Reducing Contingency through Sampling at the Luckey FUSRAP Site - 13186

David Frothingham, Michelle Barker, Steve Buechi,
U.S. Army Corps of Engineers Buffalo District
1776 Niagara St., Buffalo, NY 14207, USA
David.G.Frothingham@usace.army.mil,
Michelle.C.Barker@usace.army.mil,
Stephen.P.Buechi@usace.army.mil

Lisa Durham
Argonne National Laboratory
Environmental Science Division
9700 S. Cass Ave., Argonne, IL 60439, USA
ladurham@anl.gov

ABSTRACT

Typically, the greatest risk in developing accurate cost estimates for the remediation of hazardous, toxic, and radioactive waste sites is the uncertainty in the estimated volume of contaminated media requiring remediation. Efforts to address this risk in the remediation cost estimate can result in large cost contingencies that are often considered unacceptable when budgeting for site cleanups. Such was the case for the Luckey Formerly Utilized Sites Remedial Action Program (FUSRAP) site near Luckey, Ohio, which had significant uncertainty surrounding the estimated volume of site soils contaminated with radium, uranium, thorium, beryllium, and lead. Funding provided by the American Recovery and Reinvestment Act (ARRA) allowed the U.S. Army Corps of Engineers (USACE) to conduct additional environmental sampling and analysis at the Luckey Site between November 2009 and April 2010, with the objective to further delineate the horizontal and vertical extent of contaminated soils in order to reduce the uncertainty in the soil volume estimate. Investigative work included radiological, geophysical, and topographic field surveys, subsurface borings, and soil sampling. Results from the investigative sampling were used in conjunction with Argonne National Laboratory's Bayesian Approaches for Adaptive Spatial Sampling (BAASS) software to update the contaminated soil volume estimate for the site. This updated volume estimate was then used to update the project cost-to-complete estimate using the USACE Cost and Schedule Risk Analysis process, which develops cost contingencies based on project risks. An investment of $1.1M of ARRA funds for additional investigative work resulted in a reduction of 135,000 in-situ cubic meters (177,000 in-situ cubic yards) in the estimated base volume estimate. This refinement of the estimated soil volume resulted in a $64.3M reduction in the estimated project cost-to-complete, through a reduction in the uncertainty in the contaminated soil volume estimate and the associated contingency costs.

SITE BACKGROUND

The Luckey Formerly Utilized Sites Remedial Action Program (FUSRAP) site is located in Luckey, Ohio, approximately 32 kilometers (20 miles) south of Toledo. The site is approximately 16 hectares (40 acres) in size and is currently vacant. It is surrounded by farmland and private residences. From 1949 to the early 1960s, the Brush Beryllium Company (BBC), as a Contractor to the Atomic Energy Commission (AEC), used the Site for beryllium (Be) processing to support the national defense program. Beryllium production activities brought different types of source media or potential contaminants to the site. Primary source media at the site included materials delivered for processing or pre-processing: Be ore; scrap Be; and radiologically contaminated scrap steel.

Beryllium processing primarily occurred in the annex on the south side of the production building, where beryl ore was converted to beryllium oxides and metal. Process wastes were discharged to three lagoons south of the annex in liquid or slurry form and were allowed to either evaporate or discharge to site ditches. From 1950 through 1958, sludge from the lagoons was dredged, transported, and placed into disposal pits and trenches located in the northeast corner of the property.

The AEC contracted with BBC in 1959 to close the Luckey plant. Following closure, the lagoons were reportedly covered with 0.91 to 1.5 meters (m) (3 to 5 feet [ft]) of clean soil and later capped with up to 0.6 m (2 ft) of clay. Sampling conducted by Oak Ridge National Laboratory (ORNL) in 1988 indicated that residual sludge might still exist in all three lagoons.

The Remedial Investigation (RI) activities identified six FUSRAP-related soil contaminants of concern (COCs) that pose an unacceptable risk to human health; these include Be, lead (Pb), radium-226 (Ra-226), thorium-230 (Th-230), uranium-238 (U-238), and uranium-234 (U-234). Lead was identified as a COC because lead oxide was used as an additive in the Be production process. All six COCs were determined to pose unacceptable risks under a subsistence farmer scenario (i.e., a human health receptor who resides on the site and is self-sufficient from food grown or produced on the site), which was identified as a reasonable future use scenario (i.e., the critical group) for the site. The analyses also showed that site COCs in groundwater included Be, Pb, and total uranium.

The Feasibility Study (FS) Report [1] detailed the development, screening, and evaluation of remedial alternatives for the site. Based on the conclusions presented in the RI, the focus of the FS was the media contaminated by FUSRAP-related constituents. The FS identified remedial action objectives (RAOs) and evaluated remedial alternatives for FUSRAP-contaminated media.

Separate Records of Decision (RODs) were signed for the groundwater and soils operable units (OUs). The *Luckey Site, Luckey, Ohio, Record of Decision for Soils Operable Unit* [2] selected excavation and off-site disposal as the remedy for site soils. To address FUSRAP-related contaminants in groundwater, monitored natural attenuation was selected in the 2008 groundwater ROD.

VOLUME UNCERTAINTY

The FUSRAP COCs at the Luckey site are Be, Pb, Ra-226, Th-230, U-238, and U-234. Derived concentration guideline level (DCGL) values were developed for the Luckey site [3]. These $DCGL_W$ values, DCGLs for average concentrations over a wide area, are defined as the cleanup values in the ROD. The cleanup criterion and background concentration of each COC are presented in Table I. These cleanup criteria are used in the volume estimation analysis because they provide a conservative estimation of areas to be remediated by excavation and off-site disposal.

The historical data for the Luckey site soils include laboratory results for Be, Pb, and radionuclides, as well as a walkover survey, using a Field Instrument for Detection of Low Energy Radiation (FIDLER), of most open areas of the site provided in the *Final Remedial Investigation Report, Luckey Site, Luckey, Ohio* [4]. A contaminated soil volume estimate analysis was conducted in 2007 [5] using historical data, U.S. Army Corps of Engineers (USACE) investigation data, and the Bayesian Approaches for Adaptive Spatial Sampling (BAASS) software [6]. Because of significant uncertainty associated with gaps in historical and USACE investigation data, follow-up sampling was conducted in 2009 and 2010 to reduce the amount of volume-driven contingency in the out-year budget estimate.

Table I

LUCKEY SITE IMPACTED SOILS		
COC	Cleanup Goal	Mean Background
Be	131 mg/kg	1.13 mg/kg
Pb	400 mg/kg	23.2 mg/kg
Ra-226	2.0 pCi/g[a]	2.97 pCi/g
Th-230	5.8 pCi/g[a]	3.20 pCi/g
U-234	26 pCi/g[a]	2.61 pCi/g
U-238	26 pCi/g[a]	2.63 pCi/g

[a] Soil cleanup goals for radionuclides represent activity levels above site background activity corresponding to 25 mrem/yr (10 CFR Part 20 Subpart E and QAC 3701:1-38-22). If a mixture of radionuclides is present, then the sum of the ratios (SOR) applies per Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) and the ratio should not exceed unity. For example, use the 25 mrem/yr cleanup goals for unrestricted use by the critical group, which has been identified as the subsistence farmer for the Luckey site, for soil to get the following sum of the ratios equation:

SOR = (Ra-226/2.0 pCi/g) + (Th-230/5.8 pCi/g) + (U-234/26 pCi/g) + (U-238/26 pCi/g)

Where: SOR = sum of the ratios result

Ra-226 = the net Ra-226 soil concentration (background = 2.97 pCi/g);

Th-230 = the net Th-230 soil concentration (background = 3.20 pCi/g);

U-234 = the net U-234 soil concentration (background = 2.61 pCi/g);
U-238 = the net U-238 soil concentration (background = 2.63 pCi/g);
Net soil concentrations exclude background stated values.

UNCERTAINTY REDUCTION SAMPLING

In 2009 and 2010, the USACE conducted additional sampling at the site [7], to further delineate the horizontal and vertical extent of contaminated soils requiring remediation. Data collection activities associated with the volume uncertainty reduction investigation included radiological, geophysical, and topographic field surveys and soil and sediment sampling. More than 1,800 Be results and 800 radiological results were obtained from both on-site and off-site laboratory analyses.

The volume uncertainty reduction sampling effort focused on four principal areas of the site where evaluation indicated that significant gaps in RI data existed: sludge disposal trenches, former lagoon areas, the main drainage ditch leading northward off the site, and buildings and underground utilities. Delineating these areas and filling these gaps in site knowledge reduced the uncertainty associated with the contaminated footprint.

Sludge Disposal Trenches

A significant area of uncertainty was located in the northeast portion of the site where the RI Report suggested that 4.3-m (14-ft) wide by 5.5-m (18-ft) deep trenches received contaminated sludge from operations involving lagoons A, B, and C. The exact lengths and depths of these trenches were not clearly determined during previous field investigations. Based on geophysical anomalies and historical information, it appeared that the trenches could be approximately 122 m (400 ft) long.

Historically, approximately two out of three soil borings advanced in this area did not reach the target depth of 5.5 m (18 ft) bgs due to equipment refusal typically encountered on expanding clays. However, data collected showed that sampling results did not exceed COC cleanup criteria below 2.7 m (9 ft) bgs within the area.

Several soil borings were advanced into the purported locations of the sludge disposal trenches. However, based on a review of soil boring logs, sludge material was only identified to depths of 1.5 m (5 ft) bgs, with a ‘soft material’ detected to 4.6 m (15 ft) bgs. It appears that the majority of the soil borings advanced within this area did not intercept the sludge disposal trenches (or their purported locations) and these trenches may not extend to 5.5 m (18 ft) bgs.

In addition, several soil piles are located within the area. The exact dimensions and soil characterization of these piles were not defined during previous field investigations. These factors resulted in a large potential impact on the soil volumes potentially requiring excavation during remedial actions.

Former Lagoons

Lagoon A received wastes discharged from the conversion of plant grade Be hydroxide to Be metal in vacuum cast billets and was approximately 0.9 to 1.3 m (3 to 4 ft) deep with a clay liner. Lagoons B and C received discharges from the conversion of beryl ore to Be hydroxide by the sulfate process and were approximately 1.5 to 1.8 m (5 to 6 ft) and 0.46 m (1.5 ft) deep, respectively, with clay liners.

Each lagoon was capped with an approximately 0.61-m (2-ft) thick clay layer. The cap thickness for Lagoons A, B, and C required verification for in-situ volume estimates. There is limited RI data available within the approximate footprints of Lagoons A, B, and C. The limited radionuclide data showed no surficial samples or elevated gamma walkover survey (GWS) zones at Lagoons A or B, but Lagoon C has scattered sample exceedances and GWS hotspots. In addition, a Laser Induced Breakdown Spectroscopy (LIBS) walkover (i.e., Be scanning method) data indicated elevated Be readings across the surface of Lagoon C and south of Lagoons A and B. Based on soil sampling and monitoring results, it appeared that contaminated soils were beneath the caps at the former Lagoons A and B with clean soil overlying contaminated soil. Lagoon C has surficial contamination as well as soil sampling exceedances for radiological contaminants and Be below the purported depth of this lagoon.

The RI reports the existence of Lagoon D; this lagoon reportedly was constructed but never used; previous site owners reported to USACE that it might have been planned as a temporary storm water management system for the lagoon area runoff during large rain events.

Off-site Areas

The main drainage ditch to the north of the site had data gaps associated with a 1997 FIDLER GWS. Dredged soil from the main ditch had been placed on the ditch's bank where plowing occurs. However, the extent of dredged soil was not delineated to the east and west of the main ditch. Several radionuclide and Be exceedances were detected along the eastern side of the main ditch, but soil samples were not collected along the western side. In addition, the COC exceedances on the eastern side of the main ditch were unbounded and required further delineation to the east. Consequently, the volume estimates for FUSRAP-contaminated soil might have been significantly affected without further evaluation of the ditch sediments or contamination north of the site along the eastern and western sides of the main ditch.

Buildings and Utilities

Limited data were available regarding the presence and location of subsurface utilities (e.g., waste, storm sewer, drainage lines, and electrical conduits) and appurtenances at the site, and no sampling or scanning had been performed near underground utilities and appurtenances. Evaluation of the subsurface utilities would be required prior to any remedial efforts to identify any potential problems or concerns with migrating contamination.

During the USACE RI, on-site buildings were actively in use; therefore, no borings were advanced beneath the buildings to determine the extent of contamination.

The results of this volume uncertainty reduction sampling and analysis effort were combined with the historical data sets to support the development of a revised soil volume estimate by Argonne National Laboratory (Argonne) [8]. This revised soil volume estimate was used as a primary input for the 2012 annual Cost and Schedule Risk Analysis (CSRA), which forms the basis of the USACE out-year budgeting and planning process.

COST AND SCHEDULE RISK ANALYSIS

The CSRA process includes several steps that allow the project team to build on site-specific information and develop a complete understanding of potential cost and schedule risks and how to manage them.

Step 1: Estimate Contaminated Material Volume

The cost of cleaning up a contaminated site is primarily driven by the volume of FUSRAP-related contaminated material that requires remedial action. Estimating this volume accurately requires a thorough understanding of how the materials got to the site; where they are; and if, where, and how fast they are moving. As more is learned about the site during remedial action, the actual volume of FUSRAP-related material often exceeds the original volume estimate. This increases cost and causes schedule delays.

Step 2: Base Cost and Schedule Estimate

During the FS, a base estimate of the cost and duration required to clean up the site will be developed for each of the remedial alternatives undergoing detailed analysis, using software and techniques accepted as industry standards.

Step 3: Risk Register

The project risk register is a table of all known and suspected uncertainties related to cost and schedule for cleaning up a site. This register is compiled by the project team and each risk is discussed and assigned a qualitative likelihood and cost and schedule impact (high, medium, or low). For the Luckey site, the project uncertainty with the greatest impact on cost and schedule has been the estimated volume of soil contaminated by FUSRAP COCs. Thus, an investment in the reduction of volume uncertainty translates directly to greater precision in the out-year budget estimate and more efficient scheduling of program-wide funding in the long term.

Step 4: Cost and Schedule Risk Analysis

The results of steps one through three then serve as the basis of a statistical analysis that incorporates all of the risks. This mathematical evaluation determines how individual risks, and combinations of risks, can change the project cost and schedule. This risk analysis is applied to the base cost and schedule estimates, resulting in a range of contingency costs. These contingency amounts are added to the base cost and schedule estimates and are each associated with a confidence level. The higher the estimated cost and duration, the less likely the actual cost and schedule duration will exceed the estimate.

Step 5: Annual Updates

This process is refined each year to account for additional knowledge obtained about the sites. The cost estimate, schedule, and risk register are revised with new and current information, and the cost and schedule risk analysis is rerun to provide the most current range of contingencies for each project. As site knowledge increases, annual analysis will progressively decrease the range of cost uncertainty.

RESULTS AND CONCLUSIONS

The 2009 and 2010 volume uncertainty reduction sampling and analysis effort was conducted at the Luckey site, using American Recovery and Reinvestment Act (ARRA) funding, in an attempt to reduce the uncertainty in the estimate of contaminated soil volume. The data from this sampling effort was used by Argonne to develop an updated estimate of the contaminated soil volume requiring remediation [8]. This updated volume estimate was then used to update the project cost-to-complete estimate using the USACE Cost and Schedule Risk Analysis process, which develops cost contingencies based on project risks. An investment of $1.1M of ARRA funds for additional investigative work resulted in a reduction of 135,000 in-situ cubic meters (177,000 in-situ cubic yards) in the estimated base volume estimate. This refinement of the estimated soil volume resulted in a $64.3M reduction in the estimated project cost-to-complete, through a reduction in the uncertainty in the contaminated soil volume estimate and the associated contingency costs.

REFERENCES

1. USACE (U.S. Army Corps of Engineers), 2003, *Luckey Site, Luckey, Ohio, Feasibility Study Report*, Buffalo District, May.

2. USACE, 2006, *Luckey Site, Luckey, Ohio, Record of Decision for Soils Operable Unit (Final)*, Buffalo District, June.

3. Argonne (Argonne National Laboratory), 2006, *Development of $DCGL_{emc}$ Values for the FUSRAP Luckey Site*, prepared for U.S. Army Corps of Engineers, Buffalo District, December.

4. USACE, 2000, *Final Remedial Investigation Report, Luckey Site, Luckey, Ohio*, Buffalo District, September.

5. Argonne, 2007, *Luckey Site In Situ Contaminated Soil Volume Estimates (draft)*, prepared for U.S. Army Corps of Engineers, Buffalo District, May.

6. Argonne, 2005, *Bayesian Approaches for Adaptive Spatial Sampling (BAASS) Version 1.0: Users' Guide*, prepared by R.Johnson, D. LePoire, T. Klett, A. Huttenga, and J. Quinn, September.

7. USACE, 2011, *Final Report for the Excavation Volume Uncertainty at the Luckey FUSRAP Site in Luckey, Ohio*, Buffalo District, May.

8. Argonne, 2011, *Contaminated Soil Volume Estimates for the Luckey FUSRAP Site*, prepared for U.S. Army Corps of Engineers, Buffalo District, December.