COST AND PERFORMANCE REPORT

ThermoRetec's Segmented Gate System

Brookhaven National Laboratory
Area of Concern 16
Suffolk County, New York

Accelerated Site
Technology Deployment

U.S. Department of Energy

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LIST OF ACRONYMS

AOC	Area of Concern
ASTD	Accelerated Site Technology Deployment Program
BNL	Brookhaven National Laboratory
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	Department of Energy
EPA	Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety and Health
HSWA	Hazardous and Solid Waste Area
ITRD	Innovative Treatment Remediation Demonstration
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
TR	ThermoRetec
^{137}Cs	Radio Isotope Cesium-137

FORWARD

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 Brookhaven National Laboratory, Area of Concern 16, soil remediation site.

1. SUMMARY

ThermoRetec conducted a radioactive material volume reduction project for Brookhaven National Laboratory (BNL) at Area of Concern (AOC) 16. Within AOC 16 there were eight sites to be processed for contamination reduction with varying cubic yardage at each site, soils from only three sites were processed. The ASTD office at Sandia National Laboratories managed the deployment. The project goals were to: (a) decrease the volume of contaminated soil requiring off-site disposal and (b) to evaluate post excavation contamination using the in-situ Mower Detector. Extensive site characterization indicated the contamination was heterogeneously distributed throughout a one-foot depth. The SGS has exhibited excellent volume reduction success at sites with similar soil characterization.

The ThermoRetec Segmented Gate System was mobilized to AOC 16 on April 18, 2000 to an area that had been previously prepared by BNL onsite contractors. Off loading of the equipment was accomplished by BNL personnel and equipment. Assembly and calibration were accomplished over a ten-day period. There were thirteen days of delay, primarily due to BLN not having approved plans to allow soil processing. Additional delays were due to the inability of BNL to provide sufficient soil for sustained SGS processing operations. The cost incurred by ThermoRetec due to these delays was $98,709.00.

Soil processing began on May 16th and ended on June 1st, 2000. The total cubic yards estimated to be processed by the Segmented Gate System (SGS) was 1425 yd^3. The total cubic yards actually processed by SGS was 625 yd^3. The soil at these sites was contaminated with Cesium-137 (^{137}Cs). A set point of 23 pCi/g was established as the regulatory clean-up level for the project based on 15 mRem exposure and assumes 50 years of institutional control of the BNL site. The ^{137}Cs contamination levels ranged from background to 348 pCi/g.

BNL directed onsite contractors performed excavation, packaging and transport of soil to the SGS. Soil was placed in 30 yd^3 rolloff containers to minimize contamination spread. Special equipment requirements were necessary to empty the containers into the feed hopper at the SGS site. A total of 22.7 hours of processing time was logged with an average cleanup efficiency of 16%. Reasons for this poor separation efficiency are presented in **Sec. 9, Observations and Lessons Learned**. All the soil processed was from location 16-E-1, 16-E-2 and 16-E-3. The plan for site excavation was carefully laid out to prevent mixing of the soil as the SGS technology has proven to work better if the contamination is heterogeneous.

Prior to the deployment, an extensive “pre-deployment characterization” effort was undertaken to verify site data and validate the probability of success prior to the actual mobilization of the SGS. This “pre-deployment characterization”, led by SNL, is believed to have been valuable and is strongly recommended prior to any future SGS efforts.

Demobilization was completed on June 19, 2000. ThermoRetec’s costs at BNL were $373,509 which included $52,410 for pre-deployment site characterization, $25,700 for other pre-deployment activities, $73,300 for mobilization, $147,459 for operations and delays, $49,000 for demobilization, $18,640 for post excavation mower survey and $7,000 for the final report and documentation. BNL’s Costs were $321,000; these costs are documented in Table 8. The total cost per cubic yard processed was $1,111.

2. SITE INFORMATION

Identifying Information

Facility:	Brookhaven National Laboratory
Location:	Suffolk County, New York
OU/SWMU:	Area of Concern 16
Regulatory Driver:	RCRA
Type of Action:	Corrective Measure – Site Remediation
Technology:	ThermoRetec's Segmented Gate System
Period of Operation:	April 17th to June 1st
Processed Volume:	625 yd^3

Site Background

Brookhaven National Laboratory is located in Upton, Suffolk County, New York, near the geographic center of Long Island, approximately 60 miles east of New York City, Figure 1. Although the principle populations are shoreline communities, there has been some residential development near BNL. The site was formerly occupied by the U.S. Army as Camp Upton during World Wars I and II. Between the wars, the Civilian Conservation Corp operated the site. The site was transferred to the Atomic Energy Commission in 1947, to the Energy Research and Development Administration in 1975, and to DOE in 1977.

The BNL property is roughly square in shape, with approximately 3 miles on each side and encompasses an area of 5,265 acres (approximately 8.21 square miles). The production region includes the principal BNL facilities, which are located near the center of the site on relatively high ground. These facilities comprise an area of approximately 900 acres, of which 500 acres were originally developed for Army use. Outlying facilities occupy approximately 550 acres and include an apartment area, biology field, hazardous waste management facility, sewage treatment plant (STP), and a former landfill area.

In 1980 and in 1983 aerial radiation surveys were conducted at the BNL site and a total of 23 areas of man-made radioactivity were identified. The dominant radioisotopes found in these areas were ^{137}Cs, ^{22}Na, ^{54}Mn and ^{60}Co. Cause analysis showed most was associated with materials handling activities. The source of the radioactive material was believed to be from spills of fission products removed from the HWMF. Soils were scraped and removed from the HWMF in 1954 and 1955, 1958 and the mid-1960s. The soils were stored at a former landfill. The soil was used for landscaping purposes near Buildings 30, 355, 490, 510, 555, and 930 in AOC16. As sited in the June 1999, *Record of Decision Operable Unit 1 and Radiologically Contaminated Soils*, the maximum concentrations are 348 pCi/g ^{137}Cs and 2 pCi/g Sr^{90}.

Background concentrations in soil for radioactive species were reported in the *Operable Units II/VII Remedial Investigation Report* as being 1.5 pCi/g for ^{137}Cs, 1.0 pCi/g for ^{226}Ra, .3 pCi/g ^{90}Sr, 1.0 pCi/g for ^{232}Th and decay chain members and 1.8 pCi/g for ^{238}U and decay chain members. All other radioisotopes were reported at below detection limits.

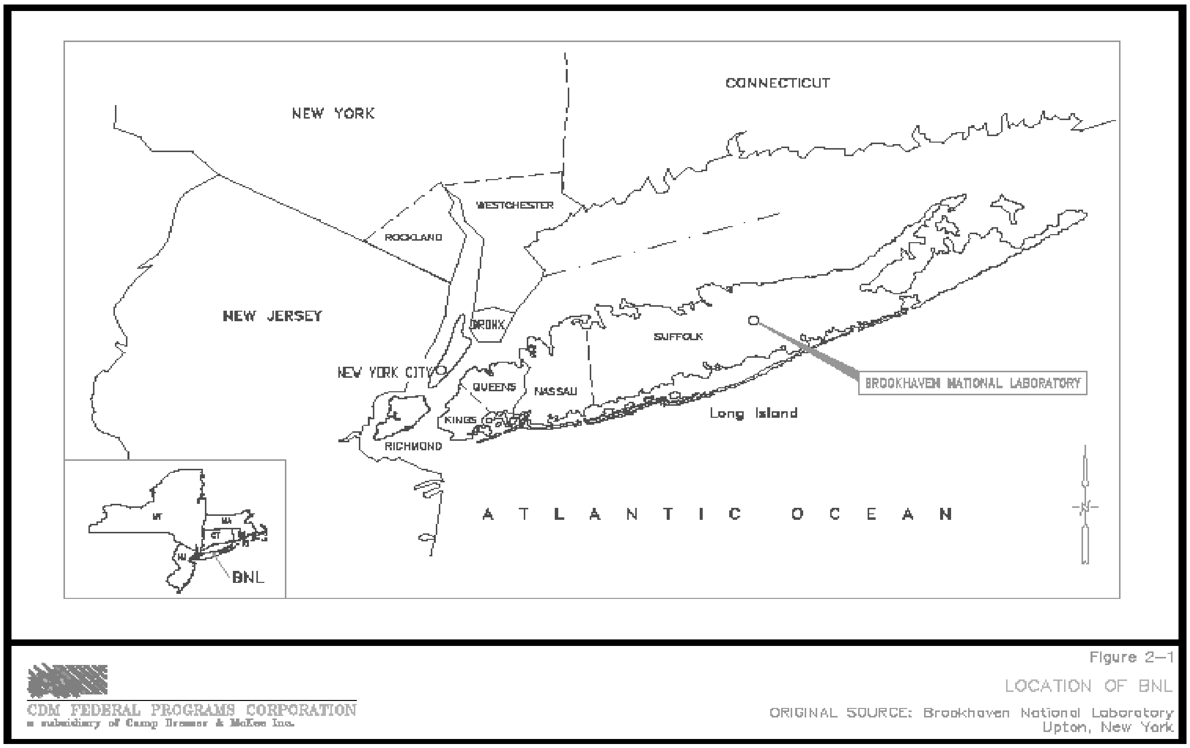

Figure 1. BNL Site Location Map

Release Characteristics

Characterization of the areas is documented in the following publications:

- Survey of Contaminated Soil at BNL for Segmented Gate System Deployment, December 29, 1999, ThermoRetec.
- Remedial Action Work Plan, Area of Concern 16 landscape Soil, April 13, 2000, BNL ER Division, CDM Federal.

Characterization of the site indicated that ^{137}Cs contamination levels ranged from background to 348 pCi/g. In addition, AOC 16.S.3 (Contaminated Landscape Soil South and West of Building 515) contained elevated levels of lead in one of two samples collected by BNL during supplemental sampling in 1999. The lead level of 2310mg/kg exceeded the cleanup goal of 400 mg/kg specified in the ROD.

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3. MATRIX AND CONTAMINANT DESCRIPTION

The type matrix processed by the SGS at AOC 16 was ^{137}Cs radionuclide-contaminated landscape surface soil.

Nature and Extent of Contamination

AOC 16, the Aerial Radioactive Monitoring System Results, consists of several sites where aerial radiation surveys performed in 1980 and 1983 identified unanticipated external dose rates exceeding background levels. These areas were investigated and the radiological contaminant was determined to be ^{137}Cs contaminated soil located adjacent to or near several buildings. The areas of contamination could not be directly related to past activities at the particular area. The source of the contaminated soil was believed to have resulted from spills of aged fission products stored and removed from the HWMF. Soils were reportedly scraped to a depth of 15 to 20 centimeters (cm) in 1954, 1955, 1958, and the mid-1960's, and "banked" at the former landfill. The field instrument of that period did not indicate levels of radiation that were a concern. The contaminated soil was later used at several buildings as landscape soil including Buildings 30 (Brookhaven Center), 355 (Contracts and Procurement), 490 (Medical), 515 (Applied Math), 555 (Chemistry), and 930 (Linear Accelerator - LINAC). ^{137}Cs contamination levels range from background to 348 pCi/g.

Matrix Characteristics Affecting Treatment Cost or Performance

No large rocks or boulders were present. Landscape grass was to be broken up with a disc to minimize the affect on handling and processing through the SGS. BNL did not use the disc, which lead to handling and processing problems as anticipated. Several samples of the soil were analyzed in detail at the ThermoRetec bench top facility in Albuquerque, NM. The soil moisture content appeared to be about optimal for SGS processing, and was estimated to be approximately 9% by weight, in field measurements were not made for moisture content. On-site moisture during the processing period was high due to the fact that the Brookhaven Weather Station had recorded 23 straight days of rain greater than 0.25 inches. The high moisture content created some handling problems to the soil processing through the SGS.

The BNL Work Plan, see Appendix, stated that a disc would be used to break up the sod for easier handling by the SGS. BNL declined to use the disc until excavation of the third area of contaminated soil began. Grass cutters were used to cut the grass as short as possible. Discussions prior to the deployment focused on problems caused by vegetation and roots to the screening process since these problems had occurred in previous deployments. As a result of these discussions, BNL project managers understood that if no action was taken to reduce the size of the sod chunks, the throughput of the SGS would be negatively impacted. ThermoRetec had suggested the use of "Roundup", a commercial herbicide, 4-6 weeks prior to excavation to kill the grass and allow better handling. BNL chose not to use the Roundup, or any other herbicide.

The scraping action of the excavator created strips of sod as large as 2-3 feet wide by 3-4 feet long. This sod, Figure 2, would blanket the grizzly and prevent soil from passing through causing down time to manually remove the sod. Figure 3 is an example of the sod screened by the screen plant. This sod would clog up the screen and prevent soil from entering the surge bin causing additional unscheduled pauses. The sod debris was estimated to be 70 cubic yards and contained a substantial volume of soil that could not be processed through the SGS.

Figure 2. Example of Sod that Blanketed the Tipping Grizzly

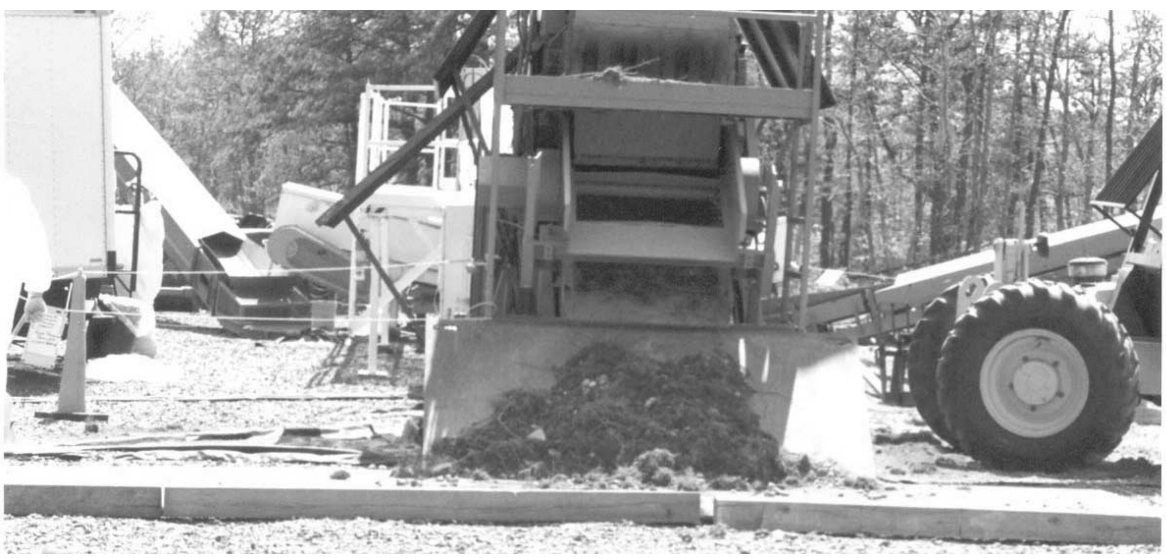

Figure 3. Sod Ejected from the Screen Deck

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 ThermoRetec 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. A forklift is needed for unloading and assembly of the smaller items. 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. Figure 4 is a schematic representation of the SGS footprint.

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

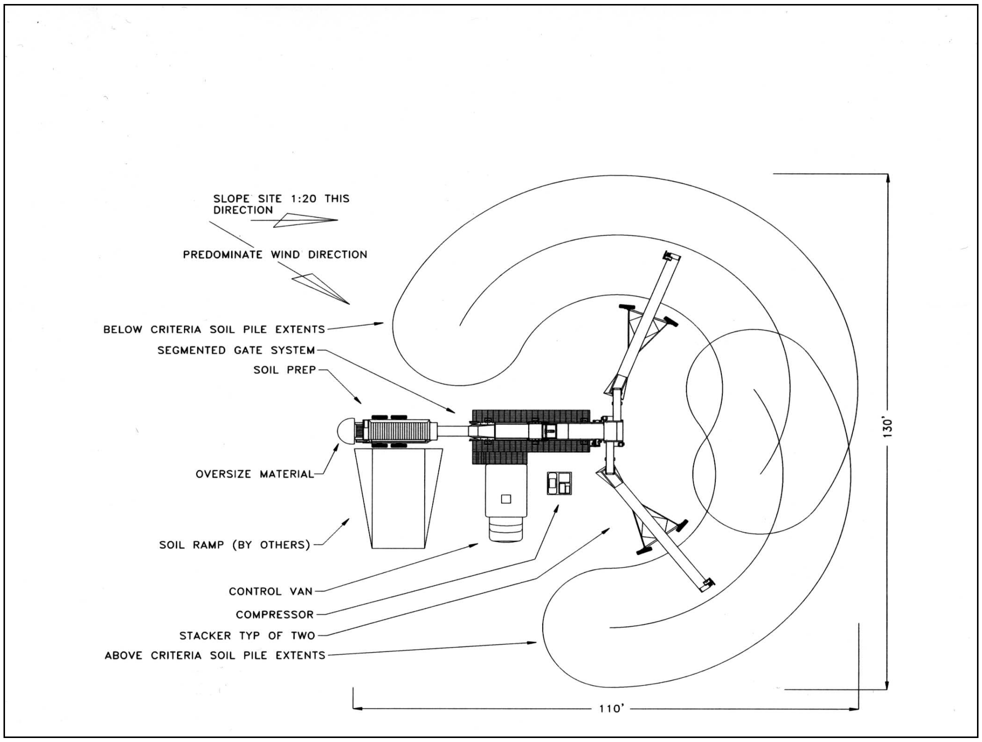

Figure 4. Segmented Gate System Footprint

Technology Advantages

The processing 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 generally limited to PPE,
- Dry decontamination of the SGS has proven effective and
- The hydraulic system contains BioSoy®; an environmentally friendly soybean 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,
- The contamination must be heterogeneously distributed in the soil
- Material greater than a nominal $1^1/_2$ inches in diameter cannot be processed by the SGS without pre-crushing and
- Soil containing greater than 20% moisture by weight creates handling difficulties and negatively impacts sustained processing operations.

Processing System Schematic and Operation

Figure 5 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 may 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.

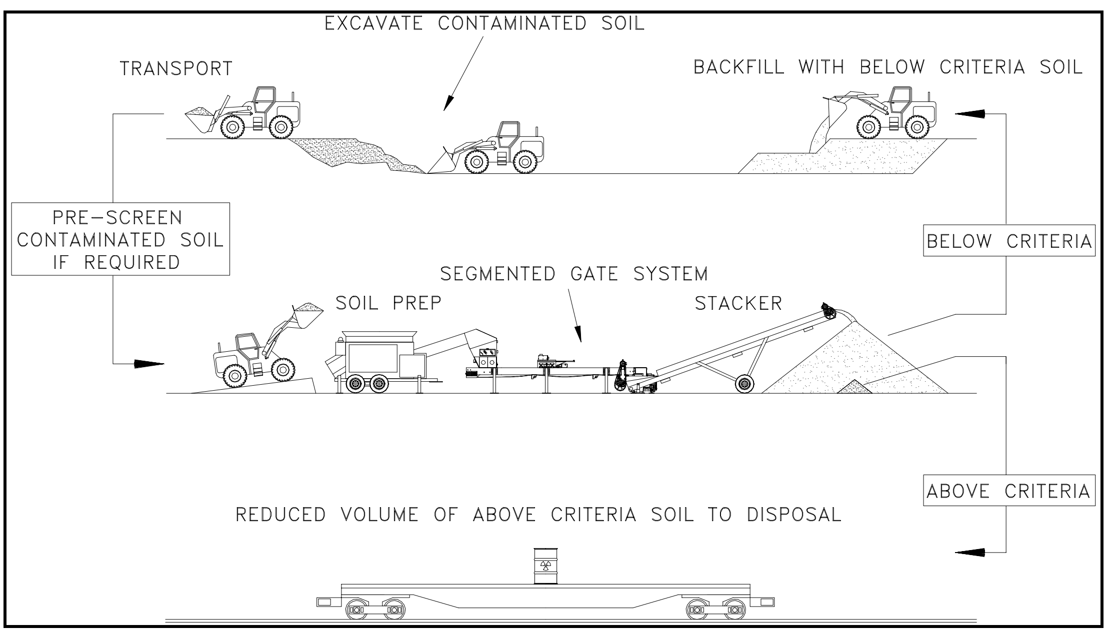

Figure 5. Process Flow Diagram

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 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 AOC 16 were selected to provide the optimum sensitivity for the contaminant of interest, Cesium-137. 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 operating parameters and detector settings are summarized in Tables 2 and 3, respectively.

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)	1.29 g/cm^3, typical
Detector type	Sodium iodide (NaI) 2.0 inch thick crystal

Table 3. SGS Detector Settings at AOC 16

Contaminant	Detector Array	Gamma Energy Region of Interest	Distributed Alarm Setpoint	Multiple Particle Factor
Cesinm-137	Thick	546-776keV	23 pCi/g	3 (69 pCi/g)

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 AOC 16 requiring off-site disposal
- Process the soil at the regulatory clean-up level of 23 pCi/g
- Reduce the overall AOC 16 remediation costs; and
- To evaluate post excavation contamination using the in-situ Mower Detector.
- Provide a basis from which to estimate SGS cost/performance for similar sites projected for future operations.

The SGS was used to sort 625 cubic yards ^{137}Cs contaminated soil excavated from AOC 16 at Brookhaven 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

Operational time for the SGS was dependent on the BNL excavation methods and no meaningful measurements of SGS capabilities can be determined for this deployment. The average daily operational time was also impacted by excessive down time required for handling the sod and some rain and weather delays. A 5-day per week, 10-hour per day schedule was mutually agreed to for soil processing operations but a 10-hour workday was not possible since no overtime was approved for the BNL excavation team.

The Segmented Gate System (SGS) was mobilized to AOC 16 on April 18th, 2000 to an area that had been previously prepared by BNL. Off loading of equipment was accomplished by BNL equipment and personnel under the direction of ThermoRetec personnel. Assembly and calibration took place over a ten-day period.

Soil processing began on Tuesday, May 16th, 2000 and continued through June 1st, with actual processing taking place on 11 of those days. A total of 22.7 hours of processing time were logged. Average daily operational time was 2.06 hours. Figure 6 represents daily volumes processed referenced to the100 yd^3 goal.

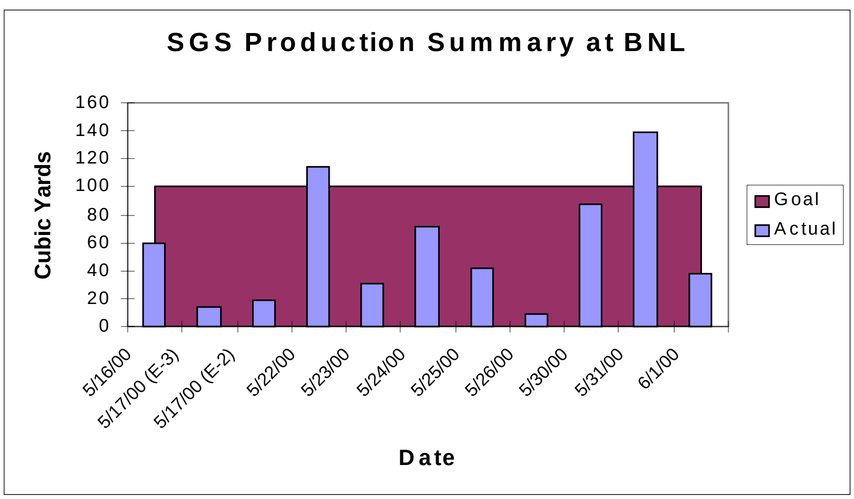

Figure 6. Daily Processing Volumes

Decontamination and demobilization of the system started on June 2nd and was completed on June 19, 2000 when the equipment arrived in Albuquerque.

An overall volume reduction of 16 percent was realized after processing 73.8 cubic yards from site 16E3, 274.9 cubic yards from 16E2, and 276.3 cubic yards from 16E1.

BNL chose to perform excavation techniques guided by field measurements instead of the prior agreed to layer excavation and as approved in their Work Plans. ASTD and ThermoRetec voiced objection to BNL about their excavation methods. The technique of excavate and evaluate the area through field measurements limited the excavation team's ability to provide sufficient soil to the SGS for sustained processing operations. In addition to the excavate/field measurement operations employed by the BNL team, excavation operations did not commence until about 9:00am and excavation operations were suspended at about 4:00pm. BNL used an excavator bucket to scrape 3-inch lifts into a pile near the excavator, Figure 7, and then load into the rolloff. This scraping caused extensive mixing of the soil.

During the evaluation phase of the Pre-SGS Site Characterization, a mixing test was performed. A number of samples were randomly selected, emptied in a pile and rebagged. The results verified that 1 or 2 samples of soil having high activity, around 300 pCi/g, could cause as many as 10 neighboring clean samples to become hot (over 23 pCi/g) through averaging and mixing. The mixing study results reconfirmed that mixing of the soil had to be minimized to maximize the volume reduction and increase cost savings. The excavation methods that BNL chose to use resulted in the ASTD and ThermoRetec being unable to fully evaluate the SGS and its full usefulness at future Brookhaven remediation projects. BNL's excavation techniques also prevented the validation of the extensive and expensive (approximately $80,000) site characterization and subsequent modeling of the collected data by both ThermoRetec and the SmartSampling™ personnel.

Figure 7. Excavation at Site 16E2

Note the pile of soil (under the excavator arm) that was scraped off in the 3-inch to 6-inch lifts prior to loading in rolloff

The use of the rolloff containers by BNL did minimize the spread of contamination; however, the containers raised some operational issues. Containers that were open top and had no cross bar when the door is opened were specified. The containers required a square cross section to allow the bucket scoop to clean the soil from the container. The first set of 6 rolloffs brought onsite by

BNL did not meet all of the requirements. Containers meeting all requirements had to be located and brought onsite.

The calibration of the SGS was completed on schedule on April 28, 2000, ten workdays prior to receiving any feed soil. The first day soil arrived at the SGS site for processing was May 16, 2000. Though BNL waited until the last minute to train excavation crews, the delays were attributed primarily to the fact that work could not proceed until revised Work Plans were approved. An Operational Readiness Review (ORR) Committee mandated the revised Work Plans. The ORR meeting was held on the afternoon of April 28, one work day prior to the scheduled May 1 commencement of soil processing operations. Table 4 outlines the operational days and the delay days throughout the deployment.

Table 4. Schedule of Delays

Date	Who's	Part of Day	Description
17-Apr-00	Delay		SGS arrives BNL, start 10-day setup/calibration.
18-Apr-00			Day 2 of 10 days for calibration.
19-Apr-00			Day 3 of 10 days for calibration.
20-Apr-00			Day 4 of 10 days for calibration.
21-Apr-00			Day 5 of 10 days for calibration.
22-Apr-00			Weekend, no work.
23-Apr-00			Weekend, no work.
24-Apr-00			Day 6 of 10 days for calibration.
25-Apr-00			Day 7 of 10 days for calibration.
26-Apr-00			Day 8 of 10 days for calibration.
27-Apr-00			Day 9 of 10 days for calibration.
28-Apr-00			Day 10 of 10 days for calibration. BNL's Operational Ready Review Team visits SGS job site and performs their review. [3]
29-Apr-00			Weekend, no work.
30-Apr-00			Weekend, no work. 1.5 hr for 1 individual to check generator.
01-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
02-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
03-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
04-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
05-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
06-May-00			Weekend, no work.
07-May-00			Weekend, no work. 1.5 hr for 1 individual to check generator.
08-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
09-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
10-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. Conducted SGS dry run. [1]
11-May-00	BNL	1.00	No approved plans by BNL to allow soil processing. [1]
12-May-00	BNL	1.00	Approved plans provided by BNL. No soil available to process. Rained almost all day.
13-May-00			Weekend, no work.
14-May-00			Weekend, no work. 1.5 hr for 1 individual to check generator.
15-May-00	TNU	1.00	Delay due to generator repairs.

Date	Who's	Part of Day	Description
16-May-00	BNL	0.40	First day of soil processing. Processed 60 yd^3. This was all the soil BNL could provide due to their training of their excavation crew and directing excavation by radiation readings versus excavating per the work plan. [2]
17-May-00	BNL	0.67	Processed 33 yd^3 of soil. No other soil provided by BNL for day. No approved overtime for BNL support staff. [2]
18-May-00	BNL	1.00	Tried to process soil but shut down by DOE OSHA & BNL RCT for dust generation. BNL didn't have dust suppression equipment ready when called for. BNL Fire Department halted operations for yet another inspection of the SGS.
19-May-00	Wind	1.00	Wind gusting well over 35 mph all day.
20-May-00			Weekend, no work.
21-May-00			Weekend, no work. 1.5 hr for 1 individual to check generator.
22-May-00			115 yd^3 of soil processed.
23-May-00	BNL	0.69	31 yd^3 of soil processed. Only 1 rolloff of soil was available at the beginning of the day and no more were provided by BNL before lunch.
24-May-00	Wet-soil	0.29	Processed 71 yd^3 of soil until the soil became too wet to process causing material handling problems. 0.82 inches of rain fall on this day.
25-May-00	Wet-soil	0.58	Processed 42 yd^3 of soil until the soil became too wet to process causing material handling problems.
26-May-00	Wet-soil	1.00	Soil too wet due to unusually high amount of rain.
27-May-00			Weekend, no work.
28-May-00			Weekend, no work.
29-May-00			Holiday, Memorial Day
30-May-00	TNU	0.13	Processed 87 yd^3 of soil. Maintenance on clean stacker and plugging problems on screen plant conveyor belt due to wet soil.
31-May-00			Processed 139 yd^3 of soil.
01-Jun-00	TNU	0.62	Processed 38 yd^3 of soil. Soil was available for TNU to process more soil to fill rail car but the drag chain on the screen broke and couldn't be repaired on site. This was the agreed upon last day on soil processing period for TNU. [4]
02-Jun-00			Demobilization of SGS started.

[1] Note: No approved plans. At all pre-mobilization meetings, weekly conference calls up to the week prior to mobilization Brookhaven assured DOE-ASTD that all plans would be ready and approved prior to equipment arriving on site.

[2] Note: No Approved overtime. BNL approved Work Plan stated the scheduled hours of operation for the SGS and the excavation as five, ten hour days. BNL had not made prior arrangements to get the overtime for the excavation team approved by their management and union.

[3] Note: ORR- Operation Readiness Review. At the February 2000 pre-mobilization readiness meeting at the BNL-ER office, BNL specifically stated no ORR approval would be required. At the time the equipment arrived onsite, an ORR was scheduled and was held on the Friday prior to the scheduled Monday start of processing.

[4] Note: Numerous attempts were made, through meetings and conference calls, to

have the BNL excavation team follow the approved work plan to allow validation of the site characterization and subsequent volume reduction predictions. During a conference call on May 24, 2000, the BNL ERD Manager verbally agreed to have the excavation team follow the work plan for a 100 yd^3 volume of soil to allow the validation of the site characterization. During a conference call on May 31, it was revealed that BNL chose not to honor the verbal commitment and continue with their status quo excavation methods. At that time the decision was made by the ASTD Management Team to have the SGS immediately suspend operations and commence demobilization. The ASTD management team reluctantly agreed to allow the SGS to continue processing until the rail car that was currently being used was full.

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Table 5. Daily Processing Statistics

SGS Production Summary						
Date	**Total Mass Processed**	**Mass Diverted**	**Cleanup**	**Processing Time**	**Volume Processed**	**Location**
	(kilograms)	**(kilograms)**	**Efficiency**	**(hours)**	**(cubic yards)**	**(Site)**
5/16/00	53526	20656	61%	2.2	60	16-E-3
5/17/00	12835	12306	4%	0.5	14	16-E-3
5/17/00	16795	56.3	100%	0.7	19	16-E-2
5/22/00	102000	92915	9%	4.2	115	16-E-2
5/23/00	27309	26535	3%	1.1	31	16-E-2
5/24/00	63358	55462	13%	2.6	71	16-E-2
5/25/00	37550	36595	3%	1.5	42	16-E-2
5/26/00	7783	1377	82%	0.3	9	16-E-1
5/30/00	77695	67988	13%	3.2	87	16-E-1
5/31/00	124000	123000	1%	5.1	139	16-E-1
6/1/00	33454	31981	4%	1.4	38	16-E-1
TOTAL	**556305**	**468871.3**	**16%**	**22.7**	**625**	

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Radiological Data

Cesium-137 was the only radionuclide processed in this project. The contamination was predicted to be heterogeneous spots of very homogeneous concentration. SGS operations could not substantiate this prediction. The data indicated that the average activities for the above and below-criteria soils exhibited a relative small range, as shown in Table 6. The sorting criteria for distributed contamination was set at 23 pCi/g.

Table 6. Summary of Radiological Data

Date	Average Below-criteria Activity (pCi/g)	Average Above-criteria Activity (pCi/g)	Distributed Sorting Criteria (pCi/g)
16-May-00	13.7	35.5	23
17-May-00	7.17	54.9	23
17-May-00	15.9	321	23
22-May-00	18.8	69.8	23
23-May-00	7.26	70.7	23
24-May-00	18.6	45	23
25-May-00	12.6	54.9	23
26-May-00	15.9	26.0	23
30-May-00	18.1	37.3	23
31-May-00	18.1	37.3	23
01-Jun-00	18.1	37.3	23

6. SEGMENTED GATE SYSTEM COSTS

CONTRACTING METHOD

The SGS project was contracted by Sandia National Laboratories on a firm fixed price for most tasks and fixed unit price for up to 1,000 cubic yards. Total invoiced cost for this project was $372,993.

COST BREAKDOWN

Pre-deployment site characterization included transportation of the “Mower Detector” and crew of 3 people from Albuquerque, NM to Brookhaven National Laboratory to perform in-situ radiological survey with the “Mower Detector” of each of the eight sites within AOC 16. On a 10-meter grid, 204 samples from 51 locations were collected and analyzed. The Mower survey provided data points every 2 feet along the survey path. Using all data from these surveys, ThermoRetec in conjunction with the “Smart Sampling” project at Sandia National Laboratories prepared extensive charts and volume reduction predictions. It was hoped that the SGS deployment would validate these predictions. However, due to the BNL’s choice of excavation methods, versus those agreed to during pre-deployment meetings and outlined in the work plans, validation was not possible.

Mobilization costs included crane costs to load, trucking to deliver the SGS and delivery charges for heavy equipment, mobile office space, etc. Demobilization charges included pickup charges for the various equipment and facilities. There was also funding for preparation of the final report. 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. Table 7 is ThermoRetec’s deployment task breakdown with the associated cost of each task.

Daily operational costs included crew wages, per diem, equipment rentals, PPE and daily operating supplies. Operational days included equipment unloading, assembly and calibration, operation during soil processing, and disassembly, decontamination and loading of the equipment for shipment of the SGS back to Albuquerque, NM. Transportation of the equipment to Albuquerque was considered part of the demobilization.

Table 7. ThermoRetec Costs

Cost element	Description	Subtotals
Task 1	Pre-deployment Site Characterization	$52,410
Task 2	Pre-deployment Activities	$25,700
Task 3	Mobilization of SGS to BNL	$73,300
Task 4	Processing of 625 @ $78	$48,750
	Delay days by BNL, 13 days @ $7,593	$98,709
Task 5	Demobilization of SGS from BNL	$49,000
Task 6	Post-deployment Mower Survey	$18,640
Task 7	Final Report/Documentation	$7,000
Total		**$373,509**

Processing costs for SGS operations provided by ThermoRetec was $78 per cubic yard (per the contract) and does not include BNL costs or the costs associated with delays.

SGS Site Remediation – BNL Incurred Costs

Costs associated with excavation, site preparation, heavy equipment and operators to support excavation and SGS operation, Health Physics support, rail car and rolloff container leasing were all the responsibility of BNL and are outlined in Table 8.

Table 8. BNL Costs

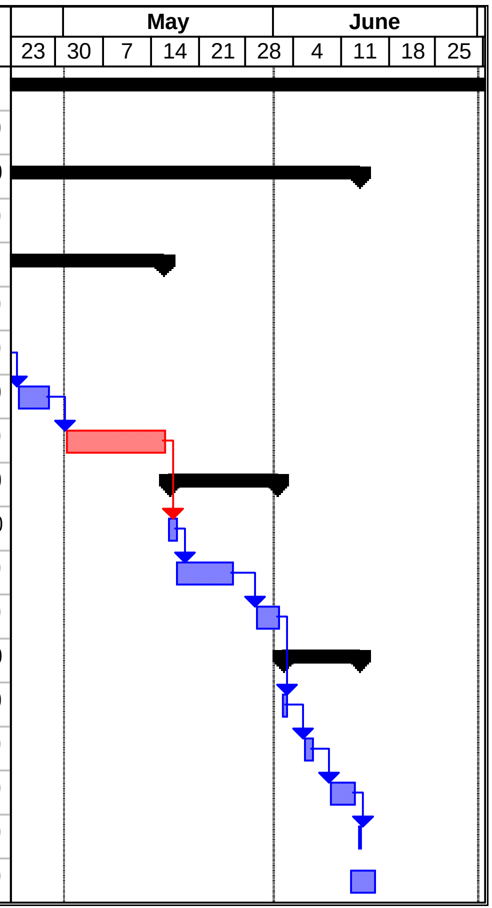
	Total Effort 10 Weeks	Other BNL Plan Costs	Excavation Costs	**Net SGS Support**
ERD Mgt./Admin	3,935	787	1,574	**1,574**
ERD Prof	36,161	7,232	14,465	**14,465**
ERD Sci.	15,116	3,023	6,046	**6,046**
Tech	4,777	4,777	0	**0**
subtotal	59,988	15,819	22,085	**22,085**
BNL Trades	36,157		18,078	**18,078**
BNL Labor	23,393		11,697	**11,697**
BNL Eng./Const.	6,170		3,085	**3,085**
Cent. Shops	1,620		0	**1,620**
BNL Rad Con FSS	33,666		16,833	**16,833**
subtotal	101,006		49,693	**51,313**
Photography	32	32	0	**0**
Copy Service	681	681	0	**0**
Body Count	8,272		3,102	**5,170**
TLD Service	138		69	**69**
Lab Service	4,080		1,360	**2,720**
subtotal	13,204	713	4,531	**7,959**
Misc.	93	93	0	**0**
Purchases	49,914		39,931	**9,983**
Materials	3,298		1,649	**1,649**
Freight	43	43	0	**0**
Card Purchases	986		493	**493**
subtotal	54,334	136	42,073	**12,261**
Spec. Procurement	8,194	0	0	**8,194**
Total Direct Costs	$236,726	$16,668	$118,382	**$101,812**
G&A	22,885	10,282	6,301	**6,301**
Site Support/Purch. OH	57,675	357	32,671	**24,647**
Procurement OH	3,714	0	0	**3,714**
subtotal OH	$84,274	$10,639	$38,973	**$34,662**
Total Costs	$321,000	$27,307	$157,354	**$136,662**

7. SCHEDULE

Table 9 shows the tasks and schedule associated with the SGS project at Brookhaven. Since only one radionuclide was present, only one calibration interval was required. The overall days allocated to this project increased due to the facility delays, lack of approved plans and the inability to provide at least 100 cubic yards of soil per day. Due to the excavation techniques employed by BNL and their choice to not follow the approved *Work Plan*, the ASTD/SGS project management team made the decision to terminate soil processing operations. The decision to immediately terminate the soil sorting operations and demobilize the SGS was made on May 31. The team reluctantly agreed that the SGS would continue to process soil until the rail car that was partially loaded with soil was completely loaded.

Table 9. Project Schedule

ID	Task Name	Start	Finish
1	**Sandia PO # 7523**	**Mon 9/20/99**	**Fri 9/8/00**
2	Pre-deployment Site Characterization	Mon 9/20/99	Fri 10/8/99
3	**Brookhaven Landscape soils**	**Wed 4/12/00**	**Tue 6/13/00**
4	Pre-deployemnt activities	Wed 4/12/00	Tue 4/18/00
5	**Mobilization**	**Wed 4/12/00**	**Mon 5/15/00**
6	Transport equipment	Wed 4/12/00	Mon 4/17/00
7	Unload SGS & Equipment	Tue 4/18/00	Tue 4/18/00
8	Assemble and calibrate	Mon 4/24/00	Fri 4/28/00
9	Approved Plans Delay	Mon 5/1/00	Mon 5/15/00
10	**Processing**	**Tue 5/16/00**	**Thu 6/1/00**
11	16E3 soil	Tue 5/16/00	Wed 5/17/00
12	16E2 soil	Wed 5/17/00	Thu 5/25/00
13	16E1 soil	Mon 5/29/00	Thu 6/1/00
14	**Demobilization**	**Fri 6/2/00**	**Tue 6/13/00**
15	Disassembly	Fri 6/2/00	Fri 6/2/00
16	Decontaminate	Mon 6/5/00	Tue 6/6/00
17	RAD Release Survey	Fri 6/9/00	Mon 6/12/00
18	Load Trucks	Tue 6/13/00	Tue 6/13/00
19	Post Excavation Mower Survey	Mon 6/12/00	Thu 6/15/00



8. REGULATORY/ INSTITUTIONAL ISSUES

Regulatory Framework

On December 21, 1989, the BNL site was included in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priority List (NPL). In May, 1992, DOE entered into an Interagency Agreement with EPA and NYSDEC under CERCLA, Section 120. The IAG established the framework and schedule for characterizing, assessing and remediating the site in accordance with the requirements of CERCLA, and the Resource Conservation and Recovery Act (RCRA). BNL originally grouped the AOCs into seven OUs, which have subsequently been combined into six OUs.

The nature and extent of the radiologically-contaminated soil in AOC 16 have been addressed in the *Final Operable Unit II/VII Remedial Investigation Report* (IT Corporation, February 1999), supplemental soil sampling collected by BNL in 1999 (BNL, 1999), and ThermoRetec sampling data collected in August 1999. An evaluation and recommendation of remedial alternatives for this soil was presented in the *Final Feasibility Study Report Operable Unit I and Radiologically-Contaminated Soils* (CDM Federal, March 1999). The *Record of Decision* (EPA, August 1999) selected excavation and offsite disposal as the remedial alternative for the radiologically contaminated soil in AOC 16. The use of the Segmented Gate System has been selected as a waste minimization technology to reduce the quantity of soil requiring offsite disposal.

9. OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

a) Using processing costs only, the cost per cubic yard is \$48,750 / 625yd^3 = \$78/yd^3.
b) Using total costs from ThermoRetec the cost per cubic yard is \$373,509 / 625yd^3 = \$598/yd^3.
c) Including total costs from BNL the cost per cubic yard is \$321,000 / 625yd^3 = \$514yd
d) The combined total cost is \$1111/ yd^3.

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 were required. A performance and cost analysis should aid in your decision whether or not to deploy the SGS.

There have been multiple deployments of the SGS garnering excellent data even when the deployment was not successful. This data has helped to provide a model for when and how the SGS can be cost and performance effective. In this case, BNL chose not to follow the agreed upon *Work Plan* which eliminated any possibility of achieving the projected separation efficiency.

Performance Observations and Lessons Learned

An overall volume reduction of 16 percent was realized after processing 73.8 cubic yards from site 16E3, 274.9 cubic yards from 16E2, and 276.3 cubic yards from 16E1. There are multiple reasons for the poor performance of the SGS.

- Failure to receive timely approval of the work permits that were a last minute requirement
- Insufficient volume of soil provided on a daily basis by BNL for sustained SGS processing. BNL's established project schedule called for processing 100 yd^3/day.
- Weather - excessive moisture, wind
- BNL decision not to follow the negotiated and approved *Work Plan*:
    1. Clumps of sod that were not broken up as per *Work Plan*
    2. BNL's excavation methods that did not remove hot spots (>200 pCi/gm), from 0-6 inches for direct disposal and not to be processed through the SGS, as negotiated and per the approved *Work Plan*
    3. BNL's excavation methods of scraping the 3-inch lifts of soil in a pile that, as opposed to following the approved *Work Plan*, ignored the consequences of mixing the soil.

The deployment of the SGS at BNL had no chance for success since the BNL did not consider the recommendations made as a result of the experience of previous deployments, choosing to not follow the approved *Work Plan*.

In addition to the ASTD funding for the mobilization, processing, delays and demobilization and the costs associated with the support of the SGS operations, BNL continued with the same excavation techniques after the SGS demobilization. The excavation methods BNL chose to use resulted in the excavation, transportation and disposal costs for a reported total of approximately 2,800 yd^3 of soil. Assuming that the prediction of a 50% to 65% reduction in volume was valid and could have been achieved if the *Work Plan* had been followed, the reduction in soil volume requiring disposal would have ranged from at least 1,400 yd^3 to as much as 1,820 yd^3. Significant cost savings could have been realized had this predicted range of volume reduction been achieved.

Had the ASTD SGS Management Team known, in advance, that the *Work Plan* would not be followed, the Segmented Gate System would not have been deployed to Brookhaven National Laboratory.

10. REFERENCES

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11. VALIDATION

“This analysis accurately reflects the performance and costs of the remediation.”

James Brower, AOC 16 Project Manager

"I have reviewed and concur with costs and performance results of the Segmented Gate System. Conclusions regarding specific factors related to the SGS performance do not necessarily reflect the views or concurrence of BNL staff or management."

Environmental Restoration Division
Brookhaven National Laboratory

Ray Patteson, Principle Investigator
Accelerated Site Technology Deployment Program
Segmented Gate System Project
Sandia National Laboratories

APPENDIX

DIRECT EXCERPTS FROM:

BROOKHAVEN NATIONAL LABORATORY
FINAL
REMEDIAL ACTION WORK PLAN
AREA OF CONCERN 16 LANDSCAPE SOIL
April 13, 2000

Prepared for:
Brookhaven National Laboratory
Environmental Restoration Division
Upton, New York 11973

Prepared by:
CDM FEDERAL PROGRAMS CORPORATION
125 Maiden Lane 5th Floor
New York, New York 10038

3.0 SOIL EXCAVATION

The contaminated soil will be excavated from each AOC 16 location and hauled to the Chemical Pits area where soil segregation will be performed by ThermoRetec. Figure 3-1 identifies the location of each excavation area and the truck route to the Former Glass Holes area where the Segmented Gate System will be operated.

The estimated area extent of the excavation for soil above the cleanup goals are provided on Figures 3-2 through 3-8. These excavation limits were developed based on data provided in the RI, as well as the supplemental data collected by BNL in 1999, and new data collected by ThermoRetec in 1999 (Appendix A). Identified on the figures are the excavation lines, and easting and northing coordinates for each corner. The precise location of radiological survey contours and excavation limits may not line up precisely on the figures due to variability in survey locations (radiological survey locations may be off by 3 to 5 ft). Therefore, excavation lines will be verified with field measurements. This will be accomplished using NaI gamma detectors.

As a first step, hot spots will be excavated to a 0.5 foot depth for offsite disposal rather than processing in the Segmented Gate System. After the hot spots have been removed, all soil greater than the cleanup goals will be removed and processed in the Segmented Gate System. Based on new data collected by ThermoRetec in 1999, Cs-137 only extends to a depth of 1 foot. As a result, excavation will be completed to a 1-foot depth, for a total of approximately 1425 CY of radiologically contaminated soil. A confirmation survey using NaI detectors will then be performed to verify that the 1-foot excavation depth is sufficient. Once final excavation limits have been reached, a verification survey will be performed using the In Situ Object Counting System (ISOCS), followed by backfilling to grade. In addition, to prevent foraging deer from consuming contaminated grass, a 6-inch soil cover will be placed over soil that is between 5 and 23 pCi/g Cs-137. As a contingency, should the Segmented Gate System be unsuccessful in sorting the contaminated soil, this soil will be disposed offsite as low level radioactive waste.

For AOC 16.S.3, 5 CY of lead contaminated soil (with maximum Cs-137 levels of 9.68 pCi/g) may require separate excavation and offsite disposal, and will be dependent on additional lead sampling data to be collected to verify lead levels. While the Cs-137 levels are below the cleanup goals, they are above detection levels. Therefore, if this material is determined to be contaminated with elevated lead levels, it will then require TCLP lead analysis to determine whether it must be handled as mixed waste. This material will be shipped directly for offsite disposal rather than being processed in the Segmented Gate System.

3.3.2 Excavation Methods

Excavation will be performed using conventional construction equipment, such as a front-end loader, backhoe, and/or excavator. Hand excavation with shovels may be required in areas near structures (e.g., when contamination is present near buildings or underground utilities) or for removal of small, localized contamination. As a result of variability in radiological survey locations (radiological survey locations may be off by 3 to 5 ft), the precise location of excavation lines will be verified with field measurements. This will be accomplished using NaI gamma detectors. All sampling will be performed in accordance with the *Remedial Action Field Sampling Plan, Area of Concern 16 Landscape Soil* (CDM Federal, 2000).
As a first step, any grass areas will be mowed as close to the ground as possible to reduce the amount of grass that will be included with contaminated soil fed to the Segmented Gate System. Also, grass areas will be mechanically broken up (e.g., mechanical discing), as necessary, but will be conducted in a manner that minimizes mixing of surface soils with underlying soils.

Based on current survey data, excavation of hot spots will be performed first to remove grossly contaminated soil from the waste stream being fed to the Segmented Gate System and placed into transport containers or rail cars for offsite disposal. Hot spots have been defined as areas with Cs-137 levels greater than 200 pCi/g (approximately ten times the 23 pCi/g cleanup goal), and to a depth of 0.5 ft. Following hot spot removal, areas will be excavated to a depth of 1-foot (including the 0.5 foot of hot spot material removed). A 20 CY load of hot spot soil will collected and fed to the Segmented Gate System to verify the assumption that this material can not be effectively segregated. Following excavation to 1 ft, a NaI detector gamma radiation survey will be performed to determine whether excavation depths are sufficient to meet the required cleanup goals. Once soil excavation is complete, a verification survey will be completed using the ISOCS system based on the Multi-Agency Radiation Survey and Site Investigation Technology (MARRSIM) methodology (with confirmation sampling for laboratory analysis) will be performed to verify that cleanup goals have been met. The NaI detector survey and verification sampling strategy is described in Section 3.4. If necessary, additional soil may need to be excavated, and will be determined based on the verification sampling data. This excavation and survey plan will minimize the excavation and processing of soil below cleanup goals.

3.3.5 Minimization of Mixing

Efforts will be made during excavation, transporting, and staging to minimize mixing of contaminated soil. This will be necessary given that the Segmented Gate System technology takes advantage of the heterogeneous distribution of contamination in the soil as a means of segregating the soil into contaminated and non-contaminated portions. To minimize mixing of material that is to be fed to the Segmented Gate System, the front-end loader or backhoe will excavate to the 1 ft depth at one location at a time, proceeding in lanes to keep adjacent soil in the same transport containers. Small sized transport containers (e.g., 15 to 20 CY rolloffs) will be used to reduce the potential for mixing of soil from different excavation locations during filling operations. Transport containers will be equipped with open tops and one side that swings to the side (including the upper bar). This will allow ThermoRetec access to the soil in the container with a small front-end loader that can be driven into the container. The process of emptying the front-end loader or backhoe bucket into the containers will be performed such that the height above the container that the bucket is emptied is minimized. Unloading of the contaminated soil from the containers will proceed one container at a time, by dumping the container directly into the Segmented Gate System feed hopper. The practice of dumping the containers onto the ground into stockpiles may occur but will be minimized.

3.3.7 Dust Suppression

Dust generation will be minimized during loading, hauling, and dumping. This will be accomplished by the use of a water truck(s). Over application of water resulting in free liquids will not be allowed due to additional requirements that would be imposed for handling of liquid waste.

Soil must not become wet or saturated since wet soil cannot be processed effectively by the Segmented Gate System…

…It is recognized that the presence of moisture as a result of using water for dust suppression will affect the Segmented Gate System's ability to efficiently segregate the soil due to the attenuation of the gamma-rays in the moist soil and difficulties with handling overly moist soil. The ability of ThermoRetec to compensate for these fluctuations in soil moisture, as well as the ability to handle such soil, is integral to the success of this project. As a result, ThermoRetec will be required to participate in field decisions to prevent the use of excessive amounts of water for dust suppression during excavation activities.

4.0 WASTE MANAGEMENT AND DISPOSAL

4.1 Waste Minimization

The primary waste stream associated with this project is the radiologically-contaminated soil resulting from past BNL operations at the task sites. The secondary waste streams are the equipment and materials that have come into direct contact from handling the primary wastes (stockpiled and excavated soil, sampling residue, and decontamination residue).

Each waste stream generated by this project will be examined in an effort to minimize the volume of waste generated. The primary method for waste reduction is use of the Segmented Gate System to segregate soil below cleanup goals from radiologically contaminated soil.

Some methods that may be employed to minimize the primary and secondary wastes generated are as follows:

- Excavating only those soil exceeding the cleanup goals using radiation survey meters prior to digging each area
- Direct loading of hot spots without sorting with the Segmented Gate System to reduce contamination of soil below cleanup goals during processing
- Minimizing stockpiling and handling of excavated soil to increase system efficiency
- Conducting the initial decontamination by dry methods (e.g., scraping, sweeping, brushing) and then using water as necessary to reach free release limits
- Using excavation methods that minimize quantities of excavated soil (i.e., hand and small equipment excavation), which are above treatment standards