LOW-LEVEL WASTE RESEARCH AND DEVELOPMENT ACTIVITIES OF THE DEPARTMENT OF ENERGY[a]

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ABSTRACT

This paper will present an overview of the technical activities of the Department of Energy's Defense and Nuclear Energy Low-Level Radioactive Waste Management Programs (LLWMPs). Although each Program was established with a different purpose, the technologies developed and demonstrated by each are transferable for use in both the commercial and DOE sectors. This paper presents an overview of the technical activities being pursued through both the Defense and Nuclear Energy LLWMP's. These technologies have been placed in the following categories; Criteria and Standards, Systems Analysis, Information and Technology Transfer, Waste Treatment and Waste Form, Improved Near Surface Disposal, Greater Confinement Disposal, Corrective Measures, and Monitoring.

OBJECTIVES/STRATEGY

Defense LLWMP

The Defense Program provides expertise to assess the long term technology needs of the Department's low-level waste (LLW) management facilities and develops criteria and technology programs to meet the Department's needs. Specific objectives of the Defense LLWMP are:

- To provide technology to support the disposal of low-level waste in a manner which protects public health and safety in the short and long term
- To improve the efficiency and cost-effectiveness of the overall waste management system and its components based on a systematic performance assessment approach.

Evolving regulatory standards require continued assessment of low-level waste technology and practices. A uniform systematic approach for evaluating performance is being developed for DOE Defense Program facilities to help ensure that the Department can meet evolving regulatory standards cost-effectively.

The Defense LLWMP has been assigned the responsibility to coordinate the development of this approach. This includes development of the necessary criteria and guidance, and conducting technology and information transfer activities to ensure the implementation of the systems approach by facility operators and site managers.

Nuclear Energy LLWMP

The objectives of the Nuclear Energy (NE) Low-Level Waste Management Program (LLWMP) are responsive to requirements of law: the 1980 Low-Level Radioactive Waste Policy Act, the Nuclear Waste Policy Act of 1982, and the Low-Level Radioactive Waste Policy Amendments Act of 1985. These objectives are to:

- Facilitate the establishment of an effective national low-level waste management system through conducting activities required by the Radioactive Waste Policy Amendment Act of 1985
- Develop the plans and procedures for implementation of DOE responsibilities under Section 151 of the Nuclear Waste Policy Act of 1982.

The Nuclear Energy Program has included technology projects targeted to commercial needs such as the development of information systems, waste treatment demonstrations, and technical assistance for the development of new LLW disposal sites.

TECHNICAL ACTIVITIES CONDUCTED BY THE LLWMP

Although each Program was established with a different purpose, the technologies developed and demonstrated by each are transferable for use in both the commercial and DOE sectors. These technologies have been placed in the following categories; System Analysis, Information and Technology Transfer, Criteria Development, Waste Treatment and Waste Form, Improved Near Surface Disposal, Greater Confinement Disposal, Corrective Measures, and Monitoring.

System Analysis

Activities conducted under the systems analysis category include the comparison of site performance methodologies in use at DOE disposal site, development of a cost-effective method for conducting a system analysis of a waste management system from generation to disposal, and the analysis required by the Low-Level Radioactive Waste Policy Amendments Act of 1985.

The comparison of DOE site performance methodologies will provide useful information on the techniques used to predict site performance at DOE sites. Information on site characterization, environmental monitoring, and performance assessment techniques.

The Department is also developing a cost effective method for conducting analysis of waste management systems to provide a useful tool for analyzing where the greatest improvements in system performance can be made. By analyzing the entire waste management system instead of just the disposal site, improvements can be made where it is most cost-effective.

Information and Technology Transfer

The information and technology transfer category includes the management of information on the generation, treatment, transportation, and disposal of low-level radioactive waste, development of a tracking system for allocation requests under the Low-Level

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Radioactive Waste Policy Amendments Act of 1985, development of a prenotification system, and the publication and distribution of low-level waste technical information.

The LLWMP maintains a data base of the volume and activity of low-level waste disposed at DOE facilities. This information is maintained on the Solid Waste Information Management System. The LLWMP has developed a data management system for commercial waste including: waste disposed at commercial system disposal sites, disposal site capacity, and other information required for preparation of the annual report required by the Low-Level Radioactive Waste Policy Act of 1985.

A Regional Waste Treatment and Disposal Model is in the final stages of development and will aid in the selection of regional treatment and disposal options. This system contains information on waste treatment systems, vendor data, and an economics model for estimating the cost of disposal.

The LLWMP responds to requests for assistance from states, compacts and the public. The program produces publications on all aspects of low-level radioactive waste management. These publications provide for the transfer of technology developed by the LLWMP and the commercial sector to the potential users.

Criteria Development

Work performed under the criteria development category provides for the development of threshold limit guidance for Department of Energy low-level radioactive waste, demonstration of a waste classification system based on total hazard, chemical and radiological, and development of guidance for stabilization and closure of DOE disposal facilities. The threshold limit is a dose limit below which radioactive waste would be treated in a manner consistent with its nonradiological characteristics. The threshold limit guidance will consist of a dose limit based on a selected risk factor, and general guidance for use by DOE sites in developing site-specific radionuclide concentrations. The waste classification system will provide a uniform system for handling, treating, and disposing of LLW in a manner that reflects the wastes' intrinsic hazards to man and the environment. The third research effort is preparing guidance for use by DOE LLW disposal site operators in planning for site stabilization and closure in accordance with DOE requirements. The guidance will address stabilization strategies for retired disposal areas, active disposal areas, and methods for complying with closure requirements.

Waste Treatment and Waste Form

Waste treatment and waste form activities are directed at developing cost-effective treatment techniques to stabilize, reduce the hazard, or reduce the volume of problem wastes. Problem wastes are those not readily amendable to treatment by conventional means. Conventional means for treating radioactive wastes are generally directed to the processing of aqueous solutions and suspensions of dry solids. These techniques are not compatible with some waste types such as organic liquids or decontamination solutions.

Research in this area includes: (a) determining problematic wastes within DOE system, (b) identifying and investigating potential agents and processes for the solidification of problematic low-level waste streams, (c) defining operating parameters for the improved solidification of low-level waste, (d) developing formulations for greater confinement disposal; (e) testing and evaluating of solidified waste forms to verify compliance with waste form performance and disposal-site acceptance criteria and with transportation requirements, and (f) development and validation of a leach test that can be utilized for the prediction of leach rates of radionuclides from solidified low-level wastes over periods of time greater than 100 years.

Additional data on leaching rates are being obtained from two studies using radioactive waste buried in closed system microcosms, referred to as lysimeters. Commercial power reactor wastes fixed in commercially available solidification agents are being monitored in separate sets of lysimeters at Savannah River Laboratory and Pacific Northwest Laboratory. These field studies will provide performance data on waste forms.

The Department has also conducted waste treatment demonstrations. Research in this area includes: (a) completion of the investigation into the feasibility of using a glass melter to volume reduce and encapsulate low-level radioactive waste, (b) completion of development and testing of chemical and thermal processes to treat nitrate waste without the subsequent production of NO_x above limits, and (c) development and licensing of a mobile incinerator at a commercial nuclear power reactor facility.

In addition to the development and testing of waste treatment systems, the LLWMP is documenting operating expense for existing waste treatment systems. This information is targeted to be useful to both small and large generators of low-level waste in the selection of waste treatment systems.

Improved Near Surface Disposal

The principal objective of this technology category is to validate improved methods for near surface disposal of low-level radioactive waste. Improperly sited, designed, constructed, operated, or closed near surface disposal facilities may result in problems which could potentially compromise disposal site performance. These problems relate to radionuclide migration resulting from ground water and surface water intrusion, plant and animal intrusion, and trench cover subsidence. Specific research tasks focus on improved techniques related to siting, construction, operation, and closing of near surface disposal facilities. Many of these tasks are designed to fill gaps in our knowledge and resolve issues related to improved near surface disposal. These tasks are specifically designed to ensure the physical stability of the disposal unit and the hydraulic isolation of the waste, and improve site performance prediction capabilities.

Current and future tasks in the improved shallow land burial technology areas may be grouped in the following manner: site selection and characterization, and surface and subsurface water management.

Research in the site selection and characterization areas include: (a) development of a site characterization manual, and (b) evaluation of individual geophysical techniques and instruments used for site characterization, including the accuracy and applicability of each instrument and technique.

Those research projects associated with surface and subsurface waste management include: (a) evaluation of trench lining and grouting prior to trench cover emplacement, (b) design and field testing of

biointrusion barriers, (c) integrated system studies of cover types, vegetation, internal drain layers and their effect on runoff and infiltration.

Research into predictive capabilities for performance of near surface disposal facilities includes: (a) development and application of performance assessment and transport models for humid and arid disposal environments, (b) use of gas tracers to predict arid site transport, (c) development of a cost-effective method to perform sensitivity analysis on site performance models, (d) development of an assessment tool for waste treatment and disposal, and (e) validation of leach rates of radionuclides from low-level wastes.

Additional data on leaching rates are being obtained from three studies using radioactive waste bured in lysimeters. Forty lysimeters filled with typical radioactive waste from the Savannah River Plant are being monitored for radionuclide migration. These field studies will provide field leaching data on nonsolidified wastes.

Corrective Measures Technology

Based on experience, conditions occur or may develop after burial which can cause problems related to the physical stability and hydrologic isolation. To assist operators in stabilizing retired LLW disposal sites, the corrective measures technology program element was established by the LLWMP. This element of the Program is designed to ensure that radionuclide releases will not exceed performance standards at any particular site.

To date, this research in these areas has tested active techniques for long term control of subsidence including: mass impact, vibratory hammer, and pile driving. Dynamic consolidation to reduce trench void volume was successfully demonstrated on an existing disposal trench at Oak Ridge National Laboratory in 1985. Direct pressure injection of particulate grouts into subsurface cribs and associated access ports and piping will be developed in conjunction with the simultaneous dynamic consolidation (vibratory) injection grouting technique.

Arid site field experiments are being conducted to quantify effective methods for use in designing remedial measures which maintain or improve the containment capabilities of disposal sites. These field experiments provide data for modeling of erosion control technologies, evaluating biointrusion barrier performance, and determining subsidence effects on multilayer trench caps.

Greater Confinement Disposal

The objective of this research area is to assure that the means are available to dispose of low-level waste in such a manner as to achieve greater confinement than that provided by conventional shallow land burial. Problem wastes, with respect to greater confinement disposal (GCD), are those generally containing radionuclides with longer half lives or very high specific activity. Wastes containing extremely mobile nuclides, such as tritium, may also be candidate GCD wastes. Those wastes exceeding the limits established by the NRC for near surface disposal (greater than Class C) probably will require some form of enhanced confinement.

Research projects being conducted in this area include: (a) preparation of a technology transfer document on greater confinement disposal, (b) demonstration of greater confinement disposal in an arid environment, (c) demonstration of greater confinement disposal in a humid environment, and (d) selection and field testing of sorbent materials for radionuclide retention.

A handbook is being prepared for greater confinement disposal which will provide information for planning, managing, and regulating GCD facilities. The document is intended to provide guidance for conducting specific studies that will be needed to choose between different site locations, facility designs, operating procedures, and closure options for GCD wastes. Structuring of the decision-making process and identification and resolution of potential problems will be emphasized. GCD alternatives to be discussed include disposal in an augered shaft, mined cavity, deep trench, engineered structures, hydrofracturing, and use of improved waste forms and high integrity containers.

Greater confinement disposal in an arid environment is being demonstrated by using the large diameter borehole concept at an arid site. The objectives are to: (a) design, construct, operate, and decommission a greater confinement disposal demonstration test using disposal in a large diameter drilled hole, (b) define the construction, operation, decommissioning, and monitoring methods to be used at greater confinement facilities of this type, (c) determine the economics of this type of greater confinement, and (d) demonstrate the radiological safety of this type of greater confinement. The facility is operational and is currently being monitored.

The humid site GCD demonstration is to show that intermediate depth disposal in conjunction with engineered clay barriers to prevent water intrusion can provide a means of disposing of higher--specific activity or otherwise problematic low-level waste. To test this concept, a small-scale landfill was constructed for the greater confinement disposal of nitrate salts (combined into a concrete matrix) produced from solidification of high-level waste. The principal activity for the duration of this project will be continued monitoring and analysis of water samples to obtain a complete picture of moisture movement over and through the engineered barriers system. Results from the test will provide definitive data on the adequacy of this concept for GCD.

The use of sorbent materials to enhance the containment of a particular disposal facility is also being researched. This effort is evaluating and providing new and cost-effective technology for restricting the migration of radionuclides from low-level waste sites. The primary emphasis is to identify and evaluate filtration and sorbent materials as engineered barriers at these sites. The degree that proper sorbent materials, improve the natural effectiveness of clay or other soils is being determined.

In addition to the technology activities described above, the Department is also conducting a Policy Evaluation of options for disposal of commercial waste above the NRC Class C limits.

Monitoring

Even though a waste disposal site is properly sited and designed, its anticipated performance must be confirmed. Performance may be evaluated by implementing an environmental monitoring program.

Research areas investigated in this area include: (a) documentation of environmental monitoring techniques, and (b) development of long term monitoring strategies for retired LLW disposal sites.

The documentation task identifies and documents current experience and improved environmental monitoring techniques employed at commercial as well as the major DOE sites. Emphasis is placed on techniques which provide verification of site performance. This research reviews recent developments, including equipment availability and cost, in techniques to detect and monitor the movement of radionuclides from disposal sites via the full spectrum of potential pathways.

Development of long term monitoring strategies provides guidance on how to select monitoring systems and plans for retired disposal facilities. Strategies on the gradual reduction in monitoring frequency and intensity as well as radionuclides to be monitored have been developed.

An improved method of analyzing water samples using inline ion exchange resin columns has been developed. Analysis of the radionuclides absorbed on the columns has effectively lowered the detection limit for select radionuclides. An automated soil gas sampling and monitoring system has been developed for use in arid environments where the lack of moisture precludes the use of monitoring wells and soil moisture sampling systems.

FUTURE RESEARCH

Future research funded through the Defense LLWMP will focus on providing the information and methodologies necessary to use a systems approach to LLW management at DOE facilities. This research will focus on the waste management system as a whole instead of its individual components (waste treatment, waste disposal). Techniques for assessing and predicting performance of enhanced treatment and disposal systems will be further developed for implementation at DOE facilities. Techniques for site stabilization and closure will be further demonstrated at DOE sites and this information will be shared with the commercial sector.