IMPLEMENTATION OF POLLUTION PREVENTION AND WASTE MINIMIZATION INITIATIVES AT A SMALL DEPARTMENT OF ENERGY ENVIRONMENTAL RESTORATION/WASTE MANAGEMENT (ER/WM) SITE

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ABSTRACT

Weiss Associates (WA) performs a broad range of environmental restoration/waste management activities for the U.S. Department of Energy (DOE) at the former Laboratory for Energy-Related Health Research (LEHR), University of California, Davis (UC Davis).

The LEHR site is a relatively small DOE site with an annual operating budget of 2 to 3 million dollars per year. Despite the small size and limited resources, the LEHR project has realized substantial reductions in waste generation and approximately $3,000,000 in project costs through planning, reduction, reuse and recycling of waste and material (Table I).

Table I. LEHR Pollution Prevention and Waste Minimization Initiatives and Cost Avoidance Summary

Principle	Initiative/Action	Waste Reduction (cubic meters)	Disposal Cost Avoidance	Other Cost Avoidance[a]	Total Cost Avoidance
Reduction	Deploy expedited data feedback	474	$305,420	$524,450	$829,870
	Deploy direct-push sample collection	76.7	$41,995	0	$41,995
	Deploy soft-sided containers	114.7	$128,600 - $182,600	$402,000	$530,600 - $584,600
Reuse	Reuse surplus B-25 waste packages	0	0	$240,000	$240,000
	Reuse overburden soil	978.6	$712,040	$28,000	$740,040
	Donate computers	1.5	0	0	0
Recycle	Recycle metal waste	546.7	$599,170	0	$599,170
	Recycle cardboard	57.3	0	0	0
	Recycle polyethylene (PETE) bottles	3.8	0	0	0
Recycle (Continued)	Recycle pallets and green waste	34.4	0	0	0
Totals		2,287.7	$1,787,225 – 1,841,225	$1,194,450	$2,981,675 – 3,035,675

[a] Other cost avoidance is the reduction of costs associated with pollution prevention and waste minimization initiatives not directly related to the reduction of waste (i.e., reduced analysis costs, reduced packaging costs, etc.).

INTRODUCTION

The former Laboratory for Energy-Related Health Research is a 15-acre site located on part of the University of California, Davis campus (Figure 1). The Atomic Energy Commission and Department of Energy sponsored experiments at LEHR during the 1960s through the 1980s. These experiments consisted primarily of exposing beagle dogs to strontium-90 and radium–226 to extrapolate the human effects from exposure to low levels of radiation. Waste from these research activities was processed in a Radium/Strontium Treatment System. Effluent from this system was discharged into the ground through a large leach field and three dry wells. Waste was also buried in the southwest corner of the site in unlined trenches (Southwest Trenches).

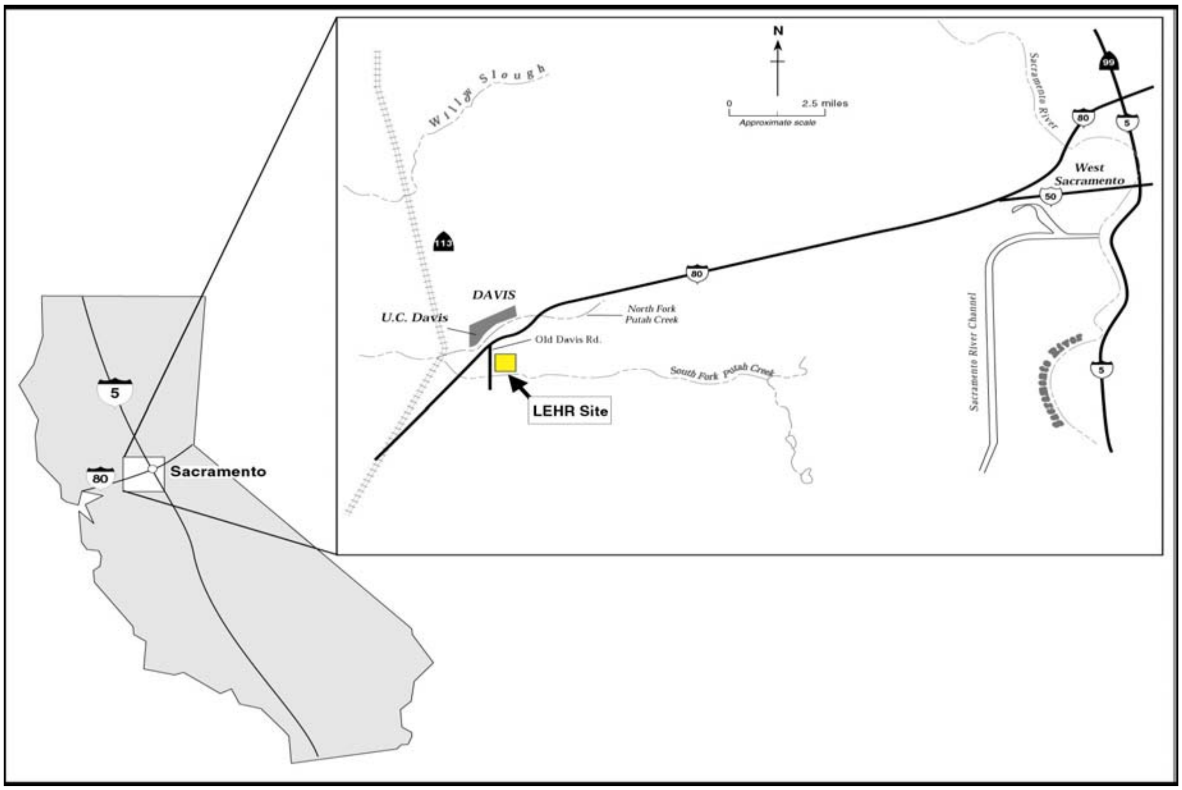

Fig. 1. LEHR Site Location, University of California, Davis

LEHR was added to the U.S. EPA's National Priorities List (NPL) in 1994. Weiss Associates prepared an Engineering Evaluation/Cost Analysis (EE/CA) report in 1998 recommending removal actions to address the radiological releases from the Radium/Strontium Treatment Systems and a landfill known as the Southwest Trenches. Between 1998 and 2000, WA conducted three multi-million dollar removal actions at LEHR that involved excavating more than 1,911 cubic meters (2,500 cubic yards) of radiologically impacted soil and debris associated with the former Radium/Strontium Treatment Systems and Southwest Trenches. An additional removal action was conducted in 2001 at the former Dog Pens area, generating approximately 1,835 cubic meters (2,400 cubic yards) of waste that is currently being characterized for disposition.

Pollution prevention and waste minimization initiatives are part of every activity at the LEHR site and are incorporated into all ER/WM work. Between 1997 and 2001, the LEHR ER/WM project implemented the pollution prevention and waste minimization programs discussed below.

WASTE REDUCTION INITIATIVES

Waste reduction is the primary objective of the LEHR ER/WM program. Source reduction is the most economical and environmentally friendly alternative to accomplish this objective. All LEHR work activities are planned to reduce the generation of hazardous, radioactive and mixed waste through substitution of alternative materials and designed to inherently reduce waste. Prior to the generation of any waste stream, site management evaluates the work procedures and applies the source reduction principle in the planning process to ensure that waste is not needlessly generated. The source reduction initiatives implemented at LEHR include expedited data feedback, direct-push soil sampling and soft-sided packaging.

Expedited Data Feedback

Prior to initiation of LEHR removal actions, the extent of site contamination was not fully defined. With the approval of state/local regulatory agencies, DOE decided to streamline the CERCLA process by conducting pre-Remedial Investigation source removals. The efficiency of the source removal process hinged on the ability to conduct real-time analysis to guide the waste removal and to confirm that cleanup goals were achieved. To this end, process knowledge was used to remove contaminated material and structures, followed by Expedited Data Feedback (EDF) to confirm that cleanup levels had been achieved. In order to implement EDF, WA managed and operated an on-site radiological laboratory (Figure 2). This laboratory provided near real-time analytical results using state-of-the art instruments, including a high-purity germanium gamma spectrometer and a fiber optic sensor for the selective measurement of beta radiation from strontium-90 (Beta Scint™).

Fig. 2. LEHR On-site Radiological Analysis Laboratory

During the removal actions WA staff collected and analyzed over 1,300 soil and gravel samples using the gamma spectrometer and over 800 soil samples using the Beta Scint™ detector. Detection limits at or below 1 pCi/g (picocuries per gram) were routine and commercial laboratory duplicate analyses indicated a high level of precision and accuracy for field analyses. Typically, sample turnaround times were between 15 minutes and 4 hours. Analysis time averaged between 10 and 15 minutes, and sample preparation time varied depending on soil moisture content.

Off-site analyses and EDF costs are compared in Tables II and III. The off-site sample costs include shipping and handling charges. It is assumed that 20 samples can be packaged in a cooler and each cooler costs $150 to ship overnight to the analytical laboratory. The sample collection costs are assumed equal in this comparison. A conservative comparison using EDF costs compared to normal, 45-day turnaround time for off-site analysis realized a project cost avoidance of approximately $124,250 for analysis only. A comparison of EDF costs and expedited 7-day turnaround time for off-site analysis indicated a $524,250 cost avoidance. This comparison does not account for the significant costs of schedule delays that were avoided using EDF.

Table II. Comparison of Actual LEHR On-Site Laboratory Analytic Costs to Standard Turnaround Time Off-Site Laboratory Costs

Sample Type	Turnaround Time	Quantity	Sample Price	Sample Shipment Cost	Total Cost
Radium Off-Site Analysis	45 days (standard)	1,300	$108	$9,750	$150,150
Strontium Off-Site Analysis	45 days (standard)	800	$158	$6,000	$132,400
EDF - Radium	15 minutes to 4 hours	1,300	$75	0	$97,500
EDF - Strontium	15 minutes to 4 hours	800	$75	0	$60,000
Savings					$125,050

Table III. Comparison of Actual LEHR On-Site Laboratory Analytic Costs to Expedited Turnaround Time Off-Site Laboratory Costs

Sample Type	Turnaround Time	Sample Quantity	Sample Price	Sample Shipment Cost	Total Cost
Radium Off-Site Analysis	7 days (rush)	1,300	$270	$9,750	$360,750
Strontium Off-Site Analysis	7 days (rush)	800	$394	$6,000	$321,200
EDF - Radium	15 minutes to 4 hours	1,300	$75	0	$97,500
EDF - Strontium	15 minutes to 4 hours	800	$75	0	$60,000
Savings					$524,450

In addition to providing substantial analytical cost savings, the EDF approach provided near real-time results to define the limits of removal action excavations, reducing the limits by approximately 10%, which avoided the generation, characterization, packaging, transportation and disposal of 474 cubic meters (620 cubic yards) of low-level radioactive waste during four removal actions (Table IV). If EDF was not available, the excavation limits would be increased at least 10% to over-excavate the contamination source and buried waste to assure clean-up goals were achieved and total waste management costs would be increased $305,420. Over-excavation is a standard practice in the environmental industry to avoid costly remobilization of equipment and staff to remove residual contamination identified in post-removal action sampling and analysis. Not only did this effort conserve project funds to implement further clean up, but it preserved valuable space at the low-level radioactive waste repository.

Table IV. Estimated Waste Volume Reduction Using EDF And Associated Cost Avoidance

Removal Action	Waste Generated (cubic meters)	10% Reduction (cubic meters)	Cost Avoidance[a]
Southwest Trenches	917.5	91.8	$77,160
Radium/Strontium Area I	611.6	61.2	$51,440
Radium/Strontium Area II	841	84.1	$46,310
Western Dog Pens	2,370.1	237	$130,510
Savings			$305,420

[a] Cost avoidance is determined by multiplying the volume of reduced waste by LEHR processing, packaging and disposal costs of the waste packaging system in place at the time for low-level radioactive soil.

By using the EDF approach, WA dramatically reduced analytical costs and substantially increased workforce utilization. Additionally, WA used the EDF approach to minimize the volume of low-level radioactive waste generated from removal action activities. The on-site laboratory provided real-time analytical results to segregate clean and marginally impacted materials. Traditional field screening tools lack the sensitivity to perform this type of screening.

Deployment of Direct-Push Sampling Technology

Previous investigations at the LEHR site left approximately 400 drums of investigation derived waste (IDW) that required subsequent management, characterization, repackaging and disposal as waste. Because of the significant volumes of waste generated by conventional sampling approaches, WA deployed a direct-push rig (Figure 3) to collect subsurface samples to depths of 12 meters (40 feet) below ground surface that realized a 15-to-1 reduction of IDW compared to hollow-stem auger techniques. Deployment of the direct-push rig achieved a 76.3 cubic meter (99.8 cubic yard) waste reduction and a cost reduction of nearly $42,000.

Auger rigs typically produce one 0.21-cubic meter (55-gallon) drum of cuttings per 3-3.7 meters (10-12 feet) of drill depth. For cost analysis purposes, one 0.21-cubic meter (55-gallon) drum of cuttings was assumed generated per 3.4 meters (11 feet) of drill depth. The diameter of the direct-push borehole was 31% the diameter of a traditional hollow-stem auger drill rig and the majority of the core generated by the direct-push system was sent off to the laboratory for analysis, further reducing drill cuttings.

Site conditions were ideal at LEHR, but this technology is not suitable for all situations. The system works well in unconfined sediments, such as at the LEHR site but will not operate properly in consolidated sediments or other rock formations.

Fig. 3. Direct Push Sample Collection System

LEHR direct-push sample statistics are compared to hollow-stem auger drilling in Table V.

Table V. Comparison of Waste Generation Between Direct-Push Sampling Rig and Traditional Hollow-Stem Auger Rig

Drilling Technology	Number of Boreholes	Total Depth (meters)	Borehole Diameter (centimeters)	Drums of Waste	Waste Volume (cubic meters)	Disposition Cost[a]
Hollow-Stem Auger	140	1,097.3	20.3	333	81	$44,626
Direct-Push	140	1,097.3	6.4	19	4.8	$2,631
Difference (waste volume and disposition avoidance)				313	76.3	$41,995

[a] Cost avoidance is determined by multiplying the volume of reduced waste by LEHR processing, packaging and disposal costs of the waste packaging system in place at the time for low-level radioactive soil.

Soft-sided Packaging Systems

Over the last three years, WA has overseen the transition of the LEHR ER/WM program from a baseline packaging system of steel 2.7-cubic meter (3.5-cubic yard) B-25 boxes to 0.8-cubic meter (1-cubic yard) and 7-cubic meter (9.1-cubic yard) soft-sided container systems (Super Sacks® and Lift Liners®, respectively) (Figure 4).

Fig. 4. Removal of 9.1 Cubic Yard Soft-sided Lift Liner® from Loading Frame at the LEHR site

The resulting increased efficiencies in processing, packaging, and storage combined with decreased package costs, achieved a $402,000 cost savings (Table VI). The packages and costs associated with the B-25 boxes are based on assumed quantities if the project had continued to utilize that packaging system. Unit prices includes package procurement through waste transportation on a per cubic meter basis and do not include tipping fees at the disposal facility.

Table VI. Comparison of Packaging Costs and Cost Avoidance for LEHR Packaging Systems

Package Class	Package Type	Package Volume (cubic meters)	Cost (per cubic meter)	Waste Volume (cubic meters)	Total Cost
Hard-Sided	B-25 Box	2.1	$823	1169	$962,000
Soft-Sided	Super Sack®	0.6	$624	233.2	$145,600
	Lift Liner®	5.4	$443	935.1	$414,400
Savings					$402,000

Soft-sided containers conform to the packaged waste, optimizing container loading by minimizing void space, which translates into the preservation of valuable landfill space and disposition cost avoidance. Void space in traditional packages (drums, steel boxes, etc.) is between 10% and 20% depending on the size, shape and density of the waste. The LEHR site preserved 153 cubic meters (200 cubic yards) of disposal facility capacity and avoided disposal costs between $128,600 and $182,600 (Tables VII) using soft-sided containers.

Table VII. Void Space and Disposition Costs Comparison between Lift Liner® System and B-25 Boxes

Package Type	Packaged Waste (cubic meters)	Package Void Space (%)	Total Void Space (cubic meters)	Disposition Cost for Soil Void Space[a]	Disposition Cost of Debris Void Space[a]
B-25 Box	1,529	10	153	$128,600	$182,600
Super Sack®	305	0	0	$0	$0
Lift Liner®	1,223	0	0	$0	$0
Difference (B-25 compared to Lift Liner®)				$128,600	$182,600

[a] Disposition cost includes package system costs discussed above plus disposal facility tipping fee specific to soil or debris.

WASTE REUSE INITIATIVES

The second principle of the LEHR ER/WM program is on-site reuse of materials and waste. This requires minimal investment of energy and resources and avoids disposition as waste. The reuse initiatives implemented at LEHR include reuse of waste packages, computers and excavated soil.

Reuse of Surplus Waste Packages

In 1996, DOE Oakland identified an opportunity to acquire used steel B-25 waste packages from the Savannah River Site (SRS). The site had a surplus of used B-25 steel boxes. Since the transfer was between two DOE entities, there was no acquisition cost to the LEHR project. LEHR paid for the transportation, survey, and some refurbishment of the packages to certify them for reuse. The LEHR project acquired 600 B-25 boxes for a transportation and refurbishment cost of less than $300 per box, or $180,000. New B-25 boxes would have cost approximately $700 per box, or $420,000. The LEHR site realized cost savings of approximately $240,000.

In addition, a liability for the 600 boxes was relieved from SRS. In some cases the boxes were returned from the disposal site after LEHR waste was emptied and after some restoration, the boxes were certified for reuse for a third waste shipment. Reuse of the boxes also saved approximately 181.4 to 249.5 kilograms (400 to 550 pounds) of steel for each reuse because the boxes are normally buried in place.

Donation of Excess Electronic Equipment for Reuse

Land disposal of certain electronic equipment is prohibited because of hazardous levels of metals in monitors and circuitry. A local vendor was identified by DOE Oakland that refurbishes computers to benefit charitable organizations and/or disassemble the equipment to reclaim metal, glass and plastic. LEHR salvage and excess computer equipment was delivered to the Alameda County Computer Resource Center (ACCRC) in Oakland, California for reuse and/or recycling on December 6, 2001. In total, the LEHR site donated:

- 10 keyboards and mice;
- 13 computers;
- 9 monitors;
- 4 printers;
- 1 box of miscellaneous external drives, hardware and cables;
- 1 typewriter; and,
- 1 scanner.

The ACCRC is utilized by other DOE Oakland sites to disposition excess electronic equipment, and was verified by the LEHR project as a suitable local recycle and reuse vendor. Per DOE Oakland direction, the hard drives of the computers were sanitized and/or physically destroyed prior to donation to ensure that sensitive data was not distributed.

Reuse of Overburden Segregated Using EDF

As part of CERCLA removal actions in FY 1999 and FY 2001, the EDF system described earlier was used to segregate clean soil from radioactive waste to avoid unnecessary off-site disposal as low-level waste. This effort avoided generation, packaging, transportation and disposal of approximately 978.6 cubic meters (1,280 cubic yards) of low-level radioactive waste and realized a project cost saving of approximately $712,040 (Table VIII), in addition to preserving valuable landfill space. This comparison considers that disposition profile preparation and the approval process for off-site disposal is offset by the RESRAD modeling and regulator approvals process for on-site reuse.

Table VIII. Overburden Segregated Using Expedited Data Feedback Approach

Removal Action	Volume Segregated (cubic meters)	Packaging System[a]	Status	Disposition Cost Avoidance[b]
Southwest Trenches, 1998	290.5	B-25	Pending approvals	$244,340
Radium/Strontium Area I, 1999-2000	305.8	B-25	Reused on site	$257,200
Western Dog Pens, 2001	382.3	Lift Liner®	Reused on site	$210,500
Savings				$712,040

[a] Packaging system used at time of excavation.

[b] Cost avoidance is determined by multiplying the volume of reduced waste by LEHR processing, packaging and disposal costs of the waste packaging system in place at the time for low-level radioactive soil.

A secondary cost savings was realized by avoiding the import of fill material from off-site locations to backfill open excavations resulting from removal actions. LEHR imports fill at an average cost of $9.50 per cubic meter. The project must first characterize the soils in order to determine if they are suitable for import and that chemical and/or radiological contaminant levels do not exceed site cleanup criteria. Off-site analysis costs approximately $3,000 per sample and the fill material is sampled at a rate of one sample per 305.8 cubic meters (400 cubic yards). By reusing 978.6 cubic meters (1,280 cubic yards) of soil, the project realized a cost avoidance of $12,000 in sampling and analysis and $16,000 in import fill costs.

WASTE RECYCLE INITIATIVES

The third principle of the LEHR ER/WM program is recycling of waste and material. The first two principles (reduce and reuse) are preferable to recycling because the cost and energy expenses are greatly reduced. Energy is required to transport and transform the waste, such as trucking and smelting metal. Recycling is preferable to waste disposition when reduction and reuse options are not available. LEHR recycle initiatives are described below.

Metal Waste Recycling

In 1998, the LEHR site conducted an extensive radiological survey to release metal waste and material that was generated during the decontamination and decommissioning of several site structures per DOE Order 5400.05 and 10 CFR 835. The waste consisted of used drums, cyclone fencing, fence posts, electrical conduit, hardware and light ballasts. Through negotiations with the metal recycler, the LEHR project arranged for the transport and recycling of 512 empty, carbon-steel drums and 546.5 cubic meters (714.8 cubic yards) of miscellaneous metal waste. A cost avoidance of $599,170 was realized by recycling this metal (Table IX). This figure also assumes that the waste does not require volume reduction to meet the waste acceptance criteria of the disposal facility.

Table IX. Comparison of LEHR Metal Recycling and Disposition Alternatives

Disposition	Volume (cubic meters)	Disposition Costs[a]
Unrestricted release	546.7	$53,625
Low-level radioactive waste	546.7	$652,745
Savings		$599,170

[a] Disposition cost for the unrestricted release was derived from survey, reporting, approvals, loading and transportation costs. Disposition cost for the low-level radioactive waste was derived from LEHR processing, packaging and disposal costs of the waste packaging system in place at the time.

Plastic Container Recycling

As required by the LEHR heat stress mitigation program, site workers are required to drink bottled water and sports drinks to remain hydrated. The 20-person crew consumed approximately 300 bottles of liquids per week. In July of 2001, WA staff introduced polyethylene (PETE) bottle recycling bins provided by the UC Davis recycling center to the remote work areas. To date, approximately 3,900 PETE containers have been recycled.

Cardboard Recycling

The LEHR site is located at the Institute of Toxicology and Environmental Health (ITEH), an active satellite facility of UC Davis, employing approximately 125-150 individuals. LEHR staff receive and ship materials and equipment through the ITEH infrastructure and noticed that the site sanitary waste receptacles were constantly filled with cardboard boxes. At the request of WA staff, the UC Davis recycling program delivered two 1.5-cubic meter (2-cubic yard) cardboard recycling bins that are utilized by the 10 –20 LEHR employees and the 125-150 ITEH employees. Use of these bins reduces the volume of sanitary waste by approximately 4.6 cubic meters (6 cubic yards) per month and, has saved approximately 57.3 cubic meters (75 cubic yards) of recyclable cardboard from disposal as sanitary waste. Because the ITEH facility operations will continue as part of the UC Davis mission for decades to come, the lifetime reduction of waste as the result of this initiative will be measured in the hundreds of cubic meters.

Wood Pallets Recycling

Following decontamination and decommissioning activities, the LEHR site had custody of over 400 used wooden pallets that were used to transport drums and other waste material on site. Many of the pallets were reused for site activities but by the year 2000, exposure to weather had damaged most of the pallets. A recycling opportunity was identified with the UC Davis green waste program. Instead of discarding the pallets to the sanitary landfill, the pallets were shredded into wood chips and transformed into compost and landscaping ground cover material to be used throughout UC Davis. This represents a waste reduction of approximately 34.4 cubic meters (45 cubic yards) and provides free compost and landscaping material to the university.

FUTURE POLLUTION PREVENTION/WASTE MINIMIZATION INITIATIVES

The LEHR project waste minimization and pollution prevention activities for FY 2002 and 2003 include:

- Continued donation of excess electronic equipment to the ACCRC;
- Transfer and reuse of 9 microcuries of radium-226 sealed source material to a cancer treatment research institute in Norway.
- Continued use of soft-sided containers;
- Internal DOE recycling and reuse of radiologically contaminated lead through the Oak Ridge National Center of Excellence for Metals Recycle;
- Reuse of salvage and excess radiological survey equipment through the DOE Metals Recycle Center for Excellence;
- Continued use of EDF to guide excavations and to minimize waste generation;
- Attempted reuse and inter-agency transfer of approximately $500,000 of equipment and materials (clean and contaminated) directly to other DOE sites, or indirectly through the DOE Complex-Wide Materials Exchange; and,
- Continued use of direct-push sampling to complete confirmation sampling and investigations.

CONCLUSIONS

The LEHR site is a relatively small DOE site with an annual operating budget of 2 to 3 million dollars per year. Despite the small size and limited resources, the LEHR project has realized substantial reductions in waste generation and nearly $3,000,000 in project costs through planning, reduction, reuse and recycling of waste and material.

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ACRONYMS

ACCRC	Alameda County Computer Resource Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
EDF	Expedited Data Feedback
EE/CA	Engineering Evaluation/Cost Analysis
EPA	Environmental Protection Agency
ER/WM	Environmental Restoration/Waste Management
IDW	investigation derived waste
ITEH	Institute of Toxicology of Environmental Health
LEHR	Laboratory for Energy-Related Health Research
NPL	National Priority List
PCi/g	Picocuries per gram
PETE	polyethylene
Ra/Sr	Radium/Strontium
SRS	Savannah River Site
SWT	Southwest Trenches
UC Davis	University of California, Davis
WA	Weiss Associates
WDP	Western Dog Pens