Improving Remedial Planning Performance: The Rattlesnake Creek Experience

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ABSTRACT

The U.S. Army Corps of Engineers (USACE), Buffalo District, has responsibility for characterizing and remediating radiologically contaminated properties under the Formerly Utilized Sites Remedial Action Program (FUSRAP). Most of these FUSRAP sites include radionuclide contamination in soils where excavation and offsite disposal is the selected remedial action. For many FUSRAP soil remediation projects completed to date, the excavated contaminated soil volumes have significantly exceeded the pre-excavation volume estimates that were developed for project planning purposes. The exceedances are often attributed to limited and sparse datasets that are used to calculate the initial volume estimates. These volume exceedances complicate project budgeting and planning. Building on these experiences, the USACE took a different approach in the remediation of Rattlesnake Creek, located adjacent to the Ashland 2 site, in Tonawanda, New York. This approach included a more extensive pre-design data collection effort to improve and reduce the uncertainty in the pre-excavation volume estimates, in addition to formalizing final status survey data collection strategies prior to excavation. The final status survey sampling was fully integrated with the pre-design data collection, allowing dual use of the pre-design data that was collected (i.e., using the data to close out areas where contamination was not found, and feeding the data into volume estimates when contamination was encountered). The use of real-time measurement techniques (e.g., X-ray fluorescence [XRF] and gamma walkover surveys) during pre-excavation data collection allowed the USACE to identify and respond to unexpected contamination by allocating additional data collection to characterizing new areas of concern. The final result was an estimated soil volume and excavation footprint with a firm technical foundation and a reduction in uncertainty. However, even with extensive pre-design data collection, additional contamination was found during the excavation that led to an increase in the soil volume requiring offsite disposal. This paper describes the lessons learned regarding improving remedial planning performance from the Rattlesnake Creek experience and evaluates the level of project uncertainty reduction achieved through pre-design data collection.

INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Buffalo District has responsibility for characterizing and remediating radiologically contaminated properties under the Formerly Utilized Sites Remedial Action Program (FUSRAP). Most of these FUSRAP sites include radionuclide contamination in soils where excavation and offsite disposal is the selected remedial action. For many FUSRAP soil remediation projects completed to date, the excavated contaminated soil volumes have significantly exceeded the pre-excavation volume estimates that were developed for project planning purposes. These volume exceedances complicate project budgeting and planning, and are often attributed to limited and sparse datasets that are used to calculate the initial volume estimates. They result in suboptimal excavation designs, budget overruns, delayed project closeouts, and ultimately could raise significant questions among stakeholders regarding the performance of remedial activities. The volume exceedance could also result in concerns about over-excavation (i.e., excavating and disposing of soils that are below the cleanup criteria at a significant cost).

In response to these issues, and based on lessons learned from completed FUSRAP soil remediation sites, the USACE Buffalo District decided to take a different approach with Rattlesnake Creek. The overall goal was to lower the uncertainty associated with the contaminated volume estimate and contaminated footprint location prior to the onset of remedial activities. This paper describes the approach used to improve underlying datasets for project planning purposes at Rattlesnake Creek and the effects these efforts had on overall project performance.

RATTLESNAKE CREEK

The USACE Buffalo District is conducting cleanup of Rattlesnake Creek (RSC), a radiologically contaminated property as part of the FUSRAP program. RSC is an intermittent creek in the Town of Tonawanda, New York, that is downstream from the Ashland FUSRAP sites and was affected by residual radioactive contamination from these sites. RSC's watershed includes the Seaway, Ashland 1, and Ashland 2 site, all of which contained radioactively contaminated soils. RSC is a natural channel about 2,320 meters (m) long that ultimately joins the Niagara River. Near the Ashland sites, the channel is approximately 3 m wide and about 1 m deep at bank-full capacity. Thick vegetation in the channel hinders flow. Through most of its length, the Rattlesnake Creek floodplain averages approximately 30 m in width and is covered by a thick growth of reeds, cattails and bulrushes. Figure 1 illustrates the conditions in a portion of Rattlesnake Creek in the Fall of 2004. The Figure 1 photograph was taken after some clearing activities had begun.

The Remedial Investigation Report for the Tonawanda Site [1] did not identify Manhattan Engineer District (MED)-related radioactive contamination in the Rattlesnake Creek sediments. However, during the 1999 Ashland 2 remedial activities, a radioactively contaminated soil lens

Fig. 1. Portion of Rattlesnake Creek and floodplain.

was unexpectedly chased into the floodplain during the excavation. The USACE Buffalo District subsequently designed a data collection program that was intended to demonstrate that the remainder of the floodplain was not contaminated with MED-related radionuclides above the cleanup criteria. In 2000 and 2001, this data collection program generated more than 300 surface and subsurface soil samples distributed along the length of the creek. Subsurface soil samples were almost exclusively composites formed from 1-m deep soil cores. In some areas of the creek, surface and subsurface sample results indicated MED-related contamination at levels that precluded releasing or closing out the RSC floodplain area. The soil sample results indicated that some remediation (i.e. soil excavation and off-site disposal) would be required at RSC. The RSC potential area of concern was approximately 10 acres in size.

PLANNING PROCESS

As a first step in the planning process, the USACE Buffalo District reviewed all available historical data from the creek to determine their sufficiency for designing the necessary remediation. This analysis indicated that the likely volume of contaminated soil was between 15,000 cubic yards (yd^3) and 33,000 yd^3 *in situ*. More importantly, from an excavation design perspective, there were portions of the creek bed where data were absent and/or the subsurface composite samples made it impossible to confidently determine contamination depths. The USACE Buffalo District wanted to implement a fixed-price contract for the remediation effort. Consequently, they needed a much higher degree of confidence in contamination volumes and footprint than the existing data allowed.

In the course of RSC project planning meetings, a strategy was developed for addressing the data gaps for RSC in as efficient and cost-effective manner as possible. These steps included:

- Developing a closure protocol and accompanying Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)-based [2] *Rattlesnake Creek Final Status Survey Plan, Tonawanda, New York* [3] (FSSP). The goal was to have a clearly defined and stakeholder-accepted FSSP in place before any additional data collection took place. The intent was to make any additional data collection as consistent with FSSP needs as possible so that data collected during pre-design activities could be used for Final Status Survey (FSS) purposes if contamination was not encountered.

- Using “real-time” analytical methods to the extent possible for additional pre-design data collection as part of a dynamic work strategy. The goal was to be able to adjust data collection to bound the soil contamination vertically and/or laterally as it was encountered in the field.

- Producing a contaminated soil volume estimate and excavation footprint that had a confidence level sufficient to support a fixed-price contract. Part of the fixed-price contracting strategy for the remediation was to have all remedial activities completed by the end of the 2005 federal fiscal year. The USACE Buffalo District goal was to have the estimated contaminated volume correct to within ± 5%.

- Incorporating real-time data collection strategies as part of the remedial action to ensure that any buried contamination lenses encountered that extended beyond the design excavation footprint vertically or laterally could be identified and pursued in a timely fashion. This was particularly important for RSC since water management concerns required quickly backfilling excavation footprints as excavation progressed.

RSC CHALLENGES

RSC posed several technical challenges that made the remedial design and remedial activities particularly difficult. Thorium-230 was the risk driver for RSC. At the required cleanup level (i.e., 14 picoCuries per gram [pCi/g] per 100-square meter [m^2] area), thorium-230 is practically impossible to identify with real-time techniques in the field. At RSC thorium-230 was commingled with radium-226 and uranium-238, allowing the possibility of targeting either radium or uranium as a surrogate for detecting thorium with real-time measurement techniques.

For some portions of the creek, the contaminated sediment layer was overlain by clean sediments. The depth of the contaminated layer varied over the length of the stream from being exposed at the surface to being buried by almost 1 m of “clean” soils. For those portions of the creek where contamination was buried, scanning surface soils was not sufficient to conclude that no contamination was present. For all portions of the creek the depth of contamination was an open question not answered by historical subsurface composite sample datasets.

Finally, the fact that the creek at times (e.g., in spring, after heavy rain falls) carried a lot of water complicated investigation and remediation plans. In the case of remediation, removal of contaminated soils meant that water had to be controlled for the portion of the creek bed and floodplain undergoing excavation. This was potentially a very expensive component of the remediation work; consequently, the excavation work was designed as a series of small digs starting upstream and working downstream, with water management applied only to the open portion of a particular dig area. After the excavation was complete for a particular area, final status survey data were collected from the exposed excavated surface, which was backfilled as quickly as possible to try and minimize the cost of water management. This approach required backfilling before off-site laboratory analytical results were available for samples taken from the final excavation surface.

FINAL STATUS SURVEY PLAN

As part of the overall strategy, a RSC FSSP [3] was designed and reviewed by the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Environmental Protection Agency, Region 2, before any additional pre-design data was collected. This plan was designed to be as consistent with MARSSIM [2] as possible. As part of the plan, the RSC area of concern was defined and divided into survey unit classes. The Class 1 unit area corresponded to the upper reaches of the creek where at least some remediation by excavation was known to be necessary. The Class 3 area included the lower reaches of the creek where historical data did not indicate contamination concerns. The Class 2 area fell between the Class 1 and Class 3 areas. Footprints of individual survey units were deferred by the plan until all excavation was complete.

Consistent with MARSSIM, derived concentration guidelines levels for wide areas ($DCGL_w$) and for smaller elevated areas ($DCGL_{emc}$) were presented in the FSSP. To be consistent with the various requirements contained in the Record of Decision [4], the primary elevated area size was set at 100 m^2. Because there was no surface scanning method that would address buried contamination concerns, the plan required a soil coring density of at least one core per 100 m^2 area. The plan did recognize that scanning soil cores could be potentially very useful for determining the presence or absence of a contaminated lens.

Once the FSSP was finalized, attention turned to developing the *Field Sampling Plan for the Ashland-Rattlesnake Creek Site, Tonawanda, New York* [5] (FSP) that would guide pre-design data collection activities. The FSP was developed to be consistent with the FSSP, i.e., the analytical methods and associated quality assurance/quality control (QA/QC) requirements were such that the data produced by the pre-design work could be used for FSS purposes as well.

REAL-TIME ANALYTICAL METHODS

Real-time analytical methods are defined as methods that return results quickly enough to influence the progression of field work. Real-time methods were critical components of the FSSP and the FSP. They were used to screen subsurface soil cores for the presence or absence of contaminated soil layers, and consequently for identifying particular soil core intervals that warranted further investigation by off-site laboratory analysis and determining the depth of contamination. They were used to scan large surface areas for evidence of surficial contamination. They were used during and immediately after the remediation work to ensure that the final exposed excavated surfaces (soil walls and floor) did not exhibit evidence of potential contamination above the cleanup requirements. The last capability was absolutely necessary since the excavations had to be backfilled for water management reasons long before final status survey sampling results from the exposed excavated soil surface were available from the laboratory.

Two primary real-time methods were used at RSC. The first was X-Ray Fluorescence (XRF) for quickly screening for the presence of elevated uranium in soil cores. As part of the FSSP preparation process, a subset of the 2000 and 2001 historical archived samples retained by the USACE was evaluated using XRF to determine its ability to accurately quantify total uranium (U-238, U-235, and U-234) and to use total uranium as a surrogate for indicating elevated levels of thorium-230. Based on that positive experience, XRF was built into the FSP and FSS process. One critical assumption was that the very limited archived dataset and its associated thorium/uranium ratios would be representative of the whole of RSC. XRF was used to screen subsurface soil cores collected as part of the FSP. Based on the XRF results, some core intervals were selected for full alpha and gamma spectroscopy analysis by an off-site lab. Figure 2 shows the XRF unit used in a bench-top configuration.

Fig. 2. XRF unit in a bench-top configuration.

The second real-time method was gamma walkover surveys (GWS) using a 3×3 NaI detector. GWS implemented with Global Positioning Systems and data logging capabilities have been an essential element of investigation and remediation work at other USACE Buffalo District FUSRAP sites. The potential performance of GWS at RSC was of concern, however, for two reasons. First, because the RSC flood plain is partially or completely covered with water at various times of the year, access was a potential issue. Secondly, the GWS would primarily be targeting radium-226 (collocated with thorium-230). An analysis of historical data for RSC suggested that to reliably identify thorium-230 at its cleanup levels would require identifying radium-226 at approximately 2 pCi/g, which is approximately 1 pCi/g above RSC Ra-226 background levels. That low level was expected to be in the range of detection capabilities for the 3×3 NaI detectors. GWS were to be used to determine where biased samples should be collected from exposed soils for off-site laboratory analysis because of the potential for exceeding the cleanup criteria.

PROJECT PERFORMANCE

The original plan called for one round of pre-design data collection activities in the spring of 2004. More than 300 soil core locations were initially identified within the RSC area of concern. However, several factors quickly complicated these plans, resulting in a second follow-up pre-design data collection deployment in the fall of 2004.

The first complication was the weather. The spring of 2004 turned out to be unusually wet; while the contractor was able to work around flowing water conditions to retrieve soil cores at all of the targeted locations, conducting GWS was virtually impossible. Figure 3 shows some of the conditions associated with the soil coring work in March of 2004. Figure 3 illustrates the coring rig adapted with a specially-designed steel cylinder to de-water soil core locations prior to and while pushing and removing the soil cores.

The second complication was the discovery during the course of the field work of areas of potential concern that extended beyond the original area of concern. This discovery was not a result of field surveys or laboratory analytical results. Rather, it was partly the result of grubbing and heavy undergrowth removal that helped to better visually define the extent of the flood plain, and partly the result of better, more detailed historical aerial photography that was obtained for the RSC area.

The third complication was detecting contamination through surveys and laboratory analytical results that extended beyond the initial area of concern. In one portion of the creek this took the form of contaminated spoils piles found along the bank, apparently the product of historical creek dredging activities. In another portion of the creek a buried lens was encountered that was not bounded by the planned soil core locations. Because the pre-design investigation work was also on a firm fixed-price contract with only limited flexibility for extending data collection (particularly, the number of soil cores) beyond the original scope, follow-up investigative work of these additional areas required a second mobilization.

Fig.3. Soil coring activity in March of 2004.

The fourth, and most significant complication from the project’s perspective, was the discovery of a push-out pile that appeared to extend into what may have been the original creek’s floodplain. The push-out pile was associated with an abandoned fuel storage facility. One of the soil cores placed at the foot of this push-out pile also encountered volatile organic contamination.

The fall 2004 follow-up data collection targeted the bounding of contaminated areas that could not be completed in the spring, characterizing extensions to the area of concern, and obtaining GWS data.

The results from the historical datasets (pre-2004) and the 2004 data collection efforts fed the volume estimates. The level of pre-design data collection was significant: almost 3,000 XRF analyses were performed, and almost 1,000 samples were sent for off-site laboratory analysis. The resulting volume estimate was 16,500 yd^3 of *in situ* contamination exceeding the cleanup guideline and a detailed excavation footprint with varying excavation soil depth. Excavation work started on schedule in the spring of 2005 and was completed on schedule late in the summer of 2005. This schedule was aided by the unusually dry summer the Buffalo area experienced which kept water management issues to a minimum. The excavation work removed 19,591 yd^3 of soil for disposal, 3,091 yd^3 more than estimated. Some of this came from expansions in the excavation footprint laterally and vertically in pursuit of contamination that extended beyond the original design excavation footprint. The bulk of the increase, however, came from contaminated soils within the push-out pile that were addressed by the excavation but not included in the original contaminated volume estimate. These were not originally included because there was initially concern that the push-put pile would have to be addressed by a separate excavation effort and the data were insufficient at the time to estimate what the scope of the problem might be. While the volume was more than projected, the disposal costs per cubic yard were less than projected because of drier, lighter material being sent for off-site disposal. Because disposal costs are ultimately driven by weight and not volume of material, the project was completed within budget.

Real-time technologies (XRF and GWS) played an important role in the project but were not without their own complications. The XRF performed as well as anticipated for quantifying total uranium present, and in fact was so successful that NYSDEC purchased their own unit. Detection limits of approximately 20 ppm total uranium were achieved with 120 second measurement times at per sample costs that were significantly less than an off-site laboratory analysis would have been. However, the ratios between total uranium and thorium-230 turned out not to be as consistent as first expected. During the 2004 pre-remediation investigations, the field investigation level (the level below which it was assumed thorium-230 was not present above cleanup guidelines) had to be dropped from 90 to 40 ppm for total uranium. For the north branch of the creek, thorium contamination was present without appreciable collocated uranium, making XRF data not very useful in this area of the creek. For the bulk of the RSC, however, the XRF provided reliable data to guide the excavation footprint design and volume estimate.

The project team was unable to develop a field investigation level for the GWS datasets that could reliably identify thorium-230 concerns without generating a large number of false positives. The issue with the GWS was not its intrinsic sensitivity, but rather the fact that fluctuations in background gross activity across RSC were on the same order as the incremental response expected from the system when thorium-230 (and consequently associated radium-226) was at levels of concern and the fact that radium-226 and thorium-230 ratios varied across the RSC area. As a result, the GWS datasets were mapped and reviewed primarily looking for trends in data (e.g., isolated slightly elevated areas at the bottom of an excavation or along a particular excavation wall) that might indicate potential problems. Based on GWS data and biased *in situ* XRF readings, the excavation was selectively expanded laterally or vertically in some instances. Figure 4 compares the actual to the planned excavation footprints for RSC.

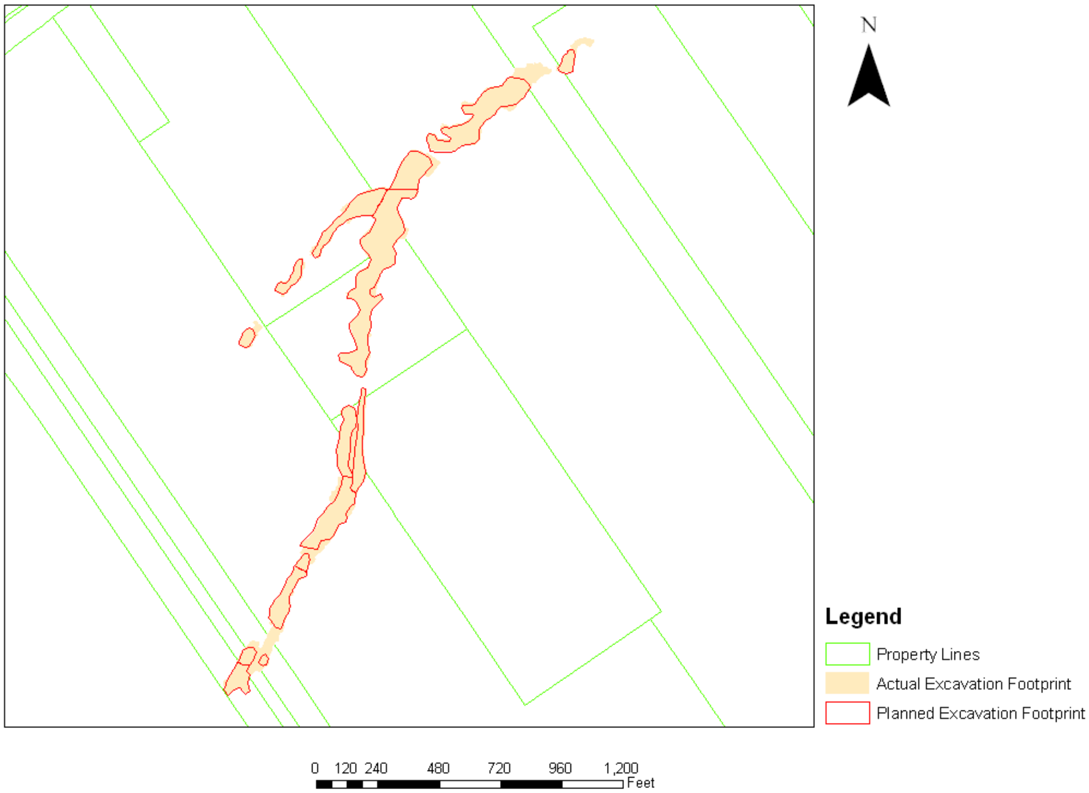

Fig. 4. Actual versus planned excavation footprints

The GWS of exposed excavation footprints did allow final status survey sampling to take place post-excavation with a high level of confidence that the unit would pass. This was critical, because for every excavated area, backfilling occurred within two to three days of the excavation being complete, leaving just enough time to scan the surface and collect samples, but no time for off-site laboratory analyses to be returned. It was essential that this be done from a water management perspective. However, backfilling the units before laboratory results were available placed each of the units at risk of requiring re-excavation based on final status survey laboratory results. Out of the 270 final status survey samples collected from the exposed excavated soil surface, there were only five instances representing five final status survey samples where limited re-excavations were necessary based on laboratory analytical results after areas were backfilled.

Of the almost 500 soil core locations sampled in 2004 as part of the pre-design data collection activities, approximately 280 fell outside the final excavation footprint. Because the samples collected from those locations had been handled and analyzed consistent with the Final Status Survey Plan requirements, their data could be used to demonstrate that the areas their locations represented met the Record of Decision requirements as part of the final status survey process.

CONCLUSIONS

RSC provided the USACE Buffalo District with the opportunity to leverage its experiences from past FUSRAP sites to address volume estimation, remedial design and scheduling issues commonly encountered in soil remediation activities. The USACE project management responded by altering the approach to remediation design and implementation. The strategy included developing the Final Status Survey Plan first, designing and implementing a significant pre-design data collection program to improve the data foundation for volume estimation, and incorporating real-time measurement technologies to the extent possible in the investigation and remediation effort. The result ultimately was a remedial action that was within schedule and budget using fixed-cost contracts, with relatively low increases in actual volume removed as compared to original estimates. The work, however, underscored two important facts: that fixed-cost contracts are a relatively inflexible mechanism for implementing investigation programs that are inherently dynamic in nature, and that no matter how much is invested in pre-design data collection, the reality of the varying characteristics of subsurface radioactive contamination means that some surprises and scope growth are almost inevitable.

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