UNCONVENTIONAL METHODS FOR LOCATING BURIED RADIOACTIVE WASTE

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ABSTRACT

A former radiological disposal site, known as the Breckenridge Disposal Site is located near St. Louis, Michigan. Michigan Chemical Company (MCC) used the site for the disposal of process wastes containing thorium and uranium. The wastes were a byproduct of MCC’s rare earth extraction process, which used thorium- and uranium-bearing feedstocks. The solid waste resulting from the extraction process was a precipitate of insoluble materials known as filtercake. The filtercake contained much of the radioactivity from the process’ feedstock and was buried at the disposal site between 1967 and 1970 under a U.S. Atomic Energy Commission (AEC) license. Site evaluations conducted after the site’s closure found that the burial process used was improper. As a result, the Nuclear Regulatory Commission deemed in necessary to unearth and remove the buried filtercake material.

Since there were no records or surface indications of the precise burial locations, standard systematic downhole sampling and analysis was employed. This proved to be of little benefit. Geophysical techniques were then employed to identify the locations of the buried material. Ground-penetrating radar (GPR) was used but provided little indication of the filtercake. The site also had a non-radiological deep injection well. The spoils from the drilling of this well confounded GPR results.

Other geophysical techniques, electromagnetic (EM) and magnetometry survey processes, were then used in the characterization process. The EM survey measures ground conductivity changes often caused by fill and detects accumulations of metallic objects. Magnetometry surveys measures local changes in the earth’s magnetic field that may be caused by buried ferrous objects. The EM and magnetometry surveys were successful in identifying nine waste locations on the site, which were all later verified using downhole sampling. Limited site remediation and extensive site trenching indicated that the magnetometry surveys were most useful.

INTRODUCTION

A former radiological disposal site, known as the Breckenridge Disposal is a 2.2 acre parcel of land surrounded by farms in a rural area near St. Louis, Michigan. Michigan Chemical Company (MCC) used the site for the disposal of process wastes containing thorium and uranium. The wastes were a byproduct of MCC’s rare earth extraction process, which used thorium- and uranium-bearing feedstocks. The rare earth extraction process primarily yielded yttrium, which was used as a phosphor for color televisions and to produce synthetic diamonds and crystals that were used in various electronic devices.

The solid waste resulting from the extraction process was a precipitate of relatively insoluble material known as filtercake. The filtercake contained much of the radioactivity from the process’ feedstock and was buried at the disposal site between 1967 and 1970 under a U.S. Atomic Energy Commission (AEC) license and in accordance with the U.S. Code of Federal Regulations (CFR), Title 10, Chapter 20.304, “Disposal by Burial in Soil.”

Site evaluations conducted after the site’s closure noted elevated levels of surface activity at a limited number of locations at the disposal site. Since the AEC regulations required an earthen cover of no less than 4 feet, the surface radioactivity raised concerns about the condition of the burial site and its potential impact on human health. Based on the identification of the surface activity, the NRC requested that the site’s current owner conduct a site radiological evaluation. The NRC also directed that the site be closed in accordance with the contemporary regulatory framework of 10 CFR 20, Subpart E, commonly known as the License Termination Rule.

In order to assess the potential level of dose to future site users, a site characterization was necessary. There were, however, no records or surface indications of the precise burial locations. Even though standard systematic downhole sampling and analysis was employed, it was a hit or miss proposition since the material was buried in distinct trenches. Of the dozens of soil cores that were initially taken, only one actually hit the filtercake material.

GEOPHYSICAL ASSESSMENT

Other methods to identify the buried material were evaluated. Historical information indicated that the material was buried in fiberboard drums with steel bottoms, lids, and closure rings. In addition, the dense, clay-like filtercake was expected to be physically different that native soils. As a result, geophysical techniques were employed to identify the locations of the buried material. Ground-penetrating radar (GPR) was used but provided little indication of the filtercake. The site also had a non-radiological deep injection well. The spoils from the drilling of this well confounded GPR results.

Other geophysical techniques, Electromagnetic (EM) and magnetometry survey processes, were then used in the characterization process. The EM survey, which was done using a Geonics EM-31 instrument, measures ground conductivity changes often caused by fill and detects accumulations of metallic objects. Magnetometry surveys were done using a Foerster Ferex 4.021 instrument. This device measures local changes in the earth’s magnetic field that may be caused by buried ferrous objects. Both methods are capable of detecting buried material to maximum depths of 20 to 30 feet, depending on the size of the accumulation.

Electromagnetic Survey

As part of the geophysical surveys, systematic EM surveys were conducted on the burial site. This process is capable of identifying conductivity and metal anomalies. The instrument that was used was a Geonics EM-31. This device includes a transmitter coil and a receiver coil mounted on either end of a long plastic boom. The transmitter induces small electrical currents in the ground by generating a primary magnetic field. The receiver coil senses a secondary magnetic field produced by the induced currents in the earth or buried items.

The instruments receiver compensates for effects of the primary field and the produces data that describe the magnitude and relative phase of the measured secondary field. The out-of-phase component is an indicator of ground conductivity. The in-phase component provides indications of the presence of metal similar to a metal detector. At Breckenridge, conductivity and in-phase (metal) data were recorded and logged digitally. The survey followed north-south parallel lines spaced 2.5 meters apart. Data were logged at 1-meter intervals. Conductivity is measured in millisiemens per meter while inphase measurements are recorded in parts per thousand.

Magnetic Survey

Magnetic surveys were also done as part of the geophysical surveys at the Breckenridge Disposal Site. This method measures the intensity of the earth’s magnetic field. Deposits of ferrous material, such as drums or in this case drum lids, cause a localized disturbance in the magnetic field. The size of the disturbance depends largely on the ferrous mass of the buried object. This process, however, only produces semi-quantatative data because the field disturbance is affected by many variables including target object orientation, target shape, inherent magnetism of target, and state of deterioration. In addition, the earth’s magnetism changes hourly based on sunspots and conditions in the ionosphere.

As is done occasionally with radiological instruments, two fields can be measured simultaneously to reduce the effects of background. This type of magnetometer, called a gradiometer magnetometer evaluates the difference of two magnetic detectors; one measures a target location and one measures background variations. The two detectors are placed apart with a vertical distance of about one meter. Subtraction of the two provides a relatively accurate indication of ferrous materials. A single drum can be detected to about three meters (1). Collections of drums have been location up to about 12 meters. At Breckenridge, we were trying to locate drum lids and rings since it was believed (accurately) that cardboard type drums were used for disposing of the filtercake material not the standard metal drums. The units of gradient magnetic data are nanoTeslas per foot.

SURVEY RESULTS

All of the geophysical techniques were successful in identifying buried waste material to some degree. The conductivity survey was the least useful technique. It only clearly showed a single burial location. The interference from the metal chain link fence, which follows the perimeter of the property, caused nearly overwhelming interference with the survey. Results of the conductivity survey along with the actual locations of the buried material are shown in Figure 1.

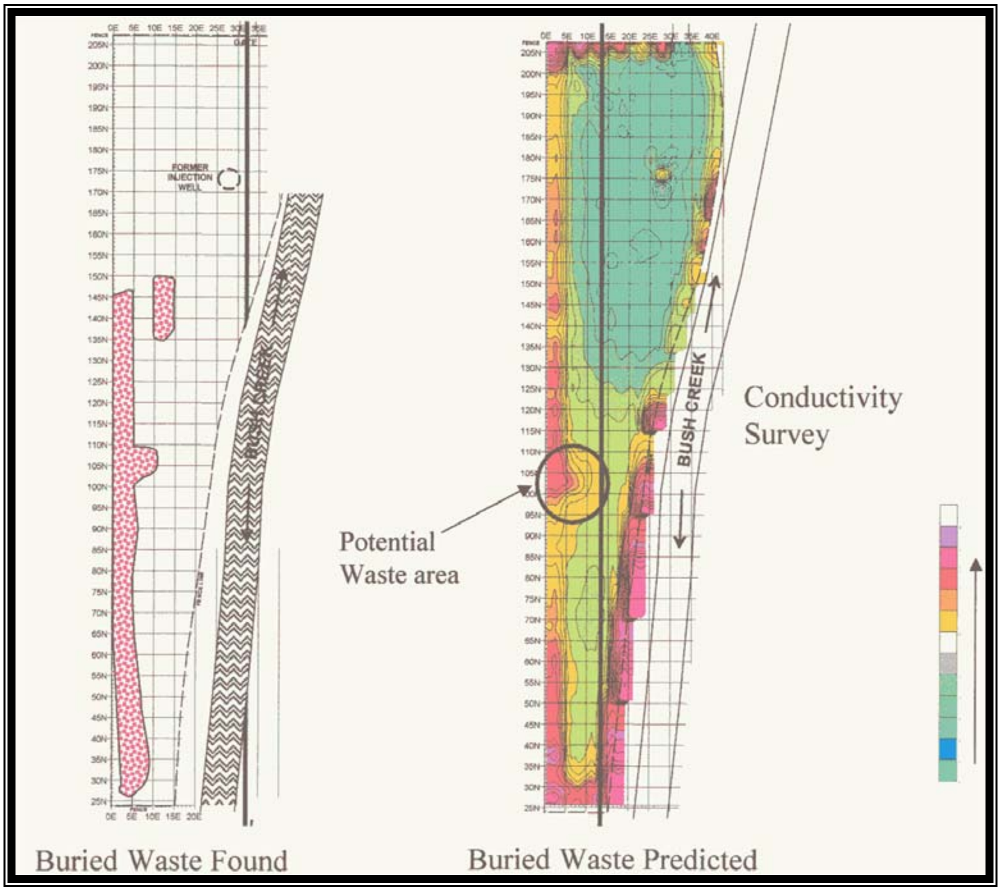

Fig. 1. Results of conductivity survey

It should be noted that, at the time this paper was completed, not all of the filtercake was exhumed; however, a combination of filtercake exhumation and extensive test trenching provided extensive and, what is believed to be, reliable location information about the buried filtercake material.

The in-phase, metal detector style survey proved to be much better than the conductivity survey. It accurately identified three burial locations, one of which was quite large. Interference from the fence was minimal with the in-phase technique. Results of the in-phase survey are provided in Figure 2.

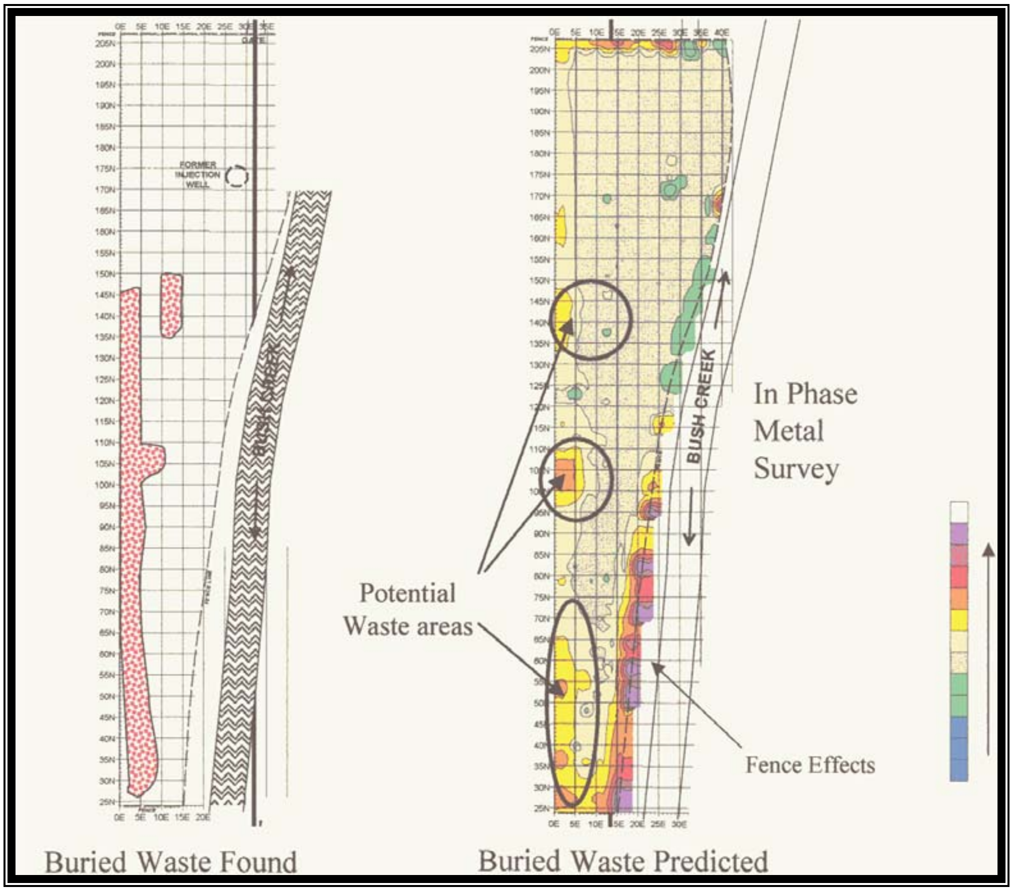

Fig. 2. Results of in phase metal survey

The magnetic survey proved to be the most useful of the geophysical survey techniques. This survey process identified seven distinct burial locations, which covered about 70% of the area that was eventually found to contain the buried filtercake material (See Figure 3). In addition, the magnetic survey was least affected by the chain link fence.

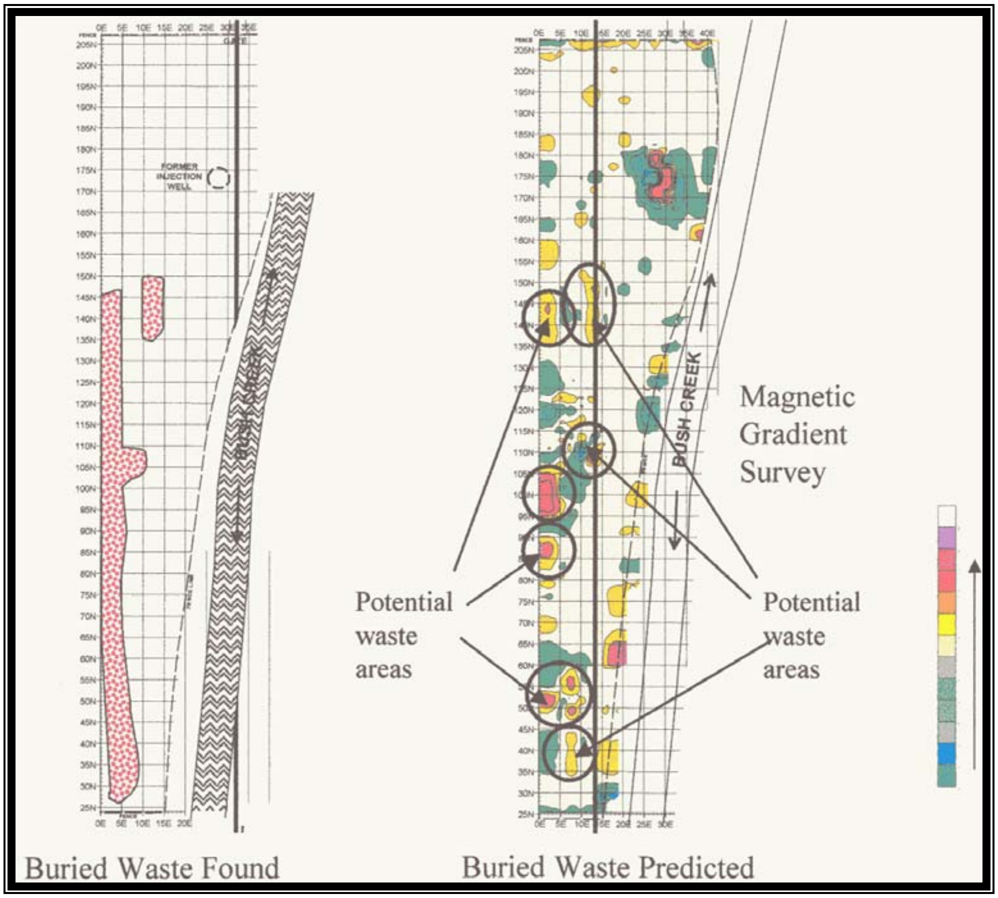

Fig. 3. Results of magnetic survey

CONCLUSION

Overall, the results of the geophysical survey were positive. They provided valuable information about the location of the buried waste material. No attempt was made to quantify the amount of buried material based on the geophysical survey results. Once the locations of the material was ascertained using these techniques, standard hollow-core (Geoprobe®), downhole samples were collected and analyzed to verify the geophysical results and to determine the radiological attributes of the buried material. All locations that were identified as probable waste locations were indeed confirmed to be waste locations by the radiological analyses. In regards to value, the geophysical surveys were very cost-effective. The service, including the instruments and a detailed report (2) for the three surveys, were provided by the survey contractor (Geosphere, Inc.) for $3500.

REFERENCES

1. Geovision. 2004. Geophysical Techniques for Shallow Investigations. Geovision Geophysical Services, Corona, California.
2. Geosphere, Inc. 2001. Geophysical survey for Buried Material at the Breckenridge Disposal Site. Geosphere No. 01-584. Geosphere, Inc., Auburn, Michigan.