A Story of Revitalization – Onondaga Lake Dredging, Capping, and Habitat Restoration Project, Syracuse, New York

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SUMMARY

As one of the largest restoration projects in North America, several aspects of the Onondaga Lake project are unique and can easily be transferred to other remedial projects nationally. The multi-year project was conceived by some of the nations' premier experts from academics, industry and the public, and involved several decades of planning, investigations, engineering and construction, before it came to fruition. Approximately 2.2 million cubic yards (MCY) of dredged material was removed from the lake bottom and pumped over 4 miles to an upland sediment consolidation area (SCA). The material was placed within 979 geotextile tubes, placed up to 5 layers high, over the 55 acre SCA. Approximately 475 acres of cap was placed over the lake bottom including placement of 1.6 MCY hydraulically, and another 1.5 MCY mechanically. Specialized amendments (over 14 million pounds of granular activated carbon, and 14,000 tons of siderite) were incorporated into the cap layers to provide additional sorption and retardation properties. Approximately 37 acres of the lake bottom received targeted habitat restoration materials and planting. The innovations discussed herein (multiple dredge use, sustainability, bulk amendment dosage and placement, data automation, and habitat restoration approaches) have resulted in technological advancements that were once thought to be unattainable in the industry (*a good example of this is the industry wide skepticism surrounding bulk amended cap placement until it was proven in full scale here*). Innovative approaches to the dredging and capping design while considering long-term habitat restoration initiatives has led to an optimized, environmentally protective solution, yielding long-term habitat restoration and economic benefits to the lake. The successfully completed project continues to be lauded by agencies and environmental groups as a model remediation case study for scrutiny and applicability elsewhere.

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INTRODUCTION

Onondaga Lake is a 4.6-square-mile (3,000 acre) urban lake located in Syracuse, New York, USA (Figure 1). A legacy of industrialization and municipal development since the late nineteenth century resulted in impaired water quality and contamination of lake sediments. Contaminants of concern (COCs) include mercury from a former chlor-alkali facility, multiple organic contaminants (volatile and semi-volatile organic compounds and polychlorinated biphenyls) from other chemical/manufacturing operations, and hyperalkaline (pH greater than 12) inorganic materials.

Figure 1: Onondaga Lake and Environs

A comprehensive lake restoration plan was developed following two decades of intensive multi-disciplinary technical studies by some of North America's leading scientific, engineering, and research organizations. The restoration plan included removal of approximately 2.2 million cubic yards of lake sediments (completed in November 2014, one season ahead of schedule); transport of the dredge slurry through a 4-mile-long, double-walled pipeline; dewatering in geotextile tubes strategically placed in a dedicated 55-acre upland sediment consolidation area; and treating effluent water to meet lake discharge requirements. More than 475 acres of the lake also received an engineered cap to isolate the remaining contamination in situ, and provide a surface for extensive habitat restoration efforts. Habitat restoration also plays a critical and ongoing role in the project; target dredge elevations and cap surfaces were designed to provide suitable habitat throughout the restored area. The deepest portion of the lake will be monitored for ongoing natural recovery. The restoration and design process involved close coordination and discussions with multiple regulatory agencies, extensive public participation, and was supported by several technical studies, including: 1) development of sediment and fish tissue remedial goals; 2) detailed evaluations of capping, dredging and upland containment, natural recovery, and nitrate addition to the lower part of the lake water column (to limit production of methyl mercury); and 3) integration of habitat restoration into the lake-wide cleanup effort.

ENVIRONMENTAL BENEFITS

The entire project focused on maximizing environmental benefits during implementation, in line with the principles of "*engineering with nature*." Several environmental features were incorporated during construction to minimize disturbance to the lake and surrounding environs, and to enhance the recovery of the lake following construction.

Hydraulic dredging was selected over mechanical as the preferred method of removal to minimize sediment suspension and to contain sediment during transport (see Figure 2). Rather than requiring trucking to transport dredged material to the 55-acre upland sediment consolidation area, hydraulic dredging allowed the conveyance of dredged slurry using a 4-mile-long, double-walled pipeline. Four electric-powered booster pumps were positioned along the pipeline route to provide the necessary lift. Biodiesel was used to power equipment in the lake and in on-shore equipment staging and support areas. This approach minimized greenhouse gas generation associated with transport and dewatering of the dredged material (as opposed to trucking), as did the use of electric booster pumps (which also minimized noise). Sediment dewatering occurred in geotextile tubes, which was chosen due to its passive nature to minimize power requirements (see Figure 3).

Figure 2: Hydraulic Dredging in Progress

Figure 3: Dredged Material Management Using Geotubes in Upland SCA

During the design process, target dredge elevations in specific areas of the lake were established for the installation of wetland habitat following the completion of dredging and capping (Figure 4).

Figure 4: Nearshore Habitat Restoration

To compensate for the construction of a sheetpile wall and groundwater collection system alongside a portion of the lakeshore, a connected wetland system was constructed further down the shoreline, and forested and emergent wetlands were installed adjacent to and above the sheetpile wall such that the wall is not visible. To date, more than 70 acres of wetlands have been restored. As part of the Onondaga Lake restoration, Honeywell is planting about 1.1 million plants, shrubs, and trees in the Onondaga Lake watershed. More than 230 species of birds, fish, and other wildlife have returned to restored habitat near the lake. More than 80 unique bird species have been identified in and around Onondaga Lake, including several species categorized as threatened or of special interest in New York State. Pied-billed Grebe, Northern Harrier, and Bald Eagle are among the notable bird species that have returned.

INNOVATION

One of the ground breaking approaches of the Onondaga Lake restoration was the design of a reactive cap system – which was perhaps the most studied environmental cap in North America. As one of the largest sediment capping projects constructed to date, the multi-function cap design (Figure 5) incorporated several innovative components, including site-specific biodegradation and reactive media (granular activated carbon [GAC] for contaminant sequestration and siderite amendment for pH control) to meet performance requirements for long-term chemical isolation and habitat restoration. The innovative capping concepts were developed through multiple years of field investigations, laboratory and bench-scale studies, and field pilot testing. In addition, state-of-the-science contaminant migration and cap effectiveness modeling studies were conducted to evaluate the required layering of the cap and to optimize the amendment media and required dosage for the various layers. Successful integration and regulatory acceptance of these unique design features provided opportunities for significant optimization of raw material needs (cap thickness and amendment dose). The study methods also resulted in streamlined and more efficient construction, while retaining environmental effectiveness.

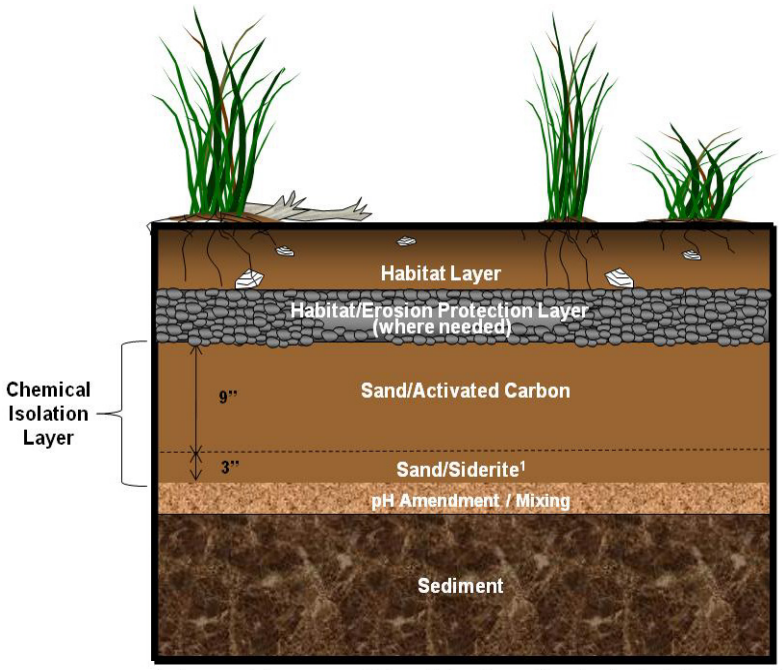

Figure 5: Example Schematic of an Amended Cap

Placement of the multi-layer cap presented an unprecedented challenge to the project team. The cap consisted of approximately 3 million cubic yards of material including siderite and GAC amendments. Cap installation required consideration of several factors, including high production rates, cap placement over very soft sediments and slopes, and ability to mix specified amendment concentrations into the cap in a uniform manner.

Figure 6: Hydraulic Capping Spreader Barge

The innovative multi-layer cap design and unique design features provided opportunities for significant optimization of raw material needs (cap thickness and amendment dose). Sand layers containing siderite or GAC amendments were generally placed hydraulically via a specially fabricated hydraulic spreader barge (Sevenson Environmental, Figure 6), with a controlled (metered) back-end land based material delivery system (for mixing amendments with sand, as the need varied across the lake, per design). This approach to cap installation proved effective to accommodate the key design requirements including cap placement thickness accuracy, high production rates, cap placement over soft sediments and on slopes, and ability to mix amendments into the cap in a uniform manner. This cap installation system also provided significant cost savings as compared to traditional material blending operations. Thermal laboratory procedures were developed to verify the presence of siderite and GAC amendments in core samples collected from the placed cap.

The cap design was modeled to have a design life exceeding 1,000 years, which was the most stringent environmental standard in North America. This cap design also allowed for a significant reduction in dredge volume, thereby promoting a sustainable remedy to restore the environment. The final surface of the cap is also conducive to the establishment of unique habitat features over time, which are expected to provide habitats for a wide variety of native species (i.e., fish, reptiles, amphibians, invertebrates, mammals, and plants). The completed in-lake habitat is linked to the shoreline habitat through the lake-wide restoration program.

ECONOMIC BENEFITS

The restoration work at Onondaga Lake contributed to the local economy in several ways. The project emphasized the employment of local craft labor whenever possible. During the peak of construction, up to 500 personnel were employed, providing direct and indirect benefits to the local economy. Over 1.6 million hours were worked during dredging and capping with an excellent safety record (*The project was chosen for the WEDA Safety Award in 2014, in recognition of outstanding safety record for a multi-party and complex site*). The Total Recordable Injury Rate (TRIR) for the project was 0.74, which is 90% better than the comparable industry rate of 7.2 for this key metric used by the Occupational Safety and Health Administration (OSHA). In addition, the OSHA Lost Time Injury Rate was 0.0, as compared to the industry rate of 2.7. The project leadership was therefore able to drive efficiency, while retaining a top industry recognized safety culture.

In addition, the innovative approaches to the design and installation of a multi-layer cap, as described above, resulted in significant savings to the total project cost, due to the reduction in total dredge volume and the efficiencies realized using the hydraulic cap spreader system (economical and sustainable solution to a complex remedial project, involving highly varying material delivery and amendment requirements).

Figure 7: Lakeview Amphitheater

Finally, the Onondaga Lake Restoration was incorporated into a larger effort to restore and revitalize the lake and its environs. In parallel to the restoration work, the Lakeview Amphitheater (Figure 7) was constructed adjacent to the newly-restored shoreline. Portions of the shoreline that were used as equipment staging areas will be converted into a public boat launch, and a walking and biking trail that when completed will be part of a trail system that encircles the entirety of Onondaga Lake, extending more than 11 miles.

TRANSFERABILITY

Many lessons were learned throughout the Onondaga Lake restoration project that are transferable to similar projects. Use of a combination of hydraulic dredges (for production and clean up passes) during the restoration provided high levels of efficiency, and the use of biodiesel, electric booster pumps, and geotextile tubes as a passive dewatering technology added to the overall sustainability indices. The multi-layer cap design and metered amendment mixing and bulk placement concepts are key technologies that can be transferred to other remediation projects.

Focus on the planned end uses of the lake (from design through construction) helped align various remedial elements efficiently and was key to the success of the project. Dredge elevations and protective caps were designed to accommodate wetland habitat to increase the diversity of wildlife in and around the lake. Real-time water quality monitoring programs with data automation facilitated efficient construction process, while ensuring environmental protection that was mandated by agencies.

One key lesson learned is the value of proactively nurturing partnerships with regulatory agencies and public organizations. The New York State Department of Environmental Conservation (NYSDEC) was the lead agency during design and construction, and NYSDEC had personnel working in the field in the same offices as the construction and engineering teams. This partnership and proximity allowed for robust discussion and timely decision making whenever issues arose in the field that required adaptive management. In addition, partnerships with public organizations increased awareness of and support for the restoration work.

OUTREACH AND EDUCATION

Figure 8: Onondaga Lake Visitors Center

A multifaceted public outreach and engagement program has been an integral part of the Onondaga Lake Restoration during and after construction. Prior to the commencement of dredging, a Visitors Center (Figure 8) was built near the shoreline to provide a location for the public to learn about, and engage with, the restoration team and their activities. To date, more than 14,000 community members have participated in tours at the Visitors Center. Several public education and habitat restoration initiatives were conducted using the Visitors Center as a hub of activity. A Summer Science Week is held annually that allows student scientists to conduct hands-on experiments and investigate the Onondaga Lake watershed.

The Onondaga Lake Conservation Corps ("Corps") was formed in 2012 and consists of hundreds of community volunteers who have become environmental stewards of the lake. The Corps contributes to restoration projects that are creating or improving wildlife habitat in the Onondaga Lake watershed. It also seeks to inspire future stewards of the lake and its watershed through a hands-on, experience-based program that offers citizens (and organizations) the opportunity to participate in activities that help restore and sustain the lake, and its value as an important bird area. In 2015, the U.S. Environmental Protection Agency awarded the Corps with their Environmental Champions Award, their highest recognition presented to the public. Public partners of the Corps include Audubon New York, Montezuma Audubon Center, Onondaga Audubon Society, SUNY College of Environmental Science and Forestry, and Habitat Gardening in Central New York. The Corps has held and continues to hold public events that engage the community in the lake restoration (Figure 9). These events include habitat planting and installation, plant and animal species identification events (BioBlitz), removal of water chestnuts (which are an invasive species to the lake and tributaries), and bird watching events (hosted by the Audubon Society partners).

Figure 9: Onondaga Lake Conservation Corps Event

Recognized as a unique case study for sustainable environmental dredging and habitat restoration in North America, the project continues to draw visitors, shorebirds and wildlife to a precious, natural resource that is so key to the history of the Greater Syracuse and Upstate New York region.