ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SEDIMENT MANAGEMENT UNIT 8) FINAL DESIGN

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CERTIFICATION

Pursuant to item 28 of the Consent Decree, the following certification is provided, signed by a licensed professional engineer in New York:

> I, Edward Glaza, am currently a registered professional engineer licensed by the State of New York, and I certify that this Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design was in my professional opinion, prepared in substantial conformance with the Consent Decree between the State of New York and Honeywell International, Inc. dated January 4, 2007.

By: ______________________

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LIST OF ACRONYMS

AMP	Ambient Monitoring Program
ARAR	Applicable or Relevant and Appropriate Requirement
BMP	best management practices
BSQV	bioaccumulation-based sediment quality value
CPOI	chemical parameter of interest
CPP	Citizen Participation Plan
CQAP	Construction Quality Assurance Plan
CY	cubic yards
DGPS	differential global positioning system
DSC	Dredging Supply Company
ESD	Explanation of Significant Differences
foc	fraction of organic carbon
FS	Feasibility Study
ft.	Feet
GAC	granular activated carbon
GPS	global positioning system
IDS	Initial Design Submittal
ILWD	in-lake waste deposit
in.	Inches
IRM	Interim Remedial Measure
koc	organic carbon partitioning coefficient
LCMM	Lake Champlain Maritime Museum
Metro	Onondaga County Metropolitan Wastewater Plant
MNR	monitored natural recovery
NAPL	non-aqueous-phase liquid
NAVD	North American Vertical Datum
NHPA	National Historic Preservation Act
NPL	National Priorities List
NRHP	National Register of Historic Places
NTU	Nephelometric turbidity units
NYCRR	New York Code of Rules and Regulations
NYSCC	New York State Canal Corporation

NYSDEC	New York State Department of Conservation
NYSDOT	New York State Department of Transportation
OCDWEP	Onondaga County Department of Water Environment Protection
OLMMS	Onondaga Lake Monitoring and Maintenance Scope
OM&M	operation, maintenance, and monitoring
OU-2	Operable Unit 2
PAF	Public Archaeology Facility of SUNY Binghamton
PDI	Pre-Design Investigation
PEC	Probable effects concentration
PECQ	Probable Effects Concentration quotient
PRAD	Proposed Response Action Document
PRG	preliminary remedial goal
QA/QC	quality assurance and quality control
RA	remediation areas
RAD	Response Action Document
RI	Remedial Investigation
RAO	Remedial Action Objective
ROD	Recorded of Decision
RTK	real-time kinematic
SAV	submerged aquatic vegetation
SCA	sediment consolidation area
SECs	sediment effects concentrations
SMU	sediment management units
SOW	Statement of Work
SVOC	semi-volatile organic compound
TSS	total suspended solids
VOC	volatile organic compound
WBB/HB	Wastebed B/Harbor Brook
WQMMP	Water Quality Management & Monitoring Plan
WTP	Water Treatment Plant
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

This Final Design is Honeywell's next step toward achieving the goals of the Record of Decision (ROD) and the community's vision for a restored Onondaga Lake. The lake remediation plan, which was selected by the New York State Department of Environmental Conservation (NYSDEC) and the U.S. Environmental Protection Agency (USEPA), calls for a combination of dredging and capping. These methods are proven environmental cleanup methods that address contamination in water and lake sediment. This document provides information on the design for remedial areas, sediment cap, habitat restoration and enhancement, areas and depths of sediment to be dredged, and dredging and capping methods.

This report also provides the design for the profundal zone—the deeper water portion of the lake where water depths exceed 30 ft. [9 meters]). This area is referred to as Sediment Management Unit (SMU) 8 in the ROD. The remedy for SMU 8 includes thin-layer capping, monitored natural recovery, and nitrate addition to reduce release of methyl mercury.

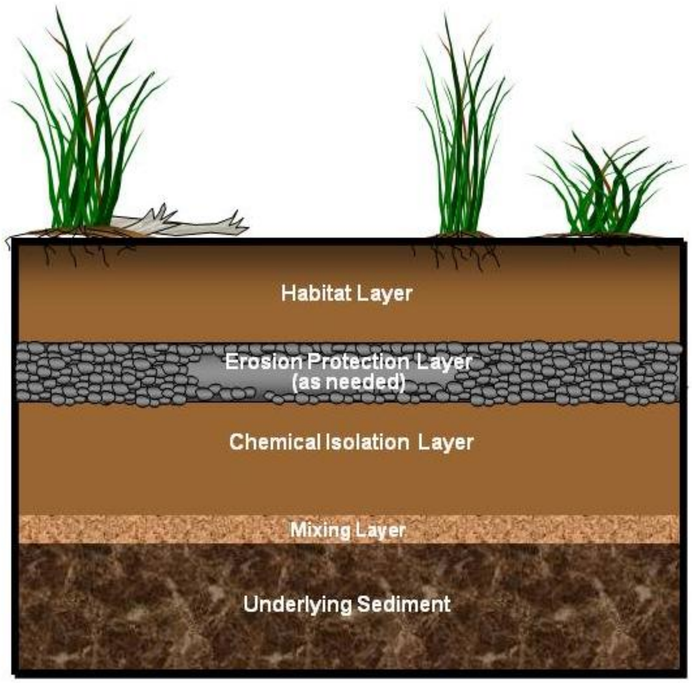
Honeywell's design team consists of more than 100 local engineers and scientists working with nationally recognized experts from various universities, research institutions, and specialty engineering firms, and with input from community stakeholders. The design generated through this collaboration is effective and meets the objectives for remediation and long-term protection of health and the environment outlined in the ROD.

Restoring diverse, functioning and sustainable habitats to the remediated areas of Onondaga Lake is one of the top priorities of this remedial program. Therefore, habitat considerations are at the forefront of the various design evaluations for the lake and have been fully integrated into this document. Habitat considerations are a major factor in developing the habitat layer and the total thickness of the cap. The cap will provide a suitable habitat layer for plants, animals, and fish to use without impacting the chemical isolation layer. The cap will also provide long-term chemical and physical isolation of underlying material from the lake and will resist erosive forces such as wind/wave-generated currents, tributary and other inflows, and ice.

Capping, Dredging, and Habitat Restoration

Detailed technical evaluations demonstrate that capping will be effective in Onondaga Lake. Sediment caps are a proven technology and have been implemented at numerous sediment remediation sites, including the Fox River in Wisconsin, the St. Louis River Interlake Duluth Tar site in Minnesota, and Commencement Bay in Washington.

In the littoral (shallow) zone of Onondaga Lake, the cap will include the following layers: habitat, erosion protection, and chemical isolation layers. The cap will also include an allowance for mixing of the bottom of the chemical isolation layer with underlying sediment. The different layers will provide long-term protection of human health and the environment, and will ensure that goals are met for habitat restoration, erosion protection and chemical isolation. The layers are depicted in the graphic below.



General Schematic of Sediment Cap

The design team performed detailed evaluations to ensure each layer meets the remedial goals and is designed to withstand expected conditions in the lake. The evaluations include the following:

- Extensive laboratory bench-scale analysis
- State-of-the-science numerical and computer modeling designed to conservatively predict long-term effectiveness
- Evaluation of capping successes and lessons learned at other remediation sites
- Evaluation of post-remediation habitat considerations
- Continuous consultation with national and local experts

The total thickness of the cap includes the habitat layer, erosion layer, and chemical isolation layer, as well as the mixing layer. As part of the habitat restoration goal, areas will be developed near the mouth of Ninemile Creek where floating aquatic plants (such as lily-pads) will thrive. The required depth for a floating aquatic plant is 1 ft. to 3 ft. Sufficient dredging will be completed in this area such that the post capping water depth will be between 1 ft. and 3 ft. Because dredging depths are based on these types of considerations, dredging designs are presented after the goals and designs for the cap and habitat restoration are developed.

Dredging is a major component of the lake remedy. To achieve removal goals specified in the ROD, dredging will be implemented in an area of the lake known as the in-lake waste deposit (ILWD). In addition to the ILWD dredging, elevation-based dredging will be conducted in other portions of the lake to allow for the subsequent placement of the sediment cap, and will result in post remedy water depths based on habitat considerations. The water depths and habitat restoration concepts were developed in the Draft Habitat Plan to achieve optimum conditions throughout the dredging and capping areas in the lake.

In addition to the capping and dredging described above, the remedy also addresses the profundal zone—the deeper water portion of the lake referred to as SMU 8. In the profundal zone, there are three components of the remedy:

- Nitrate addition to the lower waters of the deep water zone to minimize formation of methylmercury. Adding nitrate minimizes the release of methylmercury from SMU 8 sediment to overlying water where it becomes available for bioaccumulation in fish. Nitrate addition is currently being evaluated as part of a 3-year pilot study with a final decision on the use of oxygen or nitrogen to control mercury methylation to follow after the completion of the pilot test.
- Monitored natural recovery (MNR) of the top layer of the lake bottom (that is, the surface sediment). Surface sediment mercury concentrations in SMU 8 have been declining naturally for many years and are approaching the remediation goals for mercury determined in the ROD. Based on these reductions MNR was determined to be appropriate as a significant component of the SMU 8 remedy.
- Localized thin-layer capping. Thin-layer capping provides an immediate decrease in surface sediment contaminant concentrations by placing clean material on the lake bottom.

The combination of nitrate addition, a thin-layer cap over approximately 27 acres in SMU 8, and ongoing natural recovery will result in the burial or covering of older, more contaminated SMU 8 sediment and promote reductions in mercury in fish tissue.

A long-term monitoring and maintenance program will be implemented to monitor and maintain the effectiveness of the remedy.

Community Participation

Community input remains a vital component of Honeywell's design for the restoration of Onondaga Lake. Honeywell is committed to working with community leaders, interested stakeholders, and citizens to include input, recommendations, comments and perspectives into the design process. Community members have the opportunity to participate in the design, construction, and post-construction periods as detailed in the NYSDEC's *Citizens Participation Plan* (CPP) (NYSDEC 2009). Feedback received through the community participation process has already been incorporated into design-level decisions in several areas of the remedial design.

Honeywell is also committed to minimizing the carbon footprint of remedial construction activities. Part of the design included evaluations to identify ways to incorporate sustainability concepts, including those presented in the *Clean and Green Policy* (USEPA, 2009) and the NYSDEC's DER-31/Green Remediation Program policy into all aspects of the remediation. To the extent practicable, using renewable energy sources, using locally produced/sourced materials and supplies, reducing and/or eliminating waste, efficiently using resources and energy, and other practices have been incorporated into the remedial design, and will be implemented during remedial construction.

SECTION 1

BACKGROUND AND DESIGN PROCESS OVERVIEW

This Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design Report has been prepared on behalf of Honeywell and advances the design presented in the Draft Final Design. This report describes the components of the Onondaga Lake remediation pertaining to the sediment cap, sediment dredging, and habitat restoration and enhancement, as well as the thin-layer capping, monitored natural recovery and methylmercury inhibition in the deep water portion of the lake (SMU 8). Restoring diverse, functioning, and sustainable habitats to the remediated areas of Onondaga Lake is one of the top priorities of this remedial program. Therefore, habitat considerations are at the forefront of the various design evaluations for the lake and have been fully integrated into this document. Regulatory and community input and review and public feedback have been incorporated into this remedial design.

The lake bottom is on the New York State Registry of Inactive Hazardous Waste Sites and is part of the Onondaga Lake National Priorities List (NPL) Site. Honeywell entered into a Consent Decree (United States District Court, Northern District of New York, 2007) (89-CV-815) with the NYSDEC to implement the selected remedy for Onondaga Lake as outlined in the ROD issued on July 1, 2005. The following documents are appended to the Consent Decree: ROD, Explanation of Significant Differences (ESD), Statement of Work (SOW), and Environmental Easement.

The design information presented here is based on extensive information and data gathered during six years of design-related investigations, as well as data collected as part of the Remedial Investigation (RI) (TAMS, 2002). These investigations have included collection and analysis of thousands of samples, numerous bench studies, and completion of many field evaluations and data collection activities.

1.1 ONONDAGA LAKE DESCRIPTION

Onondaga Lake is a 4.6 square mile (3,000 acre) lake located in Central New York State immediately northwest of the City of Syracuse (Figure 1.1). The lake is approximately 4.5 miles long and 1 mile wide, with an average water depth of 36 ft.

Ninemile Creek and Onondaga Creek are the two largest tributaries to Onondaga Lake (Figure 1.1). Other tributaries in a clockwise direction from the southeast section of the lake include Ley Creek, Harbor Brook, Tributary 5A, Sawmill Creek, and Bloody Brook. In addition to the tributary streams, the treated effluent from the Onondaga County Metropolitan Wastewater Treatment Plant (Metro), located between Onondaga Creek and Harbor Brook, contributes a significant portion of the water entering the lake.

As part of the remedial alternative development and evaluation process during the Feasibility Study (FS) (Parsons, 2004), the lake bottom was divided into eight SMUs based on water depth, source of water entering the lake, and physical, ecological, and chemical characteristics (NYSDEC and USEPA, 2005). SMUs 1 through 7 are located in the littoral zone (less than 30 ft. water depth) of the lake where most aquatic vegetation and aquatic life reside, while SMU 8 consists of sediment in the profundal zone (deeper than 30 ft.) (Figure 1.2).

1.2 REMEDIATION OBJECTIVES AND GOALS

A key objective of all remedial activities is to ensure protection of on-site workers, the surrounding community, and the environment from potential risks associated with the completion of the remedy. The ROD also provides more specific objectives, called Remedial Action Objectives (RAOs), as listed below.

- RAO 1: To eliminate or reduce, to the extent practicable, methylation of mercury in the hypolimnion.
- RAO 2: To eliminate or reduce, to the extent practicable, releases of contaminants from the ILWD and other littoral areas around the lake.
- RAO 3: To eliminate or reduce, to the extent practicable, releases of mercury from profundal (SMU 8) sediments.
- RAO 4: To be protective of fish and wildlife by eliminating or reducing, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources, and to be protective of human health by eliminating or reducing, to the extent practicable, potential risks to humans.
- RAO 5: To achieve surface water quality standards, to the extent practicable, associated with chemical parameters of interest (CPOIs).

As part of the FS process, USEPA guidance requires the establishment of preliminary remedial goals (PRGs) that can be used to select appropriate remediation technologies and to develop remedial alternatives within the FS. The PRGs represent the primary goals of the remedial efforts. To achieve the RAOs stated above, three PRGs were developed to address the three primary affected media within the lake: sediment, biological tissue, and surface water. PRGs for Onondaga Lake, as per the ROD (NYSDEC and USEPA, 2005, p. 35), are listed below.

- PRG 1: Achieve applicable and appropriate sediment effects concentrations (SEC) for CPOIs and the bioaccumulation-based sediment quality value (BSQV) of 0.8 mg/kg for mercury, to the extent practicable, by reducing, containing, or controlling CPOIs in profundal and littoral sediments.
- PRG 2: Achieve CPOI concentrations in fish tissue that are protective of humans and wildlife that consume fish. This includes a mercury concentration of 0.2 mg/kg in fish tissue (fillets) for protection of human health based on the reasonable maximum exposure scenario and USEPA’s methylmercury National Recommended Water Quality criterion for the protection of human health for the consumption of organisms of 0.3 mg/kg in fish tissue. This also includes a mercury concentration of 0.14 mg/kg in fish (whole body) for protection of ecological receptors. These values represent the range of fish tissue PRGs.
- PRG 3: Achieve surface water quality standards, to the extent practicable, associated with CPOIs.

PRG 1 addresses RAOs 2 and 4. PRG 2 addresses RAO 4. PRG 3 addresses RAO 5.

1.3 REMEDY OF RECORD

The ROD for the lake bottom presents the remedy selected by NYSDEC and USEPA for addressing the RAOs and PRGs presented in Section 1.2 above. The SOW, presented as Appendix C of the Consent Decree, further describes design-related elements for the implementation of the remedy, such as the development of dredging areas and volume; isolation cap areas, models and components; approach for addressing the profundal zone (SMU 8); management of dredged sediments; water treatment system; and the design and construction schedule.

The selected remedy is set forth in the ROD and SOW and is summarized as follows for the in-lake components of the remedy. (United States District Court, 2007 – appendices to the Consent Decree):

- Dredging of as much as an estimated 2,653,000 CY of contaminated sediment/waste from the littoral zone in SMUs 1 through 7 to a depth that will prevent the loss of lake surface area, ensure cap effectiveness, remove non-aqueous-phase liquids (NAPLs), reduce contaminant mass, allow for erosion protection, and re-establish the littoral zone habitat. Most of the dredging will be performed in the ILWD (which largely exists in SMU 1) and in SMU 2.
- Dredging, as needed, of an additional 3.3 ft. in the ILWD to remove materials within areas of hot spots (to improve cap effectiveness) and additional dredging, as needed, to ensure stability of the cap.
- Placement of an isolation cap over an estimated 425 acres of SMUs 1 through 7.
- Completion of a comprehensive lakewide habitat restoration plan.
- Habitat reestablishment will be performed consistent with the Lakewide Habitat Restoration Plan in areas of dredging/capping.
- Placement of a thin-layer cap over an estimated 154 acres of the profundal zone (SMU 8).
- A pilot study will be performed to evaluate the potential effectiveness of oxygenation at reducing the formation of methylmercury in the water column, while preserving the normal cycle of stratification within the lake. An additional factor which will be considered during the design of the pilot study will be the effectiveness of oxygenation at reducing fish tissue methylmercury concentrations. If supported by the pilot study results, the pilot study will be followed by full-scale implementation of oxygenation in SMU 8. Furthermore, potential impacts of oxygenation on the lake system will be evaluated during the pilot study and/or the remedial design of the full-scale oxygenation system. In addition, as discussed in the SOW, a study will be performed to determine if nitrification can effectively decrease formation of methylmercury in the water column while preserving the normal cycle of lake stratification. If NYSDEC determines from this study that nitrification is effective and appropriate, a nitrification program may be implemented in lieu of an oxygenation pilot study.
- MNR in SMU 8 to achieve the mercury probably effect concentration (PEC) of 2.2 milligrams per kilogram (mg/kg or ppm) in the lake's profundal zone (where water depths exceed 30 ft. or 9 meters) and to achieve the bioaccumulation-BSQV for

mercury of 0.8 mg/kg on an area-wide basis, within 10 years following the remediation of upland sources, dredging and/or isolation capping of littoral sediment, and initial thin-layer capping in the profundal zone*.*

- Implementation of institutional controls including the notification of appropriate governmental agencies with authority for permitting potential future activities which could impact the implementation and effectiveness of the remedy.
- Implementation of a long-term operation, maintenance, and monitoring (OM&M) program to monitor and maintain the effectiveness of the remedy.

Honeywell will certify to NYSDEC that the institutional controls are in place and that Honeywell is conducting remedy-related OM&M consistent with the approved OM&M Plan.

The NYSDEC and USEPA issued an ESD as Appendix B of the Consent Decree to specify a modification to the selected remedy documented in the ROD. Based on investigation data and a stability evaluation, there was significantly less NAPL-impacted material beneath the lake in SMU 2 than was assumed during the FS and ROD, and removing this material could result in instability of the adjacent shoreline. Therefore, the alignment of the Willis/Semet Interim Remedial Measure (IRM) Barrier Wall (Willis portion) was moved offshore immediately beyond the farthest extent of pooled NAPLs within the lake in lieu of dredging of this material. NAPL recovery wells will also be installed on the landward side of the new barrier wall, and upland areas along Wastebeds 1-8 will be converted to new aquatic habitat to mitigate the loss of lake surface area resulting from placement of the barrier wall offshore.

1.4 DESIGN PROCESS OVERVIEW

Detailed technical evaluations completed during the FS demonstrated that capping in conjunction with dredging would be effective and would be the best approach to meet the remedial goals. Following completion of the FS and after the ROD was issued, extensive design-related investigation activities were initiated to supplement the data collected during the RI and provide the data necessary to allow design of the remedy. Investigations related to capping and dredging design have included:

- Bench-scale tests to evaluate cap performance and generate data pertaining to design of the chemical isolation layer
- Geophysical surveys to map the lake bottom and identify debris and in-lake utilities that will be addressed as part of the remediation
- Sediment sampling for chemical and geotechnical analyses to determine the remediation areas (RA) and dredge depth
- *In situ* geotechnical testing of sediments to provide data related to design of the cap and dredging operations
- Porewater sampling and analysis to generate data pertaining to design of the chemical isolation layer

Investigations related to the SMU 8 (profundal zone) design have included:

- Geophysical surveys to map the lake bottom

- Ongoing water quality sampling in the profundal zone on a regular basis from April to November
- Five dye tracer tests to quantify dispersion in the lower hypolimnion where nitrate is to be added
- A nitrate application field trial to confirm nitrate can be effectively placed and to provide additional measurements of dispersion
- Sediment sampling for chemical and geotechnical analyses to update the extent of natural recovery and determine the thin-layer capping areas
- Radioisotope analysis of sediment to quantify past and ongoing sedimentation rates
- Ongoing water velocity measurements in the lower hypolimnion
- Analysis of results from sediment traps to provide information about solids settling within the profundal zone
- Testing and placement of microbead markers to facilitate monitoring of subsequent sediment deposition

These activities to date have resulted in more than 12,000 samples collected from over 1,500 discrete locations, to support design of the selected remedy. Honeywell presented the results of these investigations in data summary reports and submitted them to the NYSDEC. These reports are available in the public document repositories listed in the Citizen Participation Plan.

The primary elements of the selected remedy as documented in the ROD, and as described above, include:

- sediment removal (dredging) and transport to the sediment consolidation area (SCA)
- on-site management of dredged material at the SCA
- sediment capping (isolation and thin-layer)
- water treatment system
- nitrate addition or oxygenation of the hypolimnion
- MNR
- habitat restoration and enhancement
- institutional controls
- long-term operation, maintenance, and monitoring

For most of these elements, design-related investigations, engineering assessments, and evaluation reports were completed in advance of the preparation of this report to assess specific elements of the remedy, advance design decisions, and to obtain concurrence with NYSDEC and USEPA on critical path components.

Due to interaction between the various remedial elements, and varying design schedule considerations with specific design components, it was necessary to separate the design into several distinct submittals. Separating the design into different components allows for accelerated design submittals for critical path activities (e.g., SCA and water treatment), helps the agency review process by staggering the submission of large documents, and facilitates the schedule for starting and completing the remedial action consistent with the Consent Decree.

Future design submittals and their associated submittal schedules have been developed and presented in each of the Initial Design Submittal (IDS) reports.

The content of the four IDS Reports is as follows:

- The *Dredging, Sediment Management, and Water Treatment IDS* provides conceptual design-level information pertaining to operational components of the remedy including the dredging, transportation, and dewatering of impacted lake sediments, and treatment of construction water generated during the process. This IDS was submitted to the NYSDEC in February 2009 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.
- The *SCA Civil & Geotechnical IDS* includes the civil and geotechnical design elements (*e.g.,* liner system) required for construction of the SCA. This IDS was submitted to the NYSDEC in August 2009 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.
- The *Sediment Cap and Dredge Area, Depth and Volume IDS* includes the conceptual level design for the sediment cap components of the remedy. This submittal also includes the integration of conceptual level design details pertaining to habitat restoration and also provides estimates of dredging volumes and removal areas and depths. This IDS was submitted to the NYSDEC in December 2009 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.
- The *Profundal Zone (Sediment Management Unit 8) IDS* focuses on the deep water areas of the lake, and provides conceptual design-level details pertaining to thin-layer capping (including locations, extent, materials, and sequencing), nitrate addition and/or oxygenation for the purposes of inhibiting the formation of methylmercury within the lake, and the approach to MNR in specific areas of the lake. This IDS was submitted to the NYSDEC in November 2010 and is available in the public repositories. NYSDEC's comment letter is also included with the report in the public repositories.

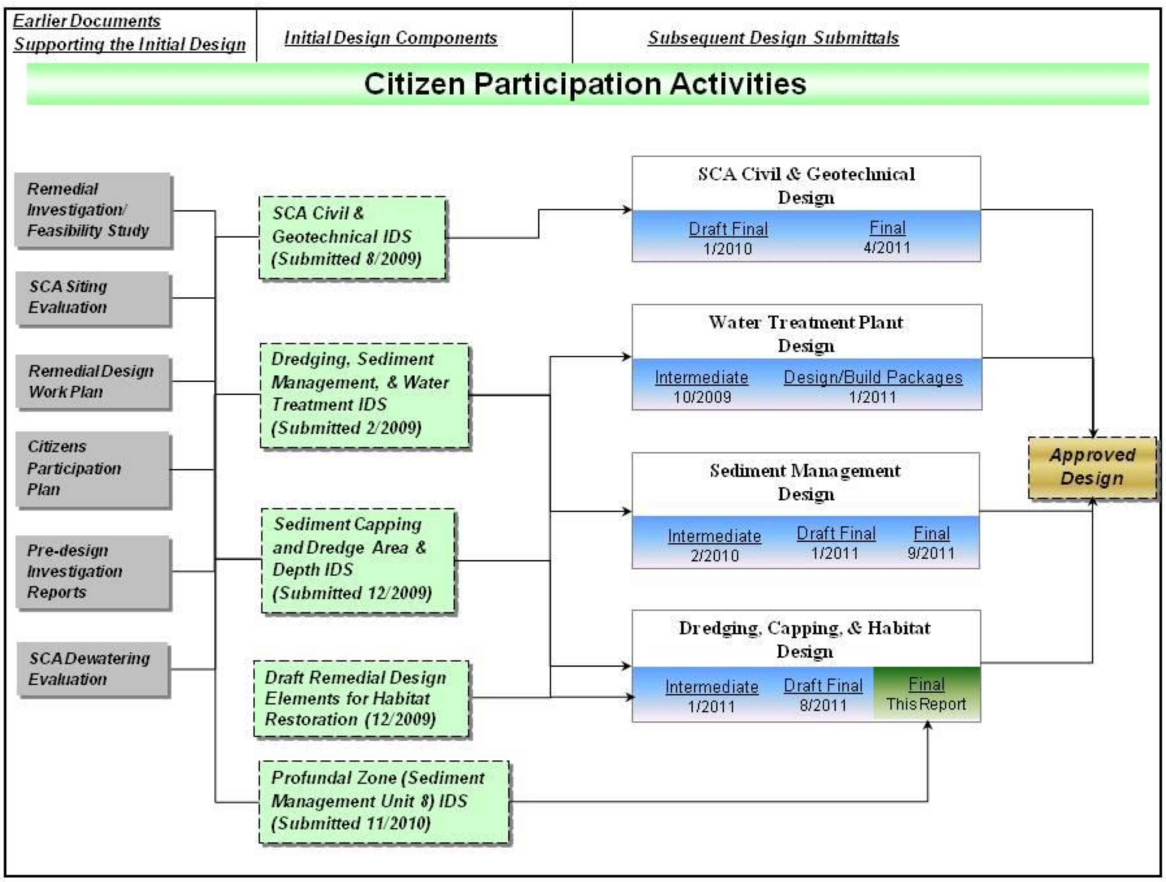
Following the initial phase of the design, separate design tracks were established, with each track ultimately constituting a portion of the overall Onondaga Lake Design. These design tracks include:

- SCA Civil & Geotechnical Design
- Water Treatment Plant (WTP) Design
- Sediment Management Design
- Dredging, Capping, & Habitat Design (Including SMU 8)

The graphic below depicts the overall Onondaga Lake Design process, how project documents submitted to date serve as the basis for the various design tracks, and presents the plan for the submittal of the remaining design components.

In addition to the design documents described above, the following three documents, which are also subject to NYSDEC review and approval, will describe procedures to be implemented during and subsequent to remedy implementation:

- Onondaga Lake Monitoring and Maintenance Scope (OLMMS) - The OLMMS presents the criteria and decision making framework for measuring progress towards, and attainment of, remedial goals. Specific topics discussed in this document include: monitored natural recovery, fish tissue, surface water, cap maintenance and monitoring and habitat.
- Construction Quality Assurance Plan (CQAP) - The CQAP details the construction monitoring activities to confirm that the dredging and sediment cap and habitat material have been constructed as designed.
- Water Quality Management and Monitoring Plan (WQMMP) - The WQMMP addresses suspension of impacted sediments as well as release of dissolved contaminants during construction. This program will be implemented to prevent potential unacceptable water quality impacts as a result of sediment disturbances during capping and dredging activities.



Onondaga Lake Design Process

1.5 DESIGN ORGANIZATION

This design report is organized into 11 sections and multiple appendices. A summary of each section is provided below.

- Section 1: Background and Design Process Overview – Presents background information, site description, remedial goals for the site, and a summary of the remedial action.
- Section 2: Community Participation, Community Health and Safety, and General Project Requirements – Highlights Honeywell's community participation efforts and presents general requirements applicable to many aspects of the project, including federal, state, and local requirements, ordinances and regulations applicable to the design.
- Section 3: Littoral and Adjacent Shoreline Remediation Areas – Provides an updated basis for the division of the littoral zone into distinct remediation areas, which include capping and/or dredging. The boundaries of these remediation areas are based on the data collected during the pre-design investigation. This section also includes the adjacent wetland areas included in the design.
- Section 4: Capping and Habitat Restoration – Presents the technical evaluations and design for the sediment cap and the details related to habitat restoration in the remediation areas.
- Section 5: Dredging – Presents the design plans for the dredging areas, depths and volumes for each remediation area and the details pertaining to dredging methods.
- Section 6: SMU 8 – Presents information related to the remedy in the deep water portion of the lake including nitrate addition, monitored natural recovery, and thin-layer capping.
- Section 7: In-Lake Debris, Utility and Cultural Resources Management – Presents the characterization and management approach for debris, cultural resources and utilities within capping and dredging areas.
- Section 8: Management of Ambient Water Quality During Dredging and Capping – Presents an overview of the ambient water quality goals and related management and monitoring approach to be implemented during construction.
- Section 9: Construction Sequencing and Schedule - Presents a preliminary analysis of the sequencing of dredging and capping operations in various remediation areas of the lake.
- Section 10: Post Cap Monitoring and Maintenance – Presents summary-level plans for post-construction maintenance and monitoring of the sediment cap.
- Section 11: References – Lists the references used to prepare this report.

SECTION 2

COMMUNITY PARTICIPATION, COMMUNITY HEALTH AND SAFETY, AND GENERAL PROJECT REQUIREMENTS

The health and safety of members of the community and consideration of community input are of paramount importance in designing the lake remedy. Section 2.1 of the *Dredging, Sediment Management, and Water Treatment IDS (*Parsons, 2009a) and the *Sediment Consolidation Area Civil and Geotechnical IDS* (Parsons, 2009b) provide detailed discussions of community considerations and project requirements relevant to those aspects of the Onondaga Lake remedy. The *Onondaga Lake Citizen Participation Plan* (CPP) (NYSDEC, 2009) provides details regarding community involvement for the entire Onondaga Lake Bottom Subsite remedial program. Community considerations and project requirements that pertain specifically to the sediment capping and habitat aspects of the remedy are discussed in the subsections below.

2.1 COMMUNITY PARTICIPATION AND HEALTH AND SAFETY

Honeywell is continuing a Community Outreach Program designed to ensure transparency of the design process, incorporate community ideas and feedback, and to maintain awareness of remedial progress and milestones. This outreach was designed in recognition of the importance of the lake as a natural resource to the surrounding area, and the level of community interest in the progress of the Onondaga Lake remediation. This section discusses the importance of community feedback and some of the design aspects that have been modified based on feedback received to date, and outlines future plans and design components which will help ensure the health and safety of the surrounding community while remedial activities are ongoing.

2.1.1 Community Participation

The NYSDEC and Honeywell are required and committed to informing and involving the public during the remedial design and construction phases of the Onondaga Lake project. Public interest in the cleanup and restoration remains high. The CPP provides a formal, yet flexible plan for communication with the public during the remediation of the Onondaga Lake bottom.

Feedback received through the community participation process has already had a significant influence on design-level decisions in several areas of the remedial design. Pertaining to the activities described in this report, community interest and feedback have primarily focused on the restoration and end-use components of the remedial design. Significant effort has been spent to develop a lakewide plan for the incorporation of habitat restoration. These plans are presented in the draft *Onondaga Lake Remedial Design Elements for Habitat Restoration* (Parsons, 2010). NYSDEC and community members and interest groups such as the Audubon Society, Ducks Unlimited, Citizens Campaign for the Environment, Salt City Bassmasters, New York Wildfowlers, Onondaga County Federation of Sportsmen, Sierra Club, Izaak Walton League of America have provided important input to ensure that the vision for post-remediation Onondaga Lake fits with the goals of the community, and that the recreational opportunities facilitated by the remedial design are aligned to maximize the benefit to the surrounding community.

Continued involvement of the community is a critical component to the successful restoration of Onondaga Lake. Opportunities for further community participation have been summarized in the CPP and are incorporated into the design process.

2.1.2 Community Health and Safety

Ensuring community safety is at the forefront of the design of the lake remedy. As part of the remedial design process, the design team will continue to work with the community to develop various performance criteria and work plans specifically designed to ensure that the health and safety of the surrounding community and environment is maintained throughout the execution of the remedy. The performance criteria developed will be approved by the NYSDEC prior to any remedial action taking place in the lake. An Onondaga Lake Remedial Operations Community Health and Safety Plan will be available for public review and input prior to commencement of in-lake remedial activities. This Community Health and Safety Plan will provide details pertaining to the following:

- Site Security
- Air Quality Management and Monitoring
- Traffic Management
- Navigational Protection
- Noise Abatement
- Spill Prevention, Control and Counter Measures
- Operational Hazards Analysis & Contingency

2.2 GENERAL PROJECT DESIGN AND PERFORMANCE CRITERIA

General requirements applicable to the dredging and capping components of the remedial design are described below. Additional details on requirements pertaining to specific aspects of the remedy are provided in Sections 3 through 6.

2.2.1 Sustainability

Honeywell is committed to minimizing the carbon footprint of construction activities anticipated as part of the execution of the remedy. During the design phase, evaluations were conducted to identify opportunities to incorporate sustainability concepts, including those presented in the *Clean and Green Policy* (USEPA, 2009) and the NYSDEC's DER-31/Green Remediation Program policy into all aspects of the Onondaga Lake remediation. To the extent practicable, use of renewable energy sources, utilization of locally produced/sourced materials and supplies, reduction/elimination of waste, efficient use of resources and energy, and other practices were incorporated into the remedial design, and will be implemented during remedial construction.

2.2.2 Federal and State ARARs

Compliance with federal and state Applicable or Relevant and Appropriate Requirements (ARARs) will ensure that the existing resources are protected during operations and provide for overall protection of human health and the environment. A comprehensive list of chemical-specific, action-specific and location-specific ARARs is included in the ROD. Compliance with federal and state ARARs frequently involves formal permit application and approval processes. Details pertaining to these processes applicable to Onondaga Lake are outlined in the Consent Decree (United States District Court, 2007).

2.2.3 Health and Safety Requirements

The health and safety of site personnel, visitors and members of the public are considered the top priority on this project. Written safety plans will be developed for each phase of the remediation project. Project Safety Plans will be developed and updated as needed to address changing activities and site conditions. The health and safety record of all bidding contractors will be evaluated as part of the bidding process. Specific requirements, including audit procedures, employee drug and alcohol screening programs, and near-miss reporting protocols will also be specified within the safety plans.

2.2.4 Property and Site Access and Right-of-Way Entry

Several components of the remedy may require the use of non-Honeywell owned property. These activities could include construction laydown and cap material storage areas. Access agreements and necessary permits will be obtained in advance of the execution of the remedial activities. All remedial contractors whose scope requires use of these properties will be required to abide by the terms and conditions of the negotiated access agreements and permits.

SECTION 3

LITTORAL AND ADJACENT SHORELINE REMEDIATION AREAS

The littoral and adjacent shoreline remediation area has been delineated based on extensive design-related investigations and covers over 450 acres. Design and performance criteria pertaining to establishment of littoral remediation areas are discussed below, followed by a discussion of the design evaluation methods and results. A discussion of remedial areas adjacent to the lake that are included in the lake design is also provided below. Development of remediation areas associated with the profundal zone (SMU 8) is detailed in Section 6.

3.1 REMEDIATION AREA DESIGN AND PERFORMANCE CRITERIA

To facilitate achievement of the RAOs and PRGs detailed in Section 1.2 and ensure protection of human health and the environment, numeric sediment cleanup criteria were developed in the ROD. The cleanup criteria that must be met within the littoral area are the PEC of 2.2 mg/kg for mercury and a mean PEC quotient (PECQ) of 1 for the 23 contaminants that showed significant contributions to toxicity on a lakewide basis. These 23 contaminants and the method for calculating the Mean PECQ are provided in Table 3.1. These are the criteria used to define the areas in the littoral zone that will be remediated.

In addition, the ROD also states that “the selected remedy will also attain a 0.8 mg/kg BSQV for mercury on an area-wide basis for the lake and for other applicable areas of the lake to be determined during the remedial design.” This BSQV criterion is relevant only in determining the remedial scope in the profundal zone (SMU 8), as discussed in Section 6.

3.2 REMEDIATION AREA EVALUATION AND DESIGN

Onondaga Lake was divided into eight different SMUs during the FS and ROD process, based on water depth, sources of water entering the lake, and ecological and chemical risk drivers. SMUs 1 through 7 are located in the shallow (littoral) zone (less than 30 ft. water depth) of the lake where most aquatic vegetation and aquatic life reside, while SMU 8 consists of sediment in the deeper (profundal) zone (deeper than 30 ft). These SMUs were developed for remedial alternative development and evaluation purposes. Also, the ROD-specified remedy presented the required in-lake portions of the remedy on a SMU-specific basis. These SMU-specific ROD requirements will be met during remedy design. However, analysis of the data collected following the FS and ROD as part of four years of design-related investigation indicated that the SMU boundaries did not always accurately define the limits of the individual sub-areas of the lake. Therefore, the concept of remediation areas has been developed to facilitate the design process.

To more accurately reflect the current understanding of in-lake conditions, the littoral area remediation has been redefined into remediation areas (RA) A through F. Remediation areas and their relationship to SMU boundaries are shown in Figure 3.1. A summary description of these remediation areas is provided below.

- Remediation Area A - Mouth of Ninemile Creek. SMU 4 was originally delineated based on the sediment impacts resulting from the discharge of Ninemile Creek. Subsequent data indicated these impacts extended into adjacent SMUs 3 and 5. Therefore, Remediation Area A includes SMU 4 and adjacent impacted areas in SMU 3 and SMU 5.
- Remediation Area B – SMU 3 was originally delineated based on the area impacted offshore of Wastebeds 1-8. This is consistent with the Remediation Area B designation. However, it excludes the portions of SMU 3 that are now included in Remediation Area A and Remediation Area C.
- Remediation Area C – This area is offshore of the New York State Department of Transportation (NYSDOT) Turn-around Area and the Willis/Semet IRM barrier wall, consistent with SMU 2. However, based on design-related investigation data, the area of contamination extends into adjacent SMU 3, which is included in Remediation Area C. Also, the ILWD was found to extend into SMU 2. The SMU 2 ILWD area is excluded from Remediation Area C.
- Remediation Area D – SMU 1 was originally delineated as the extent of ILWD in the littoral area. Based on design-related investigation data, the ILWD extends into SMU 2 and SMU 7. Remediation Area D includes the ILWD in SMUs 1, 2, and 7.
- Remediation Area E – This includes the southwestern end of the lake, inclusive of SMU 6 and SMU 7, except for the portion of the ILWD that extends into SMU 7. It also includes the contiguous remedial area that extends into adjacent SMU 5.
- Remediation Area F – This includes small areas of impacted sediment north of Remediation Area A and on the north-eastern shore within SMU 5.

The designation for SMU 8 has not been revised (i.e., profundal zone in water depths greater than 30 ft.).

Remediation area boundaries, as shown in Figures 3.2 through 3.4, were established using the extensive sediment database available from the RI and seven phases of design-related investigations. The boundaries were drawn from point to point based on sampling locations where contaminant concentrations are below the sediment cleanup criteria (i.e., neither a mean PECQ of 1 nor a mercury concentration of 2.2 mg/kg are exceeded). This provides for a more conservative establishment of remediation boundaries than methods that rely on interpolation or kriging between sampling locations to estimate remediation boundaries, and ensures all sediments exceeding cleanup criteria will be addressed.

Remediation area boundaries were drawn from point to point based on sampling locations where the sediment cleanup criteria were not exceeded at any depth from the shoreline out to a water depth of 20 ft. (6 meters). This conservative approach will prevent impacted subsurface sediments underlying sediments that do not exceed criteria from potentially being exposed in the future due to natural processes such as erosion.

Remediation area boundaries in non-ILWD areas (outside of Remediation Area D) between 20 ft. (6 meters) and 30 ft. (9 meters) were drawn from point to point based on sampling locations where the sediment cleanup criteria were not exceeded in the top 1 ft. of sediment. Due to the depth of overlying water in these areas, existing sediments are stable even under a

100-year storm event in water depths from 20 ft. to 30 ft. (6 to 9 meters) in Remediation Area A, Remediation Area B, Remediation Area C, and Remediation Area F, and would be expected to see only minor disturbances in Remediation Area E, as documented in Appendix D. This demonstrates that deeper impacted sediments would not be exposed even under extreme events (e.g., 100-year storm). Therefore, determination of remediation area boundaries in these deep water areas is appropriate based on consideration of the top 1 ft. of sediment. These areas are also net depositional, as discussed in Section 4.1.7; therefore, the thickness of clean surface sediments in these areas will increase over time. In Remediation Area D, boundaries in the 20 ft. (6 meters) and 30 ft. (9 meters) were drawn from point to point based on sampling locations where the sediment cleanup criteria were not exceeded at any depth.

As shown in Figure 3.3 and detailed in Appendix A, the area subject to a chemical isolation cap includes a small portion of SMU 8 directly adjacent to Remediation Area D. This Remediation Area D addendum cap area (approximately 5.6 acres) has elevated mean PECQ values; therefore, a chemical isolation cap rather than a thin-layer cap is appropriate for this area of SMU 8. Chemical isolation cap details are provided in Section 4.1. All other SMU 8 surface sediment mean PECQ values in the vicinity of Remediation Area D have a mean PECQ value less than 2, and therefore will be remediated with thin-layer capping and MNR, consistent with other areas of SMU 8. Additional details pertaining to delineation of this addendum cap area are provided in Appendix A. Delineation of the SMU 8 areas subject to thin-layer capping are detailed in Section 6.

Remediation Area C includes the localized area around sample location S48. This sample location does not exceed remediation criteria, but showed a chironomid mortality greater than 50 percent during the RI. The remediation boundary around sample location S48 was based on surrounding sample locations that did not exceed remediation criteria, consistent with other remedial area delineation.

Appendix A provides documentation pertaining to development of these remediation area boundaries. Discussion on boundaries associated with capping versus dredging and capping is provided in Sections 4 and 5.

3.3 LAKE BATHYMETRY, WATER ELEVATIONS, AND SHORELINE DEFINITION

The remediation area boundaries extend to the lake shoreline. The water level used to define the shoreline and for the lake remediation design was 362.5 ft. (North American Vertical Datum [NAVD] 88) in order to meet habitat objectives focused on plant communities in nearshore areas of the lake. This elevation of 362.5 ft. is the average lake level during the aquatic plant growing season. The average annual lake surface elevation is 362.8 ft. (NAVD88), which is slightly higher than the average lake surface elevation during the aquatic plant growing season.

A dam located approximately 15 miles downstream of the lake along the Oswego River in Phoenix, New York, controls the water level in the lake, but the lake level can change seasonally due to spring run-off and dry summers as well as daily due to weather events. Extreme events can raise the lake level; the highest recorded level was 369.18 ft. Low lake levels are typically not lower than 1 ft. below average due to the dam system in the river (lowest recorded level was 361 ft.). High water events are relatively frequent, with the lake elevation above 365.4 ft. more than 180 days during the past 30 years (approximately 2 percent of days on record). The lake is generally at its highest elevation in the early spring due to increased tributary flows and at its lowest elevation during the summer months.

Geophysical and bathymetric surveys of Onondaga Lake were performed by CR Environmental, Inc. to define lake bathymetry for design purposes as part of Honeywell's Phase I Pre-Design Investigations (PDI) (Parsons, 2005) as documented in *Onondaga Lake Phase I Pre-Design Investigation Geophysical Survey Report* (CR Environmental, 2007). Four types of surveys were conducted as part of the Phase I PDI: (1) bathymetric survey to identify the contours of the lake bottom; (2) side-scan sonar to characterize debris, obstructions, and other surficial features of the lake bottom; (3) sub-bottom profiling to supplement the assessment subsurface stratigraphy; and (4) magnetometer data to identify fired debris (such as bricks) and obstructions containing iron within or on top of the lake sediments. A 1-ft. contour interval bathymetric map of Onondaga Lake was generated from the 2005 data set and is the basis for the design described in this report.

3.4 ADJACENT REMEDIATION AREAS INCLUDED IN DESIGN

The lake design includes portions of the designs for three areas along the shoreline that are being remediated in addition to the lake: the spits at the mouth of Ninemile Creek, the connected wetlands and shoreline stabilization at Wastebeds 1-8, and the Wastebed B/Harbor Brook (WBB/HB) Outboard Area (Figure 3.5). Due to similarities in remedial approaches and the connectivity with the adjacent lake dredging, capping and habitat designs, remediation of these areas will occur in conjunction with the remediation of the adjacent lake area. Integration is required to provide for appropriate transitions between the lake and adjacent remediation areas. Each of these areas is included in the Draft Habitat Plan and discussed in detail below.

3.4.1 Ninemile Creek Spits

Ninemile Creek flows into Onondaga Lake and was impacted by past industrial activities, as was its tributary Geddes Brook. The remedial approach for the lower portion of Ninemile Creek, referred to as Operable Unit 2 (OU-2), is documented in the 2009 Operable Unit 2 of the Geddes Brook/Ninemile Creek Site ROD (NYSDEC and USEPA, October 2009). The spits of land that extend into the lake at the mouth of Ninemile Creek were included as part of OU-2 (Figure 3.5), and were formed by deposition of sediments coming from Ninemile Creek. As documented in the OU-2 ROD, remediation of the spits includes sediment removal, placement of a cap/backfill material, and habitat restoration, consistent with the remediation of adjacent lake areas in Remediation Area A.

Remediation of the spits will be completed as an integral part of the lake remediation, and therefore the design for this area is included in this submittal. The spits on both sides of the mouth of Ninemile Creek are delineated as emergent wetlands. The integrated design for this area includes removal of sediments within the complete area delineated as emergent wetland (approximately up to the shore tree line), construction of a chemical isolation cap similar to the lake chemical isolation cap and habitat restoration. The removal of the eastern spit terminates just prior to the start of the future shoreline groundwater collection system on the east side, and the scrub-shrub upland on the south. The western spit terminates along the deciduous forest wetland on the south border of the emergent wetland delineation.

The design for the Ninemile Creek spits area considers the engineering feasibility of the removal of channel sediments in the determination of the final depths of removal as described on page 82 of the Geddes Brook/Ninemile Creek OU2 ROD. Engineering feasibility is discussed in the footnote on page 81 and it states "…It also will not be considered feasible [to substitute additional sediment removal depth for an isolation layer in a specific area] if the required depth of removal would exceed 2 ft (60 cm) beyond that needed to otherwise remove sediments for the purpose of: placing the isolation layer, erosion protection layer, and habitat layer; …"

The depth of removal required for the purpose of placing the proposed isolation layer, erosion protection layer, and habitat layer is 5-ft. Therefore, based on the above excerpt from the NMC OU-2 ROD, it would not be considered feasible to eliminate the need for a chemical isolation layer on the spits if removals greater than 7 ft. would be required. Post-ROD PDI samples collected from the spits indicate that removals in excess of 9-ft on the western spit (see sample NMC-SB-113) and 8-ft. on the eastern spit (see sample NMC-SB-116) would be required to achieve a mercury sediment concentration of 0.5 ppm or less. Based on these sample results, it is not feasible as defined in the ROD to eliminate the chemical isolation layer. Therefore, installation of the proposed chemical isolation cap is consistent with the Geddes Brook/Ninemile Creek OU2 ROD. The cap effectiveness criteria in the Ninemile Creek Spits area is based on the criteria presented in the Geddes Brook/Ninemile Creek OU2 ROD as discussed in Appendix B.

3.4.2 Wastebeds 1-8

The Wastebeds 1-8 site, a subsite of the Onondaga Lake Superfund site, is located along approximately 2.1 miles of Onondaga Lake's southwest shoreline and borders Ninemile Creek (Figure 3.5). The wastebeds consist largely of inorganic wastes resulting from the production of soda ash using the Solvay process. The Wastebeds 1-8 IRM will include the construction/operation of a shoreline groundwater collection system (O'Brien & Gere, 2010) to control shallow and intermediate groundwater migrating toward Onondaga Lake. The groundwater will be collected along two segments of shoreline: an approximately 1,060 ft. segment east of the mouth of Ninemile Creek and an approximately 6,700 ft. segment along the east side of the wastebeds. The collection system will include a collection pipe embedded within a gravel filled drain at an elevation several feet below the lake level. Passive recovery wells will be designed and maintained for full capture down to the top of the silt and clay unit.

Dredging will be completed up to the shoreline to ensure adequate depth for placement of the cap and for habitat restoration as part of the Remediation Area B remedy. The removal will slope from the bottom of the dredge cut along the shoreline into the adjacent upland. The shoreline groundwater collection trench location will be documented in the Wastebeds 1-8 IRM design and will take into consideration this slope.

Remedial activities on Wastebeds 1-8 include construction of 9.3 acres of wetland (2.3 acres wetlands directly connected to Onondaga Lake, and 7 acres of inland wetlands) in the vicinity of Remediation Area B. Of these 9.3 total acres of wetlands, 2.3 acres will be constructed to off-set the loss of lake surface area associated with the off-shore location of the Willis IRM barrier wall in Remediation Area D, as documented in the ESD discussed in Section 1.3. The wetland mitigation complex is located within the low-lying eastern shoreline of Wastebeds 1-8 along the southern shoreline of Onondaga Lake.

The connected wetland construction on the Wastebeds 1-8 site will include removal of material above and below the water table, construction of an isolation cap, and habitat restoration. The removal design for the connected wetlands are being developed as part of this design due to the similarities in design and the connectivity between the lake remediation and connected wetland construction. The Wastebeds 1-8 IRM also includes a vegetative cover along the eastern shore and shore stabilization along the surf zone of Remediation Area A. These elements will be integrated with the shoreline stabilization along Remediation Area B required by the Onondaga Lake ROD to address erosion of Solvay waste material along the shoreline of Wastebeds 1-8. The lake design includes the shoreline treatment within the lake and extending up to an elevation of 365 ft. (NAVD88) in portions of Remediation Area A and Remediation Area B, due to the consistency of the stabilization and restoration approach from the lakeshore up to this elevation.

3.4.3 Wastebed B/Harbor Brook Outboard Area

The Outboard Area is a 16-acre strip of land that lies between Onondaga Lake and the Wastebed B barrier wall alignment, and includes the mouth of Harbor Brook and areas of wetlands along the lake shoreline. The Outboard Area is part of the WBB/HB site, which is subsite of the Onondaga Lake Superfund site. In order to maintain the overall schedule for remediation of Onondaga Lake, Honeywell has proposed to address remediation of the Outboard Area as an IRM. A CERCLA Proposed Response Action Document (PRAD) for the preferred response action for the IRM was released by NYSDEC and USEPA in January 2012 for public review. The final decision regarding the selected response action will be made after NYSDEC and EPA have taken into consideration all public comments and will be documented in a Response Action Document (RAD), the document that will formalize the selection of the response action.

Based on the wetland restoration concepts advanced as part of the Draft Habitat Plan (Parsons, 2009), the preferred response action presented in the PRAD includes removal of material above and below the water table, hot-spot removals using the same hot-spot criteria used for the ILWD, construction of an isolation cap, and habitat restoration. Due to the similarities in design and the connectivity between the lake remediation and Outboard Area construction, the design for this area is being developed as part of the lake remediation design.

SECTION 4

CAPPING AND HABITAT RESTORATION

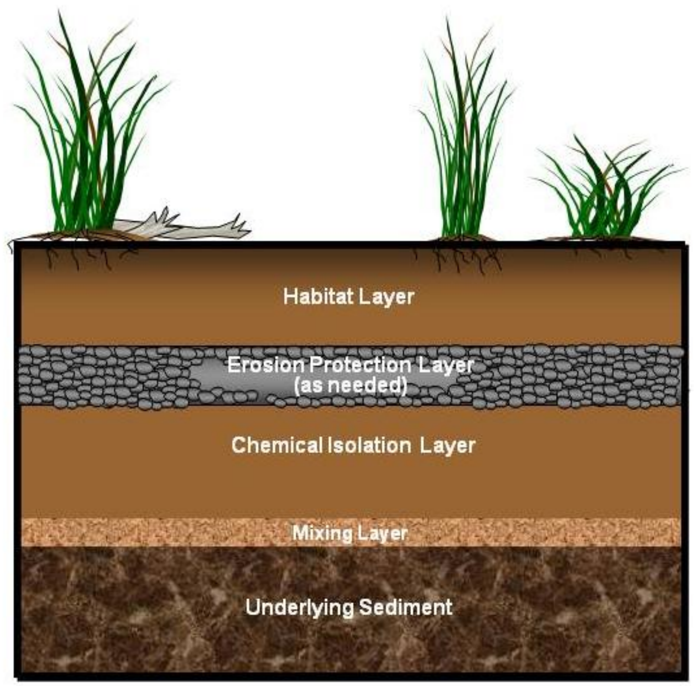
Restoring diverse, functioning and sustainable habitats to the remediated areas of Onondaga Lake is one of the top priorities of this remedial program. Therefore, habitat considerations are at the forefront of the various design evaluations for the lake and have been fully integrated into this document. Habitat considerations are a major factor in developing cap thicknesses. The cap will provide long-term chemical isolation of underlying impacted sediments and prevent exposure of fish and wildlife resources to the impacted sediments. It will be resistant to erosive forces such as wind/wave-generated currents, tributary and other inflows, and ice. It will also provide a suitable habitat substrate that plants, animals, and fish can use without impacting the chemical isolation layer.

The depth of sediments requiring dredging in many parts of the lake is determined by the depth of water desired following construction and the thickness of the cap necessary to meet chemical isolation, erosion protection, and habitat objectives. Water depths following dredging and capping were developed in the Draft Habitat Plan to achieve optimum habitat conditions. For example, in areas near the mouth of Ninemile Creek, the habitat restoration goal includes development of areas where floating aquatic plants such as lily-pads will thrive. This type of habitat is currently absent from Onondaga Lake. The optimal water depth for floating aquatic plants is 1 ft. to 3 ft. Therefore, the dredging depth has been developed in this area such that the water depth following subsequent cap placement is in this ideal water depth range. Because dredge depths are developed based on these types of considerations in many areas, the cap and habitat restoration goals and design are developed in this section prior to presentation of the dredging design in Section 5 even though dredging will be completed prior to capping as part of the construction sequence.

Detailed technical evaluations presented below demonstrate that capping will be effective in Onondaga Lake. Capping of subaqueous contaminated sediments is an accepted and proven long-term engineering option for managing dredged materials and for *in situ* remediation of contaminated sediments (USEPA, 1994, 2005; NRC, 1997, 2001; Palermo, Clausner, et al., 1998, Palermo, Maynord, et al., 1998), and is a significant component of the Onondaga Lake remedy. Sediment caps are a proven technology and have been implemented at numerous sediment remediation sites, including the Fox River in Wisconsin, the St. Louis River Interlake Duluth Tar site in Minnesota, and Commencement Bay in Washington. Based on the cleanup objectives established for the lake, the functions for the cap include:

- Restoration and enhancement of aquatic habitat in the lake
- Physical isolation of the contaminated sediment from the aquatic environment
- Reduction or elimination of the flux of dissolved contamination into the upper layers of the cap such that cap performance criteria are not exceeded
- Stabilization of contaminated sediment, preventing resuspension and transport of contaminants to the profundal area and other areas of the lake

To ensure that these goals are met and that the cap provides long-term protection of human health and the environment, the cap will include specific layers dedicated to various purposes. These layers will include a habitat layer, an erosion protection layer, a buffer layer and a chemical isolation layer, as well as an allowance for mixing of the bottom of the chemical isolation layer with the underlying existing lake sediment, as shown in the schematic below.



General Schematic of Sediment Cap

In addition to the layers shown above, a buffer or safety layer will be incorporated into the habitat layer or added to the chemical isolation layer, as required by the ROD. A detailed discussion of each cap layer and the basis for the layer thickness and substrate type is provided in Sections 4.1 through 4.3. Thicknesses and materials for these layers in each Remediation Area are shown in Figures 4.1 through 4.6.

Based on evaluations presented in these sections, the minimum habitat layer thickness will range from 1 ft. to 2 ft. depending on the water depth. The habitat layer material will consist of either topsoil, medium to coarse sand, fine to coarse gravel, or gravely cobble consistent with the intended habitat for specific areas of the cap. The minimum erosion protection layer thickness will be 1 ft. throughout the cap area. The erosion protection layer material will range from sand to gravely cobble-sized materials, consistent with the erosion protection requirements for specific areas of the cap (see Section 4.2 and Appendix D). In areas where the desired grain size of habitat layer material is consistent with the erosion protection layer material requirements, the layers will be combined since a single layer can function as both in such cases.

The chemical isolation layer will consist primarily of sand or gravely sand. Based on detailed computer modeling, the chemical isolation layer will be 1 ft. thick throughout the capped area (with the exception of the 6 to 9 meter water depths in Remediation Area A, and Model Areas E1 and E3). In certain areas, modeling indicates that a thinner cap would be effective; however the minimum cap thickness as specified by the ROD is 1 ft. In certain areas, amendments, including granular activated carbon (GAC) and siderite will be added to the chemical isolation layer. GAC will significantly improve sorption of contaminants within the isolation layer and ensure that the 1 ft. thick layer will be protective in the long term. Siderite, a naturally occurring mineral that neutralizes high pH, will be added in areas where elevated pH in underlying sediments, such as the ILWD, could impede long-term microbial degradation of contaminants within the isolation layer. The chemical isolation layer, including amendment additions, has been designed to be effective for 1,000 years or longer. As described above, the chemical isolation layer placement will include an allowance for mixing of the bottom of the cap material with the underlying existing lake sediment.

The modeling used to develop the design of the chemical isolation layer, which is described in detail in Appendix B, is conservative in that it does not include several factors that will significantly contribute to the long-term performance of the cap. Specific concepts and processes not incorporated into the model that will result in an even higher level of long-term chemical isolation than predicted by the model are detailed in Appendix B, and include:

- An allowance for placement of additional cap thickness beyond the design-specified minimum will be provided to the remediation contractor during construction to ensure that the minimum thickness is achieved everywhere. This material over-placement, which will include GAC, will result in increased contaminant sorption, biological decay, and amendment application, and will lower concentrations throughout the cap and extend its long-term performance. The amount of over-placement and resulting conservativism resulting from over-placement will vary over the area of the cap.
- Additional GAC beyond the design-specified minimum will be incorporated into the chemical isolation layer to account for potential unequal mixing of the activated carbon with the sand. The capping field demonstration conducted in late 2011 provided information relative to determining the amount of extra GAC addition required. The final amount of additional GAC required to account for field variability will be determined during the capping start-up period, as detailed in the CQAP.
- Additional material will be placed to account for mixing of the bottom of the cap with the underlying sediment (the mixing layer) which provides additional chemical isolation.

As listed above, the actual thickness of each cap layer constructed in the field will typically exceed the minimum required design thickness based on engineering analyses due to operational considerations of how the cap materials will be placed in the lake. The contract requirements will specify that the contractor will need to place a minimum thickness for each layer. To ensure that the minimum required cap thickness is obtained, the capping construction contract will allow for over-placement beyond the minimum target cap layer thickness. This over-placement allowance addresses the tolerances contractors can achieve given the water depths, bathymetry, currents, waves, capping equipment, and other factors. For each specific layer (e.g., chemical isolation, erosion protection, and habitat) the contract documents will specify the minimum thickness and the allowable amount of over-placement. The result will be that the final thickness of each layer will be equal to or more than the specified minimum thickness in each area, which will provide additional chemical isolation and habitat value. However, over-placement will be controlled during construction to prevent excessive cap material placement so that target water depths can be achieved for specified habitat objectives. Section 4.3.4 discusses how cap over-placement allowances and target habitat water depths were considered in the design of the dredge depths and areas.

There are several areas associated with design and construction of the cap where adaptive management concepts may be appropriate. Adaptive management refers to enhancements to project implementation based on lessons learned and from actual experience gained during the course of the project. These lessons learned can lead to revisions to the assumptions that were made during the course of the design, allowing the project construction schedule and final effectiveness to be optimized. Specific areas of the dredge and cap design and construction where adaptive management may be appropriate include over-dredge and cap material over-placement allowances, cap mixing layer thickness, water quality monitoring, debris removal, and project sequencing. Any design changes resulting from adaptive management during construction, such as revisions to dredge prisms, will be subject to approval by NYSDEC.

4.1 CHEMICAL ISOLATION LAYER

The chemical isolation layer will physically and chemically isolate aquatic plants, benthic organisms, animals, and humans from the underlying sediment. Chemical isolation is achieved through placement of a clean cap material that inhibits contaminant migration for a thousand years or more. This long-term isolation is a result of contaminant sorption onto the cap materials, as well as contaminant degradation through biological processes within the chemical isolation layer. This section discusses design and performance criteria, the methods and results from bench testing, design evaluations, computer modeling, and the design of the chemical isolation layer.

4.1.1 Chemical Isolation Layer Design and Performance Criteria

Design and performance criteria for the chemical isolation layer based on ROD requirements and other project-specific considerations are listed below.

- Computer modeling will be used to determine the required thickness and composition of the chemical isolation layer such that concentrations of contaminants, which may migrate into the habitat layer, do not exceed cap performance criteria for 1,000 years or more:
- As required by the ROD, the chemical isolation layer will be a minimum of 1 ft. thick.
- As required by the ROD, a buffer layer, or safety layer, equal to 50 percent of the thickness of the chemical isolation thickness will be added to the overall cap thickness. As part of the design, a decision will be made regarding what portion (if any) of the buffer layer may be considered part of the habitat restoration layer.
- The point of compliance, consistent with the ROD, is at the bottom of the habitat layer. The isolation layer will be designed to prevent unacceptable concentrations of contaminants throughout the habitat restoration layer.

- The performance criteria for the cap at the point of compliance and throughout the habitat layer will be the PEC for each of the 23 contaminants that have been shown to exhibit acute toxicity on a lakewide basis (see Table 3.1), as well as the NYSDEC sediment screening criteria for benzene, toluene, and phenol.
- A thin-layer cap in lieu of the isolation cap may be appropriate based on design evaluations in some depositional portions of the littoral zone in water depths from 20 ft. to 30 ft. (6 to 9 meters) provided it can be demonstrated that it will be effective in meeting remedial goals. The thin-layer cap in these areas will include a habitat layer and the habitat layer will not be used for chemical isolation.

The design team undertook extensive bench-scale evaluations, design analyses, and computer modeling to develop the chemical isolation layer design in accordance with these design criteria, the results of which are discussed below.

4.1.2 Chemical Isolation Layer Bench-Scale Evaluations

Tests were conducted to simulate site-specific conditions, evaluate *in situ* fate and transport processes, assess potential cap amendment performance for select areas of the lake, and provide information for the chemical fate and transport modeling (see Section 4.1.3). The design of the chemical isolation layer of the cap is supported by over seven years of site-specific laboratory and bench-scale testing. Bench tests were designed and executed in consultation with and by leading researchers in the field of sediment cap design. Specifically, bench-scale experiments were conducted to evaluate:

- Biological degradation rates for use in cap modeling to determine the isolation layer thickness
- Whether significant gas is generated within lake sediments, and if so, whether it could result in contaminant migration through the cap
- Whether consolidation of underlying sediments resulting from cap placement could result in NAPL migration into the cap
- Contaminant partitioning onto cap material for use in cap modeling to determine the isolation layer thickness
- Effectiveness of sorption amendments (carbon, organoclay and peat) in minimizing contaminant migration through the cap
- Effectiveness of amendments for buffering pH in order to promote biological decay of contaminants within the cap

The following sections provide detail on each of these evaluations, including a summary of the results and a discussion on their application and relevance to the chemical isolation layer design. Complete reports and work plans referenced below are available in the Onondaga Lake public repositories, or will be available once they receive approval by NYSDEC.

In addition to the bench scale testing listed above, the design team and selected capping contractor (Sevenson Environmental) completed numerous column studies to evaluate the effectiveness of placing a combined sand and GAC chemical isolation layer. This included construction and use of a 3-ft. square, 22-ft. tall settling column, with observation ports along the height of the column. The design height of the tank allowed the team to perform the demonstration in water depths representative of the proposed capping water depths. The demonstration was performed using multiple sand and carbon mixes, application methods and water depths. The sand/GAC mixture was hydraulically pumped into the top of the column and allowed to settle. Visual observations of the sand and GAC that settled to the bottom of the column showed a well dispersed dose of carbon throughout the placed layer. Samples of each test were removed by test pans similar to proposed sampling in the lake. The test included input from the technical team as well as observations by NYSDEC and experts in the field. Testing results were positive and achieved good mixing of GAC and sand following settlement within the large column. Calgon F-400 as well as GAC with larger particle sizes were evaluated. No improvement in placement or mixing of the GAC throughout the placed sand layer was noted for the larger GAC based on visual observations. Therefore, F-400 sized particles were selected as the preferred grain size because the smaller particle size will result in more particles for the same application rate, and thus more disperse distribution of the GAC throughout the sand.

Based on the success of the GAC large column testing described above in demonstrating the potential effectiveness of placing a chemical isolation layer consisting of a mixture of sand and GAC (Calgon F-400), a capping field demonstration was completed using full-scale capping equipment. The capping field demonstration confirmed that the hydraulic placement equipment proposed for the Onondaga Lake cap can consistently place GAC mixed throughout a sand layer at the specific water depths required for the Onondaga Lake project.

4.1.2.1 Biological Degradation Bench Testing

Biological degradation of organic contaminants within the chemical isolation layer is an important contaminant fate process considered in the design of the chemical isolation layer. Over time, natural biological processes will degrade organic contaminants as they slowly migrate upwards into the cap and reduce contaminant concentrations throughout the isolation layer and the overlying habitat layer. Several stages of bench-scale experiments were conducted to evaluate the rate of biological decay anticipated to occur within the cap for key compounds present in lake sediments and porewater.

The first stage of bench testing included batch slurry experiments as part of the Phase II PDI to qualitatively assess biological degradation (Parsons, 2006). Under these experiments, sealed vials of a mixture of lake sediment and water were sampled and analyzed over time for contaminant biological decay. The slurry experiments indicated that anaerobic biological decay of those organic compounds anticipated to drive the cap design can occur naturally in most areas of the lake (Parsons, 2009e). The slurry experiments also suggested that biological decay within the cap in Remediation Area D would likely not occur at significant rates without neutralization of the pH of porewater as it passes through the cap due to the high pH of the underlying ILWD.

Building on the results of the batch slurry experiments, column studies were executed during Phase III of the PDI (Parsons, 2007). The column studies simulated *in situ* cap conditions and provided a realistic representation of microbe density and contaminant fate and transport through a sand cap. A layer of Onondaga Lake sediment (approximately 6 in. thick) was placed at the bottom of each column, and a layer of sand capping material was added over the top of the sediment layer. Water flow was introduced through each column and effluent water samples were collected and analyzed periodically from the top of the column above the sand cap layer. In general, the results of the Phase III PDI column tests were similar to those observed in the batch slurry experiments. Biological decay was observed in columns collected in Remediation Area E (SMU 6 and 7), while columns collected in Remediation Area D (ILWD) showed little to no biological activity (Parsons, 2009d).

Additional batch and column experiments were conducted during Phase IV and Phase V to supplement the results of the Phase III PDI testing and evaluate variability in the experimental results. Column experiments were designed to collect additional information on biological decay rates in areas not impacted by elevated pH or where pH will be neutralized as part of the capping remedy (Parsons, 2008). The results of the additional column studies demonstrated degradation of certain CPOIs over the time frame of the experiment, however, the ability to replicate multi-year *in situ* chemical isolation layer residence times (assuming velocities in the range of a centimeter per year) was limited by the experimental duration.

A second, more extensive series of batch slurry experiments was executed as part of the Phase V PDI (Parsons, 2009) to provide additional detail on biological degradation rates, mechanisms, and geochemical processes. Over 70 experimental treatments, each conducted in triplicate, were tested to assess degradation using site sediment and porewater. Based on test results, anaerobic biodegradation is predicted to occur within the chemical isolation layer for benzene, toluene, ethylbenzene, xylene, chlorobenzene, dichlorobenzene, naphthalene and phenol, provided porewater pH is 8 or less. Results from this testing were used to determine the appropriate biodecay rates for these chemicals for use in chemical isolation layer modeling. Test results also indicate aerobic biodegradation of all contaminants evaluated would occur in the near-surface area of the cap provided pH is 8 or less.

4.1.2.2 Mercury Transport Bench Testing

The mercury partitioning coefficient is a key input parameter to the cap model evaluation. Isotherm experiments, as discussed in more detail in Section 4.1.2.5.1, were conducted to assess partitioning of mercury onto sand, activated carbon, peat and organoclay. Modeling of mercury partitioning is based on the results of these isotherm experiments. This is a very conservative approach to modeling mercury in the areas of the cap where siderite will be added to reduce pH. Results from leachate testing using site porewater and siderite conducted during PDI Phase IV (Appendix I) as well as batch testing conducted during PDI Phase VI (Parsons, 2010) (see Section 4.1.2.5.2) demonstrated near complete removal of mercury from porewater in the presence of siderite (presumably due to formation of stable precipitate that cannot be transported in the aqueous phase). This process has not been incorporated into the cap modeling, nor has the sorption of mercury onto activated carbon, which was documented as part of the Phase IV (Parsons, 2009e) and Phase VI PDI isotherm studies.

Prior to disassembling the Remediation Area D (SMU 1) Phase III PDI biological decay columns described in Section 4.1.2.1, the flowrate of water was increased significantly (to generate the necessary volume for analysis) and effluent water samples were collected and analyzed for mercury. Samples were also collected along the cap profile and analyzed for mercury. These results indicated that there was no transport of mercury through the cap over the course of the experiment (Parsons, 2009d). Given the lack of mercury transport into the cap, it was not possible to determine a quantitative partitioning coefficient for mercury from these studies. Nonetheless, the limited transport observed from these results is indicative of strong partitioning of mercury onto sand cap material.

Mercury-specific column experiments were conducted during the Phase IV PDI (Parsons, 2008). The sediment sampling locations used to generate sediment for these tests were located in areas with elevated porewater mercury concentrations to allow for detectable concentrations during column studies; additionally these samples were also located in areas with high pH. The results from these column studies demonstrated low partitioning coefficients under the high pH conditions present. Reduced mercury partitioning would be expected at high pH. In areas where pH is currently elevated, the current design includes pH neutralization via siderite amendments in the cap, therefore these results were not used for cap modeling.

4.1.2.3 Gas Generation Bench Testing

Bench study results, as well as the technical team's experience at other capping sites, indicate that contaminant mobilization driven by gas generation will not occur at significant levels in Onondaga Lake. Gas generation experiments were designed during Phase II of the PDI to measure the gas generation potential of sediments underlying the cap and to assess the potential for gas to impact contaminant migration (Parsons, 2006). These experiments involved measuring gas generation and release in closed tubes filled with lake sediment. Based on the gas generation rates measured in the batch studies, potential contaminant transport was assessed through column experiments. In the gas column experiments, gas was introduced to a sediment layer at a rate consistent with the upper range of gas generation rates measured in the batch tests. Monitoring results did not detect significant contaminant migration as a result of gas generation. (Parsons, 2009c).

4.1.2.4 Settlement-Induced NAPL Migration Bench Testing

Bench test results indicate that NAPL migration will not result due to consolidation of Onondaga Lake sediments as a result of capping. Settlement-induced NAPL consolidation studies were conducted during Phase II of the PDI to assess the potential for increased mobility of NAPL in Onondaga Lake sediments due to the physical loading of a sediment cap (Parsons, 2006). These studies involved subjecting a series of sediment samples to loads equivalent to the range of potential loading anticipated from placement of a sediment cap. These studies were focused on samples from areas of known high contaminant concentration and where stained sediments potentially indicative of discontinuous "blebs" of NAPL were observed.

Neither the application of a load exceeding the maximum that would result from cap placement nor the resulting consolidation of the lake sediments resulted in NAPL release in any sample. The intermittent and weathered form of NAPL observed in the sample cores was not consistent with the type of NAPL that has a high potential for migration into the cap as settlement occurs.

4.1.2.5 Amendment Bench Testing

Following the biological decay bench testing conducted during the Phase II and Phase III PDI discussed in Section 4.1.2.1, it became evident that in areas where elevated pH impacts biological activity, cap amendments would likely be appropriate in order to meet the cap performance criteria specified in the ROD. Therefore, a series of bench testing was conducted to evaluate potential cap amendments. These studies focused on amendments that would increase the sorptive capacity of the cap, as well as amendments that would neutralize the high pH within the cap resulting from elevated pH in the underlying sediment, as discussed below.

4.1.2.5.1 Isotherm Testing of Organoclay, Sand, Peat, and Activated Carbon

Isotherm testing was conducted during the Phase IV PDI on selected organic contaminants and mercury using representative porewater from Remediation Area D and Remediation Area E (SMUs 1 and 6/7, respectively) to assess the contaminant sorptive capacity of sand, activated carbon, organoclay and peat (Parsons, 2008). Based on the results of the isotherm experiments, subsequent modeling, and constructability considerations, activated carbon was selected as the most effective and appropriate cap amendment to improve contaminant sorption in areas where cap amendments will be incorporated (Parsons, 2009e).

Prior to full isotherm development, preliminary isotherms were conducted on four types of activated carbon to identify the best candidate to study in detail. The preliminary isotherm experiments were designed to obtain the necessary information for executing the full isotherm experiment. These experiments were also designed to identify the form of activated carbon most resistant to fouling by natural organic matter through a comparison of isotherm results in organic free water with those results obtained from SMU 1 porewater. The preliminary experiments identified Calgon Carbon Corporation Filtrasorb™ 400 (F400) 12 x 40 mesh as the optimal activated carbon to conduct full isotherm studies based on the sorption capacity measured as well as the fact that F400 carbon is a standard product subject to less variability than regenerated carbon. Regenerated carbon also performed well in the screening experiments, demonstrating effective sorption and resistance to organic fouling similar to the virgin F400 carbon (Parsons, 2009e).

Additional isotherm testing was conducted during the Phase VI PDI to validate the Phase IV PDI results and evaluate each isotherm point in triplicate to reduce variability relative to the initial testing (Parsons, 2010). Screening studies conducted during the Phase VI isotherm experiments indicated a potential influence of pH on activated carbon sorption for some compounds. As a result, a second round of isotherms was conducted at a neutral pH. The testing conducted during Phase VI also eliminated the effects of sparging the initial porewater which may have had an effect during Phase IV on the measured sorption rates. Results from the adjusted pH isotherms were generally consistent with or more conservative (i.e., showed less sorption) than the Phase IV results, and were based on experimental protocols that employed higher levels of quality assurance and quality control (QA/QC); therefore, the Phase VI amended pH carbon isotherms were used in the cap modeling evaluation for all lake cap areas where an activated carbon amendment will be employed. Additional isotherm testing was also conducted on samples collected in two areas of the Wastebed B Outboard Area as part of the Wastebed B/Harbor Brook IRM Outboard Area Isotherm Study Work Plan (Honeywell, 2010). Results from these isotherm studies were used for the modeling evaluation for the Outboard Area.

As part of the Phase III PDI column studies described under Section 4.1.2.1, two columns were also initiated using activated carbon. These columns ran for a three year period at a flow rate equivalent to 279 cm/yr. which is approximately two orders of magnitude higher than will be present within the cap. These columns qualitatively demonstrated the effectiveness of activated carbon.

4.1.2.5.2 pH Amendment Evaluation

Bench test results, in conjunction with constructability considerations, were used as the basis for selecting granular siderite as the preferred pH amendment. The pH amendment testing was completed during the Phase III PDI to evaluate methods to neutralize pH within the sediment cap in order to enhance biological decay in areas where pH is elevated in underlying sediments (Parsons, 2007). The amendments tested included three forms of siderite (powder, pelletized and granular), iron sulfate, aluminum sulfate, iron phosphate, aluminum phosphate, and peat. Batch testing was used to derive information on pH neutralization rates and endpoints for different application rates of the amendments tested (Parsons, 2009e). Granular siderite successfully lowered the pH and did not drop the pH below a circumneutral pH endpoint (between 6 and 8). Geochemical modeling was conducted to assess the performance of siderite and to establish dosing rates. Appendix I provides additional detail on the cap pH modeling.

Two different leaching tests were also performed on siderite to evaluate potential impacts due to trace metals and other impurities possibly present in the material. As detailed in Appendix I, results from this testing confirm that there would be no adverse environmental impacts in the lake due to placement of siderite as part of an amended cap layer. Additionally, results from the leachate testing for mercury showed that addition of siderite resulted in a reduction of mercury concentrations in porewater to levels below the reporting limit.

Following the Phase III batch testing and cap pH modeling, additional column testing was initiated to provide information on potential porous media effects that need to be considered in up-scaling from bench scale to field scale. Results from this testing indicate that porous media effects are not a significant consideration and that the pH modeling approach is valid.

4.1.3 Chemical Isolation Layer Design Evaluations

Design of the chemical isolation layer was based on site-specific data, laboratory bench-scale evaluations and computer models that simulate cap processes and evaluate long-term cap performance. Two design models, developed by experts in the field of sediment cap design, were employed to evaluate: 1) steady state; and 2) transient concentrations throughout the cap profile and to calculate concentrations within the habitat layer.

The steady-state model was used to predict concentrations that would exist after contaminants have traveled upwards into the cap and an equilibrium condition becomes established between advective and diffusive transport, biodegradation (where quantified), and exchange with the overlying water column. This model was used as a conservative screening tool to reduce the number of contaminants requiring detailed evaluation, and is described in detail in Appendix B. The transient model was used to predict time-varying concentrations within the cap system and was used to evaluate non-linear sorption processes, short-term impacts resulting from porewater expression from underlying sediment resulting from settlement, and long-term behavior for the amended cap areas.

These models have been published and discussed in peer reviewed literature (Lampert and Reible, 2009 and Palermo, Maynord, et al., 1998) and have been tested by Parsons and independent reviewers by benchmarking against other models. Appendix B provides additional detail on the models employed, modeling strategy, modeling framework and model results. Modeling results are summarized in Section 4.1.4. Isolation layer modeling was conducted for

Remediation Area A (including the Ninemile spits), Remediation Area B, Remediation Area C, Remediation Area D, and Remediation Area E, as well as the WBB/HB Outboard Area and the Wastebed 1-8 connected wetland area.

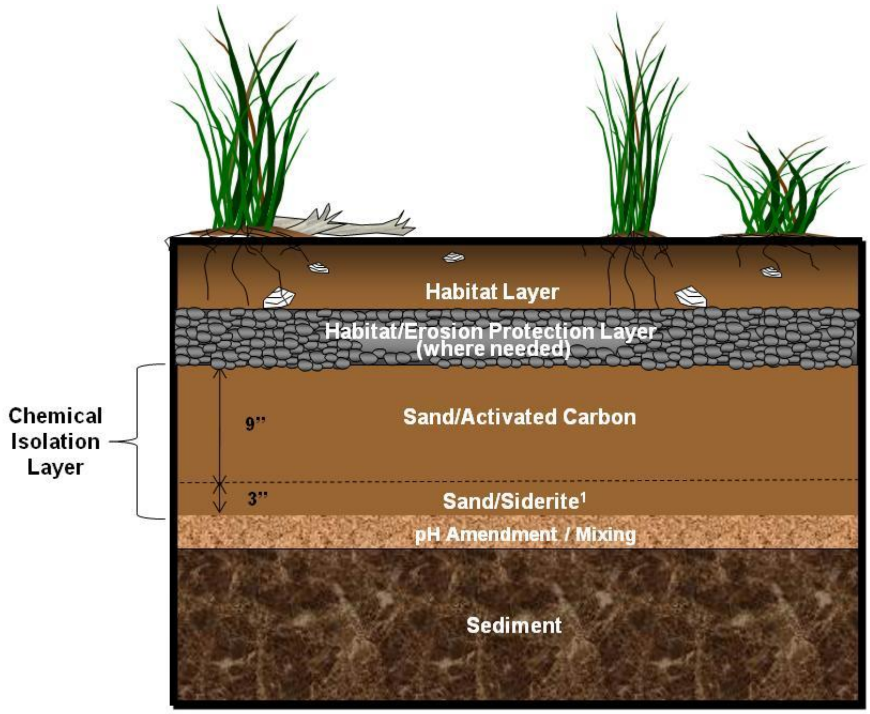
Site-specific data were used in the model to maximize the accuracy and reliability of the results. An extensive site-specific database for the most important model input parameters has been developed based on the RI and seven years of PDI data and laboratory studies, which includes the analytical results from over 7,000 sediment samples and 5,500 porewater samples. Site-specific model input parameters include:

- Initial contaminant porewater concentration
- Fraction of organic carbon (foc) in the isolation layer and habitat layer
- Groundwater upwelling velocity
- Organic carbon partitioning coefficient (koc) for the isolation and habitat layers (as well as the underlying sediments)
- Site-specific data were also collected to evaluate the performance of cap amendments, including activated carbon sorption parameters and pH buffering capacity and rate of neutralization for siderite.

In addition to the site-specific model input parameters described above, observations of biological degradation in the laboratory bench-scale testing described in Section 4.1.2.1 were used to verify the appropriateness of literature-based biological degradation rates that were used to model anaerobic degradation in the cap.

4.1.4 Chemical Isolation Layer Design

The chemical isolation layer will consist primarily of sand or gravely sand. Based on bench-scale testing summarized in Section 4.1.2, and cap modeling results presented in Appendix B, amendments will be incorporated into the cap in certain areas to ensure long-term (1,000 years or longer) effectiveness of the cap. These amendments will consist of siderite to neutralize elevated pH and promote long-term biological decay of key contaminants within the cap, and activated carbon to improve sorption of contaminants within the cap and ensure long-term protectiveness. A general schematic of an amended cap is shown below, followed by a discussion of the amendments and how they will function as part of the isolation layer in areas where they are required. In areas where amendments are not required to achieve long-term chemical isolation, the profile will be similar except that the chemical isolation layer will consist of a minimum of 12 in. of sand only.



1. In amended cap areas of Remediation Area E the chemical isolation layer will be 12" sand/carbon mix. Siderite will not be added to the cap as pH levels are at or close to neutral.

Example Schematic of an Amended Cap

The pH amendment will consist of siderite, which is a naturally occurring mineral (typically mined in rock form) that is used primarily as an iron supplement for livestock. It consists of approximately 77 percent iron carbonate, 12 percent quartz, 10 percent clay, and trace amounts of pyrite by weight. Prior to the application, the siderite will be crushed and screened to result in a grain size similar to sand. The siderite will be mixed with sand at the required dosage (with appropriate factor of safety to account for variability in field application) and placed in a pH amendment layer (part of the larger chemical isolation layer) with a minimum thickness of 0.5 ft. The final amount of additional siderite required to account for field variability will be determined during the capping start-up period, as detailed in the CQAP. This will constitute the base layer of the amended cap, and will include the "mixing" layer of the cap. Mixing of the siderite with the underlying sediment will not impact the siderite's pH neutralization capacity. As porewater passes through the pH amendment layer, it will be neutralized to a pH of approximately 7, which will produce conditions that are amenable to long-term microbial activity and biological decay of key contaminants as they migrate through the overlying sand layer.

The areas where a pH amendment will be incorporated were determined based on the biological decay studies discussed in Section 4.1.2.1, which indicated that biological activity was not impaired at a pH of 8.0 but was potentially impaired at a pH of 8.5 or greater. Therefore, pH amendment will be incorporated into those areas of the carbon-amended cap where biological decay is incorporated into the cap modeling in Appendix B and the underlying pH exceeds 8.0. Figures showing pH in underlying sediments for each remediation area are included in Appendix B. The required siderite application rate for the various areas was determined based on geochemical modeling, as detailed in Appendix I. Model areas where siderite will be incorporated are indicated in the summary table below.

As discussed above, it is anticipated that application of the pH amendment will facilitate biological decay of organic contaminants within the cap. As discussed in Section 4.1.2.1, there is evidence from the testing to date and in the literature that over time biological decay will occur in the isolation cap for all of the volatile organic compounds (VOCs). Given the inherent complexities in replicating long-term environmental processes in the relatively short-term investigation period, it is difficult to generate a robust data set to adequately quantify site-specific biological degradation rates for all organic contaminants of concern currently evaluated with the cap model. Therefore, as a conservative assumption, the modeling evaluation (Appendix B) employed literature-based VOC degradation rates that are generally consistent with or more conservative than anaerobic decay rates measured in the testing described in Section 4.1.2.1. To conservatively account for the time it may take for a sufficient microbial community to become established, a lag period before biodecay is assumed to be effective was incorporated into the modeling.

Activated carbon will be mixed with the sand used for construction of the chemical isolation layer to improve sorption of contaminants within the cap and ensure long-term effectiveness. Site-specific bench-scale testing of granular activated carbon and subsequent modeling has demonstrated that activated carbon will effectively adsorb the various dissolved organic contaminants, allowing development of a cap design that will be effective for 1,000 years or longer, as described in detail in Appendix B. This will ensure that the cap is protective and achieves long-term compliance with cap performance criteria. The amended cap design is based on application of bulk activated carbon mixed with sand, which offers several advantages over use of a carbon mat (which was considered during the Initial Design phase), including the ability to adapt the activated carbon dosage based on area-specific requirements, improved construction schedule, and improved activated carbon performance in a diffusion-dominated scenario such as that present in the remediation areas of Onondaga Lake.

Results from the modeling based on site-specific conditions and incorporation of conservative assumptions, as listed in the introduction to Section 4 and detailed in Appendix B, are summarized in the table below. Activated carbon and pH amendment application rates are provided for each model area in Appendices B and I, respectively. The cap thicknesses listed below are the minimums required based on design evaluations and do not include over-placement or over-dosing required to meet these minimums during construction. Remediation areas were subdivided as appropriate into modeling areas as discussed following the summary table.

Chemical Isolation Layer Design Summary

Remediation Cap Area	Model Area	Minimum Thickness (ft.)	Activated Carbon Amendment	pH Amendment
A and Ninemile Spits (87.8 acres)	A1 0 to 6 M	1		
	A1 6 to 9 M	0.5		
	A2	1	X	X
B (19.4 acres)	B1/C1	1	X	X
	B2	1	X	X
C (24 acres)	C2	1	X	X
	C3	1	X	X
D (98.5 acres) and Addendum Cap Area (5.6 acres)	SMU2	1	X	X
	West	1	X	X
	Center	1	X	X
	East	1	X	X
E (including CSX shoreline area) (182.8 acres)	E1 (0 to 6 M)	1		
	E1 (6 to 9 M)	0.5		
	E2	1	X	
	E3 (0 to 6 M)	1	X	
	E3 (6 to 9 M)	0.5	X	
F (<1 acres)	F	1		
WB 1-8 Wetlands (2.4 acres)		1	X	X
WBB/HB Outboard Area (16.3 acres)	East	1	X	
	Center	1	X	X
	West	1	X	X

The basis for development of each of the modeling areas listed above and the chemical isolation layer design for each model area are discussed below. The modeling areas are delineated on Figures 4.1 through 4.5. Model areas were developed to ensure that the cap would be designed specific to conditions in an area based on key model input parameters such as groundwater upwelling velocity and contaminant porewater concentrations. Supporting information such as figures showing contaminant porewater distributions in each area are included in Appendix B. The isolation layer design required for each area is based on computer modeling for all 26 contaminants for which cap performance criteria were established, as detailed in Appendix B.

Remediation Area A and Ninemile Creek Spits: As listed in the summary table above and shown in Figure 4.1, Remediation Area A was segregated into Model Areas A1 and A2. Model Area A2 was delineated due to the presence of higher levels of VOCs, higher groundwater upwelling velocities, and elevated pH in this area, as compared to Model Area A1. Due to the VOC concentrations and elevated pH, GAC and pH amendments will be included in the cap for Model Area A2. For construction simplification, the chemical isolation layer design for the spits will be the same as that for the surrounding Model Area A2. Separate modeling of the spits was completed to verify that the cap in this area would be protective and achieve the cap performance criteria specified in the Ninemile Creek ROD for this area, which are different than the lake cap performance criteria, as detailed in Appendix B. Independent modeling was completed for the area surrounding sample location OL-VC-40197 where elevated concentrations of Xylene and Ethylbenzene were measured. A higher GAC dosage, specified in Appendix B, will be applied in this area as compared to the surrounding Model Area A2.

The predominant VOC in Model Area A1 is phenol. Biodegradation of phenol has been incorporated into the modeling for this area based on the robust biodecay of phenol documented in the bench studies, and no activated carbon amendment is required in this area. There are isolated areas in Model Area A1 where pH exceeds 8.0, as shown in the Appendix B figures. However, these are not co-located in areas where phenol or other VOCs are present at levels that impact the design; therefore no pH amendment is required in this area.

Remediation Area B and Wastebed 1-8 Connected Wetlands: Remediation Area B is relatively small (4 percent of the total cap area), as shown in Figure 4.2. Remediation Area B was divided into Model Area B1 and Model Area B2 given the relative differences in groundwater velocities and contaminant distribution. The pH is elevated in both model areas, and pH and activated carbon amendments will be included in both Model Area B1 and B2. In Model Area B2 phenol is the primary VOC. In Model Area B1 multiple contaminants are present at levels that could drive the design. Given the similarities in groundwater velocities and contaminant distribution and concentration, Model Area B1 was combined with Model Area C1 (i.e., Model Area B1/C1 was treated as a single area for modeling purposes).

Conditions in the Wastebed 1-8 connected wetland are similar to those in the adjacent lake area. However, to ensure a protective design, this area has been evaluated as a separate model area.

Remediation Area C: Remediation Area C is relatively small (approximately 5 percent of the total cap area), as shown in Figure 4.3. Remediation Area C was divided into Model Areas C1, C2 and C3. The pH is elevated in all three model areas, and pH and activated carbon amendments will be included throughout. As discussed above, Model Area C1 was combined with Model Area B1 given the similarities in contaminant nature and groundwater upwelling velocities. The distinction between Model Areas C2 and C3 results from the impact of the influence of the upland hydraulic containment system along the shoreline adjacent to Model Area C3. Model Area C3 also contains a wider distribution of contaminants that may drive the cap design, while Model Area C2 is primarily impacted by higher concentrations of phenol and napthalene.

Remediation Area D: As shown in Figure 4.4, Remediation Area D is divided into four subareas based on differing levels of contamination, as discussed further in Appendix G. The pH is elevated throughout Remediation Area D, and pH and activated carbon amendments will be incorporated into the cap design in each subarea. Independent modeling was completed for the area surrounding sample locations OL-VC-10138 and 10140 where elevated porewater concentrations were measured. A higher GAC dosage, specified in Appendix B, will be applied in this area as compared to the surrounding Model Area ILWD Center.

As shown in Figure 4.4, there is a relatively small area in SMU 8 adjacent to Remediation Area D where a chemical isolation cap will be constructed. The basis for delineation of this addendum cap area is provided in Section 3.2 and Appendix A. The design for this area is consistent with the cap design in the adjacent subareas of Remediation Area D.

Remediation Area E: Remediation Area E was divided into Model Areas E1, E2, and E3, as shown in Figure 4.5. The distinction between Model Areas in Remediation Area E was based on the distribution and relative concentrations of contaminants. The groundwater upwelling velocities across Remediation Area E are relatively uniform. Cap Model Area E2 was delineated due to the presence of higher levels of VOCs in sediment porewater as compared to those in Cap Model Area E1. Concentrations of most contaminants in Model Area E3 were consistent with levels in E1; however, the concentration of naphthalene was somewhat elevated in that area, warranting evaluation of E3 as a separate Model Area. Activated carbon amendments will be incorporated into Model Areas E2 and E3 based on the levels of organic contaminants present. There are isolated areas in Model Area E1 where pH exceeds 8.0, as shown in the Appendix B figures. However, these are not co-located with areas where phenol or other VOCs are present at levels that impact the design; therefore, no pH amendment is required in this area.

Remediation Area F: Remediation Area F consists of two small areas totaling less than one acre. These areas were delineated based on sediment mercury concentrations that exceed the Mercury PEC. These areas are not close to shore; therefore, groundwater upwelling velocities are low. Mercury concentrations are much lower in these areas than in other areas where modeling indicates that a 1 ft. chemical isolation layer will be sufficient. Therefore, the chemical isolation layer thickness in this area will be a minimum of 1 ft. consistent with the ROD. The pH in these areas is not elevated, so no amendments are required.

Wastebed B/Harbor Brook Outboard Area: The WBB/HB Outboard Area was divided into the Eastern, Center, and Western areas for modeling purposes, as shown in Figure 4.4. The eastern area was modeled separately due to the lower VOC concentrations, upwelling velocities and pH values in this area. The Western and Center areas have similar porewater and pH values, but were developed as separate areas to account for the spatial variability in upwelling velocities across these two areas.

Due to the VOC concentrations and elevated pH, GAC, and pH amendments will be included in the cap for the Western and Center model areas. There are isolated areas in the Eastern area where pH exceeds 8.0, as shown in the Appendix B figures. However, areas of elevated pH are scattered, and pH levels are only slightly elevated in the sediments that will remain following dredging. In addition, VOC concentrations are low in these areas and modeling was conducted assuming no biological decay of contaminants. Therefore, no pH amendment is required in the Eastern Area.

A portion of the Outboard Area cap surface in the vicinity of the barrier wall will be above lake level. As a result, analysis was completed to evaluate the potential for infiltrating surface water to migrate into the cap and subsequently into the underlying sediment. The potential concern is that localized groundwater recharge could result in slightly higher groundwater upwelling velocities in submerged portions of the cap. However, the cap materials will have a significantly higher permeability than the underlying sediment; therefore, most of the infiltrating surface water will migrate laterally within the cap, minimizing the potential for localized groundwater recharge. As shown in the Appendix F cross-sections for this area, the elevation of the dredge cut, and thus the elevation of the bottom of the cap, is close to or below the design lake elevation of 362.5 throughout the Outboard Area, including adjacent to the barrier wall. Therefore, localized infiltration of groundwater will not impact the effectiveness of the cap.

4.1.5 Buffer Layer

As an additional level of conservatism, the ROD specifies that a 50 percent buffer or safety layer will be included in the cap design, and that the decision will be made during design as to whether this buffer layer will be added to the chemical isolation layer or will be considered as part of the habitat layer. As detailed in Appendix B, the isolation layer thickness required to meet remediation goals for those contaminants in areas that do not rely on activated carbon (A1, E1 and F) is less than 8 in., indicating that there is significant conservatism based on a 1-ft. minimum chemical isolation layer thickness. For those contaminants that rely on amendments to ensure long-term effectiveness, significant conservatism is incorporated into the modeling and minimum compliance period of 1,000 years, as summarized in introduction to Section 4. In addition, the design evaluation incorporates the results from 7 years of data gathering and thousands of sample results, and a highly sophisticated model (Appendix B), which significantly reduce uncertainty around model predictions. Therefore, the buffer layer required by the ROD as a thickness equal to 50 percent of the chemical isolation layer thickness will be applied to the habitat layer in all areas.

4.1.6 Mixing Layer Allowance

The chemical isolation layer design will include an allowance for mixing of the bottom of the cap with the underlying existing lake sediment. Based on a review of mixing layer thicknesses measured at other recently completed capping sites (Table 4.1), a mixing layer thickness of 0.25 ft. (3 in.) was determined to be a conservative and appropriate estimate of constructed mixing layer depths. This assumption may be refined through adaptive management, with concurrence from NYSDEC, based on observations and measurements made during cap construction.

The sites evaluated varied with respect to cap construction, water depth, placement mechanism and substrate properties, resulting in a relatively heterogeneous cross section of site types. Overall, sediment mixing appears to be relatively minimal for all of the 22 sites which were reviewed. Of the eight sites where quantitative results were available, one reported a mixing depth of 4 in., while the remaining seven reported a mixing depth of 2 in. or less. For those sites where mixing depths were not reported, the qualitative information indicated minimal mixing was noted or that a clear cap/sediment boundary was identified.

The 0.25 ft. mixing allowance, combined with the range of over-placement allowance that is expected for all cap layers combined (estimated mean over-placement on the order of 0.5 ft. to 1 ft. in most cap areas, as shown in Table 4.2), significantly exceeds the 0.5 ft. that was assumed in the ROD to account for mixing and over-placement.

4.1.7 Modified Cap in Six to Nine Meter Water Depths

As specified in the ROD, a thin-layer cap may be appropriate in water depths from 20 ft. to 30 ft. (6 to 9 meters) provided it can be demonstrated that it will be effective in meeting remedial goals. A thin-layer cap typically refers to placement of approximately 0.5 ft. of sand or less to reduce contaminant levels in surface sediments, and is a significant component of the SMU 8 remedy. For evaluation of thin-layer capping in the 6 to 9 meter zone, a more robust thin-layer cap was developed. This will consist of a 0.25 ft. mixing layer, a minimum 0.5 ft. chemical isolation layer, and a 1 ft. minimum habitat layer, as shown in Figures 4.1 and 4.5. This cap is referred to herein as a modified cap rather than a thin-layer cap to avoid confusion with the thin-layer cap which will be constructed in SMU 8.

A modified cap is appropriate in the 6 to 9 meter zone for Model Area A1 in Remediation Area A and Model Areas E1 and E3 in Remediation Area E. This is based on several considerations, including the results of chemical isolation layer modeling, generally low VOC concentrations (compared to other Remediation Areas) and groundwater upwelling velocities, and the depositional nature of these areas. Based on cap modeling, as detailed in Appendix B, 4 in. is sufficient thickness to achieve chemical isolation of all contaminants in the 6 to 9 meter zone in Model Areas A-1 and E-1, and chemical isolation of mercury in 6 to 9 meter zone in Model Area E-3. Long-term effectiveness of the cap with regard to organic contaminants in Model Area E-3 is a function of the GAC application rate, which has been developed specifically for the 6 to 9 meter zone of this area. Therefore, a 0.5 ft. chemical isolation layer will meet cap performance criteria and is appropriate for the 6 to 9 meter zones of Model Areas A-1, E-1, and E-3.

Although the effectiveness of the modified cap in the 6 to 9 meter zone does not depend on long-term sedimentation, the long-term depositional nature of this area will contribute to the long-term effectiveness of the cap in this area. Effler (1996) concluded that Onondaga Lake regions with depths in excess of 6 to 8 meters (20 to 26 ft.) represent the depositional basin of the lake. A more detailed evaluation of sediment stability completed in Section 10 of Appendix D also concluded that the sediments in this zone are not subject to resuspension, except under extreme events, and that this area is net depositional.

4.2 EROSION PROTECTION LAYER

The erosion protection, or armor layer, will overlie and protect the chemical isolation layer from erosional processes including:

- Wind-generated waves (waves resulting from winds blowing across the lake)
- Ice scour (stresses induced from ice freezing to the bottom of the lake in shallow water)
- Tributary flows (high flows discharging into the lake resulting from the creeks and other discharges)
- Currents within the lake
- Vessel-related effects including propeller wash (high velocities resulting from the propellers on recreational and commercial boats operating on the lake) and vessel-generated waves (i.e., vessel wake)

Design and performance criteria and the methods and results from design evaluations pertaining to the erosion protection layer are discussed below and further detailed in Appendix D. Based on the evaluations detailed in Appendix D wind-generated waves present the greatest potential erosive forces and therefore dictate the erosion protection layer design. The erosion protection layer will be a minimum of 1-ft. thick within the lake. In the adjacent wetlands, the erosion protection layer will be a minimum of 4.5-in. thick. In some areas, the materials planned to construct the habitat and erosion protection materials are the same, resulting in a top cap layer in these areas of 1 ft. or more that functions as both the habitat and erosion protection layers. The erosion protection layer material will range from sand to gravely cobble-sized particles, consistent with the erosion protection requirements for specific areas of the cap as detailed below. In areas where the habitat layer material is consistent with the erosion protection layer material requirements, the layers will be combined since a single layer can function as both in such cases.

4.2.1 Erosion Protection Layer Design and Performance Criteria

USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005) states that:

> The design of the erosion protection features of an *in situ* cap (i.e., armor layers) should be based on the magnitude and probability of occurrence of relatively extreme erosive forces estimated at the capping site. Generally, *in situ* caps should be designed to withstand forces with a probability of 0.01 per year, for example, the 100-year storm.

Incremental increases in erosive forces due to events with a return frequency of greater than 100 years tend to be smaller (when compared to frequencies lower than 100); hence, such effects are expected to be localized, resulting in minor damage potential and an easier repair of any resulting disrupted areas. Thus, in accordance with USEPA guidance and precedents from similar projects, the 100-year extreme events were used in the armor layer design to ensure long-term effectiveness of the cap.

Based on ROD requirements and other project-specific considerations, design and performance criteria for the erosion protection layer are listed below:

- The erosion protection layer will be physically stable under conditions predicted to occur based on consideration of 100-year return-interval waves. The 100-year wave is the highest wave that would be expected to occur, on average, once every 100 years. The cap will also be stable from waves induced by vessel wake.
- The erosion protection layer, specifically the areas potentially impacted by influent from tributaries, will be physically stable under conditions predicted to occur during a 100-year flood flow event.
- The cap will be designed to prevent the chemical isolation layer from being disturbed by ice.
- The cap will be designed such that the chemical isolation layer will not be negatively impacted by erosive forces resulting from propeller scour.

Design analysis methods and results pertaining to development of the erosion protection layer design to meet these criteria are provided below.

4.2.2 Erosion Protection Layer Design Evaluations

The erosion protection layer is designed to provide long-term protection of the chemical isolation layer using methods developed by the USEPA and the USACE specifically for *in situ* caps. This includes the methods included in Armor Layer Design of Guidance for *In Situ*

Subaqueous Capping of Contaminated Sediments (Maynord, 1998). The armor layer design presented herein involved evaluating the particle size (ranging from sand to gravely cobbles) required to resist a range of erosive force expected on Onondaga Lake. Appendix D presents the details of the armor layer design evaluations.

Wind measurements from 1942 to 2009 were obtained from the Hancock International Airport (formerly Syracuse Municipal Airport) and used for the wind/wave analysis. Statistical analysis was performed on the data to estimate the 100-year wave height and duration. The wind-wave analysis was used to determine the depth of the surf zone, where breaking waves result in larger required grain-sized material for erosion protection. Once the height and duration of the 100-year event was derived, the particle grain size required to withstand the erosive forces inside and outside of the surf zone was calculated.

In addition to wind-generated waves, a tributary analysis was performed to evaluate the stable particle sizes under the 100-year flood flow for the armor layer of the cap. Velocity fields generated by the 100-year flows from Ninemile Creek and Onondaga Creek were modeled using a 2-dimensional hydrodynamic model. Particle sizes necessary to withstand the 100-year flood flow were computed for the 100-year flood flow from Ninemile Creek and Onondaga Creek as well as current velocities observed under typical conditions within the lake. An additional evaluation was performed to assess the potential simultaneous combination of erosive forces from wind-generated waves and high tributary flows.

As a vessel or boat moves through the water, the propeller produces an underwater jet of water. This turbulent jet is known as propeller wash (or propwash). If this jet reaches the bottom, it can contribute to resuspension or movement of bottom particles. Types and operating conditions of commercial and recreational vessels that use Onondaga Lake were obtained. Representative vessels were selected for this analysis and the resulting particle size necessary to withstand potential propeller wash erosion from those vessels was calculated.

Finally, an evaluation of the ice processes and the potential for ice erosion along shoreline caps was performed. The analysis involved a field reconnaissance, reviews of published literature on ice processes, observations of water temperature and ice formation at Onondaga Lake, and evaluation of data from other lakes. This evaluation was used to develop required design considerations for protection of the cap against ice scour.

4.2.3 Erosion Protection Layer Design

The erosion protection layer material will range from sand to gravely cobble, consistent with the erosion protection requirements for specific areas of the cap, as detailed in Table 4.3. Details pertaining to the grain size distribution corresponding to the grain size descriptions in the table are provided in Appendix L (Cap Material Specifications). As shown on Table 4.3, the minimum potential erosion protection layer thickness ranges from 0.25 to 0.5 ft. for various areas of the cap. However, the minimum erosion protection layer thickness will be set to 1 ft. everywhere within the lake. This provides added protectiveness by ensuring that even if some of the finer overlying habitat substrate is lost due to erosion, a minimum of 1 ft. of material that will serve as the erosion protection and habitat layer will remain in place. In the adjacent wetlands, the additional erosion protection that will be provided by the wetland vegetation was taken into consideration, resulting in a minimum erosion protection layer thickness in the wetlands of

4.5 in. as detailed in Appendix D. The design of the erosion protection layer is driven primarily by consideration of wind-generated waves. Analysis of vessel wake-induced waves concluded that wind-induced waves would be more of a significant potential impact to the armor layer.

The tributary analysis resulted in stable particle sizes of fine gravel for the portions of the cap near the discharge of both Ninemile Creek (Remediation Area A) and Onondaga Creek (Remediation Area E). The required particle sizes are less than or equal to the stable particles computed from the wind-wave results (see below). Ninemile Creek and Onondaga Creek are the two largest inflows to the lake. An evaluation of the erosion protection requirements associated with the various discharges to the lake in areas to be capped, such as Tributary 5A and the Westside Pumping Station outlet, was also completed, as detailed in Appendix D. The assessment of typical current velocities measured in the lake (away from the influence of tributary flows) indicated a stable particle size of fine sand, which is less than or equal to the stable particles computed from the wind-wave results.

Based on a review of the types of vessels and operating procedures for these vessels in Onondaga Lake, there will be two types of vessel operations over the cap: 1) commercial and recreational vessels operating frequently in the New York State Canal Corporation (NYSCC) navigation channel to the Inner Harbor in Remediation Area E, and 2) recreational vessels operating in shallower water depths. The propeller wash analysis indicates that particle sizes in the coarse gravel range (1 in. to 2 in.) would be required for the armor layer in the NYSCC navigation channel. However, as discussed below, gravely cobble will be used in the channel area to provide additional protection. For the other areas of the cap, recreational vessels will likely operate infrequently and randomly. That is, these vessels will not start and stop or pass over the exact same location on a regular basis. Due to the limited area impacted by propeller wash from an individual vessel, significant movement of armor layer is not expected from propeller wash. In addition, in shallow water, the combined thickness of the habitat layer, inclusive of the erosion protection layer, is 1.5 ft. to 2 ft. thick, depending on the water depth. Any potential disturbance to particles within the surface of the habitat layer of a localized area is expected to "self-level" soon after disturbance due to natural hydrodynamic conditions within the lake.

Special consideration was given to the area along the south side of the NYSDOT turnaround area, where a future public boat launch is anticipated. The top of the sediment cap in this area will be placed at an elevation of 357.5 ft. This will provide a minimum water depth of 4.5 ft. during low water conditions. The habitat and armor layer placed as part of the cap in these areas will consist of a total of approximately 1.5 ft. of coarse gravel materials. As described in Appendix D, the stable particle size in water depths of 4 to 5 ft. for small recreational vessels (such as fishing boats) operating in these areas is coarse gravels.

As detailed in Appendix F, the Canal Corporation maintains the navigational channel leading into Onondaga Creek channel to a depth of 14 ft. deep, but typically only dredge when the water depth is less than 12 ft. Therefore, as detailed in Appendix F, the dredging and capping in this area was designed to provide a channel with a post capping water depth of 16 ft., providing a 2-ft. buffer between the top of the cap and the maximum navigational dredge depth. The gravely cobble erosion protection layer in this area would serve as a marker and provide some resistance to dredging. Based on additional consultation with the Canal Corporation this channel design will be revised as appropriate.

To mitigate the potential for chemical isolation materials to pass through the overlying erosion protection layer (e.g., a process referred to as "piping"), standard geotechnical filter criteria presented by Terzaghi and Peck (1967) were evaluated, which provide recommended particle size ratios between base and overlying materials (e.g., sand chemical isolation and overlying erosion protection materials). Compliance with the recommended filter criteria minimizes the potential for wash out of the base material by the creation of internal filters in the armor stone voids. The specifications for the erosion protection and chemical isolation layers presented in Appendix L were developed to satisfy these filter criteria.

Ice freezing to the bottom of the lake is expected in shallow water at the shoreline of Onondaga Lake. In such cases, it is expected that the normal thickening of ice will encounter the bed and freezing will continue. It was determined that the freezing of ice to the lake bottom is typically limited to water depths of less than 1.5 ft. To protect the chemical isolation layer for the cap, at least 0.5 ft. of the armor layer and chemical isolation layer will be placed below the ice freezing depth of 1.5 ft. Using a low lake water level of 362.0 ft. NAVD88, the conservative worst case ice freezing zone would be above 360.5 ft. The top of the chemical isolation layer and at least 0.5 ft. of the armor layer will be placed below an elevation of 360.5 ft. to ensure ice scour does not completely remove portions of the erosion protection layer. Effects associated with ice, if any, are expected to be localized and restricted to the habitat layer thickness. This approach is also applicable to the Ninemile Creek spits and Wastebed 1-8 connected wetland. Minor exceptions to the design approach detailed above are associated with the Outboard Area wetlands, and with the caps over the cultural resources and Metro deepwater outfall, where the shallow water depths make it impossible to meet these goals. However monitoring, and maintenance if required, will be facilitated by the shallow water in the small areas associated with the cultural resources and Metro outfall. For the WWB/HB Outboard Area, the placement of a minimum of 0.5 ft. of erosion protection material below the freeze depth was not considered necessary due to:

- The WBB/HB Outboard Area is a transition into the wetlands that are above the lake surface, making it impractical to meet this requirement everywhere.
- The WBB/HB Outboard Area will be vegetated and will have a minimum of 2 ft. of material overlying the chemical isolation layer, which will provide significant buffering from any ice scour.
- The ice evaluation is conservative; the potential for impact due to ice scour is low and will be addressed, if necessary, as part of the long-term monitoring and maintenance.

Although not a true erosive force, a bearing capacity evaluation demonstrating that human wading in nearshore areas and the placement of habitat structures will not exceed the cap bearing capacity is also presented in Appendix D. Bearing capacity pertaining to structure associated with habitat restoration was also completed to evaluate habitat structure requirements.

4.3 HABITAT DESIGN

The habitat restoration layer is a critical part of the overall habitat restoration program. It will be the upper-most layer of the cap and will provide the appropriate substrate to promote an active and diverse environment for a wide variety of species, allow for natural movement in the lake system, and exhibit micro-topography. The habitat layer thicknesses are based on an understanding of bioturbation, plant and animal biology (e.g., rooting and burrowing depth), professional experience of local and national experts, and a review of relevant scientific literature and technical guidance. Design and performance criteria and the methods and results from design evaluations pertaining to the habitat layer are discussed below and presented in more detail in Section 4 of the Draft Habitat Plan (Parsons, 2009f). Prior to dredging, capping, and restoration activities, the Final Habitat Plan and an addendum to this final design addressing restoration planting details and structure plans for the lake and wetlands will be submitted to NYSDEC for review and approval. Development of the habitat layer design requires consideration of the overall habitat restoration program; therefore, this section also develops the comprehensive habitat restoration design.

4.3.1 Habitat Layer Design and Performance Criteria

Based on the requirements specified in the ROD and other project-specific considerations, the design and performance criteria developed for the habitat layer are listed below:

- The specific habitat layer thickness and habitat layer substrate (i.e. grain size) will generally be consistent with the target habitat conditions developed as part of the Draft Habitat Plan.
- The habitat layer thickness will be determined based on consideration of plant rooting depth and animal burrowing and nesting depth species typical of central New York lake systems as well as human use.
- The habitat layer will be a minimum of 1 ft. thick in all remediation areas.

Design analysis methods and results pertaining to development of the habitat layer design are provided below.

4.3.2 Habitat Layer Design Evaluations

General habitat restoration goals are established within the Draft Habitat Plan. The first general restoration goal is to maintain or increase diversity of habitats, communities, and species in all habitats by maintaining or improving the:

- Size, diversity, and function of wetlands
- Connectivity of the lake habitats with adjacent stream and upland habitats
- Ecological function of the littoral zone
- Ecological function of the shoreline habitat
- Habitat conditions of the profundal zone
- Conserve and/or create habitats for threatened and/or endangered or rare species

The second general restoration goal is to design conditions that discourage the establishment of invasive species (e.g., avoid creating conditions conducive for invasive species) to the extent practicable.

The third general restoration goal is to develop conditions that require minimal maintenance and minimal public use restrictions. Once implemented, the habitat restoration designs are intended to provide self-sustaining, functioning habitats that require little or no maintenance over the long term. In addition, the restored areas should be open and accessible to the public to the extent practicable within the constraints of the remedy.

In order to meet the general restoration goals, the Draft Habitat Plan describes more specific restoration objectives. To achieve the habitat-specific goals and objectives, the Draft Habitat Plan and the cap and dredge area and depth design were developed concurrently. Habitat layer thickness and substrate requirements have been developed within the Draft Habitat Plan and are detailed below.

4.3.3 Habitat Layer Design

Based on the evaluations summarized above and detailed within the Draft Habitat Plan, the following habitat layer thickness criteria have been developed:

- The habitat layer will be a minimum of 2 ft. thick in wetland areas and shallow water areas with depths from 0 to 3 ft.
- The habitat layer will be a minimum of 1.5 ft. thick in water depths from 3 ft. to 7 ft.
- The habitat layer will be a minimum of 1 ft. thick in water depths from 7 ft. to 30 ft.
- The erosion protection layer will be included as part of the habitat layer thickness. In all locations where the habitat layer and erosion protection layer are different materials, the dedicated habitat material will be a minimum of 1 ft. thick.

In the adjacent wetlands included in the design, the habitat layer will consist of a minimum of 19.5 in. of fine-grained substrate with appropriate organic matter and a minimum of 4.5 in. of coarser substrate that will meet erosion protection layer requirements. With average over-placements, it is expected that there will be approximately 23 in. of fine-grained substrate in the wetland areas. This will provide more than adequate conditions for plant rooting and provide conditions that ensure hydric soils and facilitate a successful wetland restoration. The coarser erosion protection substrate at the bottom of the habitat layer will not have a negative impact on the hydric nature of the overlying habitat substrate in the wetlands. The elevation of the top of the erosion protection substrate in the Wastebed B Outboard Area wetlands is at or below 361.5 ft., resulting in erosion protection substrate that is saturated in the wetland area during average lake level conditions. The top elevation of the erosion protection layer along the shoreline for the Wastebeds 1-8 connected wetlands and the spits at the mouth of Ninemile Creek is below the average lake level of 362.5 ft. Based on these elevations and associated lake levels, the erosion protection substrate will not act as a drainage layer in the shoreline wetlands.

To ensure that the minimum thickness is achieved, over-placement of material will occur during installation of each layer. As such, the average and maximum habitat layer thicknesses will be greater than the minimums specified above. Minimum cap layer thicknesses and estimated mean over-placements are listed in Table 4.2.

These thickness requirements were developed consistent with habitat modules described in the Draft Habitat Plan. Habitat modules are areas with specific physical characteristics suitable for various representative species of fish, birds, plants, etc. In-lake habitat modules are defined by three basic habitat parameters: water depth, substrate type, and water energy. Habitat modules within the lake and the associated habitat layer material substrate are summarized below.

HABITAT MODULE SUMMARY

Module		Water Depth (ft.)	Substrate/Energy
1 -	Deep water	20 to 30	Sand. Low to medium energy.
2A -	Mid water depth	7 to 20	Sand/fine gravel. Low to medium energy.
2B -	Mid water depth	7 to 20	Coarse gravel/gravely cobble. High energy.
3A –	Shallow water	2 to 7	Sand/fine gravel. Low energy.
3B –	Shallow water	2 to 7	Sand/coarse gravel. High energy.
4A -	Floating aquatics wetland	1 to 3	Organics/fines/sand. Very low energy.
5A -	Non-persistent emergent wetland	0.5 to 2	Organics/fines/sand. Low energy.
5B -	Shoreline shallows/limited emergent wetland	0.5 to 2	Gravel. High energy.
6A -	Persistent emergent wetland or salt marsh	1 ft. above water to 1 ft. deep	Organics/fines/sand. Low energy.
6B -	On shore to shallows/limited emergent wetland or salt marsh	1 ft. above water to 1 ft. deep	Coarse gravel/sand. High energy.
8A –	Shoreline/riparian areas/successional fields	> 1ft. above water	Topsoil/sand
8B -	Shoreline/riparian areas/shrub-scrub or forested	> 1 ft. above water	Topsoil/Sand
9A –	Inland wetlands not associated with the lake/ emergent wetland	Varies	Topsoil/Sand
9B –	Inland wetlands not associated with the lake/ forested wetland	Varies	Topsoil/Sand

The habitat layer substrates listed in Table 4.2 are consistent with the resulting post-capping habitat module goals for each area, as detailed in the Draft Habitat Plan. Post-construction plan views and cross-sections and the resulting habitat modules for each Remediation Area are shown on Figures 4.7 through 4.24. The dredging approach to achieve the target habitat modules and elevations in each area is discussed in Section 4.3.4, below. Specifications for the habitat and erosion protection materials are provided in Appendix L.

In many areas where the water depths are less than 3 to 4 ft., the upper portion of the habitat layer is finer-grained material containing organic matter, which has a grain size that is smaller than what is required to resist erosive forces. Therefore, this material will move naturally as a result of wind/wave action. In these areas, the erosion protection layer will be a coarser material that will meet erosion protection requirements discussed in Section 4.2. The thickness of the erosion protection layer will be included in the overall habitat layer thickness requirements, provided the substrate required based on habitat considerations is a minimum of 12 in. thick.

In deeper water, where the habitat substrate also meets erosion protection requirements, there will still be some movement of the upper layers of this material during some wind or storm events. However, significant movement or loss of thickness is highly unlikely. Minor displacement of some of the habitat layer would not require corrective maintenance action that could impact established habitat as there would still be sufficient remaining material to meet the requirements for erosion protection. Areas with a 1 ft. thick habitat/erosion protection layer will be monitored and maintained to ensure that there is 1 ft. of material above the isolation layer consistent with the cap modeling. The areas specified to have a 1 ft. habitat/erosion protection layer are predominately in deeper water where erosion potential is minimal. In the unlikely event that a large portion of this material was eroded away, maintenance to replace the material would be required. However, this would not negatively impact the developing habitat in these locations as it would likely have already been lost with the material. Details regarding the maintenance and monitoring of the habitat/erosion protection layer will be provided in the Cap Maintenance and Monitoring section of the OLMMS.

4.3.4 Development of Dredge Depths to Achieve Habitat-Based Cap Elevations

The depth of sediments requiring dredging in Remediation Areas A, B, C, E, and portions of D were determined by the depth of water desired following capping and the thickness of the cap necessary to meet chemical isolation, erosion protection, and habitat objectives. Conceptual post-capping water depths and resulting habitat modules were provided in the Draft Habitat Plan to achieve diverse habitat conditions. Because dredge depths were developed based on those habitat-based cap elevations in most areas, the cap and habitat restoration goals and resulting dredge design were developed prior to the comprehensive dredging design (presented in Section 5). The capping and dredging design accounts for factors that may impact the final post-capping water depth and the ability to meet the habitat-based goals. Specific factors considered include over-dredging, cap material over-placement, and settlement of the underlying sediment due to the weight of the cap, as discussed below.

Habitat module-based target elevations will be met on an area-wide-average basis. Details regarding the acceptance criteria for achieving target cap elevations during construction will be provided in the CQAP. Variation in water depth beyond the variances shown in Figures 4.7 through 4.24 may occur in localized areas, which will support the goal of microtopography on the lake bottom. Microtopography has been identified as a beneficial habitat feature. The post capping elevations and habitat module boundaries are also likely to shift over time after cap placement due to natural processes such as settlement and wind and wave activity. This process is consistent with how natural habitat systems function and will enhance the variability of the cap surface as would be expected in a natural system.

In order to achieve a minimum required thickness for a specific cap layer, some over-placement (additional thickness beyond the minimum required by the design) will likely occur based on typical construction tolerances achieved at other similar capping sites. Typical mean over-placements from these other capping sites range from 0.25 ft. for materials such as sand and fine gravel to 0.5 ft. for gravely cobble-sized particles. Based on constructability evaluations by the selected dredging and capping contractor (Sevenson Environmental), and their experience on other sites using similar equipment to that planned for Onondaga Lake (discussed in Section 4.5), the following cap material over-placement tolerances are expected to be achievable.

Cap Material	Mean Over-Placement (in.)	Maximum Over-placement (in.) in Shallow Habitat Modules
Sand	3	4
Fine Gravel	3	4
Coarse Gravel	4.5	6
Gravely cobble	6	12

These anticipated over-placements were considered in developing the dredge cuts required to meet the required habitat-based post-capping elevations and elevation tolerances shown in the conceptual cross-sections for each Remediation Area (Figures 4.7 through 4.24). This includes tighter elevation tolerances in habitat modules that have a maximum water depth of 3 ft. or less (Modules 4, 5, and 6), due to the increased sensitivity associated with achieving target post-capping water depth ranges. For the wetland areas, the dredge elevations are based on the total thickness with combined average over-placements of 23 in. for the habitat substrate and 9 in. for the erosion protection substrate (along with the thicknesses of the mixing and isolation layers with average over-placements) to achieve the post-capping target elevations for the wetlands (with up to 1 m additional removals in the Outboard Area hot spots). Based on the anticipated over-placement, and taking into consideration over-dredging that will likely occur in order to achieve required minimum dredge cuts, the required minimum dredge cuts developed in Appendix F for shallow water Modules 5 and 6 anticipated to be dredged in the first dredging season are based on total cap thicknesses inclusive of maximum over-placements listed above for each cap layer. It is anticipated that this is a very conservative approach and that the first year of construction will demonstrate that target cap elevations can be met based on dredge cuts developed using average over-placements for each layer. Therefore, dredge cuts developed in Appendix F for the areas anticipated to be dredged in subsequent dredging season are based on total cap thicknesses inclusive of mean over-placements for each cap layer. Measures for assuring required elevations are met and for documenting the performance results from the first year of operation to support the change for subsequent years are provided in the CQAP.

Following placement of the chemical isolation and erosion protection layers to at least the minimum required thickness in Habitat Modules 4, 5, and 6, bathymetry will be measured. The thickness of the habitat layer placement will be increased in these areas, if necessary, and consistent with the adaptive management approach for habitat modules, in order to ensure the final surface of the habitat layer is within the target water depth range. However, based on the dredging and capping plans, placement of additional habitat material to achieve target cap elevations is not anticipated.

Adaptive management concepts will be applied to the capping and dredging program during construction. Adaptive management refers to enhancements to project implementation based on lessons learned and from actual experience gained during the course of the project. As construction proceeds, the construction tolerances will be closely monitored and the design or construction methods may be refined and optimized, as appropriate. For example, target dredge depths may be reduced if even tighter cap placement tolerances can be demonstrated during construction. Remediation Areas A and E represent the vast majority of the area where dredge depths are determined based on habitat-based elevation goals. As discussed in Section 8, remedial activities in these areas are not anticipated to begin until 2014, allowing ample time to revise the dredging depths in these areas based on initial construction performance in other areas.

The weight of the cap will result in some consolidation settlement over time of the underlying sediments, provided that the weight of sediment dredged prior to capping does not exceed the weight of the cap, as detailed in Appendix E. The magnitude and time-rate of this settlement has been predicted using state of the art models to estimate the implications of this parameter. Estimated settlements are included in the cross-sections shown in Figures 4.7 through 4.24.

As a result of the capping and dredging, bathymetry will be different from current conditions in order to achieve the target habitat goals. Changes in water depth from current conditions based on the conceptual design presented in the IDS are included in the Draft Habitat Plan. These figures will be updated in the Final Habitat Plan, which will be submitted subsequent to the Final Design.

4.3.5 Habitat in Adjacent Remediation Areas Included in Design

As discussed in Section 3.4, this lake design submittal includes portions of the designs for three areas along the shoreline that are being remediated in addition to the lake: the spits at the mouth of Ninemile Creek, the connected wetlands and shoreline stabilization at Wastebeds 1-8, and the WWB/HB Outboard Area. The habitat design pertaining to each of these areas is discussed below.

4.3.5.1 Ninemile Creek Spits

The spits on both sides of the Ninemile Creek outlet are delineated as emergent wetlands. The integrated design includes removal of the emergent wetland (approximately up to the shore tree line), and restoration of the area with an isolation cap constructed similar to the adjacent isolation cap in the lake, as shown in Figure 4.7. The post-remediation acreage of the spits and associated wetland will be the same as currently exists. The wetland area of the spits is approximately 1.9 acres. The post-remediation elevation in the area of the recreated spits will be 1 ft. above water to 1 ft. deep and the area will be restored as Habitat Module 6A. The restoration approach for this area includes a broad, shallow shelf (Module 6A) to help reduce wave energy on the sensitive nearshore environments in this remediation area and provides the only shallow water lower energy environment in the areas specified for remediation. The removal of the eastern spit will terminate just prior to the start of the shoreline groundwater collection trench on the east side, and the scrub-shrub upland on the south. The western spit terminates along the deciduous forest wetland on the south border of the emergent wetland delineation (Figure 4.7). The restoration of these spits includes approximately 1.9 acres of emergent wetland providing diverse habitat similar to previous conditions. A shallow emergent transition (0 to 1 ft.) provides connectivity between lake and Ninemile Creek and may help to reduce wave energy from impacting the adjacent floating aquatic vegetation.

4.3.5.2 Wastebeds 1-8

There will be 9.3 acres of wetlands constructed on Wastebeds 1-8 to mitigate for wetlands and open water aquatic habitat disturbed by the Willis/Semet IRM, WBB/HB IRM, and Wastebeds 1-8 Integrated IRM. This will include 2.3 acres of wetland connected directly to Onondaga Lake with free surface water exchange and 7 acres of inland wetlands (see Figures 4.10 and 4.13). The wetland mitigation complex is located within the low-lying eastern shoreline of Wastebeds 1-8.

The connected wetland will be a 2.3-acre freshwater wetland with varied habitat characteristics to offset the loss of 2.3 acres of open water due to the construction of the Willis IRM barrier wall, as documented in the ESD discussed in Section 1.3. The design includes a primary wetland pool protected from wave energy by a narrow landform (i.e., shoreline berm) with a maximum elevation of approximately 364 ft. (1.5 ft. above the typical growing season lake water level; Figure 4.10). Elevations in the connected wetland will range from 363 ft. to 359.5 ft., providing wetland community types consistent with Habitat Modules 4A, 5A, and 6A.

The connected wetland will provide open water intended for use by waterfowl, wading birds, amphibians, and reptiles that may forage on the small fish likely to inhabit the pool. The connected wetland will also provide shallow water saturated soil habitats allowing for a wide diversity of plant species and a broad range of niches, further facilitating plant diversity, wildlife use and aesthetic value. Overall, the connected wetland is intended to serve as a wildlife migration corridor between the lake and adjacent upland habitats at the Wastebeds 1-8 site.

The inland wetland complex will be located between the 365 ft. contour and the 370 ft. contour and between a groundwater collection system and seep collection system that will be constructed on the Wastebed 1-8 site. The inland wetlands will be constructed to have surface water depths ranging from 0 ft. to 3 ft. with varied microtopography and will be interspersed with deeper pools and habitat transitions with planting zones to include wetland fringe, shallow emergent and emergent/aquatic beds. Constructed berms will be used to contain the inland wetlands in concert with a low permeability layer that is intended to support retention of water in the system. The detailed design for the inland wetlands associated with the Wastebeds 1-8 site are being completed under the design for the Wastebed 1-8 site.

The Wastebeds 1-8 IRM also includes a vegetative cover along the eastern shore and shoreline stabilization along a portion of the surf zone of SMU 4. These elements will be integrated with the shoreline stabilization along SMU 3 required by the Onondaga Lake ROD to address erosion of Solvay waste material along the shoreline of Wastebeds 1-8. The lake design includes the shoreline treatment within the lake to elevation 360.0 ft. and extending up to a post –IRM elevation of 366.0 ft. in both SMU 3 and SMU 4, (existing elevation is 365.0.) due to the consistency of stabilization and restoration approach from the lakeshore up to this elevation.

4.3.5.3 Wastebed B/Harbor Brook Outboard Area

Habitat restoration in the Outboard Area was designed to take better advantage of the seasonal inundation of emergent wetland areas (i.e., Module 6A) along the shoreline and create habitat that is more suitable for northern pike reproduction. This design focuses on providing the appropriate water depths at the appropriate time of year (and concomitant water temperature) for northern pike spawning as summarized below. A more detailed evaluation of water temperature, water depths, wind wave energy and design of the realigned Harbor Brook channel are provided in Appendix K.

Water temperature is a key consideration for northern pike spawning. Research conducted by Dr. John Farrell of SUNY ESF at the St. Lawrence River Research Station indicates northern pike typically spawn in temperatures from 5 to 13°C (Farrell, 2001 and Farrell et al., 1996). The period for spawning in this part of the Northeast (i.e., south of the St. Lawrence) is typically mid March to early April. The period of March 15th through April 7th has been identified as the time of year likely to have the requisite temperature based on the input from Dr. Farrell and the recent lake conditions. Data from www.ourlake.org show mean epilimnion weekly water temperature just above 5°C in late March 2010. In addition, because those data were collected in the middle of the lake and are not representative of shallow water conditions along the Wastebed B shoreline, temperature monitoring was conducted in shallow nearshore littoral areas of Wastebed B and near the mouth of Ninemile Creek (in-lake reference) from March through May 2011. Those data are summarized in Appendix K and indicate water temperatures appropriate for pike spawning during the time period noted above.

To provide suitable conditions over a wide range of lake levels, the wetlands have been designed with a gradual slope from the areas adjacent to the barrier wall out to the Onondaga Lake shoreline. This design eliminates the need for spawning channels with specific depths, which could be prone to sedimentation, in favor of a self-designing system that will respond to natural changes in water level and patterns of sediment movement. Water levels during potential spawning season were evaluated using Onondaga Lake level data from the USGS Gauging Station at Liverpool, New York. The median, 10th percentile and 90th percentile values for Onondaga Lake water levels during this time period are included in Appendix K. The current design for the northern pike spawning wetland maximizes the acreage during the 50th percentile lake level values while balancing the acreage during more extreme conditions when the lake is above or below average water levels. Because dam and lock procedures from plant operations on the Seneca River were modified in 1997, only data from the last 12 years were used for this water level analysis. The specific water depths and total acreages for this area are shown in the table below:

Total Wetland Acreage Outboard of IRM Barrier Wall	Acreage 12-18 Inches Water Depth			Acreage 6-24 Inches Water Depth		
	10th %	50th %	90th %	10th %	50th %	90th %
14.2	1.7	2.9	2.5	5.0	9.1	7.2

The specified acreages above are contiguous within the Outboard Area. Based on the research and recommendations of Dr. Farrell and others, northern pike typically spawn in water depths of 12 in. to 18 in. (Casselman and Lewis 1996; Farrell et al., 2006). However, given the fact that spawning occurs in water depths outside this range, a calculation for the acreage of area with 6 in. to 24 in. of water has been included for reference. The wetland design is based on providing 12 in. of water depth at the midpoint of the slope for the median water level of 363.3 ft. during the period of March 15th to April 7th for Onondaga Lake. Figure 4.25 presents a schematic cross section showing the various water levels, zones of vegetation, and slope of the wetland system outboard of the IRM Barrier Wall. The restored wetland surface begins at 363.3 ft. close to the barrier wall (non-wetland habitat will be created from 363.3 ft. to the top of the barrier wall) and slopes to an elevation of 361.3 ft. at the Onondaga Lake shoreline. A key function of this sloped design will be the presence of wetlands with 12 in. to 18 in. of water during the spawning season, even during high (364.5 ft. - 90th percentile) and low (362.7 ft. – 10th percentile) water level conditions. The acreage of wetlands with 12 to 18 in. of water will vary depending on the actual water surface elevation. Because of the specific targeted goal to provide northern pike spawning habitat, plantings for this area will emphasize grasses, sedges, and narrow-leaved emergents. The specific substrate type for the habitat layer in these areas will consist of topsoil with 5 to 20 percent organic matter content, resulting in an average of approximately 7.5 percent organic matter, to support vegetative growth.

The reconfiguration of Harbor Brook will also allow for increased stream length and sinuosity, development of improved habitats suitable for a variety of species, and improved connectivity of wetlands with the lake habitats.

Due to the fluctuation of lake level throughout the year, there will be some portion of the Outboard Area that is just above lake level during average conditions. This area will serve as potential waterfowl nesting habitat during portions of the year. In addition, upland habitat modules (Modules 8A and 8B) will be restored to transition from the wetlands over the top of the final elevation of the barrier wall. Restoration of the areas on the landward side of the barrier wall will be addressed as part of the Wastebed B site.

The area of forested wetland (Habitat Module 9B) for the onshore area is designed to provide some wooded wetlands in the area, diversify the restored habitats, and provide additional leaf litter and connectivity to the Wastebed B site.

During periods of high lake water levels (at or over an elevation of 363.5 ft. [NAVD88]), the creation of shoreline wetlands will actually provide more lake water area. At these lake levels, the lake area will increase as the shoreline will actually be along the toe-of-slope near the barrier wall. Fringing wetlands are commonly flooded during seasonal high water events, increasing lake surface area.

As with other persistent emergent wetlands around the lake, the potential encroachment of Phragmites is a concern. For this reason, clean fill materials, with shade tree plantings will be implemented along the shoreline edge of the wetlands. The shade trees will help to limit the spread of Phragmites and provide additional leaf litter and organics along the edge of the wetland complex. The remainder of the wetland will be planted and seeded with a diversity of native wetland species as discussed above.

4.3.6 Planting, Organic Matter Content and Structure

The final elevation and substrates within each remediation area will provide specific habitat types (designated by habitat modules) ranging from deeper offshore areas (Modules 1 and 2), shallower areas that will support submerged macrophytes (Module 3), and shallow and intermittently submerged areas that will support wetlands (Modules 4, 5, and 6). Shoreline areas above the lake surface will support wetland and terrestrial habitats (Modules 8 and 9). The following areas/modules will be planted and seeded with a diversity of native species to restore the vegetative communities:

- Modules 4A, 5A, and 6A in Remediation Area A
- Ninemile Creek spits wetlands
- WB 1-8 connected wetlands
- WB-B/HB outboard area wetlands
- A 25 ft. strip within the lake along the WBB/HB wetlands.

These areas were selected for planting primarily because they are either wetlands, they do not have a native seed source in the lake (floating aquatics), and/or they are located along the shoreline and are susceptible to invasive species colonization. In certain areas, structure such as logs and boulders will be placed to increase the habitat diversity and suitability of these areas. Once the habitat restoration activities are completed, monitoring data will be collected to demonstrate the success of the restoration activities and achievement of the restoration goals and objectives. The monitoring data and criteria used to evaluate success will be provided in the OLMMS. Details on planting and use of structure within the habitat modules will be provided in a design addendum subject to NYSDEC approval. This addendum will be finalized prior to the implementation of related work in these areas.

Sediments in all restoration areas will accumulate organic material naturally, with the final amount in any particular area a function of substrate type, wave energy at the site, and proximity to internal and external carbon sources. To support the planting discussed above and encourage rapid colonization of the wetlands and near-shore low-energy areas, topsoil will be mixed into the habitat layer material to achieve 5 to 20 percent total organic content (organic matter) in those areas that will be planted. This level of organic matter is an appropriate value to support plant growth and comparable to the existing organic matter levels at other sites in the area like Geddes Brook and the SYW-10 wetland near the mouth of Ninemile Creek and relevant literature sources (Bruland et al. 2006). The specification of 5 to 20 percent organic matter in the habitat layer material utilized for the shoreline wetlands adjacent to Onondaga Lake is in accordance with previous NYSDEC approvals at previous sites, and exemplified by the success at the restored LCP wetlands. The habitat layer material used for the LCP wetlands resulted in an average organic matter of approximately 7.5 percent. In addition, Dr. Leopold from SUNY ESF has stated that this range of organic matter would be more than adequate for the plants that have been specified for this design.

Given the rapid expansion of submerged macrophytes in Onondaga Lake since 2005, natural recolonization of the remediation areas is expected to occur fairly rapidly given the native seed bank in the lake. For most freshwater bodies, watershed sources of organic carbon are a much greater source than internal production (Wetzel, 2001) so the proximity of most remediation areas to tributaries will also expedite this process.

4.3.7 SMU 3 and SMU 5 Habitat Enhancement

The ROD identified two locations where habitat enhancement activities would be applied even though remediation activities are not required in these areas based on exceedance of cleanup criteria concentrations. The areas are along an estimated 1.5 miles (2.4 km) of SMU 3 shoreline (which for the purposes of design has been extended to a portion of the SMU 4 shoreline), and over approximately 23 acres of lake bottom in SMU 5 to stabilize calcite deposits and oncolites and promote submerged aquatic plant growth. Both of these areas are summarized below with additional detail provided in Appendix K.

4.3.7.1 SMU 3 and SMU 4 (Shoreline Stabilization)

The shoreline stabilization/habitat enhancement in SMU 3 and 4 will be designed to reduce resuspension and turbidity along the shoreline. This stabilization will ultimately be integrated with the IRM for Wastebeds 1-8, which is still under development. Therefore, the shoreline stabilization described in this section is specific to the shallow water portion of SMU 3 and SMU 4 up to the existing elevation of approximately 365 ft. (NAVD88), which is close to the highest high water mark for Onondaga Lake (i.e., 95 percent of all recorded water surface elevations are at or below 365 ft. [NAVD88]). Stabilization and restoration measures for the shoreline areas above the 366 ft. (NAVD88) post-remediation elevation will be developed as part of the Wastebeds 1-8 IRM design.

The results of the wind/wave analysis (Section 4.2) completed for Onondaga Lake were used to determine the extent of the surf zone and the size of stone needed to stabilize the substrate (Appendix D). The surf zone associated with the 10-year wind/wave event was selected as the basis of design for defining the treatment area, resulting in a treatment area which extends to a water depth of approximately 2.5 ft.

The 10-year wind/wave event was used as the basis of design for determining the stable particle size in order to balance between stability and gravel size. Based on this analysis, coarse sized graded gravel will be placed within the surf zone, from elevation 362.5 to 360 ft, to stabilize the substrate and reduce resuspension. Consistent with areas that will be capped without dredging, the coarse gravel will be placed directly on the lake bottom with no underlying geotextile. This material will be placed to provide complete coverage of the stabilization area, with a typical minimum thickness of approximately 0.25 ft. and an average thickness of approximately 0.5 ft. in underwater portions along the entire SMU 3 and SMU 4 shoreline to a water depth of approximately 2.5 ft. The location of the shoreline enhancement is depicted on Figures 4.7, 4.10, and 4.13 and shown in detail in Appendix F. Shoreline stabilization will extend between 20 ft. and 150 ft. into the water from shore depending on the bathymetry. The length of shoreline stabilization is approximately 8,300 ft.; the in-water portion of the SMU 3 and SMU 4 stabilization covers 13.39 acres.

The approach for stabilizing the calcite deposits above the waterline from 362.5 ft. to 365 ft. along the SMU 3 and SMU 4/Wastebeds 1-8 shoreline includes placement of an average of approximately 18 in. of Sennett bank run material, including topsoil and partial revegetation to minimize hardening of the shoreline. From 362.5 to 360.0 ft., 6 in. of coarse gravel will also be placed along the shoreline from RA-A to Ditch A, spanning a total of approximately 8300 ft. Planted coir logs (bio-logs) will be placed intermittently along the inland, or perched, wetland/lake shoreline at an elevation of 362 ft. This will provide a transition between the Wastebeds 1-8 site and the lake. The stabilization design approach will provide connectivity at the shoreline-wetland interface, enhanced biodiversity at the vegetative transition, improved in-lake structures for reptiles and amphibians, as well as a greater thickness of onshore cover material.

4.3.7.2 SMU 5 (Habitat Enhancement)

As described in the ROD, habitat enhancement was planned to occur over approximately 23 acres in Remediation Area F (SMU 5) to stabilize calcite deposits and oncolites and promote submerged aquatic plant growth (NYSDEC and USEPA, 2005). The approach described in the ROD was based on stabilizing the oncolitic sediments to allow plant colonization. The target of 23 acres was based on increasing the percent cover of the littoral zone to provide optimal habitat for the largemouth bass (Stuber et al. 1982). The information used in the ROD was based on 2000 plant surveys, which documented a total of 17.8 acres in Remediation Area F (SMU 5) (EcoLogic, 2001) within the optimal water depth for plants.

Since that time, the area covered by plants has increased significantly, largely due to water quality improvements associated with the upgrades to the Metro facility. Based on the 2008 survey, there were approximately 314 acres of plants mapped in the lake and approximately 160 acres in Remediation Area F within the optimal water depth for submerged aquatic plants. As such, there is significantly more acreage covered by aquatic plants than would have resulted from implementation of the 23 acres of habitat enhancement. In fact, the majority of the treatment areas identified in the Onondaga Lake FS for habitat enhancement have been naturally colonized by aquatic plants. Therefore, the goals outlined in the ROD for habitat enhancement in this area have already been met.

4.4 CAP MATERIALS, SOURCES, TRANSPORT AND STAGING AREAS

Based on the evaluations in Sections 4.1 through 4.3 pertaining to the chemical isolation, erosion protection and habitat restoration layers, the cap areas, material types and cap material volumes have been estimated for each remediation area and are detailed in Table 4.4. Information pertaining to material specifications and sources, and how the materials will be transported and stored for the project are described below.

As discussed in Section 2.2.1, as part of its sustainability program, Honeywell is committed to minimizing the carbon footprint of construction activities anticipated as part of the execution of the remedy. To the extent practicable, use of locally produced/sourced materials and supplies, reduction/elimination of waste, efficient use of resources and energy, and other sustainable practices will be incorporated into cap material sourcing and transport.

4.4.1 Cap Material

Cap materials will be secured for the project based on the requirements of each individual layer in the cap construction. Specifications for each of the cap materials have been developed, and are provided in Appendix L. Specifications include both chemical and physical property requirements for each material type and have been coordinated with the modeling (chemical isolation), erosion protection and habitat based requirements. The CQAP will provide cap material testing protocols. The earthen materials physical requirements have been coordinated with available local material sources to ensure the material specifications take into account sustainability considerations for the procurement of the cap materials. Earthen material specifications proposed for the site have been developed to minimize the processing required to meet the physical material properties specified.

4.4.2 Material Sources

Materials required for the capping operations in the lake include aggregate materials (e.g., sand, gravel, rock, and wetland soils) as well as siderite and activated carbon that will be incorporated into the cap as amendments. A range of potential sources for the aggregate materials have been identified, and an initial source has been selected for the initial phase of the project. Other potential sources that meet the project needs continue to be evaluated. In general, material will be delivered to the site directly from the mines, quarry pits, and other material supply facilities. Multiple sources of some material may be required to meet the required cap quantities in the future.

Sources of aggregate materials required for the cap, including chemical isolation, erosion protection and habitat material, have been located local to the Syracuse area. The identified sand and gravel sources provide adequate reserves necessary for the project, and meet the materials requirements for the cap. An extensive investigation of the materials was performed in order to develop cap material specifications that minimize processing effort, meet the engineering requirements of the cap materials, and minimize the generation of by-product materials that do not have an identified use on this or other local projects.

Additional sources for potential cap materials continue to be examined. Clean material dredged for marine navigation at other sites has been investigated but is not currently proposed for incorporation in the cap, due to logistics and other considerations. Other construction and development projects that present a beneficial re-use opportunity continue to be evaluated for use in the cap and shoreline support activities.

The pH amendment, siderite, is a mined mineral that will be crushed to sand-sized particles for use in the cap. The siderite used for pH bench studies was produced by a mine in Texas that encompasses over 200 acres and has the resources and capabilities to produce the required siderite for the entire Onondaga Lake project. Additional potential siderite mines, some active and some not active, are located throughout the United States and will continue to be evaluated as the project progresses.

GAC will be incorporated into the cap for portions of the site to improve the performance of the chemical isolation layer. Carbon isotherm studies were performed to determine activated carbon sorption characteristics for site conditions using a coal based activated carbon from Calgon Carbon Corporation. Carbon can be supplied by bulk transport (truck or rail car). The activated carbon will be produced by Calgon or other vendors to the size and specifications required at the carbon activation facility.

4.4.3 Material Transport

Sustainability is a key consideration for transport of materials for the Onondaga Lake project. The following variables were considered in deciding the best methods for transport of the materials.

- Viability of the potential material source
- Efficiency of production and delivery

- Minimizing handling and minimizing the area of impact both at the pit and required for stockpile at site for imported materials
- Distance to the Onondaga Lake project site

Onondaga Lake's proximity to major transport modes provides the project with inherent transportation advantages. The lake connects to the New York State Canal System, making barge transport of capping materials potentially viable. Rail lines of the Finger Lakes Railway run adjacent to the lake and connect to CSX, Norfolk, Southern and Geneva and other major rail carriers. The lake is also located adjacent to major vehicle transportation routes from both the east/west and north/south. Several modes of transport will be considered for eventual selection during final design, with the final selection of the transport mode being a function of the material sources for the various cap materials. Based on the current evaluation of capping material sources, trucking appears to be the best delivery option for aggregate materials (sand, gravel, and stone). Using materials local to the project and minimizing the required infrastructure lend to the trucking advantage. Barge delivery for aggregate materials is still under evaluation. Rail delivery is also being considered for both pH and activated carbon amendments for the cap.

Materials will be delivered "just in time," to the extent practical, to reduce the required stockpile area for materials and reduce double handling of the materials. Transport routes to the site will maximize major highways as shown in Figure 4.26. Routes 81, 90, 481, 690, and 695 will be used as potential transportation routes to the project. Entry and exit routes from the sites have been reviewed for safety and logistics and transport through residential areas has been minimized.

In support of Honeywell's sustainability goals, delivery trucks for all earthen materials will be equipped with 2007 or better engines or meet the diesel retrofit technology to reduce their carbon footprint. Biodiesel is being evaluated and may be used in delivery trucks and on-site equipment for further carbon footprint reduction.

4.4.4 Material Staging

To keep the capping of the lake on schedule, material stockpiles will be used to provide the material to the capping operations when needed. Strong daily coordination efforts between the material supplier and the capping operations will keep the supply of material delivered to the project as it is requested, while minimizing stockpiling of materials to the extent practicable.

Only the minimum amount of material necessary will be stockpiled on site. This will minimize the need to handle the materials, reduce the amount of maintenance necessary for large stockpiles, and will result in only a small footprint of stockpiled materials. A typical stockpile area for the southeastern shore is as depicted in Figure 4.27. There are other areas adjacent to the lake that may be considered as potential stockpile locations. Due to the existing projects that are scheduled to take place at many of these areas, coordination with each project site will be required. Potential adjacent stockpile sites include Wastebed B and the existing causeway staging area. Stockpile size and locations continue to be evaluated and revisions to the proposed plans will be provided to the DEC.

4.4.5 Shoreline Support

The capping activities for Onondaga Lake will require areas adjacent to the lake to support them. The areas include support for hydraulic capping, mechanical capping, debris management and personnel. The shoreline support layout for Onondaga Lake capping activities for Remediation Areas C, D, and E is presented in Figure 4.27. The shoreline support layout for Remediation Areas A and B, scheduled for remediation in 2014, will be located on Wastebeds 1-8 near the outlet of Ninemile Creek. Shoreline activities for these areas will have similar support requirements, and will be coordinated with shoreline remediation activities in this area as the work progresses.

The hydraulic capping activities to take place in the lake will require an area for equipment and materials on shore. The designed area for the hydraulic capping support in Remediation Areas C, D, E, and the Outboard Area are located on Wastebed B, east of the temporary office trailers for the IRM barrier wall construction. Granular earthen materials and amendments will be mixed with water and pumped as a slurry out to the capping barge(s) in this area. The equipment on the shore will consist of a makeup water pump, a sand feed system, an amendment feed system (s), a slurry mix tank and cap slurry mix pump, as detailed below in Section 4.5. During years when the required cap materials placement exceeds one hydraulic operation, a second shore system will be added to increase the amount of hydraulic cap that can be placed. Earthen material will be stockpiled around the feed system to ensure that capping operations have the required materials for the multiple layers of the cap.

The mechanical capping, and debris removal support area will be located along the Willis IRM barrier wall. The support area will include a pile supported concrete pad to support the equipment along the wall due to the limitations of the loadings on the wall. The barrier wall limitations are detailed in the Willis Portion of the Willis Avenue/Semet Tar Bed Sites IRM Remedial Action Work Plan (Parsons 2008a) and summarized on Figure 4.27. Details of the sheet pile anchorage and concrete work platform can be found in the Willis Ave./Semet Tar Beds IRM Sheet Pile Anchorage Final Design (Parsons 2011). The concrete pad will support loading operations for coarse-grained capping materials such as gravely cobble, as well as equipment to unload scows containing debris removed to facilitate capping and dredging operations. The concrete pad will be located along the wall where the current water depth is approximately 15 ft., and no dredging activities are proposed to take place. The equipment support pad adjacent to the wall will include a concrete platform attached on the land side that will allow for trucks to bring materials or remove debris. The hydraulic transport pipe that will be used to transport dredged materials will be buried in this area to facilitate the required trucking activities.

Due to the load limitations on the Willis sheetpile wall, the stockpile for the earthen material will be located away from the wall. A floating conveyor or alternative method will be used to load the required coarse-grained capping material supply barges with coarse cap materials when the loading platform described above is not available.

Personnel access for lake dredge and cap operations will be by a personnel dock located adjacent to barge loading and unloading operations along the wall. The dock will be constructed with floats in the water and will be sufficient to tie off work and crew watercraft.

4.5 CAP MATERIAL PLACEMENT

This section provides an overview of the anticipated cap placement technologies and methods to be used in Onondaga Lake and the adjacent wetlands. Cap placement equipment was selected taking into consideration input from the selected cap construction contractor (Sevenson Environmental). This section also provides details on anticipated capping production rates and anticipated quality control procedures to assure appropriate cap placement.

Several methods have been used on previous projects to place granular capping materials and were considered for Onondaga Lake, including:

- Direct placement with a mechanical clamshell bucket
- Surface release from a barge, hopper, conveyor belt, or broadcast spreader
- Spreading with hydraulic pipeline and baffle box or plate
- Jetting off of a barge
- Submerged diffuser or tremie pipe
- Pneumatic placement in very shallow water or marsh areas

In selecting the most appropriate placement methods for Onondaga Lake and the wetlands, the selected capping construction contractor and design team considered numerous factors including, but not limited to:

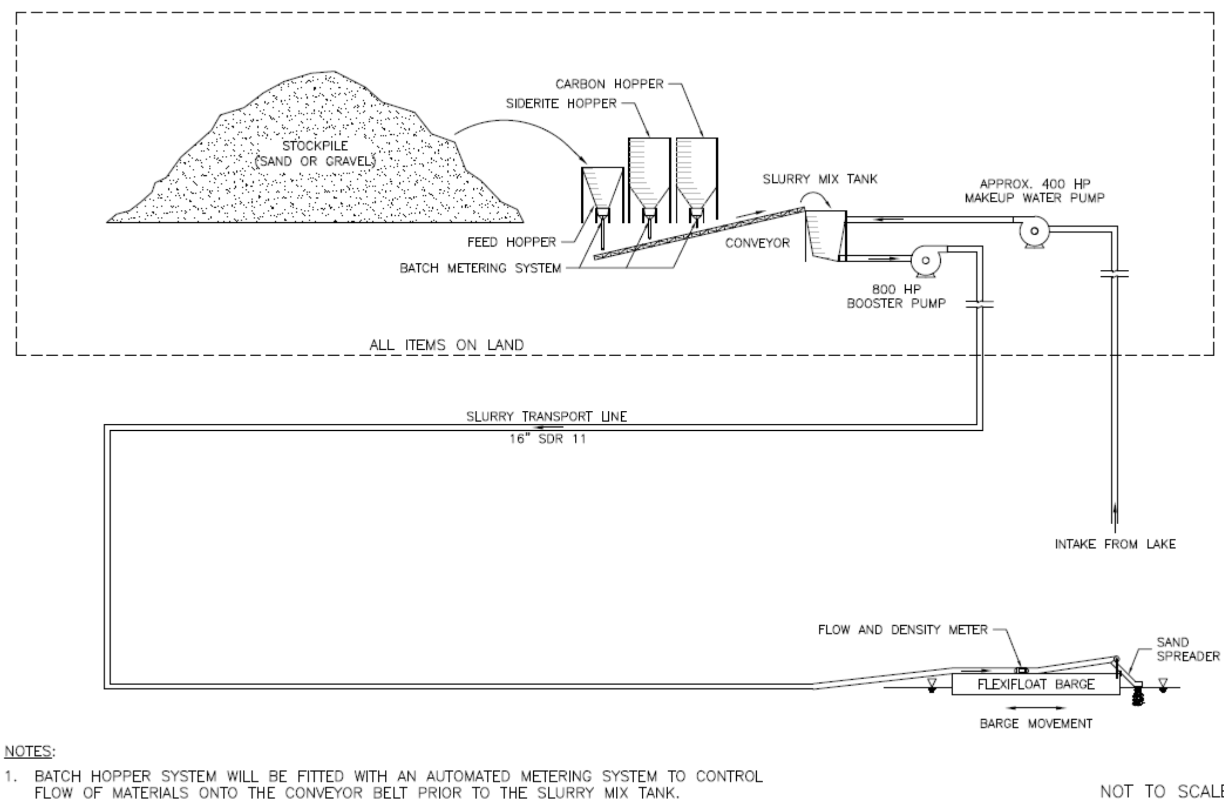
- Site conditions (e.g., water depth, water currents)
- Stability of existing sediment and the potential for resuspension during cap placement
- Method of material delivery to site (e.g., by barge, truck, rail, etc.)
- Distance between material stockpile (if applicable) and placement location
- Site access limitations (e.g., shallow water, pilings, docks, etc.)
- Grain size and volume of material being placed
- Site-specific placement requirements (e.g., production rates, lift-thicknesses, etc.)
- Availability of placement equipment (i.e., market factors)

Capping materials planned for placement as part of the Onondaga Lake and wetland caps will range from sand-sized to gravely cobble-sized, depending on the layer (chemical isolation, erosion protection, and habitat). Based on the considerations listed above, a hydraulic spreading system has been selected for placement of sand-sized cap materials (including sand, siderite, and activated carbon) as well as small armor stone up to approximately 2 to 3 in. in diameter. The larger armor materials (e.g., coarse gravel and gravely cobble) cannot be efficiently transported or placed via hydraulic slurry, and the contractor anticipates using a mechanical bucket (clamshell or other) for placement. These methods of cap placement have been successfully used at numerous other capping sites. The following sections provide a summary of the anticipated means and methods of placement. Appendix J provides a detailed discussion of the cap placement equipment.

4.5.1 Hydraulic Spreader Placement

A specially-designed hydraulic spreading unit will be used for the placement of the majority of the capping materials within the lake and wetlands, consisting primarily of sand-sized materials for the chemical isolation and habitat layers, including the SMU 8 thin-layer cap, discussed in Section 6. The hydraulic spreader will also be used for placing erosion protection and habitat layer materials ranging up to gravel-sized (approximately 2 to 3-in. diameter). Cap amendments will be mixed with the sand material and placed using the hydraulic spreader system. Similarly, habitat material with a specific organic carbon content that is required in some shallow cap areas will be placed using the hydraulic spreader system.

The hydraulic spreading system consists of a series of upland hopper bins that will feed capping materials from a stockpile to a slurry system that will entrain water for pumping. The slurry of capping materials will be pumped through a pipeline and a series of booster pumps to a spreader barge at the placement location. The spreader barge will be equipped with an energy diffuser to gently and evenly distribute the capping materials. The spreader barge will also be outfitted with electronic position tracking equipment and software so that the location of material placement can be tracked in real-time. Additional details of the hydraulic spreader system and electronic positioning system are provided in Appendix J. The schematic below presents the conceptual design of hydraulic spreading system.



Schematic of Hydraulic Cap Spreading System

Based on contractor experience with this type of capping equipment at other sites, the hydraulic slurry system will be capable of placing cap materials with a median particle size (D_{50})

up to approximately 1 in. (maximum particle size of approximately 2 to 3 in.). Larger diameter capping materials will be placed by mechanical equipment, as described below.

As discussed above, the hydraulic spreader system will be used to place the siderite and activated carbon cap amendments, which will be mixed with sand as part of the chemical isolation layer. This mixing of the sand/siderite or sand/activated carbon will be performed during the initial stages of the capping system (e.g., just after the upland hoppers) using a series of weight-metered conveyor belts to combine the correct ratio of sand and amendment. A capping field demonstration completed in 2011 demonstrated the effectiveness of this system.

The siderite planned for use as part of the amended cap will be granular (sand-sized particles) with a specific gravity of approximately 3.8 (greater than sand). The activated carbon will also be in granular form and will require a period of soaking prior to placement to remove entrained air so the material will settle more quickly through the water column. Although the siderite and activated carbon have specific gravities that differ from sand, they are expected to settle through the water column at approximately the same rate as sand when each is mixed with the sand.

4.5.2 Mechanical Bucket Placement

Certain areas of the lake and wetlands will require an erosion protection layer of coarse gravel or larger, which cannot be placed using the hydraulic spreader system described above. Therefore, the contractor will place these larger materials using a mechanical excavator positioned on a barge. A clamshell or other type of bucket will be attached to the arm of the excavator, which will be outfitted with appropriate positioning equipment such that the position of the material placement can be tracked in real-time during construction. Appendix J provides additional details of the mechanical placement equipment and position tracking system anticipated for the project.

4.5.3 Capping Production Rate

Production rates for granular cap material will vary between mechanical and hydraulic placement methods as well as between the varying material types (sand versus gravel) and site conditions (water depth, size of contiguous capping area, proximity to staging areas, pumping distances, etc.). The contractor has sized the equipment to ensure that the overall project schedule for capping can be achieved within the required project schedule (see Section 8). Depending on the overall sequence and schedule of construction operations, multiple capping operations may be working simultaneously. This may include separate capping operations for different remediation areas (or multiple areas within a single remediation area) and/or separate operations for the different material types. Cap production rates for hydraulic and mechanical placement operations are provided in Appendix J and incorporated into the sequencing discussion in Section 8.

4.5.4 Cap Placement Performance Criteria and Quality Assurance/Control Measures

A series of cap placement performance criteria and quality control procedures will be implemented to ensure that cap materials will be placed to the thickness and extent required by the design in a controlled manner, thereby providing an environmentally protective cap. The following presents cap placement performance criteria, which may be enhanced or appended during development and implementation of the CQAP.

- Cap thickness tolerances: The design provides the minimum required thickness as well as the anticipated mean and maximum cap layer overplacements. The design also provides target completed habitat layer elevations and acceptable tolerances. The contractor will be required to place the cap within these tolerances in order to satisfy chemical isolation, erosion protection, and habitat thickness/elevation objectives. Compliance with minimum cap layer thicknesses will be verified during construction, as described below.
- Mixing: Capping material will be placed in a manner that minimizes disturbance of the underlying sediment or previously placed cap material. A maximum cap lift thickness (or differential cap height) of 12 in. will initially be placed to ensure cap stability on top of existing sediments. Based on operational considerations of the cap placement equipment, actual lift thickness are expected to vary from several inches up to this maximum. Subsequent lifts of capping material may exceed 12 in. Refinements to the design-level recommendations may be made during construction through adaptive management based on the observations and results during and after cap placement.
- Cap disturbance: The contractor will develop and implement means to control construction activities so as to minimize to the extent possible any disturbance to previously placed cap material (such as from spuds, pipelines, anchors, etc.).
- In areas where slopes to be capped are greater than a given angle (e.g., 10 horizontal:1 vertical [10H:1V]) and the total elevation difference exceeds 5 to 10 ft., material placement will generally begin at the toe of the slope to provide a "foundation" against which cap material subsequently placed upslope can rest against. The selection of slopes greater than 10H:1V (approximately 5.7 degrees) for this "bottom-up" construction method is conservative since the natural angle of repose of the capping materials is significantly greater than 5.7 degrees and therefore will be stable on 10H:1V slopes independent of the direction of placement. Nevertheless, this performance criterion will provide confidence that the caps are constructed according to the design.
- Construction sequencing: Dredge and cap work will be sequenced such that they minimize recontamination of placed cap material (see Section 8).

In addition to the performance criteria discussed above, strict QA/QC measurements will be performed throughout cap placement to ensure compliance with the criteria listed above and to verify that the cap materials have been placed to the thicknesses and lateral limits specified by the design and in accordance with the performance criteria (e.g., within specified construction tolerances). The CQAP, to be submitted under separate cover, will detail the multiple QA/QC procedures that will be implemented to ensure compliance with the placement criteria. The QA/QC methods to be implemented will include:

- Accurate material volume tracking: Each cap placement operation will be outfitted with equipment to accurately monitor and control the quantity and rate of material being placed. This may include tracking of the number of excavator buckets loaded to the hopper of the hydraulic spreading system, weight-metered conveyor belts, or other appropriate techniques.

- Real-time tracking of horizontal position: Cap placement equipment will be outfitted with a positioning system that will accurately measure and track the position of the placement in real-time through the cap construction to verify that cap materials have been placed within the specific horizontal limits. This typically includes the use of global positioning system (GPS) sensors, inclinometers, tilt sensors, and/or other positioning equipment mounted directly on the placement equipment (e.g., the boom of a mechanical excavator). The positioning equipment will be connected to a computer software package specifically designed for tracking and logging the position and movement of the equipment. Appendix J provides additional details of the anticipated position tracking equipment.
- Post-cap placement samples: Post-placement cores or "catch pans" will be used to collect samples of the cap material placed. The collected samples will be used to verify the thickness and physical composition of the placed cap materials. The sample collection and measurements described above may not be suitable for verifying the placement of large armor stone or in deep water portions of the lake. Therefore, alternate means (e.g., geophysical surveys, as described below) may be required for verifying compliance with the design for these materials and areas. The CQAP (to be submitted under separate cover) provides additional details on the cap placement verification program.
- Cap amendment dose: Several metrics will be utilized to track and verify the quantity of cap amendments (e.g., siderite and activated carbon) applied relative to the dose(s) required by the design as well as the vertical distribution of the activated carbon throughout the sand isolation layer. Details of the verification metrics for capping amendments will be provided in the CQAP.
- Geophysical surveys: Acoustical and/or manual bathymetric surveying, or other geophysical measurement approaches such as sub-bottom profiling, performed prior to and after cap placement can be used to support cap layer thickness demonstrations, and to evaluate the final elevation of the cap. The specific equipment to be used and accuracy of these surveys will be dependent on site conditions.

4.6 CAPPING DATA GAPS

Input parameters pertaining to design of the chemical isolation, erosion protection and habitat layers are well defined based on seven years of investigation activities. No data gaps have been identified related to design of the various cap layers.

SECTION 5

DREDGING

Dredging of contaminated sediments is a significant part of the overall Onondaga Lake remedy. The remedy for the lake as specified in the ROD includes dredging of as much as 2,653,000 cubic yards (CY). This was an estimate of the dredge volume required to achieve the ROD-specified goals based on RI data and FS-level evaluations conducted in 2004. Subsequent data collection and more detailed design evaluations between 2004 and 2010 have allowed for a more accurate estimate of the dredge volume required to meet the ROD-specified remedial goals, resulting in an estimated dredge volume within the lake of approximately 2,000,000 CY. Details pertaining to this dredge volume estimate are provided in Section 5.2. All estimated volumes in this section are *in situ* volumes.

Based on the evaluations presented in Section 5.2, the estimated dredge volume has increased in some SMUs and decreased in other SMUs compared to the ROD estimates. For example, the estimated dredge volume in SMU 2 decreased by approximately 280,000 CY based on the ESD issued by the NYSDEC in December of 2006 and other less-significant refinements.

Design and performance criteria and the methods and results from design evaluations pertaining to dredging, including detailed volume estimates, are discussed below.

5.1 DREDGING DESIGN AND PERFORMANCE CRITERIA

Design and performance criteria relative to dredging fall into two categories: ILWD dredging and dredging to achieve a habitat-based post-capping elevation. All dredged areas will subsequently be capped; therefore, there will be no dredging completed to achieve numeric cleanup criteria. ILWD dredging will be to a specified elevation, but it is described separately in this design due to its significance to the overall dredging program. Based on ROD requirements and other project-specific considerations, design and performance criteria pertaining to dredging are listed below.

- ILWD dredging:
  - Dredging will be performed to remove sediments and/or wastes to an average depth of 6.6 ft. (2 meters) in SMU 1. Dredging of ILWD that extends into SMU 2 and SMU 7 will also average 6.6 ft. (2 meters) in each of these areas. The combined area of ILWD in SMUs 1, 2, and 7 is referred to as Remediation Area D.
  - In areas of the ILWD defined as hot spots, dredging will be performed to remove an additional 3.3 ft. (1 meter). Hot spots will be defined as those sediments and or wastes that contain contaminants above the criteria specified in the ROD, as listed below.

Benzene	208 mg/kg
Chlorobenzene	114 mg/kg
Dichlorobenzenes	90 mg/kg
Naphthalene	20,573 mg/kg
Xylene	142 mg/kg
Ethylbenzene	1655 mg/kg
Toluene	2626 mg/kg
Mercury	2924 mg/kg

  - Dredging of ILWD material will be performed if necessary to ensure the geotechnical stability of the isolation cap. The determination of geotechnical stability will consider both static and seismic stability of the ILWD. The determination of seismic stability will be based on an analysis of cap stability during an operating level event (i.e. a seismic event with a 50 percent chance of exceedance in 50 years [approximate 72 year recurrence interval]) and a contingency level event (i.e., a seismic event with a 10 percent chance of exceedance in 50 years [approximate 475 year recurrence interval]).

- Dredging to achieve a habitat-based post-capping elevation. Dredging will be performed as necessary to ensure that after the cap is placed and there is no loss of lake surface area. In certain areas, dredging will also be performed to achieve a specific post-capping water depth based on habitat considerations. Dredging will be performed to a specified elevation in these areas based on the thickness of the cap and the desired post-capping water depth.

5.2 DREDGING DESIGN EVALUATIONS AND DESIGN

Discussion regarding design evaluations and the resulting design for dredge areas, depths and volumes for Remediation Areas A through F and the adjacent areas included in the design is presented below. Areas to be dredged are shown in Figures 3.2 and 3.3. Details pertaining to development of dredge areas, depths and volumes are presented in Appendix F. The estimated total volume to be dredged from the lake is approximately 2,000,000 CY, as listed in Table 5.1. Estimated dredge volumes for each remediation area and adjacent areas being dredged are also included in Table 5.1. In most areas of the lake, sufficient dredging will be completed up to the shoreline (surface elevation of 362.5) to ensure placement of the full-thickness cap all the way to the shoreline or to the edge of the wetland being restored. As a result, the removal prisms typically extend inland of the shoreline in order to accommodate suitable dredge cut slopes. However, this is not feasible along certain portions of the shoreline due to limitations such as potential impacts to shoreline utilities or structures or stability considerations, resulting in minor losses of lake surface area. These losses are more than offset by localized gains in lake surface area resulting in the other shoreline completion areas, as detailed in Appendix F, which includes a summary of gains and losses by Remediation Area. These minor losses are summarized in Sections 5.2.1 through 5.2.5 below. Detailed shoreline completion plans are provided in Appendix F.

The dredge plans presented in Appendix F were developed based on achieving a specified post-dredging water depth. In Remediation Areas A, B, C, E, and portions of D, these are minimum dredge depths that must be achieved in order to meet the specified habitat-based post-capping elevations. Detail on how the dredge depths were developed to achieve these habitat-based elevations is provided in Section 4.3.4

To achieve the minimum required dredge depths, some over-dredging will result. Over-dredge is an allowance provided to the contractor to account for equipment accuracy and assure that target (required) elevations are met. Typical over-dredging in past similar projects has averaged approximately 4 in. to 6 in. The total dredge volumes listed in Table 5.1 include an average over-dredge of 0.5 ft. in Remediation Areas A, B, C, and E, where elevation-based dredging will be completed to a minimum specified depth. During construction, over-dredging will be minimized to the extent practical through tight control of contractor operations and QA/QC.

The dredging elevation in water depths less than 3 ft. in Remediation Area D is also based on a minimum required elevation to achieve a target post-capping water depth; therefore, an estimated removal volume associated with over-dredging is included for this area. However, the overall dredge plan in the ILWD is based on the ROD-required removal volume equal to an average of 2 meters. Therefore, the removal in the remainder of the ILWD will be to the specified target elevation plus or minus 0.5 ft. such that the final removal volume achieves the ROD-specified goal of a volume equal to a 2-meter average removal, plus the volume of hot spots, as discussed in Section 5.2.4. Details regarding how achievement of the 2-meter average removal will be ensured during construction (i.e., that the amount of overcut is equal to or greater than the amount of undercut within each SMU portion of the ILWD) will be provided in the CQAP.

Target post-capping elevations discussed in Section 4.3.5 for the adjacent wetlands being remediated as part of the lake remediation (Ninemile Creek spits, Wastebed 1-8 connected wetlands, and WBB/HB Outboard Area) were not developed as maximum elevations as were the target elevations in the majority of the areas in lake. Rather, they were developed as the ideal elevations with some expectation of variability around these elevations. Therefore, post-capping target elevations will be met in these areas with a tolerance of plus or minus 6 in. Thus, the target dredge elevations were established based on an assumption of average over-placement of each cap layer, and the dredging will be specified to meet target dredge cuts plus or minus 6 in. As a result, no overdredging is included in these areas.

5.2.1 Remediation Area A and Ninemile Creek Spits

Dredging to a target elevation (i.e., elevation-based dredging) to achieve post-cap water bathymetry for designed habitat modules will be completed along the shoreline areas in Remediation Area A, and in the adjacent area of the Ninemile spits, as shown in Figures 4.8 and 4.9. In the majority of Remediation Area A and the spits, sufficient dredging will be completed up to the shoreline (surface elevation of 362.5) to ensure placement of the full-thickness cap all the way to the shoreline or to the edge of the wetland being restored. As a result, the removal prisms typically extend inland of the shoreline in order to accommodate suitable dredge cut slopes. However, along the shoreline and southern extent of the spits west of Ninemile Creek, this would result in removal of the fringe of mature forested wetland trees which have been targeted for preservation as part of the Ninemile Creek design. Similarly, dredging full depth up to the southern edge of the spits east of Ninemile Creek could result in collapse of the steep embankment associated with Wastebeds 1-8 in this area. Therefore, a modified dredge and cap approach has been developed in these areas, as detailed in Appendix F.

The spits consist of a wetland area densely vegetated by *Phragmites*. The vegetation presents a challenge for hydraulic dredging and sediment management. The dredge contractor's experience with vegetation indicates that the vegetation can negatively impact the hydraulic dredging, and tends to cover over the screens at the sediment processing area, potentially causing reduced rates or blockage which may induce a dredge shut down at the lake. Therefore, prior to dredging, the vegetation and shallow sediments will be mechanically removed and managed at the LCP site along with the other Ninemile Creek sediments that are being removed.

The shoreline groundwater collection trench east of Ninemile Creek, being designed as part of the Wastebeds 1-8 IRM, will be located a sufficient distance from the furthest inland extent of the dredge prism so that it is not impacted by the shoreline dredge cut sloping. The shoreline groundwater collection trench is being installed to reduce nearshore groundwater upwelling velocities, allowing the cap to be effective up to the shoreline.

Consistent with Onondaga Lake and Ninemile Creek decision documents, the outlet of Ninemile Creek will also be dredged and capped as part of the lake remedy. This is the area between the spits that protrude into the lake at the mouth of Ninemile Creek. The dredging and capping will extend 300 ft. upstream from the tip of the western spit.

5.2.2 Remediation Area B and Wastebed 1-8 Connected Wetland

Dredging to a target elevation (i.e., elevation-based dredging) to achieve post-cap bathymetry for designed habitat modules will be completed along the shoreline areas in Remediation Area B, and in the adjacent Wastebed 1-8 connected wetland, as shown in Figures 4.11 and 4.12. Materials that are above and below the water table in the wetland area will be hydraulically dredged concurrent with the materials in Remediation Area B. A shoreline groundwater collection trench is currently being designed for the shoreline of Wastebeds 1-8 as part of the IRM for that site. This will reduce nearshore groundwater upwelling velocities, allowing the cap to be effective up to the shoreline.

Sufficient dredging will be completed up to the shoreline to ensure placement of the full-thickness cap all the way to the shoreline and throughout the connected wetland. As a result, the dredge prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes. The minor exception to this is along the shoreline adjacent to perched Wetland B in order to avoid impacting this wetland. The shoreline collection trench will be located a sufficient distance from the furthest inland extent of the dredge prism so that it is not impacted by the shoreline dredge cut sloping.

5.2.3 Remediation Area C

Dredging in a portion of the area adjacent to the east side of the NYSDOT turnaround area in Remediation Area C will be completed to a target elevation in order to increase the post-capping water depths from current conditions and facilitate future use of the NYSDOT turnaround area as a boat launch. The post-capping water depth was developed specifically to facilitate recreational boat traffic in the vicinity of the future boat launch. The design of the cap erosion protection layer was also developed taking into consideration the potential for significant boat traffic in this area, as discussed in Section 4.2.3. The remainder of the dredging in

Remediation Area C will be completed to a target elevation to achieve post-cap bathymetry for designed habitat modules, as shown in Figures 4.14 and 4.15.

Where feasible, sufficient dredging will be completed up to the shoreline to ensure placement of the full-thickness cap all the way to the shoreline along the shore where feasible. In these areas, the removal prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes. In portions of the shoreline, an existing utility line (force main operated by Onondaga County) and the sheet pile wall would be potentially impacted due to this sloping, while along the DOT turnaround area the hard material composing this area is too hard to dredge; therefore, the shoreline dredging and capping plan has been modified in these areas, as detailed in Appendix F.

The very steep slope along the middle portion of the NYSDOT turnaround area requires development of a modified cap design incorporating larger armor stone and a toe berm at the base of the slope to ensure slope stability. The modified cap includes chemical isolation and rip-rap erosion protection layers extending all the way to the shoreline, and covers all sampling locations where cleanup criteria were exceeded.

5.2.4 Remediation Area D

The ROD requires removal to an average depth of 6.6 ft. (2 meters) in SMU 1, which constitutes the majority of the ILWD area (Remediation Area D), plus up to an additional 3.3 ft. (1 meter) in areas defined as hot spots. This same removal approach is required in the portions of the ILWD that extend into SMUs 2 and 7. The resulting dredge volumes to achieve these goals are listed in Table 5.1. Details regarding the development of the dredge volumes are provided below.

A rigorous evaluation of the extensive ILWD sediment and porewater database was completed to develop the removal approach that optimizes contaminant mass removal and reduction of sediment and porewater contaminant concentrations underlying the cap, as detailed in Appendix G. Based on this evaluation, the ILWD was divided into four sub-areas based on chemical concentration and distribution, and optimal removal strategies were developed for each of these sub-areas, as shown in the plan view in Figure 5.1. Removal cross sections are provided in Figures 4.17 through 4.20. The primary removal strategy and basis for the removal strategy for each sub-area are summarized below and are detailed in Appendix G. Example contaminant versus depth plots that were used to identify contaminant distribution trends and the removal strategies listed below are provided in Figure 5.2. Cross-sections showing these removal depths are provided in Appendix F.

- SMU 1/SMU 7 ILWD Eastern Area: Removal of the top 9.9 ft. (3 meters) in this area will remove the highest sediment and porewater concentrations of chlorobenzene and dichlorobenzene measured anywhere in the ILWD, and will lower the concentration in this area for numerous other contaminants in sediment and/or porewater.
- SMU 1 ILWD Center Area: Sufficient dredging will be completed to ensure that the post-capping bathymetry is consistent with current bathymetry in areas where the current water depth is 7 ft. or less. The amended cap thickness in this area will have a maximum thickness of 5.5 ft. (1.7 meters) assuming maximum over-placement of each

layer. Therefore, the removal depth in this area will be approximately 5.5 ft. out to a water depth of 7 ft.

- SMU 1 ILWD Western Area: Contaminant concentrations were generally lower in this area and patterns of concentration versus depth were less defined. However, removal of the top 9.9 ft. (3 meters) in a portion of this area will reduce the concentrations of several contaminants in sediment and/or porewater, including toluene and total semi-volatile organic compounds (SVOCs).
- SMU 2 ILWD Area: Contaminant concentrations are significantly lower in this area than elsewhere within the ILWD. Therefore, habitat considerations were the primary consideration in developing the removal approach in this area. In general, the dredge removal was selected to increase water depth near shore to enhance future shoreline fishing opportunities.

As shown in Figure 5.1 and the detailed design drawings in Appendix F, there will be transition zones between the full removal depth and shoreline in some areas, and approaching the littoral area boundary based on habitat and other considerations. There are also transition zones between the removal areas.

Following development of the removal approach that results in an average removal of 6.6 ft. (2 meters), sediment data for the next 3.3 ft. (1 meter) down was evaluated to identify exceedances of the hot spot criteria listed in the ROD and the subsequent hot spot removal approach, as detailed in Appendix G. Hot spots are defined as those wastes/sediments that contain select contaminants (based on their presence at significantly elevated concentrations in the ILWD and/or the compounds to which the cap model is most sensitive) above threshold concentrations. Based on existing data, only chlorobenzene, dichlorobenzenes, and xylenes exceed their respective cap threshold values in the 1-meter interval immediately underlying the baseline dredge cut, although sporadic exceedances of hot spot criteria for other contaminants were observed in deeper sample intervals. The resulting hot spot removal areas A through G are shown on Figure 5.1. In limited areas, sediments may remain that exceed hot spot criteria following the 1-meter hot spot removal. The remedy will be protective and isolate these areas because the cap design incorporates porewater data inclusive of hot spot areas. This conservatively includes data from sediment that will be dredged.

Hot spot areas A through G shown on Figure 5.1 cover approximately 22 acres. The dredge areas around sampling points that exceeded hot spot criteria were developed based on interpolation with surrounding data points that did not exceed the hot spot criteria using conservative assumptions, as detailed in Appendix G. The resulting hot spot dredge volumes listed in Table 5.1 incorporate a dredge cut side slope of 5 horizontal to 1 vertical (5H:1V). All hot spot dredging will be based on existing data, no additional design-related or confirmatory sampling will be performed.

The detailed dredge prisms and associated design and contracting plan have been developed to ensure the volume-based goals listed in Table 5.1 corresponding to an average removal of 6.6 ft. (2 meters) are achieved (exclusive of hot spot dredging) on a SMU-specific basis. The SMU 7 ILWD dredge volume equates to greater than a 2-meter average removal in order to achieve the SMU 1/SMU 7 ILWD East removal goal listed above of 3 meters in the majority of this area.

Geotechnical stability evaluations were completed to evaluate seismic stability of the ILWD, as detailed in Appendix H. In addition to seismic stability, the stability evaluations also included evaluations of static stability during dredging/capping as required in the ROD and Statement of Work. These stability evaluations concluded that the ILWD is stable following the removal described above and no additional removal is required to meet static or seismic stability goals listed in Section 5.1.

5.2.5 Remediation Area E

Dredging to a target elevation to achieve post-cap water bathymetry for designed habitat modules and navigational considerations will be completed along the shoreline areas in Remediation Area E, as shown in Figures 4.22 through 4.24. Sufficient dredging will be completed up to the shoreline in the northern portion of Remediation Area E to ensure placement of the full-thickness cap all the way to the shoreline. As a result, the removal prism will extend inland of the shoreline in order to accommodate suitable dredge cut slopes.

In the area south and immediately north of Onondaga Creek, three active rail lines are located immediately adjacent to the shoreline. Two of these lines are operated by CSX, while the third is operated by Susquehanna. Geotechnical analysis indicates that dredging within approximately 150 ft. of the shoreline could result in an unacceptable factor of safety for the shoreline and rail line stability. Therefore, detailed dredging and capping prisms have not been developed for the area within 150 ft. from shoreline along this portion of Remediation Area E. An appropriate approach for this area that is environmentally protective and does not negatively impact the stability of the rail lines will be developed as an addendum to the final design. Table 5.1 includes a maximum estimated dredging volume from this area to ensure that the total dredge volume is not underestimated.

The channel depth at the mouth of Onondaga Creek must be sufficient to accommodate commercial boat traffic that uses Onondaga Creek and the Inner Harbor. Therefore, the proposed approach in this area is to dredge to a sufficient depth to allow cap placement while maintaining minimum required navigational depths as provided by the NYSCC.

5.2.6 Remediation Area F

The area requiring remediation in Remediation Area F consists of two small areas totaling less than one acre. The water depth is sufficient in these areas such that dredging prior to capping is not required.

5.2.7 Wastebed B/Harbor Brook Outboard Area

The minimum area and depth of material requiring removal in the WBB/HB Outboard Area in order to achieve the desired habitat was developed in Section 4.3.5.3. In addition, hot spot dredging will be completed in the Outboard Area. The hot spot criteria and method for developing the hot spot dredging areas and volumes is consistent with the hot spot methodology described above for Remediation Area D.

The Outboard Area consists of vegetated wetland and upland soils. As discussed in Section 5.2.1, the vegetation within the wetland and the upland soils present a challenge for hydraulic dredging and sediment management. Upland soils present a challenge for a hydraulic dredge due to the potential for dredge pump cavitating when the pump does not have enough water to mix with the soils. Therefore, a portion of the vegetation and upland soils will be removed prior to hydraulic dredging and managed on the WBB/HB site. It is estimated that approximately 35,000 CY of vegetative material and upland soils may be removed to facilitate conditions for the proposed hydraulic removal. Removed upland soils from the Wastebed B Outboard Area will be managed consistent with the comprehensive site management plan being developed for Wastebed B.

The East Wall IRM sheetpile east of Harbor Brook has a limitation due to potential stability concerns with dredging adjacent to the steel sheet pile. Geotechnical evaluations indicate that in the zone that is within 100 ft. outboard of the sheets, the work needs to be done in smaller increments in order to maintain stability along the sheets, as documented in the East Wall Portion of the Wastebed B/Harbor Brook IRM Design Report (Parsons, Geosyntec and OBG, June 2011). Therefore, the dredging and capping will be sequenced such that than no more than 80 linear ft. of sheeting will be exposed at any one time during dredging and capping. The 80 ft. is measured at the bottom of the dredge cut, with side slopes of 5h:1v or steeper. The sequential dredge sequence and cross sections are shown on Figure 5.3. The sequential dredge design will allow the hydraulic dredge to work its way from the Outboard Area into the 100 ft. restricted zone while dredging a path 80 ft. wide or less. Once the dredge width has been completed from the Outboard Area to the sheets, the cap will be constructed, and the dredging and capping operation will move into the next adjacent area. This sequence of dredge and then cap will progress along the restricted area.

The area outboard of the 100-ft. restricted zone will be dredged in coordination with the sequential excavation, but does not have any dredge restrictions. The final sequencing will be determined during construction and will take into consideration the Harbor Brook reconstruction. Flows in Harbor Brook may be diverted around the dredge cut through the new cap area, or may be bypass-pumped around the channel area.

Excavations outboard of both the West Wall and East Wall will require monitoring of the barrier wall as specified in the final design reports for the West Wall and East Wall. As noted in the West Wall design, excavation outboard of the sheet pile wall would start within 20 ft. from the locations of inclinometers and would not be extended farther away from the inclinometers until the monitoring results indicate the wall is stable, as directed by Geosyntec. The excavation in front of the wall would be backfilled immediately if the monitoring results indicate that the performance of the wall is not as predicted. As indicated in the East Wall Design, the excavation in front of the wall will be done sequentially (i.e., a defined area will be dredged and backfilled prior to proceeding to the next defined area). Therefore, the 20-ft. restriction described for the West Wall is not applicable to the East Wall. Additional details regarding the required wall monitoring during implementation of the lake remedy will be provided in the CQAP.

5.3 DREDGING OPERATIONS AND EQUIPMENT

This section provides an overview of anticipated dredging equipment and operations, which have been developed taking into consideration input from the selected dredge contractor (Sevenson Environmental). This section also summarizes the anticipated dredging production rates, interaction with shoreline remediation, emissions monitoring and management, and quality control measures. Details regarding the silt curtains that will be used during dredging are provided in Section 8.

5.3.1 Dredging Equipment

The use of hydraulic dredging and transportation by pipeline was evaluated relative to other options (e.g., mechanical dredging) in the Feasibility Study (Parsons 2004). The FS concluded that hydraulic dredging was the most suitable method of sediment removal. Hydraulic dredging eliminates the truck traffic associated with transportation of mechanically dredged material and minimizes exposure of the dredged material to the air, thereby minimizing the odor and emissions generation potential.

In selecting the most appropriate dredging operation for Onondaga Lake, the selected contractor and design team considered numerous factors including, but not limited to physical site conditions, physical characteristics of the dredged material, dredged material transport requirements, sediment management and dewatering, and water treatment system capacity.

The dredging contractor will use several dredges, including dredges of different sizes operating individually and concurrently. The use of multiple dredges ensures the flexibility to operate in multiple areas simultaneously or in differing site conditions (water depth, cut thickness, etc.). This redundancy and optimization in operation will allow the contractor to maintain schedule and complete the dredging within four years. The dredging contractor will utilize three hydraulic dredges based on the range of site characteristics and the required production rates and schedule. A memo developed by Sevenson summarizes the selection of the hydraulic dredges and the anticipated production rates (see Appendix J). The three dredges selected are listed below.

- Dredging Supply Company (DSC) Marlin 7650D dredge with a 16-in. diameter discharge line and a 30 ft. spud carriage
- DSC Shark 75450D dredge with a 14-in. diameter discharge line and a 30 ft. spud carriage
- DSC Moray 2000D swinging ladder dredge with an 8-in. diameter discharge line

The proposed dredges will be used in various combinations depending on the thickness of the dredge cut, the type of material and location of dredging. The 16-in. dredge will be used as the primary production dredge, focusing on areas with thick dredge cuts for efficiency of operations. Due to the discharge flow requirements of the 16-in. dredge, it will operate individually. The 14-in. dredge can operate individually as a production dredge when needed, or used in combination with the 8-in. dredge. The 8-in. dredge does not generate enough discharge flow to the sediment transport system and therefore cannot be used individually unless significant makeup water is provided to meet minimum pipeline flow requirement. It will be utilized more as a specialty dredge in areas of shallow water or thin dredge cuts, which are more efficient for the smaller dredge. More details on the likely sequencing of dredge operations are discussed in Section 8.3.

5.3.2 Dredging Production Rate

Appendix J presents the estimated production rates for each of the three selected dredges operating in each of the remediation areas. The production rate estimates are based on the *in situ* geotechnical data, dredge cut thickness, dredge characteristics (i.e. impeller diameter/horsepower), swing speed, swing distance, time required to advance the dredge and handle anchors, pumping distances to the first available booster pump, and booster pump spacing along the proposed alignment. Average dredging production rates are developed in Appendix J for each Remediation Area based on these factors. The anticipated range of average production rates for each dredge is listed below.

- 16-in. Dredge: 178 to 351 CY/hr, depending on remediation area
- 14-in. Dredge: 159 to 224 CY/hr, depending on remediation area
- 8-in. Dredge: 22 to 38 CY/hr, depending on remediation area

The estimated combined production rate for the 14-in. dredge and the 8-in. dredge when operated simultaneously ranges from 183 to 262 CY/hr, depending on Remediation Area. Due to factors within the dredging/sediment transport/solids handling/water treatment system, a 75 percent up time is estimated for the system. These production rates are more than adequate to achieve the required dredge volume within four years, as discussed in sequencing (Section 8). Depending on the overall sequence and schedule of construction operations, multiple dredging operations may be working simultaneously. This may include concurrent dredging operations for different remediation areas (or areas within a remediation area) based on operation of the 14-in. dredge and 8-in. dredge.

The dredging, slurry transport, and the dewatering activities essentially form one integrated system. The dredges and resulting production rates described above have been incorporated into the design of the sediment management system, including piping, pump station and dewatering system designs, as detailed in the sediment management design documents.

5.3.3 Nearshore Dredging and Interaction with Shoreline Areas

Nearshore dredging involves the removal of dredged material within the dredge prism along the shoreline and is defined by access to the shoreline based on bathymetry and dredge draft. Dredging will typically be completed up to the shoreline so that the required thickness of the cap can be constructed up to the shoreline without losing any lake surface after the cap is placed. The removal will then slope into the shoreline at an assumed slope of 5H:1V, although this may be revised based on field observations, as detailed in Appendix F.

Tasks associated with nearshore dredging and shoreline sloping involve tree and bush removal, shoreline debris management, and submerged aquatic vegetation (SAV) management. SAV in nearshore dredge areas will be managed appropriately to ensure it does not negatively impact dredging and sediment management operations, as detailed in Section 5.6.

The anticipated approach for nearshore dredging involves hydraulically removing targeted material within the dredge prism up to the edge of the lake, with potential mechanical removal on the upland side along the shoreline in limited areas. None of the material removed mechanically will be managed at the SCA. In Remediation Area C and Remediation Area E, onshore material that is removed as part of the sloping requirements will be temporarily stockpiled on shore and then replaced as part of the shoreline restoration following cap placement. In areas where onshore material that is removed is within the remedial boundary of an adjacent site, such as along the shoreline of Remediation Area A and Remediation Area B, removed material will be managed in kind with management of other material generated at that upland remediation site.

Nearshore dredging design will involve coordination/integration with other Honeywell upland remediation projects that are currently or will be implemented along the shoreline of the remediation areas. This includes remedial activities at Ninemile Creek, Wastebeds 1-8, Willis/Semet Barrier Wall, and Wastebed B/Harbor Brook barrier wall. Integration of the lake remedial design and construction sequencing with these remedies is discussed in Sections 3.4 and 8.1. The scopes and schedules for upland remedial activities are being advanced as part of the remedial programs for the individual sites. As these programs are advanced and additional details become available, the information will be used to further define the approach for integrating these on-shore activities with the lake remediation as the work progresses.

5.4 DREDGING OPERATIONS QUALITY CONTROLS MEASURES

The quality control measures for dredging operations have been developed with consideration of the elevation based dredging methodology and requirements for dredging in the ILWD area. Dredging within the ILWD area (Remediation Area D) will be performed to remove sediments and/or wastes to an average depth of 6.6 ft. (2 meters) in SMU 1, SMU 2 and SMU 7 and an additional 3.3 ft. (1 meter) within approximately 22 acres of hot-spot areas. Quality control measures that will be implemented related to dredging include:

- Real-time horizontal and vertical position control: Each dredge will be outfitted with a positioning system that will track, in real-time, the position of the cutterhead. This will include the use of real-time kinematic (RTK) differential global positioning system (DGPS) sensors, inclinometers, tilt sensors, and/or other positioning equipment mounted directly on the arm of the dredge (e.g., the ladder of the hydraulic dredge). The positioning equipment will be connected to a computer software package specifically designed for tracking and logging the position and movement of the cutterhead while it is in operation. The horizontal datum for the site will be U.S. State Plane – New York Central Zone NAD83, U.S. Survey feet. The vertical datum for the site will be North American Vertical Datum 1988 (NAVD88), U.S. Survey feet. Appendix J provides additional details of the planned position control systems for the dredges.
- Dredge elevation verification: bathymetric surveys will be performed after dredging for tracking and demonstrating the achievement of the required dredge elevations and volumes. The contractor will perform these surveys on a regular basis throughout construction for quality control (QC). Details of the QA program will be presented in the CQAP to be submitted under separate cover. This Plan will present the means, methods, and metrics for assessing compliance with the project objectives.
- Dredged material quantity tracking: Each dredge will be outfitted with equipment to monitor the density and rate of material being removed (see Appendix J). Additional means to track quantities will include volume computations utilizing contractor progress surveys.
- Side slopes: Removal of sediment from the side slope beyond the limit of the dredge prism are designed at a 5H:1V vertical side slope, as depicted on the Drawings (Appendix F). Dredge prism side slopes may be defined upon further evaluation of geotechnical properties, as well as adaptive management of actual conditions in the field. The side slope will reduce material from sloughing into the dredge prism during

or after construction. The actual side slope will be as steep as practical to reduce the impact of dredge operations on shoreline areas.

Quality control and quality assurance procedures, including pre, interim, and post dredging surveys and data collection, will be performed throughout the dredging operations. Detailed procedures will be provided in the CQAP.

5.5 DREDGING SHORELINE SUPPORT AREA

The dredging activities for Onondaga Lake will require support areas adjacent to the lake. The areas include support for personnel, dredge maintenance, hydraulic booster pumps, sediment transport piping and debris management. The shoreline support layout for Onondaga Lake dredging activities is presented in Figure 4.27. Dredging support for all remediation areas will be performed from this location.

The dredging activities to take place in the lake will require an area for equipment, piping, and debris unloading on the shore. The designated area for the dredging shoreline support is located on Wastebed B, west of the temporary office trailers for the lake IRM sheetpile construction as depicted in Figure 4.27. The dredge support area will include a pile supported concrete pad to support the equipment along the wall due to the limitations of the loadings on the wall, as discussed in Section 4.4.5. The concrete pad will support unloading of debris operations and dredging support operations. The hydraulic transport pipe that will be used to transport dredged materials will be buried in this area to facilitate the required trucking activities. The equipment on the shore will include a crane or backhoe to unload debris scows and trucks to remove debris. Additional equipment may be required to support dredge maintenance and other on water equipment and operations

Personnel access for lake dredge and cap operations will be by a personnel pier located adjacent to the debris unloading operations along the wall. The pier will be constructed with floats in the water and will be sufficient to tie off work and crew watercraft.

Limitations on loadings from construction equipment and material stockpiles and required setback distances from the barrier wall, as specified in Appendix B of the West Wall design, will be maintained.

5.6 SUBMERGED AQUATIC VEGETATION MANAGEMENT

Submerged aquatic vegetation in the lake remediation areas will be managed as needed to ensure that it does not impact the dredging and sediment management systems operations or ability to place the cap. Submerged aquatic vegetation has the potential to reduce the efficiency of the dredge cutter head during dredging due to entanglement of the roots or vegetation on the cutter head. This could result in a system shutdown due to the need to raise the cutter head to physically remove accumulated material. Another potential concern is the management and segregation of the SAV that would clear the cutter head(s), booster pumps, and ultimately be deposited on the particle size segregation screens prior to dewatering at the SCA. Submerged aquatic vegetation may block off or “blind” the screens, causing sediment and water flow blockages or restrictions at the SCA. This may also result in a reduction of flow to the system, or a system shutdown to remove the blockage. In addition, submerged aquatic vegetation that accumulates in the geotubes at the SCA may reduce the dewatering ability of the geotubes causing a reduction in allowable flow. Aquatic vegetation is primarily a concern in waters with depths shallower than 10 to 13 ft. (3 to 4 meters). Areas with water depths exceeding 3 to 4 meters have less aquatic vegetation than shallower areas based on past surveys of aquatic vegetation in Onondaga Lake completed by Onondaga County and SUNY ESF.

Methods to manage submerged aquatic vegetation in the remediation areas can include mechanical removal, chemical control using one or more herbicides, or a combination of the two methods. It is anticipated that chemical control will be the primary control methods given the numerous limitations associated with mechanical removal. To implement chemical control, the most appropriate herbicide(s) will be applied by an experienced applicator in accordance with 6 NYCRR Part 327 prior to when an area will be dredged or capped using the herbicide(s) and application procedure(s) approved in advance by NYSDEC. Similar chemical applications have been conducted for Onondaga County in the Seneca River near the Onondaga Lake outlet. Chemical control has also been conducted recently in other Central New York water bodies, such as Cazenovia Lake.

One or more effective, acceptable herbicides registered in the State of New York will be applied as needed in a manner approved in advance by NYSDEC prior to dredging or capping. If mechanical removal is used to supplement chemical control, rooted vegetation would be cut above the sediment after which both the cut and unrooted vegetation would be removed from each remediation work area and managed at an on-land location as needed. Use of either method will be conducted in an effective manner that is protective of human health and the environment and in compliance with applicable or relevant and appropriate rules and regulations. Use of herbicides in New York State waterways is regulated under Part 327 of Title 6 in the New York State Code of Rules and Regulations (6NYCRR Part 327).

Submerged aquatic vegetation data from Onondaga County's Ambient Monitoring Program (AMP) are being reviewed to evaluate chemical and/or mechanical control methods for each remediation area based on the vegetation in each area. Approvals for aquatic vegetation chemical control will be secured through the NYSDEC permitting process for herbicide use prior to herbicide application. Decisions such as which herbicide to apply, dosages, and timing for applications would be made as part of the permitting process. If mechanical control of aquatic vegetation is to be implemented to supplement the chemical control, approvals will be made through NYSDEC in the future as part the permitting process. Mechanical control would be completed within approximately 2 weeks prior to dredging or capping to limit the time for any re-growth.

Implementation of aquatic vegetation control methods will be coordinated with the schedule and progress of dredging and capping. The schedule for the first year of construction (2012) is to start dredging in the western portion of Remediation Area C and work east-southeast entering the ILWD (Remediation Area D) where dredging is scheduled to take place through the end of the 2013 dredging season.

5.7 DREDGING DATA GAPS

Dredging areas and depths, as well as the properties of the materials to be dredged, are well defined based on data from the RI and seven years of design-related investigations. No dredging-related data gaps have been identified.

SECTION 6

SEDIMENT MANAGEMENT UNIT (SMU) 8

Waters in the middle of Onondaga Lake stratify vertically each year typically from May to October based on water temperature. This stratification results in waters with a relatively constant temperature above waters where temperatures vary vertically over a thin water depth (called a thermocline) which, in turn, is above deeper waters also with a relatively constant water temperature. Waters above the thermocline are called the epilimnion, while waters below the thermocline are called the hypolimnion. Epilimnion and hypolimnion waters do not mix with each other when the lake is thermally stratified. Sediment within this deep water zone of Onondaga Lake that stratifies is called SMU 8. SMU 8 covers approximately 64 percent of the lake and includes sediments in waters that are deeper than 30 ft. (9 meters).

The remedy for the SMU 8 portion of Onondaga Lake includes a nitrate addition pilot study, monitored natural recovery, and thin-layer capping over a portion of the SMU. Each of these remedy components is discussed in detail below.

6.1 NITRATE ADDITION

Honeywell will conduct a three-year nitrate addition pilot test beginning in the summer of 2011 to add supplemental quantities of nitrate to the lower hypolimnion waters of Onondaga Lake as warranted. A work plan for the nitrate addition pilot test was approved by NYSDEC before the pilot test began (Parsons and Upstate Freshwater Institute [UFI], 2011). The objective of the nitrate addition pilot test is to demonstrate the ability to maintain nitrate concentrations in the hypolimnion of Onondaga Lake at levels sufficient to further inhibit release of methylmercury from lake sediment to the overlying waters. Based on detailed data collection and evaluation during the years 2007 through 2009, a minimum nitrate concentration of 1.0 milligram per liter as nitrogen throughout the lower hypolimnion during summer stratification was established as a guide for determining when to add nitrate during the pilot test. Methylmercury concentrations were measured in the lower hypolimnion waters during the 2011 portion of the pilot test in addition to nitrate. This pilot test supplements nitrate addition that is ongoing as a result of wastewater treatment upgrades at Metro completed during 2004 and 2005. Nitrate when present in the lower hypolimnion waters in sufficient concentrations inhibits methylmercury production and inhibits release of methylmercury from SMU 8 sediments. The nitrate addition pilot test includes a monitoring program to assess the effectiveness of application and evaluate potential impacts to water quality and biota. Decreases in methylmercury concentrations in the hypolimnion are expected to lead to decreases over time in mercury concentrations in Onondaga Lake biota.

The nitrate addition pilot test is being initiated in 2011 following four years of extensive water column monitoring that documents the positive impacts of the nitrate added by Metro, an extensive bench test program (Exponent et al, 2009), dye tracer tests conducted on behalf of Honeywell during 2008 (Upstate Freshwater Institute, 2009), and a nitrate application field trial conducted on behalf of Honeywell during 2009 to assess whether nitrate could be effectively released to the lower hypolimnion of Onondaga Lake (Parsons and UFI, 2010). In addition, water quality has been routinely monitored in the Onondaga Lake hypolimnion since 2006. This three-year nitrate addition pilot test will be followed by a year of monitoring in 2014 to allow for data evaluation; an assessment of recent changes in inputs to the lake from tributaries, from Metro, and from the littoral zone of the lake; consideration of potential seasonal changes in lake water quality; and determination of the path forward which may include nitrate addition or additional consideration of oxygenation.

Adding nitrate to deeper waters in the lake will not result in any significant effects on water quality, biota, or human health. Nitrate is being added as liquid calcium nitrate which is a commonly-used agricultural fertilizer with no known human health or biota effects. Adding liquid nitrate to the lower hypolimnion is not expected to stimulate growth of algae or other plants in the lake and will not result in exceeding any applicable water quality standards (Parsons and UFI, 2011). The technology for adding nitrate during the pilot test is customized to Onondaga Lake, relatively simple and was employed effectively in Onondaga Lake during 2009 on a trial basis. Protocols for safe operations and spill prevention are being implemented, and water quality is being monitored throughout the pilot test. Spill contingency for nitrate addition operations include design controls, preventive management practices for activities such as refueling of vehicles or transfer of chemicals, and spill response procedures in case an unwanted spill would occur.

6.1.1 Basis for Nitrate Addition

Methylmercury concentrations increase in the lower hypolimnion during late summer and early fall when oxygen and nitrate levels become depleted in the hypolimnion. The hypolimnion receives organic and inorganic solids that settle by gravity from the epilimnion toward the lake bottom. Decomposition of organic matter proceeds through a sequence of metabolic pathways according to energetic favorability (from respiration in the presence of oxygen, to nitrate reduction, to sulfate reduction, to methanogenesis). As the summer progresses, biodegradation of organic matter and oxidation of reduced chemical species (e.g., hydrogen sulfide and methane) depletes oxygen in the hypolimnion, creating anoxic conditions. In the absence of oxygen, biodegradation proceeds primarily through the nitrate reduction pathway (denitrification). Under anaerobic conditions (absence of oxygen and nitrate), organic matter is mineralized via sulfate reduction or methanogenesis.

When sulfate is used in biodegradation (i.e., reduced by bacteria from sulfate to sulfide), methylmercury is produced in SMU 8 sediments and may be released to overlying water in the hypolimnion, conditions permitting. The presence of oxygen or nitrate in the overlying waters results in the formation of an oxidized microzone at the sediment surface that may inhibit transport to the water column (Todorova et al., 2009). When waters in the middle of the lake turn over (typically in mid-to-late October due to cooling temperatures and wind), the water column becomes well-mixed, and depletion of oxygen and nitrate ceases. Following fall turnover, total mercury concentrations in Onondaga Lake waters decline quickly as a result of adsorption to particulate matter and settle to the lake bottom (Jacobs et al., 1995). Methylmercury concentrations in Onondaga Lake can remain elevated throughout the water column for several weeks following fall turnover but then they also decline as methylmercury is degraded or immobilized in surface waters (Sellers et al., 1996).

Since Onondaga County implemented year-round nitrification (a biological process whereby ammonia is converted to nitrate) at Metro in 2004, nitrate concentrations in Onondaga Lake have approximately doubled (Effler et al., 2010) and the period of sulfate reduction (and therefore methylmercury production) has shortened. Accumulation of methylmercury in the hypolimnion has declined 50 percent from the combined effects of decreased deposition of organic matter (due to decreased primary production resulting from the Metro upgrade in phosphorus treatment) and the increased discharge of nitrate from the facility (Todorova et al., 2009). These improvements have led to decreases in methylmercury concentrations in the lake's upper waters, particularly during fall turnover of the lake which typically takes place each year in early-to-mid October.

6.1.2 Pilot Test Design and Performance Criteria

The basis for selecting calcium nitrate to add to deep waters in the middle of Onondaga Lake is its liquid form, availability, common use, chemical content, and successful limited applications of liquid calcium nitrate to the Onondaga Lake hypolimnion during the 2009 nitrate application field trial. In order for the calcium nitrate solution to remain in the lower hypolimnion following release to the lake, the calcium nitrate solution needs to be diluted to the density of the hypolimnion water. The specific gravity of the calcium nitrate solution is 1.48, which is almost 50 percent higher than the density of water. Therefore, in order for the nitrate to remain near the bottom of the lake, water that is less dense than hypolimnion water needs to be mixed with the calcium nitrate before being pumped to the lower hypolimnion. Water from shallower depths in the epilimnion is warmer and less dense than hypolimnion waters and therefore is being mixed with the calcium nitrate prior to each application of nitrate to the hypolimnion. Pumping rates into the lake are being determined prior to application based on water temperature and specific conductance at the time of application.

6.1.3 Implementation of Nitrate Addition Pilot Test

Each application of nitrate is being conducted continuously during a single day at a single predetermined location. The application is being moved to a different location in the middle of the lake for each day nitrate is added. Estimates presented in the work plan for this pilot test indicate three day-long applications of nitrate each week should meet project objectives and allow the nitrate to spread laterally throughout the entire lower hypolimnion.

The barge used to apply diluted calcium nitrate is able to work in Onondaga Lake under weather conditions that occur commonly during summer and fall months in Central New York. The application barge is approximately 24 ft. by 40 ft. and is visible in the middle of the lake for up to eight hours each of three days weekly during the pilot test. Calcium nitrate is not being added during public recreational events on the lake.

6.1.4 Monitoring During the Nitrate Addition Pilot Test

An in-lake monitoring program will be conducted before, during, and after each of the three years of nitrate addition as provided in the pilot test work plan. Data collected as part of the nitrate addition monitoring program will be used to guide rates and locations for application of the calcium nitrate solution, to track the fate of the nitrate addition and verify that there are no negative impacts to water quality, and to assess nitrate addition as a means of abating methylmercury accumulation in the hypolimnion. The monitoring program to support the nitrate pilot test has three components: (1) fixed frequency monitoring; (2) three-dimensional specification of nitrate and sulfide levels on a frequent basis during periods of nitrate addition; and (3) measurements on board the barge. The monitoring program for the pilot test is described in the work plan (Parsons and UFI, 2011).

6.1.5 Post Pilot Test Considerations

This nitrate addition pilot test will be followed by a year of monitoring (i.e., 2014) to allow for data evaluation, an assessment of recent changes in inputs to the middle of the lake from tributaries, from Metro, and from the littoral zone of the lake, consideration of potential seasonal changes in lake water quality, and determination of the path forward, which may include nitrate addition or consideration of oxygenation. At a minimum, monitoring in the lake for methylmercury will continue beyond the year 2013.

6.2 MONITORED NATURAL RECOVERY (MNR)

Surface sediment mercury concentrations in SMU 8 have been declining naturally for many years and are approaching the remediation goals for mercury (i.e., the mercury PEC and mercury BSQV) identified in the ROD. Based on these reductions in mercury in surface sediments that were documented in the Feasibility Study (Parsons, 2004), MNR was determined to be appropriate as a significant component of the SMU 8 remedy. MNR involves allowing ongoing naturally occurring physical, chemical, and/or biological processes to lower the concentration, mobility, bioavailability, toxicity, and/or exposure of chemicals in a media such as lake sediment. Some natural processes (e.g., deposition of cleaner sediments onto impacted sediments) act as containment mechanisms, while others (e.g., biodegradation of contaminants by native bacteria) act as *in situ* treatment mechanisms.

Natural recovery is monitored to verify that specified goals are achieved within an acceptable timeframe. For Onondaga Lake, natural recovery of sediments with elevated mercury concentrations in the profundal zone is expected to lower surface sediment mercury concentrations to below the design and performance criteria for MNR (see below) within the 10-year monitoring period following completion of the remediation of Honeywell upland sources and littoral sediments. The current projection is for these remediation activities to be completed by the year 2017; therefore, the 10-year monitoring period for MNR will extend through the year 2027.

Mercury PEC and mercury BSQV performance criteria presented in the ROD are predicted to be met naturally by the end of the 10-year MNR monitoring period (i.e., the year 2027), as described in this section and in Appendix M. Based on these estimates of future sediment mercury concentrations, it is not anticipated that additional thin-layer capping will be needed to supplement MNR in order to achieve the mercury PEC or BSQV criteria**.**

The MNR remedy for Onondaga Lake includes procedures in case sufficient natural recovery is not observed within the 10-year post-remediation monitoring period. Such procedures might involve a range of activities, including additional monitoring and/or modeling of natural recovery, and implementation of thin-layer capping in those areas where MNR does not appear to be achieving the required outcome.

6.2.1 Design and Performance Criteria for MNR in Onondaga Lake

The design and performance criteria for MNR based on lake remedy requirements are:

- Achieve the mercury PEC of 2.2 mg/kg in the profundal zone within 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping in the profundal zone.
- Achieve the mercury BSQV of 0.8 mg/kg on an area-wide basis within 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping in the profundal zone.

Areas where surface sediments will not meet these goals based on MNR model predictions will require thin-layer capping prior to the start of the 10-year MNR period. The reference in the criteria listed above to initial thin-layer capping refers to these areas as well as sediments which currently exceed a mean PECQ of 1.

The remediation goals for mercury PEC and BSQV need to be met within a vertical interval of surface sediment that is relevant to potential exposures to organisms intended to be protected. This vertical interval of sediment is referred to herein as a “compliance depth”. The appropriate compliance depth for mercury PEC, for BSQV, and for mean PECQ in SMU 8 has been determined to be the top 4 cm of sediment consistent with results from the feasibility study and based on nitrate addition in lieu of oxygenation as well as site-specific considerations described in Appendix M. In the event that deep waters in the middle of the lake remain with oxygen throughout summertimes in future years (as a result of natural conditions or engineering means) or factors change such that conditions with oxygen are predicted in advance, the appropriateness of the 4 cm compliance depth would be reassessed at that time as natural recovery continues to be assessed.

The mercury PEC of 2.2 mg/kg needs to be met at each station because it is based on direct toxicity to sediment-dwelling organisms. The mercury BSQV of 0.8 mg/kg needs to be met over a larger area of the lake than a single location, because the BSQV is based on bioaccumulation, a process that involves exposure to mercury over a large area. As a result, the BSQV has been applied over five subareas that together cover the entire surface area of the lake. The five lake subareas from north to south are called the North Basin, Ninemile Creek Outlet Area, Saddle, South Basin, and South Corner (see the BSQV analysis in Appendix N).

6.2.2 Natural Recovery Processes in Onondaga Lake

The primary natural recovery mechanism operating in SMU 8 surface sediment is burial by incoming clean sediments that are continually being deposited from overlying water. This process is based on the extensive information available for the profundal zone of Onondaga Lake and the fact that mercury is strongly absorbed to sediment and is not degradable or substantially solubilized.

Substantial design evaluation and testing work have been completed over several phases of pre-design investigation work to support evaluation of MNR for SMU 8. Evaluations have included various types of specific data analyses and mathematical modeling. Surface sediment samples have been collected over many years and analyzed for mercury at over 100 locations. Figure 6.1 presents bar-chart compilations of average surface sediment mercury concentrations from multiple locations in both the north half and south half of the lake; average surface sediment mercury concentrations were significantly lower in 2005 compared to 13 years prior in 1992. To further demonstrate that natural recovery is ongoing, Figure 6.2 shows mercury concentrations in near-surface sediment in an example core from the North Basin and in an example core from the South Basin collected during 2008 are substantially lower than mercury concentrations in deeper sediments. The lower concentrations at shallower depths correspond to recent conditions showing mercury loadings entering the lake are substantially lower than in the past. The ages of deeper sediments have been estimated by analysis of lead-210 and cesium-137 radioisotopes from cores collected during the 1990s as part of the lake remedial investigation (TAMS, 2002) and also from cores collected on behalf of Honeywell during 2008 (Parsons, 2010a). The lower surface concentrations have resulted from subsequent deposition of cleaner sediments over time. Deposition rates are an important factor in determining how rapidly SMU 8 sediment is recovering that have been estimated from sediment cores and sediment trap data, as described in Appendix M.

Laminations (also called layering or varves) were initially observed in SMU 8 sediment during the 1990s (Rowell, 1992 and Effler et al, 1996) and again during the 2010 PDI as described in Appendix M. The presence of laminations indicates only limited vertical mixing occurs in SMU 8 sediment, which contributes to natural recovery. This lack of vertical mixing results primarily from the lack of benthic organisms in the sediment (due to the lack of oxygen in the Onondaga Lake hypolimnion during summer stratification each year) and the lack of resuspension by water currents (see Appendix M). Lake remediation efforts are not expected to change this condition, so natural recovery is projected to continue on an ongoing basis. In the event the profundal zone waters continue to have oxygen in the future during summer months (either naturally or through engineered means) or factors change so summertime conditions with oxygen are predicted to occur, the appropriateness of a 4 cm sediment mixed layer depth would be reassessed at that time.

6.2.3 Monitoring and Contingency Approach for Natural Recovery

To verify the accuracy of MNR projections, a long-term monitoring program is being implemented throughout the MNR period. In addition, contingency actions have been identified which would be evaluated and implemented if needed.

As the objective for monitored natural recovery is meeting the mercury PEC and BSQV which are both based on total mercury concentrations in surface sediments, mercury concentrations in surface sediments will continue to be analyzed over time to determine the effectiveness of natural recovery. Important mechanisms of MNR will be reassessed on an as-needed basis in the future if MNR deviates from the expected course. In such a situation, questions related to why MNR might be deviating from expected values are often best answered through examination of the mechanisms contributing to MNR.

The monitoring and contingency approach for MNR in SMU 8 consists of the following elements:

- Collect the same data types on regular intervals to track the course of MNR and provide early indication whether MNR is occurring as expected

- Provide a clear timing and decision framework for evaluating those data and making contingency decisions
- Provide a set of procedures, dependent on monitoring results, that allows for:
  - conducting additional analysis and/or modeling of existing data to better understand the implications of available results
  - collecting additional data and/or new types of data to help better understand existing results (with related additional data analyses/modeling as necessary)
  - evaluating and implementing (as warranted) additional remedial activities in the event that MNR is not progressing at a rate to meet lake remediation goals within the expected time period
- Consider additional procedures for unexpected or unknown events or circumstances (such as large storm events, unusual natural or anthropogenic discharge events, and other remedial activities affecting SMU 8 such as nitrate addition)

This monitoring and contingency approach is providing documentation of ongoing progress toward meeting remediation goals for mercury in profundal zone sediment. This approach also provides an assurance that contingency actions can be implemented in the future if remediation goals are not met.

A year-to-year summary schedule has been developed for implementing this monitoring and contingency approach (Table 6.1). Surface sediment data will be collected every 3 years and compared to the anticipated course of MNR as provided by the MNR model. Honeywell will provide updates to the agencies after each three-year monitoring interval to document work associated with implementing this monitoring and contingency approach and to provide recommendations for future sampling, modeling and/or remedial efforts. Detailed work scopes for specific sampling efforts will be reviewed by Honeywell with NYSDEC prior to each effort.

Use of the MNR model will continue in the future as more lake sediment data are collected. At each three-year interval, surface sediment mercury concentrations in SMU 8 will be compared to the estimated course of MNR as indicated by modeling results, as well as the theoretical trends needed to reach the remediation goals for mercury PEC and BSQV by the end of the 10-year monitoring period. If MNR is progressing as projected, little, if any, additional contingency work would be considered. If MNR is not progressing as projected, possible additional contingency actions would be discussed with the agencies and NYSDEC would subsequently determine what contingencies would be implemented, including potential placement of a thin-layer cap over a larger area of SMU 8.

6.2.4 Design Evaluations and Testing

The rate of natural recovery has been predicted based on site-specific modeling described in Appendix M. Modeling results predict that mercury PEC and BSQV remediation goals will be met with natural recovery by the end of the 10-year MNR monitoring period (i.e., the year 2027). Therefore, additional thin-layer capping is not expected to be needed to meet natural recovery objectives. Modeling results summarized in Table 6.2 show future sediment mercury concentrations in the profundal zone are projected to range between 0.48 mg/kg and 0.58 mg/kg by the year 2027 in the top 4 cm of SMU 8 sediment. The PEC of 2.2 mg/kg for mercury is projected to be achieved at all modeled locations by the year 2018, which is nine years before the end of the 10-year monitoring period for natural recovery. This analysis is presented in Appendix M and includes no temporary increases in sediment mercury concentrations in SMU 8 during dredging.

One of the goals of MNR is to achieve the mercury BSQV of 0.8 mg/kg on an area-wide basis. The BSQV was developed on a lakewide basis in the FS. Since the FS was prepared, the BSQV has also been assessed for each of five subareas that make up the lake. MNR model results were combined with projected littoral zone surface sediment mercury concentrations following remediation to estimate the future lakewide average concentration of mercury in surface sediment (0 to 4 cm sediment depth). The average mercury concentration projected for the year 2027 is 0.46 mg/kg in surface sediment on a lakewide basis, which is well below the BSQV of 0.8 mg/kg. Surface sediment mercury concentrations in SMU 8 are predicted to fall below the BSQV of 0.8 mg/kg at each of the locations modeled by the year 2024 (see Table M.4 in Appendix M). Predictions of surface sediment concentrations for the year 2027 in the five subareas of Onondaga Lake range from 0.34 to 0.61 mg/kg as presented at the end of the text in Appendix M.

6.3 MEAN PECQ EVALUATION

In addition to nitrate addition and natural recovery, the lake remedy also calls for surface sediments in the profundal zone of Onondaga Lake (SMU 8) that exceed a mean PECQ of 1 to be capped with a thin layer of sand (referred to herein as thin-layer capping). Calculation of the mean PECQ of 1 takes into consideration the 23 contaminants that show significant contributions to toxicity on a lakewide basis. The mercury PEC criterion of 2.2 mg/kg and the mean PECQ criterion of 1 are both based on considerations of benthic toxicity. The sediment compliance depth for the mean PECQ has been determined to be 4 cm consistent with the mercury PEC compliance depth.

The extensive data set used to characterize the profundal sediment was developed beginning in 1992. Table 6.3 summarizes the data sets available for assessing the mean PECQ for SMU 8 sediment. Many locations have been sampled more than once. For locations sampled more than once, the most recent data were used in this evaluation. This is appropriate given that natural processes continue to lower surface sediment concentrations through gradual deposition of sediments containing low contaminant concentrations entering Onondaga Lake.

The 2010 data set includes sediment chemical analyses from 67 locations in SMU 8 collected from the top 4 cm of sediment including many locations sampled during 1992 that were not analyzed at that time for the full suite of contaminants used to determine the mean PECQ. Twenty-two of the 43 locations sampled previously and analyzed for PECQ parameters were sampled and analyzed again during 2010 throughout SMU 8. Samples from the 2010 sampling effort had lower mean PECQs than samples collected at the same location the first time during 1992. For the 22 locations sampled during 2010, the average value of the mean PECQ was 0.83 during 1992 and 0.33 during 2010 (ranges of mean PECQs were 0.5 to 1.6 in 1992 and 0.21 to 0.54 in 2010). The 21 surface sediment locations sampled in SMU 8 during 1992 that were not sampled again during 2010 had an average mean PECQ value of 0.60 (range of mean PECQs was 0.34 to 1.1). Each of the 1992 locations that were sampled again during 2010 had a mean PECQ less than 1 based on the 2010 results (Table 6.4), and these locations had higher mean

PECQs during 1992 than locations not sampled a second time. Therefore, it was assumed that results from the 1992 locations not sampled again also have a mean PECQ less than 1.

Figures 6.3a and 6.3b present sediment mean PECQs for the top 4 cm of sediment in SMU 8 based on the data set discussed above, and highlight locations where a mean PECQ of 1 is exceeded. Field duplicates were collected at two of the 2010 sampling locations in these areas; for both locations an exceedance of the mean PECQ of 1 has been included in these figures because one of the two duplicate results shows a mean PECQ greater than 1. Figures 6.4a and 6.4b show sediment mean PECQs for the top 15 cm of sediment in SMU 8.

Sediment at locations S57 (1992) and OL-STA-80079 (1997), which had both slightly exceeded a mean PECQ of 1, was sampled again during 2011 (OL-STA-80224) and found to have a mean PECQ of 0.49 in the top 4 cm (Figure 6.3b). Given the most recent result for mean PECQ at this location is less than 1.0 based on analyses of sediment for each of the PECQ parameters, thin-layer capping is not warranted at this location.

The area of thin-layer capping in SMU 8 will be approximately 27 acres. Also shown in Figures 6.3b and 6.4b is an area approximately 5.6 acres in size at the southern end of SMU 8 along the southernmost end of SMU 8 and the north side of Remediation Area D will be remediated through the placement of an engineered cap consistent with portions of the littoral zone due to higher levels of contamination in this area.

6.4 THIN-LAYER CAPPING

6.4.1 Design and Performance Criteria for Thin-Layer Capping

The objective of the thin-layer capping is to provide an immediate decrease in surface sediment contaminant concentrations by introducing clean substrate at the surface in some areas of SMU 8.

Thin-layer capping is required in areas of SMU 8 where the mean PECQ exceeds 1, and where MNR is not predicted to meet the mercury criteria required by the ROD (PEC of 2.2 mg/kg at each location, and BSQV of 0.8 mg/kg on an area wide basis) within 10 years following the completion of upland source control and dredging and capping in the littoral zone. The two areas of SMU 8 surface sediment where the mean PECQ requirement is not met total 26.9 acres located directly adjacent to littoral zone Remediation Areas D and E (Figure 6.5). Boundaries for these two thin-layer cap areas were developed considering the top 4 cm of sediment, as discussed in Section 6.3. As discussed in Section 6.2, MNR is predicted to meet the mercury PEC performance criteria for SMU 8 and BSQV performance criteria for each portion of the lake, so no additional thin-layer cap areas are needed to meet mercury PEC or mercury BSQV goals. Additional areas of thin-layer capping may be identified as part of contingency actions that may be appropriate during the MNR period as discussed in Section 6.2 and in Appendix M.

The required thickness of the SMU 8 thin-layer cap material is 4 cm (approximately 2 in.) based on the compliance depth established from site data for the mean PECQ in SMU 8, as discussed in Section 6.2 and Appendix M.

6.4.2 Thin-Layer Cap Construction

Due to the soft nature of the SMU 8 surface sediments, it is anticipated the minimum 4 cm of material to be placed may mix with the underlying sediment during placement. This will achieve the remediation goal and provide an immediate decrease in surface sediment contaminant concentrations in SMU 8. Construction goals will include minimization of over placement. However, an allowance for over placement across the area of the cap during construction is included based on experience at other sites. An average over placement of approximately 3 in. results in an average thickness including over placement of approximately 5 in. This is consistent with the experiences of the cap placement contractor from sediment cap placement work at other sites such as Silver Lake in Massachusetts (Arcadis, 2008).

SECTION 7

DEBRIS, UTILITY, AND CULTURAL RESOURCE MANAGEMENT

Provided below are details pertaining to characterization and management of debris, utilities and cultural resources that are located within the areas that will be remediated.

7.1 DEBRIS

This subsection provides the basis and considerations for accommodating debris encountered within the areas of Onondaga Lake to be dredged and/or capped.

7.1.1 Debris Design and Performance Criteria

The primary objective in debris management, as it pertains to dredging, is to remove or otherwise manage debris in place such that targeted sediment can be efficiently and effectively dredged and dewatered through the on-site processing system. Certain debris can be left in place, including large boulders and rocks that do not pose a contamination risk and do not inhibit the dredging. Smaller debris can be effectively removed by the dredge, but other debris that could interfere with and/or damage the dredge, pipeline, or sediment processing equipment will be removed before dredging begins.

Within capping areas, debris will either be contained in place or removed to ensure that neither the ability to place the sediment cap, nor integrity and long-term effectiveness of the cap is significantly impacted. In general, debris that can be completely contained within the cap is not anticipated to pose a risk to the effectiveness of the cap. Within some capping areas, debris may be removed to facilitate, or as part of, initial dredging, as summarized above. Similar to debris management in dredge areas, it is feasible to leave some of the debris in place, while other debris may require removal prior to capping. In general, it is anticipated that only limited debris removal in the capping areas will be required.

7.1.2 Debris Characterization

Debris refers to wood, concrete, plastics, glass, metal, cable, tires, rocks, pilings, and other objects located on the surface of or within lake-bottom sediment. For purposes of this submittal, pilings are considered structures and are discussed in Section 7.2. Objects on the lake bottom identified as potential cultural resources are discussed in Section 7.3, below. The Phase I PDI geophysical survey work conducted during the fall of 2005 for Honeywell (CR Environmental, 2007), which included side-scan sonar and magnetometer surveys detected debris and obstructions, referred to as contacts, as small as 1 ft. to 2 ft. located on or above the mudline. Magnetometer surveys detected contacts containing iron or items that have been fired (such as bricks) located either at or below the mudline. Unlike side-scan sonar data, the magnetometer data do not reveal information about size or depth of those materials. Because no one single survey technology is available to characterize size, shape, or depth of debris, or other obstructions submerged below the mudline, a combination of the two methods provides the most comprehensive view of debris on the lake bottom.

Figure 7.1 presents locations of debris identified during the Phase I PDI geophysical survey work. An extensive data set was generated during this investigation. To facilitate management of the data, only debris that was equal to or greater than 5 ft. in size in any one dimension was reported on Figure 7.1. In addition, several debris features which are known to exist based on field observations but that were not detected during the 2005 survey, likely due to their location in shallow nearshore areas, are depicted on Figure 7.1.

A desktop review of the debris targets identified by the 2005 surveys was performed to identify targets that may need to be addresses for either dredging or capping (see Section 7.1.4 for details of the screening/evaluation of debris survey data related to capping). Based on this evaluation, a series of targets was identified for further underwater investigations within the areas where remediation is planned for 2012 (the first year of remediation). These additional investigations were performed in July 2011 using a remote operated vehicle to collect underwater video as a part of the Phase IB Cultural Resource investigation. The visual inspection of the identified targets was aimed at determining the following, to the extent feasible:

- Material type (e.g., wood, brick, concrete, natural rock, metal, vegetation, etc.)
- Approximate size (e.g. length, width, height above mudline)
- Relative shape
- Porosity (e.g., solid vs. open structure)

The July 2011 underwater video survey revealed that a number of debris targets identified through the 2005 geophysical surveying were no longer present, suggesting that the targets were likely submerged aquatic vegetation that has since deteriorated or been transported elsewhere. These results are summarized in Table 7.1.

As construction proceeds, additional evaluations and/or surveys will be completed to update/refine the characterization of debris that may impact dredge or cap operations in subsequent construction seasons. The approach for addressing this debris will be determined in consultation with NYSDEC as the information becomes available and construction progresses.

Despite the best efforts to identify debris in advance of the work, it is possible that some debris may be encountered during the conduct of the work that will require adaptive management in the field. Experience gained throughout the process will aid future visual survey work in the remaining remediation areas. The knowledge gained during the first year will then be applied in following years to expedite and improve debris identification and evaluation.

7.1.3 Debris Management in Dredge Areas

Based on experience at other dredging projects, proper debris management is critical to ensuring the efficiency of the dredging operation. This design provides guidelines as to the nature of debris that must be removed (completely or partially) and the debris that can remain in place. Prior field experience also indicates that debris management is most efficiently undertaken in an adaptive management mode in the field for debris that must be removed, in which the dredging contractor retains the flexibility to make real-time field decisions as to what debris will be removed prior to dredging (e.g., larger debris), and which will be removed by the dredge itself (e.g., smaller debris). As all dredging areas will be subsequently capped, dredging-area debris removal decisions will be made in consultation with NYSDEC consistent with the requirements for debris management in capping areas, as outlined in Section 7.1.4.

Based on evaluation of the geophysical survey results and other field investigations conducted to date, it is anticipated that at least some of the dredge areas will require some amount of debris removal prior to dredging. However, a general effort to rake all sediments prior to dredging will likely not be necessary. For example, reconnaissance indicates that discarded tires are scattered throughout the south end of the lake, with a concentrated area of discarded tires near the discharge of Harbor Brook, within the dredge prism for Remediation Area E (Figure 7.1). As these tires would likely become entangled in the dredge cutterhead, they will be removed prior to dredging.

As indicated in Section 7.1.2, additional characterization of debris present within portions of Remediation Areas C and D scheduled for construction in 2012 was performed in July 2011. Table 7.1 and Figure 7.2 summarize the nature of the debris identified within the area of the first year of dredging, and whether the debris will be removed or left in-place. The approach for addressing specific debris targets in areas scheduled for remediation in subsequent years will be determined in consultation with NYSDEC based on additional characterization that will be completed following initiation of construction.

7.1.4 Debris Management in Cap Areas

Debris management in cap areas fall into two categories; management of debris in cap areas not requiring prior dredging (e.g., cap-only areas), and management of debris in dredge areas that will receive a post-dredge cap (e.g., dredge-and-cap areas). Debris within the dredge-and-cap areas may be removed before or during the dredging operations as described in Section 7.1.3. However, if the debris does not require removal to facilitate dredging and would otherwise not impact the construction or performance of the cap, it may be left in place, as discussed below.

Most debris present in the capping areas would not impact the construction or performance of the sediment cap. Due to the thickness of the cap being placed, most debris would simply be buried in place. For instance, rocks, steel plates, or other similar low-profile debris can be completely covered by the full-thickness of cap and can be effectively contained within the cap. Debris removal in capping areas will be limited to those targets which will have been determined to significantly impact the constructability or effectiveness of the cap.

In general, debris targets within cap-only areas that have length and width dimensions that greatly exceed the height dimension (e.g., 30 ft. wide x 40 ft. long x 3 ft. tall) are considered “low profile” and would likely be completely covered by the capping materials regardless of the height above the bottom. Therefore, these low profile targets will not require removal prior to capping. Debris targets in cap-only areas that have height dimensions that are relatively large compared to either the length or width (e.g., 5 ft. wide x 30 ft. long x 5 ft. tall) indicate a relatively “angular” nature. These angular targets can be further evaluated based on their total height compared to the total cap thickness. However, since the exact nature of this debris is not clear from the available survey data, further classification of “angular” debris through poling or underwater video will be performed prior-to or during the debris removal process. For instance, if further investigation indicates that a debris target is simply aquatic vegetation or a boulder, it is likely that removal prior to capping isn’t necessary. In addition, angular debris may penetrate the cap in some instances without significantly impacting the cap performance. Debris will be evaluated on a case-by-case basis in consultation with NYSDEC.

As indicated in Section 7.1.2, additional characterization of debris present within portions of Remediation Areas C and D scheduled for construction in 2012 was performed in July 2011. Table 7.1 and Figure 7.2 summarize the nature of the debris identified within the area of the first year of capping and whether the debris will be removed or left in-place. The approach for addressing specific debris targets in areas scheduled for remediation in subsequent years will be determined in consultation with NYSDEC based on additional characterization that will be completed following initiation of construction.

7.1.5 Debris Removal and Management

Debris removal will likely be accomplished with barge-mounted cranes and/or excavators using various types of attachments such as grapples, clam shells, and rakes. Debris will be placed into/onto a barge, transported to shore, and loaded directly onto trucks for transportation to the SCA for processing. Details pertaining to debris management at the SCA are provided in the Sediment Management Final Design.

7.2 UTILITY AND STRUCTURE MANAGEMENT

This subsection provides the basis and considerations for accommodating utilities and structures located within the areas of Onondaga Lake to be remediated through dredging and/or capping.

7.2.1 Utility and Structure Design and Performance Criteria

The primary goal in utility and structure management, as it pertains to dredging and capping, is to achieve the remedial objectives through incorporation, modifications to, or removal of those items as necessary to insure the integrity and long-term effectiveness of the cap.

7.2.2 Utility and Structure Characterization and Management

Utilities and structures consist of active and inactive pipelines, culverts, outfalls, and water intake structures on the sediment surface or buried on the lake bottom. For purposes of this submittal, pilings are considered structures, as discussed below.

The primary sources of information on utilities and structures are: historical records, the Phase I PDI geophysical survey work conducted during the fall of 2005 for Honeywell (CR Environmental, 2007), which included side-scan sonar and magnetometer surveys, and 2011 survey which focused on in-lake utilities. A list of utilities and supporting information (i.e., owner, material of construction, remediation area location, dimensions, and active status) is provided on Table 7.2. Figures 7.1 and 7.2 present the approximate locations of these utilities and structures, as determined by the analysis of the geophysical surveys and available historical records. Individual utilities and structures and the management approach for each of them is provided below.

Settlement of the underlying sediment will occur as a result of the weight of the cap. In areas where utilities are capped in place, this may result in differential settlement which may impact the integrity of the utility. With the exception of the Metro deepwater outfall, all of the utility lines that will remain in areas of the lake planned for capping are abandoned with no future plans of reuse, as described in Section 7.2.2.5. For the abandoned lines, potential impacts to the integrity of the utility are not a concern. The Metro Deepwater Outfall is not currently active except under certain high flow events, and the possibility of increased use in the future must be considered. The cap design over the Metro deepwater outfall may be modified based on additional consultation with Onondaga County, and, if appropriate, would be revised in a subsequent design addendum subject to review and approval by NYSDEC.

Differential settlement resulting from capping in the vicinity of any of the utilities capped in place is unlikely to impact the integrity of the cap. Nevertheless, annual post-capping monitoring will be conducted in the vicinity of all of the capped utilities throughout the lake construction duration to ensure the cap integrity is not compromised. Since capping in the vicinity of most of these utility lines is planned for early in the remedial sequence, the monitoring period through the end of construction in 2016 will capture the majority of the anticipated primary settlement in the vicinity of these utilities. Monitoring will include bathymetric surveying and underwater video (if appropriate) to identify potential abrupt irregularities in the capping surface resulting from significant differential settlement over small distances. In the event that such irregularities are identified and determined to require maintenance, the capping equipment could efficiently perform the maintenance while still on-site. The frequency of subsequent monitoring following completion of the lake remedy will be determined based on the results of the monitoring completed during the construction period.

7.2.2.1 Tributary 5A Outlet (Active)

A 60-in. diameter steel culvert with a headwall structure owned by Honeywell discharges flow from Tributary 5A to the lake. The structure discharges at the lake shoreline, as shown in Figure 7.3. A rip-rap apron on the lake bottom extends into the lake to protect against scour from the discharge. The elevation of the invert of the outlet as measured in 2011 is at elevation 361.7 ft. (NAVD88).

This is an active outfall and therefore dredging and capping within the lake will be executed such that they do not impact it. An appropriate off-set and dredge slope from this outfall will be established to prevent damage during construction in conjunction with the construction contractor and the NYSDEC based on field conditions and observations, such as the dredged slope that can be maintained in adjacent areas. Typical restoration details in the vicinity of outfalls, including replacement of rip-rap, are included in Appendix F.

7.2.2.2 Westside Pumping Station Outlet (Active)

A 42-in. diameter reinforced concrete culvert with headwall structure discharges flow from the Metro Westside Pump Station to the lake at the lake shoreline, as shown in Figure 7.3. A rip-rap apron on the lake bottom extends lake to protect against scour from the discharge. The elevation of the invert of the outlet as measured in 2011 is 362.8 ft. (NAVD88).

This is an active outfall and therefore dredging and capping within the lake will be executed such that they do not impact it. An appropriate off-set and dredge slope from this outfall will be established to prevent damage during construction in conjunction with the construction contractor and the NYSDEC based on field conditions and observations, such as the dredged slope that can be maintained in adjacent areas. Typical restoration details in the vicinity of outfalls, including replacement of rip-rap, is included in Appendix F.

7.2.2.3 NYDOT (I-690) Outfall (Active)

During construction of the Willis/Semet barrier wall, outfalls from stormwater drainage along I-690 were decommissioned. A new 24-in. diameter pipeline connected to a manhole (MH-3) replaced the stormwater system, and currently discharges at a penetration though the eastern end of the Semet wall. The new outfall pipe is constructed of ductile steel and is encased in concrete where it penetrates the Semet barrier wall. The outfall discharges at the shoreline, as shown in Figure 7.3, and terminates at invert elevation 361.5 ft. (NAVD88). A 10-ft. wide rock outlet protection apron consisting of filter fabric, Type F bedding and medium rip-rap extends approximately 7 ft. from the invert. This outfall is in-use and both it and the outlet protection will not be impacted during the dredging and capping operations.

This is an active outfall and therefore dredging and capping within the lake will be executed such that they do not impact it. An appropriate off-set and dredge slope from this outfall will be established to prevent damage during construction in conjunction with the construction contractor and the NYSDEC based on field conditions and observations, such as the dredged slope that can be maintained in adjacent areas. Typical restoration details in the vicinity of outfalls, including replacement of rip-rap, is included in Appendix F.

Decommissioned outfalls (Outfalls 040 and 041) that were demolished during construction of the Willis/Semet barrier wall were replaced by the MH-3 outfall. These were 18-in. diameter reinforced concrete pipes which were not removed from outboard of the barrier wall.

7.2.2.4 48-Inch Stormwater Outfall (Active)

As part of the East Flume IRM, 60 in. and 72 in. storm drains that discharged into the East Flume were rerouted and now discharge at a penetration through the eastern end of the Willis Wall. The outfall discharges at the shoreline (barrier wall) at an invert elevation of 358.0. This is an active outfall and therefore dredging and capping within the lake will be executed such that they do not impact it. No dredging is included in this area, and the discharge invert elevation is approximately 4 ft. above the cap surface. Therefore, there will be no impacts to this outfall as a result of remedial activities.

7.2.2.5 Metro Deepwater Outfall (Active)

A discharge pipeline from Metro extends from the shoreline through the south corner of Remediation Area E and into Remediation Area D. This discharge is not currently active, however, the option to initiate use in the future must be considered, and the pipeline’s integrity must remain intact.

The pipeline is referred to as Outfall 1 (Subaqueous Conduit) on the historical Metro design detail drawings. It is a 60-in. inner diameter pipe of reinforced concrete construction with 6-in. thick pipe walls for a total outer diameter of 72 in. The pipe consists of 20 ft. lengths clamp-bolted together and sealed.

According to design drawings for this outfall, approximately 1,350 ft. of the outfall lies within a channel that was dredged as part of the construction. The final 900 ft. length is supported with timber frames spaced every 20 ft. which are pile-supported to an unknown depth. The dispersion section has pipe support structures that are spaced every 4 ft. and is also underlain by a 20 ft. wide apron of rock protection.

Previous reports have discussed the potential presence of two Metro outfalls. However, historical records and underwater photographs indicate one actual discharge pipeline (Outfall 1), discussed above. The second outfall was never constructed.

This outfall passes through the area impacted by potential stability concerns due to the shoreline railroad tracks in this area. As discussed in Section 5.2.5, the remedial approach in this area is under development. The remedial approach for the portion of this outfall that passes through this area will be determined following determination of the overall remedial approach in this area.

As shown in Figure 7.4, the water depth along this pipeline is relatively shallow (approximately 3 ft.) for much of its length. Most of the pipeline is buried beneath the sediment surface. The remedial approach in the vicinity of this outfall was developed to be environmentally protective while minimizing the potential for impacting the Metro outfall to ensure that it remains functional.

The remedial design in the vicinity of the outfall includes dredging and capping. To avoid having an adverse effect on the outfall, a buffer zone will be established such that dredging will be offset approximately 25 ft. from the outfall. A cap may be placed over the outfall and dredging offset area. Where water depths are less than 7 ft., the cap will be slightly thinner than the cap in the surrounding shallow water areas to reduce potential concerns associated with water depth over the outfall and to reduce the potential for impacts associated with the weight of the cap placed on the outfall. In deeper water where the typical cap is thinner than it is in shallow areas, the cap over the outfall will be consistent with the adjacent capping areas. To avoid potentially impacting the discharge, the 25 ft. buffer zone will also apply to capping in the area around the discharge. A rip-rap scour pad is currently present in the area of the discharge and the 25 ft. buffer zone will not impact the existing scour pad.

The cap will consist of a minimum 1 ft. chemical isolation layer consisting of gravely sand (including GAC where required), and a minimum 1 ft. habitat/erosion protection layer consisting of gravely cobble. Using these minimum thicknesses, and including average over-placements and a 3-in. mixing layer, results in an average placement of 3 ft. of cap material in these areas. This cap design will result in post-capping elevations that are below the lake surface elevation for all areas overlying the outfall.

The cap design over the Metro deepwater outfall may be modified based on additional consultation with Onondaga County, and, if appropriate, would be revised in a subsequent design addendum subject to review and approval by NYSDEC.

7.2.2.6 Metro Stormwater Drain (Active)

This is a 42-in. diameter reinforced concrete stormwater drain currently in use at the Metro facility. Its location and invert were measured in 2011. It extends a short distance from the shoreline, as shown in Figure 7.3. The invert elevation measured in 2011 is 359.5 ft. (NAVD88) and the top is above the water surface.

This is an active outfall and therefore dredging and capping within the lake will be executed such that they do not impact it. This outfall is located in the area impacted by potential stability concerns due to the shoreline railroad tracks in this area. As discussed in Section 5.2.5, the remedial approach in this area is under development. The remedial approach in the vicinity of this outfall will be determined following determination of the overall remedial approach in this area.

7.2.2.7 Metro Shoreline Outfall (Active)

This is a 96-in. diameter reinforced concrete sewerage effluent outfall which is currently in use at the Metro facility. Its location was surveyed in 2011. It extends a short distance from the shoreline, as shown in Figure 7.3. The invert elevation based on construction drawings is 361.2 ft. (NAVD88) and the top is above the water surface.

This is an active outfall and therefore dredging and capping within the lake will be executed such that they do not impact it. This outfall is located in the area impacted by potential stability concerns due to the shoreline railroad tracks in this area. As discussed in Section 5.2.5, the remedial approach in this area is under development. The remedial approach in the vicinity of this outfall will be determined following determination of the overall remedial approach in this area.

7.2.2.8 Remediation Area A Pipelines (Inactive)

Two cast-iron pipelines exist above the sediment surface within Remediation Area A. These were identified during the Phase I PDI as clusters of magnetic anomalies. Side-scan contacts for the features could not be established, as the features are located in a shallow area where limited resolution of the side-scan sonar image is available. Aerial photographs and visual reconnaissance conducted during the Phase III PDI investigations revealed the pipelines characteristics and location above the lake bottom. Historical information regarding these pipelines has not been identified. Both pipelines extend into the dredging and capping prisms in Remediation Area B.

These pipelines are relatively small (approximately 10 in. diameter) and are resting on the sediment surface and therefore can be readily removed. They will be removed prior to any dredging and capping activities in this area and managed consistent with the debris management program. These pipes are located in an area where organic contaminants are generally not present other than what has apparently migrated subsurface from Wastebeds 1-8. Therefore, it is unlikely that NAPL is present within them. Nevertheless, care will be taken during removal to verify no NAPL is present, and to ensure if it is, that the removal is done such that NAPL release is minimized and managed appropriately.

7.2.2.9 Cooling Water Intakes (Solvay Process) (Inactive)

Two known utilities within Remediation Area D, an 84-in. and a 72-in. diameter cooling water intake line, were formerly owned by Solvay Process Company, and are now the property of Honeywell. The pipes are no longer in service. Their profiles relative to the sediment surface are shown in Figure 7.5.

The 84-in. diameter pipeline is constructed of corrugated iron and is supported by 9-ft. wide timber frames, with each frame supported by two timber piles driven to unknown depths. The supports are spaced at an average of 32 ft. along the length of the pipe. Historically, a trestle structure existed above the 84-in. pipeline for a distance of approximately 125 ft. from the current shoreline. The trestle platform has been removed; however, according to observations made during construction of the Willis/Semet IRM barrier wall, the supporting steel H-piles were cut off close to the existing sediment surface. The trestle platform terminated at a valve structure. According to local knowledge and verified during the 2011 underwater video survey, this structure was not completely removed during decommissioning. It was also located by side-scan sonar as part of the debris survey, as discussed in Section 7.1.

The 72-in. diameter pipeline is constructed of cast iron, and originally lay on the lake bottom. There are two elevation transitions within the area that will be remediated, at which manholes exist.

As part of the Willis/Semet IRM barrier wall construction, the intake pipelines were plugged inboard and outboard of the barrier wall alignment. Additionally, portions of the pipes intersecting the barrier wall alignment were demolished to allow for installation of the sheet piling in this area. The demolished portions of the pipelines were not removed from outboard of the barrier wall.

These were water inlet lines, therefore NAPL would not be expected to be present within these pipelines. In addition, no NAPL was noted by divers entering the pipe as part of the plugging and demolition during completion of the Willis/Semet IRM.

These pipelines are located within the SMU-2 portion of the ILWD. The depth below the mudline to the top of these ranges from approximately 0 to 10 ft. Sufficient dredging will be completed over these pipelines in the near shore area to allow cap placement without loss of lake surface area. The dredge prism in this area has been developed to avoid impacting these buried utilities while achieving the dredging goal of a 2-meter average for the SMU-2 portion of the ILWD. The resulting bathymetry provides additional variability in this area, which may provide habitat benefit. Detailed dredging and capping prisms are provided in Appendix F.

The remaining valve structure components will also be left in place. This structure is comprised of heavy gauge metal and is not expected to represent a potential contaminant pathway. In order to provide an extra level of conservatism, a modified cap design, including an additional 1-ft. thickness of chemical isolation material, will be placed above and around this valve structure.

7.2.2.10 Water Inlet Pipes (Allied Chemical) (Inactive)

Three water inlet pipes (42-, 30-, and 16-in. diameter) lie near the western boundary of Remediation Area D. The three pipelines were installed by Allied Chemical around 1900 and are currently owned by Honeywell. The pipelines have been abandoned from service, but remain in place beneath the lake bottom. The three pipelines were detected by the magnetometer survey but were not identified during the side-scan sonar survey, indicating the three pipelines are buried. Historical mapping indicates pipeline locations, however these alignments do not concur with the magnetometer survey results, which were the basis for their locations shown on Figures 7.1 and 7.2. During the Phase III PDI, drilling was obstructed at two locations (OL-SB-10117 and OL-SB-10117A) at a depth of 16 ft. to 18 ft. below the sediment surface in the vicinity of the expected location of the 30-in. diameter pipeline. These locations were at a distance of 25 ft. to 35 ft. from the shore prior to barrier wall installation.

During the installation of the Willis/Semet IRM Barrier Wall, two of the intakes were intersected by the sheet pile driving operation, most likely the 30 in. and 42 in. As no removal of these pipelines was conducted, no verification of the sizing is available. However, it is assumed it was the 30-in. diameter pipe encountered approximately 12 to 13 ft. below the surface of the sediment, and the 42-in. diameter pipe encountered approximately 8 to 10 ft. below the surface of the sediment. The 16-in. diameter pipeline was not encountered during the installation of the barrier wall. The wall may have been driven through it without realizing it was encountered. If present, it is assumed to be at the same elevation as the other 2 inlet pipes. These were water inlet lines; therefore, NAPL would not be expected to be present within these pipelines. In addition, no NAPL or surface water sheens were noted during intersection of the pipes during sheet pile installation.

A profile of the 30-in. pipe relative to the sediment and dredging elevations is provided in Figure 7.6. Profiles along the alignment of the 42-in. and 16-in. pipelines are similar to the 30-in. pipeline profile. Based on this evaluation, these pipelines are below the bottom of the dredge cut or only slightly extend into the dredge area and therefore will not impact remedial activities or the ability to achieve base removals or hot-spot removals, and will be left in place.

7.2.2.11 Diffuser Pipeline (Inactive)

An abandoned cooling water discharge, previously owned by Allied Chemical and now owned by Honeywell, extends approximately 800 ft. into the lake, perpendicular from the shore, as shown in Figure 7.6. The 60-in. diameter pipeline of coal-tar lined steel construction originated from the East Flume pump house, although the portion from the pumphouse to the shoreline were removed as part of the west wall construction. The pipeline terminates within the lake at a diffuser of similar construction, aligned perpendicular to the pipe, and 130-ft. in length.

The pipeline originally lay on the lake bottom; however, it is currently under the sediment from the shoreline to approximately 500 ft. offshore from the flow-meter. The remaining section of pipeline and diffuser daylight from the sediment, with the diffuser itself being pile supported on a structure of unknown detail.

The dredging and capping plans in the vicinity of this utility have been developed to ensure that it can be left in place and effectively capped. As shown in Figure 7.6, the baseline dredge cut (to achieve the 2 meter average) will be implemented as designed up to the edge of the pipe. To facilitate hydraulic dredge efficiency and improve removal from on top of and directly adjacent to the pipeline, a backhoe working from a barge will be used to scrape the sediments from the top and sides and push it to where it can be effectively dredged hydraulically. To avoid undermining and potential collapse of the pipeline, the dredge cut adjacent to the pipe will not extend below the bottom of the pipe, as shown in Figure 7.6. The baseline dredge prism was developed to meet the 2 meter average removal taking this dredging approach into consideration. This will have minimal impact on the hot spot removal along a portion of the pipeline. The cap will then be placed up to, and in some cases over the top of, the majority of the pipe, ensuring that the pipeline is effectively contained within the cap. In shallow water, any cap material that extends above the water surface will removed.

Capping this utility in place avoids significant health and safety considerations that would be presented by removal. Mechanical sheers large enough to cut through this 60-in. diameter steel pipeline are not available. Therefore, removal would require significant use of divers to cut the pipeline into manageable sizes for removal and to rig the pipeline so that it can be removed. This is inherently hazardous work, which would be compounded by working in contaminated materials and under poor underwater visibility that would result from disturbance of the ILWD.

7.2.2.12 Sun Oil Pipeline (Inactive)

This is an 8-in. diameter cast-iron pipe previously owned by Sun Oil. It was abandoned in the early 1900's, and Sunoco Logistics (the successor to Sun Oil and current owner of the pipeline) has verified the pipeline as having been cleaned prior to closure. It was reportedly used subsequently as part of the cathodic protection system for the onshore pipeline. A historical plan indicates the pipeline's alignment, however, the alignment does not concur with the location established through magnetometer survey as part of the Phase I PDI, which is the basis for its location shown on Figure 7.1.

This pipeline was encountered during construction of the barrier wall along the south-east shoreline of the lake. During this construction, this portion of the pipeline was demolished to allow the barrier wall to be installed. Field observations during the demolition of that pipeline verified that the pipeline did not appear to contain any residual materials.

This pipeline was visually inspected to the extent possible during 2011. Approximately 200 ft. of the pipeline, extending from the shoreline near Metro, was observed above the sediment surface. The pipeline was observed to be disintegrating and in poor condition. It was not located throughout the remainder of the alignment, either due to disintegration or burial.

This pipeline is relatively small (approximately 8-in. diameter) and is on or near the sediment surface and therefore can be readily removed. It will be removed prior to any dredging and capping activities in this area and managed consistent with the debris management program. Care will be taken during removal to verify no NAPL is present, and to ensure if it is, that the removal is done such that NAPL release is minimized and managed appropriately.

7.2.2.13 Remediation Area C Pile Field (Former Yacht Club)

Multiple piles have been detected at the site of the former Yacht Club near the Westside Pumping Station Outlet and the Tributary 5A outlet (see Figure 7.2). A survey completed in 2011 counted 187 piles in this area. The piles are located in an area designed primarily as dredge-and-cap, but extend in a no-action area. The piles within the dredge-and-cap area will be pulled or cut close to the post-dredging surface prior to cap placement.

7.2.2.14 Remediation Area D Wooden Bulkhead

Review of aerial photographs taken during the pre-design investigations, and field observations during the construction of the shoreline barrier walls, indicate the presence of a wooden bulkhead extending from the shoreline near the Upper East Flume, into the lake at an acute angle to shore, as shown in Figure 7.1. Based on observations, the bulkhead appears to be a baffle wall, of wooden construction. No historical records of such a structure in this location have been identified, although there is evidence of use of these types of structures in this vicinity. A similarly constructed wooden bulkhead is visible along the shoreline further to the east, with an alignment indicating it may be the other end of a continuous bulkhead. This structure penetrates the surface of the sediment, and is within the dredge prism for Remediation Area D. It will be pulled or cut close to the post-dredging surface prior to cap placement.

7.3 CULTURAL RESOURCES

This subsection provides the basis and considerations for accommodating archeological remains encountered within the areas of Onondaga Lake to be dredged and/or capped that were recommended as eligible for the National Register of Historic Places (NRHP) in the Phase 1B Reconnaissance Survey Report (LCMM, 2011).

7.3.1 Cultural Resource Design and Performance Criteria

The primary objective in cultural resource management, as it pertains to remedy implementation is to remove or manage cultural resources in place such that targeted sediment can be efficiently and effectively remediated. The National Historic Preservation Act (NHPA) of 1996 encourages but does not mandate the preservation of cultural resources. To accommodate NHPA's preference for preservation, it is desirable to avoid adverse impacts completely. Where that is not possible, the adverse impacts should be minimized to the extent possible and mitigation measures consistent with the NHPA should be implemented.

7.3.2 Cultural Resource Characterization and Management

Cultural Resources for purposes of this design refers to archeological remains potentially eligible for the NRHP located on the surface of or within lake-bottom sediment. In 2004, the Public Archaeology Facility of SUNY Binghamton (PAF) carried out a Phase IA cultural resources assessment of the Onondaga Lake site. This work recommended a Phase IB archaeological survey be executed in Onondaga Lake and along the shoreline due to the high potential that those areas may contain historic cultural resources. In 2005, CR Environmental of Falmouth, Massachusetts, conducted a remote sensing survey of the lake bottom for Honeywell (CR Environmental, 2007). The effort recorded side-scan sonar, magnetometer, bathymetry, and sub-bottom profiler data primarily in support of the remedial design effort. The survey located 755 sonar targets and 1256 magnetic anomalies on the lakebed.

In 2010 and 2011, based on the Phase 1A Report and remote sensing survey, the LCMM prepared and implemented an Underwater Archaeological Resources Phase 1B Work Plan for Onondaga Lake to further investigate potential suspected cultural resources located within Remediation Areas. Based on the Phase 1B investigation results, 20 targets were identified as archaeological sites which are recommended as eligible for the NRHP. Of the 20 archeological sites recommended as eligible, 11 are watercraft, 3 are rock mounds or piles, 2 are piers, 2 are a series of wooden pilings, 1 is a submerged breakwater and 1 is a bulkhead, as shown in Figures 7.7 and 7.8. Each of these is discussed in detail below. An additional historic pier, discussed below, was identified immediately adjacent Remediation Area A, but its NRHP status was not evaluated because it will not be impacted by remedial activities.

To the extent practicable, cultural resources within the dredging and/or capping areas will be left in place and incorporated into the final cap. Only limited cultural resource removal will be required to ensure that the remedy can be implemented effectively. Cultural resources will be marked using seasonal float balls and protected during the dredging and capping operations.

Information obtained as part of the Phase IB Cultural Resource Investigation, through review of historical records, and subsequent diving efforts were used to define the alignment of individual cultural resources in the dredging and capping prisms. Details of the orientation of these cultural resources, and details pertaining to how they will be incorporated into the dredging and capping prisms, are provided below.

7.3.2.1 Syracuse Maritime Historic District

The Syracuse Maritime Historic District is a proposed National Register district comprised of the remains of 7 wooden watercraft (A3, A4-1, A4-2, A12, A35,A53, A55), 6 areas of marine infrastructure (A1/A2, A7, A38, A45, A72, A73) and 3 rock mounds/piles (A34, A75, A76) (Figure 7.7). The district covers approximately 58 acres and lies almost entirely within Remediation Area E. The boundaries are delineated by the lake shoreline to the east and Salina Pier remnants to the north. The southern and western boundaries are lines drawn to encompass the extent of the contributing targets. The characterization and potential management approach for each target is described below. The resulting revised detailed dredging and capping plans are incorporated into Appendix F.

Wooden Watercraft

The following 7 wooden watercraft, shown in Figure 7.7 were identified within the Syracuse Maritime Historic District:

- A3 is an edge-fastened, scow-ended wooden barge which is preserved up to deck level, although the deck is no longer present. The vessel is 94 ft. long by 22 ft. wide. The uppermost portions of the wreck are just above the water’s surface.
- A4-1 is an edge-fastened scow barge which is preserved up to the deck level, although the deck is no longer present. The vessel is 78 ft. long and 27 ft. wide. The barge rests in shallow water just offshore, and adjacent to another barge, A4-2. The uppermost portions of the vessel are just below the water’s surface.
- A4-2 is a scow barge with its eastern (shore) end partially broken up, but the remainder of the structure is preserved to just below deck level. The uppermost portions of the vessel are just below the water’s surface, and the remains are largely buried. The vessel is 73 ft. long and 25 ft. wide. The barge rests in shallow water abutting the shoreline and adjacent another barge, A4-1.
- A12 is an edge-fastened, wooden derrick lighter spud barge. The barge is preserved up to the deck level, although the deck is no longer present. The mechanisms for holding the spuds are exposed above water, with the remainder of the barge is just below the water’s surface. The vessel is 88 ft. long and 32 ft. wide. A12 is edge-fastened every +/- 18 in. along the 4-in. thick sides with framing every 3 to 4 ft.
- A35 represents the remains of a watercraft that could not be conclusively identified due to its buried condition. The site lies in approximately 4 ft. of water, with an extant length and beam of 64 ft. and approximately 14½ ft., respectively. Very little of the site is exposed; however, the visible remains suggest that the bottom 2 to 4 ft. of the vessel is preserved under the lake bottom.
- A53 is the bottom of a canal boat with elements visually noted including floors, bow frames, stem and cocked hats. The vessel has a beam of approximately 17½ ft. and an extent length of approximately 60 ft. The boat’s stern is buried, but the overall length is likely 97 to 98 ft. in accordance with the dimensions of the canal locks.

- Anomaly A55 is a canal scow with a length of 83 ft. and a beam of 17½ ft. The archaeological data suggests that A55 is an Erie Canal maintenance scow. The site's principal exposed structures are its scow ends and fasteners from its edge-fastened sides.

The remedial design includes dredging and capping in the areas of these watercraft. To avoid having an adverse effect on the vessel remnants, a buffer zone will be established such that dredging will be offset approximately 25 ft. from the boundaries of each target. A cap will then be placed over each target area. These targets are in shallow water, ranging from approximately 2 to 4 ft. To reduce potential concerns associated with creating post-capping elevations that are above the lake surface level, a modified cap will be placed over these targets.

The modified cap will consist of a minimum 1 ft. chemical isolation layer consisting of gravely sand (including GAC where required), and a minimum 1 ft. habitat/erosion protection layer consisting of gravely cobble. Using these minimum thicknesses, and including average over-placements and a 3-in. mixing layer, results in an average placement of 3 ft. of cap material in these areas. This modified cap design is slightly thinner than the cap in surrounding areas, but would be protective and compliant with ROD requirements. Based on the water depths associated with each target, as shown on Figure 7.7, this would result in post capping elevations that are close to or slightly above lake level for several targets.

Anomaly A3 is adjacent to, but just outside, the remediation area boundary. This watercraft will be marked and a work zone buffer will be established around it to ensure it is not adversely impacted by construction activities.

Marine Infrastructure

Anomalies A1 and A2 – Salina Pier

The pier is located along the north-eastern edge of Remediation Area E in water depth of approximately 4½ to 6 ft. At the shore side (eastern) end to the pier, the pier remnants were clearly visible in shallow water. The site consists of two parallel vertical planking walls approximately 30 ft. apart. The area between the walls is filled with stone. The area inspected was approximately 200 ft. from shore, with 1 to 2 ft. of water on top of the pier and 5 to 6 ft. of water next to the pier.

The majority of the pier lies outside of the remediation area with a small portion extending through the dredge and cap zone and terminating in the cap-only zone. To avoid having an adverse effect on the pier remnants, the pier will be left in place. Sediments will be dredged to within approximately 25 ft. of the pier. A modified cap consistent with the cap described above for the wooden watercraft will be installed over the area.

Anomaly A38 - Iron Pier

A38 was identified as dock or pier remains. The site consists of a 20 ft. by 17 ft. timber frame structure. The exterior walls are constructed of edge fastened planks reinforced with framing members every 3 to 5 ft. The remains appear to be preserved up to their original height based on the presence of four timbers forming a deck with a large mortise for the foot of a vertical timber. The pier has two box-like features constructed out of two layers of vertically oriented planking. The boxes are 2 ft. by 2 ft. and stand 1½ ft. above the bottom.

To avoid having an adverse effect on the pier remnants, the pier will be left in place. Sediments will be dredged to within approximately 25 ft. of the pier. A modified cap consistent with the cap described above for the wooden watercraft will be installed over the area.

Anomaly A45 - Concrete Breakwater

A45 is a concrete breakwater situated southeast of the entrance to the Syracuse Inner Harbor. The breakwater is 20 ft. wide and extends 250 ft. from the shoreline. The structure is constructed of concrete bags. The structure is densely packed along the exterior walls of the breakwater with an open gap containing sporadic bags of concrete in between. Only one tier is visible. The site lies in 2 to 3 ft. of water. No timber crib or other wooden structures were noted, suggesting that the site is a breakwater and not a pier.

To avoid having an adverse effect on the breakwater, it will be left in place. Sediments will be dredged to within approximately 10 ft. of the breakwater. A modified cap consistent with the cap described above for the wooden watercraft will be installed over the area. A portion of A45 (Concrete Breakwater) lies in the area where detailed dredging and capping plans have not yet been developed due to stability concerns on the adjacent lakeshore area where three active rail lines are located.

Anomaly A7 and A72 - Piling Clumps

Anomaly A7 is a series of six piling clumps marking the entrance into Syracuse's Inner Harbor. The clumps consist of between three and ten pilings driven into the lakebed and held together with cables and/or iron bands. The clumps are visible above the surface.

Anomaly A72 is a series of six wooden pilings, each cut 6 in. above the lake bottom. The pilings are spread over an area of 9 ft. by 17 ft. Five of the pilings are round, varying in diameter from 0.75 in. to 5 in.; the inshore piling is 4 in. square. The location of these pilings, close to shore in shallow water, indicates that they may have been a small pier or boathouse likely related to the Iron Pier (A38).

The piling clumps lie entirely within the dredge and cap zone. The fate of the pilings will be addressed in a subsequent design addendum subject to NYSDEC review and approval.

Anomaly A73 - Bulkhead

Anomaly A73 is a bulkhead feature consisting of 7 pilings, each standing approximately 6 in. above the lake bottom. A linear arrangement of vertically oriented planks paralleling the pilings was located 4 in. south of the line of pilings. Probing indicated that stones fill the interior of the pilings behind the bulkhead. The bulkhead structures stand 2 to 8 in. above the lake bottom. Anomaly A73 was likely part of the shoreline stabilization related to the Iron Pier (A38).

Anomaly A73 lies entirely within the dredge and cap zone. It is not possible to leave this feature in place without potentially affecting the effectiveness of the cap. Therefore, the bulkhead will be removed prior to capping.

<u>**Rock Mounds and Piles**</u>

Anomaly A34 - Rock Mound and Anomaly A75 and A76- Rock Piles

Anomaly A34 is a pile of stones varying sizes from 3 to 9 in. The mound stands 12 to 18 in. above the surrounding lake bottom tapering at the edges. The Rock Mound covers an area of 42 ft. by 23 ft. Several iron artifacts including a 24 in. iron railroad rail and unidentified iron circular object were documented within the mound. This anomaly is cultural in origin, most likely the result of a barge disposing a load of stone and other debris.

Anomaly A75 is a pile of limestone rocks approximately 10 in. in size. The pile is 10 ft. long and one layer deep. A76 is also a pile of limestone rocks. The rocks in A76 are smaller in size, approximately 8 in., and cover an area of 41 ft. long by 24 ft. wide. The pile is likely deeper than one layer and stands 12 in. above the lake bottom. No evidence of underlying wooden structure was identified.

The rock mound and piles appear to lack intentional design and have limited research potential. A34 and A75 lie entirely within the dredge and cap zone. Given their limited historical significance and research potential, these features will be removed prior to capping. A76 is adjacent to but just outside the remediation area boundary. This rock pile will be marked and a work zone buffer will be established around it to ensure it is not adversely impacted by vicinity construction activities.

7.3.2.2 Remediation Area E Cap Only Zone

Anomaly A33 - Buried Wooden Canal Boat

As presented in Figure 7.7, Anomaly A33, a buried wooden canal boat lies at the western edge of Remediation Area E within the cap prisms. The run of the boat's hull contain no structural elements exposed above the lake bottom; however, structure was encountered with a probe 2 to 3 ft. below the sediment in numerous locations. Dive verification located the stem and the very end of a wooden tiller bar and buried rudderpost located 95 ft. aft of the stem. The length of the vessel from stem to rudder post is consistent with canal boats built between 1862 and 1915.

The impact of capping is impossible to determine given the lack of information regarding the site's structural composition. The potential concern is that any cap placement could result in collapse of the deck, which is believed to be intact. Anomaly A33 is in an area where concentrations are relatively low. It is located close to sampling location OL-VC-60056, where the Mean PECQ and mercury concentrations in the 0 to 6 in. interval were 1.9 and 3.0 mg/kg, respectively. The area is net depositional, so concentrations will continue to decrease over time. Therefore, this area will remain uncapped and it would likely meet criteria in the future via natural recovery processes, particularly burial. It will present minimal environmental risk in the interim.

7.3.2.3 Remediation Area A

Anomaly A22 - Pleasant Beach Pier

A22 was confirmed as the pier associated with the Pleasant Beach Resort. The pier is 150 ft. long and 20 ft. wide with a 50 ft. long T at the end, and extends out to the edge of the

Remediation Area A boundary (Figure 7.8). The pier was built using timber cribbing and rock fill. The structure is well preserved, with the portions of the end T retaining an original stone or concrete decking surface. The Pleasant Beach pier was one structure within the larger Pleasant Beach Resort. The absence of data from the presumed terrestrial portion of the site makes the property problematic to evaluate. Although the pier retains its integrity, the integrity of this one site component alone is not sufficient to determine that the terrestrial site also retains integrity. The Pleasant Beach Resort at present remains an unevaluated site in terms of its eligibility for the NRHP.

The remedial design calls for capping in the area adjacent to the end of Pleasant Beach Pier. This capping is unlikely to have an adverse effect on the pier remnants if capping material is not dropped specifically on the pier. Capping will be completed in deeper water up to a 50 ft. buffer zone which will be established with buoys during construction at the base of the pier, the 50 ft. buffer zone will be left uncapped.

Anomaly A20 – Rock Barge in SMU-4

Anomaly A20 is a well-preserved early twentieth century wooden rock scow resting in approximately 20 ft. of water on a hard bottom, with nearly the entire structure exposed above the lake bed. A20 is 91½ ft. long by 32½ ft. wide, with most of its principal members still extant including the sides, ends, deck beams, hanging and standing knees, stringers, and framing. The vessel also retains some decking and the high deck-end bulkheads and longitudinal retaining bulkheads are displaced, but lying near or on the wreck. A20 has a small section of intact decking amidships along its southern side. Overall the site retains approximately 90 percent of the vessel's original structure.

As presented in Figure 7.8, anomaly A20 lies at the southeastern edge of Remediation Area A, in water depth of approximately 15 ft. Additional sampling was conducted within the barge during the 2011 Phase VII PDI, indicating sediments within the barge to not exceed cleanup criteria. Therefore, to avoid potential impacts to this vessel, capping will be placed to within 10 ft. of the edges of the vessel.

7.3.2.4 Shoreline Stabilization Area Remediation Area B

Anomaly A17-1 and A17-2 - Spud Barges

Two identical spud barges, A17-1 and A17-2, are located in Remediation Area B in 1 to 3 ft. of water (Figure 7.8). The sides, ends, and internal structural members of both barges remain intact while the deck and deck features are no longer present. The barges are 97 ft. in length and approximately 34 ft. wide. These two barges are believed to be part of a larger, more complex site as two additional sunken barges exist to the north and east along with a series of pilings offshore to the east.

The remedial design in this area includes shoreline stabilization consisting of 18 in. of material applied above the surf line and 6 in. of material below the surf line. To avoid impacts to the spud barges, the shoreline stabilization will be completed up to these features but not within their bounds.

SECTION 8

MANAGEMENT OF AMBIENT WATER QUALITY DURING DREDGING AND CAPPING

A comprehensive water quality management and monitoring program will be implemented to prevent potential unacceptable water quality impacts as a result of sediment disturbances during capping and dredging activities. This program will address suspension of impacted sediments as well as release of dissolved contaminants. Suspension controls, both physical (e.g., silt or turbidity curtains) and operational (e.g., minimize cutterhead rotation speed and other best management practices [BMPs]) have proven effective at numerous capping and dredging sites, and will be used to mitigate any potential impacts during Onondaga Lake remedial activities.

The method for managing ambient water quality impacts is presented in this section by describing the design and performance criteria, existing water quality and wave/lake current conditions, turbidity controls such as silt curtains that will be used, monitoring activities, and potential operations optimization activities. Additional details pertaining to these topics will be provided in the WQMMP.

8.1 DESIGN AND PERFORMANCE CRITERIA

Water quality criteria for in-lake remedial construction activities will be established in the WQMMP and will incorporate the results from 2010 and 2011 water quality sampling activities. The development of water quality criteria will consider the existing ambient water quality of the lake and incorporate spatial (e.g., distance from dredging and capping operations) and temporal (e.g., 2-hour average) components. Water quality criteria will consist of two tiers: 1) criteria to be met at performance monitoring stations; and 2) criteria to be met at compliance monitoring stations. The intent of the performance monitoring stations is to monitor near-field water quality in the general vicinity of the construction area (i.e., just outside of the silt curtains). Specific locations of the performance monitoring stations will be developed to identify and manage any dredging- or capping-related impacts, so that early warning is available to refine the dredging or capping process. Response to an exceedance at the early warning, performance monitoring station may include additional monitoring and operational improvements (see potential operations optimization activities in Section 8.6). Compliance monitoring stations will serve as the official compliance location for water quality and will be developed to assure environmental protection of the lake. An example schematic of the orientation of performance and compliance monitoring stations relative to dredging operations is shown in Figure 8.1.

Water quality criteria will be developed such that an efficient and environmentally protective program can be implemented. Turbidity will be the primary criteria used to monitor the impacts of dredging and capping in real time. This will provide for rapid implementation of corrective actions, if warranted, to ensure water quality criteria are met at the compliance monitoring stations. A review of relevant environmental dredging projects indicates that water quality criteria typically ranging from 25 to 50 Nephelometric turbidity units (NTU) above background were proven to be protective and practical limits. These same programs had "performance" and "compliance" levels at distances ranging from 300 to 600 ft., typically outside the resuspension containment systems (i.e., silt curtains, in most cases). Although turbidity will be used as the primary means of measuring potential releases of dredged material, total suspended solids (TSS) is another important metric for quantifying such releases. Thus, turbidity and TSS data collected during 2010 and 2011 as part of the Water Quality Monitoring for Construction Baseline program (Parsons, Anchor QEA, and UFI; 2010 and 2011) will be evaluated to ascertain the relative degree of correlation (if any) between these parameters. These evaluations will be presented in the WQMMP. The water quality criteria will also include chemical-specific numeric criteria for certain contaminants that will be met at the compliance monitoring stations. The water quality criteria developed for this project will be presented in the WQMMP.

8.2 EXISTING WATER QUALITY CHARACTERIZATION

Water quality, particularly turbidity, within Onondaga Lake can vary significantly due to natural events such as rain storms, high winds, and other weather events. For example, the southeast portion of the lake in the area of Remediation Area E represents the predominantly leeward end of the lake, and as a result becomes turbid on windy and stormy days due to particulate matter that enters from the tributaries and/or wind-driven resuspension of sediments (as well as Solvay Waste in the ILWD area). On calm days, water clarity can be good in shallow areas. Additionally, tributaries to the lake (e.g., Onondaga Creek, Harbor Brook, and Ninemile Creek) and outfalls (e.g., Metro) can contribute to increased turbidity within the littoral regions of the lake, particularly after rain storm events. Furthermore, biological processes (i.e., algal production) have an effect on water clarity and turbidity levels in the lake.

Data on nearshore water quality were collected by Honeywell during the RI in 1992 and 1999. Also, as presented in the RI Report, NYSDEC conducted a wind resuspension study in the ILWD area of the lake in 2001. More recently, the Onondaga County Department of Water Environment Protection (OCDWEP) has been collecting and analyzing water quality samples from various areas of the lake on a periodic basis (bi-weekly, quarterly, etc.) and after select rain storm events each year. Although OCDWEP's lake sampling is mainly focused on the profundal zone, there is also monitoring in the littoral area of the lake, including turbidity (e.g., see Appendices F and I of the Year 2009 Onondaga Lake AMP [OCDWEP 2009]). Onondaga County provides annual updates of its monitoring results for public consideration (e.g., OCDWEP 2007). A review of 2006 turbidity results in the littoral regions of the lake indicated the turbidity levels near Ninemile Creek increased from approximately five NTU to over 50 NTU during a rain storm. Similarly, 2002 turbidity results near the Metro outfall increased from approximately 10 NTU to over 40 NTU during a rain storm. The examples noted above are representative of the general patterns evident in OCDWEP's littoral zone data (i.e., increases in littoral zone turbidity are observed in response to wind and rain events).

A baseline construction water quality monitoring program was conducted by Honeywell over a six-week period during October and November 2010 (Parsons, Anchor QEA, and UFI 2010). The 2010 data revealed a similar response in turbidity to weather-related events. Continuous monitoring data from locations near the mouths of Ninemile Creek, Onondaga Creek, and Ley Creek indicated turbidity readings of generally 5 nephelometric turbidity units (NTU) or lower, with short-term increases observed to coincide with increases in wind, precipitation, and flow in nearby tributaries, on several occasions, with upwards of a 40-fold increase in turbidity recorded, depending on the magnitude of wind, rain, and/or tributary flow. These observations from 2010 along with approximately six months of continuous monitoring data collected during 2011 will be analyzed and a complete interpretation of turbidity data (and associated correlations to weather events) will be provided in the WQMMP.

While dredging and capping are being conducted, water quality will be monitored to identify and minimize impacts created by the remedial activities. To develop the baseline range of water quality conditions within the lake for an accurate benchmark for comparison during remediation, data pertaining to various water quality parameters will be evaluated in the WQMMP. This evaluation will focus on the data collected by Honeywell in 2010 and 2011 under the Water Quality Monitoring for Construction Baseline program (Parsons, Anchor QEA, and UFI; 2010 and 2011), but will also consider additional datasets, such as those collected by Honeywell and NYSDEC during the RI, by OCDWEP as part of its AMP, and by Honeywell as part of its on-going biota baseline monitoring program.

8.3 WAVE/LAKE CURRENT CONDITIONS

With any water-based dredging or capping operation, a thorough understanding of wave heights and lake currents is required. Specific planning aspects such as dredging and capping sequencing (see Section 9) and turbidity controls deployment configurations can both be heavily influenced by these conditions (see Section 8.4).

Wave heights of half a foot have been measured in Remediation Area D (Owens et al., 2009). Additionally, annual wind-generated wave heights of approximately 1 ft. to 2 ft. were predicted to occur in the southern basin based on historic average wind speeds following the procedures documented in Appendix D.

The circulation of the water within the lake is generated by wind speed and direction, tributary inflows, the outflow at the northern end of the lake, shoreline configuration, and stratification (Parsons, 2004). Currents at the water surface tend to move in the direction of the wind except close to shore, where currents move water parallel to the shoreline (Owens and Effler, 1996). General current velocity is greatest when winds are situated along the major axis of the lake basin (northwest to southeast, in a counter-clockwise direction). Although the circulation is complex and variable, the prevailing current direction is generally counter clockwise in response to the prevailing westerly wind direction. Existing current data will be taken into consideration during design of the silt curtains and development of the WQMMP.

8.4 WATER QUALITY CONTROL MEASURES

8.4.1 Silt Curtains

Silt curtains are a proven method for limiting migration of suspended sediments that result from dredging and capping activities. Silt curtains are vertical, flexible structures that extend downward from the water surface to a specified water depth. They are typically constructed of filter fabrics or impervious polyethylene sheets combined with floatation and anchoring devices. A general schematic of a silt curtain system is shown in Appendix J, and illustrates its primary components (including the boom system that provides sheen containment and flotation, anchors, obstruction lighting, and the silt curtain).

The design of the turbidity controls has been developed to minimize potential impacts to the integrity of the system that may result from hydrodynamic conditions that exist within the lake. The orientation of the lake (northwest to southeast) provides a long fetch in the direction of prevailing winds, which has the capability to produce sizeable wind-generated waves in the southern basin, as discussed in Section 8.3. The detailed design for the silt curtains takes this into consideration.

Silt curtains will be used as turbidity control devices within around each dredging work zone and will remain in place at least until the first layer of cap is placed in those areas. Capping operations are inherently a low impact activity; based on experience at numerous other capping sites, cap placement does not result in significant disturbance of contaminated sediments or release of significant contamination to the water column. Increases in turbidity that may occur during capping operations are a result of the placement of clean material. Therefore, silt curtains will not necessarily be a component of typical cap only area operations on the lake. This decision will be made in consultation with, and ultimately approved by, NYSDEC. In dredged areas, silt curtains will remain in place until at least the sand mixing layer of the cap is placed. Following placement of the mixing layer over a completed dredge area, the silt curtain may no longer be required and may be removed during the remaining capping operations. In capping areas where a silt curtain is not used, a demarcation curtain will be installed around the work zone. The demarcation curtain will include lighted buoys for visibility of the area at night. The curtain will be installed and anchored prior to the start of the capping operations.

Silt curtains will be deployed in a semicircle or “U” pattern. The silt curtain will enclose the dredging activities in a semicircular shape that is anchored to the shoreline at both ends. Silt curtain alignment will avoid inclusion of tributaries where possible.

After dredging, adjacent dredge and cap areas will be separated using an interior silt curtain that can be moved as work progresses. The interior curtain will limit migration of turbidity from a dredge area to a cap area. Movable interior curtains will also be used to isolate areas not requiring remediation located within the primary silt curtain boundary to the extent practical. The location of the movable interior curtain will vary as the dredging and capping progress through a remediation area. Preliminary silt curtain alignments for each year of construction will be included in the WQMMP. The final configurations and requirements for silt curtain placement may be modified during construction in consultation with the NYSDEC as the project advances and dredging and capping operations sequencing is finalized.

It is expected that a significant fraction of the contaminants that will be disturbed during dredging will be associated with particulate matter. Therefore, control of turbidity with silt curtains, as described above, will be an effective means of controlling release of contaminants during dredging and minimizing impacts on water quality within far-field areas of the lake. However, the potential also exists for dissolved phase contaminants and possibly sheens in areas such as the ILWD to be released during dredging activities. Sheens will be controlled through BMPs, as described below in Section 8.4.2. With regard to dissolved contaminant transport, although dissolved contaminants can pass through silt curtains, it is expected that such transport would be limited. For example, as part of the Phase 4 PDI activities in 2008, collection of large-volume bulk sediment samples within a section of the ILWD was accomplished through use of a barge-mounted excavator contained within a silt curtain cell (Note that the excavator represents an operation with a potential to create larger turbidity than the hydraulic dredging methods that will be used to dredge the lake from 2012-2015). Water column samples were collected from within and approximately 100 ft. outside of the silt curtain during these activities. The resulting data showed that turbidity levels and TSS, as well as concentrations of mercury and VOCs (when detected), were much lower outside of the silt curtain than the levels observed within the curtain. Nevertheless, contaminants of interest (i.e., mercury, VOCs, SVOCs) will be routinely monitored at the compliance monitoring stations to detect any dissolved phase transport and evaluate compliance with applicable water quality criteria. Details will be provided in the WQMMP.

8.4.2 Best Management Practices (BMPs)

In addition to silt curtains, BMPs (i.e., operational and/or physical controls) will be employed to minimize construction related impacts on water quality. BMPs will be developed as part of the WQMMP. Potential BMPs include:

- To the extent sheens are observed, they will be controlled through deployment of booms (as needed).
- Dredging on slopes steeper than a set angle (e.g., steeper than 10 horizontal to 1 vertical [10H:1V]) will begin, at the highest elevation and work towards the lowest elevation. For the vast majority of the site, dredge slopes will be shallower than 10H:1V; therefore, dredging will be conducted in a manner that is most efficient from a dredge operations standpoint (i.e., no restrictions on the direction of dredging). However, there are limited areas where the targeted dredge slope will be steeper than 10H:1V, and the above stated BMP will be implemented, to the extent feasible. Example locations are provided in Section 9.
- Sequencing of dredging and capping will be optimized (upcurrent to downcurrent, offshore to onshore, or with respect to number of lifts).
- Capping materials will generally be placed uniformly over the sediment surface, minimizing disturbance to the sediment or previously placed cap material.
- Capping materials will be placed from toe up to the top of the slope on slopes steeper than a set angle (e.g., steeper than 10 horizontal to 1 vertical).
- Location and material control equipment will be required to maximize controlled placement of cap material (see Section 4.5).

8.5 MONITORING PLAN

As discussed above, monitoring will occur at both performance (near-field) and compliance (far-field) monitoring stations to ensure that the water quality control measures described above are successful in protecting ambient water quality. The intent of the performance monitoring stations will be to monitor near-field turbidity in the vicinity of the construction area (outside of turbidity control structures) to provide an early warning of potential water quality impacts. The compliance monitoring stations will serve as the official compliance locations for water quality, and will be used to assess and manage potential impacts to water quality associated with the remedial construction activities. Specific details (e.g., location and sampling frequency) pertaining to water quality monitoring during dredging and capping operations will be provided in the WQMMP.

8.6 OPERATIONS OPTIMIZATION

Water quality monitoring at the performance and compliance monitoring locations will validate the protectiveness of the water quality controls. In the event the water quality monitoring criteria are exceeded, a series of response actions will be implemented including additional monitoring and inspection of silt curtains to identify the cause of the exceedance. Potential operations optimization activities that may be implemented include:

- Optimizing specific dredging or capping operations (e.g., ladder swing speed, cutter rotation speed, depth of cut, speed of advance of dredge, cap material placement rate)
- Limiting dredging and cap placement operations to calmer environmental/weather conditions (e.g., stopping dredging or placement when wave heights or wind speeds exceed a certain value)
- Limiting single-cut depths to approximately 80 percent of the cutterhead diameter
- Decreasing the cap lift
- Installing additional turbidity controls to contain construction-related impacts

Such modifications to operations have the potential to impact the project schedule. Modification of the dredge/cap operations from optimal production that can significantly impact schedule will be made in the field after other BMPs that have lesser schedule impacts are first field-tested. Such field modifications will be made with due consultation with NYSDEC prior to actual implementation.

SECTION 9

CONSTRUCTION SEQUENCING

The goal for the lake remediation is to complete dredging in four years (beginning in 2012), and capping in five years (beginning 2012). A sequencing plan has been developed by the design team with input from the remediation contractor and is described in Section 9.3. The sequencing plan may be revised as the construction progresses. A report documenting the dredging (areas, depths, volumes) and capping (areas, thicknesses, dosages) completed each year will be submitted at the end of each construction season. NYSDEC and Honeywell will determine, on an annual basis, whether any significant changes to the implementation of the remedy are needed to ensure the project is completed on or close to schedule.

9.1 UPLAND REMEDIATION SEQUENCING CONSIDERATIONS

There are potential Honeywell and non-Honeywell sources of contamination to the lake, which are being addressed to help prevent the restored lake bottom from being recontaminated. In addition, the lake remedy design and implementation will take into consideration how remedial actions in adjacent nearshore areas, and actions associated with onshore support zones, will be integrated with remediation activities within the lake. For example, the in-lake shoreline remediation and habitat restoration activities will be integrated with remediation and habitat restoration activities within adjacent wetlands associated with the Ninemile Creek, Wastebeds 1-8, and WBB/HB, as discussed in Section 3.4.

As the scopes and schedules for upland remedial activities are finalized, the information will be used to further define the approach for integrating these onshore activities with the lake remediation as the construction progresses. A discussion of sequencing and integration considerations for each remediation area is provided below.

Several of the upland sites subject to remediation activities are directly adjacent to those in the lake. The conceptual habitat restoration approach and integration of the onshore and in-lake remedies as it pertains to habitat restoration was developed in the Draft Habitat Plan. The overall objective of this effort is to develop and implement a habitat restoration plan for remedial actions associated with the Onondaga Lake Bottom remedy and with remedies and IRMs for adjacent Honeywell sites that provides ecological, recreational, and/or aesthetic benefits as well as complies with applicable state and federal laws and regulations, executive orders, and policies for floodplains, wetlands and surface waters.

9.1.1 Ninemile Creek (Remediation Area A)

Completing the Ninemile Creek remediation to the extent necessary to prevent recontamination will be required prior to remediation of Remediation Area A. The narrow landforms extending from the lakeshore out into the lake at the mouth of Ninemile Creek will be remediated as part of Remediation Area A, as discussed in Section 3.4. The current anticipated schedule for the completion of the Ninemile Creek remedy is 2014.

9.1.2 Wastebeds 1-8 (Remediation Areas A, B and C)

Remediation of Wastebeds 1-8 to the extent necessary to prevent recontamination will be required prior to remediation of the eastern portion of Remediation Area A, Remediation Area B and the northern portion of Remediation Area C. The scope for the Wastebeds 1-8 remedy includes installation of a shoreline groundwater collection trench to control shallow and intermediate groundwater discharging to the lake from the wastebed area, as well as remediation of sediments in Ditch A, which require completion prior to completion of remediation in adjacent lake areas. The groundwater collection trench for the Wastebeds 1-8 site and Ditch A remediation is currently scheduled to be complete in 2013.

Wastebeds 1-8 also includes a connected wetland adjacent to Remediation Area B, which will be dredged and capped concurrently with the lake dredging and capping. Materials that are above and below the water table in the wetland area will be hydraulically dredged concurrent with the sediments in Remediation Area B. The cap in the wetland area is designed to be consistent with the Remediation Area B cap, and will be placed within the same schedule as the Remediation Area B cap.

9.1.3 Barrier Wall and Tributary 5A (Remediation Area C)

Shoreline remedial activities adjacent to Remediation Area C are complete and include the Semet portion of the shoreline barrier wall installed in 2008, and the Tributary 5A remediation completed in 2011. Dredging and capping sequencing in this area will take into consideration the boat launch located in this area that is frequently used for small boats as well as shoreline fishing.

9.1.4 Wastebed B/Harbor Brook Outboard Area (Remediation Areas D and E)

Remediation of the WBB/HB Outboard Area will take place in conjunction with the adjacent work in Remediation Area D and Remediation Area E. The shoreline of the western third of Remediation Area D consists of the exposed sheet pile barrier wall installed in 2008 as part of the Willis/Semet IRM. Dredging design and implementation in this area will ensure dredging and capping operations and shoreline support activities do not subject the sheet pile wall to excessive stress and compromise structural integrity that could lead to potential damage and safety risks.

The remainder of the shoreline in Remediation Area D and the southern shoreline of Remediation Area E consists of the low-lying Outboard Area of the WBB/HB site. Remedial action in the area between the WBB/HB Willis/Semet IRM barrier wall and the lake is required, and will be performed concurrent with the lake remediation effort, as discussed in Section 3 and Section 5.2.7. This includes removal of material and construction of an isolation cap similar to Remediation Area D.

9.2 DREDGE SEQUENCING

A significant goal in sequencing the dredging activities is to minimize the potential for recontamination of previously capped areas or areas outside the proposed cap area, resulting from deposition of contaminated sediment that may be resuspended as a result of dredging operations (referred to as “generated residuals”) or due to wind/wave action. Additional factors that will be considered in developing the detailed sequence for dredging activities are listed below.

- **Other nearshore remediation activities.** In-water work will be coordinated with work in adjacent remediation areas to avoid potential recontamination.
- **Seasonal construction window.** Depending on weather and freezing temperatures, it is estimated that dredging activities will occur from April 1 to November 15 of each year. Mobilization, demobilization, equipment maintenance, and general construction planning will occur, to the extent practicable, outside of these seasonal construction windows. The seasonal construction period may be extended based on the weather conditions at the start and end of each season.
- **Production "shake down" or "ramp up" periods.** It is anticipated that during the first year of dredging, the optimal dredging production rate (i.e., cubic yards per hour or dredge days) may not be realized while developing and optimizing the system-wide integration of debris removal, dredging, slurry transport, processing dredged material at the SCA and water treatment. Dredging production will gradually increase to the optimal production rate to complete dredging in four years. This period of less-than-optimal production rates is referred to as the "shake down" or "ramp up" period, and serves a similar function as a pilot test. Dredging production in years 2, 3, and 4 is expected to have a shorter ramp up period than year 1.
- **Lake circulation patterns.** General circulation patterns in Onondaga Lake are counter clockwise in response to prevailing westerly winds. Circulation of the water within the lake is generated by wind speed and direction, tributary inflows, the outflow at the northern end of the lake, shoreline configuration, and stratification (Parsons, 2004). Resuspended dredged material will move parallel to the shore (long-shore transport) as well as in onshore/offshore direction (cross-shore transport) as a result of currents and wind-generated waves. Dredging and subsequent capping will be phased to generally proceed in an up-current to down-current direction to reduce the potential for contamination of the cap. Additional measures that will be employed to prevent contamination of the sediment cap during dredging activities are discussed under Section 9.3.
- **Dredge slopes.** In areas where targeted dredge slopes are greater than a given angle (e.g., 10 horizontal:1 vertical [10H:1V]), dredging will generally be performed in a top to bottom of slope direction to minimize potential suspended sediment or sloughed sediment transported down slope. Examples of dredge areas with a slope greater than 10h:1v is depicted in Figure 4.18 (approximately 825 ft. to 975 ft. from baseline) and Figure 4.19 (approximately 700 ft. to 730 ft. from baseline). However, in some cases there may be a need to dredge upslope into a remediation area due to shallow water depths that limit dredge access/mobility. Examples of dredge areas that require dredging in an upslope direction are depicted on Figure 4.8 (from the baseline to approximately 650 ft. from baseline) and Figure 4.9 (approximately 25 ft. to 700 ft. from baseline). Dredging upslope (from deeper water to shallower water) allows the dredge to increase the water depth required for hydraulic dredging as it approaches shore.

- **Production rate.** Dredging production rates will vary based on equipment, thickness of cut and material characteristics. For additional information and descriptions on dredging production, refer to Section 5.3 and Appendix J - Dredging and Capping Equipment Selection and Production Rates. In addition, the number and location of dredges will affect the overall production rate and therefore sequencing. One or multiple dredges can work in exclusive areas, advancing sediment removal to final dredge grade elevations. An option for multiple dredges is to have the 14-in. dredge perform production dredging, focusing on areas of relatively thick dredge cuts thereby optimizing the efficiency, and the 8-in. dredge following behind the large dredge to perform dredging better suited to low production and finer dredge control. The 14-in. and 16-in. dredges cannot operate simultaneously due to transport and water treatment flow limitations.
- **Dredge area and volume.** Table 5.1 presents a summary of the anticipated dredge volumes and areas for each remediation area. The sequence and schedule for dredging considers the amount of area that can be completed in a given year based on a production rate and dredge volume for each deposit.

Based on these considerations, dredging will likely be performed in a generally counter-clockwise direction, beginning in Remediation Area C south of the DOT turnaround area and proceeding through Remediation Area D and Remediation Area E. Dredging of Remediation Area A will be scheduled as soon as Ninemile Creek remediation is complete (2013). Remediation Area A requires a relatively low volume of sediment dredging, but will make available a large area for cap construction. When the remediation in Ninemile Creek is complete, the dredge(s) will stop at a logical point of the counter clockwise dredge progression within Remediation Area D and Remediation Area E and proceed to Remediation Area A. Dredging of Remediation Area B can begin after the remediation in Wastebeds 1-8 IRM is complete (2013), and will follow Remediation Area A dredging. Dredging in Remediation Area A and Remediation Area B represents a low risk of recontamination to other remediation areas, primarily due to the large distance between these and other remediation areas.

The preliminary dredge sequence is provided in Figure 9.1 and lists the anticipated dredge sequence, area, and potential dredge volume per year. Also depicted in Figure 9.1 are the adjacent remediation sites, with estimated year of completion, that require completion before lake dredging in the adjacent remediation area can begin. The dredge sequencing in Figure 9.1 is based the following assumptions:

- 132 dredge days per year. This assumes 32 weeks of dredging 6 days per week, less 60 days of operation due to discharge limitations at Metro.
- 70 percent operational uptime over 22 operational hours per day
- Use of the 16-in.dredge for 60 to 75 percent of the time, with the 14-in. dredge operating the remainder of the time.

9.3 CAP SEQUENCING

Depending on the overall sequence of dredging operations, multiple capping operations may be working simultaneously. This may include separate capping operations for different remediation areas and/or separate operations for the different material types (e.g., chemical isolation, erosion protection, or habitat material). General factors for developing guidelines for sequencing of cap operations include:

- **Other nearshore remediation activities (see Section 9.1).** In-water work will be coordinated with work in adjacent remediation areas to avoid potential recontamination.
- **Seasonal construction window.** Depending on weather and freezing temperatures it is estimated that capping construction activities will occur from April 1 to November 15 of each year. Mobilization, demobilization, equipment maintenance, and general construction planning (e.g., material stockpiling, etc.) will occur to the extent practicable outside of these seasonal construction windows. The seasonal construction period may be extended based on the weather conditions at the start and end of each season.
- **Coordination with dredging.** Capping operations will generally follow dredging operations in a similar pattern and sequence. Cap operations will be separated from dredge operations by an appropriate distance to avoid contamination of the cap due to dredging operations. A silt curtain will be maintained around all dredge operations to minimize the potential for resuspended sediment to be transported outside of the dredge area and settle within areas previously capped or actively being capped. The best management practices which will be implemented to minimize resuspension of materials during dredging, as discussed in Section 7, will also help minimize the potential for contamination of the cap as a result of dredging.
- **Production rate.** Capping production rates will vary based on equipment, thickness of cap and material type. For additional information and descriptions on capping production, see Section 4.5 and Appendix J of this document.
- **Capping slopes.** In areas where slopes to be capped are greater than a given angle (e.g., 10 horizontal:1 vertical [10H:1V]), capping operations will generally place material from the bottom of a slope up to the top of slope to minimize the loss of material during placement. Examples of cap areas that have a slope steeper than 10H:1V and will be capped from the bottom of slope up include RA-D Figure 4.18 (approximately 825 ft. to 975 ft. from baseline) and Figure 4.19 (approximately 700 ft. to 730 ft. from baseline). This sequence of slope capping has been successfully completed on other projects. In some shallow areas, capping from the top of slope down to the bottom of slope will be necessary in order to maintain draft for the cap placement equipment. Examples of the cap areas that will be capped from up slope down include the shallow water modules in RA-A. The capping equipment will start at shore and work out to deeper water in order to maintain capping equipment required operational water depth.
- **Interim cap.** In areas where dredging has been completed, but the final cap (i.e., full minimum total thickness up to and including the habitat layer) cannot be completed within the same construction season, an interim cap consisting of the chemical isolation and erosion protection layers will be placed to the extent possible over dredged areas prior to completion of the construction season to isolate dredged areas and ensure the layers will remain intact over the winter shutdown period. In some

cases, a modified (thinner) interim cap may be placed based on schedule and other considerations, subject to NYSDEC approval.

- **Habitat considerations.** To minimize potential habitat impacts, the habitat layer will be placed in the same construction season as the underlying cap layers. In areas where this is not feasible based on the overall schedule and other sequencing considerations, the habitat layer will be placed during the subsequent construction season.
- **Cap area and volume.** Table 4.4 presents a summary of the currently anticipated cap areas and volumes for each Remediation Area. The sequence for capping will consider the progress of the prior dredging as well as the amount of area that can be capped in a given year based on the capping production rate and cap thickness of each area.

Based on the considerations listed above, capping in a remediation area will follow dredging and will likely be performed in a general counter-clockwise direction, beginning in Remediation Area C and proceeding through Remediation Area D and Remediation Area E. Capping of Remediation Area A and Remediation Area B will follow the dredging of those respective remediation areas.

Figure 9.2 provides the preliminary cap sequence and lists the anticipated cap sequence, area and volume per year. Due to the amount of area available for capping in year one and year two (2012 and 2013), a single hydraulic cap operation is anticipated. Starting in year three (2014) it is anticipated that multiple cap operations will be required and operated simultaneously in order to meet the overall project schedule. The second capping system will not be set up at the onset of the project. It will be set up in time to allow its use in year three. Only the initial hydraulic placement system will be equipped to incorporate placement of granular activated carbon. There is adequate area available on shore to support the multiple capping operations anticipated. The cap sequencing shown in Figure 9.2 is based on an annual 32 weeks of capping 6 days per week. The production rates provided in Appendix J account for downtime associated with moving anchors, safe cable winching speed, maintenance, shift changes, weather delays, fueling and material logistics based on contractor experience at similar sites. Sequence operations consist of 6 days per week, 24 hours per day with 80 percent estimated operational uptime and weighted average rates for the sand and gravel volumes and anticipated production rates.

SECTION 10

POST CONSTRUCTION CAP MONITORING AND MAINTENANCE

The cap will be designed to provide a high level of long-term protection and to be resistant to disruption by forces such as erosion due to wind generated waves. The habitat restoration and enhancement component of the Onondaga Lake remedy has been designed to provide long-term ecological function, biological and structural diversity, and improve the physical connectivity between adjacent areas with minimal long-term maintenance. Post-construction monitoring and maintenance of the capped areas will be performed to verify that the overall integrity of the cap is maintained so that it remains physically stable (i.e., does not erode) and chemically protective over time. The conceptual cap monitoring and maintenance plan outlined below provides a high-level overview of monitoring and maintenance activities to be implemented. A discussion of potential institutional controls is also provided below. Details pertaining to cap monitoring and maintenance will be provided in the OLMMS, which will also detail the program for long-term monitoring of various media such as surface water and fish/biota to evaluate the effectiveness of the remedy in achieving the RAOs and PRGs specified in the ROD.

10.1 POST CONSTRUCTION CAP MONITORING PLAN

Long-term monitoring of the caps will include physical monitoring to verify stability and sampling of the caps to verify their chemical integrity, as well as monitoring associated with achievement of habitat-related goals, as detailed below.

In some nearshore areas, the long-term effectiveness of the cap is partly dependent on the elimination of groundwater discharging to the lake through operation of the shoreline groundwater containment/collection systems. Honeywell will operate, maintain and monitor the effectiveness of these systems long-term. The ongoing effectiveness of these systems will be documented as part of the Onondaga Lake monitoring and maintenance reporting program. Requirements for documentation of the monitoring will be specified in the OLMMS.

Physical Monitoring

Physical monitoring will involve verifying that the armor layer and underlying chemical isolation layer are stable and intact using a combination of methods including bathymetric surveys, sediment probing and coring, and other geophysical methods. The cap integrity will be monitored routinely and following wind/wave, tributary inflow, ice scour or seismic events that exceed a threshold design magnitude, consistent with USEPA (2005) recommendations. The frequency of routine monitoring will be greater initially after construction (e.g., multiple monitoring events within the first 5 to 10 years), and reduced over time once the monitoring is able to establish a consistent pattern of cap performance. Details of the monitoring methods, frequencies, and procedures and response actions will be developed based on joint discussions with NYSDEC and will be presented in the OLMMS.

Chemical Monitoring

Chemical monitoring will involve measuring chemical concentrations within the habitat and chemical isolation layers to verify that contaminants are not moving through the cap at rates and concentrations that exceed specified remedy success metrics. As described in the ROD,

> The point of compliance, with respect to ensuring that the isolation portion of the cap is effective in preventing unacceptable concentrations of contaminants (i.e., a concentration greater than the [Probable Effects Concentration] PEC of any of the [Chemical Parameters of Interest] CPOIs that have been shown to exhibit acute toxicity on a lake-wide basis or NYSDEC sediment screening criteria for benzene, toluene, and phenol) from entering the habitat restoration layer portion of the cap, will be at the bottom of the habitat restoration layer.

Samples will be collected for chemical analysis from the habitat layer and underlying chemical isolation layer. The frequency of routine monitoring may be reduced over time once the monitoring is able to establish a consistent pattern of cap performance. Details of the chemical monitoring methods, frequencies, locations, sampling intervals, procedures, and response actions will be developed based on joint discussions with NYSDEC and will be presented in the OLMMS. In areas where the habitat substrate may impact the ability to collect samples within or below the habitat layer, alternative sampling techniques will be utilized to ensure monitoring is completed. These potential methods will be presented in the OLMMS for NYSDEC review and approval.

Habitat Monitoring

The habitat component of the monitoring program will include physical and biological monitoring of the capped areas. The purposes of the habitat component of the monitoring program are to:

- Assess the performance of the capped areas relative to the habitat-related goals as described in Section 4.3, and
- Provide data to evaluate whether maintenance activities are warranted.

Physical monitoring of the habitat layer to document water depth and habitat layer thickness will be conducted as part of the overall cap monitoring program as described above in Section 10.1. The biological monitoring element will include vegetation, wildlife, fish, and macroinvertebrates. Initially, biological monitoring will focus on plant species composition and survival/expansion of planted areas. Subsequent monitoring will include evaluations of the use of the habitat modules by macroinvertebrate, fish and wildlife. Additional details regarding the habitat maintenance and monitoring, along with short-term and long-term success criteria, will be provided in the OLMMS.

10.2 POST-CONSTRUCTION CAP MAINTENANCE PLAN

In the unlikely event that the monitoring plan discussed above identifies areas where the cap may not be performing consistent with expectations, follow-on assessments and/or response actions will be implemented. Follow-on assessments/actions may include additional investigation to further evaluate potential deficiencies, continued monitoring and assessment of overall remedy effectiveness over time, and replacement of cap materials. Cap monitoring and maintenance actions will be detailed in the OLMMS.

The plan will include criteria for when a follow-on assessment or response action is required based on physical and chemical monitoring and the appropriate type of response action. For example, if bathymetric or other surveys from either the routine or event-based surveys show evidence of disruption of the armor layer, then a typical response would include an additional assessment of the affected cap areas, potentially including underwater video surveying and/or core sampling. If cap erosion is confirmed by additional assessment such that the performance of the chemical isolation layer is compromised, then response actions may be applied. Possible response actions after the cause of erosion is determined could include:

- Place additional armor or otherwise repair the cap within the identified area of erosion (e.g., reestablish cap thickness) if the performance standards are no longer being met.
- Enact managerial or institutional controls to help control any further cap erosion if it is being caused by activities such as boat traffic or stormwater discharges.

Potential response actions will also be developed based on the results of the long-term chemical monitoring. Details of the cap maintenance response actions will be developed based on joint discussions with NYSDEC and will be presented in the OLMMS.

10.3 INSTITUTIONAL CONTROLS

As described in Section 4.2, the cap armor layer has been designed to minimize damage to the chemical isolation layer from recreational vessel operations in all areas of the lake being capped, and from commercial vessel traffic in the NYSCC navigation channel. Therefore, the only institutional control envisioned to promote the long-term integrity of caps in areas other than the NYSCC navigation channel is to minimize disturbance of the caps by dredging or other in-water construction activities. As appropriate, it is anticipated that “No Dredge Areas” will be established over the capping areas, other than the NYSCC navigation channel, to minimize disturbance of the capping materials. The restrictions can be marked on the NOAA Navigation Chart for Onondaga Lake (currently included as Chart Number 14786 for the Small-Craft. Book Chart for the New York State Barge Canal System). The New York State Office of Parks, Recreation and Historic Preservation currently maintains navigation buoys in Onondaga Lake to warn boaters of hazards in water less than 4 ft. in depth and beyond 100 ft. from shore. As appropriate, additional navigation buoys may be placed.

SECTION 11

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TABLES

FIGURES