Successful Implementation of Soil Segregation Technology at the Painesville FUSRAP Site - 12281

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ABSTRACT

Typically the highest cost component of the radiological soils remediation of Formerly Utilized Sites Remedial Action Program (FUSRAP) sites is the cost to transport and dispose of the excavated soils, typically contaminated with naturally occurring isotopes of uranium, thorium and radium, at an appropriately permitted off-site disposal facility. The heterogeneous nature of the contamination encountered at these sites makes it difficult to accurately delineate the extent of contaminated soil using the limited, discrete sampling data collected during the investigation phases; and difficult to precisely excavate only the contaminated soil that is above the established cleanup limits using standard in-field scanning and guiding methodologies. This usually results in a conservative guided excavation to ensure cleanup criteria are met, with the attendant transportation and disposal costs for the larger volumes of soil excavated. To address this issue during the remediation of the Painesville FUSRAP Site, located in Painesville, Ohio, the Buffalo District of the U.S. Army Corps of Engineers, and its contractor, Safety and Ecology Corporation (SEC), employed automatic soil segregation technology provided by MACTEC (now AMEC) to reduce the potential for transportation and disposal of soils that met the cleanup limits. This waste minimization technology utilized gamma spectroscopy of conveyor-fed soils to automatically segregate the material into above and below criteria discharge piles. Use of the soil segregation system resulted in cost savings through the significant reduction of the volume of excavated soil that required off-site transportation and disposal, and the reduction of the amount of imported clean backfill required via reuse of “below criteria” segregated soil as place back material in restoring the excavations. Measurements taken by the soil segregation system, as well as results of quality control sampling of segregated soils, confirmed that soils segregated as below criteria for reuse as site fill did meet the Record of Decision cleanup criteria for the site.

INTRODUCTION

Painesville FUSRAP Site Background

The Formerly Utilized Sites Remedial Action Program (FUSRAP) was initiated in 1974 to identify, investigate and clean up or control sites throughout the United States, contaminated as the result of activities performed by the Manhattan Engineer District or the Atomic Energy Commission in support of the Nation's early atomic weapons and energy program. Both the Manhattan Engineer District and the Atomic Energy Commission were predecessors of the U.S. Department of Energy (DOE).

Congress transferred execution of FUSRAP from the DOE to the U.S. Army Corps of Engineers (USACE) in 1997. USACE continues to investigate and clean up site initiated by DOE, and also addresses sites added to the program by Congress or designated into the program by USACE. While the DOE retains responsibility for FUSRAP, USACE implements the program under a USACE/DOE Memorandum of Understanding.

The Painesville FUSRAP Site, an approximately 30-acre former industrial facility, is located in the Township of Painesville in Lake County, Ohio. The site was operated as a magnesium production facility in the 1940s and 1950s under Federal Government contract. While there is no known history of processing or production of radioactive materials at the site, site soils were contaminated through the use of radiologically contaminated scrap steel, from Atomic Energy Commission inventories, in the magnesium production process; and the site was designated into FUSRAP by the Department of Energy in 1992. In 1963 the site was sold by the General Services Administration to a chemical production company, who reconfigured the site for their own uses and conducted operations until 1999. The property is currently not in active use, and all but one of the former buildings have been torn down. [1]

Under FUSRAP, the Painesville Site was initially characterized by the Department of Energy in 1996, prior to the transfer of FUSRAP to USACE. A removal action was conducted by USACE in 1998, which was suspended due to the discovery that the extent of contamination was greater than anticipated. USACE conducted investigative sampling in 2000 and 2005 to determine the extent of FUSRAP contamination in site soils, prior to completion of the Record of Decision in 2006, which set the cleanup criteria for the site constituents of concern (COCs), radium-226 (Ra-226), thorium-230 (Th-230), thorium-232 (Th-232) and total uranium (Total U). [1] USACE initiated site remediation in April 2007, but had to place the remediation on hold in March 2008 due to the discovery of increased quantities of contaminated soil. After conducting additional investigative sampling in 2009, USACE resumed site remediation in June 2010, and completed remediation fieldwork in August 2011.

Issue

The cost to transport and dispose of radiologically contaminated materials at the disposal facilities permitted to accept them is typically the highest cost component of FUSRAP site cleanups. Thus a primary goal is to accurately delineate and excavate only those contaminated materials that exceed the cleanup limits established for the site, minimizing the amount of waste that requires disposal. However, as demonstrated by the series of investigations and remediation efforts required at the Painesville FUSRAP Site, it is difficult to accurately delineate the extent of subsurface soil contamination prior to remediation. The contamination at FUSRAP sites is typically very heterogeneous in nature. FUSRAP contamination is not typically found in small, discrete plumes where it may have originally been deposited in the 1940s and 1950s, due to natural migration processes and movement of soils during changes in site use and configuration by subsequent site owners. Subsurface soil investigations are typically conducted through installation of multiple small-diameter soil borings throughout the site, which present a limited view of subsurface soil conditions and can potentially miss areas of contamination. Contaminated soil volume estimates and footprints must be developed through interpolation of the discrete sampling point data.

Once remediation starts, waste minimization typically focuses on minimizing the quantity of soil excavated. Since prior practice has required that all excavated soils be shipped offsite for disposal, methods are employed to precisely excavate only those soils exceeding cleanup criteria, as the more soil is excavated, the higher the transportation and disposal costs. Common USACE practice has been to guide the excavation via field gamma scanning measurements and collection and analysis of in-process samples from the excavation. However, guiding excavations is more labor-intensive and time-consuming, with lower production rates, than mass excavation. Also, precision excavation efforts to minimize waste volumes must be balanced against leaving the site in an acceptable condition that meets cleanup criteria. Establishing a precise correlation between field gamma scanning measurements and cleanup levels is difficult, so that scan thresholds used to guide excavation are set conservatively. While this conservativeness bounds the uncertainty in meeting the required remediated site conditions, it also results in an increase in volumes excavated and associated transportation and disposal costs.

In the Request for Proposal issued by USACE for the 2010 - 2011 Painesville Site remediation effort, one of the technical efficiency criterion specified for evaluation by USACE was the minimization of material below ROD criteria shipped off-site. In their proposal, Safety and Ecology Corporation (SEC) as the prime contractor proposed use of automatic soil segregation technology, provided by subcontractor MACTEC's Orion *ScanSort*^{SM} System, to minimize waste requiring transportation and disposal at the Painesville Site.

METHOD

Design and Implementation at the Painesville Site

SEC proposed to excavate all impacted or potentially impacted soils and buried materials and place the excavated materials into stockpiles. Once large debris was removed from the materials all "flowable" soil would be assayed by gamma spectroscopy to determine if the material met the ROD acceptance criteria. The 100% assay of all excavated material was accomplished by using the MACTEC Orion *ScanSort*^{SM} system as follows.

To begin excavation of an impacted area a gross gamma survey using a 7.6-cm by 7.6-cm (3-inch by 3-inch) sodium iodide detector coupled to a Trimble Global Positioning System was conducted. The results were plotted on a figure to clearly mark areas above the threshold value in gross counts per minute (cpm). The threshold value was the gross count rate above which the soil was likely to be greater than the ROD acceptance criteria. The value was initially determined from a correlation of analytical sample laboratory results and corresponding field scan data and updated during the project as more correlation data became available. After the initial excavation of impacted areas the remediation was guided by field gross gamma surveys and biased sampling based on the results of the field scan data. All of the excavated soil was then stockpiled for processing by the soil segregation system. Once no areas above the threshold value remained the area was isolated for final status survey including an additional 100% coverage gross gamma survey.

Description of Soil Segregation Technology

MACTEC's Orion *ScanSort*SM system is a radiological monitoring and processing system designed to perform real-time segregation of soil into two distinct groups based upon its radiological properties. The system is capable of processing and segregating large volumes of soil with relatively high throughput rates. Commercially available material conveyors are utilized to physically manage the soil. These conveyors prepare and condition material, they transport the material past various radiation sensors, and they provide the physical means to sort material based on detector readings. The material is sorted into two distinct groups (piles), commonly referred to as the "Below Criteria" and "Above Criteria" (or "Diverted") groups. The basis upon which the soil material is sorted and segregated into distinct volumes is controlled by the establishment of diversion control setpoint(s) (DCSs) that automatically trigger the diverting mechanism, sorting the material into the appropriate group. The selection of the system's DCSs depends on a number of factors including the:

- Critical Concentration(s),
- Critical Volume(s) (against which the Critical Concentration(s) are evaluated),
- Unit Volume,
- Statistical distribution of radioactivity concentrations within the material, and
- Required confidence (or certainty) in the measured mean concentration(s) in the resulting "Below Criteria" and "Above Criteria" volumes.

In order to establish DCSs, the Critical Concentration was defined. The Critical Concentration is simply the concentration-oriented compliance metric for a radiological contaminant distributed in soil, usually expressed in units of activity per unit mass (pCi/g). At the Painesville site, the Critical Concentration was developed with respect to an appropriate dose consequence for the COCs, and is equal to the Derived Concentration Guideline Levels (DCGLs) with Sum of Ratios (SOR) applied.

Four radionuclide COCs (Ra-226, Th-232, Th-230, and Total U) comprised the radiological clean-up goal for the Painesville site. Ra-226 and Th-232 are easily and directly measurable by strong, characteristic gamma emissions. Th-230 and the uranium isotopes U-238, U-235 and U-234 (Total U) are not easily or directly measurable by gamma emission. Ra-226 served as an appropriate surrogate for COCs in the U-238 decay series including Th-230 and Total U. Based on previous site characterization, remediation and final survey activities, conservative relative activity factors were determined and applied to the Ra-226 value to attribute appropriate concentrations to Th-230 and Total U. The relative activity factors are shown in the following Table I. Use of these factors overestimated the activity concentration of Th-230 and Total U based on the measured concentration of Ra-226 for the purposes of segregating soil into above and below criteria stockpiles, thereby ensuring a conservative quantification of residual radioactivity (SOR) in the “below criteria” group.

Table I. Surrogate Ratio Correction Factors

Isotope	Concentration (pCi/g)	Relative Activity Correction	
		Ratio	Factor
Ra-226	1	Ra-226:Ra-226	1
Th-230	2	Th-230:Ra-226	2
Total U	4.09	Total U:Ra-226	4.09

The Orion *ScanSort*^{SM} system measured and quantified the Ra-226 and Th-232 gamma emissions and utilized the equilibrium correction factors to determine the Th-230 and Total U activity to determine the radiological content of the material in order to perform real-time soil segregation.

Table II presents the SOR ratio calculation based on the ratio correction factors presented in Table I and assuming a constant activity concentration of 1.75 pCi/g for Th-232. Since Th-232 had not been identified above background in characterizations samples and is not a member of the natural uranium decay series (actually the parent of the natural thorium decay series), a constant Th-232 activity concentration of 1.75 pCi/g was assumed in sum of ratios calculations. Each ratio was derived as follows:

- Ra-226 – (6.1 – 1.42) pCi/g / 9 pCi/g = 0.52, 6.1 pCi/g or Ra-226 corrected for Ra-226 background, divided by the Ra-226 DCGL
- Th-230 – ((2 x 6.1) – 2.56) pCi/g / 25 pCi/g = 0.39, Ra-226 activity x 2 corrected for Th-230 background, divided by the Th-230 DCGL
- Th-232 – (1.75 – 1.53) pCi/g / 6 pCi/g = 0.037, 1.75 pCi/g corrected for Th-232 background, divided by the Th-232 DCGL
- Total U (sum of U-238, U-235, and U-234) – (((4 x 6.1) + (0.091 x 6.1)) – 5.97) pCi/g / 482 pCi/g = 0.039, Ra-226 activity x 4 to account for U-238 and U-234, plus Ra-226 activity x 0.091 to account for U-235, corrected for Total U background, divided by Total U DCGL

The SOR approaches 1 (0.98) when the gross value of Ra-226 is equal to 6.1 pCi/g. [2]

Next, the Critical Volume was defined. The Critical Volume for material sorting is the volume upon which a compliance decision is made. The Critical Volume was developed with respect to the Critical Concentration ($DCGL_W$, $DCGL_{EMC}$) and an appropriate dose consequence for the COCs. The $DCGL_W$ values developed at the Painesville site are based on an area of 10,000 m^2, and the $DCGL_{EMC}$ values are based on an area of 100 m^2, both with a contamination layer thickness of 2 m. Table III presents areal and volumetric quantities used during the development of the $DCGL_W$ and the $DCGL_{EMC}$ values.

Table II. Sum of Ratios Calculation Based on Assumed Relative Activity Values

Radionuclide	Relative (to Ra-226) Activity	Gross Activity Concentration (pCi/g)	Ratio: Net Activity / DCGLw
Ra-226	1:1	6.1	0.52
Th-230	2:1	12.2	0.3856
Th-232	0.036:1	1.75	0.036667
Total U	4.09:1	25.0	0.039387
		SOR:	0.98

Table III. $DCGL_W$ and $DCGL_{EMC}$ Volumetric Quantities

	$DCGL_W$		$DCGL_{EMC}$	
Area	10,000 m^2	107,639.1 ft^2	100 m^2	1076.4 ft^2
Depth	2.0 m	6.5 ft	2.0 m	6.5 ft
Density	1.1 g/cc	68.7 lbs/ft^3	1.1 g/cc	68.7 lbs/ft^3
Volume	20,000 m^3	706,293 ft^3	200.0 m^3	7,062.9 ft^3
Mass	22,000,000 kg	24,251 tons	220,000 kg	242.5 tons

Using the site-specific DCGL assumptions listed in Table III, the Critical Volumes represent 20,000 m^3 or 22,000,000 kg (24,251 tons) of material, and 200 m^3 or 220,000 kg (242.5 tons) of material. The Critical Volumes are monitored to ensure, with acceptable confidence (e.g., with an acceptably low false negative error rate), that the measured mean concentration is less than the $DCGL_W$s.

Following the establishment of the Critical Concentrations and Critical Volumes, the DCSs were developed. USACE, SEC and MACTEC elected to implement (3) DCSs to sort potentially impacted soil to ensure that the mean concentrations in the “below criteria” piles did not exceed the concentration limits. If, during soil sorting operations, any of the three radiological DCSs were exceeded, the control software indicated an “Alarm” signal, and the violating soil material was sorted into the “above criteria” pile. Note that the DCS volumes listed in Table IV are significantly smaller (and therefore more conservative) than the Critical Volumes listed in Table III. The DCSs are presented in Table IV.

The volumes associated with the diversion control setpoints were selected to be conservative with respect to the critical volumes (defined by the ROD compliance criteria). Smaller DCS related volumes are more conservative in that decisions are made on incrementally smaller volumes. The result is that smaller volumes of soil exhibiting elevated concentrations of radioactivity were identified as “above criteria” and segregated for off-site disposal.

Table IV. Diversion Control Setpoints

DCS	Mass (kg)	Mass (tons)	$DCGL_W$ (SOR)	Ra-226 (Gross)
1	63,503	70	1	6.1 pCi/g
2	6,350	7	2	12.2 pCi/g
3	635	0.7	3	18.3 pCi/g

Exposure risk (dose) in a given scenario is dependent upon both the concentration and volume (mass). DCS #1 was designed explicitly to demonstrate compliance with the ROD criteria. While it has the lowest concentration component, it also has the largest volume (mass) component. DCS #2 and #3 were used as “best management practice” criteria designed to sort out even smaller volumes of materials that might occur at higher concentrations. These locally elevated volumes of soil which might arguably and justifiably be left on-site (because they would not reduce the average in the larger compliance volume to greater than) were sorted and disposed as radioactive waste. This reduced the likelihood that locally elevated anomalies remained in the soil returned to the site as place-back fill. Only one DCS is required to demonstrate compliance with the ROD; however, use of the three DCSs served to remove locally elevated radioactivity from the site even if it could be averaged away. It is analogous to a $DCGL_W$ and $DCGL_{EMC}$.

The results of the DCS settings, specifically the average activity concentration of the diverted stock piles, was continually evaluated through a rigorous QC program. The soil processed through the soil segregation system as < DCS (< ROD criteria) was stockpiled and after QC sampling confirmed the characterization of the soil as meeting the ROD acceptance criteria, was placed back on-site. Specifically, the average activity concentration of every Class 1 SU mass of soil (based on DCGL model contaminated zone), segregated by the system met the DCGL/SOR < 1 criteria in accordance with the survey and sample requirements of the FSSP.

This was verified by both a review of the 100% coverage scanning gamma spectroscopy of the entire volume of soil processed by the soil segregation system and the sample and analysis of 17 random-start, equally representative samples from every 4,399,846 kg (4,850 tons) (representing 1 Class 1 survey unit volume per the ROD). A grab sample was taken from the output conveyor belt at a sample frequency equal to 1 per every 254,012 (280 tons) passing through. For example if the system was processing soil at 90,718 kg (100 tons) per hour, a sample was taken every 2.8 hours the system was in operation until a stockpile of 4,399,846 kg (4,850 tons) has passed through the system as < DCS, resulting in the minimum 17 samples per SU. The random start requirement was met by the inherent randomness of stockpiling soil prior to processing through the system.

Each of the 17 samples was analyzed by laboratory-based gamma spectroscopy analysis. The sum of ratios (SOR) calculation was performed to predict and confirm, based on the surrogate value of 6.1 pCi/g for Ra-226, if the stockpile of soil meet the ROD criteria as defined in the expanded SOR below:

$$SOR_{DCGLw} = \frac{Ra-226}{6.1} \qquad \text{(Eq. 1)}$$

The samples were all forwarded to an appropriately certified off-site lab for analysis by alpha spectroscopy for isotopic uranium, Th-232 and Th-230, and for Ra-226 analysis by gamma spectroscopy after progeny ingrowth (Pb-214 or Bi-214) within a sealed counting container. The results were used to complete the following SOR calculation:

$$SOR_{DCGLw} = \frac{Ra-226}{9} + \frac{Th-230}{25} + \frac{Th-232}{6} + \frac{U-total}{482} \qquad \text{(Eq. 2)}$$

All of the activity concentrations were net values using the background values established for the project to calculate the net activity. A Sign test was performed using the error control DQO confidence intervals selected for the Painesville site: $\alpha = 0.025$ (2.5%) for Type I errors and $\beta = 0.05$ (5%) for Type II errors.

An Orion *ScanSort*^{SM} system output report for the 4,399,846 kg (4,850 tons) was compared to the results of the 17 sample analytical results. The QC check confirmed the results of the Orion *ScanSort*^{SM} system report and the sample and analysis results both concluded the volume of soil meets the ROD acceptance criteria, i.e., the average SOR is < 1.

RESULTS

Soil Segregation Output

In 2010 and 2011, a total of 43,499,508 kg (47,950 tons) of suspect contaminated soils and debris was excavated as part of the Painesville Site remediation effort. Of that total, 42,575,994 kg (46,932 tons) of soil and soil-like material were able to be processed through the Orion *ScanSort*^{SM} automatic soil segregation system, while 923,514 kg (1,018 tons) were not processed, consisting primarily of oversize debris and materials that could not pass through the system, along with a small amount of material that was excavated after the system was demobilized. The *ScanSort*^{SM} system segregated 41,816,680 kg (46,095 tons) of material to the "below criteria" stockpile for reuse at the site to fill the excavations, and 759,314 kg (837 tons) of material to the above-criteria stockpile for eventual shipment for offsite disposal. Of the quantity of soil processed through the automatic soil segregation system, only 2% required offsite disposal; and of the total quantity of soil excavated, only 4% required offsite disposal, a significant reduction in the amount of soil transported and disposed of from the site.

During operations, the Orion *ScanSort*^{SM} system took more than 659,000 measurements of the processed soils, assaying 91 individual batches. The average gross Ra-226 concentration measured by the system for the "below criteria" place back soils over those 91 batches was 3 pCi/g, well below both the $DCGL_w$ for Ra-226 of 9 pCi/g net above background and the first DCS for Ra-226 of 6.1 pCi/g gross.

As described above, in addition to reviewing the data from the Orion *ScanSort*SM measurements, a minimum of 17 QC samples were collected randomly from every 4,399,846 kg (4,850 tons) of “below criteria” soil segregated by the system, and analyzed at an off-site laboratory for the FUSRAP COCs. The average result of the collected QC samples for each of the COCs is shown below in Table V, compared to the site background and $DCGL_w$ concentrations.

Table V. Average Sample Results for “Below Criteria” Segregated Soils

COC	Background Level (pCi/g)	DCGLw - Net Above Background (pCi/g)	Average QC Sample Result - Gross (pCi/g)
Ra-226	1.42	9	2.12
Th-230	2.56	25	1.30
Th-232	1.53	6	0.97
Total U	5.97	482	3.13

The average QC sample results were well below the $DCGL_w$ for each of the respective COCs and on the order of background levels at the site. These results when combined with the 100% assay by the automatic soil segregation system demonstrate that the soils segregated to the “below criteria” stockpiles did indeed meet the cleanup criteria specified in the ROD and were appropriate to reuse as fill in the completed excavations.

Cost Savings

Cost savings were realized through use of the automatic soil segregation technology in two primary areas; transportation and disposal costs and clean backfill procurement costs.

The total cost to design, mobilize, calibrate, operate and demobilize the Orion *ScanSort*SM system for the Painesville Site was approximately $2.15 Million. Dividing that cost by the total amount of soil and soil-like material processed at the site yields a cost per ton processed for the Painesville Site of approximately $46. The cost per ton to transport and dispose of material from the site was $170, yielding a cost per ton savings of $124 for use of the soil segregator versus transportation and disposal for the Painesville Site remediation.

The actual total cost of the remediation contract for this Painesville Site remediation effort was approximately $17.0 Million. An estimate was made of what the total remediation contract cost would have been if all of the excavated soil had required transportation and offsite disposal, by subtracting the cost to design, set up and operate the soil segregation system from the actual total contract cost, and then adding back in the cost to transport and dispose of all of the “below criteria” segregated soil, and the cost to procure clean backfill to make up for the loss of the reusable "below criteria" segregated soil for place back in the excavations. This projected estimate of remediation contract cost without soil segregation was approximately $23.2 Million, which when compared to the actual cost yields a total cost savings of approximately $6.2 Million from use of the automatic soil segregator on this Painesville Site remediation effort.

Challenges and Future Considerations

As described above, a key factor in segregator efficiency is maintaining a uniform thickness of material on the survey conveyor, which requires the material being processed to be sufficiently flowable and less than 10 cm (4 inches) in size. During the 2010 – 2011 Painesville Site remediation effort, the site experienced heavy snowfall in the winter months, and record rainfall in the spring of 2011, which saturated the clay soils at the site, causing them to stick and clump together to an unanticipated level so that they were clogging the soil segregation equipment. This was addressed with through the application of various drying techniques to the pre-segregation soil stockpiles, and bringing on site a more powerful soil screening machine or scalper to break up the soil clumps; which while both successful were also time-consuming and slowed production. In addition, a larger volume of concrete debris was excavated than originally anticipated, which could not be processed in its excavated state. This was successfully addressed by bringing a concrete crusher on site partway through the project, which was able to reduce the concrete to a size that could be processed through the automatic soil segregator while removing the rebar that couldn't be processed from the concrete. Thus the majority of the processed concrete could be reused as fill rather than having to be disposed of. Conducting geotechnical analyses of site soils and developing a better estimate of excavated concrete and other debris in the planning stages prior to implementation of the soil segregator on site would help alleviate these issues in the future.

Another key to utilizing the automatic soil segregation technology in the most efficient manner during site remediation is in the optimization of the excavation, segregation and backfilling procedures. On the excavation side, the typical methodology for USACE FUSRAP remediations was to attempt to precisely excavate only those soils exceeding the cleanup criteria. However, the time and effort required to develop gamma scan thresholds and then guide the excavation with field scan measurements and in-process sampling results in a slower excavation process. At the Painesville Site, USACE continued to employ precise excavation methodology during the 2010 - 2011 remediation effort to minimize the soil excavated, due to USACE unfamiliarity with the ability of the Orion *ScanSort*^{SM} system to accurately measure and segregate all of the excavated site soils. The slower guided excavation rate resulted in excavations remaining open longer before final status surveys could be conducted, which subsequently led to other issues such as having to manage large quantities of water that collected in the excavations while they were open longer. For future cleanups, by relying on the ability of the automatic soil segregation technology to assay 100% of the excavated soil and determine which material exceeds the cleanup criteria, excavation of a pre-determined, more conservative soil footprint could be conducted in an uninterrupted manner, allowing quicker completion of excavation and initiation of final status surveys to close out the excavations. This would also allow quicker generation of a larger pre-segregation stockpile, another factor in ensuring efficient use of the soil segregator, as the segregator can process soil at a higher rate than it can be excavated.

On the backfilling end, it is generally desirable to backfill excavations in as timely a manner as possible after final status surveys have demonstrated that the cleanup criteria have been met in the excavations, again to avoid having to manage potentially large quantities of water collecting in open excavations. At the Painesville Site, for the majority of the project USACE did not give acceptance to reuse of "below criteria" stockpiles for place back in the excavations until the results of the QC samples analyzed in the off-site laboratory had been received, again due primarily to USACE unfamiliarity with this new technology and a desire to see definitive analysis results confirm the measurements from the *ScanSort*^{SM} system showing the cleanup criteria had been met. This would typically take 28 days or longer, due to the laboratory analysis method utilized for Ra-226. In the future, the time to approve segregated soil for reuse could be shortened through relying solely on the segregator system measurements to show criteria had been met, or through use of an on-site alpha spectroscopy laboratory for quick turnaround of confirmatory sample data.

CONCLUSION

Automatic soil segregation technology was successfully implemented as part of the 2010 - 2011 remediation effort at the Painesville FUSRAP Site. The Orion *ScanSort*^{SM} system employed at the site demonstrated the ability to accurately determine the radioactivity concentrations in the processed soil and soil-like material and quickly segregate that material for appropriate final disposition. Data from the soil segregation system and confirmatory QC samples indicated that the segregated "below criteria" soils met the cleanup criteria in the ROD, and was appropriate for reuse as fill in the excavations. The reduction of the total excavated soil volume requiring off-site disposal by 94% yielded significant project cost savings through reduction of transportation and disposal and backfill procurement costs. Use of automatic soil segregation technology was an efficient and cost-effective method for addressing the radiological contamination at the Painesville Site.

REFERENCES

1. U.S. Army Corps of Engineers, *Record of Decision, Painesville Site, Painesville, Ohio,* April 7, 2006.
2. U.S. Army Corps of Engineers, *Soil Segregator Operation Plan, Painesville FUSRAP Site Remediation, Painesville, Ohio,* March 2010.