Cost and Performance Report

Thermo NUtech's Segmented Gate System
Sandia National Laboratories, ER Site 16
Albuquerque, New Mexico

Accelerated Site
Technology Deployment

U.S. Department of Energy

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LIST OF ACRONYMS

ASTD	Accelerated Site Technology Deployment Program
CEARP	Comprehensive Environmental Assessment and Response Program
DOE	Department of Energy
DOE/AL	DOE Albuquerque Operations Office
EPA	Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety and Health
HE	High Explosive
HSWA	Hazardous and Solid Waste Amendments
ITRD	Innovative Treatment Remediation Demonstration
NMED	New Mexico Environment Department
NTS	Nevada Test Site
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
Sandia	Sandia National Laboratories/New Mexico
SGS	Segmented Gate System
SVOC	Semi-volatile Organic Compound
SWMU	Solid Waste Management Unit
TA-II	Technical Area II (Sandia National Laboratories)
VOC	Volatile Organic Compound
WBS	Work Breakdown Structure

FOREWORD

The Department of Energy (DOE) is working to accelerate the acceptance and application 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 (ITRD) 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 separate clean and 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 first ASTD deployment of the SGS at Sandia National Laboratories ER Site16.

1. SUMMARY

Thermo NUtech conducted a radioactive material volume reduction project for Sandia National Laboratories at ER Site 16 near the TA-III/TA-V complex. The goal of the project was to reduce the volume of contaminated soil that would require off-site disposal. ER Site 16 is an arroyo area contaminated with depleted uranium. The arroyo had been used as a dump site and contained large chunks of concrete and other debris as well as the radioactive contaminant.

The Thermo NUtech Segmented Gate System (SGS) was mobilized to ER Site 16 on February 17, 1998, to an area that had been previously prepared by Sandia personnel. Assembly and calibration were accomplished over an eight day period. Excavation and pre-screening of the soil to remove the large debris was accomplished over the same period. Soil was processed from February 26th through March 5th, with actual processing taking place on 5 of those days. About 24 hours of processing time were logged, and approximately 5 hours of downtime were accumulated for mechanical reasons.

A total of 661.8 cubic yards were processed through the SGS, with an estimated 25 percent additional volume in oversize material. This oversize material was predominately cobbles, which was not sorted through the SGS. With the segregation level set at 54 pCi/g actual volume reduction for the first pass was close to 97.5 percent after accounting for the volume of soil that was sent to the above criteria path due to unscheduled operational halts. Total volume sent to the above criteria path was 15.8 cubic yards. The approximately 16 cubic yards in the above criteria pile was processed again to remove the soil generated from unscheduled operational halts, and resulted in a 98 percent volume reduction (including soil from one unscheduled operational halt). This resulted in a total of 0.32 cubic yards of above criteria soil requiring off-site disposal. Total volume reduction for material processed through the SGS was in excess of 99 percent.

Demobilization of the system was delayed for several days for tours and demonstrations, and was completed on March 26th, 1998 when the equipment was shipped to the Pantex Plant near Amarillo, Texas for the second deployment under the ASTD Program.

Total cost of SGS operations at Sandia National Laboratories was $164,109 including $59,326 for mobilization, $57,770 for operations and $47,013 for demobilization. Unit treatment costs were approximately $87/cubic yard of soil processed. Baseline site soil disposal costs are $560/cubic yard for off-site disposal. The use of SGS provided overall savings of $280,000 when compared to off-site transportation and disposal.

Based on these results and those obtained after processing 8-fifty five gallon drums of soil from ER Site 228, Sandia's Environmental Restoration Project has contracted with Thermo NUtech to return in October of 1998 to process an additional 1500 cubic yards of depleted uranium contaminated soil. An expected site remediation cost savings in excess of $500,000 is projected during this particular deployment. This will also mark the first follow-up deployment completely funded by EM-40 as a result of the ASTD deployment successes.

2. SITE INFORMATION

Identifying Information

Facility:	Sandia National Laboratories
Location:	Albuquerque, Bernalillo County, New Mexico
OU/SWMU:	ER Site 16
Regulatory Driver:	RCRA
Type of Action:	Corrective Measure – Site Remediation
Technology:	Thermo NUtech's Segmented Gate System
Period of operation:	2/26/98 to 3/5/98
Treatment volume:	661.8 yd^3

Site Background

The Sandia National Laboratories, New Mexico site (Sandia), is located within the boundaries of Kirtland Air Force Base immediately southeast of Albuquerque, New Mexico (Figure 1). The Kirtland Federal Complex, including Sandia, is situated on the eastern side of the 160-km long, north-south trending Albuquerque Basin, between the Manzano and Manzanita Mountains to the east and the Rio Grande to the west. Elevations range from 5400 ft to 8000 ft. The site is characterized by a semiarid climate with an average annual precipitation of 8.6 inches.

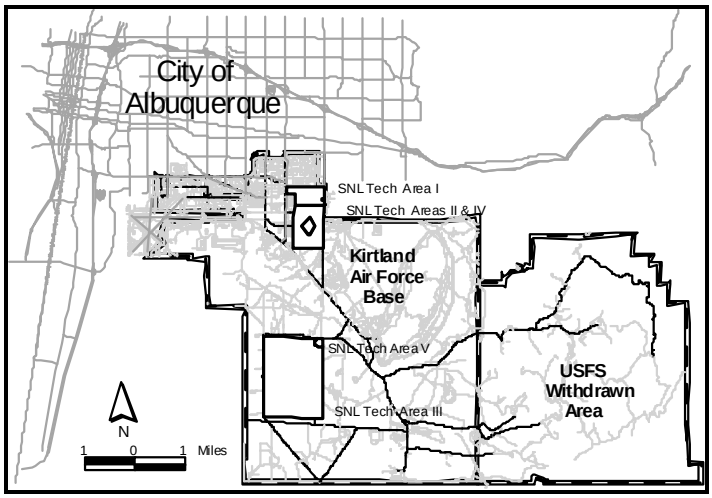

Figure 1. Sandia National Laboratories Location

Site History

Sandia's ER Site 16 is located within the boundaries of Kirtland Air Force Base immediately southwest of Albuquerque, New Mexico. ER Site 16 is northeast of Sandia's Tech Area-III/Tech Area-V complex. ER Site 16 is situated along the active Arroyo del Coyote drainage that empties into the active Tijeras Arroyo drainage. (Figure 2)

The site covers approximately 25 acres and was an open dumping ground for concrete and other rubble. This concrete debris and rubble is presumed to be the source of contamination. An area of approximately 1/3 of an acre was excavated for this project.

Release Characteristics

Characterization of the site indicated that depleted uranium was the only contaminant present at the site. The volume of possibly contaminated soil was estimated at around 1000 cubic yards. This soil was excavated from the arroyo side and bottom after the removal of the larger debris. Characterization of the site included the removal of visible depleted uranium fragments by hand.

Site Contacts

The DOE Albuquerque Operations Office (DOE/AL) provides site management for Sandia. The Managing and Operating contractor for Sandia is the Sandia Corporation, a subsidiary of Lockheed Martin Corporation. Funding for the project was provided under the Accelerated Site Technology Deployment Initiative under the direction of Tom Burford [(505) 845-9893]. The ER site contact for the Sandia SGS project is Sue Collins at Sandia National Laboratories [(505) 284-2546)]. The project manager for Thermo NUtech is Scott Rogers [(505) 424-3072].

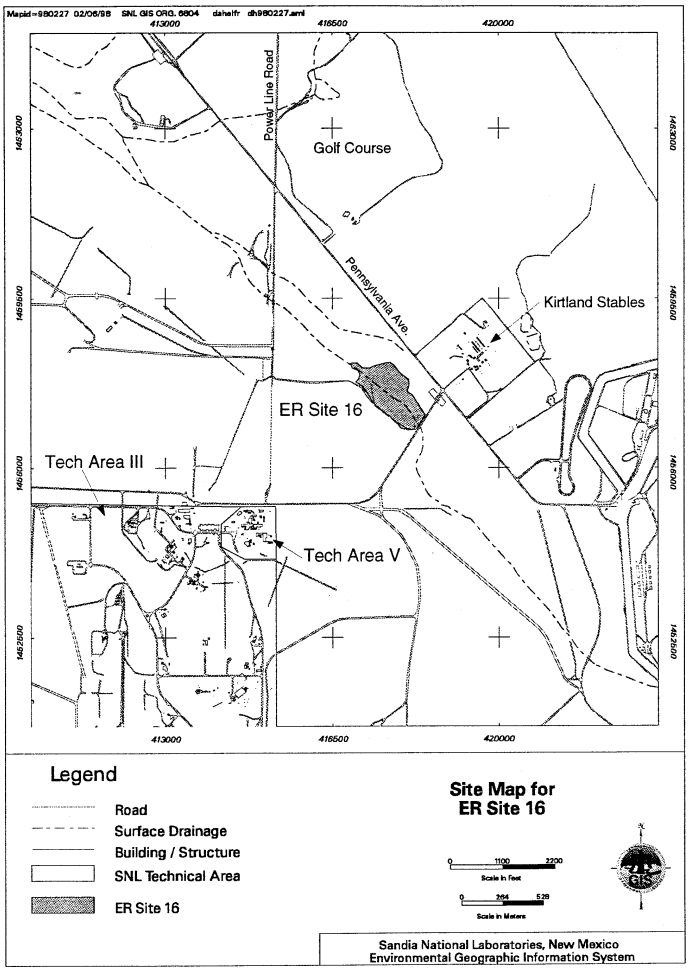

Figure 2. ER Site 16 Map

3. MATRIX AND CONTAMINANT DESCRIPTION

The type of matrix treated by the SGS at Sandia's ER Site 16 was radionuclide contaminated soil (ex situ) mixed with concrete and steel debris.

Site Geology/Hydrology

Sandia's ER Site 16 lies west of the basin-bounding fault complex and northeast of the Tijeras Arroyo fault, which are the two main structural features of the Albuquerque Basin. The fault complex consists of thick alluvial sediments, which overlie deep bedrock. An alluvial fan and piedmont colluvium overlie Santa Fe Group strata. The Santa Fe deposits are estimated to be approximately 3,000 ft thick beneath ER Site 16. Surface soils are silty sands typical of desert alluvium. Depth to regional groundwater in the vicinity of Area 16 is approximately 540 ft; however, some water-bearing units are present as shallow as 300 ft.

Nature and Extent of Contamination

The only radioactive contaminant found in the characterization of ER Site 16 was depleted uranium (U^{238}). Pretreatment contaminant concentrations ranged from background to in excess of 4100 pCi/g, excluding actual visible fragments of depleted uranium. Depleted uranium contamination was estimated to exist in approximately 1000 cubic yards of soil, to be defined by field surveys as the excavation progressed.

Matrix Characteristics Affecting Treatment Cost or Performance

Thermo NUtech did not perform any sieve analysis on the soils to be treated at ER Site 16. The soil treated at ER Site 16 presented no processing problems for the SGS. The soil was characterized as silty sand, containing 35 to 45% silt and clay, with low moisture content. Based on previous operating data, the soil moisture content appeared to be about optimal for SGS processing, and was estimated to be approximately 10% by weight. However, actual soil moisture content measurements were not made. No water was added to the soil for processing and no drying processes were used.

Cost and performance of the SGS can be affected by soil moisture content, as too little moisture presents dust control problems, while too much moisture can cause the soil to collect on or stick to various surfaces of the SGS. Optimum moisture content for the SGS is between 5 and 15%, however; based on field experience the system will tolerate soil moisture content from 2 to 25%.

The excavated soil and debris presented several challenges to SGS processing. Foremost was the presence of concrete and metal debris in the soil. This problem was alleviated by use of a field grizzly, which was a vertical bar grate measuring 10 feet on a side, mounted at a 45 degree angle to the plane of the ground surface. The vertical grate spacing was 6 inches center to center, and the bars were made of 2 inch by 1 inch plate steel. The soil was dropped onto the field grizzly directly from excavation, which separated debris with a minimum 6 inch dimension from the soil. Smaller debris and soil passed through the grate, while the larger debris slid down and were deposited in front of the grate. The larger debris were collected and spread out for possible hand survey later in the project.

Of the debris and rocks, which passed through the field grizzly, only those flattened rocks with approximately a 5 inch maximum dimension caused any processing difficulties. This size of rock would occasionally fall between the drag feed chain and drive gear, which would jam the chain and halt the flow of soil from the screen plant to the SGS. If this resulted in an emptying of the surge feed bin, the SGS would be halted by the operators due to lack of soil on the conveyor.

4. TECHNOLOGY DESCRIPTION

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.; therefore a 35 to 50 ton crane is required 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. SGS Staging and Processing Area Requirements.

Provision	Requirement
Staging Area	Level area, 100 feet x 130 feet
Power	400A, 208V, 3 phase 115V generator for overnight and weekend detector temperature control
Water	Water supply for dust suppression (100 to 200 gallons per day)
Ancillary Equipment	35 to 50 ton crane, loader with 2 to 5 yard bucket no wider than 8.5', fork lift

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 by 50-90%,
- No chemicals or other additives are used, and
- The generation of secondary waste is limited to PPE and decontamination rinse water.

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 1-2 inches in diameter cannot be processed by the SGS without pre-crushing.

Treatment System Schematic and Operation

Figure 3 shows the process flow of 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 feed soil is then sent through the SGS screen and hammer 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. Two separation criteria are used. One separation criteria is an average contaminant concentration measured over an approximately two cubic foot volume of soil. The second criteria is the separation of very high concentrations of contaminants in the soil. 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.

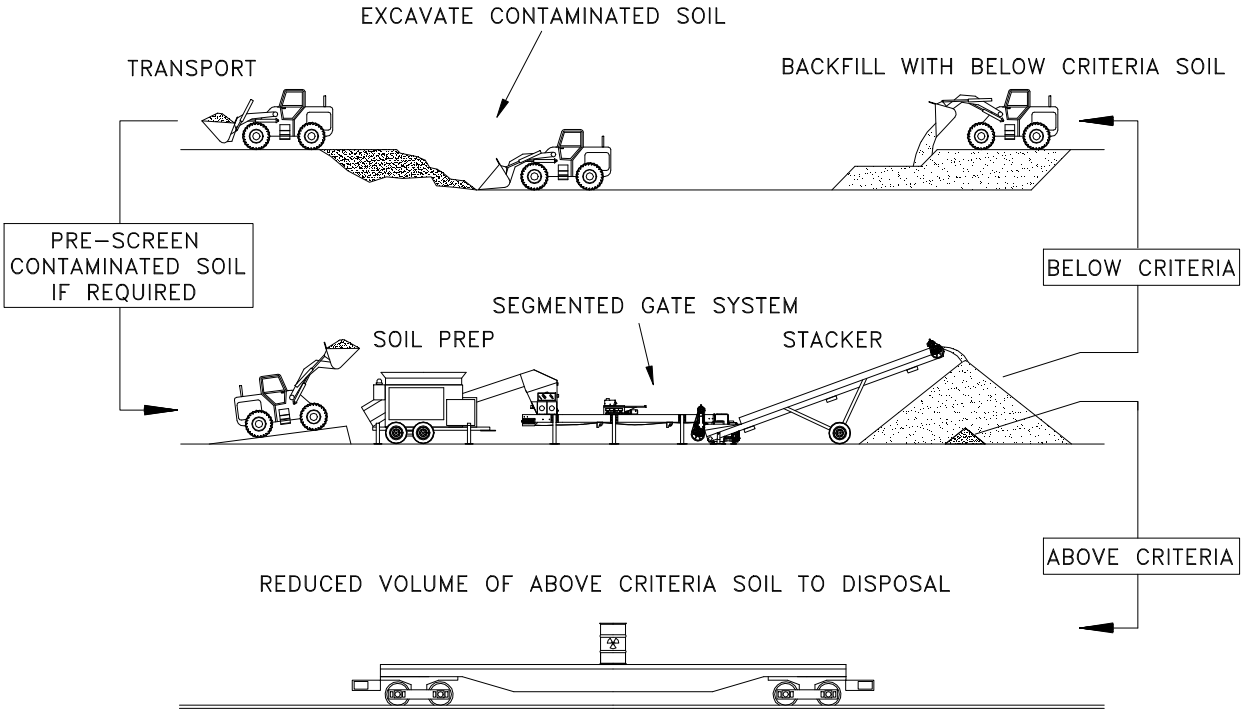

Figure 3. SGS Process Flow Diagram

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 radioisotope 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 yd3/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.

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 ER Site 16 were selected to provide the optimum sensitivity for depleted uranium, the contaminant of interest. The belt speed and soil layer thickness were chosen to maximize production for the sensitivity required to achieve the client specified separation criteria, which were developed using risk-based calculations for the anticipated future use of the site. The operating parameters and detector settings are summarized in Tables 2 and 3 below.

Table 2. Operating 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)	1.0 g/cm^3
Detector type	Sodium iodide (NaI) 1/16 inch thick crystal

Table 3. SGS Detector Settings at ER Site 16

Contaminant	Detector Array	Gamma Energy Region of Interest	Distributed Alarm Setpoint	Multiple Hot Particle Factor
Depleted U	Thin	40-110 keV	54 pCi/g	10

On-site radiation worker safety support was provided by Sandia, but may be provided by a Senior Health Physics Technician supplied by Thermo NUtech. SGS operators were required to wear Level II personal protective equipment but were not required to wear respirators.

5. SEGMENTED GATE SYSTEM PERFORMANCE

Project Objectives and Approach

The primary objectives of the Segmented Gate System project were:

- Reduce the volume of soil at ER Site 16 requiring off-site disposal;
- Reduce the overall ER Site 16 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 661.8 cubic yards of soil suspected of depleted uranium contamination excavated from ER Site 16 at Sandia National Laboratories. 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.

Performance Summary

Site preparation was completed by SNL prior to mobilization of the SGS. The SGS was mobilized to the SNL ER Site 16 site and arrived on February 17th. The Thermo NUtech SGS Engineer was on site to supervise the unloading of the equipment. The SGS Site Manager and all SGS field personnel arrived on February 18th to begin assembly of the system. Mobilization and calibration of the system were accomplished in eight days including detector and operational quality checks. This period also included excavation of the suspected contaminated material and required training for Thermo NUtech personnel. There were no weather related delays during the mobilization phase. The SGS was completely operational and ready to process soil on February 27, 1998.

Excavation was begun by Sandia personnel using a front-end loader, and was completed by Thermo NUtech personnel when the Sandia equipment and operators were no longer available. Excavation included pre-screening of the soil using a vertical bar field grizzly to remove objects whose minimum dimension was greater than 6 inches. Upon completion of the pre-screening process, the oversize material was spread out in a single layer in preparation for future hand survey by Sandia personnel. The soil was stockpiled for processing. Excavation and prescreening were completed on February 25th.

A five day per week, ten hour per day schedule was set for soil processing. Soil was processed for five days and processing continued until March 5, 1998. Figure 4 depicts the daily volumes processed. On March 8th, a feasibility study, using eight 55-gallon drums of soil from ER Site 228, was conducted. The results of that feasibility study are not included in the data for ER Site 16. The system was then decontaminated and partially disassembled. SGS personnel were placed on standby due to a delay in preparations at the Pantex Plant, near Amarillo, Texas, to receive the SGS for its next deployment.

Final disassembly was completed on March 25, 1998. On March 26, 1998, the equipment was loaded onto trucks for transportation to the Pantex Plant.

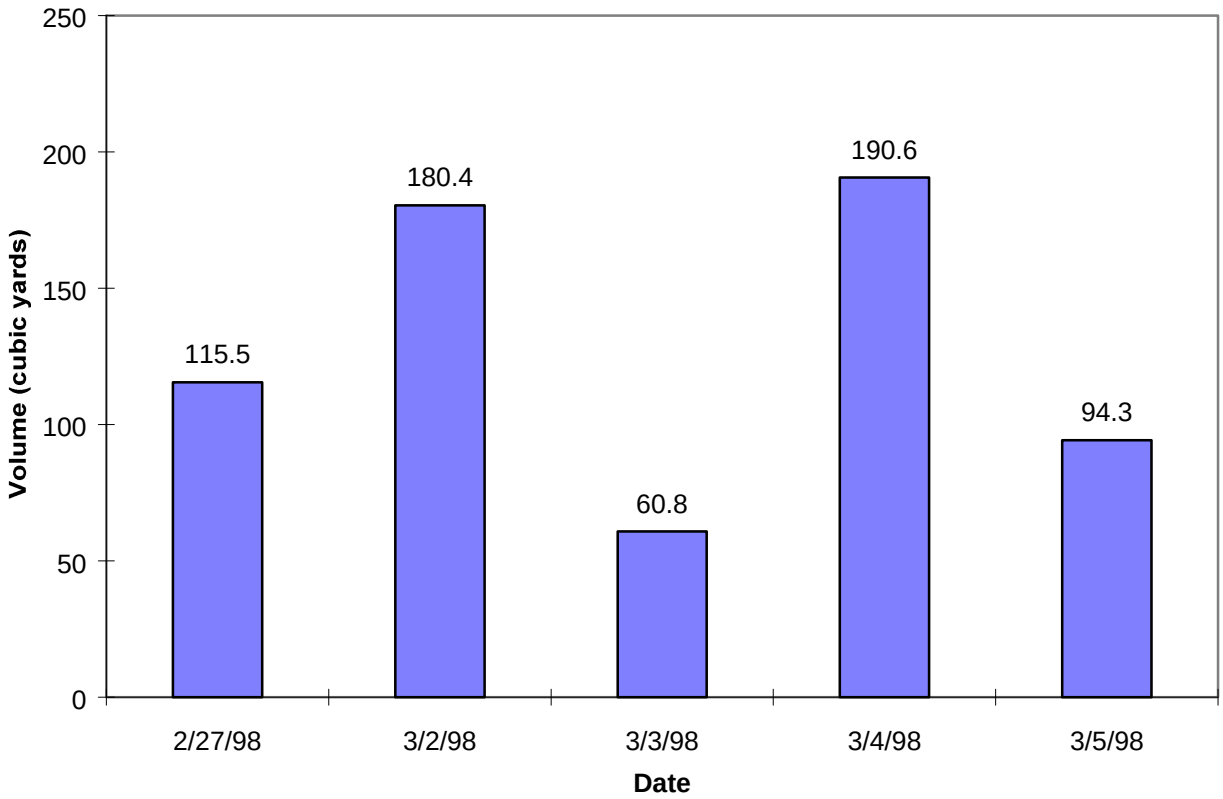

Figure 4. Daily Processing Volumes

Average daily operational time was 4.7 hours. Control boundary posting on February 27th and equipment malfunctions on March 3rd impacted the average daily operational time. A total of 5.3 hours of down time was charged to the project. This 5.3 hour charge was based on the expectation of processing for 7 hours each processing day.

An overall volume reduction of 98.5 percent was realized after processing the entire volume of soil on the first pass. This included soil that was diverted for excessive activity, soil that was diverted due to periodic source checks, and soil that was diverted due to unscheduled pauses in operations. Unscheduled pauses as a result of soil flow difficulties and other operational problems resulted in approximately 161 kg of soil diverted during each pause. The total mass diverted due to pauses was approximately 10,000 kg.

Processing was completed on March 5th, 1998. An additional 0.58 hour was required to reprocess the above criteria pile. The 15.9 cubic yards of diverted soil was processed and a volume reduction of 99.8 percent was achieved. The volume reduction was primarily due to the separation of the non-contaminated soil that was diverted after the unscheduled pauses. Processing of soil that was scraped from the operating areas, a part of the decontamination process, required another 0.17 hour. A volume reduction of 100 percent was achieved from processing this 4.7 cubic yards of soil. The 20.6 cubic yards that represents the combined volumes of the reprocessed hot pile and the scrapings were not included when defining the total volume of soil processed.

Overall volume reduction, which includes the volume reduction realized by reprocessing the hot pile, was 99.9 percent. This volume reduction yielded 358 kg of contaminated soil requiring off-site disposal.

Radiological Data

Depleted uranium was the only radionuclide processed in this project. While the sorting criteria for distributed contamination was set at 54 pCi/g, the below criteria soil average was below that level, at 4.2 pCi/g, after the first sorting pass. The above criteria soil average was 406.5 pCi/g after the first pass. These levels of activity are outlined in Table 4. The above criteria average activity excludes any activity seen by the SGS during periodic source checking of the system which verified both the detector response and gate operation while soil was being processed.

Table 4. Criteria Activity

Date	Average Above Criteria Activity (pCi/g)	Average Below Criteria Activity (pCi/g)	Distributed Sorting Criteria (pCi/g)
2/27/98	398.5	3.6	54
3/2/98	408.5	4.2	54
3/3/98	342.7	5.1	54
3/4/98	543.0	4.6	54
3/5/98	393.4	3.8	54
3/5/98 above criteria	419.9	6.9	54

Reprocessing of the above criteria pile resulted primarily in the removal of most of the below criteria soil that was generated due to the unscheduled pauses in operation as previously reported. The average activity of the below criteria soil removed from the above criteria pile was 6.9 pCi/g, while the activity of the above criteria soil after reprocessing remained relatively constant at 420 pCi/g.

No hazardous wastes were generated by SGS processing. Approximately 200 gallons of wastewater was generated during the system decontamination. Other wastes remaining were approximately four barrels of personal protective equipment (PPE). The contaminated soil was packaged into four 55-gallon drums for final disposition by Sandia.

ER Site 228 Summary

In addition to the soil sorting activities at ER Site 16, eight 55-gallon drums of soil from ER Site 228 were transferred to ER Site 16 by Sandia personnel for a pilot study. The contamination at ER Site 228 was judged to be much more extensive, and the collected data was expected to produce valuable information on the cost-effectiveness of processing soils from ER Site 228.

A total of 2.6 cubic yards of ER Site 228 soil was processed. A minimum volume reduction of approximately 70 percent was estimated for application of the SGS. The average above criteria activity reported by the SGS was 136 pCi/g, while the average below criteria activity was reported as 30.5 pCi/g. The distributed contamination separation criteria for ER Site 228 soils was set also to 54 pCi/g.

6. SEGMENTED GATE SYSTEM COSTS

Sandia National Laboratories on a daily operational rate contracted the SGS project, with separate line items for non-labor mobilization and demobilization costs. Total invoiced cost for this project was $164,109.

Cost Breakdown

Mobilization costs included trucking and crane costs to deliver the SGS and delivery charges for heavy equipment, mobile office space, toilet facilities, 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, PPE 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. For the ASTD program, trucking charges for transportation 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 5. Cost Breakdown

COST ELEMENT	DESCRIPTION	COSTS	SUBTOTALS
Mobilization	Labor	$35,988	$59,326
	Travel and per diem	$8,940	
	Equipment, materials, and other direct costs	$14,398	
	Depreciation*	$0	
Physical Treatment	Labor	$29,991	$57,770
	Travel and per diem	$3,705	
	Equipment, materials, and other direct costs	$5,304	
	Depreciation*	$12,270	
	Treatment of ER Site 228 soil	$6.500	
Demobilization	Labor	$25,422	$47,013
	Travel and per diem	$7,680	
	Equipment, materials, and other direct costs	$5,411	
	Depreciation*	$0	
	ASTD and USCOE tour support	$6,500	
	Final report	$2,000	
Total			$164,109

* The depreciation schedule is calculated on a per cubic yard basis, applied only to the physical treatment of the soil, and is based on an estimated 10,000 cubic yard volume of soil processed during the fiscal year.

Unit treatment and processing costs for SGS operations provided by Thermo NUtech were about $80 per cubic yard. Overall costs for services provided by Thermo NUtech averaged about $236 per yard. Overall costs reflect the relatively small volume processed. Increased volumes would leverage the mobilization and demobilization costs and should result in increased daily production volumes as a daily routine develops and soil is available for continuous processing.

Additional costs incurred by Sandia, estimated to be approximately $20,000, include site preparation, removal by crane of the largest concrete rubble, preliminary excavation, oversight labor, health physics support, procurement of a water supply, sample analysis, and waste disposal.

Baseline off site soil disposal costs was estimated at $563 per cubic yard for ER Site 16. Based on the volume of soil processed and the volume of oversized material, the baseline costs for this project were estimated to be approximately $465,000. The employment of the SGS provided overall savings of approximately $280,000 when compared to off-site disposal costs coupled with associated remediation and transportation costs.

7. REGULATORY/ INSTITUTIONAL ISSUES

Environmental restoration is conducted at Sandia under the Resource Conservation and Recovery Act Hazardous and Solid Waste Amendment Part B permit issued in August 1993. Sandia and DOE are responsible, as co-permittees, for compliance under the terms of the HSWA permit. The EPA Region VI (Dallas, Texas) was the authorized permitting agency at the time of issuance, but beginning in January 1996 authority was transferred to the New Mexico Environment Department (NMED).

The applicable regulatory guidance is found in DOE Order 5400.5, and in the 1995 memo “Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material.” This memo directs DOE facilities to use the RESRAD computer code to project future exposure potential. This code was used to establish site cleanup criteria and the SGS soil separation criteria.

8. SCHEDULE

Figure 5 shows the tasks and schedule associated with the SGS project at Sandia's ER Site 16. Since only one radionuclide was of concern for soil processing, only one calibration interval was required. The operations interval includes the time required set up for and processing the soil from ER Site 228. The operations interval included the requirement of isolating the Site 228 soil from the surrounding site for both pre-processing and post-processing operations. The delay between the decontamination and loading the SGS onto trucks for transport to the next deployment site was the combined result of a demonstration tour on March 25th at Sandia's ER Site 16 and a client request from the next site to delay mobilization to provide additional time for the necessary site preparation.

ID	Task Name	Start	Finish
1	**Sandia ER Area 16**	**Fri 2/13/98**	**Thu 3/26/98**
2	**Mobilization**	**Fri 2/13/98**	**Thu 2/26/98**
3	Deliver Control Van and Trailer	Fri 2/13/98	Fri 2/13/98
4	Transport Equipment	Tue 2/17/98	Tue 2/17/98
5	Assemble Equipment	Wed 2/18/98	Mon 2/23/98
6	Calibrate System	Tue 2/24/98	Thu 2/26/98
7	Excavate Arroyo (1000 yd cu)	Wed 2/18/98	Thu 2/26/98
8	Pre-screen Stockpile	Thu 2/19/98	Thu 2/26/98
9	**Operation**	**Fri 2/27/98**	**Mon 3/9/98**
10	Process Soil	Fri 2/27/98	Mon 3/9/98
11	**Demobilization**	**Tue 3/10/98**	**Thu 3/26/98**
12	Disassemble Equipment	Tue 3/10/98	Tue 3/10/98
13	Decontaminate Equipment	Wed 3/11/98	Fri 3/13/98
14	Load Equipment	Thu 3/26/98	Thu 3/26/98

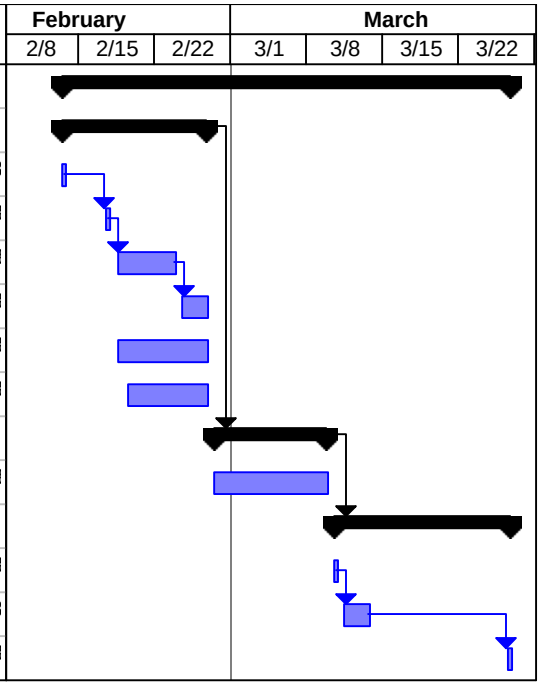

Figure 5. Project Schedule

9. OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

The unit cost for processing soil at Sandia ER Site 16 was $80 per cubic yard. The average daily processing time was 4.7 hours, significantly below the target of 7 hours per 10 hour day. The major impacts were from startup requirements on the first day of processing and early completion of the total volume of soil on the last day. The impact of these factors would be significantly reduced on a larger project. The soil was very heterogeneous, containing only sporadic hot spots. This was the primary reason for the excellent volume reduction, which is the primary driver for overall cost reduction.

Operating time for larger projects may be impacted by any time required to reprocess the above criteria pile to remove soil placed there by unscheduled operational pauses. Cost benefits could be achieved by analyzing the pause records and addressing the root causes.

Performance Observations and Lessons Learned

Several factors impacted the performance and throughput of the SGS at ER Site 16. The use of the field grizzly was a positive contributor to the ease of processing soil containing a large volume of oversize debris. By removing large debris before processing the soil, many of the challenges of keeping a uniform soil flow in the system were eliminated. While use of the field grizzly can sometimes lead to homogenization of the soil, the contaminant was very localized and appeared to be in actual fragments that were not dispersed as the soil was filtered through the grizzly.

The exception to uniform soil flow was the occurrence of screen/hammermill plant jams caused by rocks approximately 5 to 6 inches in diameter with a thinner cross-section. These rocks would occasionally lodge between the feed chain and the feed chain drive gear, causing a lack of soil to the SGS, which in turn caused an unscheduled pause. This event had been observed during previous operations, but measures taken to limit the occurrence of this event were not successful, and will require more research.

While the moisture content of the soil appeared to be near optimum, the composition of the soil caused soil buildup in the gate chutes, requiring constant monitoring of soil flow through the gates. This increased manpower usage and added to the overall project cost. Thermo NUtech is exploring new gate designs, which would improve soil flow for most soil types to minimize the need for gate area monitoring.

SUMMARY

The application of the SGS to the remediation of Sandia National Laboratories ER Site 16 resulted in significantly reducing the volume of radionuclide contaminated soil, which would require off-site disposal. The application of the SGS to the remediation of radionuclide contaminated soils can be very cost-effective in situations where the contaminant is heterogeneously distributed, the contaminant is well characterized and provides a suitable gamma signature for the SGS, and the soil type is amenable to processing on a conveyor system in a layer one to two inches thick after removal of any significant debris.

10. REFERENCES

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11. VALIDATION

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

Original Signed by Tom Burford

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Tom Burford, Project Leader
Environmental Restoration for ER Site 16
Sandia National Laboratories/New Mexico

Original Signed by Mike Hightower

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