CHAPTER 31

In Situ Contaminated Sediment Management: Unique Case Studies

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ABSTRACT

In situ management of contaminated sediments, sometimes known as in situ capping or ISC, is often a feasible and cost effective alternative to the removal of the contaminated sediments. In many cases, removal of contaminated sediments is not practical due to its accessibility, its disposition relative to the water body's use, its impact on the environment upon resuspension, its impact on the ecological system upon removal, or its shear costs for removal and management. This paper presents three unique case studies where ISC was used to manage some or all of the contaminated sediments in place at projects where sediment removal was contemplated or performed. These projects were located within an embayment area of the St. Lawrence Seaway near Massena, New York, within an inland cove directly off of the Hudson River in Cold Spring, New York, and within Little Elk Creek in Elkton, Maryland. The case studies are considered unique as they all involve multi-layered containment systems with each layer of the system serving a separate function (i.e., protective layer, barrier layer, etc.). Further, two of the three cases involve geosynthetics as the primary containment function within the cap.

INTRODUCTION

The management of sediments contaminated by point- and non-point-source discharges can be performed in several ways depending on site-specific, participant-specific, and regulatory factors. Sediment management alternatives range from no action with a monitoring element to wholesale removal of the sediment followed by treatment (as necessary) and disposal. Between this range of alternatives is in situ (i.e., in place) sediment management, sometimes known as in situ capping or ISC. In many instances, ISC offers a practical and effective alternative to sediment removal while still being able to meet the remediation objectives of the project. This alternative is often superior in light of the downsides of the no action and removal alternatives. The downsides of the no action alternative include continued exposure to the contaminants and potential spread of contamination to non-contaminated areas. For the removal alternative, the downsides include hydraulic, navigation, and accessibility restrictions, potential recontamination, ecosystem destruction, and economic prohibitiveness. Based on these downsides and assuming that ISC is effective in meeting the remediation goals of the project, it often becomes the most practical alternative in a comparative evaluation. This paper provides an overview of in situ management followed by three unique case studies where ISC was successfully implemented. The case studies are considered unique as they all involve multilayered containment systems with each layer of the system serving a separate function (i.e., protective layer, barrier layer, etc.). Further, two of the three cases involve geosynthetics as the primary containment function within the cap.

IN SITU VERSUS EX SITU SEDIMENT MANAGEMENT

Ex situ sediment management involves the removal of sediments that have been impacted by the deposition of point- or non-point-source contaminants. Sediment removal is normally performed by one of two methods; 1) hydraulic dredging, or 2) mechanical dredging. In hydraulic dredging, the contaminated sediments are suctioned and pumped in a slurry form to a holding or treatment area. As part of the hydraulic dredging, disturbance of the sediments at the point of suction is performed to free the sediments from the bottom. In mechanical dredging, the sediments are removed directly by excavation or other similar techniques. In either case, many factors enter into the feasibility of the removal. These factors include restrictions on accessibility due to location or depth of the sediments, restrictions due to navigational uses of the water body, concerns over spread of contamination due to disturbance of the contaminated sediments, concerns over damage or destruction of the ecosystem within the sediments, and cost prohibitiveness due to the magnitude of the removal area.

ISC also possesses downsides. These include feasibility of installation based on the same location, depth, or navigational restrictions as with ex situ management and the inherent ability of the cap to meet the remediation goals of the project. Considering all these factors and assuming that ISC satisfies the remediation goals of the project, ISC in some cases becomes the most practical and cost effective remedial alternative.

IN SITU SEDIMENT MANAGEMENT PURPOSE AND MATERIALS

In situ sediment management is normally performed to satisfy one or more of the three objectives listed below:

- Prevent the release or spread of contaminants due to disturbance by wave action, currents, propeller wash, or other erosive actions;
- Isolate the contaminated sediments from direct exposure to humans or ecological receptors, and;
- Prevent the release of contaminants to the water column.

There are two fundamental types of media used in ISC. They are natural materials such as sediments, sands and gravel, and geosynthetics such as impermeable membranes, geotextiles, and geosynthetic clay liners. This paper provides three case studies where all of the projects utilized multi-layered caps with each cap layer serving a separate function. Two of the projects employed both natural and geosynthetic materials in the cap.

Case Study 1: General Motors—Massena Superfund Site, Massena, NY

From May to December 1995, General Motors Corporation (GM) removed approximately 13,000 cubic yards (cy) of PCB-impacted sediment from an embayment area of the St. Lawrence Seaway near Massena, New York. In one portion of the removal area, the clean-up objective could not be achieved despite numerous passes with a hydraulic dredge. In this area, it was decided to install a sediment cap to contain the remaining PCB-impacted sediments. The cap area is approximately 75,000 square feet.

The sediment cap was designed to provide both chemical and physical isolation of the remaining sediments from the water column. The cap design consisted of three layers as shown in Figure 1. The cap system consisted of the following components listed from the bottom up:

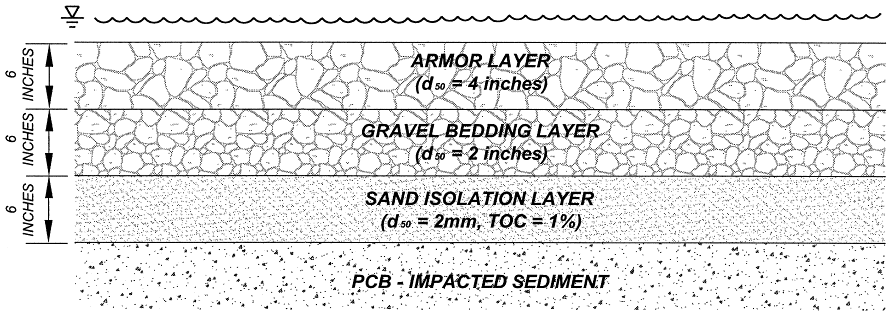

Figure 1 **In Situ Cap Case Study 1: General Motors Superfund Site, Massena, NY**

- A 6-inch thick sand isolation layer
- A 6-inch thick gravel bedding layer
- A 6-inch thick armor layer.

The sand isolation layer consisted of a medium to coarse sand with a minimum total organic carbon content (TOC) of 1%. The TOC provided the chemical isolation element to minimize the upward diffusion of PCBs through the sand and into the water column. The sand, supplied by a local quarry, did not contain the required TOC and therefore had to be mixed with granular activated carbon at the site prior to placement. The gravel bedding layer consisted of gravel with a median grain size (d_{50}) of 2 inches. The armor layer consisted of gravel with a d_{50} of 4 inches. Both the bedding and armor layers provided erosion protection for the isolation layer. The design of the gravel bedding and armor layers was based on USACE and USEPA guidance documents. Erosive forces from wave action, river flow velocities, ice scour, and propeller wash were considered during the design. The propeller wash was considered to be the most critical erosive force for design purposes.

Installation of the sediment cap was performed using a barge-mounted trackhoe. The barge contained the trackhoe, two roll-offs, and a winch system to raise and lower the spud anchoring system. The roll-offs on the barge were loaded with the sand or gravel from shore by a separate land-based trackhoe. Once both roll-offs were filled, the barge was self-propelled via the barge-mounted trackhoe to the current capping area. The capping material in the roll-offs was then dumped one bucket at a time through the water column onto the capping area until the material on the barge was exhausted. The barge then returned to shore to reload. Depth of water in the capping area varied from zero feet (shoreline areas) to approximately 15 feet.

Based on the post-capping cross-sections as well as the actual cap material quantities used, there appears to be some variability and inefficiency in the final cap product. It appears that all areas of the cap received the minimum amount of capping material; however, many areas of the cap received as much as six times (3 feet as opposed to 6 inches as designed) the required depth of material. Based on an average tonnage of material installed and the area of the cap, approximately 220% of the required amount of sand, 175% of the required amount of gravel bedding, and 140% of the required amount of armour stone were installed in the cap. The variability is assumed to be due to the installation technique.

Case Study 2: Marathon Battery Remediation Project, Cold Spring, NY

The Marathon Battery Remediation Project is located on an inland cove directly off of the Hudson River in Cold Spring, New York. The contaminants of concern at Marathon were cadmium and nickel in the sediments which were the result of point-source discharges into a marsh and the Hudson River from a battery manufacturing facility. The Marathon project consisted of three separate clean-up areas, one of which was Area I, the East Foundry Cove Marsh (EFCM). The Record of Decision (ROD) for the EFCM called for hydraulic dredging, chemical fixation of dredged sediment with off-site disposal, dredge water treatment and disposal, restoration of the marsh, and long-term monitoring. The restoration of EFCM according to the ROD included the installation of 12 inches of topsoil over a 12 inch layer of clay having a high affinity for cadmium. The construction specifications modified the requirements in the ROD and called for the placement of 6 inches of capping material, a silty clay loam with a cation exchange capacity (CEC) of no less than 60 meq/100 gm, beneath 12 inches of sandy loam planting material.

During and following the bidding process, the successful bidder proposed several Value Engineering Change Proposals (VECPs) for the project. One of the VECPs was to use a geosynthetic clay liner (GCL) in place of the 6 inches of capping material as specified in the construction specifications. The proposal was based primarily on the practicability of installing and compacting 6 inches of clay in a marsh consisting of low bearing capacity material (peat). The GCL was considered an acceptable substitution for the 6 inches of capping material to provide the required CEC. The resulting marsh cap cross-section is shown on Figure 2.

As the EFCM is a tidally-influenced marsh containing as much as 3 feet of water at mean high tide, a dike was built around the marsh to temporarily isolate the work area from the tidal water during sediment removal and restoration. In accordance with the ROD, sediments containing greater than 100 parts per million (ppm) total cadmium were removed followed by the installation of the GCL and the overlying planting material. Once planting

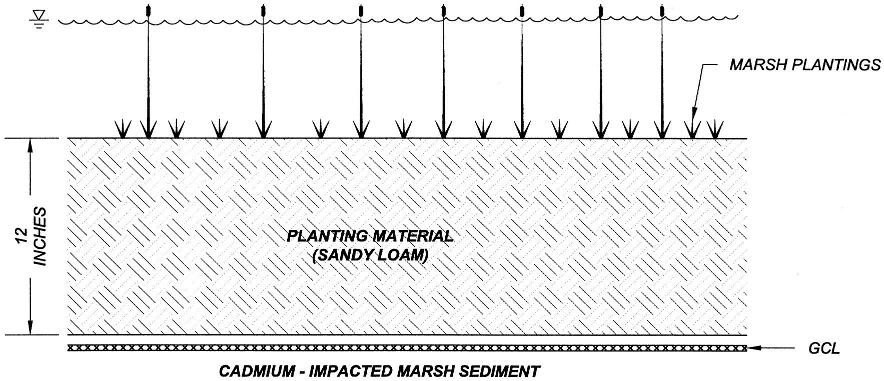

Figure 2 **In Situ Cap Case Study 2: Marathon Battery Remediation Project, Cold Spring, NY**

material installation and grading was complete, container-grown wetlands plants were planted in the marsh.

Installation of the cap system in the marsh was performed with only minor complications. The marsh subgrade following sediment removal was not uniform as is the case in a landfill system where GCL is normally deployed. Also, some areas of the marsh contained standing water. Therefore, excess GCL panel seam overlaps were required. This resulted in additional GCL material being used. Immediately following marsh planting, predation resulted in higher than expected plant loss. Minor erosion of the planting material was also noted in isolated areas. Additional plant loss was also experienced due to ice scour during the first winter following remediation. In isolated areas of the marsh, upward groundwater flow created bubbles in the GCL which required installation of additional overburden soil. Re-establishment of wetland vegetation is continuing as witnessed by the periodic operation and maintenance inspections and there is evidence of return of ecological receptors (e.g., muskrats) which were not present prior to remediation in the marsh.

Case Study 3: Galaxy/Spectron Superfund Site, Elkton, MD

The Galaxy/Spectron Superfund Site is located in Elkton, Maryland. The contaminants of concern were volatile organic compounds (VOCs) and dense non-aqueous phase liquids (DNAPLs) resulting from both point and non-point source discharge of organic solvents from a solvent recycling facility located along Little Elk Creek. The cleanup work was performed as a Removal Action (RA) which originally required improving the water quality in Little Elk Creek via sediment removal and groundwater pumping. However, because DNAPLs were present in the groundwater, sediments, and bedrock (beneath both the site and Little Elk Creek), groundwater pumping would not isolate all the sources of contamination. Also, the removal of the contaminated creek sediments via excavation would not prove successful in removing the DNAPLs from the deep Creek sediments and underlying bedrock. Therefore, a stream isolation concept via a liner (consisting of both a barrier layer and protective layer) with a passive groundwater collection system installed beneath the liner was designed to separate the surface flow of the Creek from the groundwater discharges and Creek sediments.

A cross-section of the liner system is shown in Figure 3. The liner system consisted of the following components listed from the bottom up:

- Geotextile working mat. This mat was installed for erosion and sediment control, to reduce the release of organic vapors during construction, and to serve as a cushion between the underlying subgrade and the overlying liner system.
- Geosynthetic clay liner (GCL). The GCL serves as a secondary liner.

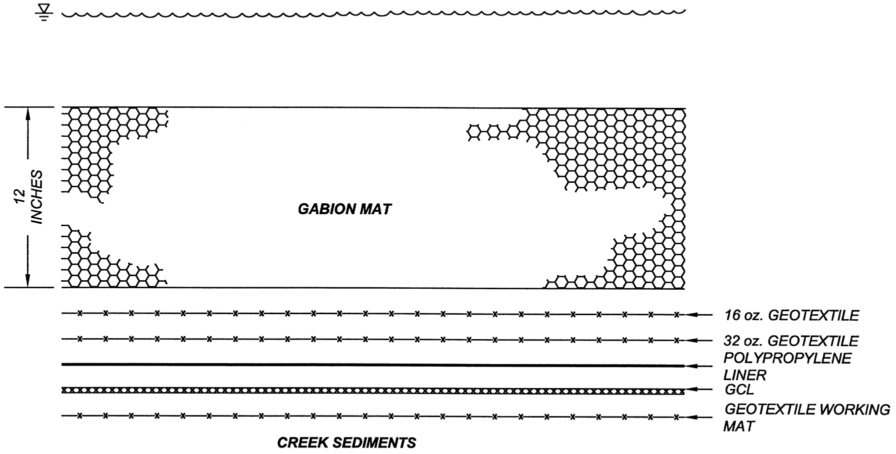

Figure 3 **In Situ Cap Case Study 3: Galaxy/Spectron Superfund Site, Elkton, MD**

- Scrim reinforced polypropylene liner. This geomembrane serves as the primary liner.
- Geotextile cushion. This cushion consists of both a 32-ounce and a 16-ounce nonwoven geotextile placed over the primary liner to protect the liner from the overlying gabion mat.
- Gabion mat. A 12-inch gabion mat was placed over the geotextile cushion to serve as the primary protective layer. The gabion stone was infilled with sand (within the Creek base flow area) and planting material (within the Creek banks) to prevent subsurface flow within the gabions and to help reestablish benthic and riparian habitats.

Construction within the 830 linear feet of Creek bed (average width of about 50 feet) was performed by diverting the Creek flow via pumps and an 18-inch diameter HDPE pipe. Prior to the installation of the liner system, concrete anchor/groundwater cutoff walls and a series of collection pipes were installed directly beneath the Creek bed. The collection pipes were connected to groundwater collection sumps located along the Creek bank. The Creek bed was then graded and prepared (sediments larger than 3/4 inches were removed from the liner subgrade) for liner installation. Following the installation of the liner system, the Creek banks were restored with plantings. The project effectively isolated the impacted sediments and groundwater from the creek flow and the groundwater is currently being removed and treated.

SUMMARY

The above projects are unique cases where in situ capping was determined to be a better solution than sediment removal. Each cap is functioning as designed with little maintenance. The habitat restoration portions of Cases 2 and 3 has been successful in restoring vegetation as well as riparian/benthic habitats. Therefore, project experience has proven that in situ capping can be both a cost effective and more constructible approach to effectively manage contaminated sediments.

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