Almost Mission Impossible: The History and Lessons Learned on Completing the Final Remedy for the Mixed Waste Landfill at Sandia National Laboratories – New Mexico

Joe G. Estrada, PMP and John Cochran
National Nuclear Security Administration – Sandia Site Office, Albuquerque, NM 87185
Sandia National Laboratories – New Mexico, Albuquerque, NM 87185

ABSTRACT

The mission is to implement the final remedy at Sandia National Laboratories' (SNL) Mixed Waste Landfill (MWL). The landfill is a 2.6-acre site located in the central portion of Kirtland Air Force Base, approximately 5 miles southeast of the Albuquerque International Sunport. The MWL was established in 1959 as a disposal area for low-level radioactive waste generated by SNL research facilities. Low-level radioactive waste and minor amounts of hazardous waste were disposed in the MWL from 1959 through 1988. Approximately 100,000 cubic feet of waste containing approximately 6,300 curies of activity (in 1989) were disposed of in the landfill. Wastes disposed of in the landfill include organic compounds, oils, depleted uranium, lead shielding, activation products, beryllium, sodium, lithium, neutron generator tubes, liquid scintillation vials, contaminated equipment, decontamination materials, construction debris, contaminated soils, and solid wastes. The landfill is separated from the groundwater by 500 feet of dry clays, sands and gravels.

The New Mexico Environment Department (NMED) regulates the characterization and corrective action of the MWL. The MWL has been monitored since 1969 and actively studied since 1991. An extensive investigation effort provided the technical foundation for the determination that the landfill is not expected to contaminate groundwater and does not represent an unacceptable risk to human health and the environment. After the extensive investigation, public meetings and a public hearing, the Secretary of NMED issued a Final Order in 2005 selecting a ~3-foot thick vegetative (evapotranspirative soil) cover with a bio-intrusion barrier as the final remedy. Also, the NMED requires a comprehensive fate and transport model, triggers for future action, a convenient method and schedule for the public to review and comment on major documents, re-evaluation of the feasibility of excavation of the landfill and remedy effectiveness every 5 years and the installation of a long-term groundwater monitoring system.

Construction of the cover was achieved in September 2009 and the other Final Order requirements are in progress. The major mission was completion of the cover; however, sharing the lessons learned about one of the most controversial landfills in New Mexico is the next opportunity. Regulatory closeout and implementation of long-term stewardship at the landfill continues to be a technical and project management challenge. Changing technical requirements, scheduling workarounds and public activism will most likely be part of the challenge.

INTRODUCTION

The MWL was established in 1959 as a disposal area for low-level radioactive waste generated by SNL research facilities. Low-level radioactive waste and minor amounts of hazardous waste were disposed in the MWL from March 1959 through December 1988. Approximately 100,000 cubic feet of waste containing approximately 6,300 curies of activity (in 1989) were disposed of in the landfill. These wastes were disposed of in seven trenches, typically 15 ft deep, 20 ft wide, and 120 ft long. The landfill is separated from the groundwater by 500 feet of dry clays, sands and gravels.

Wastes disposed of in the landfill include organic compounds, oils, depleted uranium, lead shielding, activation products, beryllium, sodium, lithium, neutron generator tubes, liquid scintillation vials, contaminated equipment, decontamination materials, construction debris, contaminated soils, and solid wastes. The only liquid waste ever disposed of in the landfill was in 1967 and consisted of approximately 200,000 gallons of reactor coolant water containing ~ 1 curie of total radioactivity. Because the disposal occurred in 1967, the short half-lived activation products have decayed to below detectable levels.

FROM CHARACTERIZATON TO COVER CONSTRUCTION

Characterization of the MWL

Environmental monitoring has been conducted at the MWL since 1969. Early monitoring activities consisted of boreholes and soil sampling to determine if contaminant releases had occurred. Using monitoring data, extensive characterization has been conducted on the air, surface soils, subsurface soils, groundwater and biota surrounding the MWL.

MWL groundwater has been monitored since 1990 for radionuclides, heavy metals, organic compounds and general water chemistry. At this time, no groundwater contamination has been detected.

A Phase 1 Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was conducted in 1989 and 1990 to begin characterizing the MWL and the nature and extent of contamination. This investigation included walkover surveys for radiation and volatile organic compounds (VOCs); surface soil sampling; air sampling; and the drilling of 18 boreholes to depths of up to 150 ft around the landfill perimeter. Surface and subsurface soil samples were analyzed tritium, gross alpha/beta, gamma emitters, isotopic uranium & plutonium, VOCs, and semivolatile organic compounds (SVOCs). The Phase 1 investigation identified tritium as the primary contaminant of concern, while no other contaminants were detected.

In 1992, a Hazardous Air Pollutant Baseline Study was conducted which consisted of three monitoring stations – one upwind and two downwind from the MWL. Samples were collected and analyzed for Pu-238, Pu-239/240, uranium and beryllium. It was found that these radionuclides were not present above Department of Energy (DOE), federal or state ambient air standards.

From 1992 to 1995, a Phase 2 RFI was conducted to investigate environmental impacts associated with disposal activities at the MWL. The investigation included surface radiological surveys; ambient air sampling; soil sampling for background metals and radionuclides; soil sampling for VOCs, SVOCs, Target Analyte List (TAL) metals, and radionuclides; nonintrusive geophysical surveys; passive and active soil gas sampling; borehole drilling; installation of groundwater monitoring wells; groundwater sampling; vadose zone tests; aquifer tests; and risk assessment. Tritium was confirmed as the primary contaminant of concern in the soil and air.

The maximum tritium level detected in the surface soils was 1103 pCi/g, while at 30 ft below ground surface (bgs); the maximum was 207 pCi/g. Below 30 ft bgs, tritium levels fell off rapidly to a few pCi/g (Peace et al. 2002). Tritium also occurs as a diffuse air emission from the landfill. Tritium flux measurements were conducted in 1993 and 2003. In 1993, tritium emissions measured 0.294 Ci/yr, while in 2003 they measured 0.090 Ci/yr. This is approximately a 70% reduction in tritium activity over a 10 year period.

During the timeframe of the Phase 2 RFI, the maximum radiological dose to the maximally-exposed on-site receptor was 0.29 mrem/yr due to combined tritium soil and vapor exposure. For comparison, the average radiation exposure due to natural sources (radon, internal radiation, cosmic radiation, and terrestrial radiation) in the United States is approximately 295 mrem/yr. In Albuquerque, the background radiation level is 300 to 500 mrem/yr. The calculated MWL doses for the industrial land-use scenario are well below the regulatory benchmark for the net dose for an industrial site of 15 mrem/yr.

The biota at the site has also been extensively studied. The vegetation along the perimeter has been sampled annually since 1980. Tritium activities in the vegetation were found to be above background levels. The highest tritium activities were found from 1991 to 2000 and averaged 9.1 pCi/ml. During this period, the maximum tritium activity measured was 26 pCi/ml. Based on this maximum value, one would have to ingest 260 lb of vegetation to receive a dose of 1 mrem. In 1997, an ecological study was conducted where small mammal samples were collected from the MWL and from a control site along the Isleta Pueblo/Kirtland Air Force Base boundary. Species trapped included Merriam's kangaroo rat, deer mouse, and silky pocket mouse. Tissue analyses were conducted for tritium, total uranium, gamma spectroscopy, metals, and strontium-90. Statistical analysis showed elevated tritium in the mice collected from the MWL, but no other contaminants were detected.

Corrective Measures Study

In 2001, the NMED directed the DOE and Sandia to conduct a Corrective Measures Study (CMS) for the MWL. This study was conducted over a two year period. The purpose of the CMS was to identify, develop, and evaluate corrective measures alternatives and recommend the corrective measure(s) to be taken at the MWL (SNL/NM 2004).

Corrective action objectives developed for the MWL are designed to protect human health and the environment and take into consideration source areas, pathways, and receptors. The objectives consist of the following: 1) minimize exposure to site workers, the public, and wildlife; 2) limit migration of contaminants to groundwater such that regulatory limits are not exceeded; 3) minimize biological intrusion into buried waste and any resulting release and redistribution of contaminants to potential receptors; and 4) prevent or limit human intrusion into buried waste over the long term (Peace and Goering 2004).

A detailed evaluation of the candidate technologies was conducted according to five criteria specified by the EPA and the NMED: 1) long-term reliability and effectiveness (risk remaining after remedy implementation, extent of long-term monitoring, and potential for failure), 2) reduction of toxicity, mobility, or volume of waste, 3) short-term effectiveness (risk to public, workers, and the environment during implementation), 4) implementability (difficulty in implementation) and 5) cost (capital, operations and maintenance).

Corrective measures alternatives are based upon the results of the MWL Phase 1 RFI, the Phase 2 RFI, MWL groundwater monitoring, environmental studies conducted at the MWL since 1969, and public input. Sixteen remedial technologies were evaluated but only four corrective measures alternatives were found suitable for the MWL and evaluated in detail. These alternatives included three containment alternatives and one excavation alternative:

1. No Further Action (NFA) with institutional controls (ICs);
2. Vegetative Soil Cover;
3. Vegetative Soil Cover with Biointrusion Barrier; and
4. Future Excavation.

Based upon detailed evaluation and risk assessment using guidance provided by the EPA and the NMED, the DOE and Sandia recommended that a vegetative soil cover be deployed as the preferred corrective measure for the MWL. The cover would be of sufficient thickness to store precipitation, minimize infiltration and deep percolation, support a healthy vegetative community, and perform with minimal maintenance by emulating the natural analogue ecosystem. There would be no intrusive remedial activities at the site and therefore no potential for exposure to the waste. This alternative poses minimal risk to site workers implementing institutional controls associated with long-term environmental monitoring as well as routine maintenance and surveillance of the site.

In 2004, the CMS report was submitted for public comment and NMED conducted a formal public hearing to review remedial options for the MWL. The following year, the Secretary of the NMED selected a vegetative soil cover with bio-intrusion barrier as the remedy for the MWL.

Corrective Measures Implementation Plan

After the extensive investigation, public meetings and a public hearing, the NMED Secretary issued the Final Order in 2005. The Corrective Measures Implementation (CMI) Plan incorporates the final remedy selected by the NMED. The document contains a description of the selected remedy, the objectives for the remedy, detailed engineering design drawings and construction specifications, a construction quality assurance plan, and a health and safety plan.

The final remedy selected is a protective cover that is comprised of 4 engineered layers, including 3 layers of compacted soil and a biointrusion rock barrier that will keep burrowing animals from intruding into the former waste disposal areas. Together, these four layers and the native plants will control water infiltration and runoff, thus isolating the wastes from the biosphere. Because the cover is constructed without rigid layers, it can accommodate differential subsidence without undue impairment of its performance.

The natural site conditions at the site include: 1) extremely low precipitation and high potential evapotranspiration, 2) negligible recharge to groundwater, 3) an extensive vadose zone, 4) groundwater approximately 500 feet bgs, and 5) a versatile, native flora that will persist indefinitely with little or no maintenance. Performance of the cover is integrated with the natural site conditions, producing a "system performance" that will ensure that the cover protects both human health and the environment.

Long-Term Monitoring and Maintenance Plan

The NMED regulates the MWL as well as the implementation of institutional controls and long-term monitoring and maintenance. In addition to ongoing groundwater monitoring, monitoring of both soil moisture and soil gas in the unsaturated subsurface soils overlying the deep groundwater will be conducted at the site. Monitoring and maintenance of the cover will also be conducted to document and address subsidence, erosion, and intrusive animal and/or plants species that could potentially have an adverse impact on cover performance.

The NMED Final Order and the Class 3 Permit Modification require the development of a Long-Term Monitoring and Maintenance Plan (LTMMP). The LTMMP describes how the DOE and Sandia will meet the long-term monitoring requirements for the MWL. The plan also describes the necessary physical and institutional controls to be implemented, the maintenance and monitoring activities for the cover, and the frequencies at which they will be conducted. These activities will be performed to ensure that the MWL vegetative soil cover and biointrusion barrier perform as designed and continue to protect human health and the environment.

MWL Cover Construction

After a review of competitive bids, Sandia awarded the construction contract to a local, small business. Construction of the cover was achieved in September 2009 and the other Final Order requirements are in progress. Cover construction was completed on-schedule and budget, at a cost of about $2.5 million dollars. More importantly, the construction proceeded without any injuries or safety incidents.

LESSONS LEARNED FROM THE MIXED WASTE LANDFILL

The major mission at the MWL was completion of the cover; however, sharing the lessons learned about one of the most controversial landfills in New Mexico is the next opportunity. The lessons learned from the MWL were compiled based on interviews from former and current members of the project staff.

Inventory

A detailed MWL waste inventory, by pit and trench, is provided in Appendix A of SNL/NM 1993. The inventory is based upon interviews with current and retired employees, photographic records, classified and unclassified disposal records, solid waste information sheets, and nuclear material management records. Most pits and trenches contain routine operational and miscellaneous decontamination wastes, which were contained prior to disposal. Larger items, such as glove boxes, construction debris, and spent-fuel shipping casks, were disposed of in bulk without containment. Disposal of free liquids was not allowed at the MWL. Liquids were solidified with commercially available agents prior to containment and disposal.

Characterization studies have shown that tritium is the primary contaminant of concern at the MWL. The initial inventory of tritium was estimated from past records (SNL/NM 1993). In performance assessment modeling activities, the extent of the contaminated waste zone was allowed to vary from the size of an individual pit to the entire size of the MWL. In addition, the inventory was allowed to vary between the estimated value (as a lower bound) and an upper bound equal to twice the estimated value.

Knowledge of the inventory has improved over time and characterization studies conducted at the MWL have helped to corroborate the inventory.

Characterization

Monitoring and characterization at the MWL have been conducted over the last 40 years. Technology has advanced substantially since that time. Monitoring and characterization methods should adjust accordingly.

For example, drilling methods have changed since the time of well installation and groundwater wells need to be replaced, using current methods, at the end of their useful life. Well installation and sampling methods should be comparable with industry-wide accepted methods.

Regulatory Issues

Regulatory closeout and implementation of long-term stewardship at the landfill continues to be a technical and project management challenge. Changing technical requirements, scheduling workarounds and public activism will most likely be part of the challenge.

There have been continuous regulatory decision delays as result of activist intervention. For example, the Soil-Vapor Sampling Work Plan was initially submitted in December of 2006. However, upon public hearing requests, the Plan was not approved until February 2008. Public intervention should be expected and planned for in advance. Public hearings can be very time consuming and costly, so staff should be trained accordingly to ensure the hearings go as smoothly as possible.

Maintaining a positive working relationship with NMED has been essential. Agreements with the regulators must be made in advance, however. Items that should be determined early during the project planning phase include things like the site regulatory framework and groundwater well point of compliance locations. For the MWL, these were not decided in advance and thus decision making added unexpected amounts of time to the project schedule. All interactions, whether with the public or governing agencies, verbal or written, should be documented and stored as project records.

Public Relations and Freedom of Information Act (FOIA) Requests

The MWL is one of the most controversial landfills in New Mexico, and is therefore frequently exposed to public scrutiny. It is important that project staff be proactive and not reactive when addressing concerns of the public. It is imperative to recognize in advance the potential significance of public concerns and how they can affect the project as a whole. It is necessary to respond with a unified voice. In order to achieve this, the project staff must prepare a strategic public relation communications plan, which should include training the technical staff to deal with the public and educating public relations personnel on the technical issues.

One way to be proactive is to expect FOIA requests and to allocate resources to address them. For records purposes and to avoid duplication of requests, it is important to keep an accurate accounting of all FOIA requests. The project should maintain a retrievable record of all incoming requests and outgoing responses. All records should be available and easily accessible to the public either via an up-to-date website or a public records center containing hardcopies of all documents.

Project Internal

The traceability of decision processes is important, and project staff should anticipate and be able to professionally handle negative publicity. It is essential that project staff understand the consequences of remedy selection and be able to communicate the decision process to the public.

It is necessary to implement a tracking system for all costs associated with additional activities (FOIAs, hearings, Notice of Disapproval, delays) in order to demonstrate the costs. Differing professional opinions will undoubtedly occur, but exit strategies must be executed. Project delays and loss of institutional memory have undermined the robustness and efficiency of the project.

Field Activities

A number of lessons were learned during field activities such as the subgrade installation and the soil vapor survey. These lessons can be helpful to other institutions conducting similar projects by saving time and money and ensuring the safety of the project staff.

A significant amount of time and resources must be allowed for pre-field work activities and document preparation given the continual increase in requirements (Environment, Safety & Health, training, etc.). It is important to allow adequate time to complete field work by considering schedule delays due to weather, maintenance, personnel schedules, and laboratory turn-around time. Also, adequate time must be allocated for report preparation and review. Consideration should be made for potential maintenance costs as well as costs associated with waste management and disposal.

Appropriate and modern equipment and methods should be used. Drilling equipment must be robust enough for project needs, as undersized equipment may result in not completing project sampling requirements and could cause schedule delays and increased cost. It should not be overlooked that smaller contracting companies may not have the infrastructure to support the necessary requirements. Only established and approved technical procedures should be used.

CONCLUSIONS

The MWL is a controversial landfill with decades of history. The lessons learned can be used to implement procedures that can enhance the trust between project staff, regulators, and the public. The key lessons learned include:

- Trust with formal documentation
- Do not underestimate public interactions
- Use a Communications Plan and trained personnel
- Maintain impeccable records
- Consider the value of proceeding with remedy at risk
- Track important costs such as Infrastructure and Work Breakdown Structure changes
- Interact with State on planning and schedule

Interactions with regulators and the public are unavoidable. Project staff must be trained accordingly, i.e. to handle negative publicity. It is important that the regulators agree in advance on planning and schedule, and included in this schedule must be time and costs associated with delays due to comment periods and public concerns.

One of the most important lessons learned on this project is that it is extremely beneficial to maintain impeccable records. Meticulous record keeping is essential for assuring that mistakes are not repeated.

References

Peace, J. L. et al., 2002, *Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation Sandia National Laboratories, Albuquerque, New Mexico,* Sandia National Laboratories, Albuquerque, NM.

Peace, J. L. and T. J. Goering, 2004, *Mixed Waste Landfill Corrective Measures Study Final Report Sandia National Laboratories, Albuquerque, New Mexico*, Sandia National Laboratories, Albuquerque, NM.

Sandia National Laboratories/New Mexico (SNL/NM), 1993, *Mixed Waste Landfill Phase 2 RCRA Facility Investigation Work Plan*, Sandia National Laboratories, Albuquerque, NM.

Sandia National Laboratories/New Mexico (SNL/NM), 2005, *Mixed Waste Landfill Corrective Measures Implementation Plan*, Sandia National Laboratories, Albuquerque, NM.

Sandia National Laboratories/New Mexico (SNL/NM), 2007, *Long-Term Monitoring and Maintenance Plan for the Mixed Waste Landfill*, Sandia National Laboratories, Albuquerque, NM.