Remediation of Uranium Impacted Sediments in a Watercourse - 12486

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ABSTRACT

In 2009, remediation was initiated for a non-operational fuel cycle facility previously used for government contract work. Between 2009 and the spring of 2011, remediation efforts were focused on demolition of contaminated buildings and removal of contaminated soil. In the late spring of 2011, the last phase of remediation commenced involving the removal of contaminated sediments from portions of a 1,200 meter long gaining stream.

Planning and preparation for remediation of the stream began in 2009 with submittal of permit applications to undertake construction activities in a wetland area. The permitting process was lengthy and involved securing permits from multiple agencies. However, early and frequent communication with stakeholders played an integral role in efficiently obtaining the permit approvals. Frequent communication with stakeholders throughout the planning and remediation process also proved to be a key factor in timely completion of the project.

The remediation of the stream involved the use of temporary bladder berms to divert surface water flow, water diversion piping, a sediment vacuum removal system, excavation of sediments using small front-end loaders, sediment dewatering, and waste packaging, transportation and disposal. Many safeguards were employed to protect several species of concern in the work area, water management during project activities, challenges encountered during the project, methods of Final Status Survey, and stream restoration.

INTRODUCTION

In 2009, remediation was initiated for a non-operational fuel cycle facility previously used for government contract work. Between 2009 and spring of 2011, the work consisted of remediation of several areas of uranium-impacted soil, decontamination and demolition (D&D) of two impacted building structures (including the slab and underlying process piping and utilities), and removal of over 1,100 meters of buried waste line piping. Late in the spring of 2011, the last phase of remediation addressing the removal and off-site disposal of uranium-impacted sediments from portions of an approximately 1,200 meter long gaining stream, known as the “Site Brook”, commenced. In November 2011, the remediation and restoration of Site Brook was completed. The following presents a discussion of safeguards employed to protect several species of concern in the work area, water management during project activities, challenges encountered during the project, methods to conduct Final Status Surveys (FSS), and post-remediation stream restoration.

BACKGROUND

The Site Brook headwaters from the outlet of an agricultural pond and flows northwest for approximately 1,200 meters until it discharges into a river. Historically the Site Brook received industrial and diluted radiological waste water discharge during a portion of the facility operational period and storm water run-off. Discharges to the Site Brook included treated sanitary wastewater, industrial wastewater, and diluted radioactive wastewater. Uranium was used in the processes that generated discharges to the Site Brook, and uranium was present in the Site Brook floodplain soils and sediment.

The floodplain topography along the Site Brook is well defined along most of the northern and southern banks of the brook, with a 30-meter difference in elevation between the top of the bank and the streambed. The Site Brook sediment is dominated by coarse material, with little silt or clay. The surface organic materials are underlain by fine washed sands at approximately 15-centimeters below ground surface. Surface water depths are generally less than 30-centimeters, and the flow rate within the brook has been estimated at 0.45 meters per second or less.

The uranium contamination identified in Site Brook floodplain soil and sediment was a result of the deposition of uranium from waste water that under pre-1970 requirements met permissible regulatory discharge limits or otherwise was allowed. Because the uranium was in an insoluble oxide chemical form, the material when discharged to the waterway would physically accumulate in Site Brook floodplain soils and sediments in depositional areas (areas with slow water velocity). Over time the accumulation of uranium in these depositional areas caused the soil/sediment to exceed the site-specific Derived Concentration Guideline Limits (DCGLs). The waterway also served as the discharge point for former naval nuclear prototype training reactor effluents. Consequently, in addition to the uranium, there were minor amounts of Co-60 detected within the floodplain soil and sediment.

Between 1993 and 2011, several radiological surveys of the Site Brook floodplain and sediments were completed to characterize impacts. The decommissioning plan prepared for the remediation specified the DCGLs for Co-60 (0.185 Becquerel per gram [Bq/g]) and total uranium (20.6 Bq/g).

The remedial design incorporated the historical survey data initially to approximate the remediation areas (areas of floodplain soil and sediment that exceeded the Site DCGLs). Prior to mobilization of the remediation contractor, a pre-construction radiological characterization effort was completed to further refine the limits of remediation.

Planning for remediation of the waterway was driven by the need to remove impacted floodplain soil and sediments while limiting the impacts to the surrounding ecological environment. The Site Brook remediation included soil and/or sediment excavation from wetlands, the wetland buffer zone (46-meter set-back from the delineated wetland boundary), and upland areas. All of these areas are ecologically sensitive areas that require regulatory permits to minimize impacts to the ecological environment and ensure the waterway ecology was restored as close as reasonably possible to its original condition. Additionally, three species of concern were identified at the site, which also required preventative measures to be implemented to minimize any impacts to these species and their habitats.

PERMITTING

Remediation of the Site Brook included obtaining the following permits:

- A Section 404 Clean Water Act permit from the United States Army Corps of Engineers required to conduct work “in waters of the United States”;
- A Section 401 Clean Water Act permit from the state required under the Federal Water Pollution Control Act (Water Quality Certification); and
- Floodplain development plan approval under the local town’s floodplain management regulations.

The process time from initial applications to approval was eighteen months and required a significant effort and coordination between AMEC, on behalf of ABB, regulatory authorities, and other stakeholders. Early and frequent communication with stakeholders during the permit application process played an integral role in efficiently obtaining the permit approvals. The permit applications included submittal of the proposed means and methods for conducting the work and a detailed restoration plan for the wetlands, wetland buffer, and upland areas. The applications included a description of the methodologies for limiting tree and foliage removal in the wetlands area and protection methods for three species of concern.

The permit application packages included the following components:

- Description of the proposed activities and remediation methodologies;
- Engineering Report;
- Flood Contingency Plan;
- Soil Scientist Report;
- Environmental Site Characterization Report; and
- Restoration Plan.

PRE CONSTRUCTION RADIOLOGICAL CHARACTERIZATION

In planning the remediation, characterization data from the historical surveys was plotted and evaluated. The evaluation revealed that contaminants in the sediment were not highly mobile; however, the survey data had a large degree of coordinate uncertainty (i.e. the highest activities could be found in the same general area and the same basic shape but the exact data points varied by as much as 1 to 3 meters). Consequently it was decided to perform a systematic survey by creating and surveying the stream in 6-meter by 6-meter grids using 5-centimeter by 5-centimeter sodium iodide detectors. Because the surveying was performed in the stream channel where surface water was present over the sediment, special water tight coverings were designed for the detectors scanning the stream channel sediment.

In addition to the in-stream surveys, sediment samples were collected using a hand auger from each grid where an elevated count rate greater than background was identified. Where there were multiple elevated readings, the highest readings were selected for sampling as well as those that bordered the area being scanned. Sediment samples were analyzed for uranium and Co-60 in an on-site laboratory using gamma spectroscopy. Data from the pre-remediation characterization effort were plotted and evaluated. The evaluation reduced the number of areas requiring remediation from nine to five with a concomitant reduction in anticipated waste volume of approximately 765 cubic meters in total.

REMEDIATION MEANS AND METHODS

The approach used to excavate impacted floodplain soils and sediments was to surgically remove material to minimize the footprint of disturbance and minimize impacts to the ecological setting. Remediation began at the furthest upstream location and proceeded downstream to eliminate the potential for recontamination of areas through sediment transport.

For excavation of areas within the stream channel, installation of a surface water diversion system was used to convey stream flow around the excavation area and reduce/eliminate the flow of surface water through the excavation. The use of the water diversion system allowed for the downstream areas of the Site Brook to continue to receive surface water flow, minimizing impacts to the brook ecosystem.

The water diversion system (Figure 1) consisted of temporary bladder berms installed upstream (to divert surface water flow in the stream channel) and downstream (to prevent groundwater infiltration from flowing out of the remediation area) and surface water conveyance piping consisting of 90-centimeter diameter corrugated polyethylene pipe. The water diversion system was supplemented with the installation of sand bags to seal leaks around the bladder berms. In order to control scouring from the water discharging from the surface water conveyance piping, 10-millimeter thick plastic sheeting with block diffusers was installed at the discharge end of the pipe. At the Site Brook outfall to the receiving river, a 5-centimeter deep turbidity curtain was installed as an additional measure to control any sediment that may have migrated past the primary control measures installed upstream.

Fig 1. Water diversion using bladder berms.

The diversion system was installed at each remediation area prior to remediation and left in place until final restoration was completed to divert surface water flow. Groundwater recharge into the excavation area was collected in a sump installed in the excavation area and pumped to a holding tank for radiological sampling and analysis prior to treatment (if needed) via filtration and discharge to the Publicly Owned Treatment Works (POTW). The permit issued for the project required discharge to the POTW to be limited to 95,000 liters per day, so it was necessary to have some water storage capacity during the project. Work crews for pumping and management of the collected water were established on a 24-hour/7-day basis.

In order to expedite the remediation, two sets of upstream/downstream bladder berms were used and “leap-frogged” down the Site Brook so that once excavation of an area was completed, restoration activities in the area would begin and the excavation activities would move to the next downstream location where the other water diversion system was already in place. Once excavation of an impacted area was completed but not yet verified by FSS, it was covered with 6-millimeter thick polyethylene held in place with sand bags to minimize the amount of precipitation contacting the sediments that would need to be collected, analyzed, treated, and discharged. Plastic was overlapped from upstream to downstream so that any water accumulation would not have come into contact with the underlying soils so it could be pumped downstream as clean water.

The issued permits allowed the use of a vacuum system, small excavation equipment, and/or hand tools to excavate material from the Site Brook. The vacuum system was the initial method attempted for excavation of contaminated soil/sediment in an effort to reduce the impact of equipment in the wetlands (and reduce the amount of restoration needed). The vacuum system was positioned approximately 150-meters outside of the remediation area and a long suction hose was used to vacuum impacted material from the remediation area. It quickly became apparent that due to the mix of root mass material, the presence of trees and stumps, and other debris in the remediation areas, the vacuum system was not effective. The excavation methodology was changed to use small excavators that were “walked” into the remediation areas atop high-density polyethylene inter-locking mats to protect the ecological setting and minimize impacts from the excavation equipment. Excavated material was placed into 0.8 cubic meter shipping bags and the bags were transferred to a waste storage area for dewatering and off-site disposal. Figure 2 shows excavation activities in an area of Site Brook.

Fig 2. Excavation activities in an area of Site Brook.

Remediation of the Site Brook was complicated further by the impact of Hurricane Irene in August and an unusually large snow storm and subsequent snow melt in the last week of October. These events generated large quantities of water to be managed, caused wide-scale area power outages, and caused significant tree destruction in the area. Because of proper planning and preparedness, these events resulted in only a two week schedule loss with the FSS and restoration activities being completed in early November. Frequent communication with stakeholders throughout the remediation process also proved to be a key factor in timely completion of the work by keeping stakeholders informed on the progress of the remediation and by quickly identifying and resolving issues that arose.

WORK CONTROLS AND FINAL STATUS SURVEY

During remediation it was necessary to pre-characterize the actual volume of waste being removed in order to ensure license requirements for handling special nuclear material (SNM) were maintained. To aid this effort a "quick counter" system was established near the remediation areas such that samples could be counted for a minute and a conservative approximation of the U-235 content made.

Prior to turn-over for FSS, a radiological scan was completed and excavation control samples were taken from the remediated area. This effort was undertaken to minimize the potential for FSS failure. This effort proved valuable in one of the remediation areas where an impacted silt layer was overlain by up to 15-centimeters of un-impacted sediment. The follow-up survey prior to the FSS resulted in the removal of an additional 76 cubic meters of contaminated material.

The FSS of the Site Brook was performed using both 5-centimeter by 5-centimeter sodium iodide detectors and 12-centimeter by 5-centimeter sodium iodide detectors for scanning. Again, special water proof housings were used to protect the detectors during scanning. The Site Brook, based upon characterization data, was divided into five Class I and four Class II survey units. Class I areas are defined as those that potentially have contamination that exceeds the DCGL, while Class II areas have potential contamination that is less than the DCGL. To successfully complete the FSS surveys and perform restoration in a timely manner, coordination with the State and the Nuclear Regulatory Commission (NRC) oversight was maintained to ensure their validation surveys followed within days of the FSS. The regulatory response was always expeditious and the service aided greatly in the successful completion of the project.

RESTORATION

Upon completion of excavation of contaminated material and after completion of the FSS that demonstrated the area met DCGLs, and state and NRC verification was completed, restoration of the excavation areas was performed. The restoration baseline was established using the extensive photographs and reconnaissance information that was collected prior to conducting intrusive work in the brook.

The excavated and disturbed segments of the Site Brook were restored with substrate closely matching that which had been removed. Backfilling of the stream channel was performed using materials that were similar to those within the existing stream bed (i.e., similar grain size and material type). The stream channel was reconstructed to closely match the existing channel, taking into consideration the flow path, entrenchment, and sinuosity of the existing channel. Wetland soil was blended using a mixture of organic material and mineral soil. Equipment used to transport wetland and stream channel backfill was limited in size to minimize impacts during the wetland and upland restoration. A wetland seed mixture was sown to promote re-vegetation of disturbed areas and woody debris was used to stabilize the wetland soil. Mulch and leaf litter were used to stabilize disturbed upland areas. Likewise, areas used for accessing the Site Brook remediation segments were restored and disturbed soils stabilized to prevent erosion.

Once the remediation, FSS and verification surveys, and stream restorative efforts were completed, the temporary diversion features were removed and surface water flow was restored to the area, and any remaining wetland/upland restoration was completed. Work then commenced, through a similar sequence at the next consecutive downstream remediation area.

Finally, once remediation and restoration activities at all of the segments had been completed, temporary access roads were removed and areas impacted by the temporary access roads were restored to original grade and stabilized. Disturbed soils were stabilized to prevent erosion until suitable vegetative cover was re-established. The restoration of the remediation areas in and along the Site Brook and the areas impacted by temporary access roads will be monitored and maintained for 10 years as required in the permits. Figure 3 shows an area of Site Brook before remediation. Figure 4 shows an area of Site Brook after remediation and restoration.

Fig 3. Site Brook conditions before remediation.

Fig 4. Site Brook conditions after remediation and restoration.

The impact of Hurricane Irene and the early snow storm at the end of October created project delays, and also created concerns as to whether the late restoration plantings would be successful. Unusually warm weather in October and November helped to ameliorate any problems associated with the late plantings. As of the end of November, the plantings appeared to have successfully rooted. A review in the spring of 2012 will determine the success of the late plantings and if any lost plantings must be replaced.

SUMMARY

The planning and permitting effort for the Site Brook remediation began in May 2009 and permits were approved and in place by February 2011. The remediation and restoration of the Site Brook began in April 2011 and was completed in November 2011. The remediation of the Site Brook involved the use of temporary bladder berms to divert surface water flow, water diversion piping, a sediment vacuum removal system, excavation of sediments using small front-end loaders, sediment dewatering, and waste packaging, transportation, disposal, FSS, and restoration. Early and frequent communications with stakeholders proved to be a key factor in timely completion of the project.

Challenges encountered during the remediation effort were overcome by proper planning and having preparedness procedures in place prior to executing the work. With the remediation and restoration successfully completed, the only remaining task is to monitor/maintain the restoration for 10 years.