COST AND PERFORMANCE REPORT

Thermo NUtech's Segmented Gate System

Los Alamos National Laboratory
Technical Area 33
Los Alamos, New Mexico

Accelerated Site
Technology Deployment

U.S. Department of Energy

November 1999

DISCLAIMER

This report was prepared for the U.S. Department of Energy by:
Sandia National Laboratories; Albuquerque, New Mexico

For more information, please contact:

Ray Patteson, Sandia National Laboratories, (505) 844-1904
or
John M^{c}Cann, Los Alamos National Laboratory, (505) 665-1091

CONTENTS

LIST OF ACRONYMS

AOC	Area of Concern
ASTD	Accelerated Site Technology Deployment Program
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	Department of Energy
DU	Depleted Uranium
EPA	Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety and Health
HSWA	Hazardous and Solid Waste Area
ITRD	Innovative Treatment Remediation Demonstration
LANL	Los Alamos National Laboratory
NU	Natural Uranium
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
PRS	Potential Release Sites
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
ROD	Record of Decision
SAL	Soil Action Level
SGS	Segmented Gate System
SNL	Sandia National Laboratories
TA-33	Technical Area 33
TNU	Thermo NUtech
VCA	Voluntary Corrective Action

FOREWORD

The Department of Energy (DOE) is working to accelerate the application and acceptance of innovative technologies that improve the way the nation manages its environmental remediation problems. The DOE Office of Science and Technology established the Accelerated Site Technology Deployment Program (ASTD) to help accelerate the acceptance and implementation of new and innovative soil and ground water remediation technologies. Coordinated by the Department of Energy's Idaho Office, the ASTD Program reduces many of the classic barriers to the deployment of new technologies by involving government, industry, and regulatory agencies in the assessment, implementation, and validation of innovative technologies.

Funding is provided through the ASTD Program to assist participating site managers in implementing innovative technologies. The program provides technical assistance to the participating DOE sites by coordinating DOE, industry, and regulatory participation in each project; providing funds for optimizing full-scale operating parameters; coordinating technology performance monitoring; and by developing cost and performance reports on the technology applications.

In 1995, the DOE's Innovative Treatment Remediation Demonstration (IRTD) Program initiated a joint project with DOE Plants in Ohio to investigate the use of innovative technologies for the remediation of heavy-metal contaminated soils. Preliminary technology assessments indicated that processing radionuclide-contaminated soils through physical separation using advanced sensors was cost-effective and could significantly reduce the volume of soil requiring either further treatment or off-site disposal. The ITRD program sponsored a study using the Segmented Gate System (SGS) for separating uranium and plutonium contaminated soil from clean soil. Based on these results, Sandia National Laboratories' Environmental Restoration Project and the ITRD Program sponsored a soil remediation effort at Sandia's Technical Area II in August and September 1997 using the SGS. The system was used to cost effectively clean and separate contaminated soil for four different contaminants; plutonium, uranium, thorium, and cesium. Based on those results, the DOE's Ohio Field Office submitted an ASTD proposal to use the SGS at seven other DOE sites across the country.

The purpose of this Cost and Performance Report is to document the project activities, project data, and provide evaluation results of the operational cost and performance of the ASTD deployment of the SGS at the Los Alamos National Laboratory Tech Area 33, soil remediation site.

1. SUMMARY

Thermo NUtech conducted a radioactive material volume reduction project for Los Alamos National Laboratory at Technical Area (TA)-33. This was a voluntary corrective action (VCA). Within TA-33, three sites were included in this remediation effort, C33-003, Water Tower Site; C33-010 (c), Gully Site; and 33-007(b), Bunker Site. The goal of the project was to reduce the volume of contaminated soil that would require off-site storage and disposal. The soils at the sites were predominately contaminated with natural uranium (NU). A set point of 50 pCi/g for NU was established as the ALARA target for the project. The actual Primary Remediation Goal (PRG) for this site was in excess of 600 pCi/g.

The Thermo NUtech Segmented Gate System (SGS) was mobilized to TA-33 on April 19, 1999, to an area that had been previously prepared by Los Alamos. Off loading of equipment was performed by a TNU subcontract crane company. Assembly and calibration were accomplished over a five-day period. Soil processing began on Wednesday, April 28, 1999. Soil was processed from April 28th through May 19th, with actual processing taking place on 15 of those days. A total of 91.10 hours of processing time were logged.

A total of 2,526 cubic yards were processed through the SGS. Volume reduction reported by the SGS for the three sites was C33-003, 99.65%; 33-010 (c), 99.79%; and 33-007(b), 75.34%. The majority of the soil processed was from the Bunker Site (C33-007b). A set point of 65 pCi/g was used for Gully Site (C33-010), since the contamination was more uniformly distributed but still below the PRG. The LANL excavation plan of digging from the back side of the bunker towards the front, where the hottest concentration of contamination was located, aided in the SGS achieving a very good volume reduction at C33-007b.

A demonstration test was conducted on 10 cubic yards of soil from TA-15 while the SGS was onsite. The test resulted in zero percent volume reduction in above criteria soil. The primary contaminate was Depleted Uranium (DU) instead of NU as was present in the TA-33 sites. At the request of the client, the set point was varied between 50 and 1200 pCi/g to determine if sorting would occur. The test determined that the Tornado Star screen, used to size the material and homogenize the High Explosive (HE) contamination, also homogenized the DU to a point where the SGS was ineffective. LANL will consider hardening and remote operation of the SGS as an alternative to using the Tornado Star or other methods to reduce HE content below 5% by volume.

Demobilization was completed on May 27, 1999 when the equipment was shipped to the Idaho Engineering and Environmental Laboratory (INEEL). Total cost of SGS operations at LANL was $275,745 including $6,600 for Pre-deployment Planning meetings, $46,000 for mobilization, $70,000 for processing 1,000 Cubic yards, $99,000 for processing additional soil, $16,445 for oversize material, $2,700 for a final report, and $35,000 for demobilization.

SITE INFORMATION

Identifying Information

Facility:	Los Alamos National Laboratory
Location:	Los Alamos, New Mexico
OU/SWMU:	Technical Area 33
Regulatory Driver:	RCRA
Type of Action:	Corrective Measure – Site Remediation
Technology:	Thermo NUtech's Segmented Gate System
Period of Operation:	April 28th, 1999 through May 19th, 1999
Processed Volume:	2,526 yd^3

Thermo NUtech conducted a radioactive material volume reduction project for Los Alamos National Laboratories (LANL) at Technical Area 33 (TA-33). Three individual sites were treated for Natural Uranium (NU) contamination using the Segmented Gate System (SGS). Thermo NUtech performed this work as a subcontractor to Sandia National Laboratories (SNL) under the Advanced Site Technology Deployment (ASTD) Program. The use of the SGS to cleanup these sites was a Voluntary Corrective Action by LANL. Figure 1 shows the site location map. LANL is a multi-disciplinary research facility owned by the DOE. LANL is located in north-central New Mexico and covers approximately 43 square miles of the Pajarito Plateau. TA-33 is located in the eastern portion of LANL.

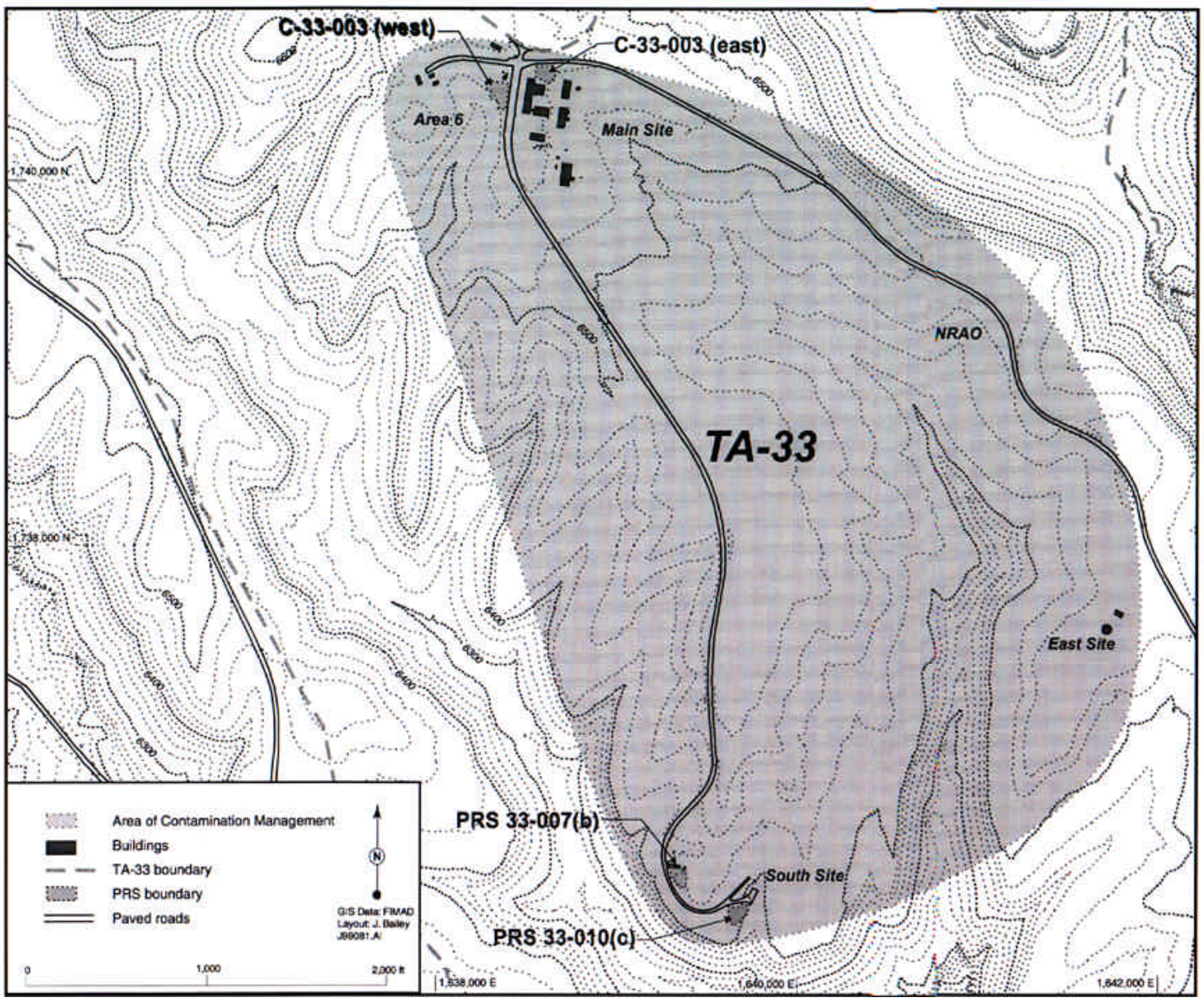


Figure 1. Site Location Map

Site Background

Technical Area 33 (TA-33), is an active testing area for the Laboratory. This site was used to test components of nuclear weapons called initiators from 1947 to the 1950's. Various experiments have been conducted using natural and depleted uranium projectiles. Early experiments focused on natural uranium and then, depleted uranium. This LANL Environmental Restoration (ER) Project remediated uranium-contaminated soil and debris from Potential Release Sites (PRSs) 33-007(b), 33-010(c), and C33-003.

PRS 33-010(c) is a Hazardous Solid Waste Area (HSWA) site consisting of a debris pile adjacent to shot pad TA-33-26, at South Site. Implosion experiments were conducted at the shot pad. Debris consisting of gravel, shrapnel, electrical cable, and wood, were moved to the pile following each shot experiment. The debris pile is approximately 50 ft x 30 ft x 4 ft deep and is located on the rim and west slope of the main drainage leading to Chaquehui Canyon. Previous LANL sampling revealed uranium and copper above Soil Action Levels (SALs).

PRS 33-007(b) is a HSWA site consisting of a berm, TA-33-63, located at South Site. The berm contains particles of uranium from projectiles fired into the berm from guns mounted in building TA-33-25. The berm was approximately 50 ft x 50 ft x 10 ft high. Previous LANL sampling revealed uranium concentrations above Soil Action Levels.

PRS C-33-003 is a non-HSWA site consisting of two fill areas at Main Site. Both areas potentially contain uranium particles and projectiles in cinder material imported from Technical Area 6.

Release Characteristics

Historical records indicated both NU and DU present at these sites. Over years of site characterization and efforts to remove identified hot debris, large amounts of fragments have been removed. Thermo NUtech analyzed a representative sample provided by the LANL and the results indicated that natural uranium was the primary contaminant in the sample. The volume of possibly contaminated soil was estimated at around 2500 cubic yards, including an estimated 20 percent of oversize material

Site Contacts

Funding for the project was provided under the Accelerated Site Technology Deployment Initiative at the direction of Thomas Burford [(505) 845-9893] and Ray Patteson [(505) 844-1904] of Sandia National Laboratories. The Managing and Operating contractor for LANL is the University of California. IT Corporation is one of three Environmental Restoration Subcontractors committed to cleaning up LANL. The technical contact for the LANL segmented gate project is John McCann of Los Alamos National Laboratory [(505) 665-1091]. The project manager for Thermo NUtech is Joe Kimbrell in Albuqueruqe, NM [(505) 254-0935 ext. 209].

3. MATRIX AND CONTAMINANT DESCRIPTION

The type of matrix handled by the SGS at TA-33 was NU contaminated soil (ex situ) mixed with silica sands and Bandelier tuff. A moderate amount of vegetation was present. The LANL subcontractor performing the excavations removed sagebrush and native trees. The 33-007 (b) site, which consisted of an earth berm into which projectiles were fired, contained lead and steel projectiles up to fifty pounds in weight. The soil matrix for the TA-15 soil was similar to TA-33 except it contained High Explosive, which required special handling prior to SGS processing. A 10 cubic yard volume of TA-15 soil was processed by the SGS.

Site Geology / Hydrology

White Rock Canyon of the Rio Grande, 1000 feet deep, is the southern boundary of TA-33. Two tributaries, Ancho and Chaquehui Canyons, join White Rock Canyon at TA-33. The firing sites are located on level mesas between the two tributary canyons. East Site is located near the south rim of Ancho Canyon. South Site lies on the north rim of Chaquehui Canyon. Runoff from East Site drains to White Rock Canyon. Runoff from West Site drains to Chaquehui Canyon. LANL activities are confined to the mesa top that is composed of Bandelier tuff. The tuffs at TA-33 are underlain by 650 ft. of basalt, including Tholeitic, Andesitic and Phreatomagmatic basalt deposits. South Site soil is a shallow, well drained soil that forms on mesa tops. It is sandy loam with a mixture of clay and gravel. East Site soil is 65% rock outcrop with the rest escarpment or sandy loam with a mixture of clay and gravel.

There are no springs in the immediate area and groundwater runoff from heavy snow or rain drains to the canyons. Depth from the surface to groundwater is in a range of from 700 to 800 feet.

Nature and Extent of Contamination

The SGS was designed to separate soils based on the radioactive contaminant content. The radioactive contaminants found in the characterization of TA-33 were depleted and natural uranium. Based on previous studies it was determined the primary contaminate was natural uranium for which each site's Primary Remediation Goals (PRGs) were based. TA-15 is another testing facility where both natural and depleted uranium was tested. The test plan for TA-15 stated the primary contaminate was depleted uranium, however; following the SGS deployment a sample of the soil was tested by TNU and it was natural uranium.

Matrix Characteristics Affecting Treatment Cost or Performance

No sieve analysis, on the soils to be treated at TA-33 was performed. The soil moisture content appeared to be about optimal for SGS processing, and was estimated to be approximately 12-15% by weight, although actual measurements were not made for moisture content. The soil from TA-33 was processed with less moisture content than previously allowed since radiation controls were not necessary until specific action level had been reached. The drier soil caused some dusting on equipment and personnel. Monitoring was performed for PM-10 nuisance dust and airborne radioactive particulates. No action levels for dust or particulates were exceeded. Wind occasionally threatened to stop processing in the afternoons.

The tests performed at these sites, in most cases, involved the firing of projectiles from Navy weapons into the earth berms. The projectiles encountered ranged in size from 1-foot long and 3-inches in diameter to 2.5 feet and 6-inches in diameter. Most were steel projectiles with no radioactive contamination. The soil matrix being sized to 1.5 inch minus produced a total of 253 cubic yards of oversized material.

4. TECHNOLOGY DESCRIPTION

Purpose of Technology

Due to depositional mechanisms, contaminated soil is often heterogeneously distributed. The SGS is used to separate radionuclide contaminated soil from clean soil. The goal is to clean the contaminated soil to a predetermined acceptable level, reduce the volume of contaminated soil requiring disposal and reduce soil disposal costs.

Segmented Gate System Description

The Thermo NUtech SGS is a transportable gamma radiation detector system with motorized conveyor belts, a variable belt speed motor controller, air actuated segmented gates, a radionuclide assay computer system, and two arrays of sodium iodide (NaI) detectors applicable to radionuclides that emit low and high energy gamma rays. This mobile unit includes a material feed conveyor, a sorting conveyor coupled to a sophisticated motor control unit to assure constant belt speed, a contaminated material conveyor, and a below criteria material conveyor.

The sorting conveyor, detector arrays, segmented gates, and all downstream conveyors and subsystems are controlled through the use of an on-board computer that is operated from a mobile van. The computer makes soil-processing decisions based on operating parameters entered by the control room technician. The operating display on the computer shows real-time status of the conveyor monitor system and will automatically shut down all components when abnormal conditions are detected.
In addition to the components of the sorting system itself, several support components are needed for operation of the system. A transportable air compressor provides air pressure for the pneumatic cylinders. A separate van houses the computer and also provides operating space for the control room technician. A portable generator may be used if commercial power is not available. The equipment weighs 40,000 lbs. so a 35 to 50 ton crane is needed for loading and unloading equipment in addition to a forklift. A front-end loader with a 2 to 5 yard bucket no greater than 8.5' in width is needed to move soil to and from the SGS plant. Site requirements for SGS staging and soil processing are listed in
Table 1.

Table 1. Site Requirements for SGS Staging

Provision	Requirement
Staging Area	Level area, 100 feet x 130 feet
Power	250A, 208V, 3 phase; a 115V supply for overnight and weekend environmental control of the detector chambers
Water	Water supply for dust suppression (100 to 200 gallons per day) as dictated by the site conditions
Ancillary Equipment	35 to 50 ton crane for off-loading the SGS unit, a loader with a 2 to 5 yard bucket no wider than 8.5'; a fork lift for system setup

Technology Advantages

The treatment of radionuclide-contaminated soils using the SGS offers the following advantages:

- The system physically surveys the entire volume of soil to be processed,
- The system typically reduces volumes of soil needing treatment or disposal,
- No chemicals or other additives are used
- The generation of secondary waste is limited to PPE.
- Dry decontamination of the SGS has proven effective
- Hydraulic system contains BioSoy®, an environmentally friendly soy bean based hydraulic fluid replacement

Technology Limitations

The SGS has the following limitations:

- The two detector arrays provide the ability to analyze a maximum of two radionuclides at a time with different gamma energies,
- The SGS is primarily limited to gamma emitting radionuclides, although it can be modified to detect beta particle emitting radionuclides,
- Prior knowledge of the primary radioactive contaminants is required and soil cannot be properly sorted for unknown radioactive contaminants,
- Soil may contain levels of radioactivity above the criteria if it is sorted based on the wrong radionuclides, and
- Material greater than a nominal $1^{1}/_{2}$ inches in diameter cannot be processed by the SGS without pre-crushing.

Treatment System Schematic and Operation

Figure 2 shows the process flow diagram for the SGS under typical operating conditions. During system operation, contaminated soil is excavated with standard heavy equipment and relocated to the feed point of the mobile SGS processing plant. The soil is first pre-sorted into piles using a vertical bar field grizzly, which removes material larger than 6 inches in diameter. The soil is then sent through the SGS screen and hammers mill, and all rocks and debris greater than 1 to 2 inches in diameter are removed. The remaining soil is deposited in the feed surge bin. The surge bin deposits soil on the SGS conveyor belt using a screed to control the thickness and width of the soil layer. The SGS screed is adjusted to spread the material across the conveyor belt to a depth appropriate for the radioisotope of interest and the soil characteristics. The soil passes under two sets of gamma radiation detector arrays housed in shielded enclosures. The first, the thin array, is designed for 0.16 inch-thick sodium iodide (NaI) detectors, which are generally used to detect gamma radiation from 15 keV to 200 keV. The second, the thick array, is designed for 2 inch- thick NaI detectors, which are generally used to detect gamma radiation from 150 keV to 1 MeV. Either set of NaI detectors may be replaced by a beta detector system that uses 100 cm^2 gas proportional detectors. These detectors may be used to monitor beta-emitting radionuclides in the top 0.25 inches of the soil layer on the conveyor belt. This measurement may then be used to infer the beta emitting contamination in the remaining thickness of the soil layer on the conveyor belt.

The process material is conveyed underneath the detector arrays at a pre-selected speed, based on the separation criteria, contaminant, and soil type. The arrays are linked to a control computer, which toggles pneumatic diversion gates located at the end of the sorting conveyor. Contaminated material that exceeds the separation criteria for radioactivity is diverted to the contaminated material conveyor, where it is transferred to a stacking conveyor on one side of the SGS. The below criteria material falls onto the below criteria conveyor that transports it to a second stacking conveyor on the opposite side of the SGS.
The SGS typically requires a footprint of 110 feet by 130 feet, as shown in Figure 3.

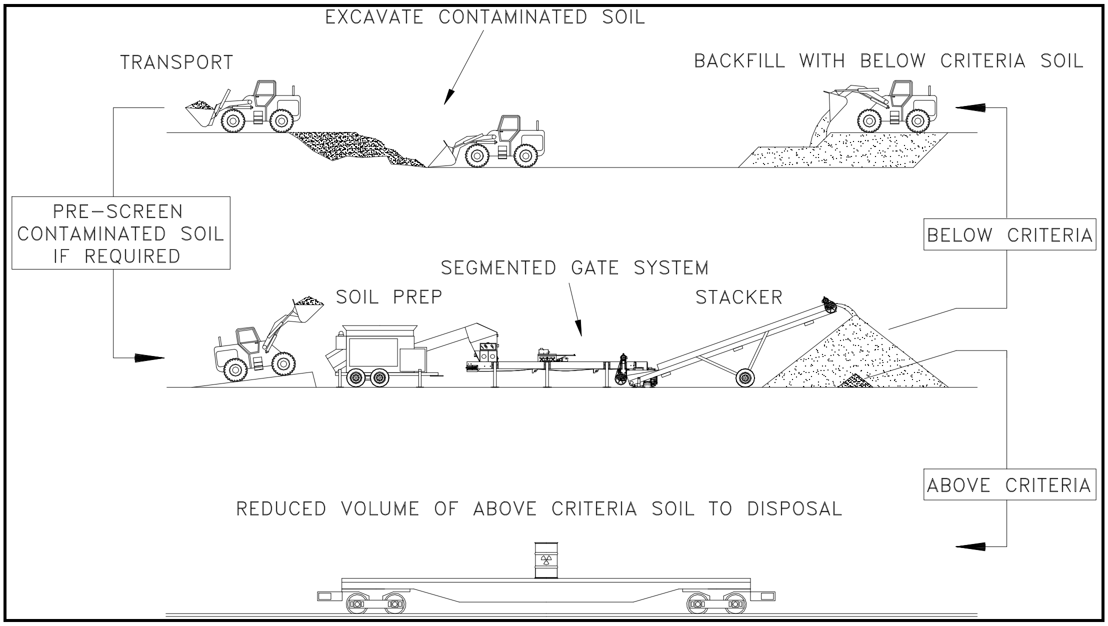


Figure 2. Process Flow Diagram

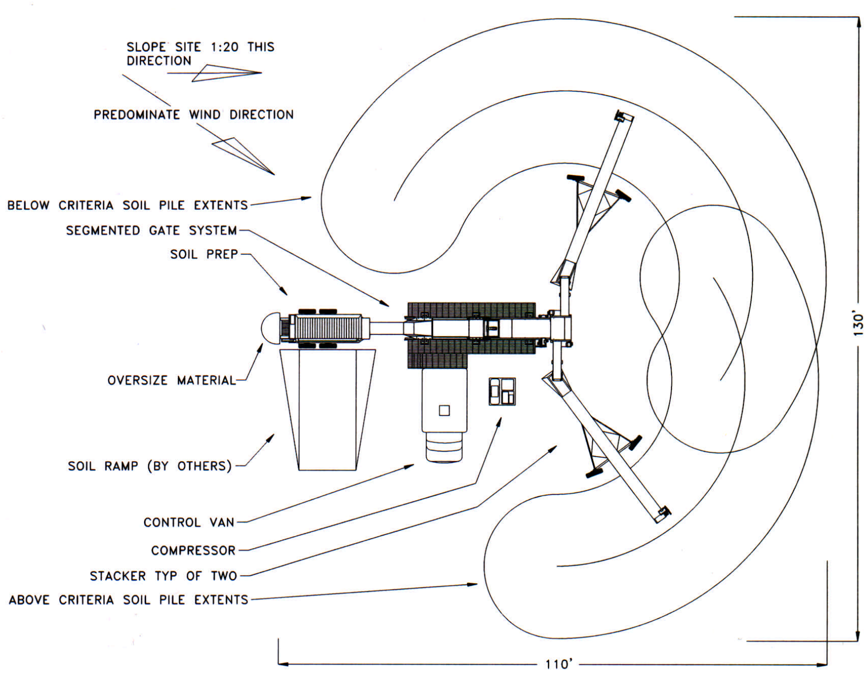


Figure 3. Segmented Gate System Footprint

Key Design Criteria

The application and utility of the SGS is affected by several site-specific factors. The primary factors are the gamma energies of the radioactive isotopes of interest, the attenuation of the soil for the energies of interest, and the density of the soil. Depending on these factors, soil may be processed in layers varying between 0.5 and 2.0 inches thick. The SGS is capable of operating at belt speeds between 20 and 40 feet per minute. The belt speed selection depends upon the sensitivity of the radiation detectors to the radioinuclide of interest, the background levels and the volume processing requirements. Minimum belt speeds allow each fraction of the soil to be counted for a longer time, increasing the sensitivity by collecting an increased number of counts for the same volume of soil. If the sensitivity is sufficient, the belt speed can be increased to enhance production levels. This results in a minimum throughput of 8.5 yd^3/hr and a maximum throughput of 28.5 yd^3/hr per sorting conveyor assuming a nominal soil density of 1.2 g/cm^3. A belt speed of 30 ft/min with a soil thickness on the belt of 2 inches has proved optimal for the majority of radionuclides heterogeneously distributed in the suspect soil, resulting in a processing throughput of approximately 28 yd^3/hr.

Since the detector arrays can be operated simultaneously, the SGS can monitor a second radioactive contaminant while looking for the primary radionuclide of concern. A separate calibration is required for each contaminant.

Operating Parameters

The operating parameters for the SGS at TA-33 were selected to provide the optimum sensitivity for the contaminant of interest, natural uranium. The belt speed and soil layer thickness were chosen to maximize production for the sensitivity required to achieve the client specified criteria, which were developed using risk-based calculations for the anticipated future use of the site. The thick detector array was not used during the project. The operating parameters and detector settings are summarized in Tables 2 and 3.

Table 2. Parameters Affecting Treatment Cost or Performance

Parameter	Value or Specification
Processing speed	30 fpm (sorting conveyor belt speed)
Belt length from detectors to conveyor end	Thin array: 16.0 ft (4.88 m) Thick array: 18.0 ft (5.5 m)
Soil layer thickness	2 inches (5.08 cm)
Soil layer width	30.75 inches (78.1 cm)
Soil density (on the conveyor belt)	1.02 g/cm^3, See Table 3
Detector type	Sodium iodide (NaI) 1/16 inch thick crystal

Table 3. SGS Detector Settings at TA-33

Contaminant	Detector Array	Gamma Energy Region of Interest	Distributed Alarm Setpoint	Multiple Particle Factor
Natural U	Thin	40-110 keV	50 pCi/g	3 (150 pCi/g)

International Technologies Corporation (IT) provided on-site radiation worker safety support. SGS operators were required to wear Modified Level D PPE but were not required to wear respirators. For Table 2, C333-010, soils were re-run at a distributed set point of 65 pCi/g and Multiple Particle Factor of 3 as requested by the client. Table 4. shows the various densities measured by site.

Table 4. Soil Densities by Site

	C33-003	C33-010	C33-007b	TA15
	0.97	1.02	0.88	1.06
	1.08	1.02	0.9	1.13
	1.08	0.99	0.92	1.20
	0.81	0.99	0.83	
	1.02	1.06	0.90	
	0.90	1.01	1.04	
		0.99	0.97	
Mean	0.97	1.01	0.92	1.13
Min	0.81	0.99	0.83	1.06
Max	1.08	1.06	1.04	1.20

5. SEGMENTED GATE SYSTEM PERFORMANCE

SGS Operational Capability

The overall impression was that the SGS operated as expected and had good reliability with the exception of hydraulic system failures and delays due to rocks in the chain drive. Mobilization, system setup and calibration were accomplished during the allotted time. Demobilization went as expected and there were no problems with decontamination of the SGS equipment prior to it departing the site.

Project Objectives and Approach

The primary objectives of the Segmented Gate System project were:

- Reduce the volume of soil at TA-33 requiring off-site disposal;
- Process the soil an ALARA Level of 50 pCi/g, given the PRG of 600pCi/g;
- Reduce the overall TA-33 remediation costs; and
- Provide a basis from which to estimate SGS cost/performance for similar sites projected for future operations.

The SGS was used to sort 2,526 cubic yards of soil suspected of natural uranium contamination excavated from TA-33 at Los Alamos National Laboratory. The reduction in the volume of contaminated soil was determined based upon the total soil processed versus the amount of soil that was determined to be below the release criteria for the site. The radionuclide activity of the below-criteria soil was compared to the pre-determined risk based release criteria.

Performance Summary

The period of performance for the project demonstration was from April 19, 1999 through May 27, 1999.

The Thermo NUtech Segmented Gate System (SGS) was mobilized to TA-33 on April 19, 1999, to an area that had been previously prepared by LANL. Off loading of equipment was accomplished by a TNU subcontract crane company. Assembly and calibration took place over a five-day period. Soil processing began on Wednesday, April 28, 1999. Soil was processed from April 28th through May 19th, with actual processing taking place on 15 of those days. A total of 91.10 hours of processing time were logged. A 5-day per week, 10-hour per day schedule was set for processing soil.

Demobilization of the system was completed on May 27, 1999 when the equipment was shipped to the Idaho National Engineering and Environmental Laboratory (INEEL). Total cost of SGS operations at Los Alamos National Laboratory was $275,745 including $6,600 for Pre-deployment Planning meetings, $46,000 for mobilization, $70,000 for processing 1,000 Cubic yards, $99,000 for processing additional soil, $16,445 for oversize material, $2,700 for Final Report, and $35,000 for demobilization.

Soil was processed using the SGS for 15 days in April and May. Figure 3 depicts the daily volumes processed. Average daily operational time was 6.48 hours, not including TA-15 soil on 5/19/99. The average daily operational time was impacted by some wind conditions, and hydraulic equipment malfunctions.

An overall volume reduction of 91.64 percent was realized after processing the entire volume of TA-33 soil, not including the 10 cubic yards of TA-15 soil. This included soil that was diverted for excessive activity (including soil that was diverted due to periodic source checks), and soil that was diverted due to unscheduled pauses in operations. Unscheduled pauses due to soil flow difficulties or other operational problems resulted in approximately 121.9 kg being diverted each time, with a total unrecorded mass diverted of approximately 9,386 kg (about 9.8 cubic yards). (Number of pauses 77 times 121.90 kg). This non-assayed soil represented 2.03% of the above-criteria soils.

On April 29, a 6 CY hot pile from C33-003 was reprocessed for an additional 94% volume reduction, On May 19, after all site soils were processed, 24 cubic yards of soil was scrapped up around the equipment and processed, resulting in 94.6% being clean.

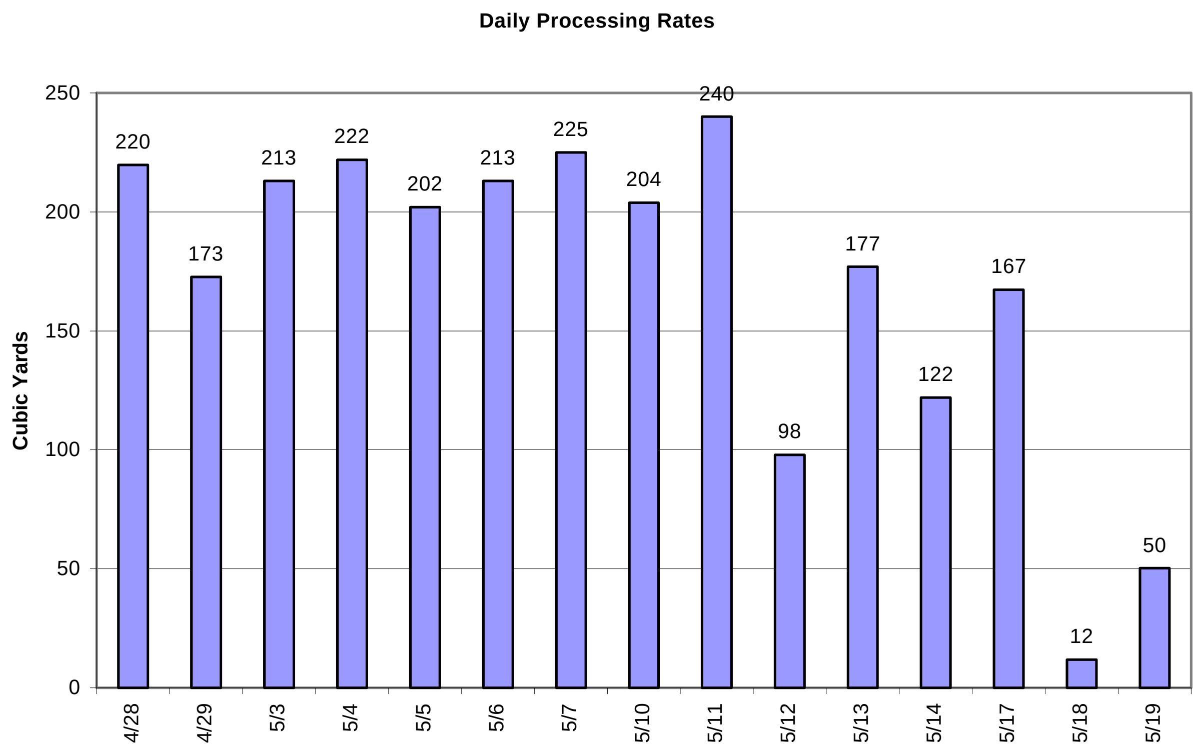


Figure 4. Daily Processing Volumes

Radiological Data

Depleted and natural uranium was present in the soil processed. The contamination was predicted to be very heterogeneous. SGS operations substantiated this prediction. The elevated activity could be removed by taking very little soil from the process. The activities for the above and below-criteria soils exhibited dramatically different levels of activity, as shown in Table 5. Samples collected and analyzed by LANL are shown for the clean soil piles. Also, the above-criteria average activity excludes any activity seen by the SGS during periodic source checking of the system that verified both detector response and gate operation while soil was being processed. No hazardous wastes were generated by SGS processing. Dry decontamination of the system resulted in no wastewater generation. Other wastes remaining were several drums of personal protective equipment (PPE).

Table 5. Soil Activity Levels

Site	Average Above-criteria Activity (pCi/g)	Average Below-criteria Activity (pCi/g)	LANL Clean Samples (pCi/g)	Distributed Sorting Criteria (pCi/g)
C33-003	318.00	3.20	5.78	50
C33-010	431.46	44.80	41.69	65
C33-007b	165.89	9.88	4.56	50
TA-15 (DU)	1,719.5	N/A	N/A	50

Demonstration Test TA-15

A demonstration test was conducted on 10 cubic yards of soil from TA-15 while the SGS was onsite. The test resulted in zero percent volume reduction in above criteria soil. The primary contaminate was Depleted Uranium (DU) instead of NU as in the TA-33 sites. At the request of LANL the set point was varied between 50 and 1200 pCi/g to determine if sorting would occur. The test determined that the Tornado Star screen, used to size the material and homogenize the High Explosive (HE) contamination, also homogenized the DU, and making the SGS ineffective. LANL will consider hardening and remote operation of the SGS as an alternative to using the Tornado Star or other methods to reduce HE content below 5% by volume. The average above-criteria activity reported by the SGS was 1,720 pCi/g.

6. SEGMENTED GATE SYSTEM COSTS

CONTRACTING METHOD

The SGS project was contracted by Sandia National Laboratories on a lump sum fixed price, with an optional production rate for a volume greater than 1000 cubic yards. The first 1,000 cubic yards were priced at $70/CY and all volume greater than 1000 priced at $65/CY. The original award amount was $160,300. Final invoiced cost for this project was $275,745, a $99,000 increase for additional soil processed (funded by Los Alamos Environmental Restoration project) and a $16,445 increase for oversize material.

COST BREAKDOWN

Mobilization costs included trucking and crane costs to deliver the SGS and delivery charges for heavy equipment, etc. Demobilization charges included pickup charges for the various equipment and facilities, crane services to load the SGS onto the trucks, and funding for preparation of the final report.

Daily operational costs included crew wages, per diem, equipment rentals, and daily operating supplies. Operational days included equipment unloading, assembly and calibration, site excavation, operation during soil processing, and disassembly, decontamination and loading of the equipment for shipment to the next job site. Truck transportation charges to the next site were considered part of the mobilization charges for the next client. In cases where the SGS is not scheduled for another project, trucking charges would be considered part of the demobilization.

Table 6. SGS Costs

Cost element	Description	Subtotals
Task 1	Pre-deployment Activities	$6,600
Task 2	Mobilization	$46,000
Task 3	Processing	$185,445
Task 4	Demobilization	$35,000
Task 5	Final Report	$2,700
Total		$275,745

Additional costs incurred by Los Alamos included excavation of the three sites, oversight labor, health physics support, procurement of a water supply, fuel services, generator rental and support, sample analysis, and waste disposal. All cost required for the technology applicability test, for TA-15 soil, were paid by separate purchase order. LANL costs are detailed in Table 7.

Processing costs for SGS operations provided by Thermo NUtech were approximately $67 per cubic yard ($185,445 divided by 2,779 cubic yards including oversize material), exclusive of TA-15. Overall costs for services provided by Thermo NUtech averaged about $103 per yard. The cost per yard went to down compared to other demonstrations mainly due to the larger volume of soil processed. Rental cost only included one loader and crew vehicle and did not include other items like generator and office trailer.

SGS Site Remediation – LANL Incurred Costs

There were substantial costs incurred by LANL in preparing for and in wrapping up the SGS deployment and demobilization. Those costs are listed in Table 7.

Table 7. LANL Incurred Costs

Staff	$41,700
Prime Contractor (IT Corp) **(1)**	$339,600
Other Services	$7,600
Recharges/G&A	$74,500
Soil Disposal Cost 350 cu. Yards (estimated)	$80,000
Site Restoration **(2)**	**---**
Total	$543,400.00

(1) An indeterminate portion of these costs were for excavation. Excavation is a cost even if the entire volume of suspect soil had been disposed of off-site at an estimated $350/yard^3 and has to be considered in the cost comparison

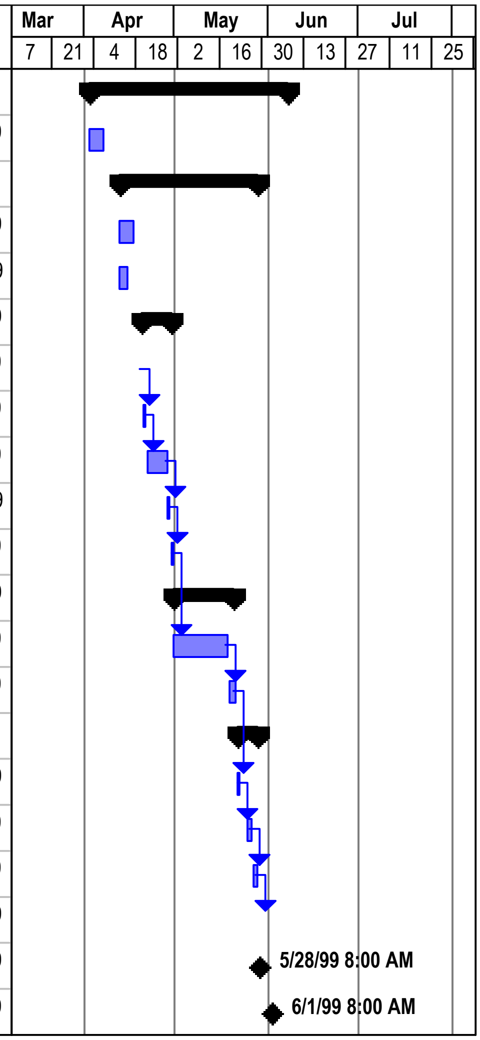
(2) Unknown at time of report

7. SCHEDULE

Table 8 shows the tasks and schedule associated with the SGS deployment at LANL. Since only one radionuclide was processed, only one calibration interval was required. The original operations schedule was increased by two days for the TA-15 demonstration.

Table 8. Project Schedule

ID	Task Name	Start	Finish
1	**Sandia Contract AY-5328**	**Fri 4/2/99**	**Mon 6/7/99**
2	Pre-deployment meetings	Fri 4/2/99	Tue 4/6/99
3	**Los Alamos, TA-33, SNL AY-5328**	**Mon 4/12/99**	**Fri 5/28/99**
4	HASP Delays	Mon 4/12/99	Fri 4/16/99
5	Training, ABQ-LANL	Mon 4/12/99	Wed 4/14/99
6	**Mobilization**	**Mon 4/19/99**	**Thu 4/29/99**
7	Transport equipment	Mon 4/19/99	Mon 4/19/99
8	Unload SGS & Equipmen	Tue 4/20/99	Tue 4/20/99
9	Assemble and calibrate	Wed 4/21/99	Tue 4/27/99
10	NM Permit Delays	Wed 4/28/99	Wed 4/28/99
11	Replace Elec Wires	Thu 4/29/99	Thu 4/29/99
12	**Processing**	**Fri 4/30/99**	**Thu 5/20/99**
13	2,500 CYs TA-33 soils	Fri 4/30/99	Mon 5/17/99
14	TA-15 Demo	Tue 5/18/99	Thu 5/20/99
15	**Demobilization**	**Fri 5/21/99**	**Fri 5/28/99**
16	Disassembly	Fri 5/21/99	Fri 5/21/99
17	Decontaminate	Mon 5/24/99	Tue 5/25/99
18	LANL RAD Release Surv	Wed 5/26/99	Thu 5/27/99
19	Load Trucks	Fri 5/28/99	Fri 5/28/99
20	Depart LANL for INEEL	Fri 5/28/99	Fri 5/28/99
21	Arrive INEEL	Tue 6/1/99	Tue 6/1/99



8. REGULATORY/ INSTITUTIONAL ISSUES

This report describes the voluntary corrective action (VCA) conducted at three PRSs at TA-33 of LANL. PRSs 33-007(b), 33-010(c), and C-33-003 are sites associated with testing of nuclear weapons initiators. A RCRA facility investigation (RFI) was conducted at PRSs 33-007(b) and 33-010(c) in 1994. PRS C-33003 was not sampled during the 1994 investigation, but a uranium-containing projectile was discovered during brush-clearing activities conducted in the spring of 1996. Pieces of uranium were observed at PRSs 33-007(b) and C-33-003. Radioactive debris (containing greater than two times the site-specific background) within and near a drainage channel were also observed at PRS 33-010(c). Based on RFI nature and extent assessments done previously, no metal or organic contamination above human health risk based levels was found at these sites.

The VCA utilized the SGS technology to separate radiological contaminated soil and debris (exceeding dose-based level) from non-radiological contaminated soil and debris (below the dose-based level). The non-radiological contaminated material (soil and debris) was returned to each PRS, and the sites were contoured and restored to mitigate further migration of debris in the associated drainage. Remediation activities were conducted from April to July 1999.

PRSs 33-007(b) and 33-010(c) are solid waste management units (SWMUs) listed in Table A of the HSWA Module of LANL's Hazardous Waste Facility Permit. PRS C-33-003 is an area of concern (AOC). PRS C-33-003 is not a HSWA SWMU. The Administrative Authority (AA) for this PRS is the Department of Energy (DOE). The area encompassing the three PRSs is designated an Area of Contamination per New Mexico Environment Department (NMED) recommendation. The purpose of designating the Area of Contamination was to allow material from the three PRSs to be processed and returned to the PRSs without invoking RCRA Land Disposal Restrictions. This Area of Contamination approach was described in a March 13, 1996; memo from Michael Shapiro, Director of the Office of Solid Waste, to RCRA Branch Chiefs and CERCLA Regional Managers entitled "Use of the Area of Contamination (AOC) Concept During RCRA Cleanups." This memo states: "Using the AOC concept, a RCRA facility owner/operator with a large contiguous area of soil contamination could consolidate such soils into a single area or engineered unit within an AOC without triggering the RCRA land disposal restrictions or minimum technology requirements." Because this VCA involves radiological contamination above levels of concern, it is regulated under DOE Order 5400.5, Radiation Protection of the Public and the Environment (proposed rule 10 CFR 843.5 in FR 16268).

Table 9. PRSs Covered by this VCA

PRS Number	PRS Type	HSWA	PRS Description
33-007(b)	SWMU	Yes	Gun-firing area
33-010(c)	SWMU	Yes	Surface Disposal
C-33-003	Area of Concern	NO	Fill Area

Based on the results of the VCA confirmatory sampling, it was decided not to propose these sites for human health and ecological NFA. Extent of non-radiological inorganic constituents has not been completely defined. It is recommended that PRS 33-010(c) be consolidated with PRS 33-006(a). Final disposition for these sites will be addressed during future work at TA-33.

9. OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

a) Using processing costs only, the cost per cubic yard is \$169,000 / 2,526yd^3 = \$67yd^3.
b) Using total costs from Thermo NUtech the cost per cubic yard is \$259,300 / 2,526yd^3 = \$103yd^3.
c) Including total costs from LANL the cost per cubic yard is \$543,400 / 2,526yd^3 = \$195yd^3
d) The combined total cost is \$298/ yd^3.
e) A total of 253 yd^3 of oversize material at a cost 0f \$16,445 was not included in the calculations for a-d.

{for qualifying information on "b & c" above, refer to **"(1) & (2)",** page 16**}**

When considering the use of any technology to reduce the volume of radioactive material the total cumulative costs should be considered. This cost can vary widely depending on what steps must be taken to mobilize the technology. Ask yourself what your part of the cost will be and will your costs result in cost savings over your baseline technology. Consider the costs associated with excavation and movement of the soil that would occur if disposal of 100% of the suspect soil is a comparison in the cost analysis. A detailed performance and cost analysis should aid in your decision.

Performance Observations and Lessons Learned

The average daily processing time was 6.48 hours, just below the target of 7 hours of processing time per each 10-hour workday. There were 8 of 14 processing days where the volume of soil exceeded 200 yd^3. Safety and electrical inspections raised some concerns resulting in unscheduled downtime to perform equipment modifications required to address these concerns. A screen plant hydraulic system failure, a broken check valve causing damage to the hydraulic pump for the hammer mill, caused delays. A total of 2,526 cubic yards were processed through the SGS. Volume reduction reported by the SGS for the three sites were (a) 33-003, 99.65%; (b), 33-01099, 79%; and (c) 33-007, 75.34%. An estimated volume of 253 yd^3 of oversize (>$1^1/_2$ inch in diameter) was handled at \$63/yd^3. The majority of the soil processed was from the Bunker Site (C33-007b). A set point of 65 pCi/g was used for the Gully Site (C33-010), since the contamination was more uniformly distributed but still below the PRG. The LANL excavation plan of digging from the rear of the bunker towards the front, where the highest level of contaminate concentration was located, aided in the SGS achieving a very good volume reduction. A total of 253 cubic yards of material from the hot piles were processed a second time to attempt addition volume reduction. A 6yd^3 hot pile from C33-003 was processed yielding an additional 94% volume reduction. On May 19th, after all site soils were processed, 24 yd^3 of soil was excavated from around the equipment and processed yielding a volume reduction of 94.6%.

10. REFERENCES

1. Yu, C., et al., *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0.* Environmental Assessment Division, Argonne National Laboratory, 1993.

2. *Guide to Documenting Cost and Performance for Remediation Projects*, Member Agencies of the Federal Remediation Technologies Roundtable, March 1995, EPA-542-B-95-002. (download at http://clu-in.com/pubitech.htm)

3. *HTRW Remedial Action Work Breakdown Structure*, Hazardous, Toxic, Radioactive Waste Interagency Cost Engineering Group, February 1996. (downloadable at http://globe.lmi.org/lmi_hcas/wbs.htm)

4. *Avoidable Waste Management Costs*, Idaho National Engineering and Environmental Laboratory, January 1995.

5. *TA-33 VCA Completion Report,* LANL, August 31, 1999

6. *Segmented Gate System Uranium Separation, Tech Area 33 Project, Final Report, May 19, 1999,* Thermo NUtech.

11. VALIDATION

"This analysis accurately reflects the performance and costs of the remediation."

Original Signed by John M^c^Cann

John M^c^Cann, Firing Sites Team Leader
Environmental Restoration Project
Los Alamos National Laboratory

Original Signed by Ray Patteson

Ray Patteson, Technical Coordinator
Accelerated Site Technology Deployment Program
Sandia National Laboratories