and installation of a closure cap. Long-lived wastes will be stored above grade in a suitable structure until a suitable disposal method and site become available.

Saltstone Facility

Concentrated liquid wastes and sludges will be disposed of as a stabilized cement wasteform called saltstone. The Saltstone Facility, originally developed for immobilization of decontaminated salt solutions produced during processing of SRP high-level radioactive wastes, is being extended to accommodate similar low-level waste streams. Two types of Saltstone Facilities are currently projected, one for low-level waste and one for mixed waste. In each case the aqueous wastes mixed with immobilizing additives will be pumped as grout into large concrete vaults.

Containment principles governing design of all new SRP waste disposal facilities were involved in the Saltstone Facility development. The facility feature a series of near-surface concrete vaults which serve as forms for the cast saltstone wasteform and provides a diffusion barrier to the environment. A slag-based saltstone formulation is pumped as grout into the vaults. Slag is also substituted for 40% of the cement in the vault concrete mix. The vaults are sized to contain about one year's saltstone generation (50,000 cubic meters). Closure will consist of a cap similar to the one described above for the low-level waste facilities.

Performance criteria imposed on the saltstone facility design require that groundwater quality at the disposal site boundary meet drinking water standards. Performance modeling validated by field tests of saltstone in lysimeters have demonstrated the capability of the Saltstone Facility to meet these standards. Improved retention of ^{99}Tc and $Cr+6$ results from the slag formulation which reduces these species with ferrous iron in the slag. Nitrate leaching is decreased because the material has a finer pore structure which encapsulates nitrate salts.

Hazardous Waste/Mixed Waste Facility

In the past radioactive waste including hazardous substances such as mercury, lead, cadmium, degraded solvent and oil have been placed in shallow land burial. Currently these materials are stored for incineration or other treatment and disposal.

Mixed wastes containing hazardous as well as radioactive materials generated at SRP will be disposed of in a facility conforming to RCRA requirements and permitted by the State of South Carolina. The Hazardous Waste/Mixed Waste Disposal Facility (HW/MWDF) has been proposed for final disposal of the solid hazardous and mixed wastes in temporary storage as well as those generated after facility completion. Examples of these wastes include radioactively contaminated equipment, lead shielding, contaminated soil, spent filters, and some incinerator ashes.

The HW/MWDF will consist of a series of an above grade reinforced concrete vaults each of which will hold about 2 years worth of waste generation. Each vault will contain double liners and a leachate collection system. Wastes will be emplaced from the top using a mobile gantry crane. Closure will consist of a reinforced concrete cover and a cap similar to those described earlier.

WASTE TREATMENT FACILITIES

Final disposal of SRP low-level radioactive, mixed and hazardous wastes will be supported by a variety of treatment facilities designed to incinerate combustible waste and to size reduce, compact, and stabilize other solid forms in suitable disposal packages. The principle facilities to be provided for these operations are described in the following sections.

Consolidated Incinerator Facility

Final design of a full-scale incinerator is in progress for volume reduction and detoxification of SRP combustible low-level, mixed and hazardous wastes. Wastes to be treated include drummed liquids, sludges, and solids, and boxed job control wastes. Up to 36,000 cubic feet per year of liquid wastes and 560,000 cubic feet per year of solid waste will be processed. Incinerator ash and offgas scrubber blowdown will be immobilized in grout. The anticipated volume reduction is about 22 to 1.

The incineration system will consist of a rotary kiln primary combustion chamber followed by a tangentially-fired cylindrical secondary combustion chamber designed to process up to 12 tons per day of solid and liquid waste.

Solid waste packaged in combustible containers will be fed to the kiln chamber using a ram system. High ash liquids will be fed to the primary chamber through a burner nozzle and low ash (high heat) liquids will be fed to the secondary combustion chamber through a high intensity vortex burner. Ash from the kiln will be placed into drums and mixed with cement and water. Blowdown water will be transferred as an aqueous sludge for disposal in the Saltstone Facility.

Waste Preparation Facility

Wastes not suitable for incineration will be processed through a waste preparation facility for size reduction, compaction and stabilization prior to disposal. This facility is being designed principally for large process equipment such as piping, canyon jumpers, glove boxes, tanks, and the like that can be effectively size reduced. Overall volume reduction of 5 to 1 is expected. Drummed alpha waste which is not suitable for disposal at WIPP will be processed for stabilization prior to onsite disposal as low-level waste. The size reduced waste will be sent to either the New Radioactive Waste Disposal Facility or the Hazardous Waste/Mixed Waste Disposal Facility.

WASTE MINIMIZATION PROGRAM

A major portion of the SRP waste management strategy and overall DOE policy emphasizes waste minimization initiatives. Methods of waste minimization which are being used include:

- Waste reduction or elimination at the source including process modifications and substitution of alternative process materials to reduce wastes and optimize product output.
- Waste volume reduction after generation, including segregation of nonradioactive and nonhazardous materials.
- Waste treatment, stabilization, recycle, and reuse.
- Delisting to remove from the RCRA hazardous chemical list by EPA, by demonstration that the waste is nonhazardous, and reclassification to certify wastes generated as nonradioactive.
- Awareness and training to educate workers in waste minimization opportunities.

The site strategy is to identify and inventory all site waste streams, select candidate streams for reductions based on regulatory requirements and cost effectiveness considerations, implement facility specific reduction programs, and monitor progress.

CONCLUSIONS

Waste management operations at the Savannah River Plant are in a period of transition. Increased awareness at SRP in particular, the DOE complex in general, and the public at large has led to a realization that past practices are no longer acceptable. SRP has developed an integrated waste management plan to insure both an effective coordinated transition and to enhance the overall site environmental protection program. Work is under way to fully implement the plan over the next five years. An Environmental Impact Statement has been written which covers closure of old waste sites and construction of new facilities. Closure activities are currently underway, and design of new facilities for low-level and mixed/hazardous waste are nearing completion. Pilot-scale tests are being used to evaluate equipment and processes to prepare waste forms suitable for disposal in the new facilities.

REFERENCES

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