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Pollution Prevention and Waste Minimization Opportunity Assessment in Environmental Restoration

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Introduction

The Environmental Restoration (ER) Project at Sandia National Laboratories implicitly subscribes to the philosophy of pollution prevention and waste minimization. At the lowest level, waste produced is waste that must be disposed of with associated costs. As good stewards of the Federal fisc, the ER Project must find all feasible and reasonable ways to efficiently utilize its funding. As a result of a Department of Energy (DOE) offer, Pollution Prevention Opportunity Assessments (PPOA) were conducted at two ER sites and a decontamination and Demolition (D&D) site.

The purpose of one of the PPOAs was to identify pollution prevention (P2) opportunities during environmental remediation at the Classified Waste Landfill located at Sandia National Laboratories, New Mexico (SNL/NM). The remediation activities at this site are scheduled to begin in the fall of 1997. The PPOA included presentations by the team members, a tour of the site, and a brainstorming session to list the waste streams, identify P2 opportunities and rank them in order of priority. Twenty-five P2 opportunities were identified during the brainstorming session of which twenty-two opportunities were selected for further investigation. Those twenty-two opportunities are discussed in this paper. A cost benefit analysis[1] was performed for each P2 opportunity based on the estimated waste volume, feasibility, and cost. Pollution Prevention by Design (P2D) was incorporated into the PPOA to introduce waste minimization techniques that can be used during the planning phase of restoration projects.

Site History

The Classified Waste Landfill, ER Site #2, located in the eastern portion of TA-II, is part of a locked, controlled-access fenced area. The Classified Waste Landfill covers approximately 2.5 acres. Classified waste is surplus classified material that by shape or content contains information important to national security. Classified waste is known to have been buried in the landfill from the early 1950s through 1990; however, classified material may have been disposed of in the Classified Waste Landfill as early as 1947. The last burial of classified waste in the TA-II disposal site occurred on October 15, 1990. The majority of classified waste in the Classified Waste Landfill is thought to be composed of metal, plastic, and paper.

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Until 1958, no records were maintained for material disposed of in the landfill. Historical information that has been located suggests that some tubes (possibly glass) containing nickel and strontium radioisotopes may have been buried in the landfill, as well as other components that may have contained tritium. Lead, poly-chlorinated-biphenyls (PCBs), depleted uranium, beryllium, and chlorinated solvents, including tri-chloro-ethylene (TCE) and 1,1,1-tri-chloro-ethane (1,1,1-TCA), are among the potential contaminants of concern. Other items buried in the landfill include weapon cases, shells, and related components, lasers, furnace parts, radar equipment, aluminum parts, test panels, and radioactive calibration sources. Some classified material containing gold plating, silver, and platinum may also have been buried. Most items in the Classified Waste Landfill are labeled as security containers, hoppers, missiles, skids, and wooden boxes.

PPOA Team

Team members included representatives from the ER project, the P2 Program, P2D, and the Department of Energy/Albuquerque. The team's intent was to study waste minimization options per accepted PPOA guidelines, including constructing a flow chart of the cleanup process, conducting root cause analysis and assessment, brainstorming, analyzing cost benefits, and making and implementing recommendations. During the process evaluation, every step of the cleanup and every wastestream was considered. All the variable operational steps were analyzed and evaluated for P2 opportunities.

Pollution Prevention by Design

Pollution Prevention by Design is a DOE-Headquarters funded project, the goal of which is to incorporate techniques during the design phase which will prevent pollution during construction, operation, and ultimate demolition of a new or modified facility or site. The P2D concepts can be applied during the planning phase of any construction, modification, restoration or demolition project. In order to be cost-effective, P2D is designed to be adaptable to the needs of individual design projects and can be applied through a pollution prevention design assessment, value engineering, or any other established process for a particular project.

The P2D team was asked to assist the P2 Program in incorporating waste minimization/pollution prevention into the remediation project at the Classified Waste Landfill. The project was in the early planning phases and was expected to generate significant wastestreams. The team worked through the Sandia PPOA process as the most cost-effective method for this particular project. Because P2D focuses on cost-effective waste minimization techniques, the result of applying pollution prevention during the design of the project will help Sandia meet its goals of lowering costs and being environmentally responsible.

Pollution Prevention Opportunities

Primary and secondary waste are expected to be generated during cleanup of ER sites. Primary waste results directly from remediation of the site (e.g., soil), whereas secondary waste is the waste generated during the cleanup action (e.g., decontamination water). Total ER waste (including soil) expected to be generated at this site without P2 processes applied is 1,940 m^3 (68,500 ft^3). This estimated waste quantity was used as the starting point for the cost-benefit analysis.

PPO1 - Pollution Prevention Language in Environmental Restoration Contracts
ER project contracts to conduct characterization or environmental remediation at various sites do not currently have cost and contractual incentives to reduce waste. The lack of P2 performance measures specific to waste reduction, waste avoidance, and recycling has made implementation and quantification of P2 techniques difficult.

The P2 opportunity is to incorporate P2 practices into project plans, specifications, budgets, and contract documents. The contract submitted to the contractor and subcontractors selected to do remediation activities at ER Site #2 will include cost incentives to lower disposal cost and to reduce waste. The modifications of contract language could include: zero-generation goal for soil and liquid waste, numerical goals for recycling and recovery of material, and negotiated risk-based cleanup levels. Specific requirements could include accurate tracking (recycled material, waste disposal, purchases), minimization of water and energy usage, use of rechargeable batteries and digital cameras, reuse of personal protective equipment (PPE) and drinking vessels, minimization of purchases and affirmative procurement (purchase of items that support P2 tenets such as recycled paper), return of test kits to manufacturer, electronic review of documents, and making double-sided copies of documents.

Estimated Waste Reduction: unknown　　　　Estimated Cost Savings: unknown

PPO2 - Segmented Gate System (SGS) for Excavated Soil
Remediation at ER Site #2 involves the excavation of potentially contaminated soil. Chemical or radioactive constituents in these soils must be removed to meet risk assessment criteria before they can be returned to the site. If the excavated soil does not meet risk criteria levels for radioactive or chemical constituents, the soil will be disposed of off site. Cleanup of the site is a highly labor-intensive process requiring numerous personnel to conduct chemical and radiological surveys. The waste reduction and cost savings calculations are based on disposal of 760 m^3 (27,000 ft^3).

The SGS is an automated system that locates, analyzes, and removes gamma-ray emitting radionuclides from soil, sand, dry sludge, or any host matrix that can be transported by conveyor belts. The SGS can identify hot particles, which are assayed in units of pCi/g of host material. The lower limit of detection (LLD) for the system is dependent on the ambient radiation background, conveyor belt speed, thickness of host material on the conveyor, and contaminant gamma-ray energy and abundance.

The SGS is able to physically separate and segregate radioactive material from otherwise "clean" soil. The SGS works by conveying radiologically contaminated material on conveyor belts under an array of sensitive radiation detectors. The automation of analysis results in a significant cost reduction for special handling, packaging, and disposal of the site's radioactive waste. It is estimated that the system will reduce the total volume of waste by 80-95%.

Estimated Waste Reduction: 608 m^3 (21,470 ft^3)　　　　Estimated Cost Savings: $1,001,600

PPO3 through PPO5 represent three options for handling excavated metals that were identified for investigation. The amount of radioactively contaminated debris (e.g. metallic items) that will be excavated from the Classified Waste Landfill is unknown. Scrap metal encountered during excavation at the landfill will be screened for radioactivity and segregated based on contamination. Contaminated items will be sent off-site for disposal as low-level waste (LLW). Free release items will be sent to Reapplication for sale at public auction.

PPO3 - Process Scrap Metal into Low-Level Waste Containers
The Scientific Ecology Group, Inc. (SEG) Metal Melt Facility located in Oak Ridge, Tennessee is able to convert contaminated scrap metal into usable waste containers for burial or storage of contaminated material. The scrap metal is collected and packaged at the environmental remediation site and shipped to SEG (or a similar metal melt facility) for the melting and fabrication steps. Metals currently accepted by the facility include stainless steel, carbon steel, iron, galvanized metal (with zinc weight percentage not greater than 1% of the galvanized metal weight), and nickel-, chromium-, and ferrous alloys (with melting points at or below 3,000°F). The melted metal is cast into ingots for further processing into rolled metal sheets or other metal forms to fabricate different types of containers or container material. These include metal (B-25) boxes, stainless steel cylindrical vitrification containers, metal reinforced concrete boxes, and rebar reinforcement materials. To implement this option the contaminated metal must meet the SEG acceptance criteria. Contaminated scrap metal excavated from this project will be combined with metals from other ER Projects or other facilities to maximize the cost effectiveness of the shipment to the metal melt facility.

Estimated Waste Reduction: 6.1 m^3 (215 ft^3) Estimated Cost Savings: ($674)

Calculations for PPO4 and PPO5 were combined and results are shown under PPO5.

PPO4 - Decontamination of Scrap Metal for Free-Release
This opportunity requires a decontamination process be selected to remove surface contamination, including radioactive contaminants and chemical contamination from scrap metal and metal equipment to allow recycling of the metals. This opportunity is labor-intensive with the potential for health and safety concerns. Decontamination can be performed by mechanical or chemical processes depending on the metals and the type of contamination. Some decontamination techniques include carbon dioxide blasting, ice blasting, water/ice blasting, grit/soda blasting, scabbling, chemical decontamination, and high-energy beam systems. After decontamination, the scrap metal would be recycled with the non-contaminated scrap metal.

PPO5 - Recycle Decontaminated and Uncontaminated Scrap Metal
Uncontaminated or "free-release" metals can be sent to off-site recyclers. The remediation contractor should initiate actions for recycling with segregation as the key technique. Contract language requiring the contractor to be responsible for waste disposal results in an effort to recycle whenever possible and reduces waste generation.

Estimated Waste Reduction: 6.1 m^3 (215 ft^3) Estimated Cost Savings: ($440)

PPO6 - Use of Historical Items as Museum Artifacts
Classified waste buried at the site is surplus classified material that by shape or content contains information important to national security. The majority of the classified material may be composed of metal and plastic that will have to be identified, documented, and its identity destroyed for security reasons. The de-classified material would be disposed of at an off-site

facility and non-contaminated items with recoverable value, such as precious metals and other metals, would be recycled.

Material that is encountered during remediation activities will be identified, segregated, and evaluated for value as a historical item by experienced personnel. The Atomic Museum will accept unclassified and non-radioactive items, if the items are approved by their Acquisition Review Committee. The Museum may not accept certain historical items if they already have one in their collection. The acquisition process could take from several weeks to several months.

Estimated Waste Reduction: 0.76 m^3 (27 ft^3) Estimated Cost Savings: $2,280

ER activities are dynamic due to changing site conditions; during excavation it is not known what material will be excavated. Printed circuit boards and radiation sources were identified as possible materials that could be encountered and segregated for P2 opportunities as described in PPO7 and PPO8. These items are typically disposed of as LLW.

PPO7 - Recycle Printed Circuit Boards

As an alternative to off-site disposal, printed circuit boards can be handled and processed to recover the value of the raw materials that are used to produce the boards. This includes metals such as silver, lead, copper, and gold. Depending upon the volume and characteristics of the printed circuit boards processed through a particular vendor, the raw materials will be recovered and the salvage value returned to the generator.

Estimated Waste Reduction: 0.76 m^3 (27 ft^3) Estimated Cost Savings: ($174)

PPO8 - Reuse Radiation Sources

Radiation sources found during excavation at the site can be sent to the Radiation Source Bank located at SNL/NM. The SNL/NM Radioactive Source program reduces the disposal of LLW by collecting, storing and redeploying radioactive sources. Generators initiate collection, transportation, and storage by submitting a form that is reviewed by the P2 program. The rad source would be held in storage until another user is found.

Estimated Waste Reduction: 0.76 m^3 (27 ft^3) Estimated Cost Savings: $916

PPO9 through PPO12 were identified for investigation during the brainstorming session of the PPOA as options for handling soil control for piles during remediation activities. Plastic sheeting/tarps are used to cover soil piles generated from excavation at ER sites. Soil control is required to prevent releases of potential contamination to workers and to the environment from the dust generated by wind and sun. Soil piles may remain on site for an extended period of time. Use of plastic sheeting/tarps requires high maintenance, including the use of dunnage to hold the plastic down. In addition, slipping and tripping hazards create safety concerns. Once the project is completed, the plastic sheeting/tarps must be disposed of as contaminated material.

PPO9 - Use of Soil-Sement®

Several non-toxic chemicals are available for dust control that can be used in place of tarps or plastic sheeting. One such product is called Soil-Sement®. Due to its molecular structure this particular chemical is able to bond and cross link with sand particles to create a bonded surface that reduces the effects of wind or water erosion. The application unit (113-liter capacity) can be parked outside the contamination zone.

Estimated Waste Reduction: 6.24 m^3 (220 ft^3) Estimated Cost Savings: $77,792

PPO10 - Use of Launderable Tarp

Launderable tarps are constructed in various sizes of a light-weight waterproof material that is launderable. A laundering contract is required to ensure that the supplier has proper contamination controls in place so the tarp is laundered separately and processed according to type and contamination level. All process equipment is cleaned thoroughly between customers.

Estimated Waste Reduction: 6.24 m^3 (220 ft^3) Estimated Cost Savings: $32,347

PPO11 - Compaction of Plastic Sheeting

Soil control material (plastic sheeting/tarps) is a waste stream that is easily compressible. By utilizing a mobile drum compactor, the waste which was not avoided at the source could be reduced in volume. A typical compaction rate for plastic site control materials using a mobile drum compactor is approximately 66%.

Estimated Waste Reduction: 4.2 m^3 (148 ft^3) Estimated Cost Savings: $3,328

PPO12 - Reuse of Site Control Material

No recycling companies were found for the tarps or plastic sheeting. Reuse of site control material during an ER remediation would be controlled by the quality of the material. A better quality product would extend the serviceability of the material, but the cost would be increased. Another method that could be used to extend the life of the material would be folding the tarps and sheeting with the contaminated side inward, so that contamination would not be spread and the material could be reused until no longer serviceable.

Estimated Waste Reduction: 3.1 m^3 (109 ft^3) Estimated Cost Savings: $19,992

PPO13 through PPO16 describe the P2 options for the use of PPE during field activities for remediation at ER sites. Current practice involves disposable PPE generally being used once, collected during the decontamination procedure and managed as potentially contaminated waste. The PPE waste is collected in plastic bags, placed in 55-gallons drums and shipped off site for disposal.

PPO13 - Use of Launderable (Reusable) Personal Protective Equipment

PPE constructed of Protech material is light weight, breathable, helps prevent heat stress, and is launderable. A laundering contract is required to ensure that the supplier has proper contamination controls in place so PPE is laundered separately, processed according to type and contamination level, and all process equipment is cleaned thoroughly between customers. Launderable PPE with cuff seals for the wrists and ankles could be provided to eliminate the use of tape.

Estimated Waste Reduction: 12.5 m^3 (441 ft^3) Estimated Cost Savings: $85,368

PPO14 - Compaction of Personal Protective Equipment
Compaction reduces volume by using a compaction force typically by a pneumatic-, hydraulic- or electric-powered compactor. A typical compaction rate of 66% is estimated using a mobile drum compactor. Treatment in the form of volume reduction is not typically included as a technique for pollution prevention, but it does reduce the volume of waste destined for disposal. Reducing the volume by compaction can result in reduced disposal cost.

Estimated Waste Reduction: 8.3 m^3 (293 ft^3) Estimated Cost Savings: $656

PPO15 - Reuse of Personal Protective Equipment
During field activity, PPE can be reused until unserviceable. PPE removed can be stored within the contamination reduction zone for reuse during the duration of the task.

Estimated Waste Reduction: 6.2 m^3 (219 ft^3) Estimated Cost Savings: $73,584

PPO16 - Reuse of Personal Protective Equipment
If the used PPE (Tyvek™) is field screened and found to be below the free release limits, it can be classified as non-radioactive waste and can be recycled. If the used PPE is above the free release limits, it may be necessary to decontaminate the PPE to remove any radiological or chemical contamination. Recyclers may refuse to accept Tyvek™ PPE due to radiological concerns.

Estimated Waste Reduction: 12.5 m^3 (441 ft^3) Estimated Cost Savings: $4,233

PPO17 - Recycle/Reuse Respirator Cartridges
Provide procedures under the site-specific Health and Safety Plan (HASP) for tracking and storage of respirator cartridges for their reuse. Respirator cartridges could be stored in plastic bags during off periods, reused, and disposed of after one week or as required by the limitations of the cartridges. The use of cartridges during remedial activities could be reduced by 50%. No company for recycling respirator cartridges was found. However, Interstate Nuclear Services will launder respirators (minus the cartridges) so they can be reused. The cost benefit analysis does not include the reuse of respirators.

Estimated Waste Reduction: 0.76 m^3 (27 ft^3) Estimated Cost Savings: $12,640

PPO18 through PPO22 represent five of six options for use of water during remediation activities, namely decontamination, personnel showers, and dust control that were considered during the PPOA. One option (use of an automatic sprinkler system) was not considered further because, although it has the potential to reduce water usage and labor costs, the complexity of the option would make it cost-prohibitive.

PPO18 - Stage Decontamination Rinses for Personnel and Equipment
Water is used for both personnel and equipment decontamination. Decontamination occurs at successive rinse stations until personnel/equipment are free of contaminants. When rinse water at any of the stations becomes too dirty, the container is replaced with clean water. Water and soap are used to decontaminate personnel exiting the contamination zone. Equipment

decontamination liquid may include water, steam, and a cleaner. Decontamination fluids have historically been collected and managed as waste, pending characterization and release as non-contaminated materials.

For successive decontamination rinses, water from the last rinses will be collected and reused for the first (dirtiest) rinse. This procedure will eliminate disposal of wastewater by using slightly contaminated rinse water to remove the most contaminated material.

Estimated Wastewater Reduction: 440 gallons Estimated Cost Savings: $801

PPO19 - Decontamination Water and Personnel Showers Used as Dust Control
As soil is excavated, it is wetted to prevent contamination spread and to control dust. During the project water will be periodically sprayed onto the excavated soil to keep it moist. Water is obtained through a fire hose, equipped with a nozzle connected to a fire hydrant, and manually sprayed on the soils. The correct degree of moisture is determined by the individual operating the fire hose. Once the contaminated soil is removed, it is placed in piles for on-site storage prior to disposal. Tarps are used for dust and contamination control.

The P2 opportunity would allow water from decontamination and personnel showers to be collected in a storage tank and used as dust control. ER personnel indicate that a storage tank is available to collect the wastewater and supply it for dust control.

Estimated Wastewater Reduction: 22,595 gallons Estimated Cost Savings: $860
Estimated Water Usage Reduced: 22,595 gallons

PPO20 - Use of Low-Flow Nozzle
Use of a low-flow nozzle to wet the excavated material and advising the operator to minimize the water used could reduce water use by 30%.

Estimated Water Usage Reduced: 324,000 gallons Estimated Cost Savings: $481

PPO21 - Eliminate Personnel Showers at Job Site
Following a work day, personnel use on-site temporary showers provided by the contractor and discharged to the sanitary sewer. It was determined that showers for temporary job sites are not required, but may be provided as best management practice. The decision whether or not to have showers at the job site would be left to the contractor.

Estimated Wastewater Reduction: 22,595 gallons Estimated Cost Savings: $286
Estimated Water Usage Reduced: 22,595 gallons
Energy Saved: 3,766 Kwh

PPO22 - Use of Low-Flow Shower Heads
If showers are to be provided, then low-flow shower heads would be installed.

Estimated Wastewater Reduction: 11,297 gallons Estimated Cost Savings: $142
Estimated Water Usage Reduced: 11,297 gallons
Energy Saved: 1,883 Kwh

Results

It is estimated that implementation of all the recommended P2 opportunities would result in waste reduction of at least 600 m^3 (21,189 ft^3) and save an estimated one million dollars for the project (Table 1). Implementation of the recommended P2 opportunities would be initiated by inclusion in the Statement of Work to solicit contractor proposals for the cleanup. Contract award would be performance-based with criteria specifically relating to pollution prevention. Return-on-Investment (ROI) proposals to fund five of the P2 opportunities cited above were submitted to DOE in April 1977 and to date a total of $88,000 has been awarded to the project.

Conclusion

Environmental remediation involves removing waste from a site that has been in place for some time; the remediation costs have generally been considered "fixed." However, there are ways to reduce the cost of cleaning up the site through the concept of waste minimization/pollution prevention. To incorporate the concept, DOE offered to fund PPOAs that were conducted at two ER sites and one decontamination and demolition (D&D) site. Because of the success of these PPOAs, the ER project leaders are very encouraged and are determined to implement the waste minimization/pollution prevention methodology in their projects.

The P2 Program will continue to focus on cost-effective waste minimization techniques for environmental remediation activities and will transmit the successes from this project to other ER projects.

Acknowledgments

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Reference

[1]Avoidable Waste Management Costs, INEL-94/0205, January 1995.

Table 1. **Pollution Prevention Opportunities Summary**

PPO No.	PPO Title	Waste Class Reduced	Project Waste Reduction or Energy Savings	Estimated Project Savings	Estimated Implementation Cost	Payback Period
1	P2 Language in ER Contract	unknown	unknown	unknown	$0	unknown
2	Segmented Gate System (SGS)	LLW	608 m^3	$1,001,600	$125,000	6 weeks
3,4,5	(1) Process into LLW Containers (2) Decontaminate for Free Release (3) Recycle metals	LLW/ Sanitary	6.1 m^3	(1) ($674) (2)/(3) ($440)	$0	none
6	Historical use of Classified Material	LLW/ Sanitary	0.76 m^3	$2,280	$0	none
7,8, 17	Recycle Printed Circuit Boards/ Reuse of Rad Sources/ Reuse of Cartridges	LLW	2.3 m^3	$13,382	$0	Immediate
9,10,11 12	(1) Use of Soil Sement (2) Use of Launderable Tarp (3) Compaction of Soil Control Matl (4) Reuses of Plastic Sheeting/ Tarp	LLW	(1) 6.24 m^3 (2) 6.24 m^3 (3) 4.2 m^3 (4) 3.1 m^3	(1) $77,792 (2) $32,347 (3) $3,328 (4) $19,992	(1) $0 (2) $0 (3) $3,000 / $10,000 (4) $0	(1) Immediate (2) Immediate (3) 1 yr/3 yrs (4) Immediate
13,14, 15,16	(1) Use of Launderable PPE (2) Compaction of PPE (3) Reuse of PPE (4) Recycle PPE	LLW	(1) 12.5 m^3 (2) 8.3 m^3 (3) 6.2 m^3 (4) 12.5 m^3	(1) $85,368 (2) $656 (3) $73,584 (4) $4,233	(1) $0 (2) $3,000/$10,000 (3) $0 (4) $0	1) Immediate (2) 4.5 yrs / 15 yrs (3) Immediate (4) Immediate
18,19 20,21,22	(1) Staging rinses (2) Reuse as Dust Control (3) Eliminate Showers (4) Low-Flow Shower Heads (5) Low-Flow Nozzles	LLW/ Sanitary	(1) wastewater: 440 gallons (2) wastewater: 23,475 gallons; water usage: 22,595 gallons (3) wastewater: 22,595 gallons; water usage: 22,595 gallons; energy: 3,766 Kwh (4) wastewater: 11,297 gallons; water usage: 11,297; energy: 1,883 Kwh (5) water usage: 324,000 gal	(1) $801 (2) $860 (3) $286 (4) $142 (5) $481	$0	(1) - (5) Immediate