RESULTS OF HAZARDOUS AND MIXED WASTE EXCAVATION FROM THE CHEMICAL WASTE LANDFILL

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ABSTRACT

This paper describes the results of the excavation of a 1.9-acre hazardous and mixed waste landfill operated for 23 years at Sandia National Laboratories, Albuquerque, New Mexico. Excavation of the landfill was completed in 2 ½ years without a single serious accident or injury. Approximately 50,000 cubic yards of soil contaminated with volatile and semi-volatile organics, metals, polychlorinated biphenyl compounds, and radioactive constituents was removed. In addition, over 400 cubic yards of buried debris was removed, including bulk debris, unknown chemicals, compressed gas cylinders, thermal and chemical batteries, explosive and ordnance debris, pyrophoric materials and biohazardous waste. Removal of these wastes included negotiation of multiple regulations and guidances encompassed in the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), and risk assessment methodology. RCRA concepts that were addressed include the area of contamination, permit modification, emergency treatment provision, and listed waste designation. These regulatory decisions enabled the project to overcome logistical and programmatic needs such as increased operational area, the ability to implement process improvements while maintaining a record of decisions and approvals.

INTRODUCTION

The Chemical Waste Landfill (CWL) is a 1.9-acre site used for disposal of chemical wastes generated by Sandia National Laboratories (SNL/NM) research laboratories from 1962 until 1985. In 1981 all liquid waste disposal was discontinued and in 1985 all pits were covered with soil backfill, and the landfill was operated as a hazardous waste drum storage facility until 1989 under the Resource Conservation and Recovery Act (RCRA). A Closure Plan for this site was approved by the State of New Mexico Environment Department (NMED) in 1992, after trichloroethylene was detected in the groundwater approximately 500 feet below the site at concentrations just over the drinking water limit of 5 parts per billion.

As part of a voluntary corrective measure, SNL/NM began excavation of the site in September 1998 to mitigate risks posed by the landfill and to provide proper management and disposal of the landfill contents. Disposal records were kept during the operation of the landfill and an attempt was made to segregate incompatible materials into different disposal trenches. However, both of these activities were not entirely successful. Landfill disposal records were only available for the last 10 years of the 23-year disposal history. Earlier records were presumably destroyed as a result of the 1975 Paperwork Reduction Act. Remaining records were incomplete, inaccurate, and vague, as evidenced by entries such as "unknown fume hood chemicals". Similarly, retiree interviews indicate that incompatible materials were occasionally placed in the same trench and containers of potentially reactive materials were sometimes broken. In fact, one account describes a chemical fire in one trench that burned for days (1).

Due to the partially unknown nature of the disposal history, the initial excavation approach was very cautious and labor-intensive. The average excavation rate was 138 cubic yards per 50-hour workweek. In July 1999, the excavation process was re-engineered, based on waste items and site conditions encountered during the first year. The new process used a commercially available mechanized screen combined with a risk-based approach. The risk-based approach, approved by the NMED in October 2000, allowed excavation to focus on the removal of highly contaminated soil, so that this soil could then be treated at an adjacent Corrective Action Management Unit (CAMU). Soils below risk-based levels were segregated for use as backfill. This new process increased the safety of site personnel by using more remote means of excavation and improved ergonomic conditions, thus increasing productivity. The average rate of excavation using this process was 413 cubic yards per 50-hour workweek.

In June 2001 the last of the buried debris from the Chemical Waste Landfill (CWL) was removed (Figure 1). Over 50,000 cubic yards of material was excavated and safely managed during this process. This included approximately 50,000 cubic yards of soil, 1,000 cubic yards of rocks, and 500 cubic yards of debris, chemical containers, and other buried waste material. Approximately 25,000 cubic yards of the excavated soil is at the CAMU and the remainder is either waiting for final characterization data or earmarked for backfill.

Costs for excavation and disposal of chemical debris and radiologically contaminated debris are projected to be $21.5 million, or about $350 per cubic yard. Additional cost will be incurred during treatment and disposal of excavated soil containing hazardous constituents and polychlorinated biphenyl compounds (PCBs) at the adjacent CAMU, pending approval of the risk-based clean-up approach requested under the Toxic Substances Control Act (TSCA).

Based on the absence of records during some of the disposal period and the fact that undocumented disposals may have occurred, health and safety of site personnel and Sandia National Laboratories employees located at neighboring facilities was of utmost importance throughout the excavation process. Extensive emergency planning, disaster scenario modeling and frequent routine communication with employees at neighboring facilities mitigated many concerns. Rigorous health and safety measures, including the use of level A-D personal protective equipment, were implemented to protect site workers resulting in over 200,000 man-hours worked without a single serious injury or accident. This outstanding safety record was accomplished using the Department of Energy's Integrated Safety Management System (ISMS). The ISMS approach, like the excavation approach, relied on continuous improvement as experience was gained and integrated during the project.

Fig. 1.Excavation of the Buried Debris from the 1.9-acre Chemical Waste Landfill was Completed in June 2001

Excavated Waste

Approximately 50,000 cubic yards (CY) of soil were excavated from the CWL. (Table I). This included 1,780 CY of soil containing RCRA regulated hazardous volatile or semi-volatile constituents at or above the treatment levels specified in the CAMU permit, 14,607 CY of soil containing RCRA-regulated metals requiring treatment, 6,160 CY of soil that require treatment for both metals and organic constituents, and 21,925 CY of soil that pass the risk-based criteria developed for the CWL and/or require no treatment at the CAMU. Polychlorinated biphenyl compounds (PCBs) were found in 5,850 CY of the excavated soil at levels that are regulated under the Toxic Substances Control Act (TSCA). Additional management controls are placed on these TSCA-regulated soils. Low levels of tritium are also associated with some of the soils, further complicating the available disposal options for these soils.

Table I. Summary of Soils Excavated from the Chemical Waste Landfill

	Volume of Material Excavated (cubic yards)	Constituents Above Risk-Based Criteria
	1,780	Organics
	14,607	Metals/Inorganics
	6,160	Organics and Metals/Inorganics
	5,850	PCBs
	21,925	None[a]
Total Volume of Soil Excavated	50,322	
	50	Wood
	40	Concrete
	188	Metal
	120	Compactable Materials
	45	Resins and Epoxies
Total Volume of Debris Excavated	443	
Total Volume of Material Excavated	50,765	

[a] Results of semi-volatile organic constituent analysis are not available yet for several hundred cubic yards of these soils, but they are all anticipated to be below the risk-based criteria.

Bulk debris materials that were recovered from the excavated soil include wood, concrete, metal, and compactable materials (paper, plastic, cardboard, cloth, etc.). Most of the 50 cubic yards of wood appears to be pieces of broken pallets that were placed in the landfill. Most of the 40 cubic yards of concrete was removed from monitor well bollards and fence posts that existed inside the landfill using a skid-steer loader equipped with a rock breaker attachment. Of the 188 cubic yards of metals recovered from the landfill, approximately 1/3 are non-ferrous materials and range from Dewar flasks to copper tubing to aluminum and stainless steel reaction vessels. The ferrous metals are predominantly highly corroded due to the ubiquitous presence of acid wastes in the disposal pits. Many corroded 55-gallon drum pieces were removed, but most of the steel is from large vessels and glove boxes and unidentifiable scrap materials. A number of components and assemblies, such as vacuum system control panels and small motors were also recovered. The compactable materials were loosely placed in 55-gallon bags that fill three 40 cubic yard roll-off bins. Resinous materials, hardened polyurethane foam products and epoxies segregated from other waste types presented a variety of physical states ranging from very hard non-porous blocks to vesicular masses to semisolid casts of glass jars that had broken off from around the solidified materials.

Approximately 2,000 chemical containers with unknown contents were recovered intact. To date, about half of these have been identified at the on-site mobile laboratory and these included laboratory reagents, acids, solvents, oxidizers, carcinogens, water reactive materials, pyrophoric materials, inert salts, plasticizers, darkroom chemicals, epoxies, oils, paints, and other industrial products. The remainder of these chemicals were characterized to allow for proper storage according to material compatibility until final identifications can be completed (Figure 2).

Fig. 2. Excavated chemical containers with unknown contents

Although intended only for chemical disposal, 357 compressed gas cylinders that appeared to be intact were also excavated. 233 were empty. Of the remaining 124 cylinders: 54 contained atmospheric gases (air, nitrogen, oxygen, argon, and/or neon), 6 contained process gases (carbon dioxide, carbon monoxide, and/or hydrogen), 45 contained other gases, and 19 contained solids and/or liquids. A detailed list of cylinder contents is presented in Table II.

Over 1,000 thermal batteries were excavated and stored safely in a special cage until testing and characterization were completed. Approximately 84% of these thermal batteries were tested in the field and determined to be safe for disposal. Prior to disposal, the remaining 171 batteries will require x-ray analysis to verify that they have been discharged. In addition, several hundred chemical batteries were excavated and managed. Sandia National Laboratories was involved with the development of nickel/cadmium batteries used in early nuclear weapons followed with the development of zinc/silver oxide batteries (2).

Table II. Contents of Cylinders Processed at the Chemical Waste Landfill

Atmospheric Gases	Process Gases	Other Gases	Solids and Liquids
Air	Carbon Dioxide	Ammonia	Ammonia/Chlorine Solution
Air,Trace Freon	Carbon Monoxide	Ammonia/Phosphine	HBr
N2, O2, Ar	Hydrogen	Carbon Disulfide	Liquid
N2,Air		Carbon Monoxide	Nickel Plating Solution/Ammonia
N2,O2		Chlorine	Solid Media
N2,O2,Argon, Liquid		Chlorine, Hydrogen Chloride	Solid Media
N2,tr O2		D2,N2,O2,tr SF6	Solid/Metal Chips
Nitrogen		Dichlorosilane	Sticky Foam
		Dichlorosilane/HCl	
		Ethane,tr O2,CO2	
		Fluorinated Hydrocarbon	
		Hexafluoroethane	
		Hydrogen Chloride	
		Hydrogen Fluoride	
		Hydrogen Sulfide	
		Methane	
		Molybdenum Hexafluoride	
		Nitric Oxide	
		Nitric Oxide/Nitrogen Dioxide	
		Nitric Oxide/Nitrous Dioxide	
		Nitrogen Trioxide	
		Nitrous Dioxide	
		Nitrous Oxide	
		Phosphine	
		Propylene	
		Silicon Tetrafluoride	
		Trimethylaluminum	
		Tungsten Hexaflouride	
		Tungsten Hexafluoride, HF	

Thermally activated batteries were introduced in 1955 using the calcium/calcium chromate electrochemical couple, until 1980 when it was replaced with lithium-silicon/iron disulfide. Ambient-temperature lithium systems were developed beginning in 1972 and the more recent focus was on lithium/sulfur dioxide, lithium/manganese dioxide and lithium/thionyl chloride cell designs and batteries.

Approximately 26 pieces of ordnance debris/potentially unexploded ordnance, and explosive compounds were excavated from the landfill. The ordnance debris included three expended 5-inch diameter rocket motors, two partially intact smoke grenades, and twenty-one flash tubes with intact primers. Flash tubes are components of 105 and 155-millimeter cartridge cases. Additionally, approximately 0.15 pounds of sodium amide were excavated. Sodium amide, NaNH2 is a white, crystalline powder used in the manufacture of sodium cyanide and in organic synthesis (3). Sodium amide is water reactive and may form toxic gases when exposed to water; but the real hazard is that sodium amide forms peroxides when exposed to atmospheric oxygen. These metal peroxides, tentatively identified by the presence of a heavy brown crust, are highly reactive and could spontaneously decompose. If present, the dangerously unstable peroxides could have exploded, even from the minimal force used to open the container (4).

Potentially biohazardous waste that was encountered during excavation included hypodermic syringes that may have originated at the Sandia National Laboratories medical clinic. Conversely, the syringes may have been used for gas chromatographic sample introduction or other laboratory use. Three vials were excavated as a group that were labeled "polio". The original laboratory researcher and their notebooks describing the history of these vials were located. Polio virus was introduced into municipal sludge during an experiment to test whether gamma irradiation would inactivate the virus and render the sludge useful as a topical fertilizer in municipal areas. These records indicated the vials had been inactivated by autoclaving prior to disposal (5).

Regulatory Issues

In 1999 the excavation process was re-engineered to incorporate the use of a hydraulic-powered, commercially available, screening device; expand the operational area; and implement a risk-based approach to excavation cessation and allowable backfill material. A Class 2 modification to the RCRA Closure Plan was approved by the NMED that included the implementation of the Area of Contamination (AOC) concept (6, 7). The AOC approval expanded the operational area beyond the confines of the landfill itself. Prior to this approval, all excavated soils and other wastes generated were stored on top of the landfill. Clearly, as excavation progressed, diminishing surface area would be available for storage of wastes and related operations such as equipment decontamination, forcing the project to cease before completion.

Following this Class 2 modification, a risk-based approach document was approved in a letter approval by NMED (8). This approval allowed excavation to cease when concentrations of RCRA-regulated constituents fell below negotiated risk values rather than background values, as originally proposed. Additionally, excavated soils that met these established risk criteria could then be returned to the excavation as backfill material once excavation was completed. This approach was implemented to maintain consistency with the approach used at other Sandia National Laboratories environmental restoration sites and to address the fact that the CAMU disposal cell was not designed large enough to hold both the soils from the burial trenches as well as the soil surrounding these disposal areas. Calculations derived for the anticipated volume of the CAMU disposal cell did not include a large enough term for contaminated soil surrounding the burial trenches.

Based on the available inventory of disposal, soils immediately under the buried debris were expected to have very high concentrations of RCRA regulated constituents and it was expected that this area of highly concentrated waste soil could be removed with a trackhoe. Once excavation began, this conceptual model proved to be inaccurate. Trenches were spaced closer together than the width of the trackhoe bucket, were not distinguishable during excavation, and concentrations of contaminants were found at moderate to very low levels in most of the excavated soils, regardless of location relative to the burial trenches.

Storage, treatment and disposal problems surfaced as more PCB-containing soils were excavated than estimated and many of these soils were found to contain low levels of tritium. In excavated soils with PCBs above 50 parts per million, the measured tritium concentrations reached 23,000 Pico curies/liter. Approximately 3,910 cubic yards of excavated soil had tritium concentrations above the background concentration of 420 Pico curies/liter. Disposal facilities for these soils are limited. Appropriate storage facilities under the TSCA self-implementing option (9) were planned for storage of these soils for a maximum of six months. Lower than expected excavation rates caused the six month storage projection to require amendment. An extended storage request was approved by the Environmental Protection Agency (EPA) that placed the project under the risk-based requirements of TSCA, rather than the self-implementing option (10, 9). Subsequently, an application was submitted to the EPA proposing that other areas of the project, such as equipment decontamination and verification sampling, be modified to be consistent with the risk-based approach and NMED-approved RCRA requirements. The EPA is currently considering this TSCA Risk-Based Application submitted to satisfy requirements listed in 40 CFR 761.61(c).

The RCRA emergency treatment exclusion has been necessary on two occasions (11). First, in December 1999 a breached container of a sodium and potassium-containing compound was removed from the excavation. Upon attempting to collect a sample, the material began to spontaneously react with the humidity in the air. Flames and smoke resulted in the debris segregation tent where the sampling was attempted. Hazardous material response team members placed type D fire extinguishing powder on the can of material, then placed the can into the fully shielded wheel loader bucket used during excavation. Site personnel reacted the compound with water in the bottom of the 12-foot deep excavation per the RCRA emergency treatment exclusion (Figure 3). Secondly, the contractors managing the compressed gas cylinders identified an intact container of solid sodium-containing material. This material was reacted by successively removing small quantities of the material from the container and fully reacting each small piece of sodium material in water.

NMED is currently considering approval of a request that would allow Sandia National Laboratories to code radioactively contaminated debris items that are currently projected for disposal at commercial off-site facilities according to detectable RCRA constituents. Due to the ubiquitous disposal of solvents in the landfill that were likely used for their solvent properties, all excavated wastes currently carry an "F" code designation to comply with regulations surrounding RCRA listed hazardous wastes. A determination that a waste material no longer contains hazardous waste if it is not measurable by common laboratory methods or is detected below health-based levels will allow disposal facilities to accept wastes that they otherwise would not allow. Many debris waste items that carry "F" listed designations even though the compounds this waste is "f-coded" for are not detectable in the waste.

Fig. 3. Reaction of sodium-potassium compound with water

Remaining Work

Remaining work to complete the excavation includes completing the characterization and disposal of excavated chemical products and selected debris items, backfilling the excavation, and demobilizing the remaining equipment and supplies. Chemical products will continue to be analyzed for identification and will be disposed at a commercial off-site facility. This process of identification is expected to take up to two years after excavation is complete. Bulk debris items will be shredded to allow the collection of a representative sample. This shredded material will be characterized for a full suite of constituents to enable disposal at the CAMU or an off-site disposal facility.

Backfilling of the excavation includes obtaining NMED approval of a backfilling plan that details the replacement of soils that passed the risk-based criteria and describing geotechnical parameters that are required in the final cover design. Although the actual cover design will be proposed at a later date in the correctives measure study report; the fill material, process, and engineering parameters must be determined prior to initiation of the backfilling activity. Additionally, data resulting from the collection of final verification samples must be evaluated for adherence to risk-based criteria. Initiation of the backfilling activity is also contingent on EPA approval of portions of the risk-based application submitted under the TSCA regulations.

Finally, as backfilling is performed, the expanded site operational boundary surface will be scraped to remove any potential contaminants. This soil is expected to meet risk-based criteria and is scheduled either for use in the CWL excavation as replaceable soil or placement in the CAMU disposal cell. Another 10,000 CY of soil is expected to result from this activity. Sampling of the expanded boundary area will confirm that removal of the area from the operational site boundary is appropriate and the site boundary will be returned to coincide with the original landfill footprint. Following this, equipment and supplies remaining on site will be demobilized and the site restored to its original condition.

CONCLUSIONS

Numerous safety hazards, large volumes of waste materials, and many regulatory hurdles were encountered during the excavation of the CWL. The large variety of buried waste materials was anticipated due to the nature of research and development activities at SNL/NM. Extremely effective safety measures were developed during the planning stages based on the expected categories of waste. However, the largely unknown specific characteristics of the buried waste material created uncertainties that were addressed during the excavation, rather than during the planning stages. Disposal of many of these materials was determined after identification of each material, based on the complexity of regulatory requirements for specific compounds and concentrations of chemical and radiological constituents. NMED and EPA personnel worked closely with site managers to address regulatory needs in real-time, which was critical to removing the buried waste in a timely manner and minimizing operational costs. This flexibility dramatically reduced the schedule of the project, while the integrity of the documented record was maintained. Agility and flexibility, continuous improvement, a close working relationship with regulatory personnel, and a strong emphasis on safety have been the primary components of this successful and cost effective project.

REFERENCES

1. ROY F. WESTON, INC., "Characterization of the Sandia NationalLaboratories (SNL/NMA) Chemical Waste Dispsoal Site," prepared by Roy F. Weston, Inc., for Sandia National Laboratories, Albuquerque, New Mexico, November 1984.
2. J. GULLIEN, "Power Sources Technology Group History", July 2001 http://www.sandia.gov/pstg/.
3. Web page for rocksandminerals.com, P.O. Box 7174, Loveland CO 80537-0174; http://www.rocksandminerals.com/finder/A9.HTM.
4. UNIVERSITY OF CALIFORNIA, SAN DIEGO, " A Close Call at the Environmental Management Facility", *Lab Notes*, University of California, San Diego, May/June 2000, No. 45. http://www-ehs.ucsd.edu/news/labnotes/ln-mj00.htm.
5. D. REED, personal communication, (2000).
6. Code of Federal Regulations, 40 CFR 270.42(b); Use of the Area of Contamination Concept During RCRA Cleanups, Memorandum from Michael Shapiro to RCRA Branch Chiefs, U.S. Environmental Protection Agency, March 13, 1995.

7. New MEXICO ENVIRONMENT DEPARTMENT, *Approval and Notice of Administrative Completeness: Class 1 Modification of Chemical Waste Landfill Closure Plan, Addendum B, Appendix S – Extension of Site Operational Boundary for Landfill Excavation Voluntary Corrective Measure,* New Mexico Environment Department, Water And Waste Management Division, September 29, 2000.
8. SANDIA NATIONAL LABORATORIES, *Risk-Based Approach for Excavation and Backfilling of the Chemical Waste Landfill, Sandia National Laboratories, New Mexico,* Sandia National Laboratories, Albuquerque, August 2000.
9. Code of Federal Regulations, 40 CFR 761.61(a).
10. Code of Federal Regulations, 40 CFR 761.61(c).
11. Code of Federal Regulations, 40 CFR 270.1 (c)(3)(i)(D).