Sevenson Environmental Services, Inc.

MEMORANDUM

DATE: **October 28, 2010**

TO: **Dave Smith and Ed Glaza, Parsons**

FROM: **Mike Crystal, Sevenson Environmental Service**
Tim Donegan, PE, Gahagan and Bryant Associates, Inc.

RE: **Onondaga Lake Dredge Selection, Anticipated Production Rates and Silt Curtain Layout**

Hydraulic Dredges

Sevenson plans on having three dredges on site for the Onondaga Lake Project. Two of the dredges will be available for performing the majority of the dredging - these are referred to herein as "production dredges" (Dredge 1 and Dredge 2). The third dredge will be available for dredging in shallow water, confined areas, or other unique conditions – this dredge is referred to herein as a "specialty dredge" (Dredge 3). Sevenson's two production dredges are each capable of handling the required daily production to meet the project schedule, thus providing buffer capacity in case of emergency needs. The third dredge will be a small specialty dredge that can be used simultaneously with the smaller of the two "production" dredges and will be operating in the vicinity of shorelines and highly vegetated areas. These dredges have been selected to maximize dredge production and efficiency for the variable site conditions.

Dredge selection criteria included:

- Capability to operate efficiently at a maximum of 5,500 gallons per minute (GPM) of slurry flow
- Capability to efficiently dredge material with a standard penetration test (SPT) blow count of 25 blows per foot (Highest recorded blow counts in Remediation Areas, Remediation Area D ILWD material)
- A large dredge (production dredge) that can efficiently remove large faces (cuts) of material (i.e. 3-foot cut)
- Small dredge (specialty dredge) that can efficiently remove shallow face material (i.e. 0.5-foot)
- Larger dredges (production dredge) that have the capability to pump long distances to the shoreline without additional boosters on the water
- Capability to operate in shallow water and neashore areas
- Provide redundancy in the dredging operations if one dredge needs to shut down for mechanical/maintenance reasons (i.e. a second dredge capable of achieving project production rates would be available for immediate use)

- Capability to dredge up to the water surface without cavitation of the pump or vortex suction of air (i.e. neashore areas where part of the cutterhead might be out of the water)
- Capability for dredge (or combination of dredges) to meet the project goal of completing the dredging in 4 years
- Capability to handle debris and submerged aquatic vegetation (SAV) by the use of cutting knives, shrouds, and possibly a "gatling plate"

The factors described above led to the decision by Sevenson and the design team to identify three dredges that will be used at the site. The two proposed "production dredges" are a 16-inch-diameter and 14-inch-diameter dredge, and the "specialty dredge" is an 8-inch-diameter dredge. The estimated removal rate of either "production dredge" could meet the required project objectives; however, to provide additional production capacity and buffer during environmental dredging, the recommendation to have two large production dredges and one smaller specialty dredge will enable the project to be completed efficiently.

Sevenson plans to use the 16-inch production dredge (Dredge 1), which can operate at a continuous flow of 5,500 GPM, during stand-alone operations. This dredge will not be used in combination with any of the other dredges. The 14-inch production dredge (Dredge 2) can be used alone (pumping 5,500 PGM) or in combination with the 8-inch specialty dredge (Dredge 3). If Dredges 2 and 3 are operated at the same time, flow for each dredge will be limited for a combined total of 5,500 GPM of slurry. The flow for the 14-inch dredge will be limited to 4,000 GPM and the flow for the 8-inch dredge will be limited to 1,500 GPM. The two dredge lines will join each other through a Y-valve connection prior to the on land booster. Dredge discharge piping will enter booster pump #1 where it will be transported up to the SCA via the 16-inch/22-inch dual wall high density polyethylene (HDPE) sediment transport pipe. If additional water is required for the slurry pipeline, the booster pump will automatically open a valve allowing "makeup" from the lake to enter the pipe system and to keep the flow at 5,500 GPM.

Dredge Specifications

The specifications for the three dredges are described below.

Dredge 1 – 16-inch-diameter Dredge "Marlin" (Dredging Supply Company Series 7650D)

- Overall dredge length: 104-feet including ladder in the up position
- Overall dredge width: 40-feet
- Hull dimensions, excluding ladder; length: 70-feet, width: 40-feet, depth: 5-feet, draft: 3-feet
- Spud carriage barge measuring 30-feet long by 10-feet wide with a 10 foot stroke
- Dredge will set forward using 1 spud centered in the stern
- Capable of dredging a 2 foot cut in shallow water
- Extended ladder for a maximum dredge depth of 56-feet below the water surface
- Impeller diameter: 40-inches
- 16-inch suction (inside diameter - ID) and 16-inch discharge (ID)
- Cutter diameter: 43-inches
- Installed power: 800 horsepower (Hp)
- Cutter motor power: 130 Hp
- Hospital grade muffler installed for added noise reduction

Figure 1. Dredging Supply Company 16-inch-diameter Dredge "Marlin"

Dredge 2 – 14-inch-diameter Dredge “Shark” (Dredging Supply Company Series 75450D)

- Overall dredge length: 68-feet including ladder in the up position
- Overall dredge width: 20-feet
- Hull dimensions, excluding ladder; length: 40-feet, width: 19-feet, depth: 4-feet, draft: 2-feet
- Spud carriage barge measuring 30-feet long by 10-feet wide with a 10 foot stroke.
- Dredge will set forward using 1 spud centered in the stern
- Extended ladder for a digging depth of 43-feet below the water surface
- Impeller Diameter: 36-inches
- 14-inch suction (ID) and 14-inch discharge (ID)
- Cutter diameter: 34-inches
- Installed power: 700 Hp
- Cutter motor power: 90 Hp
- Hospital grade muffler installed for added noise reduction

Figure 2. Dredging Supply Company 14-inch-diameter Dredge “Shark”

Dredge 3 – 8–inch-diameter Dredge "Moray" (Dredging Supply Company Series 2000)

- Overall dredge length: 42-feet including ladder in the up position
- Overall dredge width: 11-feet
- Hull dimensions, excluding ladder; length: 35-feet, width: 11-feet, depth: 4-feet, draft: 1.5-feet
- Dredge can operate in swinging ladder mode or conventional mode
- Impeller Diameter: 20-inches
- 8-inch suction (ID) and 8-inch discharge (ID)
- Cutter diameter: 28-inches
- Installed power: 275 Hp
- Cutter motor power: 20 Hp
- Hospital grade muffler installed for added noise reduction

Figure 3. Dredging Supply Company 8-inch-diameter Dredge "Moray"

Operational Plan

Sevenson plans to use Dredge 1 (16-inch Marlin Class) as the primary production dredge. The dredging production rate for this dredge will be at its highest when operating in Remediation Areas D and E, where over 75% of the targeted dredge volume for the Onondaga Lake Project is located. Specifically, the dredge plan in Remediation Area D includes up to a 13-foot face of material that will yield the highest production rate. The production of Dredge 1 is most efficient (i.e., highest production rate) when working in areas with large faces to cut (>3.5 feet). The actual operating thickness of each dredging pass will be dependent on material types encountered. Material passes can range from 1 foot up to 3.5 feet. An average cut thickness will be approximately 2 feet. Softer materials will allow thicker cuts possibly using the entire height of the cutterhead. Therefore a 13-foot face offers a large quantity for optimal dredge efficiency.

Dredge 2 (14-inch Shark Class) will serve as a backup dredge, and can also be used as a primary production dredge if conditions (i.e. water depths, swing configuration, etc.) do not allow Dredge 1 to operate or when Dredge 3 is needed for nearshore dredging. As mentioned earlier, Dredge 2 will work in tandem with Dredge 3 to maximize slurry transport volumes.

Dredge 3 (8-inch Moray Class) will be used in neashore areas or in areas where small face cuts are required. Dredge 3 operating by itself will not generate enough water to maintain an adequate flow volume/velocity within the dredged material pipeline to transport the slurry. Therefore, Dredge 2 was specifically designed to operate simultaneously with Dredge 3 providing enough combined flow to adequately transport the slurry yet within the limits of the maximum flow criteria of 5,500 GPM that the sediment management and water treatment operations can manage. Coordination with Dredge 1 and Dredge 2 will be needed to maintain scheduled production rates.

Hydraulic Dredge Instrumentation

Each hydraulic dredge will be fitted with a DeltaMass MT Series Mass Flow and Density Sensor (one unit). The DeltaMass flow meter combines a magnetic flow meter and a low-level gamma ray density sensor for measuring the density of the slurry and the flow rates, which together provide the instantaneous production rate of material being removed. This information will be visible to the operator so that he can control the flow in the pipeline to achieve a uniform slurry. Output from these two gauges will be fed into a “Totalizer Unit”, which will keep track of the total quantity of material dredged in real-time.

Figure 4. Delta Mass Instrument

GPS Equipment

Sevenson will use a new Real Time Kinematic Global Positioning System (RTK) GPS (Trimble 461 with heading) system designed and installed for the Onondaga Lake project. The Dredgepack software, which was designed for use with an excavator and/or the hydraulic dredges, will compile the information from the GPS and other positioning equipment on the dredges (e.g., inclinometer, tilt sensors, etc.), to track the horizontal and vertical position of the dredge cutterhead or excavator bucket in real-time throughout the project.

Calibration of the system will be performed by comparing water level and x, y position derived by the Dredgepack software with independent values derived from a Trimble S6 robotic total station positioned on shore with millimeter accuracy.

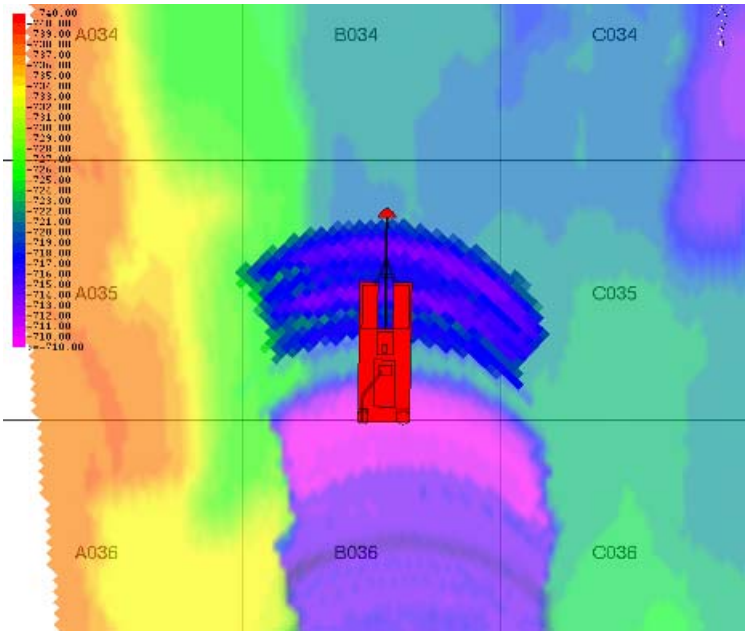


Figure 5. Example Output from Dredgepack for a Hydraulic Dredge

The information that the dredge captain looks at on the screen will be remotely broadcast back to the shoreline office trailer via cellular modem. All information collected on the dredge (e.g., dredge position, real-time swing, etc.) will be broadcast real-time in the office trailer. This remote transmitting can also be used to service the software if a problem occurs or a setting needs to be changed. The positional information will also be logged at the dredge for viewing at a later date to verify where the dredge cutterhead had traveled.

Hydraulic Dredge Production

Production rates for the proposed dredge system were developed with the understanding of a flow limitation of 5,500 gallons per minute that can be delivered to the SCA.

Tables 1 through 4 below provide a summary of estimated production rates for each dredge and combination of dredges. The production rates were developed using propriety software developed by Dredging Supply Company (DSC) based on the in-situ geotechnical data, available blow count data (SPT borings), 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.

Table 1 –Summary of Estimated Production Ranges for Remediation Areas for Dredge 1 – Marlin 16-inch-Diameter

Remediation Area	Size (Acres)	Marlin Production (CY/HR)	Marlin % Solids (dry weight basis)
A	27.1	338	16
B	5.9	178	9
C	4.9	216	11
D	89	351	12
E	91.9	342	19

Table 2 –Summary of Estimated Production Ranges for Remediation Areas for Dredge 2 – Shark 14-inch Diameter

Remediation Area	Size (Acres)	Shark Production (CY/HR)	Shark % Solids (dry weight basis)
A	27.1	215	11
B	5.9	159	8
C	4.9	203	10
D	89	224	8
E	91.9	218	12

Table 3 –Summary of Estimated Production Ranges for Remediation Areas for Dredge 3 – Moray 8-inch Diameter

Remediation Area	Size (Acres)	Moray Production (CY/HR)	Moray % Solids (dry weight basis)
A	27.1	30	6
B	5.9	24	5
C	4.9	22	5
D	89	38	5
E	91.9	30	7

Table 4 –Summary of Estimated Production Ranges for Remediation Areas for Dredges 2 and 3 Operating Simultaneously – Shark 14-inch_Diameter and Moray 8-inch-Diameter with a Maximum Flow Rate of 5,500 GPM.

Remediation Area	Size (Acres)	Shark and Moray Combined Production (CY/HR)	Shark and Moray Combined Moray % Solids (dry weight basis)
A	27.1 AC	245	12
B	5.9 AC	183	9
C	4.9 AC	225	9
D	89 AC	262	9
E	91.9 AC	248	14

All production rates shown in the four tables above are considered estimates and account for handling of anchors, fueling, mechanical maintenance, and movement of the dredge amongst the Remediation Areas.

Silt Curtain Design and Layout

Sevenson has designed a silt curtain containment system for the dredging activities in Onondaga Lake. The silt curtain has been designed to contain turbidity caused by the dredging activities, as well as to resist wind, waves, currents, rain, and other foreseeable environmental forces that are expected to occur in Onondaga Lake. Sevenson will install lights and/or buoys on the silt curtains for safety in accordance with US Coast Guard regulations.

Sevenson plans to use impermeable silt curtains, which will be installed and laid out on a seasonal basis. Details of the silt curtains are provided Figures 1 and 2. Figures depicting the locations of the silt curtains and proposed locations monitoring for turbidity are located in the Water Quality Monitoring Plan (2012). The Figures show the approximate location of the curtains on an annual basis. The curtain will be installed to completely contain the dredge area. Intermediate curtains may be used to separate the larger area into smaller, more management sections. The curtain will remain in place until the initial mixing layer of the cap is placed. A curtain will divide these cap areas and dredge areas as well. The curtains will be removed/advanced as work progresses.

To install the silt curtains, Sevenson will raise the skirt of the curtain such that it is bunched up against the floats, move the floats and curtain into position, drop the skirting to the desired depth, and attach the curtain float to a series of spud barges and/or piles spaced at various point along the silt curtain alignment as well as on-shore anchors.

In addition, the silt curtain itself will be anchored to the bottom using a anchoring system composed of Danforth type anchors, chain, and anchor line. Spacing of the anchors will allow minimal movement in the current and wind and accommodate any water level fluctuations. Curtains will be generally cut to match existing grades/contours. Reefing lines will be used to adjust curtain heights to match changing water level conditions.

The silt curtains will be weighted at the bottom using ballast chains. Removal of the curtains will be done in the opposite order that the installation is performed. The anchors will be removed, the skirt will be raised and bunched against the floats, and the curtain will be moved to the next installation location.

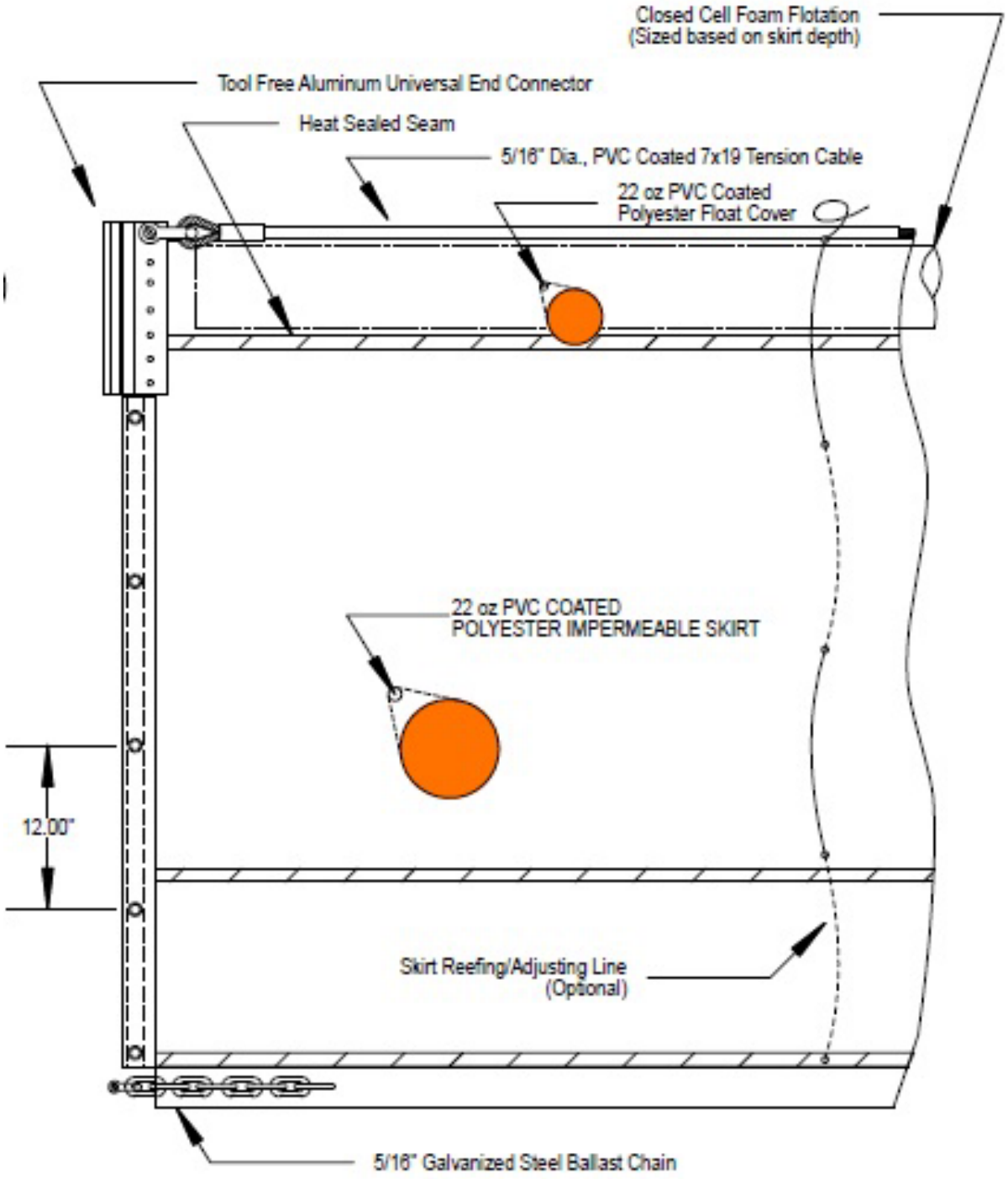


FIGURE 1 – Silt Curtain Detail

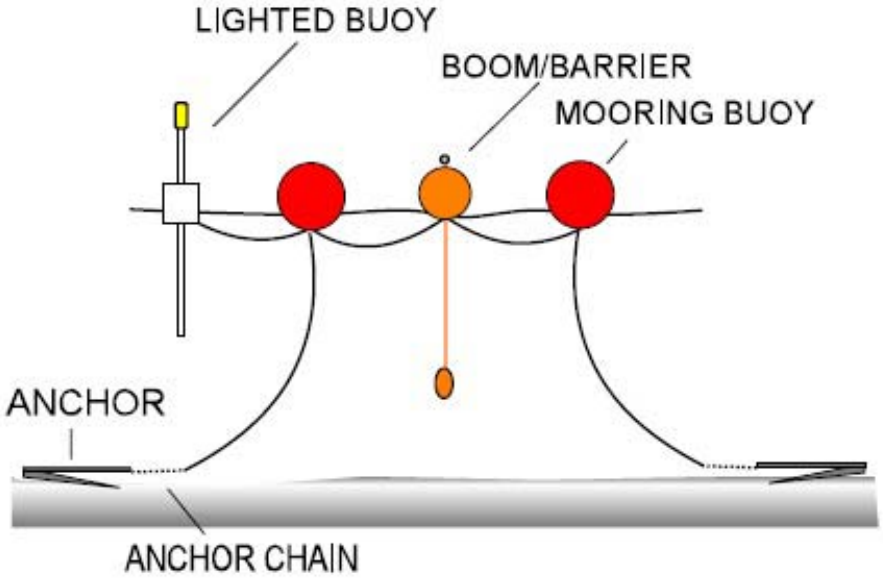


FIGURE 2 – Silt Curtain Anchoring Details

Sevenson Environmental Services, Inc.

MEMORANDUM

DATE: **November 3, 2010**

TO: **Dave Smith and Ed Glaza, Parsons**

FROM: **Mike Crystal, Sevenson Environmental Service**
Tim Donegan, PE, Gahagan and Bryant Associates, Inc.

RE: **Onondaga Lake Capping Anticipated Production Rates**

Sevenson's approach to placement of sand materials and stone materials smaller than 2 inches in diameter will involve a hydraulic slurry system. It is anticipated that armor (rock/gravel) materials larger than 2 inches in diameter will be placed using a hydraulic excavator with real-time kinematic (RTK) global positioning system (GPS). Placement approaches are discussed below.

SAND AND ROCK CAPPING OPERATIONS

Sevenson will use our custom-built slurry system for hydraulic placement of the sand cap and stone armor less than 2 inches in diameter in designated areas. The system consists of a feed hopper, oversized screening, and slurry system that will pump the sand and small stone hydraulically through a pipeline for placement through a diffuser system on a barge. The pump used to convey the sand slurry is a booster type pump commonly found on dredging projects. The hopper, screening, and slurry system will be placed on the shoreline at two potential locations to minimize pumping distances and the need for booster pumps floating on the water. The two preliminary locations have been identified on Wastebed B and Wastebeds 1-8 and will be coordinated with upland sites and finalized in a future submittal.

The following criteria were considered in selecting equipment for the placement of sand and armor materials as part of the Onondaga Lake caps:

- Minimize multiple handling of materials, extra equipment, and personnel required for placement of sand and rock materials.
- Capability to hydraulically convey sand and small armor stone materials from neashore location to the farthest points of the lake while maintaining production
- Capability to pump armor stone material up to 2-inches in diameter
- Access to shallow water (i.e. less than 1-foot of water) and still efficiently spread/place materials
- Portable system that can be broken down and relocated
- Design a system with redundancy and capacity to meet production is one system goes down.

The considerations described above led to the decision by Sevenson and the design team to select to hydraulic spreader systems that will meet the schedule and maintain production rates.

A 30-foot by 40-foot diffuser/spreader barge will be attached to the slurry system by the 16SDR11 high-density polyethylene (HDPE) pipe. The spreader system will be attached to the 30 foot side of the barge. This barge will have a waterfall type discharge apparatus (steel plate angled towards the water) fabricated on the deck (Figure 1). The angled discharge plate will act to dissipate the energy in the capping material slurry delivered to the placement barge via the floating line. Therefore, the sand cover will enter the water in a controlled fashion with minimal fall velocity. The diffuser barge will have a hydraulic cable winch system and anchors to facilitate the movement of the barge for placement of the material. The anchor system will be designed to minimize cable sweep across the cap surface with the use of cable floats and cable tensioning sensors on each winch drum. Two spreader barges will be on site operating at the same time as required.

The armor stone spreader system (Figure 2) is composed of a similar flexi float system but with a different diffuser head. The armor stone diffuser spreader system is composed of 4 energy dissipaters. With angled plates welded to the interior. The slurry flow is separated into four different flows. Materials are dropped vertical into the water for an even distribution.

The pump system is composed of a 900 HP dredge pump with a 38-inch-diameter impeller and one 24-inch-diameter Godwin pumps to deliver the slurry make up water into the mixing tank located next to the stockpiles at each potential staging location. A dedicated slurry system will be utilized for each capping operation. There is a possibility that one system will be spreading armor stone while the second system is spreading sand.

Figure 1. SES Spreader Barge System Placing Sand Cap Materials.

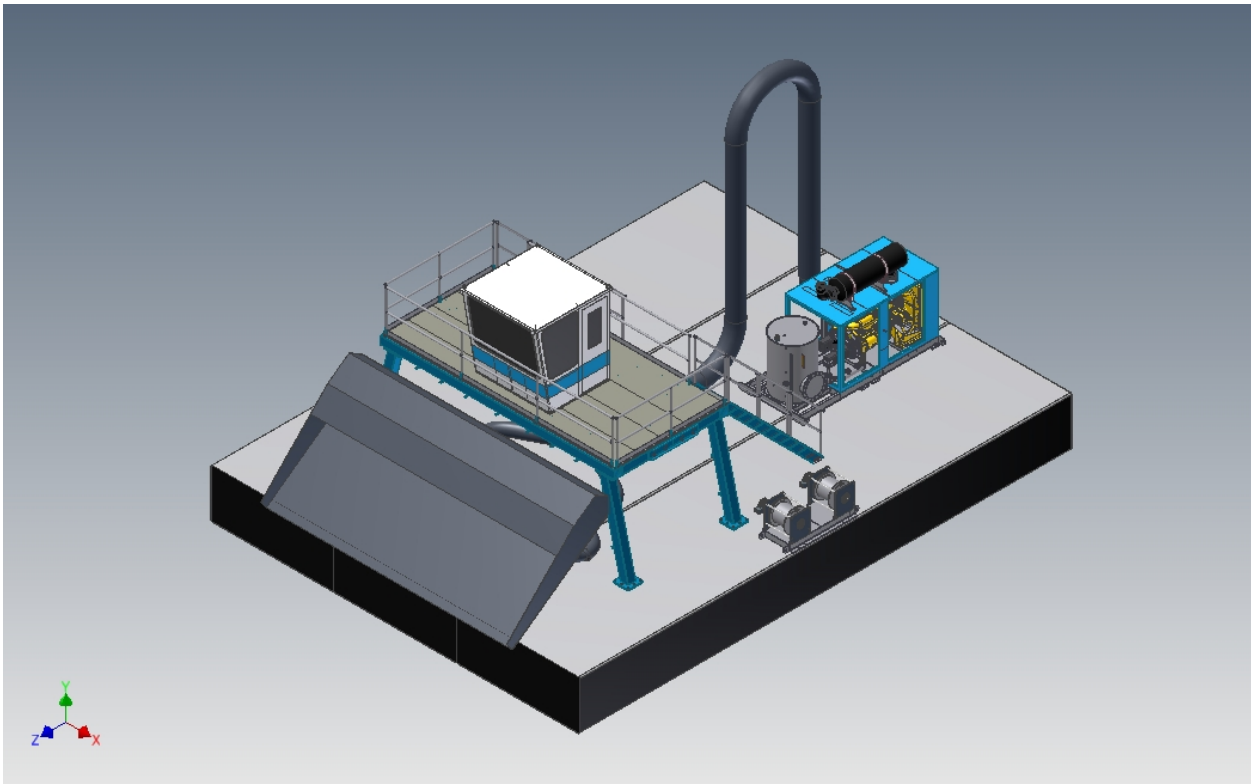


Figure 2. Schematic of the SES Spreader Barge for Sand and Fine Gravel Placement

Figure 3. Slurry Feed System that Transport Materials to the Spreader Barge

The anticipated production rate that Sevenson calculated for each cap area is based on the pumping distance to the site from the shoreline and any inefficiencies associated with moving anchors, maintenance, shift changes, weather delays, fueling, and material stockpiling logistics. The anticipated uptime is estimated to be 80% of a 24 hour work day.

Table 1 below details the range of production rates for hydraulic placement of sand materials.

SAND HYDRAULICALLY PUMPED

Remediation Area	Min Pumping Distance (Ft)	Max Pumping Distance (Ft)	Theoretical Min Prod. Rate [a] (Cy/Hr)	Theoretical Max Prod. Rate [a] (Cy/Hr)	Anticipated Prod. Rate (Cy/Day) [b]	Booster/Staging Location
A	1,100	4,300	550	630	2,073	Wastebeds/9 Mile Creek
B	2,100	4,700	500	630	2,073	Wastebeds/9 Mile Creek
C	1,700	5,100	450	630	2,073	Work Support Area
D	600	3,330	630	630	2,073	Work Support Area
E	2,200	5,500	400	630	2,073	Work Support Area

Notes:

a. Estimated minimum and maximum production rates based on manufacturer's estimates without consideration of inefficiencies related to loading the slurry hopper, achieving a consistent feed rate, time required to start and stop a given placement lane, mechanical delays, weather delays, etc.

b. Anticipated production rate based on moving anchors, safe speed that cables can be winched onto the spools, maintenance, shift changes, weather delays, fueling, and material stockpiling logistics

The anticipated production rate of approximately 108 CY/HR (2,073CY/Day) was developed based on safe operating speeds of the capping barge, equipment limitations of safe winching speeds, feeding the slurry system with a consistent feed to minimize overspreading materials and minimize barge "jerking" through the water with the cap automation system.

Characteristics and efficiencies for pumping the sand materials are:

- Velocity in the pipeline to pump a medium sand will be 16 to 18 feet per second
- Flow rate will be approximately 7,500 gpm
- Pump revolutions per minute (RPMs) will range from 500 to 680 depending on pumping distance
- Pump HP used will range from 500 to 900 depending on pumping distance
- Keeping barge movement limited to less than 20 feet per minute

Table 2 below details the anticipated range of production rates for hydraulic placement of armor stone materials less than 2 inches in diameter.

ROCK UP to 2 INCHES HYDRAULICALLY PUMPED

Remediation Area	Min Pumping Distance (Ft)	Max Pumping Distance (Ft)	Theoretical Min Prod. Rate [a] (Cy/Hr)	Theoretical Max Prod. Rate [a] (Cy/Hr)	Anticipated Prod. Rate [b] (Cy/Day)	Booster/Staging Location
A	1,100	4,300	95	304	960	Wastebeds/9 Mile Creek
B	2,100	4,700	90	304	960	Wastebeds/9 Mile Creek
C	1,700	5,100	80	304	960	Work Support Area
D	600	3,330	155	304	960	Work Support Area
E	2,200	5,500	50	304	960	Work Support Area

Notes:

a. Estimated minimum and maximum production rates based on manufacturer's estimates without consideration of inefficiencies related to loading the slurry hopper, achieving a consistent feed rate, time required to start and stop a given placement lane, mechanical delays, weather delays, etc.

b. Anticipated production rate based on moving anchors, safe speed that cables can be winched onto the spools, maintenance, shift changes, weather delays, fueling, and material stockpiling logistics

The anticipated production rate of approximately 50 CY/HR (960 CY/Day) for armor stone up to 2 inches in diameter was developed based on safe operating speeds of the capping barge, equipment limitations of safe winching speeds, feeding the slurry system with a consistent feed to minimize overspreading materials and minimize barge "jerking" through the water with the cap automation system.

For placement of sand and armor stone less than 2 inches in diameter, Sevenson plans to use two spreader barge systems. It is anticipated that each barge system will operate 24 hours per day. Two crews will be required per spreader system each day. Each crew will work 12 hours per day. Sevenson anticipates an uptime of 80%. The anticipated 80% uptime and 20% downtime was calculated based on potential delays associated with setting anchors, weather delays, mechanical delays, fueling, greasing and routine maintenance.

Characteristics and efficiencies for pumping the armor stone materials up to 2 inches in diameter are:

- Velocity in the pipeline to pump a medium sand will be 14 to 18 feet per second
- Flow rate will be approximately 6,000 to 7,500 gpm
- Pump RPMs will range from 500 to 700 depending on pumping distance
- Pump HP used will range from 500 to 900 depending on pumping distance
- Keeping barge movement limited to less than 15 feet per minute

6.3 Armor Capping Operations

For the mechanical placement of armor materials larger than 2 inches in diameter, Sevenson will use one hydraulic excavator (Komatsu PC 300) stationed on a modular Flexifloat barge. The details of the placement system are:

- Aftermarket boom and stick capable of reaching 47 feet.
- Flexifloat barge 40 feet wide and 60 feet long (six assembled Flexifloat barges each measuring 10 feet by 40 feet).
- Draft of the barge with excavator will be approximately 2 feet.
- DREDGEPACK® software system, RTK GPS.
- Seven inclinometers for the boom, stick, bucket, and rocking of the barge.
- Real time water surface elevation display in the cab.
- A 2 CY clamshell bucket will be used to place material. The bucket will be similar to an environmental clamshell.
- Cycle times are anticipated to be approximately 45 seconds to 2 minutes depending on the complexity of the placement, material type, water depth, location of stockpile material (i.e. supply barge on the hip or located to the stern because of draft limitations)

Figure 4. Mechanical Placement of Rock Cap Materials from a Shallow Draft Barge

Production rates for mechanical placement of armor materials larger than 2 inches in diameter are calculated to be approximately 50 CY/HR. These production rates account for uptime/downtime, repositioning barges, etc. Sevenson plans to operate 2 crews each working two 12 hour shifts. Sevenson anticipates an uptime of 80%.

ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

APPENDIX K – HABITAT

Prepared for:

Honeywell

301 Plainfield Road, Suite 330
Syracuse, NY 13212

Prepared by:

PARSONS

301 Plainfield Road, Suite 350
Syracuse, NY 13212

ANCHOR QEA

290 Elwood Davis Road, Suite 318
Liverpool, NY 13088

MARCH 2012

TABLE OF CONTENTS

Page

SECTION 1 INTRODUCTION 1-1

SECTION 2 NINEMILE CREEK SPITS AND ADJACENT LAKE AREA 2-1

SECTION 3 WASTEBEDS 1-8 CONNECTED WETLAND 3-1

3.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES 3-1

3.2 HYDROLOGY 3-1

SECTION 4 WASTEBED B/HARBOR BROOK OUTBOARD AREA 4-1

4.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES 4-1

4.2 HARBOR BROOK CHANNEL 4-2
4.2.1 Design Objectives 4-2
4.2.2 Design Considerations and Constraints 4-2
4.2.3 Flow Hydrology 4-3

4.3 WATER TEMPERATURE 4-3
4.3.1 Methods 4-4
4.3.2 Results 4-4

4.4 SHORELINE WAVE ATTENUATION 4-5
4.4.1 Historical Wave Analysis 4-5

SECTION 5 TOTAL ORGANIC MATTER CONTENT IN HABITAT LAYER 5-1

SECTION 6 SHORELINE TRANSITION AREAS 6-1

6.1 AREAS WITHOUT ADJACENT REMEDIATION 6-1

6.2 SHORELINE STABILIZATION ADJACENT TO REMEDIATION AREAS 6-1

6.3 SHORELINE STABILIZATION IN AREAS WITHOUT ADJACENT REMEDIATION 6-2

SECTION 7 REFERENCES 7-1

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

Figure K-1 Planting Plan Remediation Area A & Ninemile Creek Spits

Figure K-2 Planting Plan Remediation Area B & WB 1-8 Connected Wetland

Figure K-3 Planting Plan Remediation Area C

Figure K-4 Planting Plan Remediation Area D & Wastebed B Outboard Area

Figure K-5 Onondaga Lake Hydroperiod by Month

Figure K-6 Onondaga Lake Hydroperiod by Year

Figure K-7 Pike Spawning Area Section

Figure K-8 Plan View of Outboard Area Harbor Brook Channel

Figure K-9 Water Temperature in Littoral Zone East of Harbor Brook

Figure K-10 Water Temperature in Littoral Zone West off Harbor Brook

Figure K-11 Water Temperature in Littoral Zone West of Harbor Brook

Figure K-12 Water Temperature in Harbor Brook and Along Bank

Figure K-13 Water Temperature in Littoral Zone Off Ninemile Creek

Figure K-14 Wave Analysis for Outboard Area

Figure K-15 Wave Analysis for Outboard Area

LIST OF TABLES

Table K-1 Annual Flow Evaluation Data Summary Harbor Brook

Table K-2 Dissolved Oxygen Data Summary Harbor Brook

SECTION 1

INTRODUCTION

This appendix provides details associated with the habitat restoration activities within Onondaga Lake and at the mouth of Ninemile Creek, the connected wetlands at the base of Wastebeds 1-8, the Outboard Area near the mouth of Harbor Brook, and the SMU 3 and 4 shoreline. Habitat design features like water depth and areas that will be planted are addressed in this appendix, along with a discussion of shoreline transition areas. Separate submittals describing the details of the structure and planting plans and success criteria will be provided to NYSDEC for review and approval.

SECTION 2

NINEMILE CREEK SPITS AND ADJACENT LAKE AREA

As discussed in Section 4.3.5.1 of the Final Capping, Dredging, Habitat and Profundal Zone (SMU 8) Design Report, the two small areas that extend out into Onondaga Lake at the mouth of Ninemile Creek ("the spits") have been delineated as emergent wetlands. The habitat and planting plan for this area has been integrated with the figures for the adjacent Remediation Area A to ensure a consistent design at the lake shoreline. The integrated design for this area includes removal of the emergent wetlands, which are currently dominated by *Phragmites*, and restoration of the area with an isolation cap similar to the adjacent areas in the lake. The post-remediation acreage of the spits and associated wetland will be the same as currently exists, and the elevations in this area will range from 1 ft. above water to 1 ft. deep. The restoration of these spits includes approximately 1.9 acres of emergent wetland, which will provide connectivity to the shallow littoral areas and Ninemile Creek with floating leaved and submerged vegetation. Figure K-1 illustrates the Habitat Module application and planting plan for this area.

Three vegetative zones have been established for this area of the design. The zones are consistent with the Habitat Modules described in the Draft Habitat Plan (Parsons 2009) and will include floating aquatic, non-persistent emergent wetlands, water fringe (edge of persistent emergent wetland), and interior of persistent wetlands, forested wetlands and shoreline bank area. A discrete Module 6A planting zone at the lake side edge of the module will be developed to separate it from the remainder of the persistent emergent wetland. Plants more tolerant of water energy will be selected for this fringe zone. Module 9B is designed as a deciduous forested wetland and the shoreline bank area consists primarily of wetland and conservation seed mixes.

Details of the planting program will be submitted as an addendum to the Final Design, subject to review and approval by NYSDEC.

SECTION 3

WASTEBEDS 1-8 CONNECTED WETLAND

As discussed in Section 4.3.5.2 of the Final Capping, Dredging, Habitat and Profundal Zone (SMU 8) Design Report, the Wastebed 1-8 wetland complex has both connected and inland wetlands. The designs for the inland wetlands will be provided in the Wastebed 1-8 Design Reports. The connected wetland is designed to be a 2.3-acre freshwater marsh with varied habitat characteristics that will provide high ecological value through plant and wildlife diversity.

3.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES

Three vegetative zones have been established for this design; a deep emergent community, a shallow emergent community, and a wet meadow community. The zones are consistent with the Habitat Modules described in the Draft Habitat Plan (Parsons 2009). The deep emergent community type is planned in areas where the average growing season (May 1 to October 31; Parsons 2009) water depth does not typically drop below 24 inches, with a maximum depth of 36 inches. The deep emergent community comprises nine herbaceous species. The deep emergent design primarily includes submerged aquatic species.

The shallow emergent community type is planned in areas where the average growing season water depth ranges from 6 to 24 inches during a year with normal precipitation; however, this community may dry out during dry years (Edinger *et al.* 2002). The wet meadow community type is planned in areas where the average growing season water depth ranges from 6 inches above to 6 inches below the habitat layer surface. Figure K-2 presents the Connected Wetland Habitat Module application and the designed zonation of plant communities. Details of the planting program will be submitted as an addendum to the Final Design, subject to review and approval by NYSDEC.

3.2 HYDROLOGY

The connected wetland will be located adjacent to Onondaga Lake and directly affected by its water level variation. The design includes a main pool that will be protected from wave energy by a shoreline berm that will be constructed about 10-ft. wide, up to an elevation of 364 ft. (1.5 ft. above the typical growing season water level). Two breeches in the berm will facilitate hydrologic connection with the lake. The upper wetland border is planned at 363 ft. which will, based on historical lake water data (USGS 2010), be flooded 5 percent of the time and will be about 6 inches above the typical lake water level during the growing season. From this upper elevation, the wetland slopes gradually downward to an elevation of 359.5 ft. in the main wetland pool. This elevation will typically provide for a water depth of 30 to 36 inches during the growing season based on data for representative wet (1990) and dry (1999) years (Figures K-5 and K-6). The water depths in the design are based on USGS data from Lakeland station minus the elevation of the bottom of the wetland, or 359.5 ft. Based on this grading plan and likely lake water level variation, approximately 0.6 acres of deep emergent wetland (Habitat Modules 4A

and 5A) are expected to be created as well as 1.2 acres of shallow emergent and 0.5 acres of wet meadow (Habitat Module 6A).

SECTION 4

WASTEBED B/HARBOR BROOK OUTBOARD AREA

As discussed in Section 4.3.5.3 of the Final Capping, Dredging and Habitat, Profundal Zone (SMU 8) Design Report, habitat restoration for the Wastebed B/Harbor Brook Outboard Area is designed using the seasonal inundation of areas along the shoreline to create habitat suitable for northern pike (*Esox lucius*) reproduction. The design focuses on providing the appropriate water depths at the appropriate time of year (and concomitant water temperature) for northern pike spawning in shallow (6 inches to 3.5 ft. water depth range, 362.75-359.75 ft. elevation) and deep emergent wetlands (3.5 ft. to 6.5 ft. water depth range, 359.75-356.75 ft. during spawning season). Figure K-7 provides a general cross section of this condition. Restored habitats will include the Harbor Brook channel, shallow and deep emergent wetlands, forested wetlands, and transition to upland areas (Figure K-4). Figure 4.4 in the design provides sectional and cap profile illustration that correlate to Figure K-4.

4.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES

The free exchange of water between the lake, Harbor Brook, and the shallow and deep emergent wetlands is a key element of the design to support a robust mix of plant species to transition from upland habitat near the barrier wall to wetland habitats along the shoreline.

Figure K-4 describes the Habitat Module delineation, and areas to be planted. Module 6A is divided into three planting zones; wetland fringe, persistent emergent interior, and persistent emergent Harbor Brook. Because of the specific targeted goal to provide northern pike spawning habitat, a specific plant list was developed for Module 6A for this area that emphasizes grasses, sedges, and narrow-leaved emergents. Similar to Module 6A in Remediation Area A, there is a different planting zone for the lake ward fringe of Module 6A as well as a 25-ft. planted buffer strip lake ward of the current outboard area shoreline designed specifically to encourage a robust transition from lake to wetland. The habitat layer will be topsoil and will be planted with species appropriate to adjacent Habitat Modules 3B, 5A, and 6A (See figure 4.4). Flowering plant species are proposed in the remainder of Module 6A and module 8B.

The critical vegetative transition from upland to wetland vegetation occurs from the top of the barrier wall to an elevation of approximately 364.5 in the outboard area. This transition zone will consist of primarily scrub/shrub forest species that will be planted and seeded including native willows (*Salix* spp.), maples (*Acer* spp.), dogwoods (*Cornus* spp.), and alder (*Alnus incana* ssp. *rugosa*). Details of the planting program will be submitted as an addendum to the Final Design, subject to review and approval by NYSDEC.

The forested wetlands located at the terminus of the former East Flume in the Outboard Area will provide additional wetland diversity in this area. The design includes a variety of native woody tree and shrub species that will provide organic material and leaf litter to the adjacent emergent system, as well as wildlife habitat. Due to the limited acreage of forested wetlands

adjacent to the lake, this additional forested acreage will add valuable diversity along the Wastebed B shoreline.

4.2 HARBOR BROOK CHANNEL

The Harbor Brook Channel will provide increased sinuosity and length and sufficient water depths under low flows to support fish passage. The channel banks will be sloped to maximize wetland acreage in the surrounding low lying areas and provide stability. Based on the flows and velocities in the Harbor Brook channel and the lake surface elevations, a final (i.e., to be constructed as part of the lake work) channel alignment was developed (Figure K-8). The upstream thalweg elevation is set at 360.4 ft., equal to the culvert invert elevation, with a downstream thalweg elevation of 360.4 ft. The channel slope is flat out to the lake since the hydrology in this area is driven by the lake level. The wetland areas described above will be inundated by the lake, rather than flows overtopping the channel banks, although a significant brook discharge coupled with a low lake level will also inundate the wetland areas. Design objectives, considerations and constraints, and flow hydrology for Harbor Brook are discussed in further detail below.

4.2.1 Design Objectives

The objectives for the Harbor Brook channel design include:

- Maintaining the design hydraulic capacity of Culvert #1
- Providing a channel design that is constructible with the anticipated habitat layer material
- Providing a channel that allows for maximum wetland area for northern pike spawning
- Providing an increase in channel length and sinuosity
- Allowing for periodic sediment deposition and erosion in the channel
- No increase in flooding or water surface elevation during storm events

4.2.2 Design Considerations and Constraints

A preliminary hydraulic and hydrological evaluation was completed to identify a potential final channel alignment. The following channel design considerations were used to satisfy the channel design objectives and work within the design constraints presented by the remediation design:

- In order to maintain the design discharge capacity of Culvert #1, a channel bottom width of 20 ft. was selected to match the culvert's bottom width. Using a consistent bottom width maintains the effective flow area and does not create a downstream constriction for flow through the culvert and thereby does not reduce the design discharge capacity of Culvert #1.
- The upstream channel thalweg elevation matches the proposed Culvert #1 outlet invert of 360.4 ft.
- Although a vertical bank E type channel (Rosgen 1996) has been suggested by state environmental agencies to be desirable for other stream restorations in the vicinity of

Onondaga Lake, the restoration of Lower Harbor Brook is not amenable to this channel type. The stability of the habitat fill material and the depositional setting caused by the backwater effect of Onondaga Lake, limit the ability to create an E-type channel for Lower Harbor Brook. The side slopes for the channel are 4:1, which is the slope used for all capped areas.

- The typical backwater condition in the channel caused by the lake limits flow velocities and shear stresses. These hydraulic conditions are likely to permit the deposition of finer grained material (e.g., silt, sand and gravels) in the channels that are transported into the area by Harbor Brook. A more complex channel design would further reduce velocities and shear stresses, allowing the channel to fill in with sediment over time.
- The wetland areas are designed to be inundated primarily by the lake, rather than flows overtopping the channel banks. Although a significant brook discharge coupled with a low lake level will also inundate the wetland areas.
- The upstream and downstream thalweg elevation (360.4 ft.) provides a minimum water depth of 2.1 ft. for a lake level of 362.5 ft. at a negligible channel discharge.

4.2.3 Flow Hydrology

Using the mean daily discharge data from the USGS gage 04240105 on Harbor Brook, percent exceedance discharges were calculated on a daily basis for the period of record. The minimum, mean, and maximum discharges were also calculated on a daily basis for the period of record. These daily statistics were then averaged to determine representative monthly values.

The monthly discharge exceedance probability values aggregated from the daily exceedance probability calculations are provided in Table K-1. The average value for the water year is also provided in the far right column for each exceedance probability.

The annual flow hydrology analysis indicates that a majority of the time the channel water surface elevation will be primarily determined by the lake's water surface elevation as the channel discharge will be significantly less than the channel's discharge capacity. In addition, as discussed above, the Harbor Brook channel thalweg elevation will be from 360.4 ft. As shown in Figure 3 in Attachment D to the Geddes Brook 100% Design Report (Parsons and Anchor QEA, 2011), the lake level has never been below 361 ft. (based on the period of record 1970-2009). As such, the channel will have a minimum of 7 inches, regardless of Harbor Brook flow.

4.3 WATER TEMPERATURE

Water temperature data were collected from the littoral zone in and around Harbor Brook from March through mid-May, 2011 to estimate the time period in Onondaga Lake when preferred water temperatures for spawning are available to confirm the design elevations selected for this area. The specific objective for the water temperature monitoring is to evaluate water temperatures in the shallow nearshore littoral zone in Onondaga Lake near Harbor Brook to better understand the potential timing of northern pike spawning in this system.

Water temperature was monitored at several locations in Harbor Brook and Onondaga Lake from just after ice out in early March to mid-May to determine the timing for preferred conditions for pike spawning.

4.3.1 Methods

HOBO® data loggers were placed in the lake near Harbor Brook in 1, 2, and 5 ft. of water (3 locations each), in the Harbor Brook channel, along the Harbor Brook bank, and near Ninemile Creek in 1 and 2 ft. of water. Monitors were programmed to record water temperature hourly. Data loggers were installed at each targeted water depth on March 11, 2011, in the Harbor Brook area just after the majority of ice out, and on March 23, 2011 in the Ninemile Creek area (ice out was later in this area). Loggers were attached to cinder blocks at the deep locations, and a dog stake in the shallower depths and suspended just above the substrate (i.e., approximately 6 inches). Monitors were inspected, location slightly adjusted if not within the targeted water depth, and the temperature data were downloaded on a weekly basis.

Dissolved oxygen was measured at each location using a hand held probe during each download. This data is summarized in Table K-2. Locations were not visited during May due to high water and safety concerns; loggers were removed from the lake on June 6, 2011.

4.3.2 Results

Data from the hourly temperature readings at each location from late March through mid-May are presented in Figures K-9 through K-13. One logger was not able to be downloaded following the first event on April 4 (Harbor Brook West Bank); data are not available from this location after this date. Several loggers were out of the water during downloading due to water level fluctuations and were relocated in the appropriate water depth (generally within 10-30 ft. of original location); these are noted on each figure as applicable. The preferred northern pike spawning temperature range (between 41°F and 55°F) is provided on each graph for comparison with the collected data.

Based on visual inspection of the figures, there is not a discernable difference in temperature among the various depths along the shoreline, all three depths appeared to reach suitable spawning temperatures approximately mid-March and extended into early May (Figures K-9, 10, 11). The Harbor Brook channel and wetland locations also followed the same general trend as the littoral locations with suitable spawning temperatures recorded between mid-March to late April (Figure K-12). The Ninemile Creek location warmed later with suitable spawning temperature recorded near the end of March and lasting into early May (Figure K-13). These results are consistent with the assumptions in the Intermediate Design with water surface elevations during March to late April used to determine the habitat layer elevation.

Dissolved oxygen measurements recorded from each location during weekly downloads ranged from 9.19 to 12.79 mg/L (Table K-2). These are consistently higher than minimum dissolved oxygen concentration (4.5 mg/L) that is suitable for embryo development (Inskip 1982). As long as eggs remain suspended on the vegetation, dissolved oxygen concentrations should be suitable for incubation and hatching in the future.

4.4 SHORELINE WAVE ATTENUATION

An evaluation was completed to determine if measures to attenuate wave energy, such as an offshore wave break, are necessary to facilitate northern pike spawning and wetland development in the WBB/HB Outboard Area. Some degree of water movement is beneficial and necessary to create suitable pike spawning habitat (Casselman and Lewis 1996, Brodeur et al. 2004). However, water movement caused by large waves (i.e., > 2 ft.) could hinder the establishment of wetland vegetation, which is also required for suitable pike spawning habitat. As discussed in Section 4.2.3, Harbor Brook channel flows are generally low, and velocities and sheer stresses are low due to the backwater effect of the lake and are unlikely to affect wetland vegetation. The potential for waves to impact the site due to the long fetch associated with this portion of the lake was evaluated based on wind data from1942 to 2009. The results of the wind analysis, presented below, demonstrate that there is only a 3 percent chance of a wave greater than 1.0 ft. reaching the shore in this area. The period of March 15th - April 7th was selected to capture the pike spawning season and the beginning of the growing season in the spring for plants that may be subjected to wave action. During this period, over 60 percent of the time there are no measurable waves that reach the shore.

Due to the limited potential for large waves to impact the site, and the desire to allow water movement to support pike spawning and vegetative growth, it is not necessary to construct permanent feature(s) above the average lake level to attenuate wave energy.

4.4.1 Historical Wave Analysis

One of the key design considerations for the habitat restoration is the amount of wave energy that reaches the Harbor Brook/Outboard shoreline. From May 18, 2005 to August 4, 2005, Upstate Freshwater Institute (UFI) measured significant wave heights in the littoral zone in vicinity of the ILWD (Owens et al, 2009). The maximum significant wave heights were measured to be approximately 2-3 ft. Long-term historical wave height measurements have not been collected in Onondaga Lake. Therefore, an analysis of wave heights at this location was performed to evaluate the frequency of various wave heights.

Historical wave heights were estimated from continuous wind measurements collected at the Hancock International Airport from 1942 to 2009 using the procedures described in Section 5 – Wind-Wave Analysis of the Armor Layer Design Appendix to the *Draft Onondaga Lake Capping and Dredge Area and Depth Initial Design Submittal*. This report was submitted to the New York Department of Environmental Conservation (NYSDEC) in December 2009. That report describes the wind-wave analysis methods and procedures in detail, provides documentation of the inputs and data used in the analysis, and presents an example calculation. The procedures used in the analysis are summarized below.

Continuous hourly wind measurements (speeds and direction) from 1942 to 2009 were obtained from Hancock International Airport. The airport is located approximately 5 miles east of Onondaga Lake. The winds were measured at the following heights above the ground:

- 1942 to 1949: 57 ft.
- 1949 to 1962: 72 ft.

- 1962 and 1963: 84 ft.
- 1963 to 2009: 21 ft.

The methodology used to estimate wind speeds for wave prediction is consistent with that described in Part II – Chapter 2 of the U.S. Army Corps of Engineers (USACE's) *Coastal Engineering Manual* (CEM; USACE 2006). In accordance with the CEM, the measured wind speeds were first converted to hourly-averaged wind speeds at heights of 32.8 ft. (10 meters) above the ground for predicting waves (USACE 2006). The hourly-averaged wind speeds were then converted to 15-minute-averaged wind speeds using procedures outlined in the CEM. In large lakes, the wave generation process tends to respond to average winds over a 15- to 30-minute interval (USACE 2006), because shorter duration gusts are generally not sufficient for significant wave generation. It is assumed that Onondaga Lake represents fetch-limited conditions and not duration-limited conditions for wave growth. Using 15-minute averages produces higher wind speeds than 30-minute averages, so the more conservative 15-minute averaging interval was used in this analysis. The methods described in the USACE *Automated Coastal Engineering System* (ACES) computer program were used to model wave growth and propagation due to winds (USACE 1992).

The wave analysis was performed using wind data collected for all months, as well as between March 15 and May 15. The period March 15 to May 15 are the critical time periods for northern pike spawning and initial plant growth. Wind directions were divided into 30-degree bins, and for each parcel, a representative fetch was estimated for each directional bin from the shoreline near the Harbor Brook confluence with Onondaga Lake. For each wind speed and direction, the corresponding significant wave height and period were calculated, and wave roses were developed for each parcel. The significant wave height and period represents the average of the largest 1/3 of all the wave heights and periods.

Figure K-14 presents the wave roses for all months and for the March 15 to May 15 period, respectively. The largest significant wave heights are from the northwest. There is a slightly higher percentage of waves in the 1-2 ft. range during the March 15 to May 15 period, compared to the average for all months. However, the cumulative frequency distribution of computed significant wave heights for all months, and for the March 15 to May 15, period shows that wave heights in excess of 1 ft. occur very infrequently, less than 3 percent of the time in either time period. (Figure K-15.)

SECTION 5

TOTAL ORGANIC MATTER CONTENT IN HABITAT LAYER

The amount of organic matter in lake sediments can vary considerably. In Onondaga Lake, areas with higher organic matter are generally associated with tributary deltas and deeper depositional areas. This pattern is understandable since in lacustrine systems, allochthonous input is generally much larger compared to internal (autochthonous) sources. Over time, the organic matter levels in the sediments placed in Onondaga Lake as part of the remedy are expected to reflect existing patterns due to continued organic matter input from the watershed and addition of organic matter is not considered to be necessary in all locations. However, in wetland locations, topsoil will be used as the habitat layer to support initial plant establishment. The amount of organic matter in the habitat layer was determined based on samples collected from wetlands adjacent to the lake in SYW-10 and Geddes Brook floodplain and review of the scientific literature (Ballantine and Schneider 2009). The sediment samples from SYW-10 and Geddes Brook flooplain had average organic matter content values of 4.7 percent and 3.1 percent, respectively, with an overall range of 1.8 percent to 15.6 percent. Based on that range and results from other studies (Bishel-Machung et al. 1996; Bruland and Richardson 2006; Campbell et al. 2002), a target range 5 percent to 15 percent and an approximate average of 7.5 percent was selected for the wetland modules that will be planted as discussed in Section 4.3.6 of the final design.

The areas currently colonized by submerged macrophytes in Onondaga Lake have organic matter values that range from 0.1 percent to 31 percent. This wide range is consistent with the range of values observed at other sites (e.g., St. Louis River Tar Site). This is also consistent with the scientific literature which shows that submerged macrophytes exist under a wide variety of environments. One aspect of the physical environment, sediment properties, has been widely studied, in particular sediment grain size, organic matter content and sediment nutrients (Van Wijck et al., 1991, Koch, 2001). Rogers et al. (1992) reported that sediments in a *Vallisneria* bed in Lake Onalaska were intrinsically infertile and plant growth was dependent on nutrient supply/renewal, most likely by way of sedimentation (Rogers et al. 1992). Other studies have shown that high levels of organic matter can inhibit growth of submerged macrophytes (Barko and Smart 1983). Since 2005, submerged macrophytes in Onondaga Lake have rapidly expanded into areas with varying sediment types and organic matter ranging from 0.17 percent to 26 percent.

Successful colonization of sediments with such a wide range of organic matter suggests that organic matter levels were not the primary factor limiting the distribution of submerged macrophytes. Rather, the increased macrophyte distribution is likely the result of increased light availability due to water quality improvements. As such, addition of organic matter to the submerged macrophyte habitat modules is not considered necessary. Natural colonization of these areas from the native seed bank is expected to occur fairly rapidly. The exceptions to this are the habitat modules adjacent to the Ninemile Creek spits, and a 25 ft. transition zone within

the lake adjacent to the Outboard Area. As discussed in Sections 2 and 3, these areas will be planted, and therefore the habitat substrate in these areas will consist of topsoil with an organic content of 5 percent to 20 percent.

Benthic macroinvertebrates (BMI) also comprise an important component of secondary production in the littoral zone. The distribution and composition of the BMI community is based on a combination of factors including physical and biological habitat conditions, feeding mode and food ability (Merritt and Cummins 1988). Physical factors such as littoral slope and water depth have been shown to be the most critical factors influencing benthic community composition of lakes (Duarte and Kalf 1986; Rasmussen 1988; Stantec 2006). Sediment organic content has also been shown to be important. In lacustrine systems, BMI feed on particulate organic matter that settles to, or grows upon, the substrate (Rasmussen 1988). While the amount of particulate organic matter produced within the lake has decreased due to improvements in water quality (and concomitant reduction in primary production by algae), there is still significant particular organic matter produced within and entering the lake. Higher organic matter can reduce oxygen levels in sediments and at the sediment-water interface, and thus reduce the abundances of taxa like mayflies and caddisflies that have a higher requirement for oxygen than worms, chironomids and clams (Hilsenhoff, 1987). Therefore, addition of organic matter to the habitat layer is not considered necessary to support benthic macroinvertebrates.

SECTION 6

SHORELINE TRANSITION AREAS

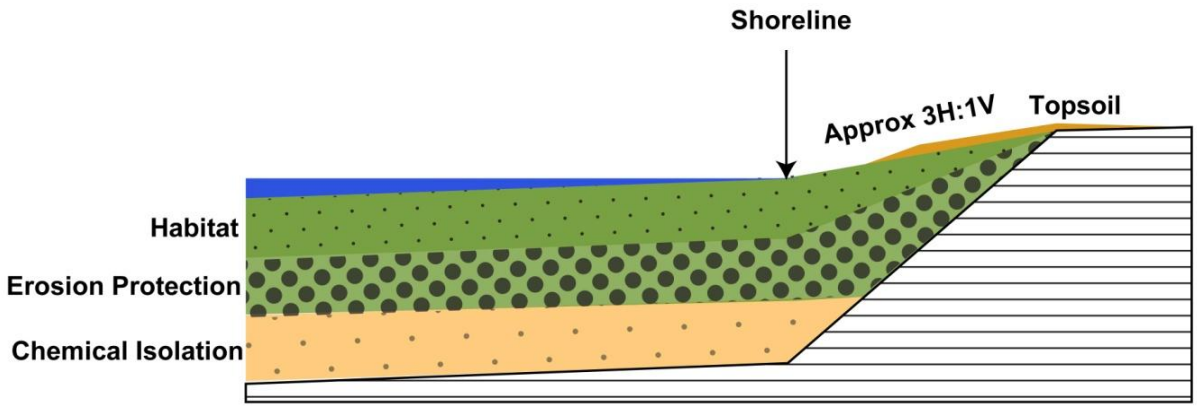
6.1 AREAS WITHOUT ADJACENT REMEDIATION

In areas where the dredge and cap design does not abut adjacent shoreline remediation, such as Remediation Areas C and E, the treatment for the shoreline areas will be the same as was used in the Willis Avenue Lakeshore Barrier Wall IRM (Site No.: 734026) Restoration/Mitigation Design Semet IRM (Parsons 2009). This restoration will include placement of top soil over the restored habitat layer above elevation 362.5 ft., and the establishment of a native plant community using upland and shoreline plantings and seeding.

Topsoil will be placed using conventional construction techniques. Once grading is completed, the upland area above elevation 362.5 ft. will be seeded with the conservation seed mix. Details of the planting/seeding program will be submitted as an addendum to the final design.

The second component of the shoreline transition includes the establishment of shrub species along the lake shoreline. The establishment of waterside vegetation will provide shade and leaf litter input that will enhance the fish and benthic macroinvertebrate habitat in the adjacent shallow water areas of Onondaga Lake that will be restored as part of the in-lake remediation work (Figure K-3.)

A typical schematic section is described below.



6.2 SHORELINE STABILIZATION ADJACENT TO REMEDIATION AREAS

There are several areas within the lake that require remediation up to the shoreline along Wastebeds 1-8. Per the requirements outlined in the ROD, shoreline stabilization is required

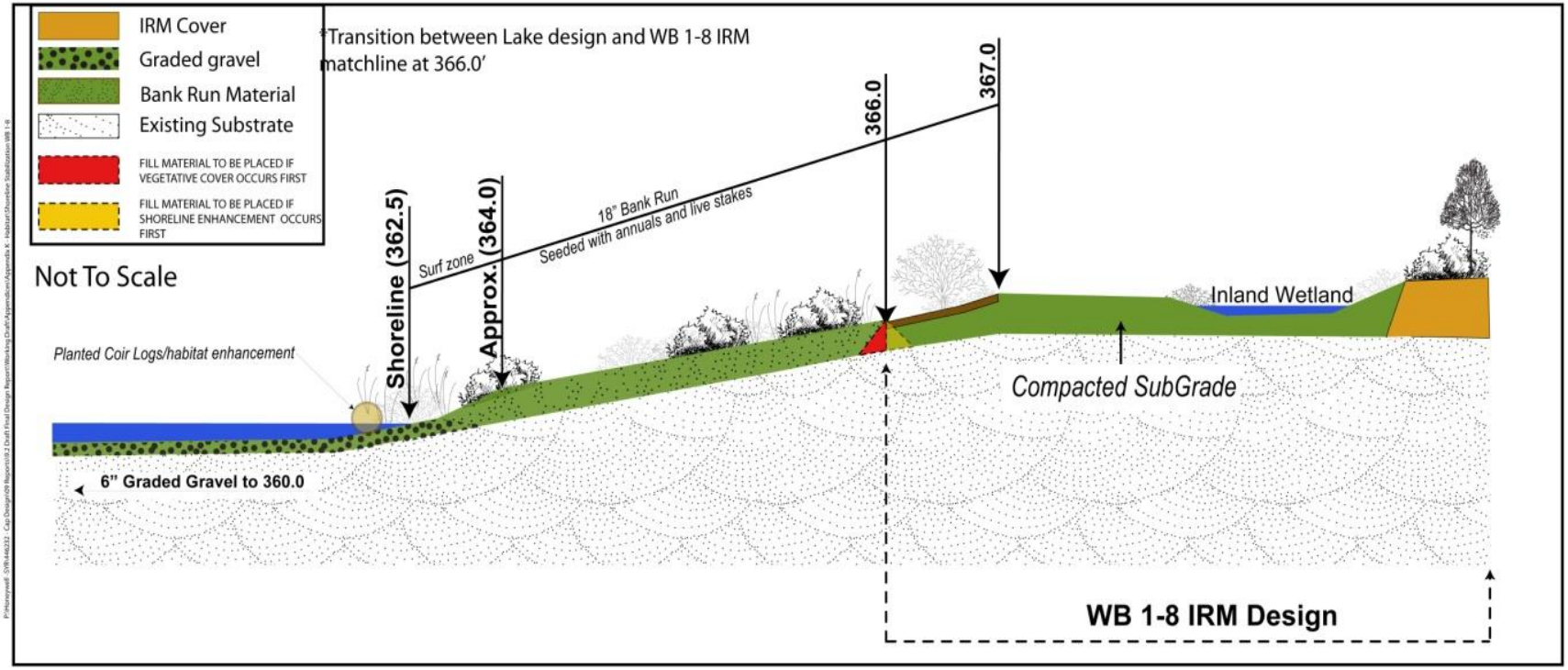
along the shoreline in this area. Given the sloping condition required for the dredge cut in these areas as noted on the cross section above for the isolation cap and habitat layer, the shoreline treatment will cover the adjacent upland area (362.5-365 ft.) and additional shoreline stabilization will not be required.

6.3 SHORELINE STABILIZATION IN AREAS WITHOUT ADJACENT REMEDIATION

The majority of the Wastebeds 1-8 shoreline does not require remediation for the adjacent in the lake areas. However, the shoreline stabilization requirements from the Onondaga Lake ROD identify the need to address this shoreline area. The in-lake portion of the stabilization will consist of 6 inches of graded gravel from elevation 360-362.5 ft. This elevation was determined by evaluating the surf zone for the 10-yr. storm event. The design in this area will enhance the existing shoreline with structure and planting with minimal impact on lake surface area.

In order to address resuspension of Solvay waste materials due to shoreline wave action and enhance the ecological integration of the Wastebed 1-8 IRM with the lakeshore edge, material placement and planting will be conducted from 362.5 to 365 ft. (existing conditions). A summary of the design in this area is included below along with a schematic cross section.

- 18 inches of native run-of-the-bank material will cover from the average lake shoreline (362.5 ft.) up to 366.0 ft.
- 362.5 to 366.0 ft.; this area will be planted with 2-inch plugs and seeded with native annuals and perennials in addition to placement of coir logs and larger woody debris (plant species to be consistent with predicted hydrology).
- Targeted placement of pre-vegetated, bio-degradable coir logs along the shoreline adjacent to the perched wetlands at the 362.0 elevation (locations to be shown in the design addendum). The area between and upland of coir logs will be seeded with native grasses and forbs. This approach will provide suitable area for additional sediment trapping and development of shoreline vegetation. Additionally, this enhancement will create a smooth vegetated transition to the shoreline revetment activities in the Wastebed 1-8 IRM.
- Live stakes will be installed into the 18 inches of native bank run material along SMU 3 shoreline between elevation 363 and 366 to provide vegetated buffer to invasive colonization along shoreline as well as shading for nesting birds and mammals.


IRM Cover
Graded gravel
Bank Run Material
Existing Substrate
FILL MATERIAL TO BE PLACED IF VEGETATIVE COVER OCCURS FIRST
FILL MATERIAL TO BE PLACED IF SHORELINE ENHANCEMENT OCCURS FIRST
*Transition between Lake design and WB 1-8 IRM matchline at 366.0'
Not To Scale
Shoreline (362.5)
Approx. (364.0)
Surf zone
18" Bank Run
Seeded with annuals and live stakes
366.0
367.0
Inland Wetland
Planted Coir Logs/habitat enhancement
Compacted SubGrade
6" Graded Gravel to 360.0
WB 1-8 IRM Design

SECTION 7

REFERENCES

Ballantine, K. and R. Schneider. 2009. Fifty-Five Years of Soil Development in Restored Freshwater Depressional Wetlands.

Barko, J.W. and R.M. Smart. 1983. Sediment-Related Mechanisms of Growth Limitation in Submersed Macrophytes. Ecology 67(5):1328-1340.

Basset, C.E. 1994. Use and Evaluation of Fish Habitat Structures in Lakes of the Eastern United States by the USDA Forest Service. Bulletin of Marine Science 55(2-3): 1137-1148(12).

Bishel-Machung et al. 1996. Soil Properties of Reference Wetlands and Wetland Creation Projects in Pennsylvania. Wetlands 16(4):532-541.

Boers, A.M. and J.B. Zedler. 2008. Stabilized Water Levels and *Typha* Invasiveness. Wetlands 28(3): 676-685.

Brodeur, R.D., Emmett, R.L., Fisher, J.P., Casillas, E., Teel, D.J. and T.W. Miller. 2004. Juvenile Salmonid Distribution, Growth, Condition, Origin, and Environmental and Species Associations in the Northern California Current. Fisheries Bulletin 102:25-46.

Bruland, G. L., and C. J. Richardson. 2006. Comparison of Soil Organic Matter in Created, Restored and Aired Natural Wetlands in North Carolina. Wetlands Ecology and Management 14:245–251.

Campbell et al. 2002. A Comparison of Created and Natural Wetlands in Pennsylvania, USA. Wetlands Ecology and Management 10:41–49.

Casselman, J.M. and C.A. Lewis. 1996. Habitat Requirements of Northern Pike (*Essox lucius*). Canadian Journal of Fisheries and Aquatic Sciences 53(S1): 161-174.

Duarte, C. and J. Kalff. 1986. Littoral Slope as a Predicator of Maximum Biomass of Submerged Macrophyte Communities. Limnol. Oceanogr. 31:1072-1080.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. (Draft for review). New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

Hilsenhoff, W.L. 1987. An Improved Biotic Index of Organic Stream Pollution. Great Lakes Entomologist, 20:31-39.

Houser, D.F. 2007. Fish Habitat Management for Pennsylvania Impoundments. Pennsylvania Fish and Boat Commission.

Inskip, P.D. 1982. Habitat Suitability Index Models: Northern Pike. Fish and Wildlife Service Fort Collins Co Western Energy and Land Use Team.

Koch, 2001. Beyond Light: Physical, Geological, and Geochemical Parameters as Possible Submersed Aquatic Vegetation Habitat Requirements. Estuaries 24(1):1-17.

Merritt, R.W., and K.W Cummins. 1988. An Introduction to the Aquatic Insects of North America, second edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Owens, E.M., R. Bookman, S.W. Effler, C.T. Driscoll, D.A. Matthews, and A.J.P. Effler. 2009. Resuspension of Mercury-Contaminated Sediments from an In-Lake Industrial Waste Deposit. Journal of Environmental Engineering, 135:7(526).

Parsons. 2009. Remedial Design Elements for Habitat Restoration. Prepared for Honeywell. Morristown, NJ. December 2009

Parsons, 2011b. 100% Design Report for the Geddes Brook Interim Remedial Measure. Prepared for Honeywell, Inc. by Parsons. March 2011.

Parsons. 2005. Onondaga Lake Pre-Design Investigation: Data Summary Report. Prepared for Honeywell, Morristown, New Jersey. Syracuse, New York.

Parsons. 2009c. Onondaga Lake Pre-Design Investigation: Phase II Data Summary Report. Prepared for Honeywell, Morristown, New Jersey and Syracuse, New York

Parsons. 2009d. Onondaga Lake Pre-Design Investigation: Phase III Data Summary Report. Prepared for Honeywell, Morristown, New Jersey and Syracuse, New York

Parsons 2009e. Onondaga Lake Pre-Design Investigation: Phase IV Data Summary Report. Prepared for Honeywell, Morristown, New Jersey and Syracuse, New York

Parsons, 2010. Onondaga Lake Phase IV Pre-Design Investigation Data Summary Report. Prepared for Honeywell. July. Draft.

Pratt, T.C. and K.E. Smokorowski. 2003. Fish Habitat Management Implications of the Summer Habitat use by Littoral Fishes in a North Temperature Mesotrophic Lake. Canadian Journal of Fisheries and Aquatic Sciences 60(3): 286-300.Rasmussen, J.B. (1988): Littoral Zoobenthic Biomass in Lakes, and Its Relationship to Physical, Chemical and Trophic Factors. Canadian Journal of Fisheries and Aquatic Science. 45: 1436- 1447.

Rogers, S. J., D.G. McFarland and J.W. Barko. 1992. Evaluation of the Growth of Vallisneria Americana Michx. in Relation to Sediment Nutrient Availability. Lake and Reserv. Manage. 11(1): 57-66.

Rosgen, D. L., 1996. “Applied River Morphology”, Wildland Hydrology Books, 1481 Stevens Lake Road, Pagosa Springs, Co. 81147, 385 pp.

Smokorowski, K.E. and T.C. Pratt. 2007. Effect of a Change in Physical Structure and Cover on Fish and Fish Habitat in Freshwater Ecosystems – A Review and Meta-Analysis. Environmental Reviews 15: 15-41.

Stantec. 2006. Benthic Macro-invertebrate Sampling and Analysis of Lake Simcoe Final Report. Prepared for Lake Simcoe Region Conservation Authority. March.

United States Army Core of Engineers (USACE). 1992. Coastal Engineering Manual (CEM).

United States Army Core of Engineers (USACE). 1992.

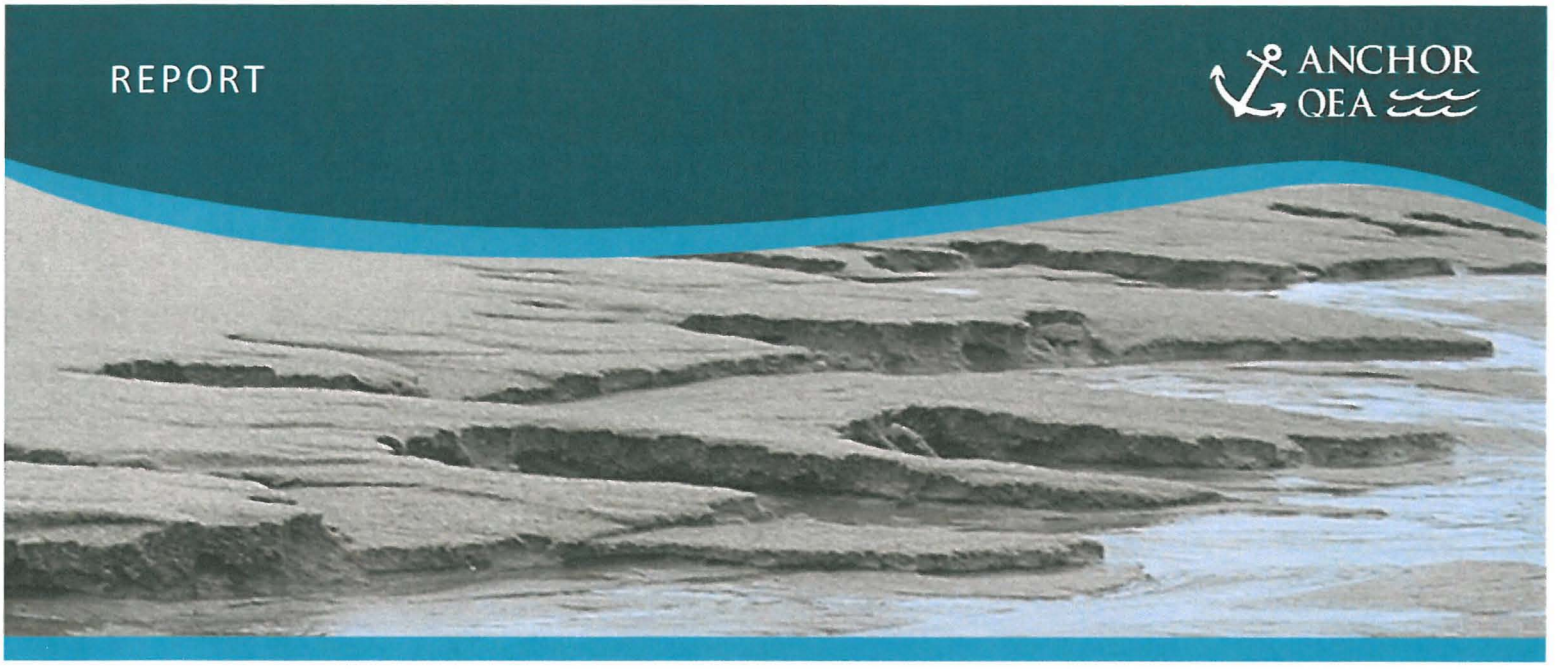
USGS Historical Water Data. 2010. http://waterdata.usgs.gov/ny/nwis/swVan Wijck, C., C.J. De Groot, and P. Grillas. 1991. The Effect of Anaerobic Sediment on the Growth of Potamogeton pectinatus L.: The Role of Organic Matter, Sulphide and Ferrous Iron. Aquat. Bot. 44:31-49.

Wilbur, R.L. 1974. Florida's Freshwater Fish Attractors. Project F-26. Florida Game and Freshwater Fish Commission, Tallahassee.

APPENDIX L

CAP MATERIAL SPECIFICATIONS

REPORT



CAP MATERIALS SPECIFICATIONS APPENDIX – ONONDAGA LAKE

Prepared for

Honeywell
PARSONS

Prepared by

Anchor QEA, LLC

March 2012

Matthew R. Henderson, P.E.
New York State Professional Engineer
License No. 083603-1

Date: March 2, 2012

It is a violation of law for any person, unless he is acting under the direction of a licensed professional engineer, to alter this item in any way. If this item bearing the seal of an engineer is altered, the altering engineer shall affix to this item his seal and the notation "altered by" followed by his signature and the date of such alteration, and a specific description of the alteration.

APPENDIX L
CAP MATERIAL SPECIFICATIONS

Prepared for

Honeywell

PARSONS

Prepared by

Anchor QEA, LLC
290 Elwood Davis Road
Liverpool, NY 13088

March 2012

TABLE OF CONTENTS

1 INTRODUCTION 1

2 CONSIDERATIONS RELATED TO CAP MATERIAL GRADATIONS 2

3 SPECIFICATION DEVELOPMENT FOR AGGREGATE MATERIALS 5

4 AMENDED CAP MATERIALS 14

4.1 Granulated Activated Carbon 14

4.2 Siderite 14

5 EARTHEN MATERIAL CHEMICAL CRITERIA 16

6 REFERENCES 20

List of Tables

Table 1 Habitat Material and Erosion Protection Layer D_{50} 5

Table 2 Erosion Protection Materials Initial Design D_{50} by Remediation Area 8

Table 3 Final Design Material Types 10

Table 4 Armor and Isolation Material Filter Criteria Comparison 12

Table 5 Unrestricted Use Soil Cleanup Objectives 16

List of Figures

Figure 1 Sand Material Gradations

Figure 2 Gravelly Cobbles and Gravel Material Gradations

Figure 3 Gravel Filter Criteria Comparison

Figure 4 Gravelly Cobbles Filter Criteria Comparison

List of Attachments

Attachment A Earthen Material Specifications

LIST OF ACRONYMS AND ABBREVIATIONS

CQAP	Construction Quality Assurance Plan
GAC	Granulated Activated Carbon
Lake	Onondaga Lake
mg/g	milligrams per gram
mm	millimeters
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This document presents the process for developing specifications for capping and habitat materials for the Onondaga Lake (Lake) remediation project. In addition to the conventional aggregate materials necessary for cap construction, amended cap materials (e.g., Granulated Activated Carbon [GAC] and siderite) are incorporated into the design of the chemical isolation layer materials.

Materials to be used in the construction of caps in the Lake and adjacent wetlands can be categorized into habitat, chemical isolation, and erosion protection materials based on their function within the overall cap design. For habitat materials, general grain size characteristics were identified to provide the desired habitat substrate; additional details regarding habitat material development are included in Section 4.3 and Appendix K of the Onondaga Lake Capping, Dredging, and Habitat Final Design Report (Final Design). Similarly, chemical isolation material characteristics were identified to provide the selected isolation properties (primarily based on porosity) in conjunction with the design mixes of siderite and GAC. Appendix B of the Final Design provides additional details on the design of the chemical isolation layer. The general grain size characteristics of erosion protection materials were selected based on the hydrodynamic and wave conditions expected within each remediation area as discussed in Appendix D of the Final Design.

In general, the specifications for the capping materials for the Lake and adjacent wetlands were developed through a series of steps including the following:

- Initial design requirements based on habitat objectives and erosion protection evaluations
- Consideration of site-specific design factors
- Development of gradation specifications

These steps and the resulting specifications are discussed in detail below.

2 CONSIDERATIONS RELATED TO CAP MATERIAL GRADATIONS

Technical analyses completed as part of the Lake design included the initial development of general material classifications and mass median particle sizes (D_{50}: diameter at which 50 percent by weight is finer) required by the design. These initial design requirements are narrowly focused on the material type or D_{50} particle size and do not include a complete gradation specification. Therefore, a number of factors (including site-specific factors) were considered in developing the complete material specifications, including the following:

- Local availability of materials: The local availability of cap materials was considered to minimize transport distances and associated environmental impacts. Furthermore, use of a local source provides for "just-in-time" deliveries to the project site, which reduces the required on-site storage requirements. Though not a driver for cap design, locally available materials were considered when developing gradations so as not to unreasonably limit material sourcing. All potential influences of local materials were verified to pass design criteria prior to incorporation in gradation development.
- Material processing effort required to meet specifications: Honeywell has committed to focus on sustainability for the overall Syracuse portfolio of projects. As part of this focus, cap material specifications were aimed at minimizing the level of effort required to produce the materials as well as minimizing the amount of by-product generated by the processing that would not otherwise be used for the Onondaga Lake project or other local projects.
- Habitat considerations: The potential for cap materials to provide suitable habitat functionality was also considered during material specification development. Naturally occurring rounded or run-of-bank material is preferred over crushed rock to aid in habitat development. In addition, topsoil with an organic matter content requirement for specified habitat materials is included to provide suitable substrate in wetland areas and areas of the lake that will be planted.
- Cap material placement equipment and limitations: As discussed in Section 4.5 of the Final Design, the majority of capping materials will be placed using a hydraulic spreader system. Discussions with the selected contractor regarding the ability to hydraulically transport the materials without excessive pumping and pipeline issues lead to identifying an upper size limit (e.g., D_{100}) of approximately 2 to 3 inches in

diameter for gravels and sands. Larger diameter materials (e.g., gravelly cobbles and coarse gravels) will be placed mechanically; therefore, the restriction was not applied to those materials.

- Required quantities: Required quantities of material were reviewed to evaluate the feasibility for minimizing the total number of material types required. By evaluating the quantity of materials involved at different design sizes, it was possible to reduce the total number of specified material types by combining several required sizes under one specified material. For example, design requirements indicate that several areas require sand-sized particles with varying median diameters (D_{50} ranging between 0.03 and 0.08 inches for these areas). Because the median particle sizes for these areas were not significantly different, the design requirements for the areas were combined into a single specification where the specified D_{50} will be at least 0.08 inches, thereby satisfying the minimum sizing requirements for stability for the range of required materials.
- Well-graded materials: Development of gradations considered the design D_{50} values and criteria from the U.S. Army Corps of Engineers (USACE) Engineering Manual 1110-2-2300 - General Design and Construction Considerations for Earth and Rock-Fill Dams (USACE 2004). In addition, the potential for vertical migration of one granular material through another (often referred to as "piping") was considered, as recommended by the U.S. Environmental Protection Agency (USEPA)/USACE's "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments" (Palermo et al. 1998). The potential for piping can be minimized through the use of well-graded gradations for the two materials. The compatibility of the two materials in combination was verified in accordance with geotechnical filter criteria (Terzaghi and Peck 1967).
- Fines content relative to water quality (turbidity): To minimize the potential for turbidity to impact water quality during material placement, the fines content (percent passing the U.S. no. 200 sieve) of each material type was considered. Section 3 discusses specification of a range of fines content and a target within that range that will achieve the objectives of minimizing water quality impacts while maintaining flexibility in individual loads.

- Layer thickness and over-placement allowance: The thickness of each layer within the cap is governed, in part, by the particle sizes of the material comprising that layer —for example, layer thickness is typically a function of the mass median and maximum particle sizes (D_{50} and D_{100}). In addition, an over-placement allowance will be provided for each layer of the cap to account for placement inaccuracies. The over-placement allowance will vary for each material based on the D_{50} and D_{100}. Based on a general objective to minimize cap thickness, grain size specifications (especially D_{100}) were developed with consideration of layer thickness and over-placement allowances.

3 SPECIFICATION DEVELOPMENT FOR AGGREGATE MATERIALS

Table 1 presents a description of the habitat material and the initial design requirements for erosion protection layer for each remediation area. As noted above, these initial design requirements form the basis for the material specifications with consideration of several site and operational factors summarized in Section 2. Remediation areas were divided into habitat modules representing different water depth ranges, with corresponding grain size and organic matter content requirements. For erosion protection materials, Table 1 presents the calculated D_{50} size requirements based on the design described in Sections 1 and 2 and described in Appendix D (Armor Layer Design) of the Final Design. Note that in some areas, habitat material size coincides with that of the erosion protection materials, while other areas require an additional layer of habitat material over the erosion protection layer to provide suitable habitat substrate.

Table 1
Habitat Material and Erosion Protection Layer D_{50}

Remediation Area	Habitat Module	Habitat Layer Material Description	Erosion Protection Layer – Design D_{50} (inches)	Organic Matter Content (percent)
A	6A	Topsoil	1.5	5 to 20
	5A	Topsoil	1.5	5 to 20
	4A	Topsoil	1.5	5 to 20
	3A (in 2- to 3-foot water depth)	Topsoil	1.5	5 to 20
	3A (in 3- to 7-foot water depth)	Fine Gravel [a]	0.51	N/A
	3B (NMC Channel)	Coarse Gravel [a]	1.0	N/A
	2B (NMC Channel)	Coarse Gravel [a]	1.0	N/A
	2A (in 7- to 10-foot water depth)	Fine Gravel [a]	0.51	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.08	N/A
	1	Medium Sand [a]	0.08	N/A
B	5A	Fine Gravel	1.7	N/A
	3A (in 2-4 foot water depth)	Fine Gravel	1.7	N/A
	3A (in 4-7 foot water depth)	Fine Gravel [a]	0.67	N/A
	2A (in 7-10 foot water depth)	Fine Gravel [a]	0.2	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.03	N/A
	1	Medium Sand [a]	0.03	N/A

Remediation Area	Habitat Module	Habitat Layer Material Description	Erosion Protection Layer – Design D_{50} (inches)	Organic Matter Content (percent)
C	8A	Fine Gravel	1.9	N/A
	5B	Fine Gravel	1.9	N/A
	5B (Boat Launch Area)	Coarse Gravel [a]	1.9	N/A
	3B (in 2- to 4-foot water depth)	Fine Gravel [a]	1.9	N/A
	3B (Boat Launch Area)	Coarse Gravel [a]	1.9	N/A
	3B (in 4- to 7-foot water depth)	Fine Gravel [a]	0.52	N/A
	2A (in 7- to 10-foot water depth)	Fine Gravel [a]	0.3	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.08	N/A
	1	Medium Sand [a]	0.08	N/A
D	25-foot buffer [b]	Topsoil	1.9	5 to 20
	6A	Medium Sand	1.9	N/A
	5A	Medium Sand	1.9	N/A
	3B (in 2- to 4-foot water depth)	Medium Sand	1.9	N/A
	3B (in 4- to 7-foot water depth)	Fine Gravel [a]	0.52	N/A
	2A (in 7- to 10-foot water depth)	Fine Gravel [a]	0.3	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.08	N/A
	1	Medium Sand [a]	0.08	N/A
E	25-foot buffer [b]	Topsoil	3.0	5 to 20
	6B	Coarse Gravel	3.0	N/A
	5B	Coarse Gravel	3.0	N/A
	3B (in 2- to 3-foot water depth)	Coarse Gravel	3.0	N/A
	3B (in 3- to 7-foot water depth)	Gravelly Cobbles [a]	3.0	N/A
	2B	Coarse Gravel [a]	1.1	N/A
	2A	Fine Gravel [a]	0.4	N/A
	2A (Navigation Channel)	Gravelly Cobbles [a]	3.0	N/A
	1	Medium Sand [a]	0.04	N/A
NMC Spits	6A	Topsoil	wetlands	5 to 20
	9B	Topsoil	wetlands	5 to 20
WB 1-8 Connected Wetland	6A	Topsoil	wetlands	5 to 20
	5A	Topsoil	wetlands	5 to 20

Remediation Area	Habitat Module	Habitat Layer Material Description	Erosion Protection Layer – Design D_{50} (inches)	Organic Matter Content (percent)
WBB Outboard Area	6A	Topsoil	wetlands	5 to 20
	5A	Topsoil	wetlands	5 to 20
	3A	Topsoil	wetlands	5 to 20
	8A	Topsoil	wetlands	5 to 20
	9B	Topsoil	wetlands	5 to 20

Notes:
N/A = not applicable
NMC = Ninemile Creek
WB = Wastebed
WBB = Wastebed B
a. Habitat layer and erosion protection layer will be comprised of the same material
b. 25-foot buffer – Habitat substrate from the shoreline to 25 feet offshore will be topsoil along Remediation Area D and the Wastebed B Outboard Area.
Wetlands – In the adjacent wetlands, the additional erosion protection that will be provided by the wetland vegetation was taken into consideration, resulting in an erosion protection layer of Coarse Gravel (Type B) with a minimum erosion protection layer thickness in the wetlands of 4.5 inches, as detailed in Appendix D

To advance the development of the specifications and reduce the required number of material types for cap construction, design sizes for the erosion protection material from Table 1 were grouped into similar size categories based on Unified Soil Classification System (USCS) material classifications. Table 2 presents a summary of the calculated D_{50} for the erosion protection layer material in each remediation area (from Table 1), with materials having similar required particle sizes grouped into four general categories: sand, fine gravel, coarse gravel, and gravelly cobbles.

Table 2
Erosion Protection Materials Initial Design D_{50} by Remediation Area

Material Type	Capping Area	Design Calculated D_{50}[a] (inches)
Sand	Remediation Area A	0.08
	Remediation Area B	0.03
	Remediation Area C	0.08
	Remediation Area D	0.08
	Remediation Area E	0.04
	Remediation Area F	0.08
Fine Gravel	Remediation Area A	0.51
	Remediation Area B	0.67
	Remediation Area C	0.52
	Remediation Area D	0.52
	Remediation Area E	0.4
	Remediation Area F	0.51
Coarse Gravel	Remediation Area A	1.5
	Remediation Area B	1.7
	Remediation Area C	1.9
	Remediation Area D	1.9
	Remediation Area E	1.1
	Remediation Area F	-
Gravelly Cobbles	Remediation Area A	-
	Remediation Area B	-
	Remediation Area C	-
	Remediation Area D	-
	Remediation Area E	3.0
	Remediation Area F	-

Note:
a. Design calculated D_{50} sizing indicated is a minimum size necessary for material stability; specifications will require material to have D_{50} greater than or equal to values shown.

After grouping materials into the categories listed in Table 2, the largest design D_{50} size for each category was selected for use in specification development. The selection of the maximum design D_{50} for each material type allows the use of one material specification to cover the range of design conditions found throughout the various remediation areas, thereby reducing the required number of material types and associated material processing.

Based on a review of design conditions outlined in Section 2, it was determined that additional material subdivisions would be required for sand material and coarse gravel material. The sand category was subdivided into two material types (i.e., medium sand and gravelly sand) based on geotechnical filter criteria consideration when used as isolation material underlying the erosion protection material. Specifically, use of the gravelly sand planned for the chemical isolation layer in Remediation Area E will minimize the potential for the sand portion of the chemical isolation layer material to wash out through the larger void spaces of the overlying gravelly cobble material. The medium sand will be used for the chemical isolation material in all other remediation areas, as well as for the habitat layer where sand is the required material type (see Table 1).

Similar to the sand category, the coarse gravel category was further subdivided into two types (A and B) based on the ability to hydraulically place the material. Approximately 80 percent of the total coarse gravel volume required for the project is located in Remediation Area E and requires a D_{50} of at least 1.1 inches; the remaining 20 percent requires a D_{50} of approximately 1.5 inches to 2 inches. By developing two separate specifications for coarse gravel (types A and B), the majority of the coarse gravel material (that with the smaller particle size) could likely be hydraulically placed, reducing cost and schedule implications of mechanical placement required of the larger materials.

The selected D_{50} sizing for each erosion protection material type is presented in Table 3.

Table 3
Final Design Material Types

Material Type	Capping Area	Required D_{50} [a] (inches)
Medium Sand	Remediation Areas A, B, C, D,E, and F	0.08
Gravelly Sand	Remediation Area E, DOT turnaround area steep slope	0.13 [b]
Fine Gravel	Remediation Areas A, B, C, D, E, and F	0.67
Coarse Gravel (Type A)	Remediation Areas A, B, C, and D	1.9
Coarse Gravel (Type B)	Remediation Area E	1.1
Gravelly Cobbles	Remediation Area E	3.0

Notes:
a. Required D_{50} based on largest required D_{50} from initial design analyses for each applicable remediation area (see tables 1 and 2). D_{50} sizing indicated is a minimum sizing, specifications will require material to have D_{50} greater than or equal to values shown.
b. Required D_{50} for gravelly sand based on geotechnical filter criteria (see below).

The selected D_{50} for each material type listed in Table 3 was compared against standard U.S. sieve sizes to select a standard sieve size to use in the specification. The specification was then developed around this selected sieve size such that no more than 50 percent (by weight) in the design gradation would pass this sieve, ensuring that material meeting the specification would have a D_{50} equal to or larger than the selected sieve size. A range was then included on the selected sieve size (e.g., 30 to 50 percent passing), allowing for some natural variation in the gradation specification while still ensuring that the required D_{50} would be achieved.

An upper bound maximum particle size (D_{100}) for each material type was selected based on design considerations such as hydraulic transport and overplacement tolerances, as discussed in Section 2. For example, the gravelly cobble specification includes a maximum stone size of 6 inches to maintain a 6-inch over-placement allowance. The maximum particle sizes for the coarse gravels (Type A and Type B) were selected to prevent excessive larger material in the specification while still allowing a broad range of materials to meet the specification (i.e., allowing a naturally occurring bank run material with minimal processing). The maximum particle size for the remainder of capping materials was limited to 2 to 3 inches to allow hydraulic transport and placement of the material.

The lower bound of the material types was selected to limit the fines content of the materials to minimize the potential for water quality (i.e., turbidity) impacts during placement. The specifications for each material type were developed to limit the fines content to a maximum of 10 percent (by weight) passing the U.S. no. 200 sieve. However, acquisition of materials will target a range of fines from 0 to 3 percent (by weight). Target ranges provide a goal for lower fines content material while the upper limit allows a greater flexibility in individual loads, preventing excessive load rejection based on fines content only.

Standard geotechnical filter criteria presented by Terzaghi and Peck (1967) provide recommended particle size ratios between base and overlying materials (e.g., sand chemical isolation and overlying erosion protection materials). The primary filter criteria particle size relationship primarily applicable to subaqueous capping materials is the ratio of D_{15} of the armor stone to the D_{85} of the base layer. This relationship relates to the ability of the base layer material (e.g., sand) to pass through the void spaces in the overlying larger material (e.g., erosion protection armor stone). 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 Terzaghi filter criteria recommend the following relationship to prevent material loss through the armor layer:

$$d_{15(Armor)} < 5d_{85(Base)}$$

After reviewing the selected sizing of erosion protection and isolation materials relating to this filter criteria, additional gradation specifications were added to medium sand and gravelly sand to meet the filter criteria while also holding to the required D_{50} and general well-sorted sizing expectations. Table 4 presents a comparison of calculated D_{15} to D_{50} ratios for each armor material and the potential base isolation material.

Table 4
Armor and Isolation Material Filter Criteria Comparison

Armor Material	Armor D_{15} Range [a] (inches)		Base (Isolation) Material	Base D_{85} Range [a] (inches)		D_{15}/D_{85} Max Ratio [b]
	Min	Max		Min	Max	
Gravelly Cobbles	0.025	0.75	Gravelly Sand	0.625	1.2	1.2
			Medium Sand	0.21	0.3	3.6
Coarse Gravel Type A	0.007	0.75	Gravelly Sand	0.625	1.2	1.2
			Medium Sand	0.21	0.3	3.6
Coarse Gravel Type B	0.0065	0.5	Gravelly Sand	0.625	1.2	0.8
			Medium Sand	0.21	0.3	2.4
Fine Gravel	0.006	0.05	Gravelly Sand	0.625	1.2	0.08
			Medium Sand	0.21	0.3	0.24

Notes:
a. D_{15} and D_{85} size ranges, where not specified, were selected based on standard geotechnical gradation curves developed from the specified gradation.
b. Terzaghi criteria recommends a D_{15}/D_{85} ratio of less than 5 to prevent loss of base material through armor void spaces. Maximum ratio applies to the worst case scenario comparison of the maximum armor D_{15} compared to the minimum base D_{85}.

Figures 1 and 2 illustrate the design gradations; Figures 3 and 4 illustrate the D_{15} to D_{85} ratio relationships between the armor materials and underlying sand chemical isolation materials.

There are two additional materials that are also specified. An armor stone will be placed along the steep slope of the New York State Department of Transportation (NYSDOT) Turnaround Area to physically isolate the slag material. The armor cap over the isolation layer will consist of a layer of gravelly sand material as a bedding layer beneath the armor stone, to the extent possible, and an armor stone ranging in diameter size of 4 to 18 inches.

Additionally, material will be placed along a portion of the surf zone of Remediation Area B to address erosion of Solvay waste material along the shoreline of WB 1-8. Shoreline stabilization material consisting of a graded gravel, bank-run material will be placed at an average thickness of approximately 1.5 feet from elevation 365 feet to 362.5 feet (upland from the shoreline). Shoreline stabilization material consisting of Coarse Gravel (Type B)

will be placed at an average thickness of approximately 6 inches from elevation 362.5 feet to 360 feet (within the Lake).

Attachment A presents material specifications and gradation for each material type based on the requirements and considerations detailed above.

5 EARTHEN MATERIAL CHEMICAL CRITERIA

Prior to the procurement of capping materials, borrow sources will be inspected and the materials characterized to ensure compliance with the specifications presented in Attachment A. Selected borrow sources will also be subject to materials testing requirements performed routinely throughout construction to verify continued compliance with project specifications. Suitable representative samples and test reports will be submitted to and approved prior to delivery of materials to the job site. The frequency and detailed procedures for sampling and analysis of cap materials will be provided in the Onondaga Lake Construction Quality Assurance Plan (CQAP).

Sampling will include standard geotechnical analyses (e.g., grain size, moisture content, and bulk density) in addition to chemical testing. Chemical testing will be performed to confirm that the materials comply with the Unrestricted Use Soil Cleanup Objectives listed in NYSDEC 6 NYCRR Part 375 (summarized in Table 5). Exceedance of any single chemical compound limit will mean that the entire material batch will be rejected unless subsequent testing on sub-sets of the batch demonstrates compliance with the criteria.

Table 5
Unrestricted Use Soil Cleanup Objectives

Contaminant	Unrestricted Use Criteria (parts per million)
Metals	
Arsenic	13
Barium	350
Beryllium	7.2
Cadmium	2.5
Chromium, hexavalent	1
Chromium, trivalent	30
Copper	50
Total Cyanide	27

4 AMENDED CAP MATERIALS

Isolation materials utilized in cap construction will include amendment materials blended with the cap layer to provide appropriate isolation properties. Amendment materials include GAC and siderite for the chemical isolation layer. Application of these materials is based on an addition of specified quantities by weight per square foot of cap construction. Additional details regarding amendment rates and design are presented in Appendix B and Appendix I of the Final Design.

4.1 Granulated Activated Carbon

The GAC for use in the cap chemical isolation layer will be Calgon F400 or equivalent. The specifications that a supplier will have to meet, whether it is Calgon or another supplier, are the following Calgon F400 specifications:

- The material shall be virgin condition
- The base material must be bituminous coal
- Steam will be used as its activation method
- A minimum iodine number of 1,000 milligrams per gram (mg/g)
- A maximum moisture of 2 percent by weight
- A minimum abrasion number of 75
- An effective size of 0.55 to 0.75 millimeters (mm)
- A maximum uniformity coefficient of 1.9
- No more than 5 percent by weight greater than 12 mesh (1.7 mm)
- No more than 4 percent by weight less than 40 mesh (0.42 mm)

The size of the GAC particles (specified in the last two bullets above) will be subject to change following NYSDEC review and approval in the event that the GAC is not vertically well-mixed throughout the sand isolation layer.

4.2 Siderite

The siderite for use in the cap chemical isolation layer will be granular, composed of approximately sand-sized particles, and will meet the following specifications:

- The base material will be a siderite ore

- Gradations will conform to the following specifications:

U.S. Standard Sieve Size	Percent Passing (by weight)
U.S. No. 4	95 to 100
U.S. No. 30	0 to 5

- The target ferrous carbonate content will be 74 percent by weight. If the ferrous carbonate content is less than 74 percent by weight, then the siderite dosing in the sediment cap will be adjusted as appropriate. The method for verifying the ferrous carbonate will be provided independently following additional consultation and discussions with the selected siderite supplier.

Contaminant	Unrestricted Use Criteria (parts per million)
Lead	63
Manganese	1600
Total Mercury	0.18
Nickel	30
Selenium	3.9
Silver	2
Zinc	109
PCBs/Pesticides	
2,4,5-TP Acid (Silvex)	3.8
4,4'-DDE	0.0033
4,4'-DDT	0.0033
4,4'-DDD	0.0033
Aldrin	0.005
alpha-BHC	0.02
beta-BHC	0.036
Chlordane (alpha)	0.094
delta-BHC	0.04
Dibenzofuran	7
Dieldrin	0.005
Endosulfan I	2.4
Endosulfan II	2.4
Endosulfan sulfate	2.4
Endrin	0.014
Heptachlor	0.042
Lindane	0.1
Polychlorinated biphenyls	0.1

Contaminant	Unrestricted Use Criteria (parts per million)
Semivolatile Organic Compounds	
Acenaphthene	20
Acenapthylene	100
Anthracene	100
Benz(a)anthracene	1
Benzo(a)pyrene	1
Benzo(b)fluoranthene	1
Benzo(g,h,i)perylene	100
Benzo(k)fluoranthene	0.8
Chrysene	1
Dibenz(a,h)anthracene f	0.33
Fluoranthene	100
Fluorene	30
Indeno(1,2,3-cd)pyrene	0.5
m-Cresol	0.33
Naphthalene	12
o-Cresol	0.33
p-Cresol	0.33
Pentachlorophenol	0.8
Phenanthrene	100
Phenol	0.33
Pyrene	100
Volatile Organic Compounds	
1,1,1-Trichloroethane	0.68
1,1-Dichloroethane	0.27
1,1-Dichloroethene	0.33
1,2-Dichlorobenzene	1.1

Contaminant	Unrestricted Use Criteria (parts per million)
1,2-Dichloroethane	0.02
cis -1,2-Dichloroethene	0.25
trans-1,2-Dichloroethene	0.19
1,3-Dichlorobenzene	2.4
1,4-Dichlorobenzene	1.8
1,4-Dioxane	0.1
Acetone	0.05
Benzene	0.06
n-Butylbenzene	12
Carbon tetrachloride	0.76
Chlorobenzene	1.1
Chloroform	0.37
Ethylbenzene	1
Hexachlorobenzene	0.33
Methyl ethyl ketone	0.12
Methyl tert-butyl ether	0.93
Methylene chloride	0.05
n - Propylbenzene	3.9
sec-Butylbenzene	11
tert-Butylbenzene	5.9
Tetrachloroethene	1.3
Toluene	0.7
Trichloroethene	0.47
1,2,4-Trimethylbenzene	3.6
1,3,5-Trimethylbenzene	8.4
Vinyl chloride	0.02
Xylene (mixed)	0.26

6 REFERENCES

Palermo, M., S. Maynord, J. Miller, and D. Reible, 1998. Guidance for In-Situ Subaqueous Capping of Contaminated Sediments, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Terzaghi, K. and R. B. Peck, 1967. Soil Mechanics in Engineering Practice, 2nd ed., John Wiley and Sons, New York.

United States Army Corps of Engineers (USACE), 2004. Engineering and Design – General Design and Construction Considerations for Earth and Rock-Fill Dams. Engineering Manual EM 1110-2-2300. July 30, 2004.

FIGURES

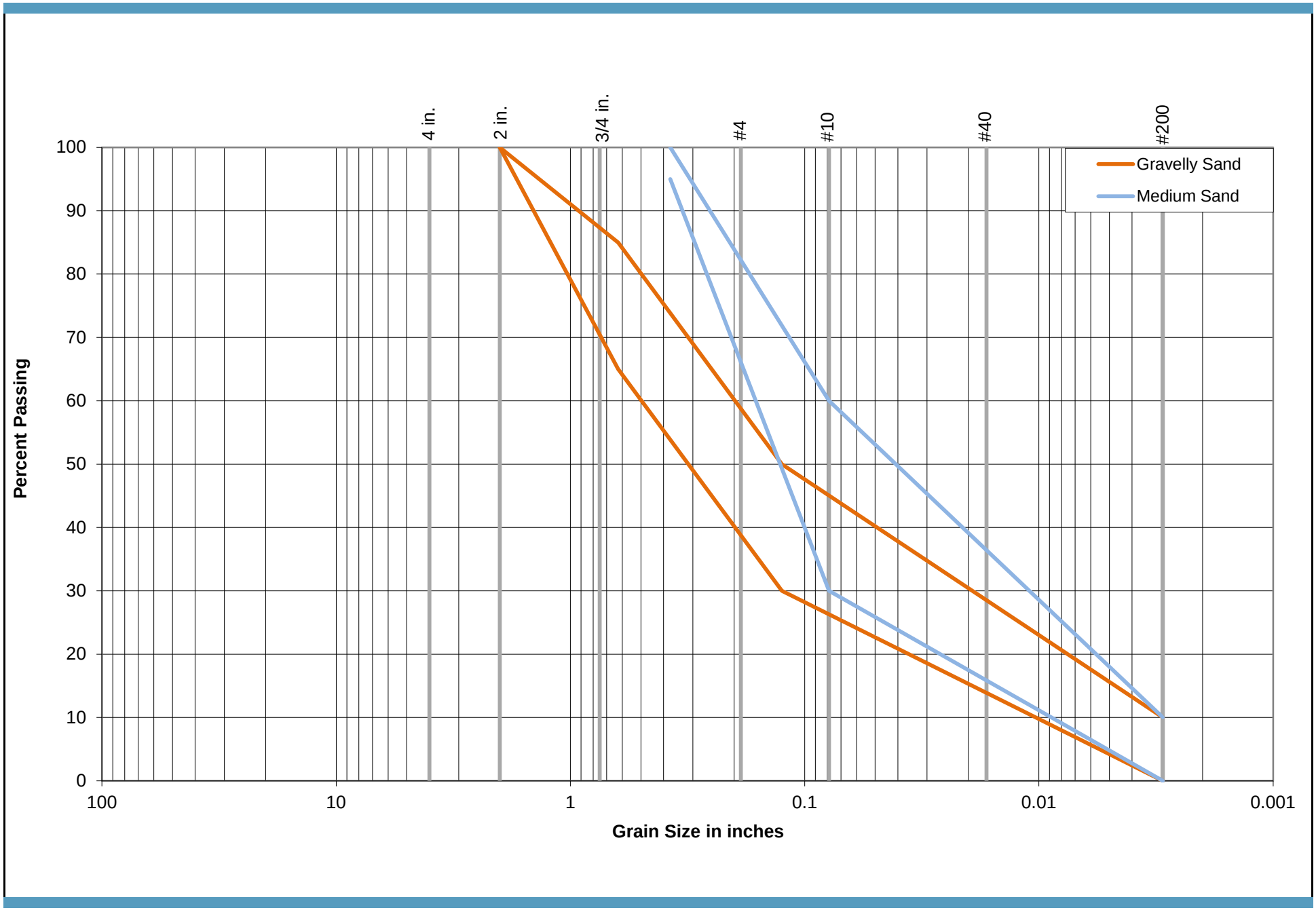


Figure 1
Sand Material Gradations
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

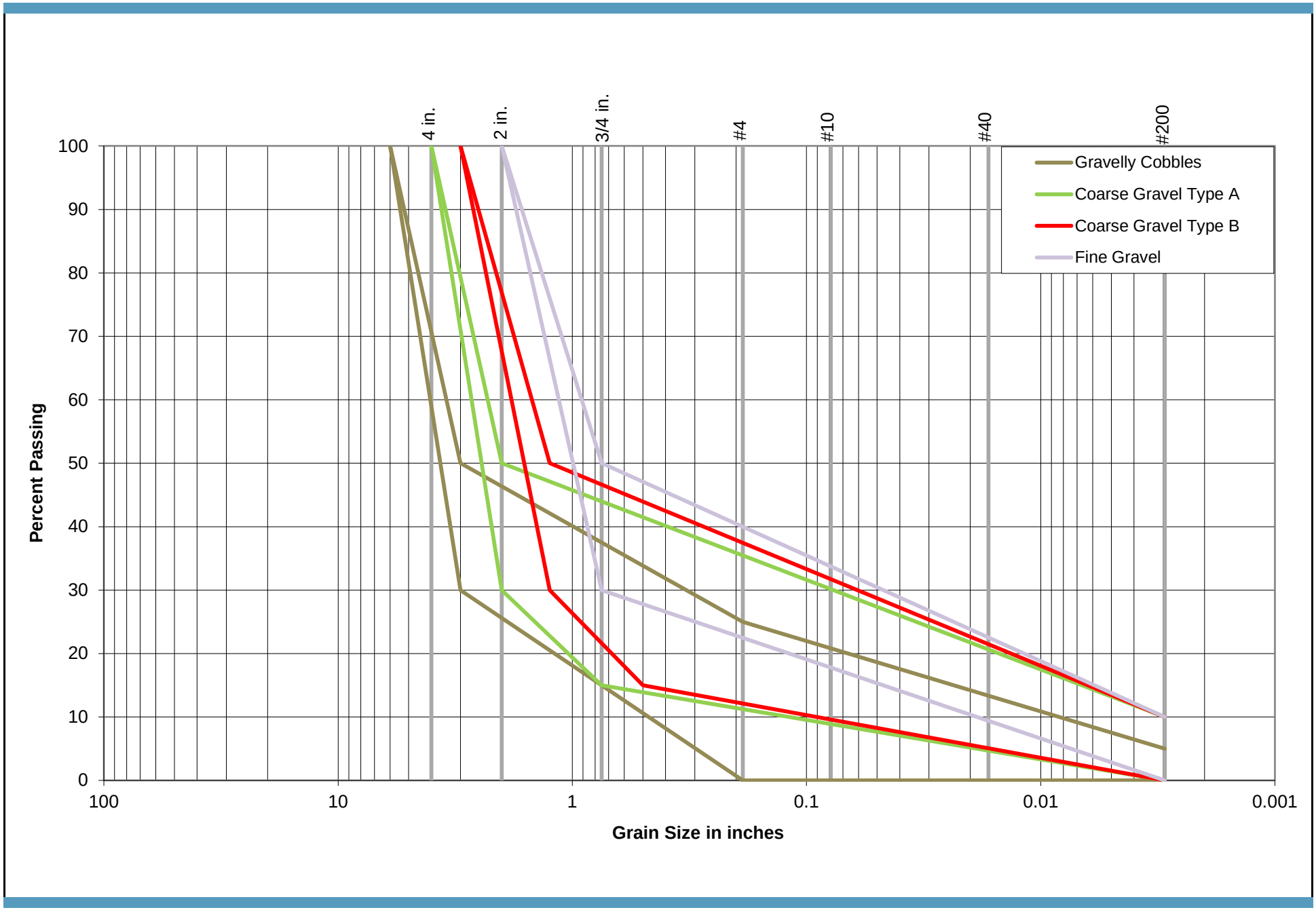


Figure 2
Gravelly Cobbles and Gravel Material Gradations
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

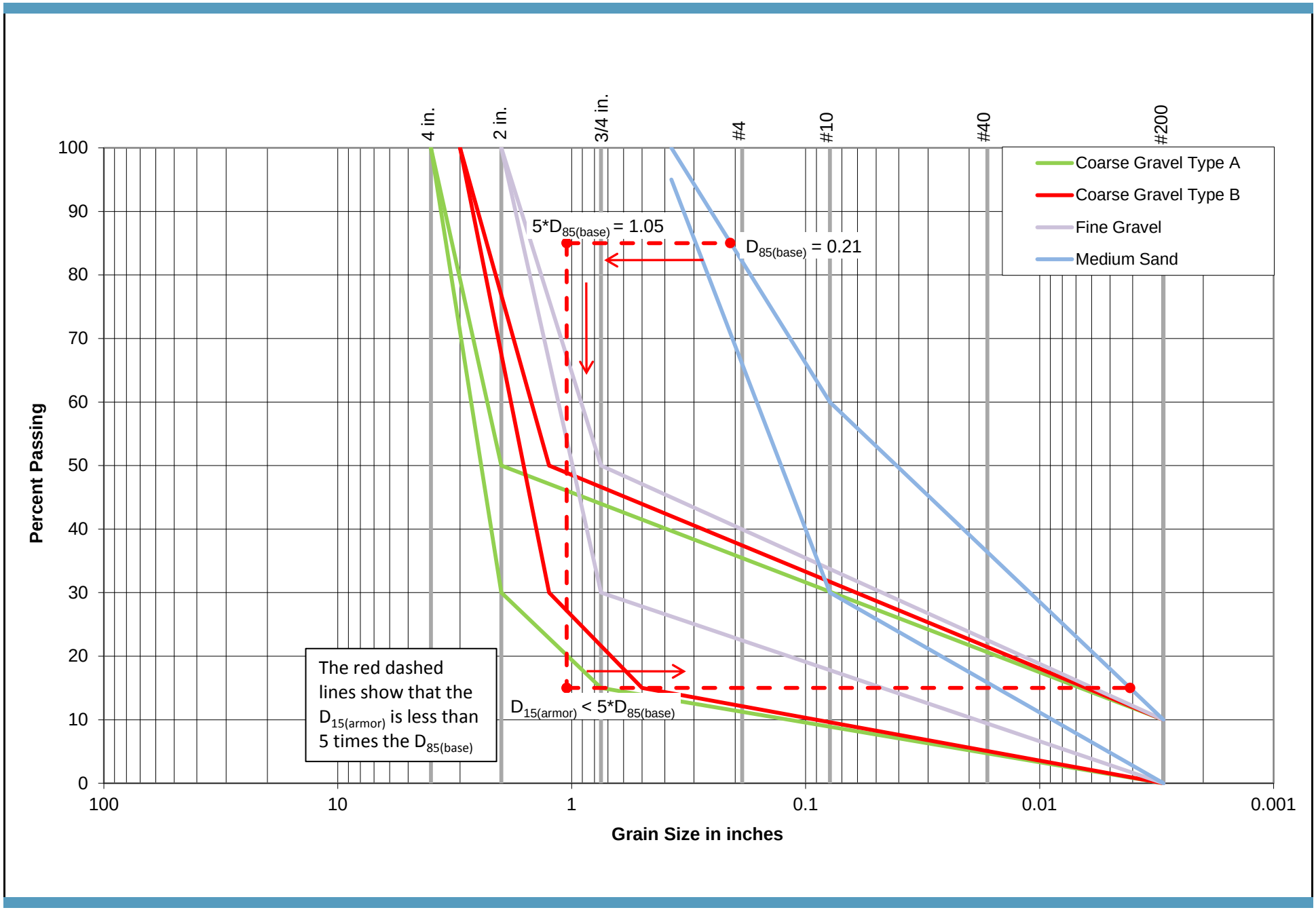


Figure 3
Gravel Filter Criteria Comparison
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

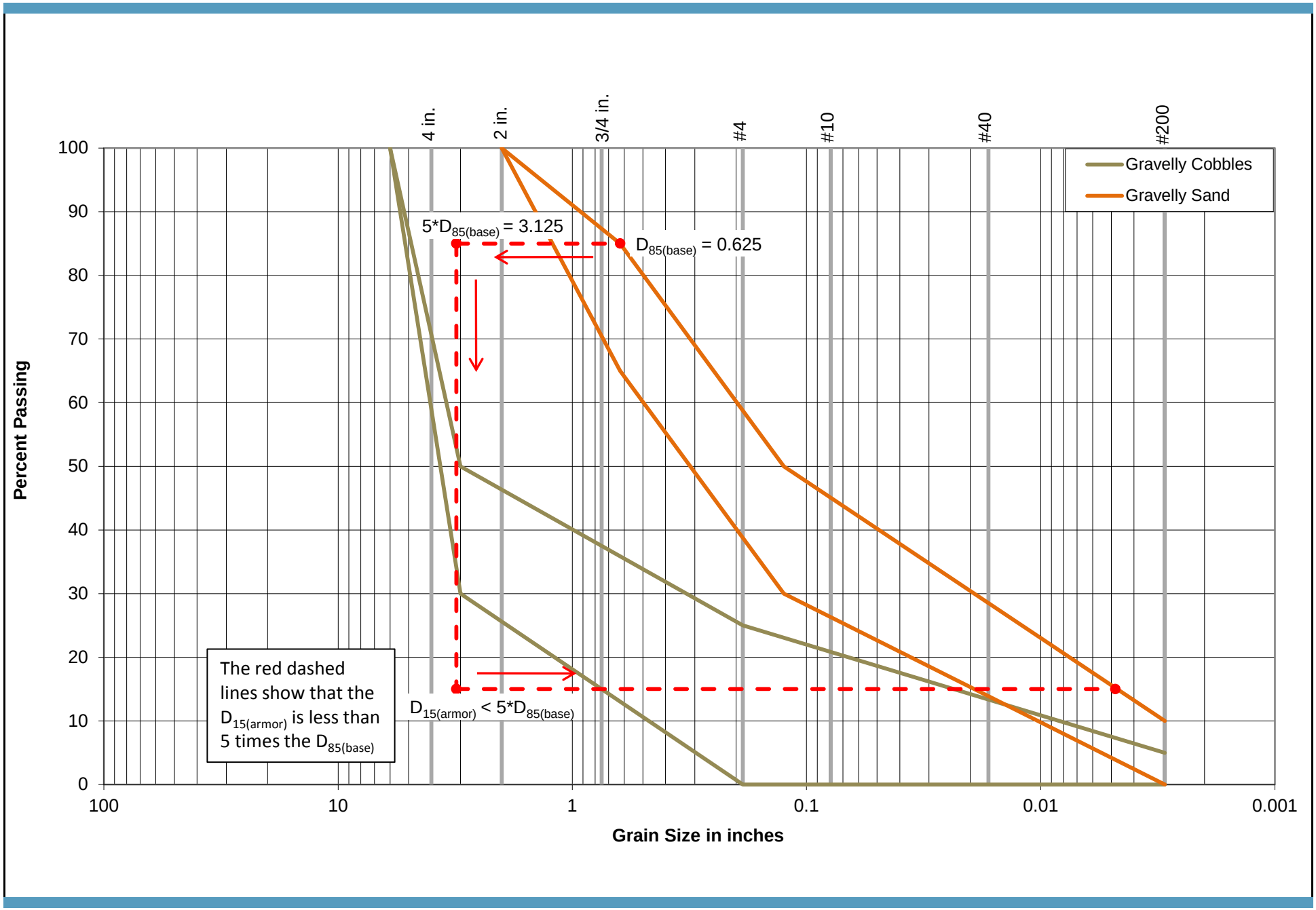


Figure 4
Gravelly Cobbles Filter Criteria Comparison
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

ATTACHMENT A
EARTHEN MATERIAL SPECIFICATIONS

All materials shall be of the quality, size, shape, and gradation or equal to that manufacture as specified herein. Materials will be procured from an approved borrow source in accordance with the Onondaga Lake Construction Quality Assurance Plan.

Gravelly Cobbles

Gravelly cobble material will consist of naturally occurring stone, gravel, screened gravel or run-of-bank material. Screened gravel or bank run material will consist of uncrushed particles. Gravelly cobble material designed below the top 12 inches of the cap may be a crushed product. Crushed stone and gravel will consist of clean, durable, sharp-angled rock fragments of uniform quality. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
6 inch	100
3 inch	30 to 50
U.S. No. 4	0 to 25
U.S. No. 200	0 to 5 (0 to 3 preferred)

Coarse Gravel – Type A

Coarse Gravel material will consist of naturally occurring screened or run-of-bank gravel or other acceptable granular material. Crushed stone would be acceptable when used below the top 12 inches of the cap. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
4 inch	100
2 inch	30 to 50
3/4 inch	>15
U.S. No. 200	0 to 10 (0 to 3 preferred)

Coarse Gravel – Type B

Coarse Gravel material will consist of naturally occurring screened or run-of-bank gravel or other acceptable granular material. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
3 inch	100
1 1/4 inch	30 to 50
1/2 inch	>15
U.S. No. 200	0 to 10 (0 to 3 preferred)

Fine Gravel

Fine Gravel material will consist of naturally occurring screened or run-of-bank gravel or other acceptable granular material. Crushed stone would be acceptable when used below the top 12 inches of the cap. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
2 inch	100
3/4 inch	30 to 50
U.S. No. 200	0 to 10 (0 to 3 preferred)

Gravelly Sand

Gravelly Sand material will be naturally occurring, clean, and free-draining. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
2 inch	100
5/8 inch	65 to 85
U.S. No. 6	30 to 50
U.S. No. 200	0 to 10 (0 to 3 preferred)

Medium Sand

Medium Sand material will be naturally occurring, clean, free-draining sand. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
3/8 inch	95 to 100
U.S. No. 10	30 to 60
U.S. No. 200	0 to 10 (0 to 3 preferred)

Topsoil

Topsoil shall be natural or manufactured, friable, and fertile soil that meets the U.S. Department of Agriculture (USDA) basic soil texture classes of loam, silt loam, or sandy loam to be recovered from the A horizon of an in-place soil. Topsoil shall be capable of sustaining healthy plant life and be reasonably free of subsoil, heavy or stiff clay, brush, roots, weeds, other objectionable plant matter, foreign material, stones larger than 4 inches in greatest dimension, and any other materials unsuitable or harmful for plant growth. Topsoil as delivered to the site or stockpiled shall meet the following requirements:

- Gradations conforming to the table below:

U.S. Standard Sieve Size	Percent Passing (by weight)
4 inch	100
1 inch	85 to 100
¼ inch	65 to 100
U.S. No. 200	15 to 80

  The 2 micron particle size shall not be greater than 20 percent of the total sample mass, as determined by hydrometer analysis.
- pH between 5.5 and 7.6
- Percent organic matter:
  - For wetland modules, topsoil shall contain greater than or equal to 5 percent and less than 20 percent organic matter as determined by loss on ignition of moisture-free samples dried at 100° to 110° Celsius. A mean value of approximately 7.5 percent organic matter will be targeted in the wetland areas.
  - For non-wetland areas (planted areas within the lake and upland modules with topsoil), topsoil shall contain greater than 5 percent and less than 20 percent

organic matter as determined by loss of ignition of moisture-free samples dried at 100° to 110° Celsius.

- Contain no nuisance weeds including seeds, stems, or rhizomes of Purple Loosestrife, Phragmites, Japanese Knotweed, or any plants on the Federal Noxious Weeds list.

NYSDOT Turnaround Area Shoreline Armor Stone

The armor stone used for the NYSDOT Turnaround Area shoreline will be riprap conforming to the following gradations:

Stone Size	Percent Passing (by weight)
Heavier than 100 pounds	50 to 100
Larger than 12 inches	50 to 100
Larger than 18 inches	0
Smaller than 4 inches	0 to 10

Remediation Area B Graded Gravel

The graded gravel to be used for the Remediation Area B shoreline stabilization between an elevation of 362.5 and 365 feet will be screened or run-of-bank gravel or other acceptable granular material. The material shall contain greater than 0.5 percent but less than 6 percent organic content by weight as determined using ASTM D2974. Gradations must conform to the table below:

U.S. Standard Sieve Size	Percent Passing (by weight)
8 inch	100
4 inch	80 to 100
¼ inch	30 to 75
No. 40	15 to 60
U.S. No. 200	Less than or equal to 25

Below elevation 362.5 feet, coarse gravel will be used for the shoreline stabilization material.

Outfall Scour Protection

The stone used for the outfalls will be riprap conforming to the following gradations (based on the NYSDOT Standard Specification for Medium Stone Filling specified in Figure 620-1):

Stone Size	Percent Passing (by weight)
Heavier than 100 pounds	50 to 100
Smaller than 6 inches	0 to 10

Sevenson Environmental Services, Inc.

MEMORANDUM

DATE: **November 3, 2010**

TO: **Dave Smith and Ed Glaza, Parsons**

FROM: **Mike Crystal, Sevenson Environmental Service**
Tim Donegan, PE, Gahagan and Bryant Associates, Inc.

RE: **Onondaga Lake Capping Anticipated Production Rates**

Sevenson's approach to placement of sand materials and stone materials smaller than 2 inches in diameter will involve a hydraulic slurry system. It is anticipated that armor (rock/gravel) materials larger than 2 inches in diameter will be placed using a hydraulic excavator with real-time kinematic (RTK) global positioning system (GPS). Placement approaches are discussed below.

SAND AND ROCK CAPPING OPERATIONS

Sevenson will use our custom-built slurry system for hydraulic placement of the sand cap and stone armor less than 2 inches in diameter in designated areas. The system consists of a feed hopper, oversized screening, and slurry system that will pump the sand and small stone hydraulically through a pipeline for placement through a diffuser system on a barge. The pump used to convey the sand slurry is a booster type pump commonly found on dredging projects. The hopper, screening, and slurry system will be placed on the shoreline at two potential locations to minimize pumping distances and the need for booster pumps floating on the water. The two preliminary locations have been identified on Wastebed B and Wastebeds 1-8 and will be coordinated with upland sites and finalized in a future submittal.

The following criteria were considered in selecting equipment for the placement of sand and armor materials as part of the Onondaga Lake caps:

- Minimize multiple handling of materials, extra equipment, and personnel required for placement of sand and rock materials.
- Capability to hydraulically convey sand and small armor stone materials from neashore location to the farthest points of the lake while maintaining production
- Capability to pump armor stone material up to 2-inches in diameter
- Access to shallow water (i.e. less than 1-foot of water) and still efficiently spread/place materials
- Portable system that can be broken down and relocated
- Design a system with redundancy and capacity to meet production is one system goes down.

The considerations described above led to the decision by Sevenson and the design team to select to hydraulic spreader systems that will meet the schedule and maintain production rates.

A 30-foot by 40-foot diffuser/spreader barge will be attached to the slurry system by the 16SDR11 high-density polyethylene (HDPE) pipe. The spreader system will be attached to the 30 foot side of the barge. This barge will have a waterfall type discharge apparatus (steel plate angled towards the water) fabricated on the deck (Figure 1). The angled discharge plate will act to dissipate the energy in the capping material slurry delivered to the placement barge via the floating line. Therefore, the sand cover will enter the water in a controlled fashion with minimal fall velocity. The diffuser barge will have a hydraulic cable winch system and anchors to facilitate the movement of the barge for placement of the material. The anchor system will be designed to minimize cable sweep across the cap surface with the use of cable floats and cable tensioning sensors on each winch drum. Two spreader barges will be on site operating at the same time as required.

The armor stone spreader system (Figure 2) is composed of a similar flexi float system but with a different diffuser head. The armor stone diffuser spreader system is composed of 4 energy dissipaters. With angled plates welded to the interior. The slurry flow is separated into four different flows. Materials are dropped vertical into the water for an even distribution.

The pump system is composed of a 900 HP dredge pump with a 38-inch-diameter impeller and one 24-inch-diameter Godwin pumps to deliver the slurry make up water into the mixing tank located next to the stockpiles at each potential staging location. A dedicated slurry system will be utilized for each capping operation. There is a possibility that one system will be spreading armor stone while the second system is spreading sand.

Figure 1. SES Spreader Barge System Placing Sand Cap Materials.

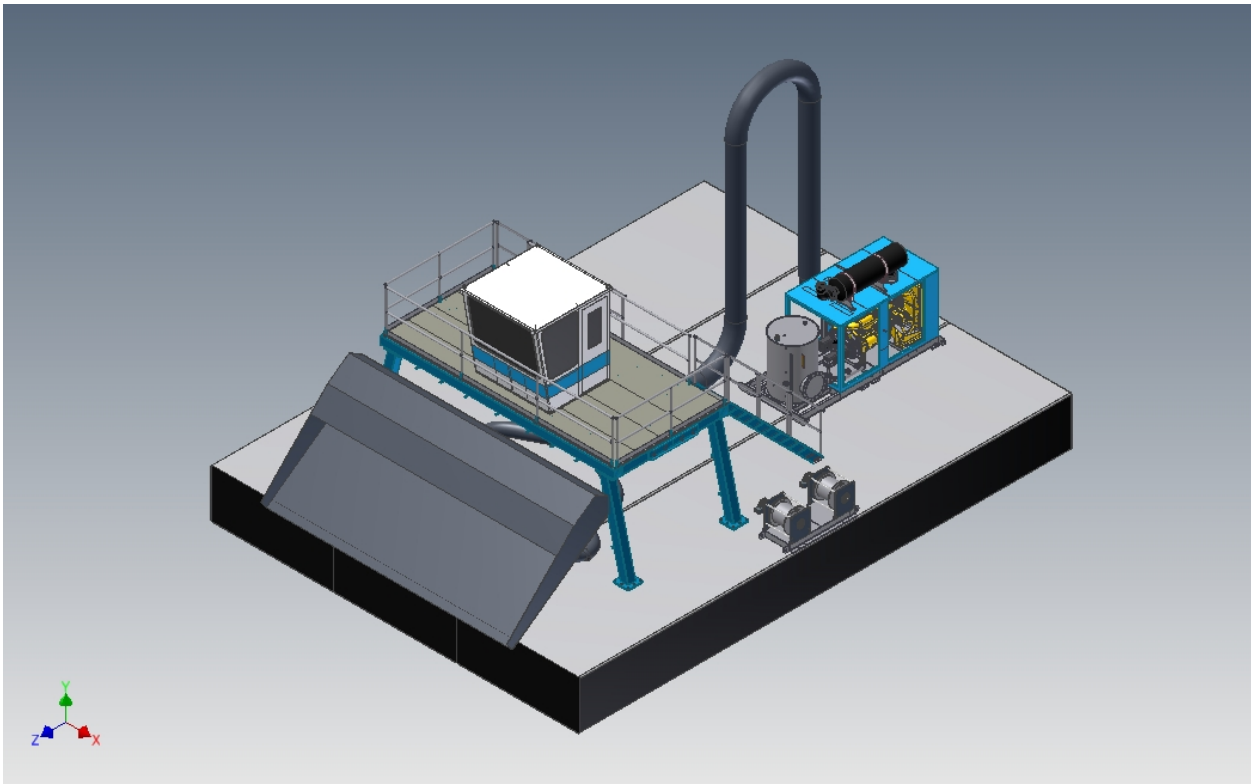


Figure 2. Schematic of the SES Spreader Barge for Sand and Fine Gravel Placement

Figure 3. Slurry Feed System that Transport Materials to the Spreader Barge

The anticipated production rate that Sevenson calculated for each cap area is based on the pumping distance to the site from the shoreline and any inefficiencies associated with moving anchors, maintenance, shift changes, weather delays, fueling, and material stockpiling logistics. The anticipated uptime is estimated to be 80% of a 24 hour work day.

Table 1 below details the range of production rates for hydraulic placement of sand materials.

SAND HYDRAULICALLY PUMPED

Remediation Area	Min Pumping Distance (Ft)	Max Pumping Distance (Ft)	Theoretical Min Prod. Rate [a] (Cy/Hr)	Theoretical Max Prod. Rate [a] (Cy/Hr)	Anticipated Prod. Rate (Cy/Day) [b]	Booster/Staging Location
A	1,100	4,300	550	630	2,073	Wastebeds/9 Mile Creek
B	2,100	4,700	500	630	2,073	Wastebeds/9 Mile Creek
C	1,700	5,100	450	630	2,073	Work Support Area
D	600	3,330	630	630	2,073	Work Support Area
E	2,200	5,500	400	630	2,073	Work Support Area

Notes:

a. Estimated minimum and maximum production rates based on manufacturer's estimates without consideration of inefficiencies related to loading the slurry hopper, achieving a consistent feed rate, time required to start and stop a given placement lane, mechanical delays, weather delays, etc.

b. Anticipated production rate based on moving anchors, safe speed that cables can be winched onto the spools, maintenance, shift changes, weather delays, fueling, and material stockpiling logistics

The anticipated production rate of approximately 108 CY/HR (2,073CY/Day) was developed based on safe operating speeds of the capping barge, equipment limitations of safe winching speeds, feeding the slurry system with a consistent feed to minimize overspreading materials and minimize barge "jerking" through the water with the cap automation system.

Characteristics and efficiencies for pumping the sand materials are:

- Velocity in the pipeline to pump a medium sand will be 16 to 18 feet per second
- Flow rate will be approximately 7,500 gpm
- Pump revolutions per minute (RPMs) will range from 500 to 680 depending on pumping distance
- Pump HP used will range from 500 to 900 depending on pumping distance
- Keeping barge movement limited to less than 20 feet per minute

Table 2 below details the anticipated range of production rates for hydraulic placement of armor stone materials less than 2 inches in diameter.

ROCK UP to 2 INCHES HYDRAULICALLY PUMPED

Remediation Area	Min Pumping Distance (Ft)	Max Pumping Distance (Ft)	Theoretical Min Prod. Rate [a] (Cy/Hr)	Theoretical Max Prod. Rate [a] (Cy/Hr)	Anticipated Prod. Rate [b] (Cy/Day)	Booster/Staging Location
A	1,100	4,300	95	304	960	Wastebeds/9 Mile Creek
B	2,100	4,700	90	304	960	Wastebeds/9 Mile Creek
C	1,700	5,100	80	304	960	Work Support Area
D	600	3,330	155	304	960	Work Support Area
E	2,200	5,500	50	304	960	Work Support Area

Notes:

a. Estimated minimum and maximum production rates based on manufacturer's estimates without consideration of inefficiencies related to loading the slurry hopper, achieving a consistent feed rate, time required to start and stop a given placement lane, mechanical delays, weather delays, etc.

b. Anticipated production rate based on moving anchors, safe speed that cables can be winched onto the spools, maintenance, shift changes, weather delays, fueling, and material stockpiling logistics

The anticipated production rate of approximately 50 CY/HR (960 CY/Day) for armor stone up to 2 inches in diameter was developed based on safe operating speeds of the capping barge, equipment limitations of safe winching speeds, feeding the slurry system with a consistent feed to minimize overspreading materials and minimize barge "jerking" through the water with the cap automation system.

For placement of sand and armor stone less than 2 inches in diameter, Sevenson plans to use two spreader barge systems. It is anticipated that each barge system will operate 24 hours per day. Two crews will be required per spreader system each day. Each crew will work 12 hours per day. Sevenson anticipates an uptime of 80%. The anticipated 80% uptime and 20% downtime was calculated based on potential delays associated with setting anchors, weather delays, mechanical delays, fueling, greasing and routine maintenance.

Characteristics and efficiencies for pumping the armor stone materials up to 2 inches in diameter are:

- Velocity in the pipeline to pump a medium sand will be 14 to 18 feet per second
- Flow rate will be approximately 6,000 to 7,500 gpm
- Pump RPMs will range from 500 to 700 depending on pumping distance
- Pump HP used will range from 500 to 900 depending on pumping distance
- Keeping barge movement limited to less than 15 feet per minute

6.3 Armor Capping Operations

For the mechanical placement of armor materials larger than 2 inches in diameter, Sevenson will use one hydraulic excavator (Komatsu PC 300) stationed on a modular Flexifloat barge. The details of the placement system are:

- Aftermarket boom and stick capable of reaching 47 feet.
- Flexifloat barge 40 feet wide and 60 feet long (six assembled Flexifloat barges each measuring 10 feet by 40 feet).
- Draft of the barge with excavator will be approximately 2 feet.
- DREDGEPACK® software system, RTK GPS.
- Seven inclinometers for the boom, stick, bucket, and rocking of the barge.
- Real time water surface elevation display in the cab.
- A 2 CY clamshell bucket will be used to place material. The bucket will be similar to an environmental clamshell.
- Cycle times are anticipated to be approximately 45 seconds to 2 minutes depending on the complexity of the placement, material type, water depth, location of stockpile material (i.e. supply barge on the hip or located to the stern because of draft limitations)

Figure 4. Mechanical Placement of Rock Cap Materials from a Shallow Draft Barge

Production rates for mechanical placement of armor materials larger than 2 inches in diameter are calculated to be approximately 50 CY/HR. These production rates account for uptime/downtime, repositioning barges, etc. Sevenson plans to operate 2 crews each working two 12 hour shifts. Sevenson anticipates an uptime of 80%.

ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

APPENDIX K – HABITAT

Prepared for:

Honeywell

301 Plainfield Road, Suite 330
Syracuse, NY 13212

Prepared by:

PARSONS

301 Plainfield Road, Suite 350
Syracuse, NY 13212

ANCHOR QEA

290 Elwood Davis Road, Suite 318
Liverpool, NY 13088

MARCH 2012

TABLE OF CONTENTS

Page

SECTION 1 INTRODUCTION 1-1

SECTION 2 NINEMILE CREEK SPITS AND ADJACENT LAKE AREA 2-1

SECTION 3 WASTEBEDS 1-8 CONNECTED WETLAND 3-1

3.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES 3-1

3.2 HYDROLOGY 3-1

SECTION 4 WASTEBED B/HARBOR BROOK OUTBOARD AREA 4-1

4.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES 4-1

4.2 HARBOR BROOK CHANNEL 4-2
4.2.1 Design Objectives 4-2
4.2.2 Design Considerations and Constraints 4-2
4.2.3 Flow Hydrology 4-3

4.3 WATER TEMPERATURE 4-3
4.3.1 Methods 4-4
4.3.2 Results 4-4

4.4 SHORELINE WAVE ATTENUATION 4-5
4.4.1 Historical Wave Analysis 4-5

SECTION 5 TOTAL ORGANIC MATTER CONTENT IN HABITAT LAYER 5-1

SECTION 6 SHORELINE TRANSITION AREAS 6-1

6.1 AREAS WITHOUT ADJACENT REMEDIATION 6-1

6.2 SHORELINE STABILIZATION ADJACENT TO REMEDIATION AREAS 6-1

6.3 SHORELINE STABILIZATION IN AREAS WITHOUT ADJACENT REMEDIATION 6-2

SECTION 7 REFERENCES 7-1

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

Figure K-1 Planting Plan Remediation Area A & Ninemile Creek Spits

Figure K-2 Planting Plan Remediation Area B & WB 1-8 Connected Wetland

Figure K-3 Planting Plan Remediation Area C

Figure K-4 Planting Plan Remediation Area D & Wastebed B Outboard Area

Figure K-5 Onondaga Lake Hydroperiod by Month

Figure K-6 Onondaga Lake Hydroperiod by Year

Figure K-7 Pike Spawning Area Section

Figure K-8 Plan View of Outboard Area Harbor Brook Channel

Figure K-9 Water Temperature in Littoral Zone East of Harbor Brook

Figure K-10 Water Temperature in Littoral Zone West off Harbor Brook

Figure K-11 Water Temperature in Littoral Zone West of Harbor Brook

Figure K-12 Water Temperature in Harbor Brook and Along Bank

Figure K-13 Water Temperature in Littoral Zone Off Ninemile Creek

Figure K-14 Wave Analysis for Outboard Area

Figure K-15 Wave Analysis for Outboard Area

LIST OF TABLES

Table K-1 Annual Flow Evaluation Data Summary Harbor Brook

Table K-2 Dissolved Oxygen Data Summary Harbor Brook

SECTION 1

INTRODUCTION

This appendix provides details associated with the habitat restoration activities within Onondaga Lake and at the mouth of Ninemile Creek, the connected wetlands at the base of Wastebeds 1-8, the Outboard Area near the mouth of Harbor Brook, and the SMU 3 and 4 shoreline. Habitat design features like water depth and areas that will be planted are addressed in this appendix, along with a discussion of shoreline transition areas. Separate submittals describing the details of the structure and planting plans and success criteria will be provided to NYSDEC for review and approval.

SECTION 2

NINEMILE CREEK SPITS AND ADJACENT LAKE AREA

As discussed in Section 4.3.5.1 of the Final Capping, Dredging, Habitat and Profundal Zone (SMU 8) Design Report, the two small areas that extend out into Onondaga Lake at the mouth of Ninemile Creek ("the spits") have been delineated as emergent wetlands. The habitat and planting plan for this area has been integrated with the figures for the adjacent Remediation Area A to ensure a consistent design at the lake shoreline. The integrated design for this area includes removal of the emergent wetlands, which are currently dominated by *Phragmites*, and restoration of the area with an isolation cap similar to the adjacent areas in the lake. The post-remediation acreage of the spits and associated wetland will be the same as currently exists, and the elevations in this area will range from 1 ft. above water to 1 ft. deep. The restoration of these spits includes approximately 1.9 acres of emergent wetland, which will provide connectivity to the shallow littoral areas and Ninemile Creek with floating leaved and submerged vegetation. Figure K-1 illustrates the Habitat Module application and planting plan for this area.

Three vegetative zones have been established for this area of the design. The zones are consistent with the Habitat Modules described in the Draft Habitat Plan (Parsons 2009) and will include floating aquatic, non-persistent emergent wetlands, water fringe (edge of persistent emergent wetland), and interior of persistent wetlands, forested wetlands and shoreline bank area. A discrete Module 6A planting zone at the lake side edge of the module will be developed to separate it from the remainder of the persistent emergent wetland. Plants more tolerant of water energy will be selected for this fringe zone. Module 9B is designed as a deciduous forested wetland and the shoreline bank area consists primarily of wetland and conservation seed mixes.

Details of the planting program will be submitted as an addendum to the Final Design, subject to review and approval by NYSDEC.

SECTION 3

WASTEBEDS 1-8 CONNECTED WETLAND

As discussed in Section 4.3.5.2 of the Final Capping, Dredging, Habitat and Profundal Zone (SMU 8) Design Report, the Wastebed 1-8 wetland complex has both connected and inland wetlands. The designs for the inland wetlands will be provided in the Wastebed 1-8 Design Reports. The connected wetland is designed to be a 2.3-acre freshwater marsh with varied habitat characteristics that will provide high ecological value through plant and wildlife diversity.

3.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES

Three vegetative zones have been established for this design; a deep emergent community, a shallow emergent community, and a wet meadow community. The zones are consistent with the Habitat Modules described in the Draft Habitat Plan (Parsons 2009). The deep emergent community type is planned in areas where the average growing season (May 1 to October 31; Parsons 2009) water depth does not typically drop below 24 inches, with a maximum depth of 36 inches. The deep emergent community comprises nine herbaceous species. The deep emergent design primarily includes submerged aquatic species.

The shallow emergent community type is planned in areas where the average growing season water depth ranges from 6 to 24 inches during a year with normal precipitation; however, this community may dry out during dry years (Edinger *et al.* 2002). The wet meadow community type is planned in areas where the average growing season water depth ranges from 6 inches above to 6 inches below the habitat layer surface. Figure K-2 presents the Connected Wetland Habitat Module application and the designed zonation of plant communities. Details of the planting program will be submitted as an addendum to the Final Design, subject to review and approval by NYSDEC.

3.2 HYDROLOGY

The connected wetland will be located adjacent to Onondaga Lake and directly affected by its water level variation. The design includes a main pool that will be protected from wave energy by a shoreline berm that will be constructed about 10-ft. wide, up to an elevation of 364 ft. (1.5 ft. above the typical growing season water level). Two breeches in the berm will facilitate hydrologic connection with the lake. The upper wetland border is planned at 363 ft. which will, based on historical lake water data (USGS 2010), be flooded 5 percent of the time and will be about 6 inches above the typical lake water level during the growing season. From this upper elevation, the wetland slopes gradually downward to an elevation of 359.5 ft. in the main wetland pool. This elevation will typically provide for a water depth of 30 to 36 inches during the growing season based on data for representative wet (1990) and dry (1999) years (Figures K-5 and K-6). The water depths in the design are based on USGS data from Lakeland station minus the elevation of the bottom of the wetland, or 359.5 ft. Based on this grading plan and likely lake water level variation, approximately 0.6 acres of deep emergent wetland (Habitat Modules 4A

and 5A) are expected to be created as well as 1.2 acres of shallow emergent and 0.5 acres of wet meadow (Habitat Module 6A).

SECTION 4

WASTEBED B/HARBOR BROOK OUTBOARD AREA

As discussed in Section 4.3.5.3 of the Final Capping, Dredging and Habitat, Profundal Zone (SMU 8) Design Report, habitat restoration for the Wastebed B/Harbor Brook Outboard Area is designed using the seasonal inundation of areas along the shoreline to create habitat suitable for northern pike (*Esox lucius*) reproduction. The design focuses on providing the appropriate water depths at the appropriate time of year (and concomitant water temperature) for northern pike spawning in shallow (6 inches to 3.5 ft. water depth range, 362.75-359.75 ft. elevation) and deep emergent wetlands (3.5 ft. to 6.5 ft. water depth range, 359.75-356.75 ft. during spawning season). Figure K-7 provides a general cross section of this condition. Restored habitats will include the Harbor Brook channel, shallow and deep emergent wetlands, forested wetlands, and transition to upland areas (Figure K-4). Figure 4.4 in the design provides sectional and cap profile illustration that correlate to Figure K-4.

4.1 WETLAND AND AQUATIC VEGETATIVE COMMUNITIES

The free exchange of water between the lake, Harbor Brook, and the shallow and deep emergent wetlands is a key element of the design to support a robust mix of plant species to transition from upland habitat near the barrier wall to wetland habitats along the shoreline.

Figure K-4 describes the Habitat Module delineation, and areas to be planted. Module 6A is divided into three planting zones; wetland fringe, persistent emergent interior, and persistent emergent Harbor Brook. Because of the specific targeted goal to provide northern pike spawning habitat, a specific plant list was developed for Module 6A for this area that emphasizes grasses, sedges, and narrow-leaved emergents. Similar to Module 6A in Remediation Area A, there is a different planting zone for the lake ward fringe of Module 6A as well as a 25-ft. planted buffer strip lake ward of the current outboard area shoreline designed specifically to encourage a robust transition from lake to wetland. The habitat layer will be topsoil and will be planted with species appropriate to adjacent Habitat Modules 3B, 5A, and 6A (See figure 4.4). Flowering plant species are proposed in the remainder of Module 6A and module 8B.

The critical vegetative transition from upland to wetland vegetation occurs from the top of the barrier wall to an elevation of approximately 364.5 in the outboard area. This transition zone will consist of primarily scrub/shrub forest species that will be planted and seeded including native willows (*Salix* spp.), maples (*Acer* spp.), dogwoods (*Cornus* spp.), and alder (*Alnus incana* ssp. *rugosa*). Details of the planting program will be submitted as an addendum to the Final Design, subject to review and approval by NYSDEC.

The forested wetlands located at the terminus of the former East Flume in the Outboard Area will provide additional wetland diversity in this area. The design includes a variety of native woody tree and shrub species that will provide organic material and leaf litter to the adjacent emergent system, as well as wildlife habitat. Due to the limited acreage of forested wetlands

adjacent to the lake, this additional forested acreage will add valuable diversity along the Wastebed B shoreline.

4.2 HARBOR BROOK CHANNEL

The Harbor Brook Channel will provide increased sinuosity and length and sufficient water depths under low flows to support fish passage. The channel banks will be sloped to maximize wetland acreage in the surrounding low lying areas and provide stability. Based on the flows and velocities in the Harbor Brook channel and the lake surface elevations, a final (i.e., to be constructed as part of the lake work) channel alignment was developed (Figure K-8). The upstream thalweg elevation is set at 360.4 ft., equal to the culvert invert elevation, with a downstream thalweg elevation of 360.4 ft. The channel slope is flat out to the lake since the hydrology in this area is driven by the lake level. The wetland areas described above will be inundated by the lake, rather than flows overtopping the channel banks, although a significant brook discharge coupled with a low lake level will also inundate the wetland areas. Design objectives, considerations and constraints, and flow hydrology for Harbor Brook are discussed in further detail below.

4.2.1 Design Objectives

The objectives for the Harbor Brook channel design include:

- Maintaining the design hydraulic capacity of Culvert #1
- Providing a channel design that is constructible with the anticipated habitat layer material
- Providing a channel that allows for maximum wetland area for northern pike spawning
- Providing an increase in channel length and sinuosity
- Allowing for periodic sediment deposition and erosion in the channel
- No increase in flooding or water surface elevation during storm events

4.2.2 Design Considerations and Constraints

A preliminary hydraulic and hydrological evaluation was completed to identify a potential final channel alignment. The following channel design considerations were used to satisfy the channel design objectives and work within the design constraints presented by the remediation design:

- In order to maintain the design discharge capacity of Culvert #1, a channel bottom width of 20 ft. was selected to match the culvert's bottom width. Using a consistent bottom width maintains the effective flow area and does not create a downstream constriction for flow through the culvert and thereby does not reduce the design discharge capacity of Culvert #1.
- The upstream channel thalweg elevation matches the proposed Culvert #1 outlet invert of 360.4 ft.
- Although a vertical bank E type channel (Rosgen 1996) has been suggested by state environmental agencies to be desirable for other stream restorations in the vicinity of

Onondaga Lake, the restoration of Lower Harbor Brook is not amenable to this channel type. The stability of the habitat fill material and the depositional setting caused by the backwater effect of Onondaga Lake, limit the ability to create an E-type channel for Lower Harbor Brook. The side slopes for the channel are 4:1, which is the slope used for all capped areas.

- The typical backwater condition in the channel caused by the lake limits flow velocities and shear stresses. These hydraulic conditions are likely to permit the deposition of finer grained material (e.g., silt, sand and gravels) in the channels that are transported into the area by Harbor Brook. A more complex channel design would further reduce velocities and shear stresses, allowing the channel to fill in with sediment over time.
- The wetland areas are designed to be inundated primarily by the lake, rather than flows overtopping the channel banks. Although a significant brook discharge coupled with a low lake level will also inundate the wetland areas.
- The upstream and downstream thalweg elevation (360.4 ft.) provides a minimum water depth of 2.1 ft. for a lake level of 362.5 ft. at a negligible channel discharge.

4.2.3 Flow Hydrology

Using the mean daily discharge data from the USGS gage 04240105 on Harbor Brook, percent exceedance discharges were calculated on a daily basis for the period of record. The minimum, mean, and maximum discharges were also calculated on a daily basis for the period of record. These daily statistics were then averaged to determine representative monthly values.

The monthly discharge exceedance probability values aggregated from the daily exceedance probability calculations are provided in Table K-1. The average value for the water year is also provided in the far right column for each exceedance probability.

The annual flow hydrology analysis indicates that a majority of the time the channel water surface elevation will be primarily determined by the lake's water surface elevation as the channel discharge will be significantly less than the channel's discharge capacity. In addition, as discussed above, the Harbor Brook channel thalweg elevation will be from 360.4 ft. As shown in Figure 3 in Attachment D to the Geddes Brook 100% Design Report (Parsons and Anchor QEA, 2011), the lake level has never been below 361 ft. (based on the period of record 1970-2009). As such, the channel will have a minimum of 7 inches, regardless of Harbor Brook flow.

4.3 WATER TEMPERATURE

Water temperature data were collected from the littoral zone in and around Harbor Brook from March through mid-May, 2011 to estimate the time period in Onondaga Lake when preferred water temperatures for spawning are available to confirm the design elevations selected for this area. The specific objective for the water temperature monitoring is to evaluate water temperatures in the shallow nearshore littoral zone in Onondaga Lake near Harbor Brook to better understand the potential timing of northern pike spawning in this system.

Water temperature was monitored at several locations in Harbor Brook and Onondaga Lake from just after ice out in early March to mid-May to determine the timing for preferred conditions for pike spawning.

4.3.1 Methods

HOBO® data loggers were placed in the lake near Harbor Brook in 1, 2, and 5 ft. of water (3 locations each), in the Harbor Brook channel, along the Harbor Brook bank, and near Ninemile Creek in 1 and 2 ft. of water. Monitors were programmed to record water temperature hourly. Data loggers were installed at each targeted water depth on March 11, 2011, in the Harbor Brook area just after the majority of ice out, and on March 23, 2011 in the Ninemile Creek area (ice out was later in this area). Loggers were attached to cinder blocks at the deep locations, and a dog stake in the shallower depths and suspended just above the substrate (i.e., approximately 6 inches). Monitors were inspected, location slightly adjusted if not within the targeted water depth, and the temperature data were downloaded on a weekly basis.

Dissolved oxygen was measured at each location using a hand held probe during each download. This data is summarized in Table K-2. Locations were not visited during May due to high water and safety concerns; loggers were removed from the lake on June 6, 2011.

4.3.2 Results

Data from the hourly temperature readings at each location from late March through mid-May are presented in Figures K-9 through K-13. One logger was not able to be downloaded following the first event on April 4 (Harbor Brook West Bank); data are not available from this location after this date. Several loggers were out of the water during downloading due to water level fluctuations and were relocated in the appropriate water depth (generally within 10-30 ft. of original location); these are noted on each figure as applicable. The preferred northern pike spawning temperature range (between 41°F and 55°F) is provided on each graph for comparison with the collected data.

Based on visual inspection of the figures, there is not a discernable difference in temperature among the various depths along the shoreline, all three depths appeared to reach suitable spawning temperatures approximately mid-March and extended into early May (Figures K-9, 10, 11). The Harbor Brook channel and wetland locations also followed the same general trend as the littoral locations with suitable spawning temperatures recorded between mid-March to late April (Figure K-12). The Ninemile Creek location warmed later with suitable spawning temperature recorded near the end of March and lasting into early May (Figure K-13). These results are consistent with the assumptions in the Intermediate Design with water surface elevations during March to late April used to determine the habitat layer elevation.

Dissolved oxygen measurements recorded from each location during weekly downloads ranged from 9.19 to 12.79 mg/L (Table K-2). These are consistently higher than minimum dissolved oxygen concentration (4.5 mg/L) that is suitable for embryo development (Inskip 1982). As long as eggs remain suspended on the vegetation, dissolved oxygen concentrations should be suitable for incubation and hatching in the future.

4.4 SHORELINE WAVE ATTENUATION

An evaluation was completed to determine if measures to attenuate wave energy, such as an offshore wave break, are necessary to facilitate northern pike spawning and wetland development in the WBB/HB Outboard Area. Some degree of water movement is beneficial and necessary to create suitable pike spawning habitat (Casselman and Lewis 1996, Brodeur et al. 2004). However, water movement caused by large waves (i.e., > 2 ft.) could hinder the establishment of wetland vegetation, which is also required for suitable pike spawning habitat. As discussed in Section 4.2.3, Harbor Brook channel flows are generally low, and velocities and sheer stresses are low due to the backwater effect of the lake and are unlikely to affect wetland vegetation. The potential for waves to impact the site due to the long fetch associated with this portion of the lake was evaluated based on wind data from1942 to 2009. The results of the wind analysis, presented below, demonstrate that there is only a 3 percent chance of a wave greater than 1.0 ft. reaching the shore in this area. The period of March 15th - April 7th was selected to capture the pike spawning season and the beginning of the growing season in the spring for plants that may be subjected to wave action. During this period, over 60 percent of the time there are no measurable waves that reach the shore.

Due to the limited potential for large waves to impact the site, and the desire to allow water movement to support pike spawning and vegetative growth, it is not necessary to construct permanent feature(s) above the average lake level to attenuate wave energy.

4.4.1 Historical Wave Analysis

One of the key design considerations for the habitat restoration is the amount of wave energy that reaches the Harbor Brook/Outboard shoreline. From May 18, 2005 to August 4, 2005, Upstate Freshwater Institute (UFI) measured significant wave heights in the littoral zone in vicinity of the ILWD (Owens et al, 2009). The maximum significant wave heights were measured to be approximately 2-3 ft. Long-term historical wave height measurements have not been collected in Onondaga Lake. Therefore, an analysis of wave heights at this location was performed to evaluate the frequency of various wave heights.

Historical wave heights were estimated from continuous wind measurements collected at the Hancock International Airport from 1942 to 2009 using the procedures described in Section 5 – Wind-Wave Analysis of the Armor Layer Design Appendix to the *Draft Onondaga Lake Capping and Dredge Area and Depth Initial Design Submittal*. This report was submitted to the New York Department of Environmental Conservation (NYSDEC) in December 2009. That report describes the wind-wave analysis methods and procedures in detail, provides documentation of the inputs and data used in the analysis, and presents an example calculation. The procedures used in the analysis are summarized below.

Continuous hourly wind measurements (speeds and direction) from 1942 to 2009 were obtained from Hancock International Airport. The airport is located approximately 5 miles east of Onondaga Lake. The winds were measured at the following heights above the ground:

- 1942 to 1949: 57 ft.
- 1949 to 1962: 72 ft.

- 1962 and 1963: 84 ft.
- 1963 to 2009: 21 ft.

The methodology used to estimate wind speeds for wave prediction is consistent with that described in Part II – Chapter 2 of the U.S. Army Corps of Engineers (USACE's) *Coastal Engineering Manual* (CEM; USACE 2006). In accordance with the CEM, the measured wind speeds were first converted to hourly-averaged wind speeds at heights of 32.8 ft. (10 meters) above the ground for predicting waves (USACE 2006). The hourly-averaged wind speeds were then converted to 15-minute-averaged wind speeds using procedures outlined in the CEM. In large lakes, the wave generation process tends to respond to average winds over a 15- to 30-minute interval (USACE 2006), because shorter duration gusts are generally not sufficient for significant wave generation. It is assumed that Onondaga Lake represents fetch-limited conditions and not duration-limited conditions for wave growth. Using 15-minute averages produces higher wind speeds than 30-minute averages, so the more conservative 15-minute averaging interval was used in this analysis. The methods described in the USACE *Automated Coastal Engineering System* (ACES) computer program were used to model wave growth and propagation due to winds (USACE 1992).

The wave analysis was performed using wind data collected for all months, as well as between March 15 and May 15. The period March 15 to May 15 are the critical time periods for northern pike spawning and initial plant growth. Wind directions were divided into 30-degree bins, and for each parcel, a representative fetch was estimated for each directional bin from the shoreline near the Harbor Brook confluence with Onondaga Lake. For each wind speed and direction, the corresponding significant wave height and period were calculated, and wave roses were developed for each parcel. The significant wave height and period represents the average of the largest 1/3 of all the wave heights and periods.

Figure K-14 presents the wave roses for all months and for the March 15 to May 15 period, respectively. The largest significant wave heights are from the northwest. There is a slightly higher percentage of waves in the 1-2 ft. range during the March 15 to May 15 period, compared to the average for all months. However, the cumulative frequency distribution of computed significant wave heights for all months, and for the March 15 to May 15, period shows that wave heights in excess of 1 ft. occur very infrequently, less than 3 percent of the time in either time period. (Figure K-15.)

SECTION 5

TOTAL ORGANIC MATTER CONTENT IN HABITAT LAYER

The amount of organic matter in lake sediments can vary considerably. In Onondaga Lake, areas with higher organic matter are generally associated with tributary deltas and deeper depositional areas. This pattern is understandable since in lacustrine systems, allochthonous input is generally much larger compared to internal (autochthonous) sources. Over time, the organic matter levels in the sediments placed in Onondaga Lake as part of the remedy are expected to reflect existing patterns due to continued organic matter input from the watershed and addition of organic matter is not considered to be necessary in all locations. However, in wetland locations, topsoil will be used as the habitat layer to support initial plant establishment. The amount of organic matter in the habitat layer was determined based on samples collected from wetlands adjacent to the lake in SYW-10 and Geddes Brook floodplain and review of the scientific literature (Ballantine and Schneider 2009). The sediment samples from SYW-10 and Geddes Brook flooplain had average organic matter content values of 4.7 percent and 3.1 percent, respectively, with an overall range of 1.8 percent to 15.6 percent. Based on that range and results from other studies (Bishel-Machung et al. 1996; Bruland and Richardson 2006; Campbell et al. 2002), a target range 5 percent to 15 percent and an approximate average of 7.5 percent was selected for the wetland modules that will be planted as discussed in Section 4.3.6 of the final design.

The areas currently colonized by submerged macrophytes in Onondaga Lake have organic matter values that range from 0.1 percent to 31 percent. This wide range is consistent with the range of values observed at other sites (e.g., St. Louis River Tar Site). This is also consistent with the scientific literature which shows that submerged macrophytes exist under a wide variety of environments. One aspect of the physical environment, sediment properties, has been widely studied, in particular sediment grain size, organic matter content and sediment nutrients (Van Wijck et al., 1991, Koch, 2001). Rogers et al. (1992) reported that sediments in a *Vallisneria* bed in Lake Onalaska were intrinsically infertile and plant growth was dependent on nutrient supply/renewal, most likely by way of sedimentation (Rogers et al. 1992). Other studies have shown that high levels of organic matter can inhibit growth of submerged macrophytes (Barko and Smart 1983). Since 2005, submerged macrophytes in Onondaga Lake have rapidly expanded into areas with varying sediment types and organic matter ranging from 0.17 percent to 26 percent.

Successful colonization of sediments with such a wide range of organic matter suggests that organic matter levels were not the primary factor limiting the distribution of submerged macrophytes. Rather, the increased macrophyte distribution is likely the result of increased light availability due to water quality improvements. As such, addition of organic matter to the submerged macrophyte habitat modules is not considered necessary. Natural colonization of these areas from the native seed bank is expected to occur fairly rapidly. The exceptions to this are the habitat modules adjacent to the Ninemile Creek spits, and a 25 ft. transition zone within

the lake adjacent to the Outboard Area. As discussed in Sections 2 and 3, these areas will be planted, and therefore the habitat substrate in these areas will consist of topsoil with an organic content of 5 percent to 20 percent.

Benthic macroinvertebrates (BMI) also comprise an important component of secondary production in the littoral zone. The distribution and composition of the BMI community is based on a combination of factors including physical and biological habitat conditions, feeding mode and food ability (Merritt and Cummins 1988). Physical factors such as littoral slope and water depth have been shown to be the most critical factors influencing benthic community composition of lakes (Duarte and Kalf 1986; Rasmussen 1988; Stantec 2006). Sediment organic content has also been shown to be important. In lacustrine systems, BMI feed on particulate organic matter that settles to, or grows upon, the substrate (Rasmussen 1988). While the amount of particulate organic matter produced within the lake has decreased due to improvements in water quality (and concomitant reduction in primary production by algae), there is still significant particular organic matter produced within and entering the lake. Higher organic matter can reduce oxygen levels in sediments and at the sediment-water interface, and thus reduce the abundances of taxa like mayflies and caddisflies that have a higher requirement for oxygen than worms, chironomids and clams (Hilsenhoff, 1987). Therefore, addition of organic matter to the habitat layer is not considered necessary to support benthic macroinvertebrates.

SECTION 6

SHORELINE TRANSITION AREAS

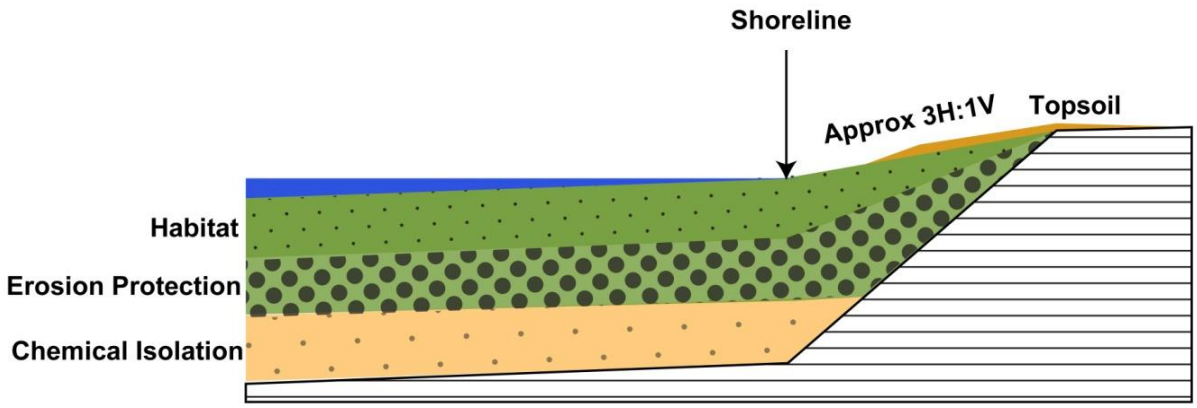
6.1 AREAS WITHOUT ADJACENT REMEDIATION

In areas where the dredge and cap design does not abut adjacent shoreline remediation, such as Remediation Areas C and E, the treatment for the shoreline areas will be the same as was used in the Willis Avenue Lakeshore Barrier Wall IRM (Site No.: 734026) Restoration/Mitigation Design Semet IRM (Parsons 2009). This restoration will include placement of top soil over the restored habitat layer above elevation 362.5 ft., and the establishment of a native plant community using upland and shoreline plantings and seeding.

Topsoil will be placed using conventional construction techniques. Once grading is completed, the upland area above elevation 362.5 ft. will be seeded with the conservation seed mix. Details of the planting/seeding program will be submitted as an addendum to the final design.

The second component of the shoreline transition includes the establishment of shrub species along the lake shoreline. The establishment of waterside vegetation will provide shade and leaf litter input that will enhance the fish and benthic macroinvertebrate habitat in the adjacent shallow water areas of Onondaga Lake that will be restored as part of the in-lake remediation work (Figure K-3.)

A typical schematic section is described below.



6.2 SHORELINE STABILIZATION ADJACENT TO REMEDIATION AREAS

There are several areas within the lake that require remediation up to the shoreline along Wastebeds 1-8. Per the requirements outlined in the ROD, shoreline stabilization is required

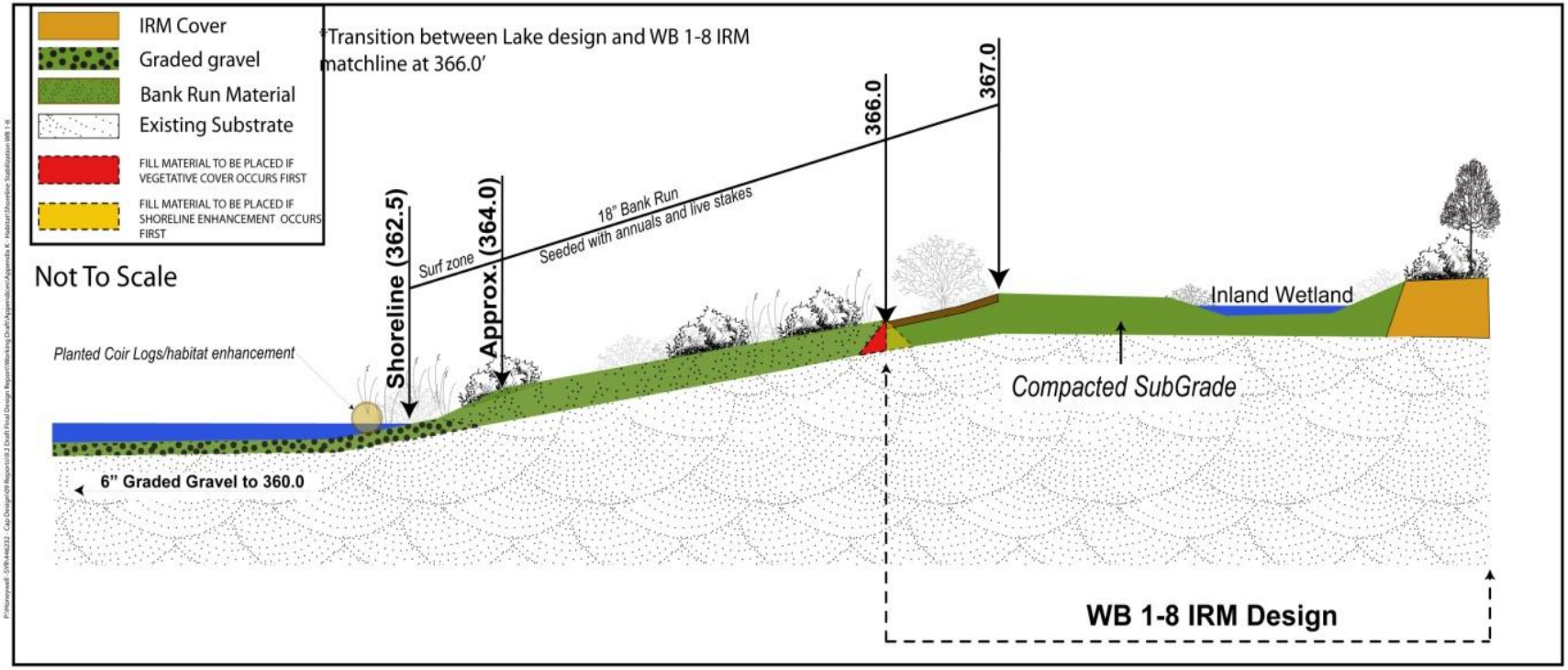
along the shoreline in this area. Given the sloping condition required for the dredge cut in these areas as noted on the cross section above for the isolation cap and habitat layer, the shoreline treatment will cover the adjacent upland area (362.5-365 ft.) and additional shoreline stabilization will not be required.

6.3 SHORELINE STABILIZATION IN AREAS WITHOUT ADJACENT REMEDIATION

The majority of the Wastebeds 1-8 shoreline does not require remediation for the adjacent in the lake areas. However, the shoreline stabilization requirements from the Onondaga Lake ROD identify the need to address this shoreline area. The in-lake portion of the stabilization will consist of 6 inches of graded gravel from elevation 360-362.5 ft. This elevation was determined by evaluating the surf zone for the 10-yr. storm event. The design in this area will enhance the existing shoreline with structure and planting with minimal impact on lake surface area.

In order to address resuspension of Solvay waste materials due to shoreline wave action and enhance the ecological integration of the Wastebed 1-8 IRM with the lakeshore edge, material placement and planting will be conducted from 362.5 to 365 ft. (existing conditions). A summary of the design in this area is included below along with a schematic cross section.

- 18 inches of native run-of-the-bank material will cover from the average lake shoreline (362.5 ft.) up to 366.0 ft.
- 362.5 to 366.0 ft.; this area will be planted with 2-inch plugs and seeded with native annuals and perennials in addition to placement of coir logs and larger woody debris (plant species to be consistent with predicted hydrology).
- Targeted placement of pre-vegetated, bio-degradable coir logs along the shoreline adjacent to the perched wetlands at the 362.0 elevation (locations to be shown in the design addendum). The area between and upland of coir logs will be seeded with native grasses and forbs. This approach will provide suitable area for additional sediment trapping and development of shoreline vegetation. Additionally, this enhancement will create a smooth vegetated transition to the shoreline revetment activities in the Wastebed 1-8 IRM.
- Live stakes will be installed into the 18 inches of native bank run material along SMU 3 shoreline between elevation 363 and 366 to provide vegetated buffer to invasive colonization along shoreline as well as shading for nesting birds and mammals.


IRM Cover
Graded gravel
Bank Run Material
Existing Substrate
FILL MATERIAL TO BE PLACED IF VEGETATIVE COVER OCCURS FIRST
FILL MATERIAL TO BE PLACED IF SHORELINE ENHANCEMENT OCCURS FIRST
*Transition between Lake design and WB 1-8 IRM matchline at 366.0'
Not To Scale
Shoreline (362.5)
Approx. (364.0)
Surf zone
18" Bank Run
Seeded with annuals and live stakes
366.0
367.0
Inland Wetland
Planted Coir Logs/habitat enhancement
Compacted SubGrade
6" Graded Gravel to 360.0
WB 1-8 IRM Design

SECTION 7

REFERENCES

Ballantine, K. and R. Schneider. 2009. Fifty-Five Years of Soil Development in Restored Freshwater Depressional Wetlands.

Barko, J.W. and R.M. Smart. 1983. Sediment-Related Mechanisms of Growth Limitation in Submersed Macrophytes. Ecology 67(5):1328-1340.

Basset, C.E. 1994. Use and Evaluation of Fish Habitat Structures in Lakes of the Eastern United States by the USDA Forest Service. Bulletin of Marine Science 55(2-3): 1137-1148(12).

Bishel-Machung et al. 1996. Soil Properties of Reference Wetlands and Wetland Creation Projects in Pennsylvania. Wetlands 16(4):532-541.

Boers, A.M. and J.B. Zedler. 2008. Stabilized Water Levels and *Typha* Invasiveness. Wetlands 28(3): 676-685.

Brodeur, R.D., Emmett, R.L., Fisher, J.P., Casillas, E., Teel, D.J. and T.W. Miller. 2004. Juvenile Salmonid Distribution, Growth, Condition, Origin, and Environmental and Species Associations in the Northern California Current. Fisheries Bulletin 102:25-46.

Bruland, G. L., and C. J. Richardson. 2006. Comparison of Soil Organic Matter in Created, Restored and Aired Natural Wetlands in North Carolina. Wetlands Ecology and Management 14:245–251.

Campbell et al. 2002. A Comparison of Created and Natural Wetlands in Pennsylvania, USA. Wetlands Ecology and Management 10:41–49.

Casselman, J.M. and C.A. Lewis. 1996. Habitat Requirements of Northern Pike (*Essox lucius*). Canadian Journal of Fisheries and Aquatic Sciences 53(S1): 161-174.

Duarte, C. and J. Kalff. 1986. Littoral Slope as a Predicator of Maximum Biomass of Submerged Macrophyte Communities. Limnol. Oceanogr. 31:1072-1080.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. (Draft for review). New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

Hilsenhoff, W.L. 1987. An Improved Biotic Index of Organic Stream Pollution. Great Lakes Entomologist, 20:31-39.

Houser, D.F. 2007. Fish Habitat Management for Pennsylvania Impoundments. Pennsylvania Fish and Boat Commission.

Inskip, P.D. 1982. Habitat Suitability Index Models: Northern Pike. Fish and Wildlife Service Fort Collins Co Western Energy and Land Use Team.

Koch, 2001. Beyond Light: Physical, Geological, and Geochemical Parameters as Possible Submersed Aquatic Vegetation Habitat Requirements. Estuaries 24(1):1-17.

Merritt, R.W., and K.W Cummins. 1988. An Introduction to the Aquatic Insects of North America, second edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Owens, E.M., R. Bookman, S.W. Effler, C.T. Driscoll, D.A. Matthews, and A.J.P. Effler. 2009. Resuspension of Mercury-Contaminated Sediments from an In-Lake Industrial Waste Deposit. Journal of Environmental Engineering, 135:7(526).

Parsons. 2009. Remedial Design Elements for Habitat Restoration. Prepared for Honeywell. Morristown, NJ. December 2009

Parsons, 2011b. 100% Design Report for the Geddes Brook Interim Remedial Measure. Prepared for Honeywell, Inc. by Parsons. March 2011.

Parsons. 2005. Onondaga Lake Pre-Design Investigation: Data Summary Report. Prepared for Honeywell, Morristown, New Jersey. Syracuse, New York.

Parsons. 2009c. Onondaga Lake Pre-Design Investigation: Phase II Data Summary Report. Prepared for Honeywell, Morristown, New Jersey and Syracuse, New York

Parsons. 2009d. Onondaga Lake Pre-Design Investigation: Phase III Data Summary Report. Prepared for Honeywell, Morristown, New Jersey and Syracuse, New York

Parsons 2009e. Onondaga Lake Pre-Design Investigation: Phase IV Data Summary Report. Prepared for Honeywell, Morristown, New Jersey and Syracuse, New York

Parsons, 2010. Onondaga Lake Phase IV Pre-Design Investigation Data Summary Report. Prepared for Honeywell. July. Draft.

Pratt, T.C. and K.E. Smokorowski. 2003. Fish Habitat Management Implications of the Summer Habitat use by Littoral Fishes in a North Temperature Mesotrophic Lake. Canadian Journal of Fisheries and Aquatic Sciences 60(3): 286-300.Rasmussen, J.B. (1988): Littoral Zoobenthic Biomass in Lakes, and Its Relationship to Physical, Chemical and Trophic Factors. Canadian Journal of Fisheries and Aquatic Science. 45: 1436- 1447.

Rogers, S. J., D.G. McFarland and J.W. Barko. 1992. Evaluation of the Growth of Vallisneria Americana Michx. in Relation to Sediment Nutrient Availability. Lake and Reserv. Manage. 11(1): 57-66.

Rosgen, D. L., 1996. “Applied River Morphology”, Wildland Hydrology Books, 1481 Stevens Lake Road, Pagosa Springs, Co. 81147, 385 pp.

Smokorowski, K.E. and T.C. Pratt. 2007. Effect of a Change in Physical Structure and Cover on Fish and Fish Habitat in Freshwater Ecosystems – A Review and Meta-Analysis. Environmental Reviews 15: 15-41.

Stantec. 2006. Benthic Macro-invertebrate Sampling and Analysis of Lake Simcoe Final Report. Prepared for Lake Simcoe Region Conservation Authority. March.

United States Army Core of Engineers (USACE). 1992. Coastal Engineering Manual (CEM).

United States Army Core of Engineers (USACE). 1992.

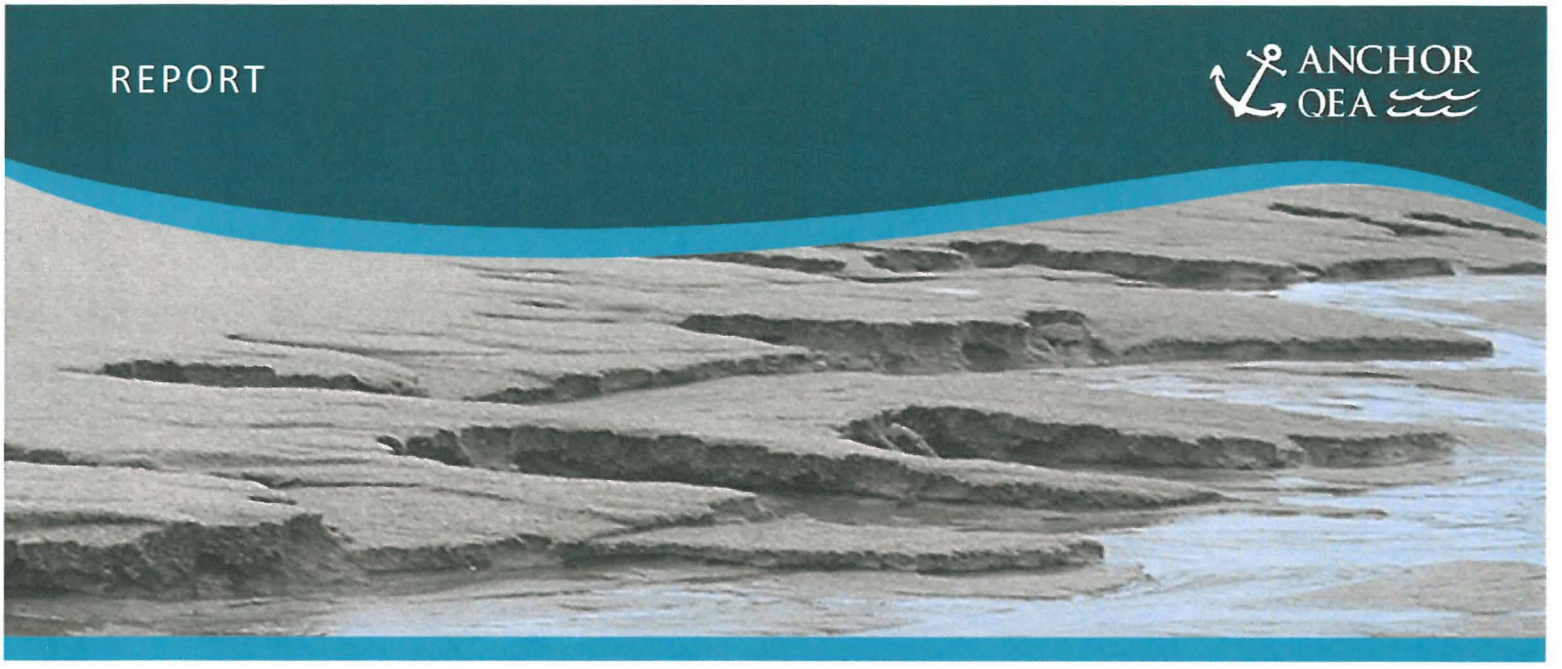
USGS Historical Water Data. 2010. http://waterdata.usgs.gov/ny/nwis/swVan Wijck, C., C.J. De Groot, and P. Grillas. 1991. The Effect of Anaerobic Sediment on the Growth of Potamogeton pectinatus L.: The Role of Organic Matter, Sulphide and Ferrous Iron. Aquat. Bot. 44:31-49.

Wilbur, R.L. 1974. Florida's Freshwater Fish Attractors. Project F-26. Florida Game and Freshwater Fish Commission, Tallahassee.

APPENDIX L

CAP MATERIAL SPECIFICATIONS

REPORT



CAP MATERIALS SPECIFICATIONS APPENDIX – ONONDAGA LAKE

Prepared for

Honeywell
PARSONS

Prepared by

Anchor QEA, LLC

March 2012

Matthew R. Henderson, P.E.
New York State Professional Engineer
License No. 083603-1

Date: March 2, 2012

It is a violation of law for any person, unless he is acting under the direction of a licensed professional engineer, to alter this item in any way. If this item bearing the seal of an engineer is altered, the altering engineer shall affix to this item his seal and the notation "altered by" followed by his signature and the date of such alteration, and a specific description of the alteration.

APPENDIX L
CAP MATERIAL SPECIFICATIONS

Prepared for

Honeywell

PARSONS

Prepared by

Anchor QEA, LLC
290 Elwood Davis Road
Liverpool, NY 13088

March 2012

TABLE OF CONTENTS

1 INTRODUCTION 1

2 CONSIDERATIONS RELATED TO CAP MATERIAL GRADATIONS 2

3 SPECIFICATION DEVELOPMENT FOR AGGREGATE MATERIALS 5

4 AMENDED CAP MATERIALS 14

4.1 Granulated Activated Carbon 14

4.2 Siderite 14

5 EARTHEN MATERIAL CHEMICAL CRITERIA 16

6 REFERENCES 20

List of Tables

Table 1 Habitat Material and Erosion Protection Layer D_{50} 5

Table 2 Erosion Protection Materials Initial Design D_{50} by Remediation Area 8

Table 3 Final Design Material Types 10

Table 4 Armor and Isolation Material Filter Criteria Comparison 12

Table 5 Unrestricted Use Soil Cleanup Objectives 16

List of Figures

Figure 1 Sand Material Gradations

Figure 2 Gravelly Cobbles and Gravel Material Gradations

Figure 3 Gravel Filter Criteria Comparison

Figure 4 Gravelly Cobbles Filter Criteria Comparison

List of Attachments

Attachment A Earthen Material Specifications

LIST OF ACRONYMS AND ABBREVIATIONS

CQAP	Construction Quality Assurance Plan
GAC	Granulated Activated Carbon
Lake	Onondaga Lake
mg/g	milligrams per gram
mm	millimeters
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This document presents the process for developing specifications for capping and habitat materials for the Onondaga Lake (Lake) remediation project. In addition to the conventional aggregate materials necessary for cap construction, amended cap materials (e.g., Granulated Activated Carbon [GAC] and siderite) are incorporated into the design of the chemical isolation layer materials.

Materials to be used in the construction of caps in the Lake and adjacent wetlands can be categorized into habitat, chemical isolation, and erosion protection materials based on their function within the overall cap design. For habitat materials, general grain size characteristics were identified to provide the desired habitat substrate; additional details regarding habitat material development are included in Section 4.3 and Appendix K of the Onondaga Lake Capping, Dredging, and Habitat Final Design Report (Final Design). Similarly, chemical isolation material characteristics were identified to provide the selected isolation properties (primarily based on porosity) in conjunction with the design mixes of siderite and GAC. Appendix B of the Final Design provides additional details on the design of the chemical isolation layer. The general grain size characteristics of erosion protection materials were selected based on the hydrodynamic and wave conditions expected within each remediation area as discussed in Appendix D of the Final Design.

In general, the specifications for the capping materials for the Lake and adjacent wetlands were developed through a series of steps including the following:

- Initial design requirements based on habitat objectives and erosion protection evaluations
- Consideration of site-specific design factors
- Development of gradation specifications

These steps and the resulting specifications are discussed in detail below.

2 CONSIDERATIONS RELATED TO CAP MATERIAL GRADATIONS

Technical analyses completed as part of the Lake design included the initial development of general material classifications and mass median particle sizes (D_{50}: diameter at which 50 percent by weight is finer) required by the design. These initial design requirements are narrowly focused on the material type or D_{50} particle size and do not include a complete gradation specification. Therefore, a number of factors (including site-specific factors) were considered in developing the complete material specifications, including the following:

- Local availability of materials: The local availability of cap materials was considered to minimize transport distances and associated environmental impacts. Furthermore, use of a local source provides for "just-in-time" deliveries to the project site, which reduces the required on-site storage requirements. Though not a driver for cap design, locally available materials were considered when developing gradations so as not to unreasonably limit material sourcing. All potential influences of local materials were verified to pass design criteria prior to incorporation in gradation development.
- Material processing effort required to meet specifications: Honeywell has committed to focus on sustainability for the overall Syracuse portfolio of projects. As part of this focus, cap material specifications were aimed at minimizing the level of effort required to produce the materials as well as minimizing the amount of by-product generated by the processing that would not otherwise be used for the Onondaga Lake project or other local projects.
- Habitat considerations: The potential for cap materials to provide suitable habitat functionality was also considered during material specification development. Naturally occurring rounded or run-of-bank material is preferred over crushed rock to aid in habitat development. In addition, topsoil with an organic matter content requirement for specified habitat materials is included to provide suitable substrate in wetland areas and areas of the lake that will be planted.
- Cap material placement equipment and limitations: As discussed in Section 4.5 of the Final Design, the majority of capping materials will be placed using a hydraulic spreader system. Discussions with the selected contractor regarding the ability to hydraulically transport the materials without excessive pumping and pipeline issues lead to identifying an upper size limit (e.g., D_{100}) of approximately 2 to 3 inches in

diameter for gravels and sands. Larger diameter materials (e.g., gravelly cobbles and coarse gravels) will be placed mechanically; therefore, the restriction was not applied to those materials.

- Required quantities: Required quantities of material were reviewed to evaluate the feasibility for minimizing the total number of material types required. By evaluating the quantity of materials involved at different design sizes, it was possible to reduce the total number of specified material types by combining several required sizes under one specified material. For example, design requirements indicate that several areas require sand-sized particles with varying median diameters (D_{50} ranging between 0.03 and 0.08 inches for these areas). Because the median particle sizes for these areas were not significantly different, the design requirements for the areas were combined into a single specification where the specified D_{50} will be at least 0.08 inches, thereby satisfying the minimum sizing requirements for stability for the range of required materials.
- Well-graded materials: Development of gradations considered the design D_{50} values and criteria from the U.S. Army Corps of Engineers (USACE) Engineering Manual 1110-2-2300 - General Design and Construction Considerations for Earth and Rock-Fill Dams (USACE 2004). In addition, the potential for vertical migration of one granular material through another (often referred to as "piping") was considered, as recommended by the U.S. Environmental Protection Agency (USEPA)/USACE's "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments" (Palermo et al. 1998). The potential for piping can be minimized through the use of well-graded gradations for the two materials. The compatibility of the two materials in combination was verified in accordance with geotechnical filter criteria (Terzaghi and Peck 1967).
- Fines content relative to water quality (turbidity): To minimize the potential for turbidity to impact water quality during material placement, the fines content (percent passing the U.S. no. 200 sieve) of each material type was considered. Section 3 discusses specification of a range of fines content and a target within that range that will achieve the objectives of minimizing water quality impacts while maintaining flexibility in individual loads.

- Layer thickness and over-placement allowance: The thickness of each layer within the cap is governed, in part, by the particle sizes of the material comprising that layer —for example, layer thickness is typically a function of the mass median and maximum particle sizes (D_{50} and D_{100}). In addition, an over-placement allowance will be provided for each layer of the cap to account for placement inaccuracies. The over-placement allowance will vary for each material based on the D_{50} and D_{100}. Based on a general objective to minimize cap thickness, grain size specifications (especially D_{100}) were developed with consideration of layer thickness and over-placement allowances.

3 SPECIFICATION DEVELOPMENT FOR AGGREGATE MATERIALS

Table 1 presents a description of the habitat material and the initial design requirements for erosion protection layer for each remediation area. As noted above, these initial design requirements form the basis for the material specifications with consideration of several site and operational factors summarized in Section 2. Remediation areas were divided into habitat modules representing different water depth ranges, with corresponding grain size and organic matter content requirements. For erosion protection materials, Table 1 presents the calculated D_{50} size requirements based on the design described in Sections 1 and 2 and described in Appendix D (Armor Layer Design) of the Final Design. Note that in some areas, habitat material size coincides with that of the erosion protection materials, while other areas require an additional layer of habitat material over the erosion protection layer to provide suitable habitat substrate.

Table 1
Habitat Material and Erosion Protection Layer D_{50}

Remediation Area	Habitat Module	Habitat Layer Material Description	Erosion Protection Layer – Design D_{50} (inches)	Organic Matter Content (percent)
A	6A	Topsoil	1.5	5 to 20
	5A	Topsoil	1.5	5 to 20
	4A	Topsoil	1.5	5 to 20
	3A (in 2- to 3-foot water depth)	Topsoil	1.5	5 to 20
	3A (in 3- to 7-foot water depth)	Fine Gravel [a]	0.51	N/A
	3B (NMC Channel)	Coarse Gravel [a]	1.0	N/A
	2B (NMC Channel)	Coarse Gravel [a]	1.0	N/A
	2A (in 7- to 10-foot water depth)	Fine Gravel [a]	0.51	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.08	N/A
	1	Medium Sand [a]	0.08	N/A
B	5A	Fine Gravel	1.7	N/A
	3A (in 2-4 foot water depth)	Fine Gravel	1.7	N/A
	3A (in 4-7 foot water depth)	Fine Gravel [a]	0.67	N/A
	2A (in 7-10 foot water depth)	Fine Gravel [a]	0.2	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.03	N/A
	1	Medium Sand [a]	0.03	N/A

Remediation Area	Habitat Module	Habitat Layer Material Description	Erosion Protection Layer – Design D_{50} (inches)	Organic Matter Content (percent)
C	8A	Fine Gravel	1.9	N/A
	5B	Fine Gravel	1.9	N/A
	5B (Boat Launch Area)	Coarse Gravel [a]	1.9	N/A
	3B (in 2- to 4-foot water depth)	Fine Gravel [a]	1.9	N/A
	3B (Boat Launch Area)	Coarse Gravel [a]	1.9	N/A
	3B (in 4- to 7-foot water depth)	Fine Gravel [a]	0.52	N/A
	2A (in 7- to 10-foot water depth)	Fine Gravel [a]	0.3	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.08	N/A
	1	Medium Sand [a]	0.08	N/A
D	25-foot buffer [b]	Topsoil	1.9	5 to 20
	6A	Medium Sand	1.9	N/A
	5A	Medium Sand	1.9	N/A
	3B (in 2- to 4-foot water depth)	Medium Sand	1.9	N/A
	3B (in 4- to 7-foot water depth)	Fine Gravel [a]	0.52	N/A
	2A (in 7- to 10-foot water depth)	Fine Gravel [a]	0.3	N/A
	2A (in 10- to 20-foot water depth)	Medium Sand [a]	0.08	N/A
	1	Medium Sand [a]	0.08	N/A
E	25-foot buffer [b]	Topsoil	3.0	5 to 20
	6B	Coarse Gravel	3.0	N/A
	5B	Coarse Gravel	3.0	N/A
	3B (in 2- to 3-foot water depth)	Coarse Gravel	3.0	N/A
	3B (in 3- to 7-foot water depth)	Gravelly Cobbles [a]	3.0	N/A
	2B	Coarse Gravel [a]	1.1	N/A
	2A	Fine Gravel [a]	0.4	N/A
	2A (Navigation Channel)	Gravelly Cobbles [a]	3.0	N/A
	1	Medium Sand [a]	0.04	N/A
NMC Spits	6A	Topsoil	wetlands	5 to 20
	9B	Topsoil	wetlands	5 to 20
WB 1-8 Connected Wetland	6A	Topsoil	wetlands	5 to 20
	5A	Topsoil	wetlands	5 to 20

Remediation Area	Habitat Module	Habitat Layer Material Description	Erosion Protection Layer – Design D_{50} (inches)	Organic Matter Content (percent)
WBB Outboard Area	6A	Topsoil	wetlands	5 to 20
	5A	Topsoil	wetlands	5 to 20
	3A	Topsoil	wetlands	5 to 20
	8A	Topsoil	wetlands	5 to 20
	9B	Topsoil	wetlands	5 to 20

Notes:
N/A = not applicable
NMC = Ninemile Creek
WB = Wastebed
WBB = Wastebed B
a. Habitat layer and erosion protection layer will be comprised of the same material
b. 25-foot buffer – Habitat substrate from the shoreline to 25 feet offshore will be topsoil along Remediation Area D and the Wastebed B Outboard Area.
Wetlands – In the adjacent wetlands, the additional erosion protection that will be provided by the wetland vegetation was taken into consideration, resulting in an erosion protection layer of Coarse Gravel (Type B) with a minimum erosion protection layer thickness in the wetlands of 4.5 inches, as detailed in Appendix D

To advance the development of the specifications and reduce the required number of material types for cap construction, design sizes for the erosion protection material from Table 1 were grouped into similar size categories based on Unified Soil Classification System (USCS) material classifications. Table 2 presents a summary of the calculated D_{50} for the erosion protection layer material in each remediation area (from Table 1), with materials having similar required particle sizes grouped into four general categories: sand, fine gravel, coarse gravel, and gravelly cobbles.

Table 2
Erosion Protection Materials Initial Design D_{50} by Remediation Area

Material Type	Capping Area	Design Calculated D_{50}[a] (inches)
Sand	Remediation Area A	0.08
	Remediation Area B	0.03
	Remediation Area C	0.08
	Remediation Area D	0.08
	Remediation Area E	0.04
	Remediation Area F	0.08
Fine Gravel	Remediation Area A	0.51
	Remediation Area B	0.67
	Remediation Area C	0.52
	Remediation Area D	0.52
	Remediation Area E	0.4
	Remediation Area F	0.51
Coarse Gravel	Remediation Area A	1.5
	Remediation Area B	1.7
	Remediation Area C	1.9
	Remediation Area D	1.9
	Remediation Area E	1.1
	Remediation Area F	-
Gravelly Cobbles	Remediation Area A	-
	Remediation Area B	-
	Remediation Area C	-
	Remediation Area D	-
	Remediation Area E	3.0
	Remediation Area F	-

Note:
a. Design calculated D_{50} sizing indicated is a minimum size necessary for material stability; specifications will require material to have D_{50} greater than or equal to values shown.

After grouping materials into the categories listed in Table 2, the largest design D_{50} size for each category was selected for use in specification development. The selection of the maximum design D_{50} for each material type allows the use of one material specification to cover the range of design conditions found throughout the various remediation areas, thereby reducing the required number of material types and associated material processing.

Based on a review of design conditions outlined in Section 2, it was determined that additional material subdivisions would be required for sand material and coarse gravel material. The sand category was subdivided into two material types (i.e., medium sand and gravelly sand) based on geotechnical filter criteria consideration when used as isolation material underlying the erosion protection material. Specifically, use of the gravelly sand planned for the chemical isolation layer in Remediation Area E will minimize the potential for the sand portion of the chemical isolation layer material to wash out through the larger void spaces of the overlying gravelly cobble material. The medium sand will be used for the chemical isolation material in all other remediation areas, as well as for the habitat layer where sand is the required material type (see Table 1).

Similar to the sand category, the coarse gravel category was further subdivided into two types (A and B) based on the ability to hydraulically place the material. Approximately 80 percent of the total coarse gravel volume required for the project is located in Remediation Area E and requires a D_{50} of at least 1.1 inches; the remaining 20 percent requires a D_{50} of approximately 1.5 inches to 2 inches. By developing two separate specifications for coarse gravel (types A and B), the majority of the coarse gravel material (that with the smaller particle size) could likely be hydraulically placed, reducing cost and schedule implications of mechanical placement required of the larger materials.

The selected D_{50} sizing for each erosion protection material type is presented in Table 3.

Table 3
Final Design Material Types

Material Type	Capping Area	Required D_{50} [a] (inches)
Medium Sand	Remediation Areas A, B, C, D,E, and F	0.08
Gravelly Sand	Remediation Area E, DOT turnaround area steep slope	0.13 [b]
Fine Gravel	Remediation Areas A, B, C, D, E, and F	0.67
Coarse Gravel (Type A)	Remediation Areas A, B, C, and D	1.9
Coarse Gravel (Type B)	Remediation Area E	1.1
Gravelly Cobbles	Remediation Area E	3.0

Notes:
a. Required D_{50} based on largest required D_{50} from initial design analyses for each applicable remediation area (see tables 1 and 2). D_{50} sizing indicated is a minimum sizing, specifications will require material to have D_{50} greater than or equal to values shown.
b. Required D_{50} for gravelly sand based on geotechnical filter criteria (see below).

The selected D_{50} for each material type listed in Table 3 was compared against standard U.S. sieve sizes to select a standard sieve size to use in the specification. The specification was then developed around this selected sieve size such that no more than 50 percent (by weight) in the design gradation would pass this sieve, ensuring that material meeting the specification would have a D_{50} equal to or larger than the selected sieve size. A range was then included on the selected sieve size (e.g., 30 to 50 percent passing), allowing for some natural variation in the gradation specification while still ensuring that the required D_{50} would be achieved.

An upper bound maximum particle size (D_{100}) for each material type was selected based on design considerations such as hydraulic transport and overplacement tolerances, as discussed in Section 2. For example, the gravelly cobble specification includes a maximum stone size of 6 inches to maintain a 6-inch over-placement allowance. The maximum particle sizes for the coarse gravels (Type A and Type B) were selected to prevent excessive larger material in the specification while still allowing a broad range of materials to meet the specification (i.e., allowing a naturally occurring bank run material with minimal processing). The maximum particle size for the remainder of capping materials was limited to 2 to 3 inches to allow hydraulic transport and placement of the material.

The lower bound of the material types was selected to limit the fines content of the materials to minimize the potential for water quality (i.e., turbidity) impacts during placement. The specifications for each material type were developed to limit the fines content to a maximum of 10 percent (by weight) passing the U.S. no. 200 sieve. However, acquisition of materials will target a range of fines from 0 to 3 percent (by weight). Target ranges provide a goal for lower fines content material while the upper limit allows a greater flexibility in individual loads, preventing excessive load rejection based on fines content only.

Standard geotechnical filter criteria presented by Terzaghi and Peck (1967) provide recommended particle size ratios between base and overlying materials (e.g., sand chemical isolation and overlying erosion protection materials). The primary filter criteria particle size relationship primarily applicable to subaqueous capping materials is the ratio of D_{15} of the armor stone to the D_{85} of the base layer. This relationship relates to the ability of the base layer material (e.g., sand) to pass through the void spaces in the overlying larger material (e.g., erosion protection armor stone). 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 Terzaghi filter criteria recommend the following relationship to prevent material loss through the armor layer:

$$d_{15(Armor)} < 5d_{85(Base)}$$

After reviewing the selected sizing of erosion protection and isolation materials relating to this filter criteria, additional gradation specifications were added to medium sand and gravelly sand to meet the filter criteria while also holding to the required D_{50} and general well-sorted sizing expectations. Table 4 presents a comparison of calculated D_{15} to D_{50} ratios for each armor material and the potential base isolation material.

Table 4
Armor and Isolation Material Filter Criteria Comparison

Armor Material	Armor D_{15} Range [a] (inches)		Base (Isolation) Material	Base D_{85} Range [a] (inches)		D_{15}/D_{85} Max Ratio [b]
	Min	Max		Min	Max	
Gravelly Cobbles	0.025	0.75	Gravelly Sand	0.625	1.2	1.2
			Medium Sand	0.21	0.3	3.6
Coarse Gravel Type A	0.007	0.75	Gravelly Sand	0.625	1.2	1.2
			Medium Sand	0.21	0.3	3.6
Coarse Gravel Type B	0.0065	0.5	Gravelly Sand	0.625	1.2	0.8
			Medium Sand	0.21	0.3	2.4
Fine Gravel	0.006	0.05	Gravelly Sand	0.625	1.2	0.08
			Medium Sand	0.21	0.3	0.24

Notes:
a. D_{15} and D_{85} size ranges, where not specified, were selected based on standard geotechnical gradation curves developed from the specified gradation.
b. Terzaghi criteria recommends a D_{15}/D_{85} ratio of less than 5 to prevent loss of base material through armor void spaces. Maximum ratio applies to the worst case scenario comparison of the maximum armor D_{15} compared to the minimum base D_{85}.

Figures 1 and 2 illustrate the design gradations; Figures 3 and 4 illustrate the D_{15} to D_{85} ratio relationships between the armor materials and underlying sand chemical isolation materials.

There are two additional materials that are also specified. An armor stone will be placed along the steep slope of the New York State Department of Transportation (NYSDOT) Turnaround Area to physically isolate the slag material. The armor cap over the isolation layer will consist of a layer of gravelly sand material as a bedding layer beneath the armor stone, to the extent possible, and an armor stone ranging in diameter size of 4 to 18 inches.

Additionally, material will be placed along a portion of the surf zone of Remediation Area B to address erosion of Solvay waste material along the shoreline of WB 1-8. Shoreline stabilization material consisting of a graded gravel, bank-run material will be placed at an average thickness of approximately 1.5 feet from elevation 365 feet to 362.5 feet (upland from the shoreline). Shoreline stabilization material consisting of Coarse Gravel (Type B)

will be placed at an average thickness of approximately 6 inches from elevation 362.5 feet to 360 feet (within the Lake).

Attachment A presents material specifications and gradation for each material type based on the requirements and considerations detailed above.

4 AMENDED CAP MATERIALS

Isolation materials utilized in cap construction will include amendment materials blended with the cap layer to provide appropriate isolation properties. Amendment materials include GAC and siderite for the chemical isolation layer. Application of these materials is based on an addition of specified quantities by weight per square foot of cap construction. Additional details regarding amendment rates and design are presented in Appendix B and Appendix I of the Final Design.

4.1 Granulated Activated Carbon

The GAC for use in the cap chemical isolation layer will be Calgon F400 or equivalent. The specifications that a supplier will have to meet, whether it is Calgon or another supplier, are the following Calgon F400 specifications:

- The material shall be virgin condition
- The base material must be bituminous coal
- Steam will be used as its activation method
- A minimum iodine number of 1,000 milligrams per gram (mg/g)
- A maximum moisture of 2 percent by weight
- A minimum abrasion number of 75
- An effective size of 0.55 to 0.75 millimeters (mm)
- A maximum uniformity coefficient of 1.9
- No more than 5 percent by weight greater than 12 mesh (1.7 mm)
- No more than 4 percent by weight less than 40 mesh (0.42 mm)

The size of the GAC particles (specified in the last two bullets above) will be subject to change following NYSDEC review and approval in the event that the GAC is not vertically well-mixed throughout the sand isolation layer.

4.2 Siderite

The siderite for use in the cap chemical isolation layer will be granular, composed of approximately sand-sized particles, and will meet the following specifications:

- The base material will be a siderite ore

- Gradations will conform to the following specifications:

U.S. Standard Sieve Size	Percent Passing (by weight)
U.S. No. 4	95 to 100
U.S. No. 30	0 to 5

- The target ferrous carbonate content will be 74 percent by weight. If the ferrous carbonate content is less than 74 percent by weight, then the siderite dosing in the sediment cap will be adjusted as appropriate. The method for verifying the ferrous carbonate will be provided independently following additional consultation and discussions with the selected siderite supplier.

5 EARTHEN MATERIAL CHEMICAL CRITERIA

Prior to the procurement of capping materials, borrow sources will be inspected and the materials characterized to ensure compliance with the specifications presented in Attachment A. Selected borrow sources will also be subject to materials testing requirements performed routinely throughout construction to verify continued compliance with project specifications. Suitable representative samples and test reports will be submitted to and approved prior to delivery of materials to the job site. The frequency and detailed procedures for sampling and analysis of cap materials will be provided in the Onondaga Lake Construction Quality Assurance Plan (CQAP).

Sampling will include standard geotechnical analyses (e.g., grain size, moisture content, and bulk density) in addition to chemical testing. Chemical testing will be performed to confirm that the materials comply with the Unrestricted Use Soil Cleanup Objectives listed in NYSDEC 6 NYCRR Part 375 (summarized in Table 5). Exceedance of any single chemical compound limit will mean that the entire material batch will be rejected unless subsequent testing on sub-sets of the batch demonstrates compliance with the criteria.

Table 5
Unrestricted Use Soil Cleanup Objectives

Contaminant	Unrestricted Use Criteria (parts per million)
Metals	
Arsenic	13
Barium	350
Beryllium	7.2
Cadmium	2.5
Chromium, hexavalent	1
Chromium, trivalent	30
Copper	50
Total Cyanide	27

Contaminant	Unrestricted Use Criteria (parts per million)
Lead	63
Manganese	1600
Total Mercury	0.18
Nickel	30
Selenium	3.9
Silver	2
Zinc	109
PCBs/Pesticides	
2,4,5-TP Acid (Silvex)	3.8
4,4'-DDE	0.0033
4,4'-DDT	0.0033
4,4'-DDD	0.0033
Aldrin	0.005
alpha-BHC	0.02
beta-BHC	0.036
Chlordane (alpha)	0.094
delta-BHC	0.04
Dibenzofuran	7
Dieldrin	0.005
Endosulfan I	2.4
Endosulfan II	2.4
Endosulfan sulfate	2.4
Endrin	0.014
Heptachlor	0.042
Lindane	0.1
Polychlorinated biphenyls	0.1

Contaminant	Unrestricted Use Criteria (parts per million)
Semivolatile Organic Compounds	
Acenaphthene	20
Acenapthylene	100
Anthracene	100
Benz(a)anthracene	1
Benzo(a)pyrene	1
Benzo(b)fluoranthene	1
Benzo(g,h,i)perylene	100
Benzo(k)fluoranthene	0.8
Chrysene	1
Dibenz(a,h)anthracene f	0.33
Fluoranthene	100
Fluorene	30
Indeno(1,2,3-cd)pyrene	0.5
m-Cresol	0.33
Naphthalene	12
o-Cresol	0.33
p-Cresol	0.33
Pentachlorophenol	0.8
Phenanthrene	100
Phenol	0.33
Pyrene	100
Volatile Organic Compounds	
1,1,1-Trichloroethane	0.68
1,1-Dichloroethane	0.27
1,1-Dichloroethene	0.33
1,2-Dichlorobenzene	1.1

Contaminant	Unrestricted Use Criteria (parts per million)
1,2-Dichloroethane	0.02
cis -1,2-Dichloroethene	0.25
trans-1,2-Dichloroethene	0.19
1,3-Dichlorobenzene	2.4
1,4-Dichlorobenzene	1.8
1,4-Dioxane	0.1
Acetone	0.05
Benzene	0.06
n-Butylbenzene	12
Carbon tetrachloride	0.76
Chlorobenzene	1.1
Chloroform	0.37
Ethylbenzene	1
Hexachlorobenzene	0.33
Methyl ethyl ketone	0.12
Methyl tert-butyl ether	0.93
Methylene chloride	0.05
n - Propylbenzene	3.9
sec-Butylbenzene	11
tert-Butylbenzene	5.9
Tetrachloroethene	1.3
Toluene	0.7
Trichloroethene	0.47
1,2,4-Trimethylbenzene	3.6
1,3,5-Trimethylbenzene	8.4
Vinyl chloride	0.02
Xylene (mixed)	0.26

6 REFERENCES

Palermo, M., S. Maynord, J. Miller, and D. Reible, 1998. Guidance for In-Situ Subaqueous Capping of Contaminated Sediments, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Terzaghi, K. and R. B. Peck, 1967. Soil Mechanics in Engineering Practice, 2nd ed., John Wiley and Sons, New York.

United States Army Corps of Engineers (USACE), 2004. Engineering and Design – General Design and Construction Considerations for Earth and Rock-Fill Dams. Engineering Manual EM 1110-2-2300. July 30, 2004.

FIGURES

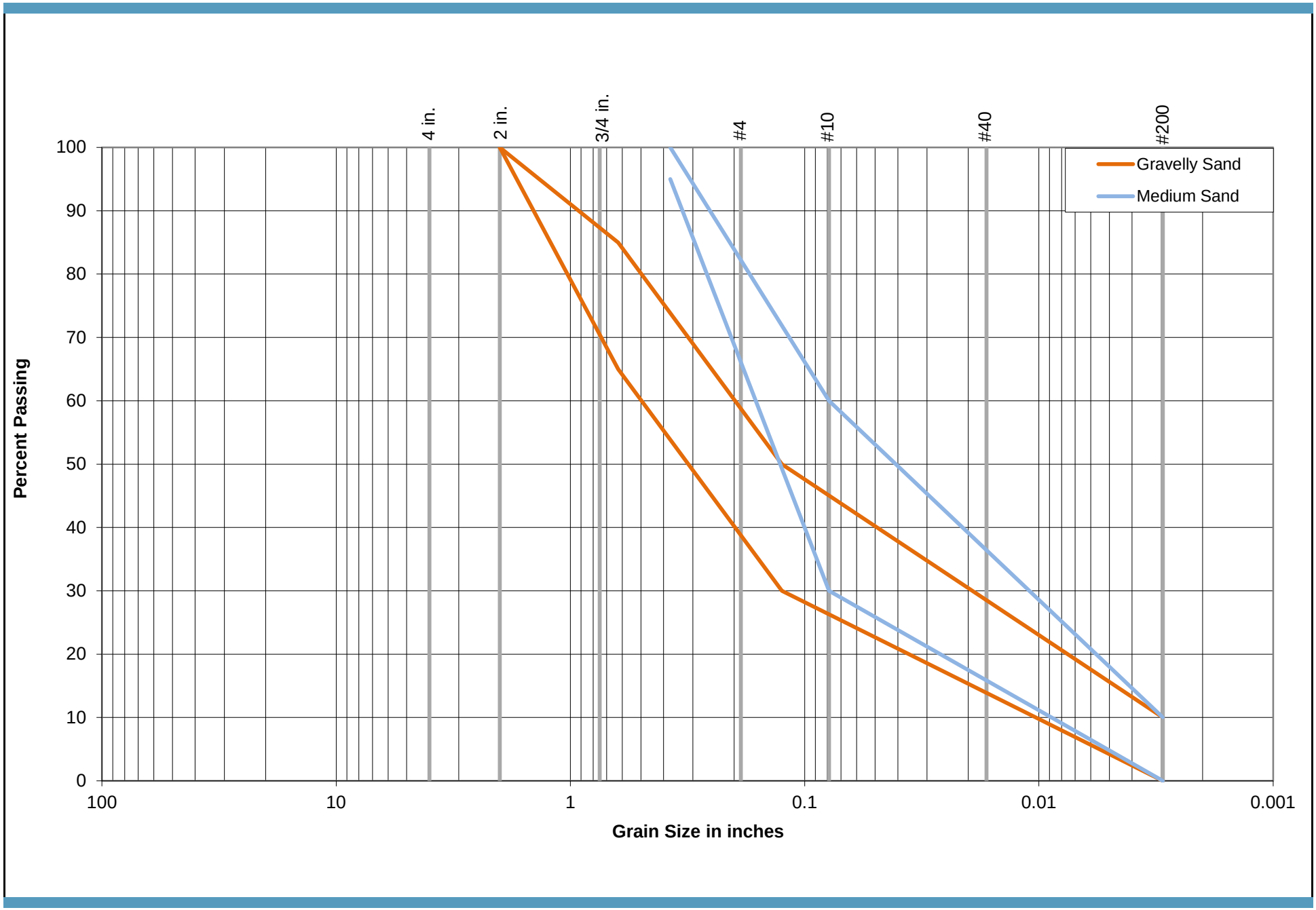


Figure 1
Sand Material Gradations
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

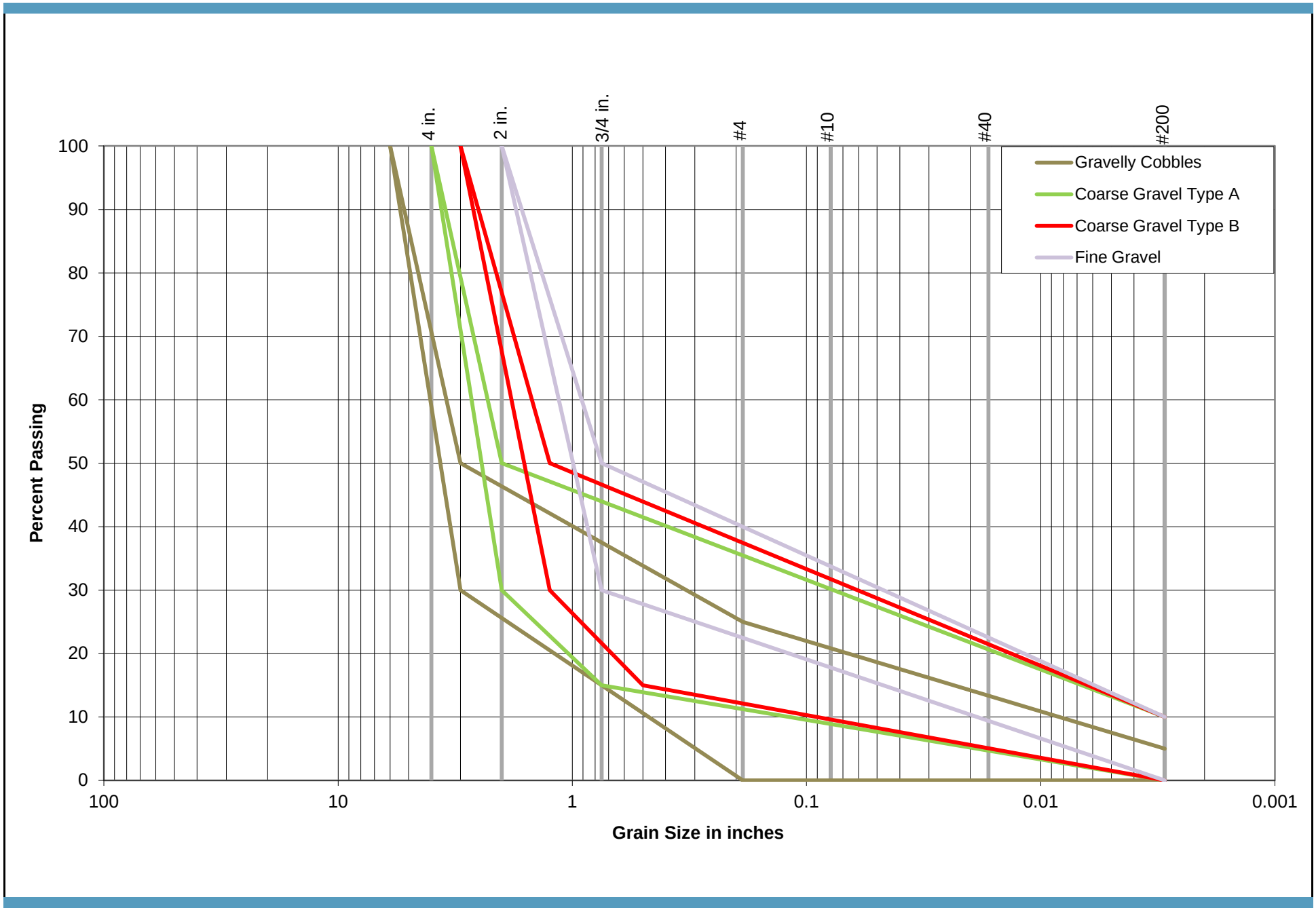


Figure 2
Gravelly Cobbles and Gravel Material Gradations
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

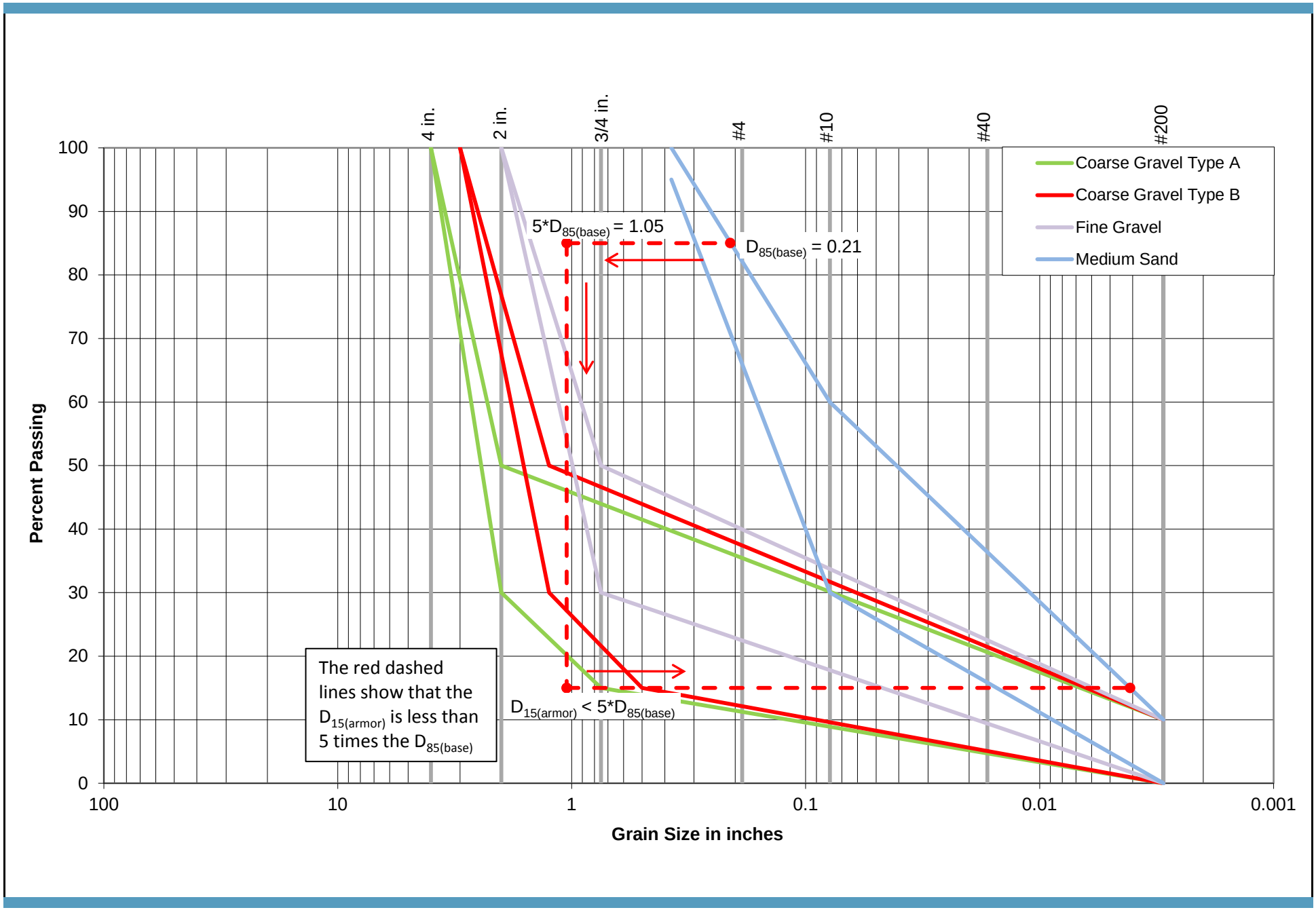


Figure 3
Gravel Filter Criteria Comparison
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

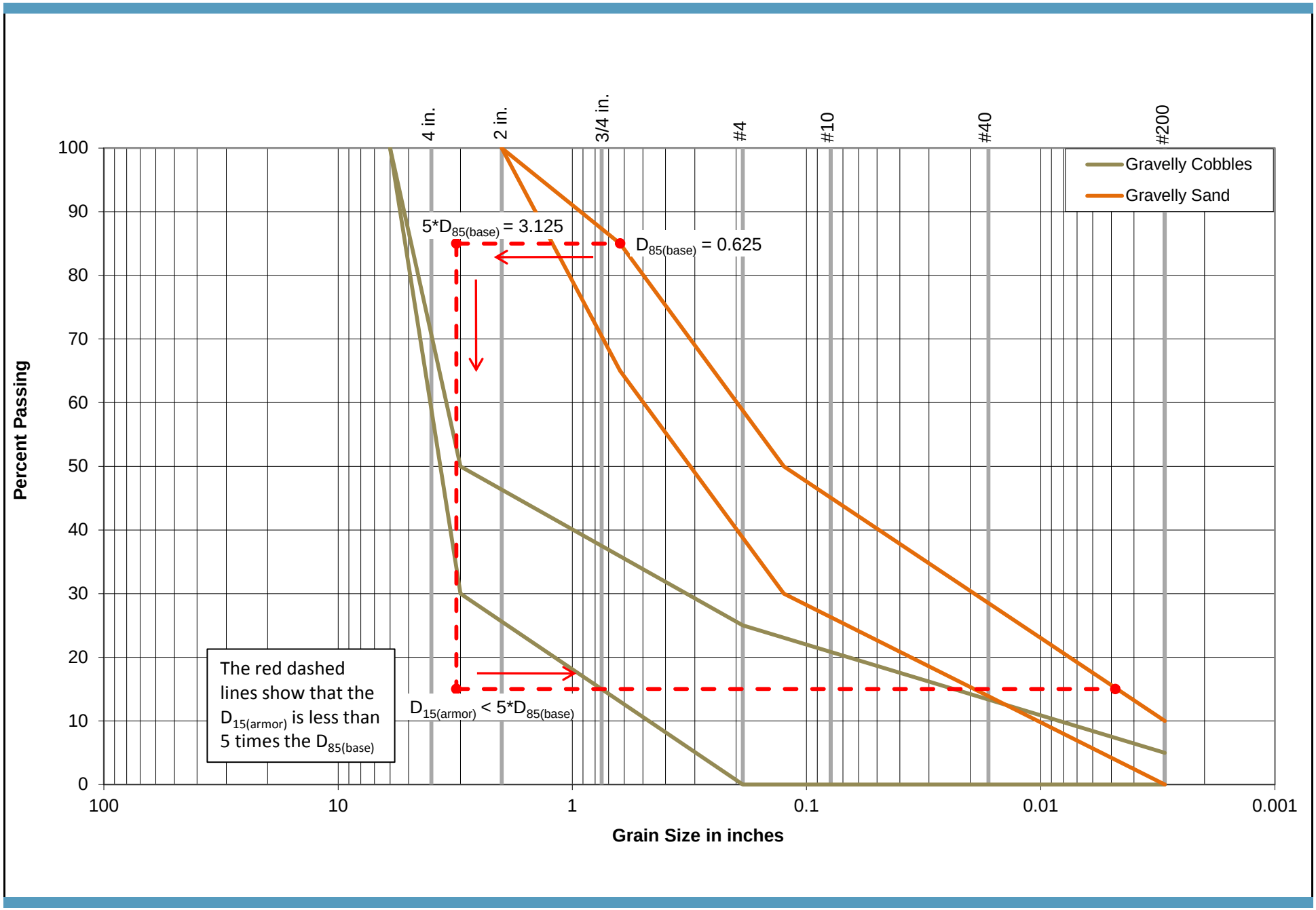


Figure 4
Gravelly Cobbles Filter Criteria Comparison
Cap Material Specifications
Onondaga Lake

ANCHOR QEA

ATTACHMENT A
EARTHEN MATERIAL SPECIFICATIONS

All materials shall be of the quality, size, shape, and gradation or equal to that manufacture as specified herein. Materials will be procured from an approved borrow source in accordance with the Onondaga Lake Construction Quality Assurance Plan.

Gravelly Cobbles

Gravelly cobble material will consist of naturally occurring stone, gravel, screened gravel or run-of-bank material. Screened gravel or bank run material will consist of uncrushed particles. Gravelly cobble material designed below the top 12 inches of the cap may be a crushed product. Crushed stone and gravel will consist of clean, durable, sharp-angled rock fragments of uniform quality. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
6 inch	100
3 inch	30 to 50
U.S. No. 4	0 to 25
U.S. No. 200	0 to 5 (0 to 3 preferred)

Coarse Gravel – Type A

Coarse Gravel material will consist of naturally occurring screened or run-of-bank gravel or other acceptable granular material. Crushed stone would be acceptable when used below the top 12 inches of the cap. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
4 inch	100
2 inch	30 to 50
3/4 inch	>15
U.S. No. 200	0 to 10 (0 to 3 preferred)

Coarse Gravel – Type B

Coarse Gravel material will consist of naturally occurring screened or run-of-bank gravel or other acceptable granular material. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
3 inch	100
1 1/4 inch	30 to 50
1/2 inch	>15
U.S. No. 200	0 to 10 (0 to 3 preferred)

Fine Gravel

Fine Gravel material will consist of naturally occurring screened or run-of-bank gravel or other acceptable granular material. Crushed stone would be acceptable when used below the top 12 inches of the cap. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
2 inch	100
3/4 inch	30 to 50
U.S. No. 200	0 to 10 (0 to 3 preferred)

Gravelly Sand

Gravelly Sand material will be naturally occurring, clean, and free-draining. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
2 inch	100
5/8 inch	65 to 85
U.S. No. 6	30 to 50
U.S. No. 200	0 to 10 (0 to 3 preferred)

Medium Sand

Medium Sand material will be naturally occurring, clean, free-draining sand. Gradations must conform to the table below.

U.S. Standard Sieve Size	Percent Passing (by weight)
3/8 inch	95 to 100
U.S. No. 10	30 to 60
U.S. No. 200	0 to 10 (0 to 3 preferred)

Topsoil

Topsoil shall be natural or manufactured, friable, and fertile soil that meets the U.S. Department of Agriculture (USDA) basic soil texture classes of loam, silt loam, or sandy loam to be recovered from the A horizon of an in-place soil. Topsoil shall be capable of sustaining healthy plant life and be reasonably free of subsoil, heavy or stiff clay, brush, roots, weeds, other objectionable plant matter, foreign material, stones larger than 4 inches in greatest dimension, and any other materials unsuitable or harmful for plant growth. Topsoil as delivered to the site or stockpiled shall meet the following requirements:

- Gradations conforming to the table below:

U.S. Standard Sieve Size	Percent Passing (by weight)
4 inch	100
1 inch	85 to 100
¼ inch	65 to 100
U.S. No. 200	15 to 80

  The 2 micron particle size shall not be greater than 20 percent of the total sample mass, as determined by hydrometer analysis.
- pH between 5.5 and 7.6
- Percent organic matter:
  - For wetland modules, topsoil shall contain greater than or equal to 5 percent and less than 20 percent organic matter as determined by loss on ignition of moisture-free samples dried at 100° to 110° Celsius. A mean value of approximately 7.5 percent organic matter will be targeted in the wetland areas.
  - For non-wetland areas (planted areas within the lake and upland modules with topsoil), topsoil shall contain greater than 5 percent and less than 20 percent

organic matter as determined by loss of ignition of moisture-free samples dried at 100° to 110° Celsius.

- Contain no nuisance weeds including seeds, stems, or rhizomes of Purple Loosestrife, Phragmites, Japanese Knotweed, or any plants on the Federal Noxious Weeds list.

NYSDOT Turnaround Area Shoreline Armor Stone

The armor stone used for the NYSDOT Turnaround Area shoreline will be riprap conforming to the following gradations:

Stone Size	Percent Passing (by weight)
Heavier than 100 pounds	50 to 100
Larger than 12 inches	50 to 100
Larger than 18 inches	0
Smaller than 4 inches	0 to 10

Remediation Area B Graded Gravel

The graded gravel to be used for the Remediation Area B shoreline stabilization between an elevation of 362.5 and 365 feet will be screened or run-of-bank gravel or other acceptable granular material. The material shall contain greater than 0.5 percent but less than 6 percent organic content by weight as determined using ASTM D2974. Gradations must conform to the table below:

U.S. Standard Sieve Size	Percent Passing (by weight)
8 inch	100
4 inch	80 to 100
¼ inch	30 to 75
No. 40	15 to 60
U.S. No. 200	Less than or equal to 25

Below elevation 362.5 feet, coarse gravel will be used for the shoreline stabilization material.

Outfall Scour Protection

The stone used for the outfalls will be riprap conforming to the following gradations (based on the NYSDOT Standard Specification for Medium Stone Filling specified in Figure 620-1):

Stone Size	Percent Passing (by weight)
Heavier than 100 pounds	50 to 100
Smaller than 6 inches	0 to 10