# Integrating Intrusive and Nonintrusive Characterization Methods To Achieve A Conceptual Site Model For The SLDA FUSRAP

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## ABSTRACT

The U.S. Army Corps of Engineers (USACE) is addressing radiological contamination following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements at the Shallow Land Disposal Area (SLDA) site, which is a radiologically contaminated property that is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). The SLDA is an 18-hectare (44-acre) site in Parks Township, Armstrong County, Pennsylvania, about 37 kilometers (23 miles) east-northeast of Pittsburgh. According to historical record, radioactive wastes were disposed of at the SLDA in a series of trenches by the Nuclear Materials and Equipment Company (NUMEC) in the 1960s. The wastes originated from the nearby Apollo nuclear fuel fabrication facility, which began operations under NUMEC in the late 1950s and fabricated enriched uranium into naval reactor fuel elements. It is believed that the waste materials were buried in a series of pits constructed adjacent to one another in accordance with an Atomic Energy Commission (AEC) regulation that has since been rescinded. A CERCLA remedial investigation/feasibility study (RI/FS) process was completed for the SLDA site, and the results of the human health risk assessment indicated that the radiologically contaminated wastes could pose a risk to human health in the future. There are no historical records that provide the exact location of these pits. However, based on geophysical survey results conducted in the 1980s, these pits were defined by geophysical anomalies and were depicted on historical site drawings as trenches. At the SLDA site, a combination of investigative methods and tools was used in the RI/FS and site characterization activities. The SLDA site provides an excellent example of how historical documents and data, historical aerial photo analysis, physical sampling, and nonintrusive geophysical and gamma walkover surveys were used in combination to reduce the uncertainty in the location of the trenches. The data and information from these sources were used to refine the conceptual site model, complete the RI/FS, and support the ongoing remedial design and action, which will achieve site closure acceptable to all stakeholders.

## SITE BACKGROUND

The SLDA is an 18 hectare (44-acre) site in Parks Township, Armstrong County, Pennsylvania, near Leechburg and Vandergrift (Figure 1), and about 37 kilometers (23 miles) east-northeast of Pittsburgh.

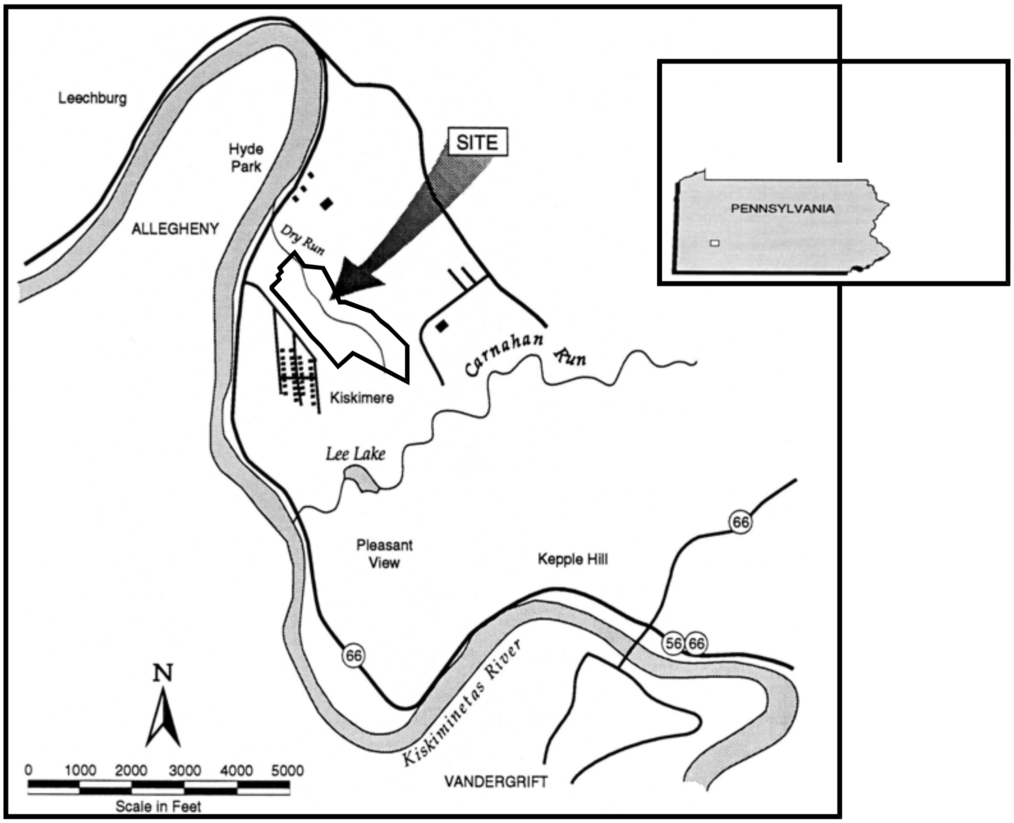


**Fig. 1. SLDA site location map.**

Between 1961 and 1970, NUMEC reportedly buried process and other wastes from the nearby Apollo nuclear fuel fabrication facility at the SLDA site. NUMEC owned both the Apollo facility and the SLDA site. The Apollo nuclear fuel fabrication facility performed a number of conversion and production activities for uranium and thorium nuclear fuel from 1957 to 1986. Most of these activities were with uranium of various enrichments, with only a limited amount of thorium-based fuel. The Atlantic Richfield Company (ARCO) bought the stock of NUMEC in 1967, and use of the SLDA site for radioactive waste disposal reportedly ended in 1970. In 1971, Babcock & Wilcox Company (B&W) acquired NUMEC. B&W subsequently changed its name to BWX Technologies (BWXT), and it assumed ownership of the SLDA site in 1997. Although BWXT is the current owner, ARCO retains environmental liability for the SLDA site. BWXT is the current licensee for the site and is responsible for compliance with the terms and conditions of U.S. Nuclear Regulatory Commission (NRC) License SNM-2001.

According to site records, the wastes from the Apollo facility were buried at the SLDA site in a series of pits constructed adjacent to one another. Based on the results of geophysical data, the pits appear as elongated anomalies and are depicted on site drawings as trenches. (The term "trench" is used in this paper to describe these disposal pits for consistency.) The trenches are separated by geography into two general areas: one area containing Trenches 1 through 9 (referred to as the upper trench area) and a second area containing Trench 10 (referred to as the lower trench area). The trenches are identified as 1 through 10, based partially on the sequential construction and use of each trench (with 1 being the oldest and 9 being the most recently constructed trench in the upper trench area). Trench 3 is actually a backfilled settling pond used to contain runoff and groundwater inflow that occurred during the exhumation of Trenches 2, 4, and 5 in 1965. Trench 10 was excavated in coal strip mine spoils along the northwest side of a bedrock outcrop, or high wall, and was used for disposal purposes throughout the

1960s and 1970. The trenches cover an area of about 0.49 hectares (1.2 acres), or less than 3% of the site. The layout of the SLDA site is provided in Figure 2.

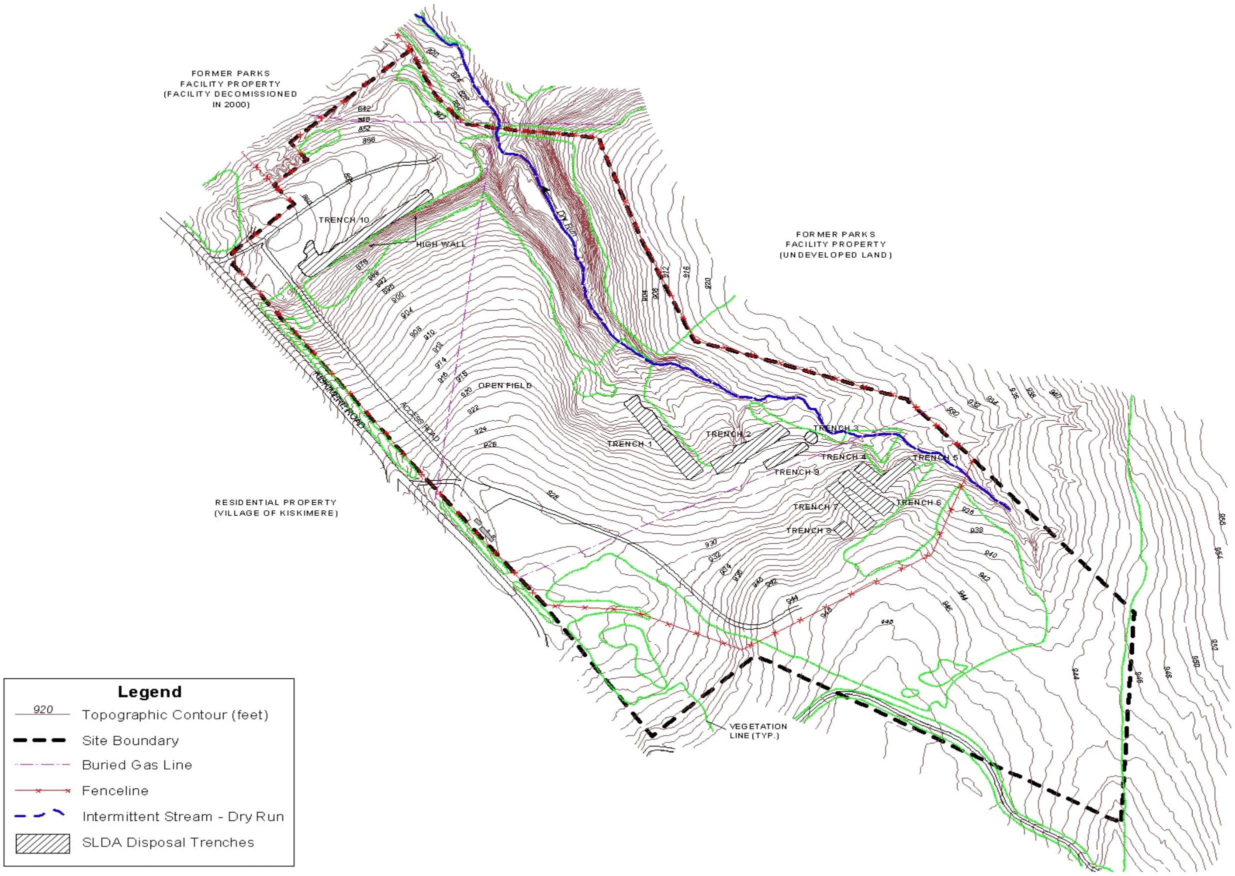


**Fig. 2. SLDA site map.**

The SLDA is predominantly an open field, with wooded vegetation along most of the northeastern boundary and in the southeastern and southern corners. The land slopes downward from the southeast toward the northwest, with a change in elevation of about 35 meters (m) (115 feet [ft]) over a distance of 305 m (1,000 ft). A small, intermittent stream identified as Dry Run, collects surface runoff from the site and groundwater seepage from adjacent hillsides. A portion of the flow in Dry Run infiltrates through the coal mine spoils in the lower trench area and into abandoned coal mines that underlie the majority of the site. During the times of high flow, the balance of Dry Run flow continues off-site to the Kiskiminetas River. Land use surrounding the SLDA site is mixed, consisting of medium-sized residential communities and individual rural residences, small farms with croplands and pastures, idle farmland, forestlands, and light industrial areas.

After performing a historical records review for the SLDA, the U.S. Department of Energy concluded that the site contained radioactive wastes from activities that supported the nation's early atomic energy program and was eligible for evaluation under the FUSRAP. This determination was provided to the USACE on May 25, 2000, consistent with the responsibilities of each organization for the administration and execution of FUSRAP. Subsequent to that determination, the Senate Committee on Appropriations recommended that up to $5 million appropriated for FUSRAP in 2001 be used to determine the appropriate response action for the SLDA site under CERCLA. The House of Representatives

Committee of Conference concurred with this resolution, and in November 2000, the USACE referred the SLDA site to the Great Lakes and Ohio River Division of USACE for action.

In accordance with the CERCLA process, a Preliminary Assessment (PA) was performed and released in March 2002. The PA recommended no further action at the site under FUSRAP, due to the absence of an unpermitted release as defined by CERCLA. However, this recommendation was subsequently superseded by Section 8143 of the Department of Defense Appropriations Act for 2002, which directed the Secretary of the Army, acting through the Chief of Engineers, to clean up radioactive waste at the SLDA site consistent with a 2001 Memorandum of Understanding (MOU) between USACE and NRC. This MOU applies to FUSRAP sites with NRC-licensed facilities (such as the SLDA), where USACE response actions meet the decommissioning requirements specified in 10 CFR 20.1402 [1].

Based on the 2002 legislation cited above and in accordance with the CERCLA process, the USACE completed an RI/FS and issued a proposed plan (PP) for public comment on January 12, 2007. A public meeting on the PP was held on January 25, 2007, near Vandergrift, Pennsylvania. Following the public review period for the PP, the USACE issued a Record of Decision (ROD) documenting the remedy selected for the site [2]. The selected remedy entails excavation of the contaminated waste and soil that exceeds the site-specific cleanup criteria, the segregation or treatment of excavated material for efficient and safe transportation, and the off-site disposal of all contaminated material at an appropriate permitted facility in accordance with their waste acceptance criteria. Following confirmation that the cleanup criteria have been attained, the excavated areas will be backfilled with soil and restored in a manner to promote site drainage and allow unrestricted release.

While there are still a number of issues that need to be resolved during the detailed engineering design phase, the use of various intrusive and nonintrusive characterization methods proved very useful in developing a good conceptual site model for the SLDA site to allow for timely completion of the RI/FS process and issuance of the ROD. This information is being used by the contractor selected to implement this remedy at the site in developing a detailed plan for site remediation. These approaches are described below.

## INTRUSIVE INVESTIGATIONS

The first action taken in developing the RI/FS was a thorough review of existing records to determine the types of materials disposed of at the site and the expected extent of contamination. Records indicate a wide variety of wastes were placed in the excavated trenches in a highly heterogeneous manner. According to historical record, the waste materials were covered with about 1.2 m (4 ft) of clean soil, and the trenches were separated from each other by about 1.8 m (6 ft) of clean soil consistent with the requirements specified in the AEC regulations in effect at that time (these regulations were subsequently rescinded in 1981). The average waste thickness in trenches 1 through 9 was reported to range from about 2.6 to 4.9 m (8.5 to 16 ft), and the average waste thickness in Trench 10 is about 5.5 m (18 ft). The volume associated with the trenches has been estimated to be about 18,000 cubic meters ($m^3$) (23,500 cubic yards [$yd^3$]), much of which may be uncontaminated soil separating the individual trenches. Most of the radioactive contamination at the site is associated with the upper trench area. Historical information indicates that the wastes disposed of in Trench 10 were generally equipment and construction debris. In addition to reviewing records, interviews were conducted with individuals familiar with previous waste disposal actions at the SLDA site.

The primary radioactive contaminants in the disposed wastes were uranium and thorium, with most of the waste containing uranium. The uranium-contaminated materials placed in the trenches were reportedly present in a wide range of enrichments, ranging from less than 0.2% (by weight) uranium-235 (U-235) to greater than 45% U-235. The uranium isotopes of concern at the site are those associated with natural uranium (i.e., [U-234], U-235, and [U-238]. The thorium disposed of at the SLDA was principally Th-232, and since more than 30 years have passed since disposal activities ceased, significant ingrowth of Ra-228 has occurred. Additional contaminants, specifically Pu-239, Pu-241, and Am-241, were also identified as being present in soil near Trench 10.

Intrusive characterization activities were conducted from August 2003 through January 2004 and included surface and subsurface soil sampling and radiological analysis. A total of 304 soil samples was collected from 103 soil borings outside the trench areas, and 47 samples were collected from 44 bores within the trench areas. Biased samples were collected from intervals where potential contamination was observed, and for those locations where such evidence was not evident, samples were collected at regularly spaced 0.6-m (2-ft) subsurface intervals. Surface soil samples were collected at each boring location. While the plan was to advance each boring to a depth of 6 m (20 ft) or until refusal, the majority of bores completed encountered refusals at depths less than 3.7 m (12 ft). This RI field characterization program was also conducted in accordance with an approved Field Sampling Plan [3]. This CERCLA-based effort supplemented historical surface and subsurface soil samples collected from 1981 through 2000.

These results confirmed that the radioactive contaminants at the site are generally confined to the immediate vicinity of the trenches; however, some localized areas of contaminated soil were detected outside of these areas, especially off both the southwestern and northeastern ends of Trench 10 and northeast of Trench 7. The concentrations of radioactive contaminants in most soil samples were generally comparable to background, although a few samples had total uranium concentrations in excess of 100 picoCuries per gram (pCi/g). The concentrations of radionuclides in the materials contained within the trenches are much greater than in nearby soils. Consistent with historical records, uranium of various enrichments was the most prevalent radionuclide present in the trench materials. Historical results indicated concentrations of uranium in excess of 1,000 pCi/g, with the radionuclide U-234 generally having the highest concentrations. There are also a number of locations in the trench areas that do not appear to contain any waste material.

These results were consistent with the historical record and are provided in the RI Report [4]. These field investigations indicated that there is uncertainty as to the exact locations of the previous disposals. Previous investigations conducted by the site owners to try to reduce this uncertainty were generally on the perimeter of the trenches. However, these results were not felt to be conclusive as to the exact locations of the buried materials. Nonintrusive investigations were used to reduce this uncertainty.

## NONINTRUSIVE INVESTIGATIONS

Based on this historical information, the USACE instituted an initial nonintrusive investigation at the site as part of the RI process in accordance with an approved Field Sampling Plan [5]. A gamma walkover of the entire site was conducted in June of 2003; this gamma survey used both a 3 x 3 sodium iodide (NaI) detector and a FIDLER (Field Instrument for Detection of Low Energy Radiation) detector [6]. All of the data collected by the 3 x 3 NaI detector were less than twice background, while five relatively small areas were identified by the FIDLER as having gamma radiation above twice the mean background value. The five small areas of potential concern were sampled, and two of the localized areas resulted in clean-up-level exceedances. These investigations confirmed the general absence of elevated surfical gamma radiation levels at the site.

A second nonintrusive investigative technique used at the SLDA site included a historical aerial photographical and imagery analysis performed by the U.S. Army Topographic Engineering Center (TEC) [7]. The TEC analysis delineated locations of previous activities at the site by focusing on potential disposal activities such as land scars, waste or soil piles, and open excavations that occurred from 1957 to 2002. Visible signatures such as size, shape, shadow, tone, and pattern allowed features to be recognized on the aerial photography and satellite imagery. Limitations inherent in some of the data included substandard photo reproduction, for example, granularity, washout, or vagueness in the image and scale. Key findings from photographical analysis included the following:

- Evidence of disturbed ground surface at or near Trench 1 and south of the upper trenches, where waste exhumation had reportedly occurred;
- A raised area in the lower trench area, where the ground surface appears to have been scraped;
- Time periods during the 1960s where there were soil piles apparent in the upper trench area that appear to coincide with waste exhumation activities;
- Apparent trenches that correspond well with the locations of Trenches 4 and 6;
- A pit in the area coincident with Trench 9;
- Stockpiled materials and two cleared areas north of Trench 10; and
- A disturbed area showing vehicle tracks toward a rectangular area oriented parallel to and just south of Trench 8.

While this investigation was useful in confirming the general locations of the trenches, it did not provide the desired level of detail (i.e., definitive disposal activities or techniques, nor a one-to-one correlation between disturbed soil areas and historically delineated trench outlines).

A third nonintrusive geophysical investigation conducted at the site included using two geophysical survey methods: EM31 and EM61 [8]. First, the EM31 survey was conducted using a terrain conductivity meter as a reconnaissance method of determining the electromagnetic properties of subsurface materials. The conductivity measurement is dependent on the density, porosity, moisture content, and presence or absence of electrolytes or colloids of the subsurface materials. Typically, clay soils have a high conductivity as a result of their cation exchange capacity and the electrostatic properties of clay minerals. Bedrock typically has a lower conductivity because of high density and the generally lower porosity present within the rock matrix. The irregular nature of landfill material and the frequent presence of ferrous metals provide for an electromagnetic response that typically contrasts with the more homogeneous natural materials in an area. Because of the variety of factors that affect terrain conductivity measurements, the actual magnitude of the terrain conductivity values measured is less important than the trends and anomalies in the measurements.

Based on the results of the EM31 terrain conductivity surveys, a high-sensitivity EM61-MK2 survey was conducted over two general areas of the site that were consistent with the trench locations identified from historical investigations. The EM61-MK2 is a time domain instrument that transmits a high-frequency electromagnetic pulse that creates electric currents of greater magnitude and duration in the subsurface where metallic objects exist than for nonmetallic objects. A measurement of the remnant electromagnetic field is collected with two receiver coils. The magnitude of the remnant electromagnetic field provides a measurement of the electromagnetic field amplitude, which is dependent on the metallic presence in the subsurface. Field-generated global positioning system (GPS) location coordinates were incorporated into the survey data for easy mapping with spatial data collected at the site.

The results of the EM31 and EM61-MK2 surveys are shown in Figures 3 and 4, respectively. The EM31 terrain conductivity survey identified several elongated conductivity anomalies consistent with the shape and size of previously reported trenches. (Note that on Figure 3, the two long and thin linear features that extend across the length of the entire site are buried utilities.) The EM61-MK2 high-sensitivity detector survey results appear to provide better lateral resolution of subsurface metallic debris. These anomalous zones are consistent with the magnetic susceptibility anomalies identified in the EM31 data. Overall, the geophysical investigation appears to have been successful in identifying the lateral locations of the areas associated with historical waste disposal activities at the site. The geophysical methods used during this investigation cannot assess the vertical limits of the trenches.

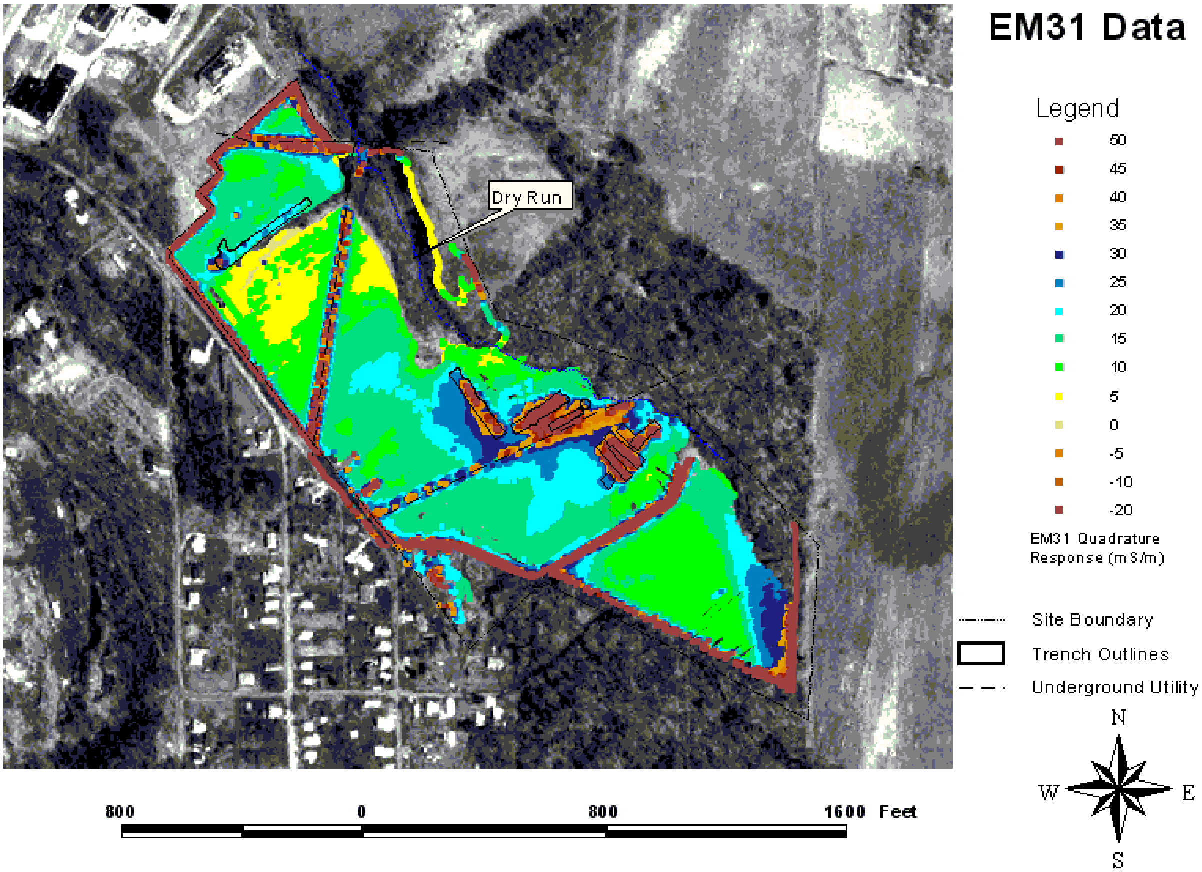


**Fig. 3. EM31 survey results.**

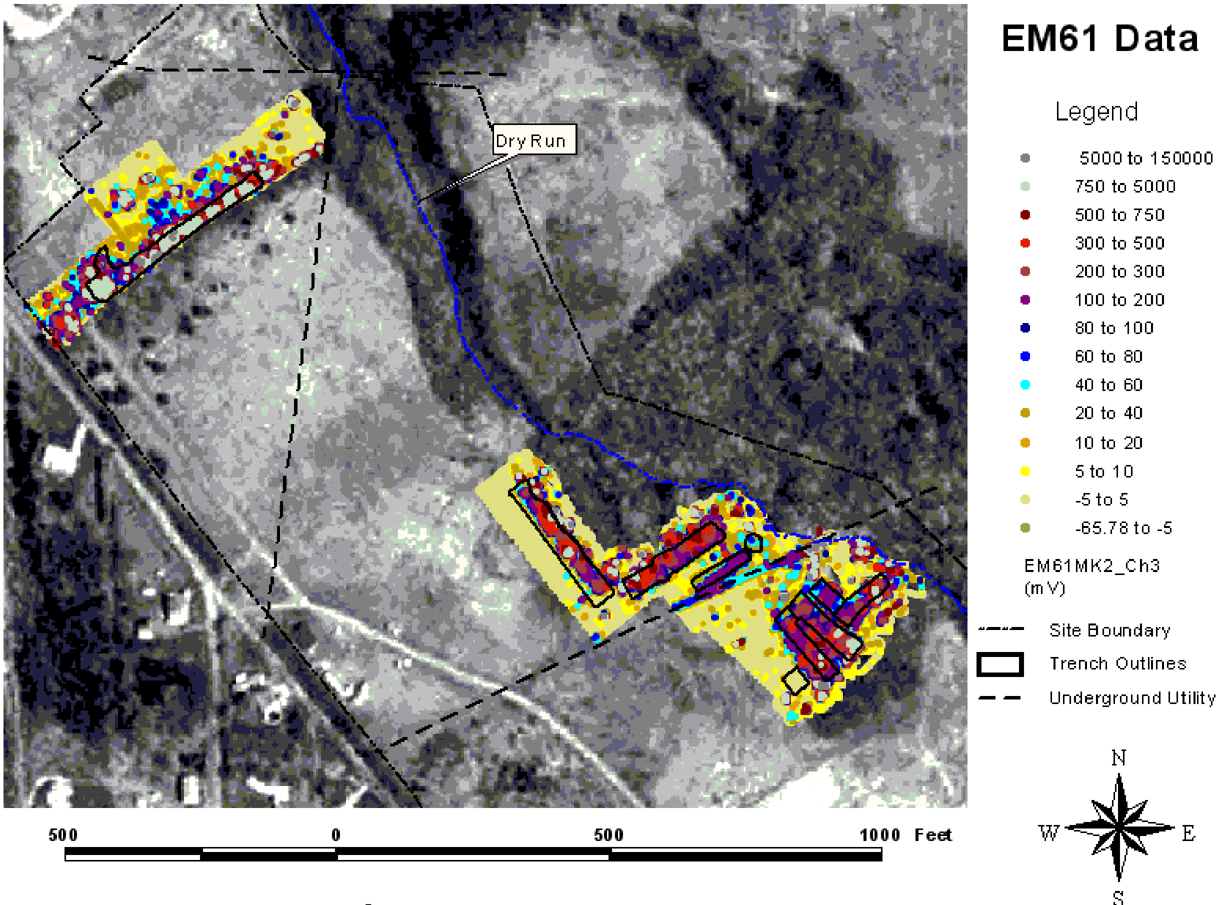


**Fig. 4. EM61-MK2 survey results.**

## CONCLUSIONS

Radioactive wastes were disposed of at the SLDA in a series of pits adjacent to one another by NUMEC in the 1960s from the nearby Apollo nuclear fuel fabrication facility. While there are no existing historical records that provide the exact locations of these disposal pits, intrusive and nonintrusive characterization techniques were used to define several discrete areas of subsurface and surface contamination. Use of several complementary techniques optimized the USACE understanding of the nature and extent of contamination at the site. The SLDA site provides an excellent example of how historical information, nonintrusive methods (i.e., gamma walkover surveys, historical photographic analysis, geophysical investigations) and intrusive investigative techniques (i.e., surface and subsurface soil sampling) were used in combination to refine the conceptual site model, complete the RI/FS, minimize uncertainties associated with the exact locations of the burial pits, and support a cost-effective and efficient remediation plan for the SLDA site.

**REFERENCES**

1. NRC (U.S. Nuclear Regulatory Commission), "Radiological Criteria for Unrestricted Use", Part 20.1402 of Subpart E of Title 10, *Code of Federal Regulations*", Washington, D.C. (2006).

2. USACE (U.S. Army Corps of Engineers), "Record of Decision for the Shallow Land Disposal Area Site, Parks Township, Armstrong County, Pennsylvania," Pittsburgh District, Great Lakes and Ohio River Division, Cincinnati, Ohio (2007).

3. USACE, "Final Remedial Investigation Sampling and Analysis Plan, Part 1 – Field Sampling Plan, Project Work Plans, Acquisition of Field Data and Technical Support for the Shallow Landfill Disposal Area (SLDA) Parks Township Armstrong, Pennsylvania," prepared by URS Corporation (2003).

4. USACE, "Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania," prepared by URS Group, Inc., Buffalo, New York (2005).

5. USACE, "Final Gamma Walkover Survey Sampling and Analysis Plan, Project Work Plans, Acquisition of Field Data and Technical Support for the Shallow Landfill Disposal Area (SLDA) Parks Township Armstrong, Pennsylvania," prepared by URS Corporation (2003).

6. USACE, "Final Gamma Walkover Survey Report, Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania," prepared by URS Corporation (2003).

7. TEC (U.S. Army Topographic Engineering Center), "Shallow Land Disposal Area (SLDA) Historical Photographical Analysis, Armstrong County, Pennsylvania," prepared by the U.S. Army Topographic Engineering Center, Operations Division, Alexandria, Virginia (2003).

8. USACE, *Shallow Land Disposal Area Geophysical Investigation, Geophysical Survey Report, Revision 0*, December (2006).