Improving Data Collection Efficiency During Site Inspection Through Innovative Data Collection and Focused Sampling – 11418

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ABSTRACT

U.S. Army Corps of Engineers and Cabrera Services, Inc. conducted a Site Investigation at the Middlesex Municipal Landfill located within the Borough of Middlesex, New Jersey. Landfill investigations are full of challenges and this effort was no exception. The scope of this SI was limited to the collection of a relatively small number of samples from areas of elevated activities within a limited timeframe as compared to those for a remedial investigation. Therefore, it was very important to accurately identify areas of elevated activities along with the types and nature of contamination that may potentially be present at the Site. To accomplish this objective the project team conducted gamma surveys using various methods to allow for the focused sampling that would provide sufficient information to determine areas of further remedial investigation activities or other actions. During this project, the project team employed an innovative site investigation strategy through which the team was able to identify areas of interest and determine the types and nature of the contaminants at those locations within a limited time period. The results of the investigation also identified areas that require no additional investigation.

INTRODUCTION

The U.S. Army Corps of Engineers (USACE) and Cabrera Services, Inc. (CABRERA) conducted a Site Investigation (SI) at the Middlesex Municipal Landfill (MML) (hereafter referred to as the Site or MML) under the Formerly Utilized Site Remedial Action Program (FUSRAP). The MML is a 15-hectares former landfill located within the Borough of Middlesex, NJ (Figure 1). The project team employed innovative methodologies and technologies during the data collection process of the SI to overcome the challenges of investigating a landfill.

These challenges included:

- Schedule and funding constraints combined with a relatively large area (15 hectares) both wooded and open to investigate.
- Surface and subsurface sampling (to a depth of 3.6 meters), groundwater, and a combination of diffuse (lenses) and discrete (nuggets) contamination, to investigate,
- A predetermined number of samples to be collected,
- Methane gas during soil boring advancement,
- Weather,
- Varied subsurface conditions including overburden thickness, landfill thickness and contents and native materials,
- Part of former landfill is proximate to a church and daycare center,

- Data needs were greater than that of a typical SI.

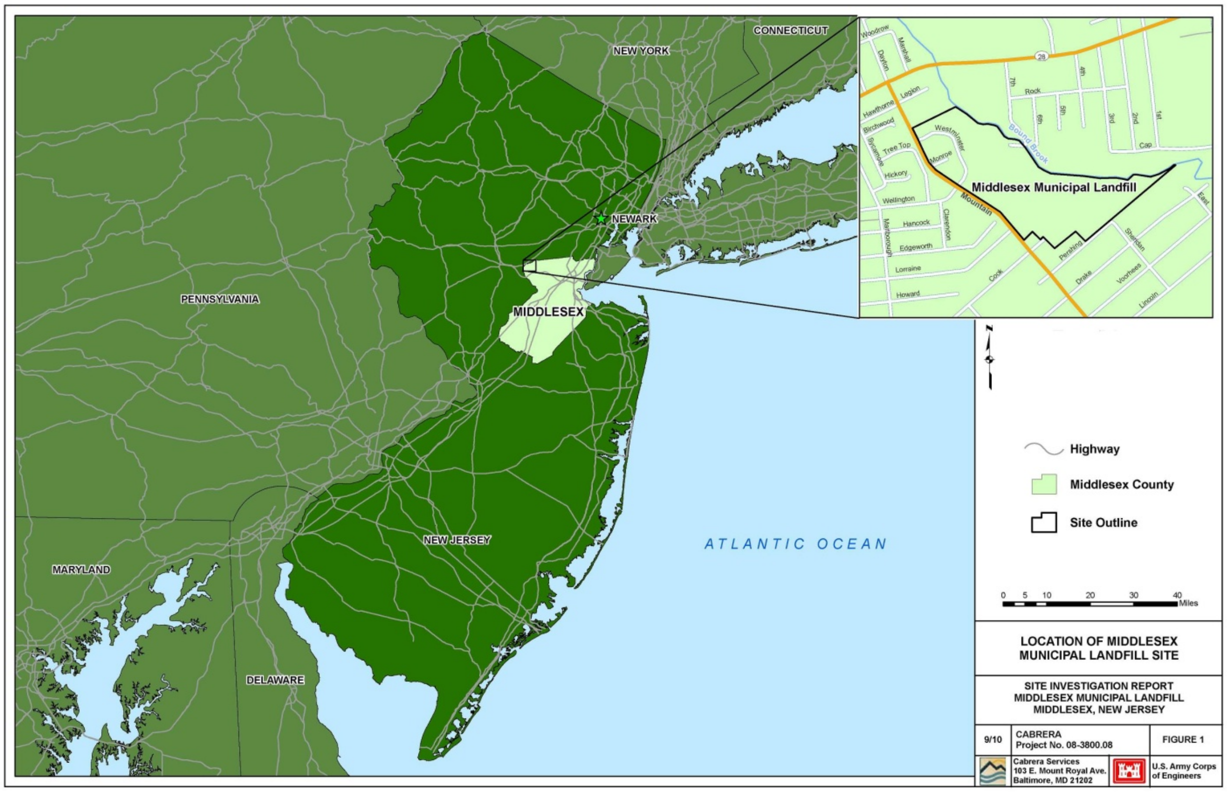

Figure 1: Location of Middlesex Municipal Landfill Site

This SI was conducted under a Firm Fixed Price (FFP) contract and while a Cost Reimbursable Contract may have been better suited given the uncertainties of the field work, the team was able to successfully utilize the FFP mechanism. The FFP presented obstacles that required the project team to overcome beginning with scope development and continuing through execution. This meant that the scope had to be fully defined including the number of samples, analytical suites, field methods and technical approaches. During scope development, the team used a conservative approach to the quantity of samples and dealt with uncertainties using priced options to the maximum extent possible. This included optional tasks for collecting additional soil and groundwater samples. However, given these obstacles, the iterative process used by the team allowed for modifying sample locations and technical approaches as additional data was obtained and processed. This also meant that the team had to make decisions based on the field data and in the end, strengthened the quality and usefulness of the data obtained. Weather was an additional obstacle that had to be overcome as the field investigation was conducted during the winter months of December through early March. The field team had to contend with two significant snowfalls which slowed progress and hampered some sample collection.

One of the primary objectives of this SI was to conduct a gamma survey of the accessible portions of the 15-hectares site. To accomplish this objective the project team employed three survey methods including CABRERA'S Large Area Survey System (CLASS) and two methods of walk-over surveys; with and without Global Positioning System (GPS). Each of these methods is discussed in more detail below. Given the large survey area, the CLASS was able to cover the majority of the site approximately 50% faster than the more traditional methods. Initially, as gamma survey data was collected, surface soil and test pit locations were determined based on the survey data and information from previous investigations. As more data was obtained and available to the team, adjustments were made that assisted in the determination as to the horizontal and vertical extent of contamination especially given the limited number of samples available. These adjustments allowed for samples to be collected in a manner to provide a more accurate characterization of the Site.

The information obtained during the SI was required to be of sufficient quality and quantity to facilitate USACE decisions regarding future work at the Site and to delineate areas within MML that require further remedial investigation (RI) and/or areas within the MML for which no further action is required. The objective of this paper is to present the methodologies and technologies employed during the SI, to provide data of sufficient quality and overcome project challenges.

BACKGROUND

The MML is located approximately 26 kilometers southwest of Newark, New Jersey (Figure 1) and consists of parcels belonging to the Borough of Middlesex and the Middlesex Presbyterian Church. The Site occupies approximately 15 hectares and is bounded on the south by Mountain Avenue, on the southeast by Pershing Avenue, and on the west by the Municipal Building and Recycling Center. Bound Brook provides the northern boundary of the former landfill. The Borough is considering future use of the former MML as a community recreational area.

Between 1943 and 1955, the Middlesex Sampling Plant (MSP) in the Borough of Middlesex, NJ assayed uranium and thorium ores for the Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC). Between 1947 and 1948 the pitchblende storage area at MSP was paved. The excess soil, containing small quantities of uranium ore from the grading operation, was transported to the MML and dispersed as cover material for sanitary landfill operations over approximately three to five acres of the landfill.

In 1961, the AEC removed the portion of the contaminated materials laying nearest the surface — approximately 497 cubic meters and backfilled the excavation with approximately 0.6 meters of clean fill. In 1984 and 1986, characterization, remedial action, and a final survey were conducted for a portion of the landfill under the FUSRAP. These remediation activities addressed about five acres at the north end of the Site where soil was disposed from the MSP. The Site was then released to the Borough of Middlesex for unrestricted use. In 2001 and 2002, a radiological survey of the entire landfill was conducted that identified elevated radiation levels along the south boundary of the landfill. During 2002 and 2003, the Borough of Middlesex conducted a RI that identified metals, pesticides, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) in soil exceeding the New Jersey Department of Environmental Protection (NJDEP) direct contact soil screening levels. This investigation also determined that site soil and groundwater had not been impacted by radiological contaminants. In 2008, a DOE-funded radiological survey of the Site identified small areas of low-level surface radiation. These findings led to the Site being declared eligible for the FUSRAP in March 2009.

The Site surface is generally flat; however, depressions measuring up to 46 meters across have developed from differential settlement of the buried municipal waste. Along the Site's northern boundary the elevation decreases towards Bound Brook where the flat flood plain is dominated by a mature forested wetland. The flood plain contains several depressions that are intermittently flooded and range in size from 91 to 274 meters in length. Work was conducted in winter months, as noted above, thus the weather caused some schedule delays and did impact some aspects of the investigation (snow and water accumulation in depressions).

Mature trees and other ground cover remain along the south and east perimeter fence. Individual trees and large bushes are also disbursed throughout the central and southern portions of the property. The site was cleared with the exception of larger bushes and mature trees by use of a brush hog.

To the west are the Middlesex Presbyterian Church and the Borough of Middlesex facilities. The church manages a day care center on the property. The day care facility was of obvious community concern. The public concern for the daycare center resulted in accelerating the project schedule. To minimize project and facility disruptions the investigations around the day care was scheduled for hours when the facility was closed or less active.

The Borough plans to install a methane mitigation system at the landfill. Identification of areas impacted by radiological contamination was necessary for the Borough to take into account during the system design or potentially for USACE to perform a removal action to facilitate the methane mitigation work. The radon mitigation work also resulted in an accelerated project schedule. USACE decided to conduct the SI during development of the Preliminary Assessment Report to help accelerate the schedule.

The methane problem at the landfill also created a safety issue for the investigation team. Lower explosive limit monitoring was conducted and several methods were used to protect workers during the investigation.

RADIONUCLIDES OF POTENTIAL CONCERN

Previous environmental investigations confirmed that the Site contained soil with the following radionuclides of potential concern (ROPCs): radium -226 (Ra-226), thorium-232 (Th-232), and natural uranium (Unat consisting of uranium (U)-234, U-235, and U-238 in natural ratios).

SITE INVESTIGATION METHODOLOGIES AND RESULTS

Site conditions and concerns required multiple sampling strategies to accomplish the project objectives. Portions of the Site had been covered, portions had been remediated, and some areas appeared to be relatively free of cover materials. Additionally differing potential contaminant distribution and media required a multiple sampling methodologies strategy.

Previous radiological investigation by the Borough and DOE identified elevated gamma readings in the surface as well as localized elevated surface and subsurface contamination. Additionally, DOE had previously remediated the subsurface of a small portion of the landfill. Accordingly, the SI required surface and subsurface investigation.

DOE documents identify that small chunks or nuggets or uranium ore were found across remediated portions of the site. The nuggets on the surface were removed by DOE. This documentation resulted in a concern for such nuggets to still be present in the subsurface.

Since a landfill with a long history spanning the use of Ra-226 and the history of radium facilities in NJ, it is also necessary to collect data of sufficient quality to evaluate potential sources for the contamination. Specifically isotope identification and ratios of activities are required. Thus the scans were evaluated isotopically.

As a part of the SI, surface gamma scan surveys were conducted over an area of approximately 14 hectares. Of the 15 hectares roughly two acres were inaccessible due to structures or pools of standing water.

The information obtained from previous site investigations set some surface sampling locations. The results of the gamma surveys were then utilized to locate the remainder of a total of 50 surface soil samples and to locate 14 test pits from which nine samples were collected. Test pit scanning, surface gamma scanning, and previous data were used to locate the 50 soil borings advanced during the field work. Core frisking and down-hole logging directed the collection of 103 subsurface soil samples and a single groundwater sample. This combination of sampling strategies and using an iterative approach to locating sample locations facilitated data collection to overcome the project challenges and meet its objectives.

The following sections summarize the sampling strategies as well as the results during each of the investigation steps.

Gamma Scan Surveys

Open areas of the site required mowing and clearing to facilitate scanning. It was not possible given schedule and funding limitations to clear mature trees. This and the few buildings on site impacted scanning approach considerations. Surface gamma surveys were performed over 100% of the accessible ground surfaces within the MML site boundary using three different scanning methods. The Site included areas with developed land including parking lots and roadways, open grass land and wooded area with mature growth. Gamma drive-over scans, utilizing CLASS mounted on an all-terrain vehicle (ATV) with GPS, were conducted over all areas accessible to wheeled vehicles. The second method utilized, traditional gamma walkover surveys (GWS), were performed in areas where tree cover, terrain, or obstacles prevented access by the ATV-mounted CLASS system. Finally, the manual GWS was performed in areas where tree cover prevented access to the ATV- mounted CLASS and where a GPS signal could not be established in order to perform a traditional GPS-correlated GWS.

The CLASS survey was used to rapidly measure, spatially correlate, and map gamma radioactivity concentrations. The CLASS consists of a Radiation Solutions Incorporated (RSI) RS-701 integrated controller and data acquisition system, a digital gamma ray spectrometer/multi-channel analyzer (MCA), a data controller, two RSX-256 4-liter sodium-iodide (thallium activated) (NaI(Tl)) gamma scintillation detectors, an integrated low-resolution GPS, and input for connection to an external high resolution Trimble Pro XH GPS receiver. Radiation and location information was collected by the system at a very high data transfer rate (nominally one data point every second) and stored in an onboard data file for real-time operator feedback as well as data validation post-processing. The drive-over survey was advanced at a speed of one meter/second or slower to ensure that adequate data collection and survey coverage requirements were met. Approximately 7 hectares were surveyed over a period of 15 business days or one acre per day using the CLASS method.

A Ludlum Model 2221 scaler/ratemeter and 7.62x7.62 centimeter NaI detector were utilized during traditional GWS to scan the soil surface for elevated gamma emissions. Surveys were performed by walking straight, parallel lines at a rate of approximately 0.5 meters per second while moving the 7.62x7.62 centimeter NaI detector in a serpentine motion of approximately one meter wide and a consistent distance (two to four inches) above the ground surface.

Approximately 7 hectares were surveyed over a period of 15 business days using the traditional GWS methods with two to three-person teams.

During manual GWS within the wooded area, gross external gamma measurements were hand recorded using the 7.62x7.62 centimeter NaI detector on survey forms/maps to correlate the survey measurements with their approximate horizontal locations. Transects were marked in the field to divide the wooded area into approximately one-acre plots. These transects allowed lines of sight to aide in keeping parallel lines during the manual GWS, ensure complete coverage, and provide increased accuracy of data measurement locations. A field screening value of 20,000 counts per minute (cpm) or greater was developed based on background levels for Ra-226, Th-232 and U-238 as determined by investigations conducted at the MSP, previous MML site investigations, and the definition of Uncontaminated Surface Soils in the New Jersey Administrative Code (NJAC) 7:28-12,: "Uncontaminated surface soil" means soil whose average natural background radionuclide total concentrations are less than the remediation standards for radionuclides, and cannot exceed the background established for the site by more than two standard deviations." Locations identified during the manual survey as having gross gamma emissions greater than the established screening value were pin-flagged in the field. One-minute static measurements were taken at these locations and recorded at each location. GPS coordinates were also recorded utilizing cell phone signals, in lieu of a Trimble GPS receiver, due to the heavy tree canopy blocking the line of sight satellite signals.

The survey results and positional data collected using the CLASS system and the traditional GWS were downloaded in the field and transferred to CABRERA'S office in Baltimore, Maryland via the internet on a nearly daily basis. Positional data was used to track progress of the coverage area and to determine gaps in the survey. All three gamma scan surveys measured gross external gamma measurements at each location. The results of gross external gamma radiation measurements were reviewed to discover any identifiable spatial patterns or trends that might indicate elevated activity and their corresponding locations. The GWS conducted during the first two methods identified three areas exhibiting elevated gamma readings. These include – (1) along the southeast boundary of the Site; (2) an area within the southeast portion of the Site and north-northeast of area 1; and (3) an area encompassing the perimeter of the former DOE excavation. The manual GWS, conducted within the wooded area identified three areas of elevated activities, including one northeast of the former DOE excavation; one east of the former excavation (central part of the wooded area); and one near the northeast corner of the Site.

In addition to gross external gamma radiation measurement, the CLASS system also measured the radionuclide-specific external gamma radiation. The CLASS is equipped with a multichannel analyzer, which allows for collection and analysis of nuclide-specific scan data using defined regions of interest (ROI) that correspond to specific gamma ray energies for each ROPC. The uranium progeny, including radium, that emit gamma radiation can be identified in many cases by their characteristic spectrum, if the gamma intensity is sufficiently high. U-238 itself emits a single very low-energy, low-intensity gamma photon when it decays; thus it cannot be measured directly by field gamma spectrometry. Most gamma detectors measure the radiation from nuclides that are far down the decay chain; thus uranium activity can only be inferred by assuming the sample or sample site is in secular isotopic equilibrium. To identify and track specific gamma radiation emissions from the site ROPCs, the CLASS digital interface was pre-set to ROIs within the energy spectrum. The RSI-700 controller comes pre-installed with International Atomic Energy Agency (IAEA) standard energy windows for thorium (based on

2614 keV photon from its Thallium-208 daughter). An ROI were also established for Ra-226 (Radium-226 186 keV photon). As the Site is heavily contaminated with Ra-226, the natural correlation of Bi-214 to U-238 did not exist but Ra-226 and U-238 were collocated. Setting ROPC-specific ROIs during field scanning is advantageous as it reduces the detector background as well as the scan detection limits. In addition, the large area system utilizes internal energy-gain stabilization to ensure that the ROIs remain centered on the corresponding energy peaks.

Following collection of radionuclide-specific gamma radiation measurements, areas of elevated activities were identified for each ROPC and plotted on site figures as requiring additional characterization and/or remediation. Figures 2 and 3 present the areas of elevated activities for thorium and radium, respectively. A number of isolated elevated areas for thorium were identified adjacent to the wooded areas and around the former DOE excavation. For Ra-226, the ROI figure confirmed that the elevated radium count rates were concentrated along the southeast perimeter. The radium plot also generally agrees with the uranium plot; they share the same decay progeny for unprocessed or unrefined sources of uranium, where the entire decay chain (which includes Ra-226) may be in equilibrium. The ROI figure developed by the project team was later utilized to locate biased locations for surface soil samples, test pits and soil borings.

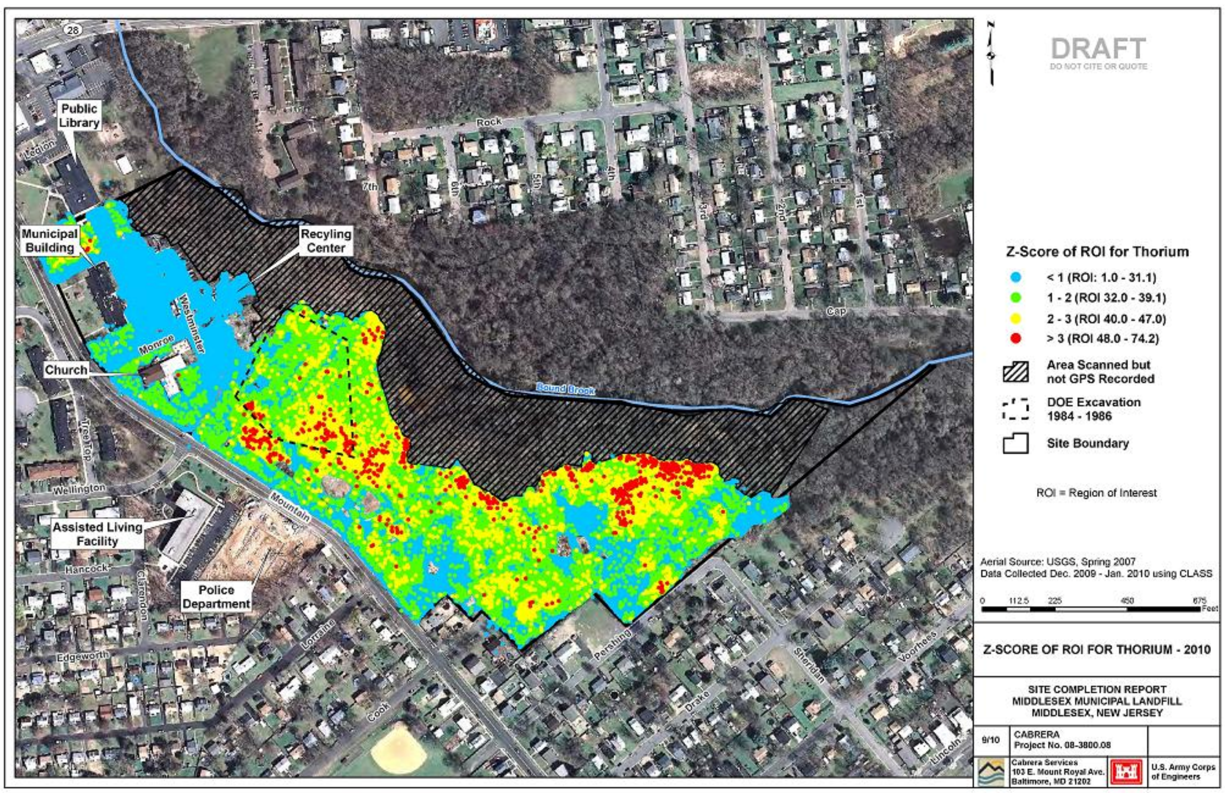

Figure 2: Areas of Elevated Activities for Thorium

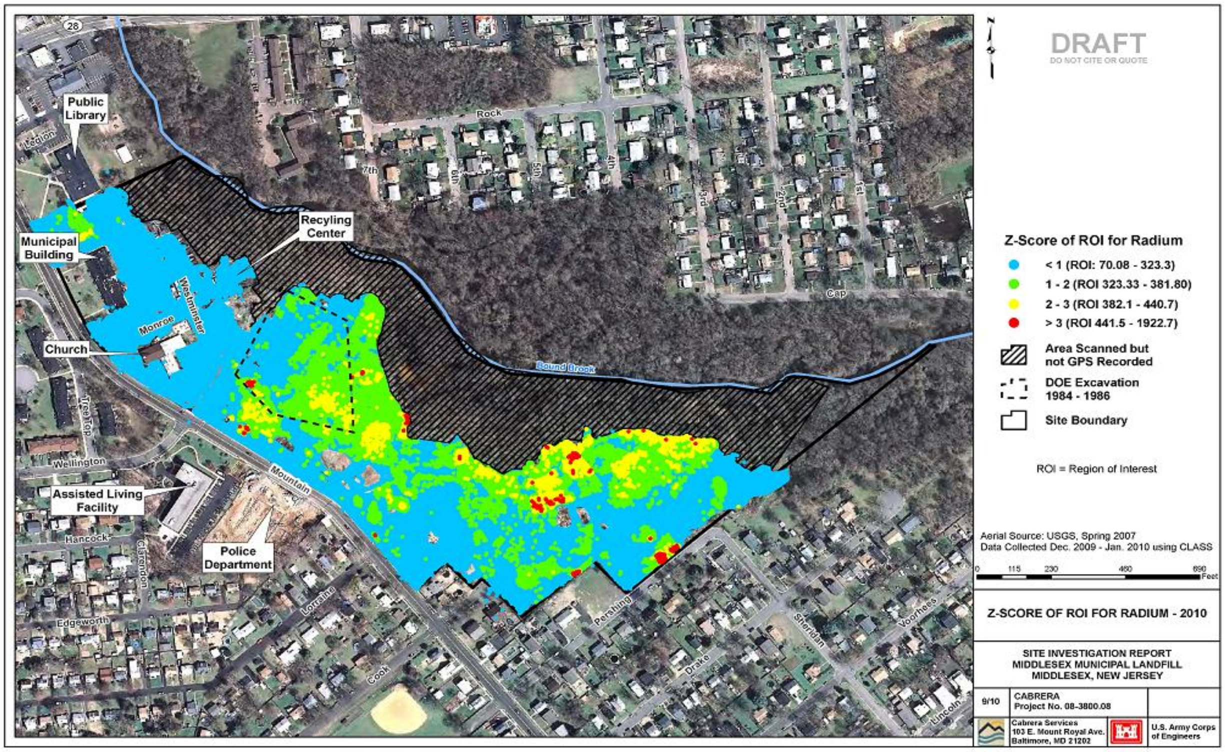

Figure 3: Areas of Elevated Activities for Radium

Sampling of Surface Soils

Initially, a portion of the total planned surface soil sample locations was chosen based on site history and the results from previous investigations. The sampling locations for the remaining surface soil samples were determined using an iterative process. As gamma survey activities progressed, results were provided to the project team on an almost daily basis to show project progress as well as to evaluate suitable biased sample locations. As field survey data was collected and interpreted, these observations were then used in plotting additional biased sample locations. Some of the surface samples were collected from low gamma reading areas to aid in future decisions regarding those areas of the site. A total of 51 systematic and biased surface soil samples were collected from a depth of zero to six inches below ground surface, based on the results of the previous site investigation, gross gamma radiation and gamma radiation emitted by individual ROPC collected during GWS.

Sampling results for 14 samples along the southeast perimeter indicate several locations with Ra-226 concentrations above the investigative screening value (ISV) for Ra-226. A total of 17 surface soil samples were collected from the wooded area at biased locations based on the manual scan surveys. Of those samples, 14 had concentrations exceeding the Ra-226 ISV. Twelve surface soil samples were collected from the perimeter of the former DOE excavation, based on the ROI for radium and each exceeded the ISV for radium. Comparison of the surface soil laboratory results to the GWS suggests a strong correlation between the two. Two locations within the limits of the former DOE excavation exceeded the ISV for Th-232. These locations were chosen based on the ROI results from the CLASS survey. For U-238, the reported sampling results at 17 locations exceeded its corresponding ISV. These exceedances were collocated with elevated Ra-226 concentrations.

Excavation and Sampling of Test Pits

Test pits were utilized as a means of screening for the presence of high-activity ore “nuggets” that may have been buried as part of a waste stream from the former MSP FUSRAP site. The project team worked together to determine the locations of all 14 test pits based on the gamma survey data in conjunction with the site historical data. A threshold of greater than 20,000 cpm was used as a screening value based on the CLASS survey during the selection of test pit locations. Seven test pits were excavated within and surrounding the limits of the former DOE excavation area. Three test pits were excavated at the southeast portion of the Site. One test pit was excavated within the main body of the landfill, and one excavated within the wooded area. Each of those test pits were excavated to a depth of 2.4 meters below ground surface over a length up to 2.4 meters. Based on the scanning of excavated soil and visual observations, the project team decided to collect a total nine soil samples from four of the test pits. In addition to the gamma survey data identifying test pit locations this same data in conjunction with the field observations led to the locating of soil borings as discussed below. Methane concentrations impacted the excavation of test pits. The first methane protection method employed was to evacuate the area when the lower explosive limit (LEL) reading exceeded 10% and allow the methane to dissipate with time. This method worked well for test pits.

Soil Borings and Sampling of Subsurface Soil

Soil borings were used to characterize potential subsurface contaminant distribution as well as a means of determining if any “nuggets” of uranium ore existed in the subsurface. Similar to the test pits, soil boring locations were based on the interpretation of the gamma surveys and the ROI maps by the project team. An initial set of systematic borings were advanced based on the gamma survey results. As additional data was obtained and interpreted, subsequent soil borings were located to ‘bound’ those points of elevated activity identified from the test pits and surface soil locations. Several borings were advanced within the limits of the former DOE excavation with soil samples exceeding the ISV for radium. Based on the CLASS survey and the core scans, additional soil borings were advanced in this area. One of these locations, advanced along the eastern edge of the former DOE excavation, encountered a small rock believed to be a “nugget” of uranium ore.

A track-mounted GeoProbe 7720 in a direct-push, macro-core sampling configuration was utilized to collect incremental core subsurface soil samples in four-foot sections to a maximum depth of 3.6 meters below ground surface or refusal. A Ludlum™ Model 44-20 7.62x7.62 centimeter NaI detector was used to screen each core for gross gamma radiation and identify areas of elevated count rates. Core samples were direct frisked. Down-ole gamma logging was conducted at each of the 50 soil borings advanced during this investigation. Gross gamma down-hole measurements were performed in six-inch increments starting from the bottom of each hole and proceeding toward the ground surface. A Bicron Model G-1 ½”x1” environmentally-sealed NaI detector was suspended from a nylon cord with depth markings in order to ensure that accurate depth interval measurements were recorded. Count rates were recorded using a coupled Ludlum Model 2221 scaler/ratemeter. The gamma logging was conducted to aid in sample point identification as well as expand the sampling aspects of the boring. Specifically, while a “nugget” may not be collected in the core sample, it may be possible to detect its presence adjacent to the borehole through gamma logging. Alternately, small increases in contaminant concentrations may be detected in a borehole, due to geometry effects, that are not detectable by scanning the cores alone.

The frisking of the core samples in conjunction with the elevated reading of the scans and down-hole gamma surveys were then used to determine which soil core interval to sample. To characterize potential subsurface contaminant distribution, 103 subsurface soil samples were collected during this SI. Soil sample analysis for determining ROPCs relied on gamma spectroscopy. Alpha spectroscopy analysis was used to determine the isotopic concentrations of all three uranium isotopes present in natural uranium.

Additionally, boring logs were produce to document subsurface conditions. Areas of the landfill were known to have been covered with a soil/clay cover. The generation of boring logs allowed the team to identify areas of cover, fill, municipal wastes, and native materials. This information will aid future site investigations and decisions. The subsurface soil sampling results indicated that Ra-226 was the more prominent isotope with largest number of sampling results exceeding its corresponding ISV while thorium was not detected above its ISV. Uranium concentrations in excess of their ISV were detected at the north, northeast and central portions of the former DOE excavation. Additionally, a single location in the wooded area and at the southeast corner of the Site also exceeded the ISV for uranium. Each of these exceedances was co-located with the exceedance for Ra-226.

Methane concentrations impacted soil boring advancement. The first methane protection method employed was to evacuate the area when the LEL reading exceeded 10% and allow the methane to dissipate with time. This method worked well but resulted in lengthy delays. An alternative approach for methane control in the borings was developed. Initially dry ice and water was introduced into borings to reduce methane build up; however, this caused some issues with core recoveries due to the dry ice freezing the soil at the base of the bore hole. Later nitrogen gas was pumped into borings which effectively controlled the explosion hazard and allowed sampling to continue.

Sampling of Groundwater

Following consultation with USACE technical personnel and based on the ROI data for uranium, a single groundwater sample was collected from a soil boring within the central portion of the Site. This boring was positioned within an area with a uranium Z-score of between two and three. The sample was analyzed to determine gross alpha, gross beta, Ra-226, Ra-228 drinking water constituents. Alpha spectroscopy analysis was used to determine the isotopic concentrations of all three uranium isotopes present in natural uranium. The results were compared to the NJDEP Maximum Contaminant Limits (MCLs). Gross alpha, Ra-226, and Ra-228 were not detected above the method detection limit. The sample had a gross beta concentration of 8.7 (picoCuries per liter (pCi/L) whereas, U-234, U-235 and U-238 were not detected.

AREAS OF INTEREST (AOIs)

The results of the gamma walkover survey and soil sampling results were then utilized to select five areas of interest (AOIs). Four AOIs where additional investigations may be warranted in order to delineate the known radiological contamination at the Site and one AOI where additional data is needed to release the area. Figure 4 presents the locations of the five AOIs for the Site. The AOIs identified included:

- AOI 1 - The southeast portion of the Site along Pershing Avenue up to the wooded area
- AOI 2 - The wooded portion of the Site between the landfill and Bound Brook

- AOI 3 - The area within and surrounding the former DOE excavation
- AOI 4 – The area within the central portion of the landfill between AOIs 1 and 2
- AOI 5 – The northwest portion of the site adjacent to AOI 3 occupied by the church and municipal building

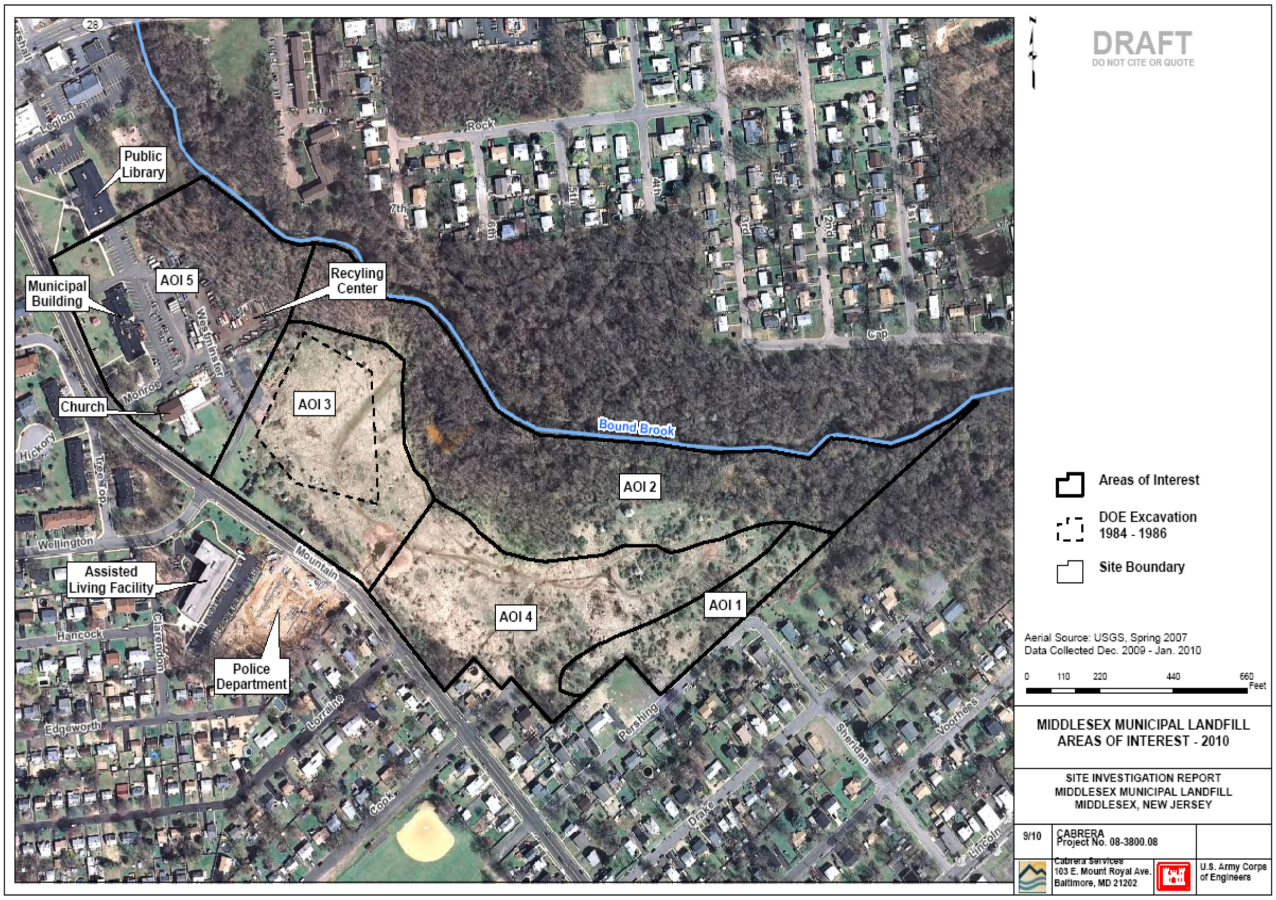

Figure 4: Areas of Interest

CONCLUSIONS

One of the major objectives of this investigation was to conduct gamma surveys over a large area quickly and efficiently in order to identify areas of elevated activity and to determine the nature of the contaminations present at those locations. The USACE project team utilized three different innovative surface gamma scan technologies and systems – CLASS, traditional GWS and manual GWS to identify areas of elevated activities and determine sampling locations. Use of the CLASS allowed the team to cover the majority of the site at a rate roughly 50% faster than traditional GWS. Additionally, it was possible to transfer this data to the office daily for processing, interpretation and distribution to the project team. By interacting with the team members, locations of surface soil samples, test pits, soil borings and subsurface soils were determined. Soil and groundwater sampling was conducted for three ROPCs present at the Site. The results of the investigations identified five AOIs and types and nature of the contaminants that are present at those locations. The area surrounding the borough building and church (AOI

5) is considered suitable for conducting a Final Status Survey to allow that area to be released without further characterization. By applying innovative site investigation strategies and technologies as well as an iterative communication process between field team and the project manager and technical staffs, the project team successfully conducted the SI at the MML despite multiple project constraints that included a limited time frame and contract restrictions.