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THE ACCELERATED SITE TECHNOLOGY DEPLOYMENT PROGRAM PRESENTS THE SEGMENTED GATE SYSTEM

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ABSTRACT

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.

BACKGROUND

In 1995, the Department of Energy's Innovative Treatment Remediation Demonstration (ITRD) Program initiated the "Ohio Heavy Metals in Soils Project", to investigate the use of innovative technologies for the remediation of contaminated soils. Preliminary technology assessments indicated that processing radionuclide contaminated soils through physical separation using advanced sensors was cost-effective and could significantly reduce the volume of soil requiring either further treatment or off-site disposal. The ITRD program sponsored a study using the Segmented Gate System (SGS) for separating uranium and plutonium contaminated soil from clean soil. Based on these results, Sandia National Laboratories' Environmental Restoration Project and the ITRD Program sponsored a soil remediation effort at Sandia's Technical Area II in August and September 1997 using the SGS. The system was used to cost effectively separate clean and contaminated soil for four different radionuclides: 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.

DISCLAIMER

DISCLAIMER

SEGMENTED GATE SYSTEM DESCRIPTION (1)

Introduction

The ThermoRetec (formally Thermo NUtech) Segmented Gate System (SGS), Figure 1, is a combination of conveyor systems, radiation detectors, and computer controls that remove contaminated soil from a moving feed supply on a conveyor belt. Contaminated or suspect soil is loaded into a screening plant with a front-end loader. The soil entering the screening plant is extracted by the screen conveyor belt that deposits the extracted soil on a screen feed conveyor belt. When the soil is discharged from the screen feed conveyor belt, it falls onto the soil feed conveyor. The soil is spread evenly across the sorter belt by a screed (leveling gate) that is attached to the bottom of the charge bin. The soil passes under an array of sodium-iodide (NaI) detectors that measure the gamma-ray emitting radionuclides in the soil. The control computer that also controls the gates at the end of the sorter belt processes signals from the detectors. The contaminated soil is diverted to the contaminated soil conveyor belt by the segmented gates. This belt subsequently discharges the contaminated soil to a container or stockpile for further processing or final disposition.

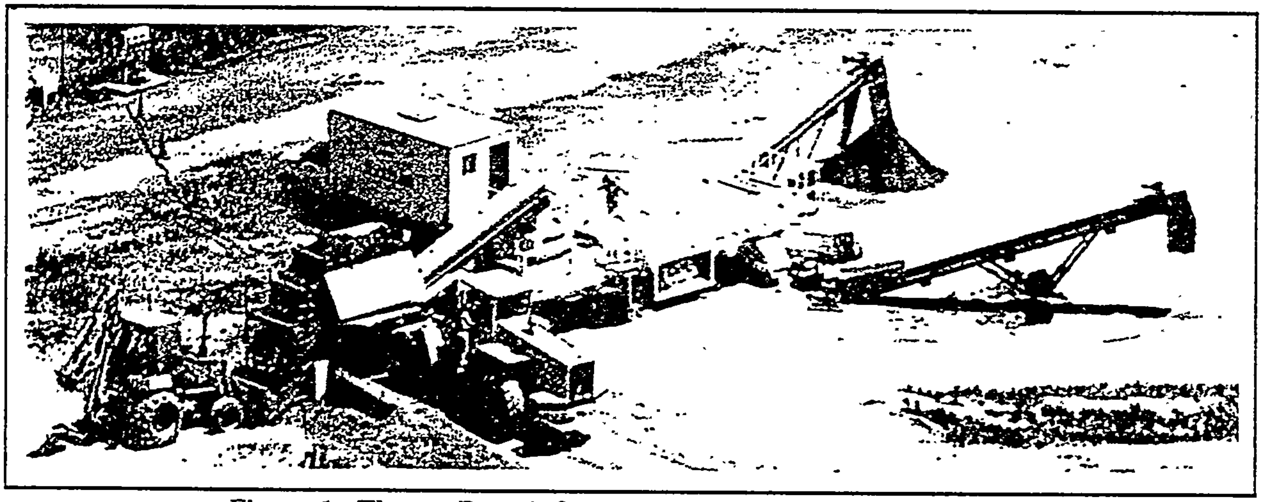


Figure 1. ThermoRetec's Segmented Gate System in Operation

Mechanical System Description

Thermo NUtech's SGS is a mobile, radiological soil assay system with motorized conveyor belts, a variable belt speed motor controller, air actuated segmented gates, a radionuclide assay computer system, and two sets of radiation detector systems. The SGS 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. Two detector arrays can be deployed across the flat 81.3-cm (32-in.) wide assay conveyor

Process Description

Contaminated soil is excavated with heavy equipment, such as a grader and end-loader, and relocated to the feed point of the SGS processing plant. Feed soil is screened by the SGS mobile screen/hammermill plant to remove all oversized material. The remaining soil is deposited in the feed surge bin using the conveyor built into the screen/hammermill plant. 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(s) of interest and the soil characteristics.

Process material is conveyed at a preselected speed underneath the detector arrays. These 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 criteria for radioactive materials is diverted to the contaminated material conveyor, where it is transferred to a stacking conveyor. The below criteria material falls directly onto the below criteria conveyor which transports it to the other stacking conveyor, Figure 2

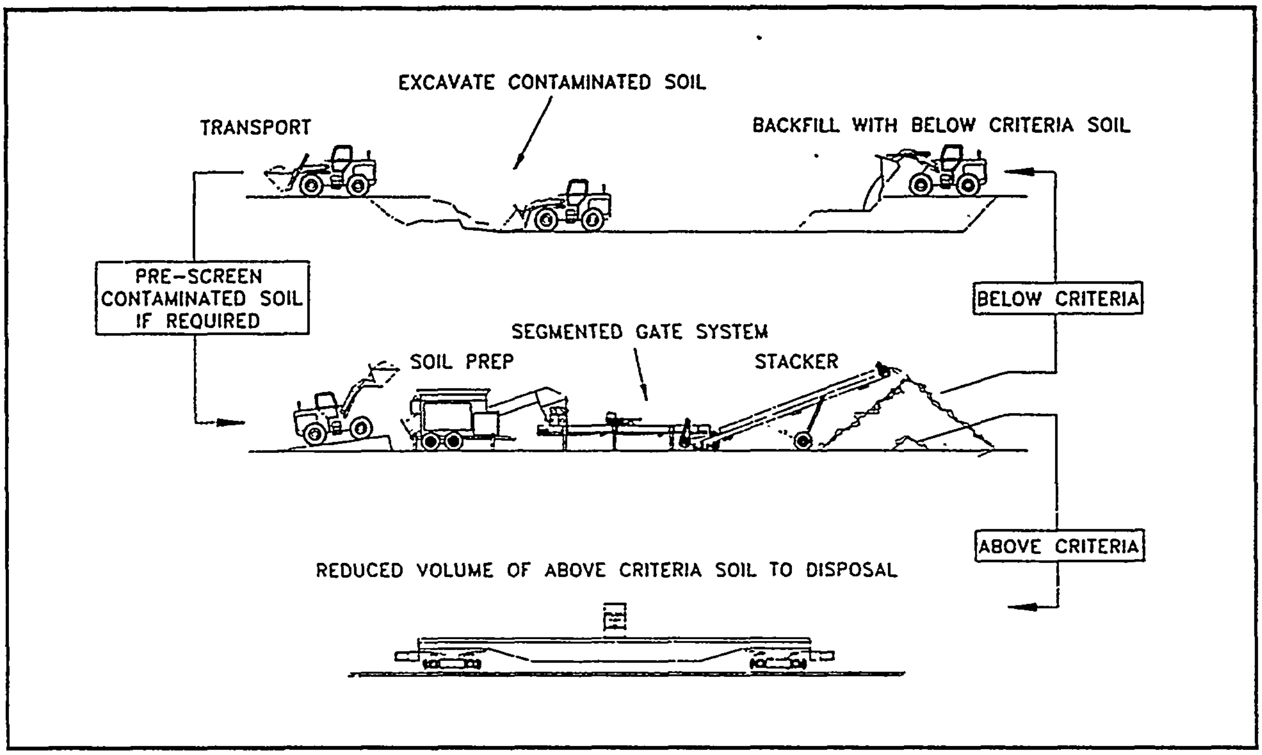


Figure 2. Process Flow

Radiation Detectors

Two sets of radiation detector arrays are housed in shielded enclosures that can be adjusted vertically above the flat assay conveyor belt allowing for various soil thicknesses. The detector arrays have a shadow shield below the conveyor belt that is constructed of steel plate lined with 5 cm (2 in.) thick lead brick to reduce the intensity of the background radiation immediately below the detectors. The detector arrays can be operated simultaneously and are arranged in two rows of eight detectors that span the entire width of the belt. The SGS was originally designed for the detection of gamma-ray emitting radionuclides using NaI detectors; however, minor software and hardware changes can be implemented for deployment of other detector types to allow for the detection of some beta-emitting radionuclides. Gas proportional detectors for the measurement of beta particles, compatible with the same interface electronics and control computer system as the NaI detectors, have also been deployed with the SGS. The detector housing has thick aluminum sides and a thin aluminum bottom, designed to shield the detectors from background radiation events and low energy beta particles emitted by ^{137}Cs and other man-made radionuclides. While the gas proportional detectors have some gamma sensitivity, the efficiency is very low for the ^{137}Cs gamma emissions and the shielding provided by the NaI detector enclosure and the shadow shield effectively reduce the ambient gamma background.

The shield assemblies are provided with penetrations for an air supply and an exit opening for coaxial cables that connect the detectors to the electronics housing. An environmental control unit maintains a constant temperature by recirculating the air supply through the shield assemblies and heating or cooling it as necessary.

System Electronics

The electronics housing contains the detector interfacing and signal processing electronics for operation of the detectors and segmented gates. The housing is provided with penetrations and connection points for temperature control, conditioned 115 volt AC power, signal cables for the detector arrays, computer communications, and communication port for a laptop computer. The electronics housing also includes the control computer and the modular detector board (MDB) cards and cages. The control computer provides the required data processing and communication interfacing to the detectors through the MDBs. The MDBs are high performance detector interface boards that provide detector high voltage, amplifier and signal processing circuitry, and a single channel analyzer.

The MDBs mount in MDB card cages. DC power supplies are provided for +5 V and +12 V for the control computer and MDBs.

The segmented gates, Figure 3, have magnetically activated limit switches that provide electrical signals when the gates are fully extended or retracted. The control computer monitors the position of each segmented gate during soil processing operations. A safeguard alarm will activate if a gate is not in the required position for any reason. This alarm will automatically stop the processing conveyor belts and the system must be reset manually after the cause for alarm has been corrected.

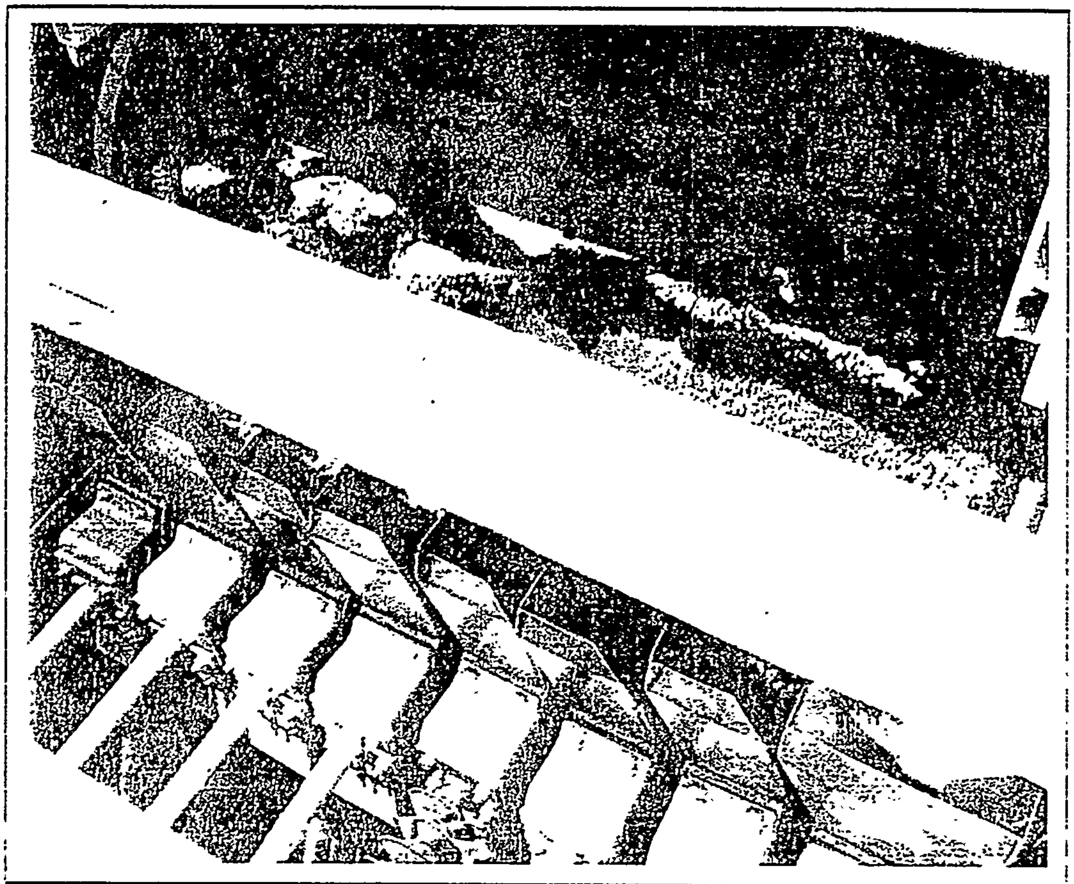


Figure 3. Pneumatically Operated Segmented Gates

The control computer interfaces with a remote computer located in an adjacent control van. The remote computer has a local display and keyboard and stores proprietary software on its internal hard drive. The remote computer monitors soil processing based on operating parameters supplied by the operator. When the SGS is operating, the remote computer stores in memory the chronological time of each diversion to the contaminated path, the amount of radioactivity diverted, amount not diverted, and the amount of soil processed. The operating display on the remote computer shows real-time status of the conveyor monitor system and will shut down all conveyor feed belts when abnormal conditions are detected or on operator command.

System Algorithm

The primary function of the control computer is to count the soil increment under the detector and make hot particle and distributed activity determinations using appropriate mathematical algorithms. Count rate determinations are made directly by the control computer via its on-board counters. Data processing, including hot particle and distributed activity determinations, are made by the control computer.

The control computer analyzes the detector data using several proprietary algorithms and the results are used to control the divert commands to the segmented gates. The control computer then tracks contaminated material on the assay conveyor belt and determines when each increment of soil will reach the segmented gates. The computer signals the appropriate gate(s) to activate, catch, and route contaminated material to the proper path.

Counting is performed via a time-slice method. Time-slice integration for distributed counts occurs every two seconds. The integrated gross counts are divided by two seconds and the background is subtracted to give the net count rate. Combined, distributed net count rates from the detectors are used to make a distributed contamination determination over a number of soil increments in a grid array. In cases of high count rates that qualify as hot particles, the soil increments are marked for diversion. These marked elements are not included in the distributed contamination calculation since they are diverted regardless of the status of the rest of the material on the belt.

Segmented Gate Control - Hot Particle Activity

The control computer totals the net counts for each detector in the array during each count time slice, and tracks the results on an 8 by 10 segment matrix. This matrix is 8 detectors wide x 20 seconds long (10-two second segments). The microprocessor distinguishes the higher activity segments and diverts them until the activity drops below the threshold activity level. If the net activity in the array exceeds a predetermined threshold count for total dispersed activity per total mass, the control computer sends a signal to the appropriate segmented gate(s) to divert selected high-activity increments of soil from the array. The gate(s) remain extended until the activity in the units of the array no longer exceed the threshold activity level, at which time the gate(s) are retracted by signal from the microprocessor. If enough segments are diverted such that the measurement of the remaining activity is no longer statistically distinguishable from the background levels in the soil, and the average activity still exceeds the criteria, the remainder of the soil is diverted. This ensures that soil with activity marginally above the criteria is routed to the hot pile.

Segmented Gate Control - Distributed Activity

All diversions, including hot particle diversions, will divert two or four seconds worth of soil. The microprocessor obtains a net count from each detector at the end of every time-slice and sends it to the control computer. The control computer analyzes the shape of the activity peak generated by the signal to determine if the count threshold level is exceeded. If the count threshold was exceeded, the control computer determines the specific time the increment will reach the segmented gates and sends a message to actuate the appropriate gate(s). A return signal is sent to the computer to confirm that switch closure occurred. If succeeding increments exceed the count threshold, the selected gates continue to divert soil towards the contaminated pathway until all above criteria elements are diverted. After the last contaminated element has been diverted, the control computer stops the signal to the gate(s), and they return to their original position.

Data Storage

The control computer records the date, time, activity amount, gates used, and mass of each contaminated soil diversion. The SGS software calculates the mass of the below criteria material processed and volume of contaminated material diverted. The calculation is based on a value for material density entered by the operator and material thickness on the assay belt at a specified width and speed. This information is stored on the internal hard disk of the control computer for data archiving and report generation. The data is also backed up daily on removable storage media. Upon command, the control room computer can generate production reports.

Segmented Gate System - Technology Advantages

The system physically surveys the entire volume of soil processed and typically reduces the volume of soil requiring treatment or disposal by 50% to 90%. Though limited primarily to gamma emitting radionuclides, the system can be modified to detect beta emitting radionuclides. Through processing, no chemicals or other additives are used. Dry decontamination has repeatedly been proven effective for free release of the system from the sites so the generation of secondary waste is generally limited to personnel protective equipment.

Segmented Gate System - Technology Limitations

Employing two detector arrays limits the ability of the system to analyze a maximum of two radionuclides at a time with different gamma energies. The soil cannot be properly sorted for unknown radionuclides so prior knowledge of the primary radioactive contaminate is required. Material greater than a nominal 1.5 inches in diameter inches, for a typical 2-inch soil thickness on the belt, cannot be processed without pre-crushing. The radioactive contaminate must be heterogeneously distributed within the suspect soil.

ACCELERATED SITE TECHNOLOGY DEPLOYMENT PROGRAM - SUCCESSFUL SITE DEPLOYMENTS

Sandia National Laboratories
Environmental Restoration Site 16
Albuquerque, New Mexico (2)

Project Objectives and Approach

The primary objectives of the Segmented Gate System project were to reduce the volume of soil at Sandia National Laboratories' Environmental Restoration Site 16 requiring off-site disposal. The volume reduction would therefore, reduce the overall ER Site 16 remediation costs. The results of the deployment would also provide a basis from which to estimate SGS cost/performance for similar sites projected for future operations.

The SGS was used to sort 661.8 cubic yards of soil suspected of depleted uranium contamination excavated from ER Site 16 at Sandia National Laboratories. The reduction in the volume of contaminated soil was determined based upon the total soil processed versus the amount of soil that was determined to be below the release criteria for the site.

Performance Summary

Site preparation was completed by SNL prior to mobilization of the SGS. The SGS was mobilized to the SNL ER Site 16 site and arrived on February 17, 1998. Mobilization and calibration of the system were accomplished in eight days. This period included completing the excavation of the suspected contaminated material and site-specific training for Thermo NUtech personnel. Excavation was started by Sandia personnel, using a front-end loader, and was completed by Thermo NUtech personnel. Excavation included pre-screening of the soil using a vertical bar field grizzly to remove material and debris with a minimum dimension of 6 inches. Upon completion of the pre-screening process, this oversize material was deposited in a single layer for future hand survey by Sandia personnel. The remaining soil was stockpiled for processing. Excavation and prescreening were completed on February 25th. The SGS was completely operational and ready to process soil on February 27, 1998.

A five day per week, ten hour per day schedule was set for soil processing. Soil was processed for five days, Table I, with processing continuing through March 5, 1998.

Table I. Daily Processing Volumes

PROCESSING DATE	SOIL VOLUMES PROCESSED
February 27, 1998	115.5 cubic yards
March 2, 1998	180.4 cubic yards
March 3, 1998	60.8 cubic yards
March 4, 1998	190.6 cubic Yards
March 5, 1998	94.3 cubic yards

Average daily operational time was 4.7 hours. Control boundary posting and equipment malfunctions impacted the average daily operational time. A total of 5.3 hours of down time, based on the expectation of processing for 7 hours each processing day, was charged to the project. An overall volume reduction of 98.5 percent was achieved after processing the entire volume of soil on the first pass. This included soil that was diverted for excessive activity, soil that was diverted due to periodic source checks and soil that was diverted due to unscheduled pauses in operations. Unscheduled pauses as a result of soil flow difficulties and other operational problems resulted in approximately 161 kg of soil diverted during each pause. The total mass diverted due to pauses was approximately 10,000 kg.

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

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

Radiological Data

Depleted uranium was the only radionuclide of concern on this project. The risk based clean-up criterion of 540 pCi/gm was established and the sorting criteria for the distributed contamination was set at an ALARA level of 54 pCi/gm. The below criteria soil average activity was 4.2 pCi/g, after the first sorting pass. The above criteria soil average was 406.5 pCi/g after the first pass.

Pantex Plant, Firing Site 5
Amarillo, Texas (3)

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 was contaminated with depleted uranium from test operations conducted at the Pantex Plant. The firing site had been excavated and material had been screened for activity by surveying each loader bucket of soil using a hand held survey meters. Soil was segregated, dependent upon the activity measured with the survey meters, into separate piles. The object of this project was to provide volume reduction for the segregated soil that was above the release criteria based on the original hand survey.

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 and immediately adjacent to the FS-5 site. Pantex has active operations at adjacent firing sites preventing access 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.

High winds postponed the mobilization of the SGS until March 29th. Assembly and calibration were accomplished over an eleven-day period. Soil processing began on April 17, 1998 and continued through April 19th, Table II. 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. Based on a 7 hour processing day, 1.7 days of downtime were accumulated for weather conditions and mechanical challenges not under the contractor's control. Average daily operational time, impacted by adverse weather conditions, was 2.67 hours.

Table II. Daily Processing Volumes

PROCESSING DATE	SOIL VOLUMES PROCESSED
April 15, 1998	10.24 cubic yards
April 17, 1998	145.36 cubic yards
April 18, 1998	42.95 cubic yards
April 19, 1998	95.53 cubic Yards

Over a four day period, a total of 294 cubic yards were processed through the SGS. There was an estimated 15 percent additional volume in oversize material that was not processed 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 the SGS separation criteria 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 had no impact on volume reduction.

Of the 294 cubic yards processed at the 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.

Radiological Data

Depleted uranium was the only radionuclide of concern during the processing on this project.

The average activity for soils from the berm that were originally characterized as below criteria using the hand survey method and determined to be 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.

Performance Observations and Lessons Learned

The primary factor for the less than desirable volume reduction was the pre-sorting of the soil using the hand survey method prior to SGS processing. 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 does provide a 100 percent assay of the soil, insuring that small areas of elevated activity can be removed while allowing the averaging over larger volumes, as was done with the hand survey method. Loader 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 localized elevated activity. It is these localized volumes of elevated activity where the SGS excels at volume reduction.

Conclusions

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 were indeed below the Pantex soil cleanup action levels.

Tonapah Test Range
Clean Slate 2
Tonapah, Nevada (4)

Summary

On May 4,1998, the ASTD Program, in cooperation with Bechtel Nevada, deployed Thermo NUtech's Segmented Gate System for a radioactive material volume reduction project. The deployment took place at the U.S. Department of Energy, Nevada Operations Office (DOE/NV), Clean Slate-2 soil remediation site.

The DOE/NV Environmental Restoration Program includes sites with large quantities of soil contaminated with finely dispersed plutonium. The contamination resulted from safety shot experiments conducted in 1963. Interim corrective actions have been completed at Double Tracks and Clean Slate 1. Future corrective actions are scheduled for three additional sites: Clean Slate 2, Clean Slate 3 and Project 57.

Field activities using Thermo NUtech's SGS took place between May 4, 1998 and June 12, 1998. The initial work involved the mobilization of the Bechtel Nevada support equipment and facilities, and the receipt and setup of the Thermo NUtech equipment. Mobilization, system setup and calibration were accomplished during the allotted time.

Soil processing began on May 18, 1998, and continued through June 3, 1998. A total of 333 cubic yards of soil was processed through the SGS. The soil volume reduction ranged from 4 percent to 99 percent and was dependent on the activity in the processed soil compared to the set-point value used to activate the sorting gates. Since a corrective action level had not been established, different set points were tested relative to the soil activity level in order to maximize data points for comparison.

Operating Parameters

The operating parameters for the SGS at Clean Slate-2 were varied to provide a large number of data points to help determine the acceptable level of contaminant reduction. Seventy-nine separate periods of operation or "runs" occurred, each characterized by different soil activity levels and equipment operating parameters that included set points and soil thickness on the belt.

Project Objectives and Approach

The volume reduction objective of the Clean Slate-2 SGS ASTD project was abandoned and an R&D mode of operation was instituted. The R&D operations were designed to assess various operating parameters and determine their influence on the volume of plutonium that could be removed, thus potentially reducing the volume of soil requiring off-site disposal.

The SGS was used to process 333 cubic yards of plutonium contaminated soil excavated from Clean Slate-2. The results from this effort were then used to define optimum operating parameters and costs for a possible follow-on effort at this and the remaining sites at the Tonapah Test Range. To accomplish this, the data from the various operating parameters were evaluated for volume reduction and contaminant removal. Based on this data, optimum-operating criteria could be recommended for the soil processing at the site. When an acceptable criterion is established using this data, the expected overall system performance and remediation costs for operations at the sites can be developed. Comprehensive results of the multiple runs can be found in the Cost and Performance Report, July 1999, for the Clean Slate-2 Deployment (4).

Performance Observations and Lessons Learned

An accurate estimate of system throughput cannot be extrapolated from test runs when the set point criteria are changed so frequently. The 333 cubic yards of soil were processed during 79 different runs. A large number of set points were tested, relative to the soil activity level, in an effort to maximize data points for comparison of separation efficiencies. Better, more accurate site characterization data would have eliminated the need for the multiple set point changes. This would have, in turn, yielded better equipment reliability and soil throughput results.

Soil excavation using a motor grader to scrape soil into windrows significantly mixes the soil, homogenizing potentially high concentration areas and rendering the SGS less effective. Some type of marking system to identify hot areas within the windrow would tell the loader operator which sections of the windrow to transport to the SGS feed point for processing and which sections should not be processed for volume reduction.

Los Alamos National Laboratory
Technical Area 33
Los Alamos, New Mexico (5)

Summary

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

The Thermo NUtech Segmented Gate System (SGS) was mobilized to TA-33 on April 19, 1999, to an area that had been previously prepared by Los Alamos. Assembly and calibration were accomplished over a five-day period. Soil processing began on April 28, 1999 and continued through May 19, 1999. Actual processing occurred on 15 of those days and a total of 91.10 hours of processing time were logged.

A volume of 2,526 cubic yards was processed through the SGS. A set point of 65 pCi/g was used to reprocess the diverted soil from the Gully Site since the contamination was more uniformly distributed but still significantly below the PRG. The separation efficiencies listed in Table III include the reprocessed soil from the Gully Site.

Table III. Processing Results by Site

TA-33 SITE	SEPARATION SET POINT	SEPARATION EFFICIENCY
C33-003, Water Tower Site	50 pCi/gm	99.65%
C33-010 (c), Gully Site	65 pCi/gm	99.79
C33-007 (b), Bunker Site	50 pCi/gm	75.47

Project Objectives and Approach

The primary objectives of the Segmented Gate System project were to reduce the volume of soil at TA-33 requiring off-site disposal reducing the overall TA-33 remediation costs and to process the soil at an ALARA Level of 50 pCi/g given the PRG of 600pCi/g.

The project would also provide a basis from which to estimate SGS cost and performance for similar LANL sites projected for future operations.

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

Performance Summary

Soil was processed, using the SGS, for 15 days in April and May 1999. The average daily processing time was 6.48 hours, just below the target of 7 hours of processing time per each 10-hour workday. There were 8 of 14 processing days where the volume of soil processed exceeded 200 yd^3, Table IV.

Table IV. Daily Processing Volumes

PROCESSING DATE	SOIL VOLUMES PROCESSED
April 28, 1999	220 cubic yards
April 29, 1999	173 cubic yards
May 3, 1999	213 cubic yards
May 4, 1999	222 cubic yards
May 5, 1999	202 cubic yards
May 6, 1999	213 cubic yards
May 7, 1999	225 cubic yards
May 10, 1999	204 cubic yards
May 11, 1999	240 cubic yards
May 12, 1999	98 cubic yards
May 13, 1999	117 cubic yards
May 14, 1999	122 cubic yards
May 17, 1999	167 cubic yards
May 18, 1999	12 cubic yards
May 19, 1999	50 cubic yards

An overall volume reduction of 91.64 percent was realized for the TA-33 soils. This included soil that was diverted for excessive activity including soil that was diverted due to unscheduled pauses in operations. Unscheduled pauses, due to soil flow difficulties or other operational problems, resulted in a volume of about 9.8 cubic yards. This non-assayed soil represented 2.03% of the below criteria soil.

Performance Observations and Lessons Learned

The LANL excavation plan of digging from the rear of the bunker towards the front, where the highest level of contaminate concentration was located, aided in the SGS achieving a very good volume reduction. A total of 253 cubic yards of material from the hot piles were processed a second time to attempt addition volume reduction. A 6yd^3 hot pile from C33-003 was processed yielding an additional 94% volume reduction. On May 19th, after all site soils were processed, 24 yd^3 of soil was excavated from around the equipment, as a part of the decontamination, and processed yielding a volume reduction of 94.6%.

Idaho National Engineering and Environmental Laboratory
Auxiliary Reactor Area 23
Idaho Falls, Idaho (6)

Summary

Idaho National Engineering and Environmental Laboratory (INEEL) at Auxiliary Reactor Area-23 (ARA-23). ARA-23 is a 41.8-acre CERCLA site containing windblown contamination. Most of the contamination came from the accidental destruction of the SL-1 reactor in 1961 and the subsequent clean-up activities. The contaminant of concern is Cesium-137. The preliminary remediation goal for this site was established at 23 pCi/g, which represents future residential development.

The Thermo NUtech Segmented Gate System (SGS) was mobilized to ARA-23 site on June 1, 1999, to an area that had been previously prepared by LMITCO personnel. INEEL contractors provided crane support for equipment offloading during mobilization, all heavy equipment support throughout the deployment and crane support for the demobilization. Assembly and calibration were accomplished over a five-day period.

Soil processing began on Wednesday, June 10th and ended on June 30th, 1999. The goal of the project was to reduce the volume of contaminated soil that would require disposal in an on-site disposal cell . An estimated total of 1,040 yd^3 of soils were excavated and stockpiled from two areas within ARA-23, representing both sediment (spill) and windblown type contaminant depositions. The scope of work for the SGS deployment called for processing 1,000 yd^3. Only 442 yd^3 of the stockpiled soil was processed because the expected results were not being achieved and prior arrangements had not been made for disposal, as waste, of more than 30% of the volume.

Operating Parameters

The operating parameters for the SGS at ARA-23 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 thin detector array was not used and was replaced with gas proportional beta detectors in monitoring mode. Once production sorting was stopped by the client processing changed to an R&D mode. Parameters and settings were changed for each test.

Area A -Sediment Radionuclide Deposition

Area A soils were excavated first by using a grader to windrow the top 3 to 4 inches of soil. A front-end loader was used to pick up the soils and load them into dump trucks. After the excavated soil was removed from the area, INEEL's Global Positioning Radiometric Scanner (GPRS) surveyed the area. The results of the initial and second survey show that a considerable amount of the activity above 23 pCi/g was removed during the excavation.

Of the estimated 152 yd^3 of soil stockpiled, 113 yd^3 were processed with 97.3% of the soil exceeding the 23 pCi/g set point for Cs-137. The low separation efficiency achieved for the ARA-23 Area A soils was assumed, and accepted. The homogeneous distribution of contamination was expected with a spill or sediment type contaminant deposition, and confirmed with the SGS processing effort

Area C - Windblown Radionuclide Deposition

Area C soils were excavated using a grader and a bulldozer to windrow the top 3 to 4 inches of soil. A bulldozer was used when the soils became too muddy for efficient use of the grader. These soil windrows were picked up using a front-end loader, and loaded into dump trucks for stockpiling inside the SGS exclusion zone.. After the excavated soil was removed from the area, the GPRS surveyed the area. The results of the initial and second survey show that approximately 50% of the remaining soils are below the 23 pCi/g action level. The remainder of the area soil exceeds 23 pCi/g, and would require further excavation.

Poor separation efficiency was observed with the Area C soils and led to termination of routine soil processing. The windblown radionuclide contamination in this area was thought to be heterogeneous in nature and there was not an obvious explanation for the poor separation efficiency. At this point the parties involved agreed to investigate the reason(s) for the poor separation results that were being achieved. The resulting investigation consisted of a series of performance tests to verify the proper operation of the SGS and determine the reason(s) for the poor separation efficiency results.

A number of R&D tests were performed at varying set points, varying Multiple Particle Factor settings, varied excavation techniques and reprocessing of soil at decreasing detection set points. The results of these tests verified the proper operation of the SGS and indicated that the radionuclide contamination was homogeneous in nature and well above the established clean-up criteria of 23 pCi/gm. A separation efficiency of 90% to 95% could be achieved at approximately 90 pCi/gm indicating that both the level and homogeneity of the contamination was considerably greater than originally thought. The results of these extensive R&D tests are outlined in the November 1999 ASTD Cost and Performance Report for the INEEL Deployment (6).

Conclusions

Although the desired volume reduction of 90% at the separation criteria of 23 pCi/gm was not met, several lessons were learned during the treatability study that will reduce the cost of site remediation for the INEEL. Additional lessons were learned that can be applied to future deployments of the SGS. The lessons learned are outlined and discussed in the November 1999 ASTD Cost and Performance Report for the INEEL Deployment (6).

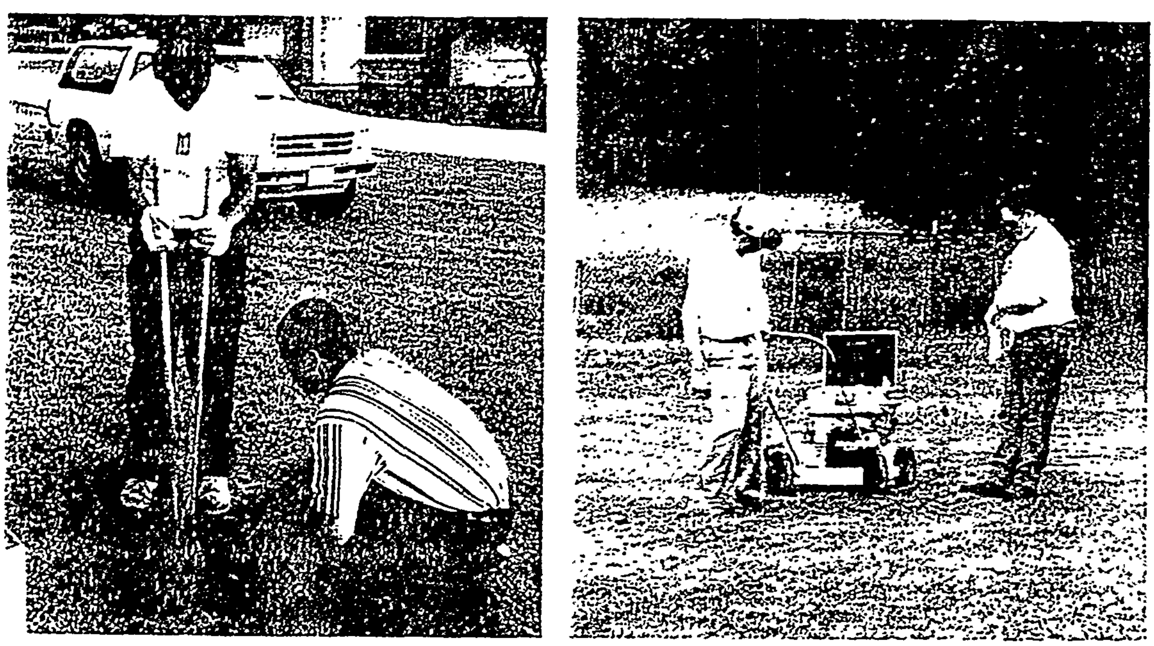
A PATH FORWARD

Background

As a result of the poor separation efficiency experienced at the INEEL, predominately due to the level and homogeneity of the contaminate, a plan was defined by a team of stakeholders and was implemented in an effort to prevent these unexpected and less than desirable results during future deployments. The plan defined was to evaluate the existing site data determine if that data was valid, sufficient and complete to allow an estimated range of volume reduction with some level of confidence. If the validity, quantity or completeness of the existing data is not sufficient for a volume reduction range estimate, a pre-deployment site characterization plan meeting certain objectives would be developed.

Implementation

In the spring of 2000, an ASTD deployment of the SGS is scheduled at Brookhaven National Laboratory (BNL). The radionuclide contaminate of concern is cesium-137 to depth of two feet. With insufficient existing data, a pre-deployment characterization plan was developed and implemented. A sample grid was surveyed in and at the sites scheduled for excavation and SGS volume reduction soil processing. A team of SGS and BNL personnel collected 204-4Kg samples at 51 locations. The team collected these depth profile samples at each of the 51 locations at depths of 0 to 6 inches, 6 to 12 inches, 12 to 18 inches and 18 to 24 inches, Figure 4a. The samples were packaged and transported to the ThermoRetec facility in Albuquerque, New Mexico where they were evaluated for radioactivity on a mock-up, bench top SGS with a sodium iodide detector. The results of the sample evaluation were plotted and an estimate range of volume reduction efficiency was predicted.



Collecting Depth Profile Samples

"Lawnmower" Detector in Operation at 30 ft/min

Figure 4a & 4b. Brookhaven National Laboratory Pre-Deployment Site Characterization

The second phase of the Brookhaven site characterization was the employment of a calibrated "lawnmower" detector developed by ThermoRetec and used for determining the level and extent of surface contamination. The detector was calibrated daily prior to site characterization with the calibration procedure consisting of counting an NTS traceable radioactive source followed by a background count on a plot known to be clean.

The "lawnmower" detector is a collimated, shielded sodium iodide detector mounted on what resembles a lawnmower. There is an integrated control computer for the "lawnmower" detector unit that records and stores the levels of radioactivity, in pCi/gm, every two seconds as the unit is maneuvered over the surface of the suspected area of contamination at a timed rate of 30 feet per minute, Figure 4b. This data was downloaded, manipulated and contour maps of the surface contamination levels were plotted. These contour plots combined with the depth profile results will allow, with some level of confidence, 3-D plots of the level of contamination in the areas of concern and the potential for homogeneity of the radionuclide in the suspect soil. These results will enhance the confidence level of the estimated ranges in volume reduction.

Another ASTD project, Sandia National Laboratories' SmartSampling™, was enlisted to assist in evaluation of the data that was collected. The SmartSampling™ project uses a proprietary computer program to develop a risk based probability model using the available data. The depth profile data was incorporated into the surface data from the "lawnmower" detector and the probability of the extent of the subsurface contamination, in six-inch increments, was modeled.

Discussion

Analysis of the depth profile samples and the surface data collected using the "lawnmower" detector during the pre-deployment characterization indicates that an estimated volume reduction range of 50% to 65%. This estimated range of volume reduction efficiencies is based on excavation of the contaminated soil within the original boundaries to a depth of 12 inches. During the analysis of the surface data, it was discovered that the area of contamination exceeded the previously defined boundaries of excavation. The area of excavation will be increased to insure that the contamination outside the original boundaries is removed.

Both the SmartSampling™ and the ThermoRetec surface modeling indicate that, within the boundaries of the contaminated plots, there are areas with high levels of surface contamination that should be excavated and treated as contaminated waste requiring off site disposal. There are also areas with less contamination that should be excavated and processed through the SGS for potential volume reduction. The selective excavation, in areas with high levels of contamination and in six-inch lifts, will reduce the cost of SGS processing since there is only a very remote possibility that any volume reduction could be realized from processing the soil in the highly contaminated areas. A small volume of soil with high levels of contamination, approximately 10 to 15 cubic yards, will be processed by the SGS to verify that the decision to treat these areas as waste is a valid decision.

The SmartSampling™ models indicate there is a very low probability that the subsurface contamination exceeds a depth of 12 inches in other than very isolated areas. The excavation will be completed in six-inch lifts and once a depth of 12 inches is reached, the area will be surveyed and only the isolated areas of contamination that exceed the criteria will be excavated and processed through the SGS. This excavation method has the potential of reducing the volume of soil to be excavated by 35% to 40%, further reducing the overall cost of the project.

Conclusions

The validity of the pre-deployment characterization process and the subsequent modeling of the data cannot be verified until the SGS deployment in the spring of 2000 is completed. The total cost of the SGS deployment coupled with the cost per cubic yard for off-site disposal and the volume reduction efficiencies for the processed soil will be factors in the determination of the validity of the site characterization plan, the data collected and the risk-based modeling. The depth of excavation that is required to remove all contaminated soils that exceed the criteria will also be a determining factor in the validity of the SmartSampling™ models.

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