Cost and Performance Report

Thermo NUtech's Segmented Gate System

Pantex Plant, Firing Site 5
Amarillo, Texas

Accelerated Site
Technology Deployment

U.S. Department of Energy

March 1999

THERMO NUTECH

SEGMENTED GATE SYSTEM

FIRING SITE 5
PANTEX PLANT
AMARILLO, TEXAS

Final Report

March 1999

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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
FS-5	Firing Site Five
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
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 (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 first ASTD deployment of SGS at the Pantex Plant, Firing Site 5.

1. SUMMARY

Thermo NUtech conducted a radioactive material volume reduction project for the Pantex Plant at Firing Site 5 (FS-5). The goal of the project was to reduce the volume of contaminated soil that would require off-site storage and disposal. The soil in the firing site was contaminated with depleted uranium from test operations conducted at the Pantex Plant. The firing site had already been excavated, and material had been screened for activity by surveying each loader bucket of soil using a hand held survey meter. Soil was segregated into separate piles dependent upon the activity measured with the survey meters. The intent of this project was to provide volume reduction for the soil that was segregated as above the release criteria based on the original hand survey. In addition, the client would gain information for use in evaluating the potential for future applications of the SGS at other presently active Pantex Plant firing sites.

The Thermo NUtech Segmented Gate System (SGS) was mobilized to Pantex FS-5 on March 27, 1998, to a small area covered with a liner in an area immediately adjacent to the FS-5 site. Pantex has active operations at adjacent firing sites, and access is not allowed during firing site operations. These active operations dictated a work schedule of Friday through Monday, or after 1600 hours on Tuesday through Thursday. Work was planned on a 10-hour day schedule, Friday through Monday.

Due to high winds, the equipment could not be unloaded from the trucks until March 29th. Assembly and calibration were accomplished over an eleven-day period. Wind conditions and precipitation that limited access to the site, gate failure troubleshooting and late arrival of a spare part caused delays. Unscheduled repair work was performed on April 14th through April 16th. Soil processing began on April 17, 1998. Soil was processed from April 17th through April 19th. At the end of operations on April 19th, a decision was made to discontinue processing due to a lack of volume reduction. 10.7 hours of processing time were logged, and 1.7 days of downtime were accumulated for weather conditions and mechanical challenges under the contractor's control, based on a 7 hour processing day. Other impediments to daily processing were under the control of the client and are not included as downtime.

A total of 294 cubic yards were processed through the SGS, with an estimated 15 percent additional volume in oversize material, which was not sorted through the SGS. Overall volume reduction reported by the SGS after processing soils from various areas of the firing site was 38.5 percent based on an SGS operating criterion of 50 pCi/g. The client selected this criterion as an appropriate level below the soil cleanup action level to insure that soil designated as below criteria by the SGS could be used to backfill the excavation. Soil excavated from the firing site was segregated into three categories for processing by the SGS. Soil from a staging area that was characterized as above site cleanup action levels resulted in no significant volume reduction. A stockpile from the edge of the gravel pit excavation characterized as slightly above the site cleanup action level produced a 60 percent volume reduction. Soil that was excavated from the berm surrounding the firing site and was characterized as below the site cleanup action level resulted in an 89 percent volume reduction based on the SGS criteria. Very little volume reduction was lost to unscheduled pauses, which causes an information loss for the soil on the conveyor belt. Most halts in production were associated with changing the source of the soil to be processed, and resulted in no volume reduction loss.

Of the 294 cubic yards processed at a criterion of 50 pCi/g, 113.2 cubic yards were determined to be below the SGS criteria, and 180.8 cubic yards were assayed as above the SGS criteria. In addition, about 11 percent of the soil above the SGS criteria was shown to comply with the site soil cleanup action level.

Demobilization of the system began April 20th, and was completed on May 1st, 1998 when the equipment was shipped to the Tonopah Test Range in Nevada for the next ASTD deployment.

Total cost of SGS operations at the Pantex Plant was $203,887 including $18,768 for regulatory permit work, $103,015 for mobilization including weather related delays, $32,594 for operations and $49,510 for demobilization.

2. SITE INFORMATION

Identifying Information

Facility:	Pantex Plant
Location:	Northeast of Amarillo, Texas
OU/SWMU:	Firing Site 5
Regulatory Driver:	RCRA
Type of Action:	Corrective Measure – Site Remediation
Technology:	Thermo NUtech's Segmented Gate System
Period of operation:	4/17/98 to 4/19/98
Treatment volume:	294 yd^3

General

This report provides the results of Thermo NUtech's soil remediation demonstration for the suspected contaminated soil at the Pantex Plant using the Segmented Gate System (SGS). This work was performed by Thermo NUtech as a subcontractor to the Pantex Plant (PANTEX) as a contaminated soil volume reduction project in the remediation of Firing Site 5 (FS-5), funded by the Accelerated Site Technology Deployment (ASTD) Initiative.

Site Background

The Pantex FS-5 is situated within the boundaries of the Pantex Plant located northeast of Amarillo, Texas. FS-5 is located in the northeast quadrant of the site, along with several other active firing sites. The site covers an area approximately 132 feet by 162 feet and was used to conduct test shots of combined explosives and depleted uranium. The actual firing site was surrounded on three sides by an earthen berm approximately 10 feet high and 33 feet thick at the base. The test shots were conducted inside a reinforced concrete building covering approximately 485 square feet. This site had already been excavated, and the soil characterized using hand survey meters as each front-end loader bucket of soil was excavated. The soil was segregated by activity level into stockpiles.

Release Characteristics

Characterization of the site indicated that depleted uranium was the only contaminant present at the site. The volume of soil characterized as above criteria by the hand survey method was estimated at around 800 cubic yards. This soil was to be processed in the hope of providing additional volume reduction. Soil characterized as below criteria by the hand survey method was not expected to be processed, but was run to gain information for use in evaluating the potential for future applications of the SGS at other presently active Pantex Plant firing sites.

Site Contacts

The Mason and Hanger Company provided site management, with technical support from Battelle Pantex. Funding for the project was provided through the Accelerated Site Technology Deployment Initiative under the direction of Tom Burford [(505) 845-9893]. The technical contact for the FS-5 segmented gate project is Martin Amos of Battelle Pantex [(806) 477-6458]. The project manager for Thermo NUtech is Scott Rogers [(423) 481-0683].

3. MATRIX AND CONTAMINANT DESCRIPTION

The Type of matrix processed by the SGS at the Pantex FS-5 was radionuclide contaminated soil (ex situ) mixed with small amounts of native rock and no significant debris except that contributed by destruction of some of the pile covers during soil handling.

Nature and Extent of Contamination

The SGS was designed to separate soils based on the radioactive contaminant content. The only radioactive contaminant found in the characterization of FS-5 was depleted uranium (U^{238}). Pretreatment activities ranged from background to in excess of 567 pCi/g. Depleted uranium contamination above the release criteria was estimated to exist in approximately 800 cubic yards of soil, to be defined by field surveys as the excavation progressed.

Matrix Characteristics Affecting Processing Cost or Performance

Thermo NUtech did not perform any sieve analysis on the soils to be processed at FS-5. The soil moisture content was above optimal for SGS processing, and was estimated to be approximately 17% by weight, although actual measurements were not made for moisture content. Misting systems added water to the soil at open transfer points to minimize dust generation.

The only major impediments to processing the soil were the moisture levels combined with the high apparent clay content of the soil. This soil composition required constant monitoring for clogging and non-uniform soil layer deposition on the conveyor belt. The plastic pile covers that were torn in the process of soil handling also caused clogging problems in the screen plant, under the mechanical screed and at the sorting gates.

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. 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. 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.

Segmented Gate System Schematic and Operation

Figure 1 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 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.

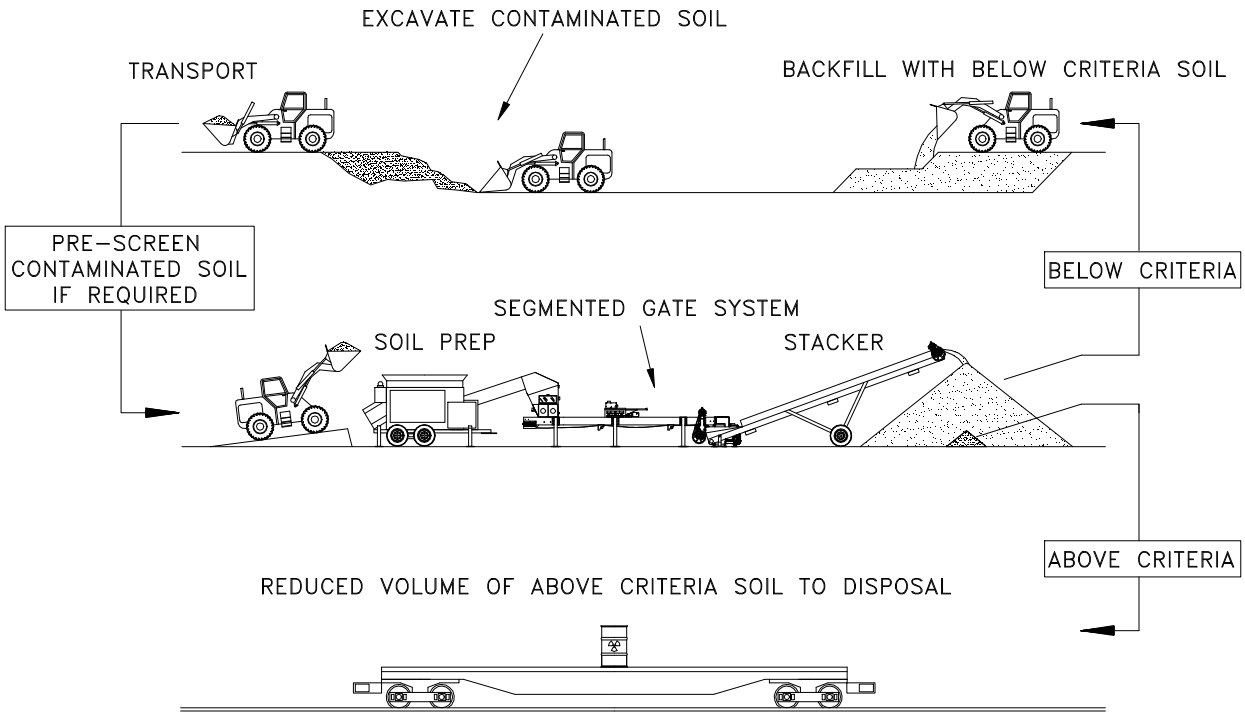

Figure 1. SGS process flow diagram

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 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.

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.

Segmented Gate System Requirements

The SGS typically requires a footprint of 110' by 130 feet, as shown in Figure 2. If the radial stacking conveyors are not needed, this footprint may be reduced significantly. The minimum operating surface is a flat dirt pad, free of debris and vegetation. Compaction of the surface is not normally required unless the soil is unusually soft. The screen/hammermill plant is towed into place. The remaining SGS components are removed from the flatbed trucks used to deliver the system and placed in position using a crane with a minimum capacity of 35 tons.

The SGS is completely electrically operated, requiring 208 volts at approximately 300 amperes. Power can be supplied from site electrical service if available, or using fuel powered electrical generators. The SGS uses a single phase of the 3-phase power to provide any needed 115-volt single-phase service during operational hours. If generators are used, it is usually desirable to have both a large generator for operating power, and a small 115 volt generator which is used during non-operating hours to supply power for the environmental control unit to maintain a constant temperature environment for the detectors.

A water source is normally required for the decontamination process. Water may also be required for dust suppression, both for the dirt pad and as an addition to the soil be processed if necessary.

A local or temporary office building is used for project management and record keeping, as well as for breaks and relief of heat stress or other conditions caused by the local climate. Telephone and fax support are not crucial, but significantly add to the convenience of operations, allowing for the transmission of daily reports, client communications, and support from the corporate office for supplies, repairs, etc. Other required amenities are toilet facilities and a potable water supply.

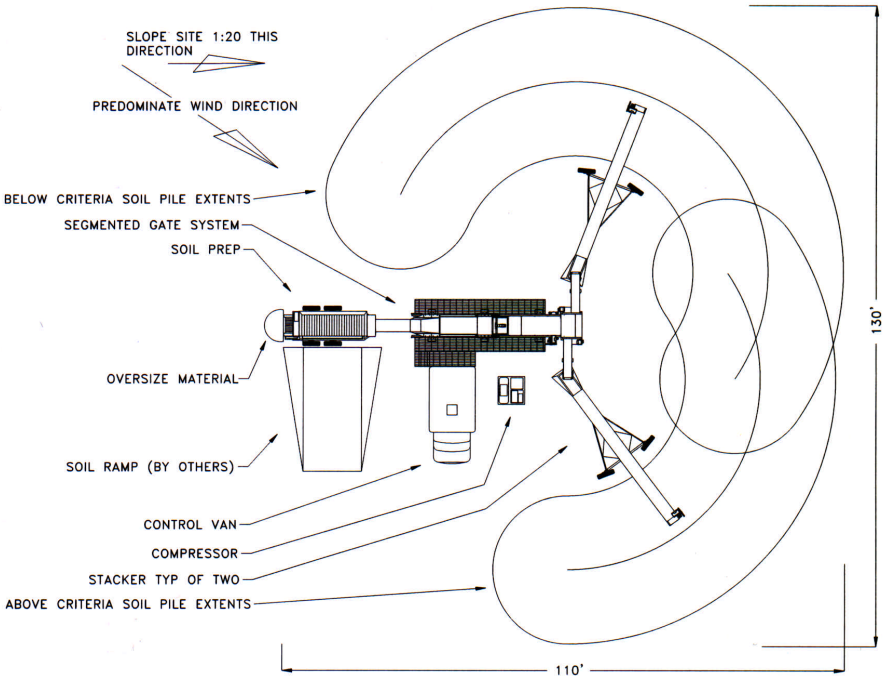

Figure 2. Segmented Gate System Footprint

Soil is usually delivered to the SGS via a front-end loader. The front-end loader is often also used to excavate the site and to move any accumulated soil piles. Front-end loader operations necessitate the availability of fuel and lubrication services, as do the use of any fuel powered electrical generators.

While health physics support is typically provided by the client, Thermo NUtech can provide senior health physics technicians and full radiation safety support. Personal Protective Equipment (PPE) requirements are determined by the entity providing the radiation safety support and PPE can be provided by Thermo NUtech or the client as site conditions dictate.

Operating Parameters

The operating parameters for the SGS at FS-5 were selected to provide the optimum sensitivity for the contaminant of interest, depleted uranium. The belt speed and soil layer thickness was chosen to maximize production for the sensitivity required by the client-specified criteria. The operating parameters and detector settings are summarized in Tables 2 and 3 below.

Table 2. Operating Parameters Affecting Processing 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 FS-5

Contaminant	Detector Array	Gamma Energy Region of Interest	Distributed Alarm Setpoint	Multiple Hot Particle Factor
Depleted U	Thin	40-110 keV	50 pCi/g	4

On-site radiation worker safety support was provided by Pantex, 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 FS-5 requiring off-site disposal
- Reduce the overall FS-5 remediation costs

The SGS was used to sort 294 cubic yards of soil suspected of depleted uranium contamination excavated from FS-5 at the Pantex Plant. 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 March 27, 1998 through May 1, 1998.

Pantex completed site preparation prior to mobilization of the SGS. The SGS was mobilized to the Pantex FS-5 site and arrived on March 26 in Amarillo, TX, where it sat over night awaiting the first scheduled work day. The Thermo NUtech SGS personnel were on site to supervise the unloading of the equipment. High winds delayed the unloading of the equipment for 2 days. Mobilization and calibration of the system required 14 days of labor including detector and operational quality checks. This period was much longer than normal and was adversely impacted by precipitation and wind conditions that prevented operations at the site. This period also spanned the Easter holiday. No work was performed on Easter Sunday, April 12th. The SGS was completely operational and ready to process soil on April 15, 1998. After a short processing period, a gate failure developed, and repairs were made on April 16. The system was again ready for operation on April 17, 1998.

A 4-day per week, 10 hour per day schedule was set for processing soil. Due to active operations on adjacent firing sites, scheduled workdays were Friday through Monday. The client also made support available Tuesday through Thursday after 1600 hours. Soil was processed through April 19, 1998. At the end of processing on April 19th, an evaluation of the volume reduction achieved was made for the soil that was characterized as above criteria via the hand survey, and the results were deemed unsatisfactory. Processing was terminated for the project, and demobilization efforts began the following day.

Disassembly and decontamination were completed April 27, 1998, and the SGS components were loaded on the trucks for transport to Tonopah Test Range in Nevada on May 1, 1998.

Soil was processed on four separate days, although minimal processing was conducted on several of those days due to weather and mechanical challenges. The main mechanical challenge was difficulties with the diversion gate control system, which were resolved on April 16th. Figure 3. depicts the daily volumes processed.

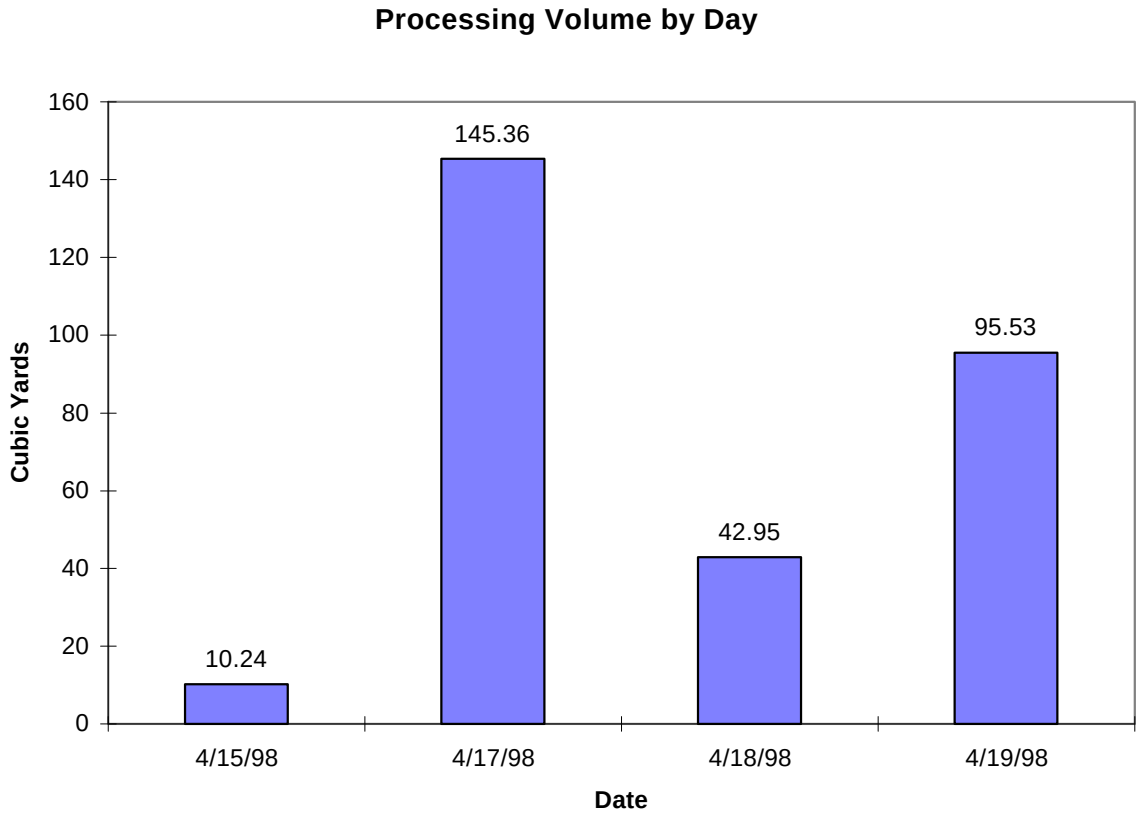

Figure 3. Daily processing volumes

Average daily operational time was 2.67 hours. The average daily operational time was impacted the adverse weather conditions. Processing impediments were not due to factors under the contractor's control, and no downtime was charged during actual processing days.

Overall volume reduction reported by the SGS after processing soils from various areas of the firing site was 38.5 percent based on an SGS operating criterion of 50 pCi/g. The client selected this criterion as an appropriate level below the soil cleanup action level to insure that soil designated as below criteria by the SGS could be used to backfill the excavation. Soil excavated from the firing site was segregated into three categories for processing by the SGS. Soil from a staging area that was characterized as above site cleanup action levels resulted in no significant volume reduction. A stockpile from the edge of the gravel pit excavation characterized as slightly above the site cleanup action level produced a 60 percent volume reduction. Soil that was excavated from the berm surrounding the firing site and was characterized as below the site cleanup action level resulted in an 89 percent volume reduction based on the SGS criteria.

Processing was halted at the end of the day on April 19th, 1998.

RADIOLOGICAL DATA

The average activity for soils from the berm (which were originally characterized as below criteria using the hand survey method) which were designated as above criteria by the SGS

was 125 pCi/g, while the average activity for the below criteria soils from the berm was 20 pCi/g. The overall average activity for the soil processed from the berm was 31.3 pCi/g, which was below the site criteria.

The average activity for soils classified as above criteria by the hand survey method was 206.8 pCi/g. There was no volume reduction obtained for the 53.2 cubic yards of soil processed from this source.

Depleted uranium was the only radionuclide processed in this project. The radiological data is presented on a daily basis in Table 4.

Table 4. Criteria Activity

Date	Average Above Criteria Activity (pCi/g)	Average Below Criteria Activity (pCi/g)	Distributed Sorting Criteria (pCi/g)
4/15/98	179.62	No soil generated	50
4/17/98	146.89	54.5*	50
4/18/98	213.92	24.25	50
4/19/98	124.94	20.06	50

*The cause for the SGS allowing soil with activity greater than the criteria to sort as below criteria was due to a computer software problem. The software problem became evident when the activity of the soil was approximately equivalent to the criteria set point of 50 pCi/g. As a result of the problem, on April 17 approximately 25% of the "Above Criteria" soil was diverted as “Below Criteria” by the SGS. As shown in Table 4a, the activity of 25% of the "Above Criteria" soil was, in fact, between 50 and 65 pCi/g.

Table 4a. Activity of Below Criteria Soil Processed on April 17

Below Criteria Activity Ranges, pCi/g	Count	Mass, kg	Average Activity, pCi/g	% of Total Mass
>65.00	0		0	
60.00-64.99	**133**	**11053.7**	**63.88**	**13.84%**
50.00-59.99	**85**	**9086**	**55.27**	**11.38%**
40.00-49.99	56	5953	45.57	7.46%
30.00-39.99	27	2873.9	36.14	3.60%
20.00-29.99	34	3615.7	23.07	4.53%
10.00-19.99	347	37650.8	14.52	47.16%
>0-9.99	91	9610.1	7.46	12.04%
Totals		79843.2		100.00%

No hazardous wastes were generated by SGS processing. Approximately 200 gallons of wastewater were generated during the decontamination of the system. Other wastes remaining were approximately 8 barrels of personal protective equipment (PPE). The processed soils were left in covered piles at the site, awaiting disposition by the client.

6. SEGMENTED GATE SYSTEM COSTS

CONTRACTING METHOD

Sandia National Laboratories, for the ASTD program, contracted the SGS on a daily operational rate, with separate line items for non-labor mobilization and demobilization costs. Total invoiced cost for this project was $203,887.

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. Mobilization costs for transportation of the crew to the work site were invoiced at cost plus G&A and were not included in the defined mobilization costs.

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
Regulatory Compliance Issues	Air permit exemption application, site specific health and safety plan, operating procedures		**$18,768**
Mobilization	Labor	$46,405	
	Travel and per diem	$14,470	
	Equipment, materials, and other direct costs	42,140	
	Depreciation*	$0	**$103,015**
Soil Processing	Labor	$12,728	
	Travel and per diem	$2,680	
	Equipment, materials, and other direct costs	$5,651	
	Depreciation*	$2,760	
	Treatment of FS-5 soil	$8,775	**$32,594**
Demobilization	Labor	$22,710	
	Travel and per diem	$10,357	
	Equipment, materials, and other direct costs	$14,443	
	Depreciation*	$0	
	Final report	$2,000	**$49,510**
Total			**$203,887**

***** The depreciation schedule is calculated on a per cubic yard basis, based on an estimated 10,000 cubic yards processed for the fiscal year. Depreciation was charged only to the physical treatment period, although the daily rate was calculated based on even recovery of the depreciation over the full project life.

Additional costs incurred by Pantex included site preparation, excavation, oversight labor, health physics support, sample analysis, and waste disposal.

Unit treatment and processing costs for SGS operations provided by Thermo NUtech were about $111 per cubic yard. Overall costs for services provided by Thermo NUtech averaged about $694 per cubic yard. Treatment costs reflect the relatively small volume processed and the weather and administrative delays. 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 processing for full days.

7. REGULATORY/ INSTITUTIONAL ISSUES

Environmental restoration is conducted at Pantex under Permit Number HW-50284, a Resource Conservation and Recovery Act, Hazardous and Solid Waste Amendment Part B permit issued in February 1996. DOE is responsible for compliance under the terms of this permit. The Texas Natural Resource Conservation Commission (TNRCC) is the authorized permitting agency.

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 3 shows the tasks and schedule associated with the SGS project at PANTEX FS-5. Since only one radionuclide was processed, only one calibration interval was required.

ID	Task Name	Start
1	**Pantex ASTD Project**	**Thu 3/26/98**
2	**Mobilization**	**Thu 3/26/98**
3	Transport equipment	Thu 3/26/98
4	Assemble and calibrate	Fri 3/27/98
5	**Processing**	**Fri 4/17/98**
6	Process soil	Fri 4/17/98
7	**Demobilization**	**Mon 4/20/98**
8	Disassembly	Mon 4/20/98
9	Decontaminate	Fri 4/24/98
10	Load Trucks	Fri 5/1/98

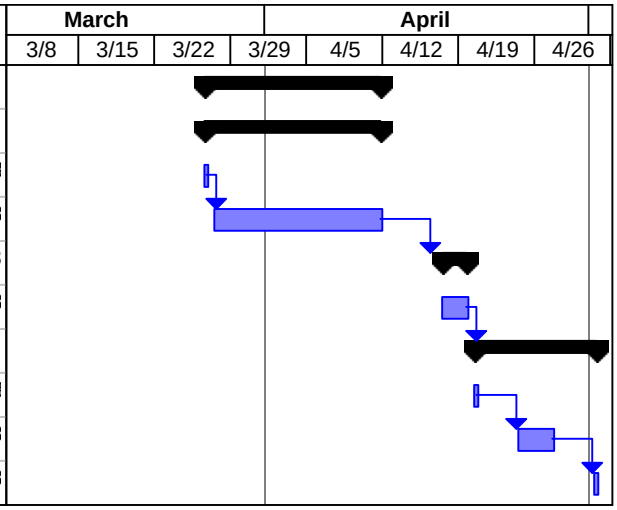

Figure 4. Project Schedule

9. OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

The unit cost for processing soil at Pantex FS-5 was $111 per cubic yard. The average daily processing time was only 2.67 hours, significantly below the target of 7 hours per 10-hour day. Major impacts were daily logistical support issues, weather delays, and changing feed soil sources in an attempt to find soil that might provide a better volume reduction than the soil classified as above the Pantex soil cleanup action levels. Since soil was only processed on four days, there was not enough time to solve the logistical issues involved at this site. Operations were also impaired by the weekend based work schedule, for which support from vendors was difficult. The impact of these factors would be significantly reduced on a larger project.

A constant impact factor that is independent of the length of the project is the time required each day to cover and uncover the piles. This process would need to be streamlined to minimize its effect. A possible solution is to schedule processing time for a season with a more predictable precipitation and wind pattern, when the piles could be left uncovered.

The area used for SGS operations was very small, requiring maneuvering between various piles of soil and very little room for the normal processes required for soil processing. Operations were conducted on a liner, which created a slip hazard with any precipitation or dew accumulation. SGS operations are much more efficient when the SGS is set up in an accessible area which can be scraped after operations to pick up any contamination that might have been spilled.

The primary feed soil which was classified as above the Pantex soil cleanup action levels using the hand survey method, while somewhat heterogeneous, was almost without exception uniformly above the SGS criteria, and could not be sorted to provide any cost benefit. The soils that were classified as slightly above or below the Pantex soil cleanup action levels by the hand survey method exhibited a greater degree of heterogeneity, and could be sorted to provide cost benefits. A comparison should be done of the costs for the hand survey method versus use of the SGS, as well as the confidence levels achieved by each method.

PERFORMANCE OBSERVATIONS AND LESSONS LEARNED

The main factor in the poor volume reduction was the classification of the soil using the hand survey method. While this method is primarily an indicator of activity near the surface of the soil in the loader bucket, it does succeed in segregating high activity soil from soils that may contain lower levels of activity that still exceed the established criteria. The SGS provides a 100 percent assay of the soil, insuring that small areas of elevated activity can be removed, while still allowing the averaging over larger volumes, as was done with the hand survey method. Buckets of soil that were classified as above the Pantex soil cleanup action levels with the hand survey method appeared to be relatively homogeneous. In contrast, soils that were classified as slightly above or below the Pantex soil cleanup action levels were indeed mostly below the SGS criteria, but still contained volumes of localized elevated activity. It is these localized volumes of elevated activity that the SGS excels at removing.

SUMMARY

The application of the SGS to the remediation of the Pantex Plant FS-5 resulted in very little volume reduction in the soils classified as above the Pantex soil cleanup action levels. The results were significantly better in soils that were classified as slightly above or below the Pantex soil cleanup action levels, where isolated volumes of soil with elevated activity were found and removed. The application of the SGS to the remediation of radionuclide contaminated soils can be very 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 conveyorized system in a layer one to two inches thick after removal of any significant debris. The SGS may be a viable, cost-effective alternative to the hand survey classification if it were used to process all soils excavated from a firing site rather than just the soils with elevated activity. This would provide a 100 percent assay of all soils and a high degree of confidence that the activity remaining in the below criteria soils was indeed below the Pantex soil cleanup action levels.

10. REFERENCES

1. *RCRA Facility Investigation Report (RFI) for Firing Sites 5, 6 and 15, AL-PX-9,* U. S. Army Corps of Engineers, February 1996

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

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

4. *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)

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

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11. VALIDATION

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

Original Signed by Martin Amos

Martin Amos, Project Leader
Environmental Restoration for FS-5
Battelle Pantex

Original Signed by Tom Burford

Tom Burford, Technical Coordinator
Accelerated Site Deployment Program
Sandia National Laboratories