
APPENDIX L: EVALUATION OF DREDGING OPTIONS FOR THE ONONDAGA LAKE FEASIBILITY STUDY

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EXECUTIVE SUMMARY

This paper evaluates dredging as a sediment management action for Onondaga Lake sediments. Viable dredging alternatives are considered in detail, including estimates of production rates; residual sediment depths and concentrations; water quality impacts during dredging; deposition of resuspended sediments; effluent quality within the sediment consolidation area (SCA); and volatilization losses from the water column and during sediment rehandling. These conclusions will be used in the feasibility study (FS) as the basis for comparing alternatives.

Most conventional dredging methods should be capable of removing existing bottom sediments in the littoral areas of Onondaga Lake. Difficulties and limitations associated with transporting dredging equipment to the lake as well as water depths in the dredging areas and disposal types and locations may restrict the size of dredges that can be used and possibly eliminate some from consideration. In contrast, sediments in the profundal zone would be considerably more difficult to remove with conventional dredging equipment because they are rather deep, typically more than 50 feet (ft) (15 meters [m]) below the water surface.

This paper considers mechanical dredges using 3- and 6-cubic-yard (CY), enclosed clamshell buckets and 12- to 16-inch (0.3 to 0.4 meter) hydraulic pipeline dredges. A 3-CY bucket was estimated to have a 50- to 80-cubic yard per hour (CY/hr) (*in situ* volume) production rate, while a 6-CY bucket was estimated to have a 100- to 160 CY/hr (*in situ* volume) production rate. We estimate that a 12-inch (0.3-meter) hydraulic dredge can remove sediments at about 75 to 150 CY/hr, a 14-inch (0.35-meter) hydraulic dredge can remove sediments at roughly 85 to 170 CY/hr, and a 16-inch (0.4-meter) hydraulic dredge can dredge about 150 to 250 CY/hr.

Mechanical dredging would require a nearshore offloading facility to remove dredged sediment from haul barges to be placed into trucks. Mechanically dredged sediments could also be pumped directly from haul barges to a nearby disposal site. Hydraulic dredges would pump the material straight to the SCA.

The Solvay wastebeds appear suitable for consolidating dredged material from Onondaga Lake. The SCA would require containment berms, a low permeability layer at the base, and a final cover over the sediments for closure. The SCA would be sized to account for a sediment bulking factor of 1.3 and to have enough surface area and ponding depth to allow settling of the solids in the slurry.

Two distinctly different dredging operations in Sediment Management Unit (SMU) 1 were considered illustrative of dredging in SMU 1 and other SMUs. First, a single-cut dredging operation representing the removal of about 3 ft (1 m) of sediment over 45 acres of SMU 1 was evaluated (over 300,000 CY of dredging). This was estimated to require about 2,120 dredging hours to complete, pumping 5,000 to 5,500 gallons per minute and moving 150 CY/hr. Water

quality analyses were based on average sediment constituent concentrations over the single dredging pass. Tables L.4 and L.6 show predicted water column concentrations above background around the dredging operation and in the SCA's primary effluent. The U.S. Environmental Protection Agency's (USEPA's) CSTR-CHEM model was used to predict water quality impacts around the dredge. Highly soluble compounds such as chlorobenzene seem to be problematic in the SCA effluent.

Second, a multiple-pass dredging event removing almost 30 ft (8 m) of sediment over 84 acres of SMU 1 was evaluated (4 million CY of dredging). It is estimated that this would require about 27,000 dredging hours at 150 CY/hr. Water quality conditions were estimated for the maximum constituent concentrations found across the SMU 1 sediment profile. Since the highest concentrations of most constituents are found in the upper layer, water quality modeling assumed that all maximum constituent concentrations occurred in the first dredging pass. Numerous contaminant concentrations will likely exceed water quality criteria around the dredge during some point in the dredging operation. Tables L.9 and L.12 summarize all water quality estimates for the maximum conditions.

Residual sediment concentrations after dredging the 3-ft (1-m) cut are expected to be comparable to the sediment concentrations within the dredge cut. After successive passes, a residual level is calculated based on the depth-weighted average of: 1) the in situ concentrations of the sediment depth interval just dredged, and 2) a calculated residual layer on top of the in situ sediments from the previous dredge pass. Table L.11 presents the estimated residual total mercury concentration, assuming 3-ft (1-m) dredge cuts. The thickness of the residuals was estimated to be 10 percent by volume left behind, with an average concentration of the previous 3 ft (1 m) of sediments removed. It shows that higher surface concentrations may exist during the dredging operation. Impacts to profundal sediments from this dredging operation, using conservative assumptions, are estimated to be equivalent to only 0.1 percent of the current natural sedimentation mercury flux. Therefore, impacts to profundal sediments are minimal.

Volatile emissions at the point of dredging did not exceed health benchmarks or the odor threshold for either a single-pass dredging event or an extended depth dredge scenario in SMU 1 (see Tables L.5 and L.10). The only air quality issue associated with the point of dredging is the potential for the occurrence of non-aqueous phase liquid (NAPL) containing VOCs in the dredge materials (this may be a particular issue in SMU 2). Under this scenario, the maximum one-hour air concentration of benzene resulting from emissions during the dredging of NAPL has the potential to exceed health benchmarks for benzene by factors of 9 to 33. In the absence of more complete site characterization data, it is reasonable to assume that the greater the volume of material dredged, the greater the probability of encountering NAPL. This condition is, therefore, considered more likely to occur as the volumes of dredged materials increase from the single-pass dredge scenario to the extended depth dredge scenario.

Volatile emissions from the SCA did not exceed health benchmarks or the odor thresholds based on the average sediment concentrations, for single- or multiple-pass dredging events in SMU1 (see Tables L.6 and L.13).

The paper presents estimated equipment and crew sizes for mechanical and hydraulic dredging operations. Daily costs can be estimated by multiplying labor and equipment by appropriate rates. Dredging unit costs can be estimated by dividing the daily dredging costs presented by the estimated production rates.

SECTION L.1

INTRODUCTION

L.1.1 BACKGROUND

A feasibility study (FS) has been conducted to evaluate remedial alternatives for Onondaga Lake near Syracuse, New York. The remedial investigation (RI) (TAMS, 2002) cites ongoing releases from lake sediments as the primary cause of impaired water quality in the lake and impact to biological systems supported by the lake. Available data show that lake sediments contain a variety of anthropogenic constituents resulting from historical manufacturing near the lake. Thus, the FS considers alternatives for managing, treating, or capping these lake sediments. This paper investigates dredging as a sediment management action for Onondaga Lake littoral sediments. As discussed in Section L.2.1, dredging of profundal sediments is not evaluated in this paper.

L.1.2 OBJECTIVES

This paper evaluates dredging alternatives for Onondaga Lake. It provides estimates of production rates and recommends methods for estimating post-dredging sediment quality (i.e., residual sediment depths and concentrations); water quality impacts during dredging; effluent quality in the sediment consolidation area (SCA); deposition of resuspended sediments; and volatilization losses during dredging, and during sediment rehandling. This paper also presents conceptual design of the SCA to contain hydraulically dredged sediments. A few representative dredging strategies are used to illustrate the technical approaches. Production estimates, the basis and approaches of estimating dredging-related impacts, and the illustrated approaches are used in the FS to compare remedial alternatives for Onondaga Lake.

L.1.3 DREDGING STRATEGIES CONSIDERED

Two distinct types of dredging operations are expected to be considered in the FS. One dredging operation would remove all sediments within a sediment management unit (SMU) that have constituent concentrations exceeding a risk-based standard. A lower-volume dredging operation would remove sufficient sediment to create suitable habitat, reduce erosive forces on a cap, or allow placement of a protective sediment cap without impacting the lake volume or area. A summary of the dredging areas and average depths of sediments to be dredged for each of these approaches by specific SMU is presented in the FS. This paper will evaluate two strategies for SMU 1:

- Removal of about 3 feet (ft) (1 meter [m]) of sediment over 45 acres, called the limited dredge depth operation; and
- Removal of approximately 30 ft (8 m) of sediment over an area of 84 acres, called the extensive dredge depth operation.

L.1.4 ORGANIZATION

The remainder of this paper is organized as follows:

- Section L.2 discusses dredging approaches and evaluates their feasibility for application to Onondaga Lake.
- Section L.3 presents conceptual design of the SCA.
- Section L.4 presents methods for estimating constituent losses during all phases of dredging operations.
- Section L.5 applies these methods to the limited dredge depth and extensive dredge depth operation.
- Section L.6 presents construction methods for dredging.
- Section L.7 summarizes the findings of the paper.
- Section L.8 lists the references cited.
- Attachment A contains a print out of predicted air and water quality impacts associated with each SMU dredging alternative for the different lake-wide alternatives.

SECTION L.2

FEASIBLE DREDGING APPROACHES

This section identifies and describes feasible dredging approaches for littoral sediments within Onondaga Lake without regard for sediment removal. The capabilities and limitations of available dredging equipment are described as they apply to Onondaga Lake. Dredging methods must be compatible with transportation, treatment, and sediment management methods¹. Thus, transportation alternatives for moving sediments from the point of dredging to the point of management are discussed. To simplify the transportation discussion, the only disposal alternatives considered in this appendix are offsite disposal (e.g., a landfill) and onsite consolidation at one of the larger waste beds. It is assumed that landfill disposal would involve onsite rehandling and transportation to the offsite disposal location. Sediment transportation to the onsite facility would either be directly by hydraulic pipeline or using trucks to haul the sediments from the lake to the onsite facility.

L.2.1 GENERAL OBSERVATIONS

Based on the physical data available for the littoral areas of Onondaga Lake, most conventional dredging methods should be capable of removing existing bottom sediments. Difficulties and limitations associated with transporting dredging equipment to Onondaga Lake may restrict the size of dredges that can be used and possibly eliminate some from consideration. The dredging method selected for littoral zone sediments will depend on a variety of factors, including the equipment a specific contractor has available. In fact, multiple dredge types may be used to expedite project completion. It is also important to remember that the compatibility of dredging and transportation systems with the selected disposal method dictates dredge selection in many projects. Since the objective of this paper is to identify feasible dredging methods, or conversely to identify dredging methods that are not applicable to Onondaga Lake, a variety of dredging, transportation, and processing systems are considered.

As identified in Section L.1, sediments in the profundal zone are not evaluated in this paper. Sediments more than 50 ft (15 m) below the water surface will be considerably more difficult to remove, although dredging equipment is available that can competently remove sediments from these (and even deeper) depths; bucket dredges and pneumatic dredging systems are the most commonly used in such environments. However, dredge production and other operational inefficiencies will hamper dredging of profundal sediments because of the water depth.

¹ *Sediment management method* and similar terms will be used throughout this document to refer to the immediate disposition of sediments after dredging. This could be final placement directly into an upland, onsite SCA, such as one of the existing waste beds, without treatment; direct discharge into a treatment facility; direct placement onto rail cars for offsite landfill disposal; or any of the many other alternatives that can be considered.

L.2.2 BUCKET DREDGING

Bucket dredges are clamshell buckets hoisted on a crane (Figure L.1). The crane may either be affixed directly to the dredge barge or can be a land-based crane operating from the barge deck; larger units tend to be affixed directly to the barge. The U.S. Environmental Protection Agency (USEPA 1994) provides a good summary of characteristics of bucket dredging equipment and operations.

An equivalent-sized, on-shore rehandling/loading facility must be available to avoid interrupting the dredging operations. USEPA also presents a summary of offloading operations to on-shore rehandling/loading facilities (1994).

L.2.2.1 Operation

Because of the limited water depth nearshore in the littoral areas, a contractor would likely elect to use a medium-size dredge, such as a 3- to 6-cubic-yard (CY) bucket. Relatively small cranes (50 to 100 tons) can handle this size bucket. The cable arm buckets are even lighter in weight than the traditional buckets. A 40- to 50-ft by 120-ft (12 to 15 m by 35 m) barge would probably be required to support the crane. This size barge with this type of equipment would typically require 3 to 5 ft (1 to 2 m) of water to operate. Dredged material would be placed directly into barges for transport to the offloading facility. Barge sizes of 1,500 CY or smaller would be appropriate for this site. A horizontal profiler mounted on an excavator could also be used. The option to use an alternate mechanical system would be left open and considered during final design (assuming mechanical dredging was being considered), if dredging is selected by the State and USEPA for Onondaga Lake.

L.2.2.2 Bucket Selection

An enclosed bucket would likely be required if mechanical dredging were used; buckets with a level-cutting ability would be preferred. Some types of enclosed or environmental buckets, such as the Cable Arm bucket, are lighter and are therefore limited to dredging softer sediments with blow counts less than 4 to 5 blows per foot (Anchor 1999). Therefore, a lighter Cable Arm bucket may have difficulty dredging the stiff calcite deposits. Heavier enclosed buckets are available. For our analysis, we assumed a heavier, enclosed bucket would be used.

L.2.2.3 Dredge Production

A variety of clamshell bucket sizes could be used to dredge littoral area sediments. Two representative bucket sizes were selected for evaluation to simplify the feasibility analyses. A 3-CY bucket is assumed to be representative of bucket sizes likely used for dredging operations with lesser volumes, and a 6-CY bucket is assumed to be representative of dredging operations with greater volumes.

Bucket dredging lends itself to the use of multiple dredges operating simultaneously, so the total production may be multiples of the per-dredge values indicated below. The off loading facility will need to be sized to handling the total volume from the multiple dredging operations.

L.2.2.3.1 3-Cubic Yard Bucket Dredge

Bucket Fill. Dredge operation will vary based on a number of factors, mostly related to site conditions. For general production estimates, it is assumed that each grab, on average, is 80 percent filled with *in situ* sediments and 20 percent filled with ambient water, typical of an enclosed clamshell bucket. Thus, a 3-CY bucket will average 2.4 CY of sediment removal each cycle.

Cycle Time. Cycle times can vary significantly, depending upon the water depth and location of the hopper barge. Most of the area is relatively shallow (5 to 10 ft [1.5 to 3 m]), which tends to decrease cycle time, and the dredge operation will be attempting to minimize releases, which tends to extend cycle time. It is assumed that the dredge would be able to accomplish between 30 and 50 cycles per hour during active dredging operations, excluding downtime.

Dredge Efficiency. Dredging is an erratic operation, subject to significant variations due to site conditions, expected operational downtime such as repositioning, and unexpected equipment failures. A dredge efficiency of 60 to 70 percent is normal for conventional bucket dredging operations and was assumed to apply here. Dredging efficiency could fall well below 60 to 70 percent if substantial debris was present. Dredging efficiency is the actual time of dredging divided by the total time working.

Production Estimate. Based upon the above factors, a 3-CY bucket should be capable of removing 50 to 80 CY/hr (*in situ* volume). This sediment volume and the entrained water represent an equivalent flowrate of 0.5 to 0.8 cubic ft per second (cfs) into the disposal facility.

L.2.2.3.2 6-Cubic Yard Bucket Dredge

Since sediment depth is not considered to be an issue, doubling the bucket size and using the same operational assumptions essentially doubles the expected dredge production to 100 to 160 CY/hr. This sediment and entrained water flowrate would also double to about 1.0 to 1.6 cfs.

L.2.2.4 Other Considerations

The presence of debris can impact any type of dredging equipment. Side scan sonar was completed as part of the RI (TAMS, 2002). Debris observed from that survey include a sunken barge, pipe, cultural artifacts, and miscellaneous small debris. When debris is brought up in a bucket, the debris can wedge the bucket open, causing sediment to be lost to the water column.

Ancillary equipment such as skiffs, tugs, and barges will be required to assist the dredging operation. This equipment has the potential to impact water quality. Propeller wash from tugs or other boats can produce velocities at the sediment surface high enough to mobilize sediment into the water column. It is assumed that overflow from the haul barges will not be allowed, as it can also significantly affect the water column.

L.2.2.5 Sediment Transportation for Bucket Dredging Operations

Bucket dredging has several advantages, but typically its most useful characteristic is that limited dilution of sediment with excess water occurs during the dredging process. However, the higher density complicates transportation and generally requires the dredged sediments to be rehandled, often several times prior to final disposal. This section discusses sediment transportation issues associated with bucket dredging operations.

L.2.2.5.1 Dredge-to-Shore Sediment Transport

Except in unusual cases, bucket dredges place sediment directly into a hopper barge moored adjacent to the dredge. Once a barge is filled, a tug moves it to an off-loading area; empty barges immediately replace filled ones alongside the dredge to minimize disruption of the dredging operation. Thus, sediment is usually transported from the dredge to a shore-side rehandling facility in a hopper barge.

The shore-side rehandling facility may either remove sediments mechanically (i.e., essentially another dredging operation from the hopper barge) or hydraulically. Hydraulic transport typically requires adding sufficient water to reduce the sediment concentration to about 15 percent solids so that it can be pumped. More dense mixtures can be pumped if the pumping distance is short.

The nature of the rehandling facility is typically defined by the transportation selected to move the sediment to the next phase of treatment or disposal. The most likely transportation and disposal alternatives for Onondaga Lake are discussed in the following sections.

L.2.2.5.2 Mechanical Rehandling for Offsite Disposal

The most efficient mechanical dredging operation occurs when the dredged sediments are sufficiently dense to be placed directly into a consolidation facility without further concentration. Sediments can then be removed from a filled barge moored to the dock and placed directly into watertight haul trucks or rail cars for transport to a distant landfill facility. Excess water – that is, water not transported to the offsite location – is usually limited to small quantities and may or may not require treatment. In this case, the most important components of a mechanical rehandling facility for offsite disposal are a dock, on-shore crane with clamshell bucket, and nearby truck or rail car parking.

If consolidation or dewatering of dredged sediment is necessary, then an additional step is necessary prior to offsite transport. Dewatering can be accomplished by mixing stabilizing agents with the sediment or using temporary onsite storage to allow further drainage, settling, compression, and consolidation prior to transportation and disposal.

Stabilization agents can often be mixed with sediments either inside the hopper barge, in a mixer used during the rehandling process, or with standard earthmoving equipment to facilitate placement into the truck or rail car. However, the stabilization process can increase the final disposal volume and costs, due to the cost of stabilizing agents and increased disposal requirements.

Temporary, onsite storage avoids these increased costs and helps temper the variations in production rate and material water contents due to the nature of dredging operations. However, it requires an onsite facility and additional rehandling of the sediments. Additionally, porewater squeezed from the sediments may require treatment prior to discharge.

L.2.2.5.3 Mechanical Rehandling for Onsite SCA

Mechanical rehandling for sediment placement into an upland, onsite SCA would essentially be the same as for offsite disposal at the dredged sediment density. Sediments can be removed from a filled barge moored to the dock and placed directly into watertight haul trucks or rail cars for transport to the SCA. The primary requirements are a dock, on-shore crane with clamshell bucket, and nearby truck parking. The primary disadvantage of this option is the large number of trucks and associated traffic between the rehandling facility and the SCA.

L.2.2.5.4 Hydraulic Rehandling for Onsite SCA

Sediments can be pumped from the filled barges to an onsite SCA. If the SCA is within a few hundred feet and the sediment consistency is compatible, high-density pumps may be able to pump sediment very near the dredged sediment density. Locations farther from the rehandling site will require diluting the sediments from their dredged sediment density to about 15 percent solids. At that concentration, mechanically dredged sediments can be pumped directly into a SCA within several miles with appropriate booster pumps. Dilution water can be recycled from the SCA to reduce the total water added; however, this becomes less plausible as the distance between the rehandling facility increases.

Hydraulic pumping of bucket-dredged sediments essentially eliminates the most significant advantage of bucket dredging: the higher solids content. However, bucket dredges have other advantages, and the combination of bucket dredging and hydraulic transport is not uncommon. The use of a mechanical dredge/hydraulic rehandling system and the possible ability to recycle slurry water and utilize a reduced water treatment system are considered to be refinements of the commonly used, feasible dredging/sediment management options described in this appendix and in Appendix K and are not further addressed in this document.

L.2.3 HYDRAULIC DREDGING

Hydraulic dredges are efficient sediment movers. They simplify transportation, since sediments can be pumped directly to an onsite SCA or rehandling facility. Section L.3 discusses sizing a SCA for hydraulic dredging and transportation. The primary disadvantage of hydraulic dredges is the large addition of water required to dilute the *in situ* sediments to a hydraulically transportable density; typical hydraulic dredges pump sediments at 10 to 15 percent solids. These concentrations represent adding about 4 to 6 volumes of water for every equivalent volume of *in situ* sediment. Pumped solids concentrations can decrease to well below 10 percent when the dredge operation fails to provide sufficient solids to the pump.

A variety of hydraulic dredges capable of removing and transporting the littoral sediments are available. For simplicity, this section will consider only conventional cutterhead suction

dredges. USEPA (1994) presents a summary of available hydraulic dredging equipment. Figure L.2 presents a schematic of a small hydraulic dredge.

L.2.3.1 Dredge Size

Many hydraulic cutterhead dredge sizes could be used to remove littoral sediments from Onondaga Lake. However, the dredge size will likely be limited by available draft in shallow areas and difficulties in mobilizing larger dredges to the site. Mobilizing dredges larger than a 16-inch (0.4 meter) pipe size to the site may be difficult. These and smaller dredges can typically be transported to the site by truck and are likely to fit under most vertical barriers on even small navigation channels. A 12-inch (0.3-m) cutter suction dredge needs about 3 ft (1 m) of water to operate; a 16-inch (0.4-m) dredge needs about 4 ft (1.2 ft). Larger dredging equipment could potentially be brought to the site by barge or rail.

A variety of other factors must be considered in hydraulic dredge size selection. For cutter suction dredges, optimal dredge cuts are sediment thicknesses between 80 percent and 110 percent of the cutter basket diameter. Shallower cuts entrain more water and can substantially reduce the slurry solids concentration. Shallow cuts and operational restrictions that limit the rate of sediment available to the dredgehead can also increase the relative rate at which sediments are lost to the water column. While the actual amount of resuspension is similar to normal cuts, or possibly even smaller, the rate of sediment removal is greatly reduced. The result is that the relative resuspension rate, or rate of resuspension as a percentage of dredged sediment, is increased. Deeper cuts leave behind a deeper-than-normal residual sediment layer, since they increase the volume of sediment disturbed, but not captured. Deeper cuts also tend to increase the amount of resuspended sediment in the water column.

Typical cutter diameters for small hydraulic dredges range between 3 and 4 times the dredge size, with most being about 3.5 times the pipe diameter (see Figure L.2). For example, a typical 12-inch (0.3-meter) hydraulic cutter suction dredge would use a 36- to 42-inch-diameter (0.9- to 1.1 meter-diameter) cutter. The cutter turns slowly to move sediments toward the suction pipe as the dredge swings laterally. While the rotating cutter basket on most dredges can be interchanged, the cutter should be sized to deliver the appropriate amount of sediment to the suction intake during normal operation.

Analyses in this paper assume that a single 14-inch (0.35-meter) cutter suction dredge would be used for sediment removal projects of smaller than 300,000 CY, and multiple 14-inch (0.35-meter) cutter suction dredges will be used for larger volumes. When construction approaches, the contractor will decide the optimal combination of dredges. The contractor will consider such issues as length of dredging season, dredging and disposal locations, water depths, site features, and dredge cuts when determining the optimal layout of equipment. Note that the contractor will also be required to use the equipment such that they meet the project criteria included in the technical specifications. Most areas to be dredged either have suitable drafts available or would be dredged to sufficient draft.

L.2.3.2 Dredge Production and Flowrates

L.2.3.2.1 12-Inch (0.3-Meter) Hydraulic Cutterhead Dredge

A 12-inch (0.3-meter) hydraulic cutterhead dredge typically consists of a 12-inch (0.3-meter) discharge line, a 12- or 14-inch (0.3- or 0.35-meter) suction line, and a centrifugal pump driven by a diesel engine of about 400 horsepower. Pipe velocities must be maintained above 10 ft per second (3 m per second) to avoid sediment deposition during transport and should be about 15 ft per second (4.5 m per second) during normal operation. Thus, the instantaneous flowrate from a 12-inch (0.3-m) dredge is expected to range from 3,500 gallons per minute (gal/min) to 5,500 gal/min. An average flowrate may be more applicable to some evaluations. A dredging efficiency of 60 to 70 percent should be expected under these conditions.

With a smaller dredge and a longer pumping distance, sediment slurry concentrations will likely be about 10 percent solids during normal operation. Slurry concentrations may drop to as low as 5 percent solids during thinner cuts and cleanup passes. Thus, the average rate of sediment production for a 12-inch (0.3-meter) cutter suction dredge is expected to be 75 to 150 CY/hr (including downtime).

L.2.3.2.2 14-inch (0.35-Meter) Hydraulic Cutterhead Dredge

A 14-inch (0.35-meter) hydraulic cutterhead dredge typically consists of a 16- to 18-inch (0.4 to 0.45-meter) suction line, a 14-inch (0.35-meter) discharge pipe, and a diesel-powered centrifugal pump with about 600 horsepower (HP). This extra power results in a more sustainable operation and an ability to pump greater distances, but actual dredge performance changes only proportionally to the differences in size. Thus, the 14-inch (0.35-meter) dredge is expected to yield an instantaneous flowrate of 5,000 to 7,000 gal/min and an average dredge production of 85 to 170 CY/hr. For the analyses in this paper, we assumed a 14-inch (0.35-meter) dredge working at a nominal production rate of 150 CY/hr.

L.2.3.2.3 16-inch (0.4-Meter) Hydraulic Cutterhead Dredge

A 16-inch (0.4-meter) hydraulic cutterhead dredge typically consists of an 18 to 20-inch suction line, a 16-inch (0.4-meter) discharge pipe, and a diesel-powered centrifugal pump with about 600 HP. Thus, the 16-inch (0.4-meter) dredge is expected to yield an instantaneous flowrate of 6,000 to 10,000 gal/min and an average dredge production of 150 to 250 CY/hr.

L.2.4 HYBRID DREDGES

A newer type of dredging equipment is one that dredges the sediment mechanically and then transports the material hydraulically to the disposal site. There are two nationally-known contractors with this type of “hybrid” equipment on the market:

- DryDredge has a dredge with a fixed arm and mechanical bucket. The material is placed into a hopper on the dredge, where a high-solids cement pump transports the material to the disposal site.

- The Bean Environmental High Precision Grab (HPG) dredge has a fixed bucket that dredges the material mechanically and places it into a hopper on the dredge. Water is added to the dredged material as necessary to get the material to around 15 to 20 percent solids by weight, and the material is then pumped to the disposal site. Figure L.3 shows photos of Bean's HPG dredge.

Traditional mechanical and hydraulic dredging equipment have been the focus of the feasibility study; hybrid dredges are considered implicitly, since they combine characteristics of both. It is anticipated that hybrid dredges will be further evaluated during final design.

SECTION L.3

CONCEPTUAL SEDIMENT CONSOLIDATION AREA DESIGN

This section presents the dredge to consolidation conceptual design for hydraulic dredging with sediment consolidation, dewatering, and containment at an SCA. The SCA would utilize a diked impoundment to retain dredged solids while allowing the supernatant to be released from the containment area, either by discharging to the lake or to a water treatment process. The two operating objectives of the SCA are:

1. To attain the highest possible efficiency in retaining solids during the dredging operation to meet discharge requirements, and
2. To provide adequate storage capacity to meet dredging requirements and to provide storage for equalization of inflow and outflow.

These considerations are interrelated and depend upon effective design, operation, and management of the containment area. Solids separation by sedimentation followed by onsite consolidation into the SCA includes the following tasks:

- SCA construction;
- Sediment dredge and transfer to SCA;
- SCA operation; and
- SCA closure.

L.3.1 SCA CONSTRUCTION

For this evaluation, it was assumed that the SCA will be constructed on one of the Solvay wastebeds. The need for geotechnical stabilization of the wastebeds will be investigated and defined during the pre-design phase.

The SCA will be constructed on top of the existing Solvay waste material by constructing 3:1 (horizontal:vertical) dikes with imported soil. At least one internal dike is needed in the SCA to create operational areas. The height of the dikes will depend on the required storage volume, as described in the following paragraphs. Excavation into the existing wastebed materials and regrading the excavated sediment into dikes is not currently considered an option because the limited existing data suggest the wastebed material has low strength. However, this will be more fully evaluated during the pre-design geotechnical evaluation of the wastebeds.

The SCA may require a low permeability layer to prevent migration of water to underlying zones, and an overlying drainage layer to provide drainage and leachate collection during the SCA closure and long-term monitoring phases. The low permeability layer may consist of existing Solvay waste material, amended Solvay waste material, imported material, or synthetic

liner(s). Geotechnical data collected during the pre-design phase will be evaluated to determine the suitability of the Solvay waste material as an underliner. The drainage layer will consist of imported sand, a geonet, or a combination of sand and a geotextile. The liner components for the SCA will be determined during the design phase based on geotechnical data from the Solvay wastebeds and sediment treatability data.

For evaluating the feasibility of building and operating the SCA, a preliminary design was done based on limited data, specifically two data points from the Harrington study. The data used are not assumed to be representative of all dredging areas, but are the best available site-specific information. Pre-design activities will include collecting samples representative of all dredging areas and settleability testing to develop information for the design of the SCA. The size and configuration of the SCA were designed by the following steps (from *Engineering and Design - Confined Disposal of Dredged Material*, Publication Number: EM 1110-2-5027, CECW-EH-D, 30 September 1987):

- a) Selection of minimum average ponding depth
- b) Calculation of volume for initial storage
- c) Calculation of minimum area for effective zone settling
- d) Calculation of required retention for flocculent settling
- e) Calculation of required retention time for flocculent settling in supernatant water
- f) Computation of design surface area for flocculent settling
- g) Estimation of hydraulic efficiency correction factor
- h) Determination of disposal area geometry

For Step a), the minimum average ponding depth is determined from the above-referenced document, which recommends a 2 ft (0.6 m) minimum average ponding depth.

For Step b), the volume for initial storage is estimated by adjusting the dredge volume for the volume change that is expected after placement in the SCA. The void ratios of pre-mixed bulk samples (to represent in-lake sediments) and post-settled samples measured during the settling study (HE&C, 2003) were used to calculate the volume adjustment. The void ratio of the pre-mixed bulk samples averaged 2.45. The void ratio of the post-settled samples averaged 3.45. The bulking ratio is calculated as follows:

$$\text{Bulking ratio} = \frac{(\text{post settled void ratio} - \text{pre mix void ratio})}{1 + \text{pre mix void ratio}} + 1 = \frac{(3.45 - 2.45)}{(1 + 2.45)} + 1 = 1.3$$

Therefore, the total storage volume needed for each alternative is 130 percent of the dredge volume. For example, a dredging volume of 1,500,000 CY would occupy 1,950,000 CY after placement.

For Step c), the minimum area for effective zone settling is calculated by dividing the inflow rate by the zone settling velocity (as measured by the settling tests) and adjusting for a hydraulic efficiency factor.

The inflow rate is based on the assumed number of dredges in use and their production rates. As described in the preceding sections, it is assumed that the dredging for volumes exceeding roughly 300,000 CY is to be performed with two 14-inch (0.35 meter) hydraulic dredges, each removing 150 *in situ* CY per hour of lake sediments. At a pumping velocity of 10 ft per second, a slurry percent solids of 10 percent, a specific gravity of solids of 2.48 (as measured in the settling tests), and a production efficiency of 70 percent, the slurry inflow rate is 6,700 gpm (note: this assumes the dredges are operating 16 hrs per day).

The zone settling velocity is determined from the settling tests. The settling velocity is the straight-line portion of the depth to interface versus time graph. The average settling velocity from the two samples tested is 4.5 ft per hour.

The hydraulic efficiency correction factor is a function of the geometry of the SCA. The determination of the hydraulic efficiency correction factor is performed in several of the later steps of this design procedure. Because this is the early portion of the design phase, a hydraulic efficiency correction factor of 1.6 (which is typical for a rectangular SCA) is assumed for this and subsequent steps.

Dividing the inflow rate (6,700 gpm) by the zone settling velocity (4.5 ft per hour), multiplying for the hydraulic efficiency correction factor (1.6), and adjusting for units, yields a minimum area for effective zone settling of only 0.4 acres. This is not the controlling factor of SCA design, as will be demonstrated in the subsequent design steps.

For Step d), required retention for flocculent settling is determined by multiplying the inflow rate by the required detention time and the hydraulic efficiency correction factor.

The inflow rate and the hydraulic efficiency correction factor have been described in Step c).

The average required detention time, as determined from the analysis and summary of the settling study (HE&C, 2003), is 36 hours. Of the two samples tested in column settling tests, one reached a no-further-reduction level of turbidity at 20 NTUs after one day, and the second reached a no-further-reduction level of turbidity of 20 NTUs after two days. The average of these two durations, 36 hours, was used in this design example.

Multiplying the inflow rate (6,700 gpm), the hydraulic efficiency correction factor (1.6), the average required detention time, and a unit conversion yields a required retention for flocculent settling of 23,200,000 gallons or 115,000 CY.

For Step e), the derivation of the required retention time for flocculent settling in supernatant water has been described in Step d).

For Step f), the design surface area for flocculent settling is determined by dividing the volume calculated in Step d), by the assumed depth of slurry for settlement. In order to provide a conservative estimation of the required area, a low depth of slurry should be used. Using the 2 ft (0.6 m) minimum (as described in Step a), the calculated design surface area is 1,550,000 square ft or 36 acres.

Steps g) and h) are performed to obtain an estimation of hydraulic efficiency correction factor. These steps are simplified by using a typical hydraulic efficiency correction factor of 1.6, as described in Step c).

L.3.2 MATERIAL DREDGING AND TRANSFER TO SCA

The dredge slurry will be pumped to the SCA via double-contained HDPE pipelines. A booster pump and operator will be stationed approximately every one mile of pipeline in order to maintain sufficient pressure and velocity. The pipeline will be floated when in the lake and laid overland (not buried) when on land. Some sections may need to be buried at road crossings.

L.3.3 SCA OPERATION

During dredging, it is expected that the SCA will require 24-hour-per-day staffing with at least one person. It is expected that continuous air monitoring will also be required at the SCA. Operation of the SCA will consist of monitoring and directing the dredge slurry inflow, communicating with the dredge crew as necessary, and monitoring and controlling the outflow. The thickness of the dredged material layer will increase with time until the dredging operation is completed. Upon completion of the dredging process, operation of the SCA will continue while the settled solids consolidate.

Environmental monitoring of the air quality downgradient of the SCA may be required, depending on estimated air releases from the SCA. Air release may be mitigated by application of activated carbon to the water surface (for organic compounds), or by providing a cover over the SCA, or other engineering controls. These requirements will be determined during the SCA design phase as a result of treatability testing.

Water released from the consolidating solids into the drainage layer at the bottom of the SCA will initially continue to be treated as required on-site. After dredging is completed and consolidation water flow rate declines, there will come a point when the water removal will be more economically managed through treatment at the Willis Avenue/Semet Groundwater Treatment Plant or sent offsite for treatment and disposal.

L.3.4 SCA CLOSURE

The SCA will be capped when dredging is completed and the consolidation process has progressed far enough that the settled material has sufficient strength for cap construction. The

time for this consolidation to occur depends on the dredged solids characteristics and thickness. It is assumed that the settled solids will have low strength even when the cap is constructed, and a foundation layer may be required. The foundation layer may be constructed from sand, soil, or other consolidation material. Vent piping may be installed if significant methane production is anticipated.

The overall objectives of the SCA cap design are to minimize infiltration to the consolidated sediments and to maximize the durability and permanence of the cap. The cap components may include low permeability soil, geomembrane, geosynthetic clay layer (GCL), and/or drainage layer. Typically, these cap components will be determined in coordination with the SCA liner components during the design of the SCA. A soil and topsoil/vegetative cover will be placed over the low permeability layer(s). The cap will be constructed to achieve final slopes of approximately 2 to 3 percent to ensure proper drainage and reduce infiltration.

SECTION L.4

CONSTITUENT FATE AND TRANSPORT DURING DREDGING

L.4.1 BACKGROUND

This section considers the impacts of dredging and removal of sediments from the bottom of Onondaga Lake, their transport, and their disposal in either an onsite SCA or offsite landfill. Mass balances on sediments and the primary constituents of concern are used to estimate their redistribution during and after dredging. Water quality impacts during dredging, post-dredging residual sediments, transportation, sediment rehandling operations, primary treatment by the SCA, and subsequent treatment of the effluent are all considered. Additionally, estimates of volatile releases and redeposition of suspended sediments in the profundal zone of the lake are made. This section gives the procedures and methods of analysis, and Section L.5 presents the actual results.

L.4.2 WATER QUALITY IMPACTS NEAR THE DREDGING OPERATION

L.4.2.1 Estimating Resuspension Losses

The rate of sediment loss to the water column is the subject of considerable debate. A wide range of resuspension rates has been published for dredges. Hayes and Wu summarize published values for hydraulic cutterhead and clamshell bucket dredges (2001). Observed resuspension rates for cutterhead suction dredges range from less than 0.1 percent to just over 0.5 percent. Observations for bucket dredges range from 0.2 percent to 0.9 percent, but many of those included significant turbid overflow contributions from a disposal barge. A number of authors have published substantially higher resuspension rates for horizontal auger hydraulic dredges. Steuer estimated the constituent loss rate from a horizontal auger dredge working in the Lower Fox River as 2.2 percent (2000).

In absence of site-specific data, a mass loss rate of 1 percent of fine sediments is assumed for all dredging operations. This should be conservative for hydraulic cutterhead dredges or enclosed clamshell dredges, since available data suggest that loss rates from those dredge types could be closer to 0.5 percent.

L.4.2.2 Modeling Fate and Transport

Actions associated with dredging, including the operation of vessels to support the dredging operation, resuspend bottom sediments into the water column. These

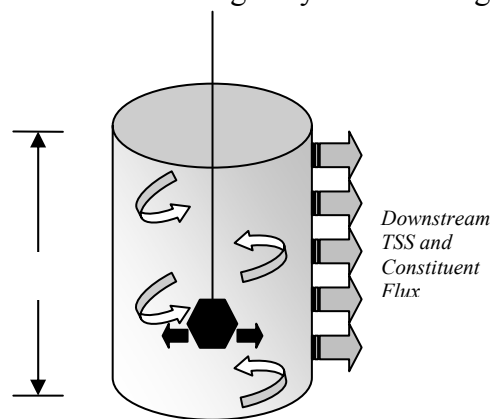


FIGURE L.4
NEAR FIELD CSTR
REPRESENTATION FOR BUCKET
DREDGING OPERATIONS

suspended sediments can visibly impair water quality in the immediate vicinity of the dredging operation. The visibility of these impacts also raises concerns about more significant water quality impacts resulting from the increased water column total suspended solids (TSS) concentration and increased concentrations of other sediment-associated constituents. Transport of these constituents and redeposition of contaminated sediment particles in other areas of the water body are additional concerns. This section describes previously developed water quality models for estimating near-field water column constituent concentrations from dredging operations.

L.4.2.3 CSTR-CHEM Models

The USEPA utilized the CSTR-CHEM model to estimate sediment and constituent transport near Hudson River dredging operations in order to develop engineering performance standards (USACE 2003a). The CSTR-CHEM model assumes well-mixed, steady-state conditions in the vicinity of the dredging operation and equilibrium partitioning of sediment-bound constituents. The well-mixed steady-state conditions in the vicinity of the dredging operation are represented by a continuous stirred tank reactor (CSTR), as depicted in Figure L.4. Suspended sediment concentrations in the vicinity of the dredging operation are estimated as:

$$m_{nf} = \frac{m_{us} Q + \dot{M}_R}{\lambda_m V_{nf}}$$

and

$$\lambda_m = \frac{1}{\theta_{nf}} + \frac{v_s}{H}$$

where,

m_{nf} = TSS concentration in the near-field volume approximated as a CSTR in grams per cubic meter (g/m^3)

Q = flow into the near-field volume (m^3/sec)

m_{us} = TSS concentration of flow entering the near-field volume (g/m^3)

\dot{M}_R = rate of bed sediment resuspension into the near-field area due to dredging (g/sec)

V_{nf} = volume of the near-field area in cubic meters (m^3)

θ_{nf} = hydraulic retention time within CSTR (sec)

v_s = settling velocity of suspended particles in near-field volume (m/sec)

H = water depth (m)

Theoretical retention time within the well-mixed area is the volume of the area divided by the flow rate into and out of the area. Average constituent concentrations within the area can be estimated as:

$$c_{nf} = \frac{Qc_{us} + \dot{M}_R q_{in\ situ}}{\lambda_c V_{nf}}$$

and

$$\lambda_c = \frac{1}{\theta_{nf}} + k_c + \frac{v_v (F_d)_{nf}}{H} + \frac{v_s (F_p)_{nf}}{H}$$

where:

c_{nf} = constituent concentration within the near-field volume ($\mu\text{g}/\text{m}^3$)

c_{us} = constituent concentration flowing into the near-field volume ($\mu\text{g}/\text{m}^3$)

$q_{in\ situ}$ = total constituent concentration on bottom sediments ($\mu\text{g}/\text{g}$).

k_c = constituent transformation rate (1/sec)

v_v = volatilization mass-transfer coefficient (m/sec)

F_d = fraction of constituent mass in dissolved form (unitless)

F_p = fraction of constituent mass in particulate form (unitless)

L.4.2.4 Defining the Well-Mixed Area

The CSTR-CHEM models compute average water column concentrations over an area approximated as being well-mixed. Typically, only a small area in the immediate vicinity of the dredging operation is actually well-mixed (Figure L.4), but the specific conditions of Onondaga Lake are expected to result in a reasonably large area with relatively uniform water concentrations. Each of these represents important conditions that should be considered in the evaluation of dredging impacts. Thus, two analyses using CSTR-CHEM models are recommended: one with a 100-ft-diameter (30-m-diameter) well-mixed zone and one that assumes the entire dredging area within the SMU is well-mixed. The latter approach should provide a reasonable approximation of water quality conditions within the vicinity of the dredging operation, given the absence of a defined directional current in the lake environment and the likelihood that large areas will be hydraulically separated to reduce transport.

The average water depth of the well-mixed area is assumed as the pre-dredging depth plus one-half of the expected dredge cut. This represents the mid-point of dredging over the area, i.e., 50 percent of the area to be dredged is complete. The expected dredge cut includes a 1-ft (0.3-m) overdredge depth to account for dredging inaccuracies. For example, if a specific dredging alternative proposes to remove an average of 1.6 ft (0.5 m) of sediment across the SMU, the average dredge cut would be 2.6 ft (0.8 m) across the SMU. If the predredging water depth is about 9 ft (2.7 m), the average water depth is estimated to be 10.3 ft (3.1 m) when dredging is 50 percent complete.

Flow through the well-mixed area is crucial to an accurate estimate of near-field concentrations. Owens and Effler (1996) describe the complex flow conditions in Onondaga Lake. River flows and runoff combine to generate sufficient inflow for complete lake exchange approximately every 90 days. However, the oblong shape of the lake along the direction of dominant winds results in substantial wind-driven currents in shallow areas of the lake. Owens and Effler (1996) show results from a wind-driven finite element circulation model that shows surface velocities of 4 to 10 cm/sec. The average wind speed at Syracuse airport for the period 1988 to 1992 is 3.86 m/sec. Continuity of shear stresses between the air and the water surface suggests that the water velocity at the surface is equal to the air velocity times the square root of the density ratio between air and water ($v_w = 0.035v_a$). An average airspeed of 3.86 m/sec suggests an average surface water velocity of 13.5 cm/sec.; a logarithmic velocity profile would extend to the bottom where the water velocity is zero. Based on this information, an average horizontal water velocity of 7 cm/sec is used to estimate flow through the vertical cross-sectional area.

L.4.2.5 Sedimentation and Constituent Partitioning

Only silt- and clay-sized particles, those smaller than 74 micrometers (μm), are likely to remain in the water column very long after being resuspended. Sediment resuspension rates should be adjusted by SMU to apply only to the silt and clay fraction. These small and irregularly shaped particles settle as the result of complex particulate interactions rather than as discrete particles. Settling velocities for these particles range between 1 ft and 100 ft (0.3 and 30 m) per day (Chapra, 1999). In the absence of site-specific data, a settling velocity of 10 ft (3 m) per day is used in computations.

Table L.1 presents K_{oc} and K_d values for constituent distribution between dissolved and particulate phases recommended for modeling dredging operations in Onondaga Lake. These values are consistent with those applied for cap modeling; Appendix H, capping issues, provides additional insight into the selection of these values.

TABLE L.1
CONSTITUENT PARTITIONING COEFFICIENTS RECOMMENDED
FOR USE IN ONONDAGA LAKE

Chemical Parameter of Interest (CPOI)	K_{oc} mL/g	K_d mL/g
Benzene	100	
Benzo[a]pyrene	1,096,478	
Chlorobenzene	500	
Dichlorobenzenes (Sum)	2,399	
Ethylbenzene	588	
Fluorene	15,136	
Hexachlorobenzene	1,513,561	
Naphthalene	2,344	
Phenanthrene	342,748	
Phenol	100	
Polychlorinated biphenyls	1,380,384	
Pyrene	208,930	
Toluene	490	
Total mercury		6,961
Trichlorobenzene	18,197	
Xylene isomers (total)	1,413	

L.4.2.6 NAPL Considerations

Non-aqueous-phase liquids (NAPL) has been reported to exist in many areas of the lake, especially in the in-lake waste deposit (ILWD). Sampling results suggest that these are likely agglomerations of low-miscibility NAPL remaining from direct waste discharges into the lake. However, there is at least one area near the causeway in SMU 2 where pure-phase chlorobenzene may exist. Dredging sediments where the pore spaces are filled with highly soluble, pure-phase liquids (e.g., chlorobenzene) could quickly result in high-dissolved-phase concentrations in the water column. The CSTR-CHEM model does not readily consider the introduction of pure-phase product into the water column.

The potential locations of NAPL within SMUs 1 and 2 may require additional control measures during dredging. It is expected that NAPL would be further characterized during remedial design. Measures to control NAPL if encountered during removal include inner silt curtains within the outer containment measures. These silt curtains would have as small a circumference around the dredge as possible to reduce the exposed surface area. Booms and absorbents would be used in this area as well to capture any sheen. Measures to control NAPLs within the SCA would be similar in nature to the point-of-dredging measures. They would include the use of silt curtain baffles and booms to minimize the surface area and absorb any sheen.

L.4.3 ESTIMATED IMPACTS TO PROFUNDAL SEDIMENTS

Constituent concentrations in the littoral sediments are substantially higher than in profundal sediments. Thus, there is a potential for dredging of littoral sediments to increase the contamination levels in profundal sediments. This section evaluates the potential impact of higher concentration resettled sediments on profundal sediment concentrations.

Ideally, a complex water quality model for the lake would be used to determine the fate of resuspended sediments and associated particulate constituents. Since such a model does not exist for Onondaga Lake, a more simplistic approach will be used to determine if there is a substantial risk of measurably increasing constituent concentrations in the profundal sediments.

Section L.4.2.1 referenced data showing that 1 percent should be a conservative estimate of sediment loss during dredging. Due to natural sedimentation, only a much smaller percentage will actually remain in suspension long enough to reach the profundal sediments. If a 1 percent sediment loss reached the profundal sediment zone, it would contribute about 0.01 cm per 100,000 CY of sediment dredged, if distributed evenly over the profundal zone. In contrast, the estimated natural deposition rate is about 0.67 cm/year over SMU 8 (assuming in-place porosity of surface sediments of 0.75 [see Appendix N, monitored natural recovery]).

Mercury contributions to the profundal sediments are also of concern. Current surface concentrations in profundal sediments range from 1.5 to 7.5 parts per million (ppm) of total mercury; the mode is 2 to 3 ppm (see Appendix B, sediment management units). Ambient suspended sediments that currently settle into the profundal zone carry about 0.6 to 1.9 mg/kg total mercury, yielding a current mercury flux to the profundal sediments of 0.0003 to 0.0009 mg/cm²/year (see Appendix N, monitored natural recovery).

L.4.4 POST DREDGING RESIDUAL SEDIMENTS

Dredging operations seem to consistently leave a mixture of targeted sediments along the dredge cut, similar to that postulated in Figure L.5. Herrenkohl *et al.* (2003) summarize available data on the existence of residual sediments after attempts to completely dredge contaminated sediment layers. Unfortunately, the available data are limited to only a few projects, insufficient to fully characterize post-dredging residual sediments. Some suggest that newer dredging methods reduce the residual sediment problem, but insufficient data are available to substantiate that claim.

This section proposes a method for estimating constituent concentrations in residual sediments. Additionally, the depth of residual sediment expected to remain after dredging operations is estimated.

L.4.4.1 Residual Sediment Concentration

In the absence of data or knowledge about the physical processes leading to residual sediment remaining after dredging, Reible *et al.* (2003) assumed a depth-weighted average concentration of the dredged sediments. Following this approach assumes that all sediment layers removed by a dredge pass are equally represented in the post-dredging residual layer.

Multiple dredge passes require the residual sediment depth from any prior passes be considered as an additional sediment layer.

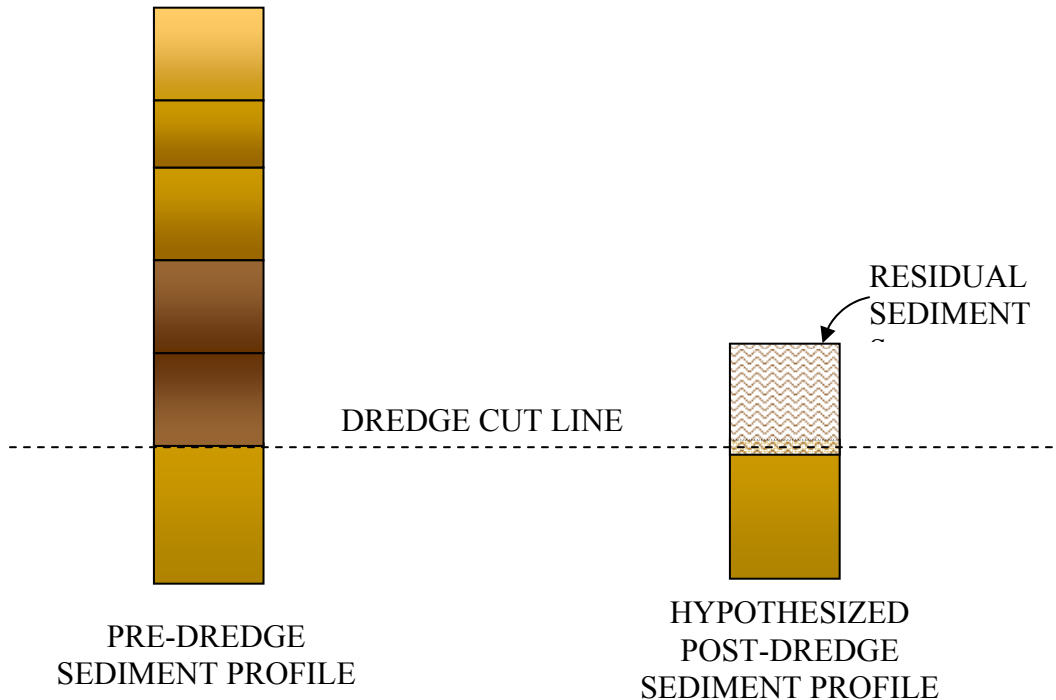


FIGURE L.5
HYPOTHESIZED RESULT OF DREDGING OPERATIONS ON SEDIMENT

L.4.4.2 Residual Sediment Thickness

Reliable data are not available on which to estimate the actual depth of post-dredging residual sediments. A mass of sediment equivalent to 10 percent of the mass of sediment targeted by dredging is assumed to be left behind. While there is no specific basis for the 10 percent assumption, it seems to be a reasonable estimate in the absence of data. Moreover, the post-dredging density may be substantially lower than the *in situ* sediment density, resulting in a residual sediment depth markedly deeper than 10 percent of the initial dredge cut.

L.4.5 HYDRAULIC TRANSPORT AND SCA CONSOLIDATION

A comprehensive understanding of constituent redistribution during transportation and consolidation is required to evaluate the long-term fate of constituents and estimate losses during those components of the dredging operation. This section presents mathematical approaches for estimating constituent redistribution during hydraulic transportation and disposal into an SCA.

L.4.5.1 *In Situ* Constituent Distribution with Particle Size

Since particle size separation occurs within the treatment process, it is important to consider the constituent load distribution with particles size. Most hydrophobic constituents preferentially adsorb to finer sediment particles, with generally decreasing adsorption as particle size increases. Thus, the silt and clay sediment fraction, plus any organic particles that may exist, usually carry the majority of the constituent load. In the absence of constituent distribution with particle size data for Onondaga Lake, it is assumed that the entire constituent load is absorbed only onto the fine sediment fraction. Thus,

$$(q_{in\ situ})_{fines} = q_{in\ situ}/f_{fines}$$

where

$(q_{in\ situ})_{fines}$ = *in situ* constituent concentration on fine sediment particles, mg/kg or µg/g

f_{fines} = fraction of fine sediment in bulk sample

L.4.5.2 Constituent Redistribution during Hydraulic Slurry Transport

Hydraulic dredging of *in situ* sediments substantially changes the physical characteristics of the sediments by adding large volumes of water to facilitate hydraulic transport. Sediment dilution rates of 4:1 and higher are not uncommon, since *in situ* sediments typically exist at 40 to 70 percent solids (by weight) and fine sediments are typically pumped at a concentration of 5 to 15 percent solids. The USACE (2003) indicates that hydraulically pumped slurry concentrations can be estimated by assuming 4 parts of site water are added to one part *in situ* sediment or by using the relationship:

$$m_{slurry} = 100f_{fines} + 300(1 - f_{fines})$$

where

m_{slurry} = total solids concentration in pumped slurry (g/L)

Mechanical dredges add considerably less water. An estimate of an increase in total volume of 20 percent is probably reasonable.

Depending on the speed at which constituents repartition under their new circumstances, the dilution potentially changes the chemical characteristics. Assuming that the constituents repartition during hydraulic transport (approximately 1 minute per 900 ft of pipe length), the dissolved and particulate fractions may change substantially from the *in situ* conditions.

Total constituent mass in the slurry includes that from the *in situ* sediments, including porewater and particulate concentrations, plus any from site water in the immediate vicinity of

the dredging operation. The total constituent concentration in the slurry can be computed based on the relationship:

$$c_{slurry} = \frac{P_{dredge} m_{in situ} q_{in situ} / 3600 + Q_{nf} c_{nf}}{Q_{slurry}}$$

where

C_{nf} = total constituent concentration in the near-field zone ($\mu\text{g/L}$)

$m_{in situ}$ = *in situ* bulk sediment total solids concentration (g/L)

c_{slurry} = total constituent concentration in the slurry ($\mu\text{g/L}$)

P_{dredge} = removal rate of *in situ* sediment by the dredging operation (m^3/hr)

Q_{nf} = flow of dilution water from the near-field zone (m^3/sec)

Q_{slurry} = total flow of slurry through pipeline (m^3/sec)

The average dredge production rate and discharge can be reliably estimated based on the dredge and site conditions. Thus, the average flow of dilution water from the near-field zone can be computed as:

$$Q_{nf} = Q_{slurry} - P_{dredge} / 3,600$$

The total constituent concentration associated with dredged *in situ* sediments includes the particulate-associated fraction and any porewater concentration. While the constituent mass in the porewater is typically small for sediment-based constituents, the presence of pure-phase product or NAPL may result in significant constituent mass originating from the porewater. Thus, the total *in situ* sediment constituent concentration can be computed as:

$$c_{in situ} = 10^3 q_{in situ} m_{in situ} + c_{pw} \phi_{in situ}$$

where

$c_{in situ}$ = *in situ* sediment constituent concentration ($\mu\text{g/L}$)

c_{pw} = constituent concentration in the porewater ($\mu\text{g/L}$)

ϕ = porosity of the *in situ* sediments

Porosity, ϕ , can be computed from concentration using the relationship:

$$\phi = 1 - \frac{m_{in\ situ}}{10^3 G_s}$$

where

G_s = specific gravity of the *in situ* solids

The total constituent concentration in the pumped sediment slurry can be computed as:

$$c_{slurry} = 10^{-3} q_{in\ situ} m_{slurry} + c_{pw}(\phi_{in\ situ}/\phi_{slurry})$$

It is useful to note that

$$q_{in\ situ} m_{slurry} = (q_{in\ situ})_{fines} (m_{slurry})_{fines}$$

This indicates that the total mass is the same when both parameters are adjusted properly to conform to the assumption that the constituent preferentially adsorbs to fine sediment particles.

Repartition concentrations are computed as:

$$(c_{slurry})_{dissolved} = (F_d)_{slurry} c_{slurry}$$

$$(c_{slurry})_{organic} = (F_o)_{slurry} c_{slurry}$$

$$(c_{slurry})_{particulate} = (F_p)_{slurry} c_{slurry}$$

where

$$(c_{slurry})_{dissolved} = \text{dissolved constituent concentration in the slurry } (\mu\text{g/L})$$

$$(c_{slurry})_{organic} = \text{organic constituent concentration in the slurry } (\mu\text{g/L})$$

$$(c_{slurry})_{particulate} = \text{particulate constituent concentration in the slurry } (\mu\text{g/L})$$

The partitioning computations below are adjusted to conform to the assumption that the particulate loading is entirely on the fine fraction of sediment, which could mean that the coarse fraction is clean. This would be reasonable, based on the discussion of constituent distribution with particle size in Section L.4.5.1.

$$(F_d)_{slurry} = \frac{1}{1 + 10^{-6} K_{poc} f_{oc} (m_{slurry})_{fines} + 10^{-6} K_{doc} DOC}$$

$$(F_o)_{slurry} = \frac{10^{-6} K_{doc} DOC}{1 + 10^{-6} K_{poc} f_{oc} (m_{slurry})_{fines} + 10^{-6} K_{doc} DOC}$$

$$(F_p)_{slurry} = \frac{10^{-6} K_{poc} f_{oc} (m_{slurry})_{fines}}{1 + 10^{-6} K_{poc} f_{oc} (m_{slurry})_{fines} + 10^{-6} K_{doc} DOC}$$

L.4.5.3 Constituent Redistribution during SCA Treatment

Sedimentation will change the hydraulically pumped slurry as it is discharged into the SCA. Coarse sediment particles will mound in the immediate vicinity of the slurry discharge, typically to a density of about 2,000 g/L. The rate of coarse sediment accumulation can be estimated as:

$$\dot{V}_{sand} = \left[\frac{m_{in situ}}{m_{sand}} \right] P_{dredge} (1 - f_{fines})$$

where

m_{sand} = solids concentration of deposited sand (g/L)

\dot{V}_{sand} = rate of sand accumulation in SCA (yd³/hr)

Since coarse particles can stabilize with modest angle of repose, it is not unusual for sand mounds that are above the supernatant elevation to develop near the discharge.

Sedimentation testing shows that the remaining fine sediment particles will exhibit zone settling. Thus, a clear supernatant liquid should exist across the entire SCA, except those areas of coarse deposition above the supernatant elevation. The settling slurry will distribute itself across the SCA in a nearly flat, uniform layer beneath the supernatant layer.

The result of these processes is that dissolved concentrations in the slurry will contribute directly to constituent concentrations in the supernatant. Particulate-associated constituents in the slurry should be removed at a rate similar to fine sediment removal. These processes should result in a total constituent concentration in the supernatant of:

$$c_{\text{supernatant}} = 10^{-3} (q_{\text{slurry}})_{\text{fines}} m_{\text{supernatant}} + (c_{\text{slurry}})_{\text{dissolved}} (\phi_{\text{supernatant}} / \phi_{\text{slurry}})$$

and

$$m_{\text{supernatant}} = (1.00 - R_m)(m_{\text{fines}})_{\text{slurry}}$$

where

$c_{\text{supernatant}}$ = total constituent concentration in supernatant (µg/L)

R_m = TSS removal effectiveness of the SCA (fraction)

Constituents will repartition within the supernatant based on the relationships:

$$(C_{\text{supernatant}})_{\text{dissolved}} = (F_d)_{\text{supernatant}} (C_{\text{supernatant}})_{\text{total}}$$

$$(C_{\text{supernatant}})_{\text{organic}} = (F_o)_{\text{supernatant}} (C_{\text{supernatant}})_{\text{total}}$$

$$(C_{\text{supernatant}})_{\text{particulate}} = (F_p)_{\text{supernatant}} (C_{\text{supernatant}})_{\text{total}}$$

where

$(C_{\text{supernatant}})_{\text{dissolved}}$ = dissolved constituent concentration in the supernatant (µg/L)

$(C_{\text{supernatant}})_{\text{organic}}$ = organic constituent concentration in the supernatant (µg/L)

$(C_{\text{supernatant}})_{\text{particulate}}$ = particulate constituent concentration in the supernatant (µg/L)

The supernatant constituent repartitioned fractions can be computed according to the relationships:

$$(F_d)_{\text{supernatant}} = \frac{1}{1 + 10^{-6} K_{poc} f_{oc} m_{\text{supernatant}} + 10^{-6} K_{doc} DOC}$$

$$(F_o)_{\text{slurry}} = \frac{10^{-6} K_{doc} DOC}{1 + 10^{-6} K_{poc} f_{oc} m_{\text{supernatant}} + 10^{-6} K_{doc} DOC}$$

$$(F_p)_{\text{supernatant}} = \frac{10^{-6} K_{poc} f_{oc} m_{\text{supernatant}}}{1 + 10^{-6} K_{poc} f_{oc} m_{\text{supernatant}} + 10^{-6} K_{doc} DOC}$$

L.4.5.4 Constituent Redistribution during Mechanical Transport

The analysis presented above focused on hydraulic transport. However, the same formulations apply to mechanical dredging, transportation, and rehandling operations. The only

difference is that the slurry concentration is much higher, since the volume of dilution water is much smaller. Assuming the dilution water is 20 percent, the solids concentration in the slurry is now computed as:

$$m_{\text{slurry}} = m_{\text{in situ}}/1.2$$

L.4.6 ASSESSMENT OF VOLATILE LOSSES DURING DREDGING

Because the sediment to be dredged contains volatile and semi-volatile organic constituents, a portion of the constituents resuspended to the water column will be volatilized into the air. The most substantial rates of volatilization are likely to occur from:

- The water column immediately around the dredgehead,
- The mixing pad during handling of mechanically dredged sediments, and
- A dewatering facility (SCA) for hydraulically dredged sediments.

Volatilization occurs most commonly from the water column, whether in the lake or in a dewatering/SCA. Exposed sediment may also release volatile constituents, but this tends to be a short-term phenomenon during and immediately after exposing a fresh dredged material surface. Any volatiles are quickly lost from the surface, and the rate of volatilization of the remaining constituents drops quickly as the diffusion path from the surface increases. The rate of volatilization of many high-volatility compounds such as benzene or toluene is controlled primarily by the rate of mixing of the water in which they are contained. Contaminated porewater in dredged material is essentially motionless, while lake or ponded water is easily mixed by the motion of the wind and hydraulic forces.

The volatilization rate during dredging was estimated using the following equation:

$$Rate_{vol} = k_{ov} A \left(C_w - \frac{C_a}{H} \right)$$

where

A = exposed surface area (m²)

C_w and C_a are the concentration of the volatilizing constituent in the water and air, respectively

H is the Henry's Law Constant, the ratio of the air and water concentrations at equilibrium, H=(C_a/C_w)_{eq}

k_{ov} is an overall mass transfer coefficient that can be estimated by mass transfer coefficients in the water, k_w, and air, k_a, phases

$$\frac{1}{K_{ov}} = \frac{1}{k_w} + \frac{1}{Hk_a}$$

In very volatile compounds such as benzene and toluene, H is sufficiently large that the second term is negligible relative to the first, and the overall coefficient is largely defined by the water-side mass transfer or mixing coefficient. This is one of the reasons that exposed water surfaces are more important sources of volatiles than exposed dredged material containing static water.

Thibodeaux (1996) reports a correlation for k_w as a function of wind speed, which can be written:

$$k_w = 0.094 v_a^2 \left(\frac{74}{MW} \right)^{1/4}$$

where

v_a = wind speed measured at the standard meteorological measuring height of 10 m above the ground (m/sec)

MW = molecular weight of the compound of interest (g/mole)

The value of k_w is in units of cm/hr. This formula is valid at wind speeds above 5 m/sec but is approximately valid to wind speeds of 3.3 m/sec. Below 3.3 m/sec, k_w tends to be approximately constant, that is with the quantity $0.094 v_a^2 \sim 1$ cm/hr.

Thibodeaux (1996) also reports a simple correlation for air-side mass transfer coefficient, which can be written:

$$k_a = 861 v_a A^{-0.05} \left(\frac{74}{MW} \right)^{1/4}$$

where

k_a = mass transfer coefficient in the air (cm/hr)

A = surface area (acres)

v_a = the wind velocity (m/sec)

The correlation was originally derived from data at a 26-ft-high (8-m-high) measuring height but can be used with data from the standard height of 33 ft (10 m) with little error.

Emissions from the SCA for hydraulically dredged sediments were based on the same algorithm used for the point of dredge described above. This emission source was modeled as an elevated area source based on the diked configuration of the SCA on Wastebeds 13 and 14. Air emissions were modeled for the dike heights listed below. The configurations of the SCA for each alternative were as follows (obtained from Appendix F, cost estimates):

- Alternative B – 28 acre area; 14 ft dike height
- Alternative C – 54 acre area; 14 ft dike height
- Alternative D – 84 acre area; 14 ft dike height
- Alternative D2 - 112 acre area; 14 ft dike height
- Alternative E – 262 acre area; 50 ft dike height
- Alternative F1 – 112 acre area; 14 ft dike height
- Alternative F2 – 172 acre area; 14 ft dike height
- Alternative F3 – 215 acre area; 14 ft dike height
- Alternative F4 – 257 acre area; 14 ft dike height
- Alternative G – 308 acre area; 14 ft dike height
- Alternative H – 325 acre area; 14 ft dike height
- Alternative I – 282 acre area; 50 ft dike height
- Alternative J – 442 acre area; 50 ft dike height

The liquid phase concentrations used for the source term in the model were based on the average of the dissolved CPOI concentration in the influent to the SCA and effluent to the SCA (supernatant after primary treatment).

Emissions from the mixing pad and handling operations associated with the solidification operation, were based on the USEPA model for estimating volatile organic compound (VOC) emissions from stabilization/solidification processes (USEPA, 1993), which is based on a mass balance equation presented by Thompson *et al.* (1991). This emission source was modeled as a ground-level area source, assumed to be a one-acre square pad located in the center of Wastebed B. The emission rate from the mixing pad was estimated using the following equation:

$$ER = C \times F \times (2.78 \times 10^{-7}) \times (V / 100)$$

where

ER is the emission rate (g/sec)

C is the concentration of CPOI in sediment (ug/g)

F is the treatment feed rate of sediment (kg/hr)

2.78×10^{-7} is a conversion factor [(g/kg)(g/ug)(hr/sec)]

V is the fraction of CPOI volatilized (percent).

Different assumptions were used for modeling short-term and long-term emissions from the mixing pad. For long-term emissions, the fraction of CPOI volatilized was assumed to be 100 percent. For short-term emissions, the fraction of CPOI volatilized was assumed to be 80 percent. It may be feasible to control mixing pad emissions via an enclosure with a controlled ventilation system.

SECTION L.5

APPLICATION TO SPECIFIC DREDGING SCENARIOS IN SMU 1

The tools for estimating constituent redistribution and losses during dredging presented in Section L.4 provide a conceptual understanding of constituent fate and transport. However, their presentation alone does not shed light on the relative magnitude of each loss mechanism. This section combines the physical conditions and physical and chemical sediment characteristics of SMU 1 with these procedures to estimate results for two example dredging actions. These analyses are intended to provide illustrative, quantitative computations to allow qualitative evaluation of the proposed tools and dredging in Onondaga Lake. Attachment A to this appendix contains the predicted water and air quality impacts for the different SMU dredging alternatives in each lake-wide alternative.

L.5.1 SMU 1 CHARACTERISTICS

Water depths in SMU 1 range from less than 1 ft (0.6 m) near the shore to greater than 20 ft (6 m) as it transitions into the profundal zone of the lake; the average water depth over SMU 1 is 9 ft (2.7 m). SMU 1 does not receive any direct discharges other than local runoff. Wind-driven currents dominate flow in SMU 1. See Section L.4.2.4 for the discussion of the well-mixed areas for Onondaga Lake.

SMU 1 sediments include the ILWD, which encompasses about 65 of the 92 acres in the SMU. The ILWD consists of alternating layers of brittle calcium carbonate material and soft clayey sediments. The dense calcium carbonate layers visually appear to be resistant to resuspension and transport. Transport characteristics of the soft layers are uncertain. Average sediment physical characteristics of SMU 1 are shown in Table L.2.

TABLE L.2
AVERAGE PHYSICAL SEDIMENT CHARACTERISTICS IN
SMU 1 (FROM APPENDIX B, SEDIMENT MANAGEMENT UNITS)

Physical Characteristic	Value
Fines (percent)	92
Specific gravity of solids	2.36
Total organic carbon (percent)	2.0
<i>In situ</i> sediment density (percent solids by weight)	41

Sediment quality characteristics vary spatially and with depth. Specific sediment constituent concentrations are presented for each dredging scenario evaluated.

L.5.2 DREDGING CHARACTERISTICS

A 14-inch (0.35-meter) cutter suction hydraulic dredge is assumed for the purpose of evaluating dredging performance in SMU 1. It is assumed that the 14-inch (0.35-meter) cutter suction dredge pumps at a constant rate of 5,000 gal/min (pipe velocity of approximately 10 ft [3 m] per second) with a production (sediment removal) rate of 150 CY/hr (approximately 10 percent solids in dredge slurry). No specific allowances for downtime or releases due to debris or other unforeseen circumstances are considered. Based on the discussion in Section L.4, a resuspension loss rate of 1 percent is assumed; also 10 percent of the targeted cut depth is assumed to remain after each dredge pass as residual sediment with an average constituent concentration of the depth-weighted average.

L.5.3 SINGLE-PASS DREDGING PROJECT EVALUATION

L.5.3.1 Application Characteristics

One dredging approach that addresses a number of the remedial action objectives would be to make a single-pass with the proposed dredge to remove sufficient sediment to allow for capping without reducing the lake surface area or existing water depth. Implementing that approach in SMU 1 would dredge a total of 318,000 CY from 45 acres. The average dredge cut would be 2.6 ft (0.8 m) (including overdredge), with an average post-dredging water depth over the 45-acre dredge area of 4.2 ft (1.3 m). It should take about 2,120 dredging hours to complete this dredging effort in SMU 1. Table L.3 summarizes these dredging characteristics.

**TABLE L.3
DREDGING PROJECT CHARACTERISTICS FOR AN EXAMPLE
SINGLE-PASS DREDGING EVENT IN SMU 1**

Site Characteristics	Value
Area of dredge site within SMU (acres)	45
Total dredge volume (CY)	318,000
Average dredge cut (ft)	2.6
Average post-dredging water depth (ft)	4.2
Dredging Characteristics	
Dredge type	Hydraulic
Dredge size (inches)	14
Production rate (CY/hr)	150
Resuspension rate (percent)	1

Note: Average *in situ* sediment concentrations in the 0- to 3-ft (0- to 1-m) dredge cut were taken from Table B.9 of Appendix B, sediment management units. *Dividing the total volume by the dredge area will not yield the average dredge cut because the total volume includes quantities associated with overdredging and side-sloughing.*

L.5.3.2 Dredging Impacts

A detailed assessment of the evaluations outlined in Section L.4.2 for a single-pass dredging event is presented below.

L.5.3.2.1 Near-Field Water Quality

The northwest two-thirds of Onondaga Lake is classified by the state of New York as a Class B waterbody. The designated uses of Class B waters are primary and secondary contact recreation and fishing. They specifically are required to be suitable for fish propagation and survival. The southeastern one-third of the Lake and the Ninemile Creek delta are classified as a Class C Waterbody. Onondaga Lake was identified in the 2002 New York State Section 303(d) List of Impaired Waters submitted to the USEPA as impaired due to PCBs, mercury, and dioxin.

Table L.4 summarizes modeled dissolved water column constituent concentrations for a single-pass dredging event in SMU 1 with two different mixing zone assumptions. One assumed a 100-ft-diameter (30-m-diameter) well-mixed zone and the other used a larger mixing zone equivalent to the dredged area, 45 acres. Table L.4 also includes a variety of comparative water quality values to help understand the impacts of the dredging operation on the lake. Note that these predicted concentrations are above background concentrations. That is, actual water column concentrations will be background concentrations plus the predicted dredge-induced concentrations. Background concentrations from a 1999 study provide an approximate range of ambient conditions in Onondaga Lake. Water quality standards associated with Class B and C waters show constituents concentrations essential to maintain its designated uses.

Water quality modeling results show that some water column concentrations in the immediate vicinity of the dredging operation, as well as over the entire dredge area, exceed water quality criteria. It must be remembered that these represent average sediment concentrations and that actual water column concentrations will fluctuate with sediment concentration, including both higher and lower values.

TABLE L.4
COMPARISON OF WELL-MIXED ZONE CONSTITUENT DISSOLVED
CONCENTRATIONS WITH AMBIENT CONDITIONS AND RELEVANT WQ
CRITERIA FOR A SINGLE-PASS DREDGING OPERATION WITHIN SMU 1

Analyte	Near-Field Conc. (µg/L) (a)		1999 Background Lake Conc. (ug/L)(b)	Class B/C WQ Standard or GV (µg/L)
	100-ft Mixing Zone	45-acre Mixing Zone		
Total suspended solids (mg/L)	63	3.9	2 to 5	No impairment
Benzo[a]pyrene	0.038	0.002	ND	0.0012(GV)
Chlorobenzene	2.6	0.16	6.3(2)/ND	5
Dichlorobenzenes (Sum)	3.1	0.19	0.8	5
Ethylbenzene	0.13	0.008	ND/ND	17(GV)
Fluorene	0.078	0.005	NM	0.54(GV)
Naphthalene	2.6	0.17	NM	13(GV)
Phenanthrene	0.13	0.008	NM	5(GV)
Polychlorinated biphenyls	0.11	0.007	NM	10 ⁻⁶
Pyrene	0.072	0.005	NM	4.6(GV)
Mercury	1.0	0.065	0.01/0.013	0.0007
Xylene isomers (sum)	1.8	0.12	0.4(2)/ND	65(GV)
Benzene	0.14	0.009	3.2(2)/NM	10
Hexachlorobenzene	0.027	0.002	NM	3E-5
Phenol	0.078	0.005	NM	exp [1.005 (pH) - 4.869]
Toluene	0.26	0.017	0.16(1)/NM	6,000
Trichlorobenzene	0.37	0.024	NM	5

GV = guidance value; ND = none detected; NM = not measured; NL = no limit specified

(a) Values shown represent contributions due to the dredging operation *above* background conditions.

(b) Average detected water concentrations from TAMS, 2002 (Tables G1-64 and G1-65 in the Onondaga Lake RI) for water depths less than 9 m / more than 9 m. Listing of one value represents average lake-wide water quality from 12 samples analyzed. Numbers in parentheses following concentrations are number of detects from the 12 samples analyzed lake-wide.

L.5.3.2.2 Volatile Releases in Vicinity of Dredging Operation

Table L.5 summarizes the predicted emission rates due to volatilization from the point of dredging for a single-pass dredging event in SMU 1 based on average water column concentrations. The modeled maximum 1-hour air concentrations at the point of maximum exposure are presented and compared to appropriate health benchmarks and odor thresholds. The results indicate that the applicable health benchmarks and odor thresholds are not exceeded near the point of dredge.

TABLE L.5
ESTIMATED EMISSION RATES DUE TO VOLATILIZATION AND PREDICTED
MAXIMUM AIR CONCENTRATIONS AT THE POINT OF DREDGING FOR A
SINGLE-PASS DREDGING OPERATION WITHIN SMU 1

Analyte	Emission rate (g/sec)	Maximum 1-hour Conc (mg/m ³)	NYS SGC (mg/m ³)	Odor Threshold (mg/m ³)
Benzene	6.5E-06	6.4E-06	1.30E+00	1.95E+02
Benzo[a]pyrene	8.0E-08	8.8E-08	-	-
Chlorobenzene	1.1E-04	1.1E-04	-	6.00E+00
1,4 Dichlorobenzene	5.9E-05	5.9E-05	3.00E+01	7.00E-01
Ethylbenzene	5.5E-06	5.4E-06	5.40E+01	-
Fluorene	2.6E-06	2.6E-06	-	-
Methyl Mercury	5.2E-12	5.9E-12	3.00E-03	-
Naphthalene	1.1E-04	1.0E-04	7.90E+00	2.00E-01
Phenanthrene	4.7E-06	4.1E-06	-	-
Pyrene	1.0E-06	1.1E-06	-	-
Toluene	1.2E-05	1.1E-05	-	6.00E+00
Xylene isomers (total)	1.6E-04	7.6E-05	4.30E+00	2.70E+00
Hexachlorobenzene	9.0E-07	7.6E-07	-	-
Phenol	1.6E-07	2.0E-07	5.8E+00	2.3E-01
Trichlorobenzene	1.4E-05	1.3E-05	3.70E+00	-

Notes: NYS SGC = New York State Short Term Guideline Concentration; RfC = Reference Concentration; concentrations at point of maximum exposure

The only air quality issue associated with the point of dredge is the potential for the occurrence of NAPL containing VOCs in the dredge materials (this may be a particular issue in SMU 2). Assuming that the dredging of materials containing NAPL results in water column concentrations equivalent to the mean solubility limit, the maximum one-hour air concentration of benzene resulting from emissions during the dredging of NAPL has the potential to exceed the New York State Short Term Guideline Concentration (SGC) for benzene of 1.3 mg/m³ by a factor of 33. Similarly, the maximum predicted air concentration of benzene at the point of dredging has the potential to exceed OSHA PEL values for workers operating the dredge by a factor of 9.

L.5.3.2.3 Initial Residual Sediment Concentrations

Since the 2.3-ft (0.8-m) cut is less than the 3-ft (1-m) accuracy of the sediment quality, it is estimated that the 0.23 ft residual layer would have constituent concentrations identical to the sediment characteristics. These concentrations are expected to be comparable to sediments below the dredge cut, since inventory is not totally removed.

L.5.3.2.4 Estimated Impact to Profundal Sediments

Using the assumptions and method presented in Section L.4.3, the equivalent mercury flux to the profundal sediments from this dredging operation is approximately 2×10^{-8} kg/m²/day, or about 0.1 percent of the current natural sedimentation mercury flux of 0.0006 mg/cm²/year (see Section 4.3). Therefore, impacts to profundal sediments are minimal.

L.5.3.3 SCA Treatment and Operation

L.5.3.3.1 Supernatant Concentration and Effluent Quality

Table L.6 shows estimated SCA effluent concentrations after only primary treatment for the average sediment concentrations associated with a single cut over the 45-acre dredging area of SMU 1, along with comparative water quality values. Note that these predicted concentrations represent contributions due to the dredging operations above background conditions. The SCA is assumed to have a supernatant retention time of at least 24-hours. These results show that the SCA effluent, with only primary treatment, will exceed most water quality standards for most CPOIs, including mercury, at these average sediment concentrations without mixing.

TABLE L.6
COMPARISON OF SCA EFFLUENT DISSOLVED CONCENTRATIONS AFTER
ENHANCED PRIMARY TREATMENT WITH AMBIENT CONDITIONS AND
RELEVANT WQ CRITERIA FOR A SINGLE -PASS DREDGING OPERATION
WITHIN SMU 1

Analyte	Effluent Conc. (µg/L) (a)	Background Lake Conc. (µg/L) (b)	Class B WQ Stds (µg/L)
Total suspended solids (mg/L)	100	2 to 5	No impairment
Benzo[a]pyrene	0.09	ND	0.0012(GV)
Chlorobenzene	2,111	6.3(2)/ND	5
Dichlorobenzenes (Sum)	883	0.8	5
Ethylbenzene	96	ND/ND	17(GV)
Fluorene	4.24	NM	0.54(GV)
Naphthalene	763	NM	13(GV)
Phenanthrene	0.52	NM	5(GV)
Polychlorinated biphenyls	0.26	NM	10 ⁻⁶
Pyrene	0.41	NM	4.6(GV)
Total mercury	4.2	0.01/0.013	0.0007
Xylene isomers (total)	775	0.4(2)/ND	65(GV)
Benzene	190	3.2(2)/NM	10
Hexachlorobenzene	0.06	NM	3E-5
Phenol	109	NM	exp [1.005 (pH) - 4.869]
Toluene	217	0.16(1)/NM	6,000
Trichlorobenzene	17	NM	10

GV = guidance value; ND = none detected; NM = not measured; NL = no limit specified

(a) Values shown represent contributions due to the dredging operation *above* background conditions.

(b) Average detected water concentrations from TAMS, 2002 (Tables G1-64 and G1-65 in the Onondaga Lake RI) for water depths less than 9 m / more than 9 m. Listing of one value represents average lake-wide water quality from 12 samples analyzed. Numbers in parentheses following concentrations are number of detects from the 12 samples analyzed lake-wide.

L.5.3.3.2 Volatile Releases from SCA

The effluent concentrations shown in Table L.6 also represent the average supernatant concentration within the SCA during disposal. Table L.7 summarizes the predicted emission rates due to volatilization from the SCA for a single-pass dredging event in SMU 1 based on average water column concentrations. The modeled maximum 1-hour air concentrations at the point of maximum exposure are also presented and compared to appropriate health benchmarks and odor thresholds. The results indicate that the maximum 1-hour concentrations do not exceed the applicable health benchmarks or odor thresholds.

TABLE L.7
ESTIMATED EMISSION RATES DUE TO VOLATILIZATION AND PREDICTED
MAXIMUM AIR CONCENTRATIONS FROM THE SCA FOR A SINGLE-PASS
DREDGING OPERATION

Analyte	Emission rate (g/sec)	Maximum 1-hour Conc (mg/m ³)	NYS SGC (mg/m ³)	Odor Threshold (mg/m ³)
Benzene	8.0E-02	1.6E-02	1.30E+00	1.95E+02
Benzo[a]pyrene	2.8E-06	5.5E-07	-	-
Chlorobenzene	8.1E-01	1.6E-01	-	6.00E+00
1,4 Dichlorobenzene	1.5E-01	3.0E-02	3.00E+01	7.00E-01
Ethylbenzene	3.8E-02	7.4E-03	5.40E+01	-
Fluorene	1.3E-03	2.5E-04	-	-
Methyl Mercury	1.3E-07	2.5E-08	3.00E-03	-
Naphthalene	2.8E-01	5.4E-02	7.90E+00	2.00E-01
Phenanthrene	2.3E-04	4.5E-05	-	-
Pyrene	6.4E-05	1.3E-05	-	-
Toluene	8.8E-02	1.7E-02	-	6.00E+00
Xylene isomers (total)	3.1E+01	5.9E-02	4.30E+00	2.70E+00
Hexachlorobenzene	2.9E-05	5.7E-06	-	-
Phenol	2.0E-03	3.9E-04	5.80E+00	2.31E-01
Trichlorobenzene	5.8E-03	1.1E-03	-	-

Notes: NYS SGC = New York State Short Term Guideline Concentration; RfC = Reference Concentration; concentrations at point of maximum exposure

L.5.4 EXTENDED DEPTH DREDGE PROJECT EVALUATION

Removing a significant depth of sediment from a large area represents a substantially different operation than removal to allow cap placement without impacting lake volume. Removing the estimated 30 ft (9 m) of sediment from SMU 1 would require numerous dredge passes, since the maximum dredge cut for the assumed 14-inch (0.35-m) hydraulic dredge is about 4 ft (1.2 m). That suggests that eight passes are likely necessary to completely remove sediments.

Extended depth dredging in SMU 1 would remove approximately 4 million CY from 84 acres. The average dredge cut would be 26 ft (8 m) (including overdredge), with an average post-dredging water depth over the 84-acre dredge area of about 35 ft (10 m). It would take about 27,000 dredging hours to complete this dredging effort in SMU 1 using one 14-inch (0.35-m) dredge. Table L.8 summarizes the dredging project characteristics.

TABLE L.8
DREDGING PROJECT CHARACTERISTICS FOR
DEEP SEDIMENT REMOVAL DREDGING EVENT IN SMU 1

Site Characteristics	Value
Area of dredge site within SMU (acres)	84
Total dredge volume (CY)	4,028,000
Average dredge cut (ft)	26
Average post-dredging water depth (ft)	35
Dredging Characteristics	Value
Dredge type	Hydraulic
Dredge size (inches)	14
Production rate (CY/hr)	150
Resuspension rate (percent)	1

In situ sediment concentrations for the constituents of concern were taken as the maximum concentrations observed in SMU 1.

A number of approaches could be taken to evaluate the impacts of dredging almost 30 ft (9 m) of sediment over eight dredge passes. Using average sediment conditions represents the average impact over the project and was therefore used to assess air impacts. However, water quality analyses are based on the maximum concentration of each constituent found throughout the sediment profile. Using maximum concentrations provides an assessment of the worst-case conditions for each constituent, although they would not all necessarily occur simultaneously. The depths of the maximum concentrations were assumed to be in the upper 3 ft (1 m), based on a review of existing data.

L.5.4.1 Dredging Impacts

L.5.4.1.1 Near-Field Water Quality

Table L.9 summarizes modeled water column constituent concentrations for a multiple-pass dredging event in SMU 1. Note that these concentrations represent contributions due to the dredging operation above background conditions. Results are shown for a 100-ft-diameter (33-meter-diameter), well-mixed zone and a mixing zone equivalent to the dredged area (84 acres for SMU 1).

Numerous contaminants will exceed typical water quality criteria around the dredge operation, and a lesser group will exceed typical water quality criteria within the dredging area under maximum conditions. It is important to realize that these maximum concentrations will only occur at specific locations and that not all constituents will be at their maximum concentration.

TABLE L.9
COMPARISON OF WELL-MIXED ZONE CONSTITUENT DISSOLVED
CONCENTRATIONS WITH AMBIENT CONDITIONS AND RELEVANT WQ
CRITERIA FOR AN EXTENSIVE DREDGING OPERATION WITHIN SMU 1

Analyte	Near-field Conc. (µg/L)(a)		Background Lake Conc. (µg/L) (b)	Class B WQ Stds (µg/L)
	100-ft Mixing Zone	84-acre Mixing Zone		
Total suspended solids (mg/L)	7.5	0.35	2 to 5	No impairment
Benzo[a]pyrene	0.045	0.002	ND	0.0012(GV)
Chlorobenzene	1.2	0.057	6.3(2)/ND	5
Dichlorobenzenes (Sum)	2.1	0.096	0.8	5
Ethylbenzene	0.10	0.005	ND/ND	17(GV)
Fluorene	0.30	0.014	NM	0.54(GV)
Naphthalene	3.2	0.15	NM	13(GV)
Phenanthrene	0.60	0.028	NM	5(GV)
Polychlorinated biphenyls	0.032	0.001	NM	10 ⁻⁶
Pyrene	0.34	0.016	NM	4.6(GV)
Total mercury	0.27	0.012	0.01/0.013	0.0007
Xylene isomers (total)	1.6	0.074	0.4(2)/ND	65(GV)
Benzene	0.14	0.006	3.2(2)/NM	10
Hexachlorobenzene	0.004	<0.001	NM	3E-5
Phenol	0.063	0.003	NM	exp [1.005 (pH) - 4.869]
Trichlorobenzene	1.4	0.063	NM	10

GV = guidance value; ND = none detected; NM = not measured; NL = no limit specified

(a) Values shown represent contributions due to the dredging operation *above* background conditions.

(b) Average detected water concentrations from TAMS, 2002 (Tables G1-64 and G1-65 in the Onondaga Lake RI) for water depths less than 9 m / more than 9 m. Listing of one value represents average lake-wide water quality from 12 samples analyzed. Numbers in parentheses following concentrations are number of detects from the 12 samples analyzed lake-wide.

L.5.4.1.2 Volatile Releases in Vicinity of Dredging Operation

Table L.10 summarizes the predicted emission rates due to volatilization from the point of dredging for a multiple pass dredging event in SMU 1 based on average water column concentrations. The modeled maximum 1-hour air concentrations at the point of maximum exposure are also presented and compared to appropriate health benchmarks and odor thresholds. The results indicate that the health benchmarks and the odor threshold are not exceeded near the point of dredge.

TABLE L.10
ESTIMATED EMISSION RATES DUE TO VOLATILIZATION AND PREDICTED
MAXIMUM AIR CONCENTRATIONS AT THE POINT OF DREDGING FOR A
COMPREHENSIVE DREDGING OPERATION WITHIN SMU 1

Analyte	Emission rate (g/sec)	Maximum 1-hour Conc (mg/m ³)	NYS SGC (mg/m ³)	Odor Threshold (mg/m ³)
Benzene	1.5E-06	1.1E-06	1.30E+00	1.95E+02
Benzo[a]pyrene	1.8E-08	1.7E-08	-	-
Chlorobenzene	5.0E-06	3.6E-06	-	6.00E+00
1,4 Dichlorobenzene	4.0E-06	3.0E-06	3.00E+01	7.00E-01
Ethylbenzene	1.7E-06	1.2E-06	5.40E+01	-
Fluorene	1.8E-06	1.3E-06	-	-
Methyl Mercury	4.8E-13	4.5E-13	3.00E-03	-
Naphthalene	3.6E-05	2.6E-05	7.90E+00	2.00E-01
Phenanthrene	2.9E-06	2.0E-06	-	-
Pyrene	4.2E-07	3.5E-07	-	-
Toluene	3.8E-06	2.8E-06	-	6.00E+00
Xylene isomers (total)	4.8E-05	1.7E-05	4.30E+00	2.70E+00
Hexachlorobenzene	4.9E-08	3.5E-08	-	-
Phenol	6.7E-08	6.5E-08	5.80E+00	2.31E-01
Trichlorobenzene	2.2E-06	1.6E-06	-	-

Notes: NYS SGC = New York State Short Term Guideline Concentration; RfC = Reference Concentration; concentrations at point of maximum exposure

As discussed in Section L.5.3.2.2, the only air quality issue associated with the point of dredge is the potential for the occurrence of NAPL containing VOCs in the dredge materials, which potentially could result in a maximum one-hour air concentration of benzene exceeding the SGC for benzene of 1.3 mg/m³ by a factor of 33. Additionally, the predicted air concentration of benzene at the point of dredging has the potential to exceed OSHA PEL values for workers operating the dredge by a factor of 9. In the absence of more complete site characterization data, it is reasonable to assume that the greater the volume of material dredged, the greater the probability of encountering NAPL. This condition is, therefore, considered more likely to occur as the volumes of dredged materials increase from the single-pass dredge scenario to the extended depth dredge scenario.

L.5.4.1.3 Initial Residual Sediment Concentrations

Post-dredging residual sediment concentrations for the extended dredging operation pose a particular concern. The soft nature of the sediments will probably require removal of an entire single layer over the entire dredging area prior to dredging the next-deeper layer. Since at least

eight passes are estimated to be required, significant constituent concentrations may be left exposed for extended periods of time (the dredging will likely require multiple construction seasons). Table L.11 estimates the residual total mercury concentration, assuming a 3.3-ft (1-meter) dredge cut with 10 percent by volume left behind, with an average concentration of the 3.3 ft (1 m) of sediments removed. It shows that below 10 ft (3 m), higher surface concentrations may exist during the dredging operation.

TABLE L.11

**ASSESSMENT OF POTENTIAL POST-DREDGING RESIDUAL (SURFACE)
SEDIMENT CONCENTRATIONS OF TOTAL MERCURY**

Depths (m)	<i>In situ</i> Total Mercury Conc. (mg/kg)	Dredge Pass	Estimated Post-Dredging Total Mercury Conc. (mg/kg)
0-1	16.37	1	16
1-2	9.88	2	10
2-3	24.26	3	23
3-4	13.72	4	15
4-5	5.12	5	6.0
5-6	2.57	6	2.9
6-7	1.93	7	2.0
7-8	1.00	8	1.1

L.5.4.1.4 Estimated Impact to Profundal Sediments

Using the conservative assumptions and methods presented in Section L.4.3, the equivalent mercury flux to the profundal sediments from this dredging operation is approximately 1×10^{-8} kg/m²/day, or about 0.1 percent of the current natural sedimentation mercury flux. Therefore, impacts to profundal sediments are minimal.

L.5.4.2 SCA Treatment and Operation

L.5.4.2.1 Supernatant Concentration and Effluent Quality

Estimated supernatant and effluent concentrations from the SCA while dredging the maximum concentration sediments are shown in Table L.12, along with representative water quality standards. These results show that the supernatant, with only primary treatment, will exceed many of the water quality standards.

TABLE L.12
COMPARISON OF SCA EFFLUENT DISSOLVED CONCENTRATIONS AFTER ONLY
PRIMARY TREATMENT WITH AMBIENT CONDITIONS AND RELEVANT WQ
CRITERIA FOR A COMPREHENSIVE DREDGING OPERATION WITHIN SMU 1

Analyte	Effluent Conc. (µg/L) (a)	Background Lake Conc. (µg/L) (b)	Class B WQ Stds (µg/L)
Total suspended solids (mg/L)	0.10	2 to 5	No impairment
Benzo[a]pyrene	0.93	ND	0.0012(GV)
Chlorobenzene	8,300	6.3(2)/ND	5
Dichlorobenzenes (Sum)	4,900	0.8	5
Ethylbenzene	620	ND/ND	17(GV)
Fluorene	130	NM	0.54(GV)
Naphthalene	7,500	NM	13(GV)
Phenanthrene	20	NM	5(GV)
Polychlorinated biphenyls	730	NM	10 ⁻⁶
Pyrene	16	NM	4.6(GV)
Total mercury	9.2	0.01/0.013	0.0007
Xylene isomers (total)	5,632	0.4(2)/ND	65(GV)
Benzene	1,500	3.2(2)/NM	10
Hexachlorobenzene	0.07	NM	3E-5
Phenol	730	NM	exp [1.005 (pH) - 4.869]
Toluene	2,500	0.16(1)/NM	6,000
Trichlorobenzene	510	NM	10

GV = guidance value; ND = none detected; NM = not measured; NL = no limit specified

(a) Values shown represent contributions due to the dredging operation *above* background conditions

(b) Average detected water concentrations from TAMS, 2002 (Tables G1-64 and G1-65 in the Onondaga Lake RI) for water depths less than 9 m / more than 9 m. Listing of one value represents average lake-wide water quality from 12 samples analyzed. Numbers in parentheses following concentrations are number of detects from the 12 samples analyzed lake-wide.

L.5.4.2.2 Volatile Releases from SCA

Table L.13 summarizes the predicted emission rates due to volatilization from the SCA for a single-pass dredging event in SMU 1, based on average water column concentrations. The modeled maximum 1-hour concentrations at the point of maximum exposure are also presented and compared to appropriate health benchmarks and odor thresholds. The results indicate that the health benchmarks and the odor thresholds are not exceeded at the point of maximum exposure near the SCA.

TABLE L.13
ESTIMATED EMISSION RATES DUE TO VOLATILIZATION AND PREDICTED
MAXIMUM AIR CONCENTRATIONS FROM THE SCA FOR A COMPREHENSIVE
DREDGING OPERATION WITHIN SMU 1

Analyte	Emission rate (g/sec)	Maximum 1-hour Conc (mg/m ³)	NYS SGC (mg/m ³)	Odor Threshold (mg/m ³)
Benzene	1.2E-01	2.3E-02	1.30E+00	1.95E+02
Benzo[a]pyrene	4.0E-06	7.8E-07	-	-
Chlorobenzene	2.3E-01	4.5E-02	-	6.00E+00
1,4 Dichlorobenzene	6.4E-01	1.3E-02	3.00E+01	7.00E-01
Ethylbenzene	7.1E-02	1.4E-02	5.40E+01	-
Fluorene	5.4E-03	1.1E-03	-	-
Methyl Mercury	7.3E-08	1.4E-08	3.00E-03	-
Naphthalene	5.7E-01	1.1E-01	7.90E+00	2.00E-01
Phenanthrene	8.4E-04	1.6E-04	-	-
Pyrene	1.6E-04	3.1E-05	-	-
Toluene	1.8E-01	3.4E-02	-	6.00E+00
Xylene isomers (total)	1.1E+00	1.1E-01	4.30E+00	2.70E+00
Hexachlorobenzene	9.6E-06	1.9E-06	-	-
Phenol	5.4E-03	1.1E-03	5.80E+00	2.31E-01
Trichlorobenzene	5.7E-03	1.1E-03	-	-

Notes: NYS SGC = New York State Short Term Guideline Concentration; RfC = Reference Concentration; concentrations at point of maximum exposure

SECTION L.6

CONSTRUCTION REQUIREMENTS FOR COST ESTIMATING

Costs of dredging operations vary, depending on characteristics of dredge material and physical conditions of the site. This analysis considered the labor and equipment requirements for typical hydraulic and mechanical dredging equipment in Onondaga Lake. These efforts will be modified during final design, when specific conditions are better known.

Daily costs can be estimated by multiplying labor and equipment by appropriate rates. Dredging unit costs can be estimated by dividing the daily dredging costs presented below by the production rates presented in Section L.2.

L.6.1 HYDRAULIC DREDGING COSTS

Mobilization and demobilization costs for the hydraulic dredging equipment would include the following tasks:

- Prepare, deliver, and assemble dredge;
- Haul and prepare (fuse) pipe;
- Prepare, deliver, and assemble end barge;
- Deliver tug; and
- Supervise for one month.

In addition, there will be yearly costs during the winter shutdown and spring start up. This cost includes:

- Securing all the equipment;
- Re-starting all the equipment; and
- Providing for security for 5 months.

Daily operational costs include labor costs and direct costs for the rental, operation, and supplies of various pieces of equipment. Labor costs assumed that two 8-hour shifts would work 14 productive hours per day. The other two hours will be used towards preparation and close-down each day.

The following labor would be required for a hydraulic operation (this is total number of person-shifts each day):

On the dredge

- 1 captain

- 2 lever operators
- 2 mates
- 2 deck hands

On support vessels (tug)

- 2 on tug

At each booster pump

- 2 laborers

At disposal site

- 1 mechanical
- 1 supervisor

Daily equipment costs would cover the rental, operation, and supplies for the dredge, tug, end barge, and pipeline.

L.6.2 MECHANICAL DREDGING COSTS

Mobilization and demobilization costs for the clamshell dredging equipment would cover the following tasks:

- Prepare and tow dredge, barges, and tug and
- Supervise for one-half month.

In addition, there will be yearly costs during the winter shutdown and spring start up. These costs would be similar to those identified in section 6.1 for the hydraulic operation.

Unit costs are the daily cost of the operation divided by the daily production of the operation. Daily operational costs include labor costs and direct costs for rental, operation, and supplies of the various pieces of equipment. Labor costs assumed that two 8-hour shifts would work productive 14 hours per day. The other two hours would be used in preparation and close-down each day.

The following labor would be required for a mechanical operation (this is total number of person-shifts each day):

On the dredge

- 1 captain
- 2 clam operators
- 2 mates

- 2 deck hands

On support vessel (tug)

- 2 on tug

At off-loading facility

- 2 offload operators
- 2 offload deck hands
- 1 mechanical
- 1 supervisor

Daily equipment costs would cover the rental, operation, and supplies of the dredge, tug, containment barges, offload equipment, and transport equipment.

SECTION L.7

CONCLUSIONS

The primary conclusions of this dredging appendix are the following:

- Most conventional dredging equipment should be capable of dredging sediments in the littoral zone.
- Transport limitations as well as water depths and disposal types/locations will limit the size of the equipment. The most suitable equipment would consist of mechanical dredges with 3- to 6-CY buckets or 12- to 16-inch hydraulic dredges.
- Production rates will range from 50 to 250 CY/hr, depending on the size and type of dredging equipment.
- Water column constituent concentrations during dredging at the rate of 150 CY/hr are estimated as follows (only one dredge operating):

For average sediment concentrations over a single dredge cut in SMU 1

- TSS: from 63 mg/L near the dredging operation to 4 mg/L over the dredging area.
- Water quality modeling results indicate water column concentrations for several contaminants exceed water quality criteria in the immediate vicinity of the dredging operation (100-ft-diameter [30-m-diameter]).

For maximum sediment concentrations over extensive depth, multiple dredging cuts in SMU 1

- TSS: from 8 mg/L near the dredging operation to less than 1 mg/L over the dredging area.
- Water quality modeling results indicate water column concentrations in the immediate vicinity of the dredging operation 100-ft-diameter (30-m-diameter) exceed water quality criteria for several constituents.
- A thin layer of residual sediments will occur after an area is dredged. The concentration of this layer is estimated to be the depth-weighted average concentration of the dredged sediments.
- Impacts to profundal sediments from either the single-pass or extended depth dredging scenario would be small compared to the sediment and constituent transport that currently is occurring (about 0.1 percent of the current levels).
- SCA effluent predictions for the single-pass dredging indicate that the effluent will not meet water quality standards for mercury and some organics with only primary treatment and no allowance for mixing. Water quality monitoring of the effluent will be conducted to ensure that end-of-pipe discharge limits (to be established by NYSDEC) are being met.

- SCA effluent predictions for the maximum concentrations in extended depth removal indicate that the effluent will exceed water quality standards with only primary treatment and no mixing allowance. Water quality monitoring of the effluent will be conducted to ensure that end-of-pipe discharge limits (to be established by NYSDEC) are being met.
- Predicted volatile emissions from the point of dredge and from the SCA (based on average sediment concentrations) indicate that health benchmarks and odor threshold would not be exceeded when dredging in SMU1.
- The only air quality issue associated with the point of dredge is the potential for the occurrence of NAPL containing VOCs in the dredge materials, which potentially could result in the exceedance of health benchmarks by factors of 33 to 110. Additionally, the predicted air concentration of benzene at the point of dredging has the potential to exceed OSHA PEL values for workers operating the dredge by a factor of 9. In the absence of more complete site characterization data, it is reasonable to assume that the greater the volume of material dredged, the greater the probability of encountering NAPL. This condition is, therefore, considered more likely to occur as the volumes of dredged materials increase from the single-pass dredge scenario to the extended depth dredge scenario.

SECTION L.8

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APPENDIX L

FIGURES



Bean HPG Hybrid Dredge



Bean HPG Dredge Bucket

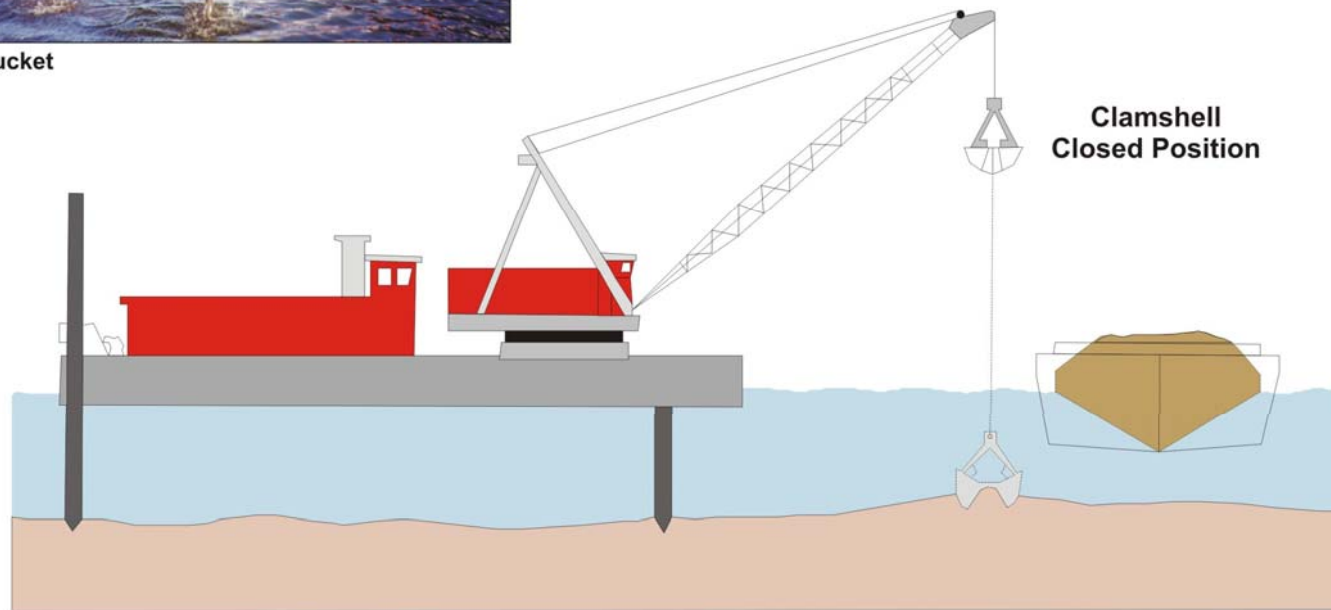
FIGURE L.3

ONONDAGA LAKE
SYRACUSE, NEW YORK

PHOTOS OF HYBRID MECHANICAL/
HYDRAULIC DREDGE



Clamshell Bucket



**Clamshell
Closed Position**

FIGURE L.1

Onondaga Lake
Syracuse, New York

**SCHEMATIC AND PHOTO OF
MECHANICAL DREDGE**



10-inch Hydraulic Dredge



10-inch Hydraulic Dredge

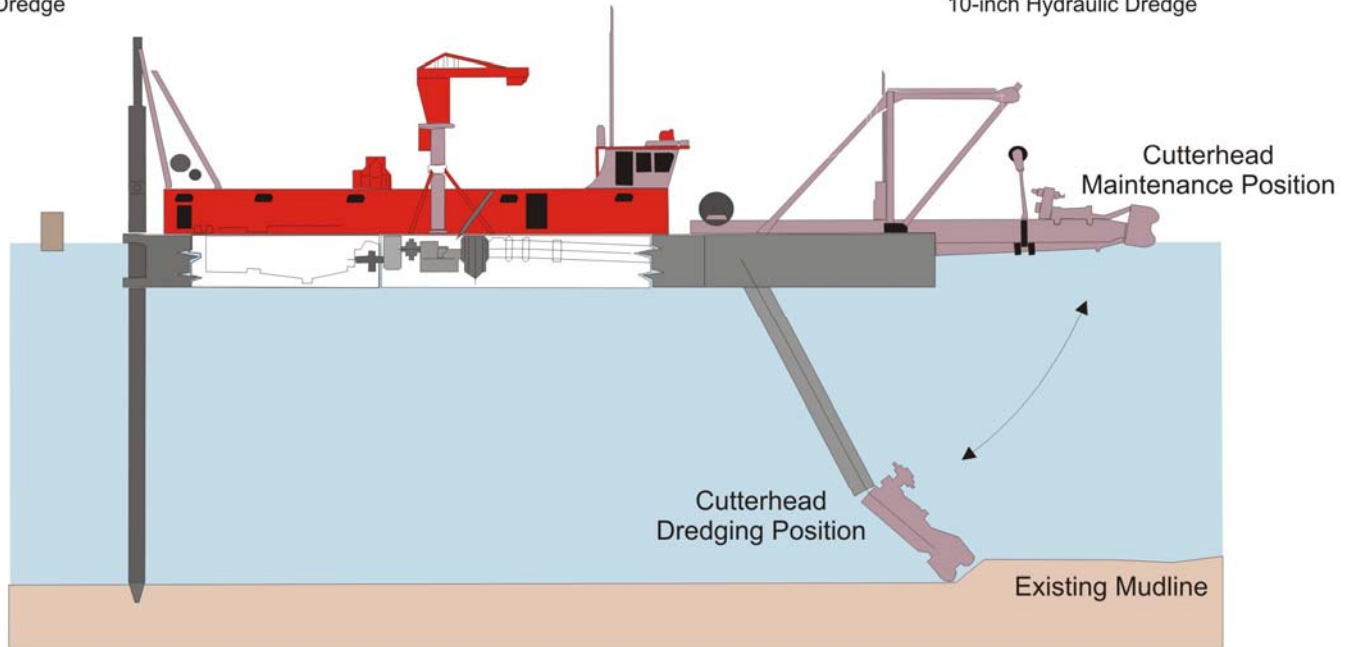


FIGURE L.2

Onondaga Lake
Syracuse, New York

SCHEMATIC AND PHOTO OF
HYDRAULIC DREDGE

**ATTACHMENT A
PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED
WITH DREDGING**

**ONONDAGA LAKE FEASIBILITY STUDY
APPENDIX L**

ATTACHMENT A

PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 1

SMU (Insert Value: 1 through 7): 1
 Selected Dredge Cut (Insert Value e.g. "0-1", "0-2", "0-3"... "0-8"): 0-1
 Select Maximum ("M") or Average ("A") Sediment Conc. Values A

Alternative:
 Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 45
 Total dredge volume in cy: 318000
 Dredge cut in feet (either average or to max conc): 2.6
 Post-dredge water depth (either average or to max conc.) in feet: 4.2

Dredging Characteristics

Dredge type: Hydraulic
 Dredge size (inch): 14
 Production rate in cy/hr: 150
 Resuspension rate (%): 0.01
 Dredging duration in hours: 2120

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr) 191,029 Based on dredging production rate and an avg specific gravity for all SMU sediments
 % volatilized during mixing 80.0
 % volatilized after 40 days of curing 100.0
 Area of Mixing Pad (acres) 1
 Area of Mixing Pad (m2) 4,047

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres) 26 Insert acreage associated with Lakewide Alternative
 Area of Lagoon (m2) 105,218

Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
 Specific gravity: 2.36
 TOC: 0.02
 In Situ Sediment Density (% solids by weight) 0.41
 DOC (mg/L) 6

Avg Sed Specific gravity 2.5

Point of Dredging Impacts - Hydraulic Cutterhead or Clamshell Dredge

Analyte	Sediment concentration of dredged material in mg/kg	Partitioning Coefficients		Average Total Water Quality Constituent Concentration in ug/L		Average Dissolved Water Quality Constituent Concentration in ug/L		Predicted Air Concentration in mg/m ³		Reference Values			Short-term Risk		Odor "HQ" = Air Concentration/Odor Threshold	
		Koc (mL/g)*	Kd (mL/g)	Around Dredge (1)	Over Dredging Area in SMU	Around Dredge (1)	Over Dredging Area in SMU	Worker	Short-term Residential	Res. and Worker	Worker	Max 1-hr Residential	Worker	Residential	Worker	Residential
				Around Dredge (1)	Over Dredging Area in SMU	Around Dredge (1)	Over Dredging Area in SMU	Around Dredge (1)	Highest 1-Hour Concentration Outside SMU perimeter (AERMOD)	Odor Threshold (mg/m ³)	OSHA Threshold (mg/m ³)	NY SGC (mg/m ³)	OSHA: Conc / OSHA PEL	HQ-1	Around Dredge (1)	1-Hr
Total suspended solids (mg/L)				62,512	3,903											
Benzene	2.24	100		0.140	0.009	1.4E-01	8.9E-03	3.8E-06	6.4E-06	1.9E+02	3.2E+00	1.3E+00	1.2E-06	4.9E-06	2.0E-08	3.3E-08
Benz[a]pyrene	0.61	1,096,478		0.038	0.002	3.2E-02	2.4E-03	5.3E-08	8.8E-08	-	-	-	-	-	-	-
Chlorobenzene	41.26	500		2.582	0.163	2.6E+00	1.6E-01	6.5E-05	1.1E-04	6.0E+00	3.5E+02	-	1.8E-07	-	1.1E-05	1.8E-05
Dichlorobenzenes (sum) (1,4 Dichlorobenzene for air calculations)	49.36	2,399		3.088	0.195	3.1E+00	2.0E-01	3.5E-05	5.9E-05	7.0E-01	-	3.0E+01	-	2.0E-06	5.0E-05	8.4E-05
Ethylbenzene	2.05	588		0.128	0.008	1.3E-01	8.1E-03	3.3E-06	5.4E-06	-	4.3E+02	5.4E+01	7.5E-09	1.0E-07	-	-
Fluorene	1.25	15,136		0.078	0.005	7.7E-02	5.0E-03	1.5E-06	2.6E-06	-	-	-	-	-	-	-
Hexachlorobenzenes	0.44	1,513,561		0.027	0.002	2.3E-02	1.7E-03	4.6E-07	7.6E-07	-	-	-	-	-	-	-
Naphthalene	42.24	2,344		2.643	0.167	2.6E+00	1.7E-01	6.3E-05	1.0E-04	2.0E-01	5.2E+01	7.9E+00	1.2E-06	1.3E-05	3.1E-04	5.2E-04
Phenanthrene	2.03	342,748		0.127	0.008	1.1E-01	8.0E-03	2.5E-06	4.1E-06	-	-	-	-	-	-	-
Phenol	1.25	100		0.078	0.005	7.8E-02	5.0E-03	1.2E-07	2.0E-07	2.3E-01	2.0E+01	5.8E+00	6.0E-09	3.4E-08	5.2E-07	8.6E-07
Polychlorinated biphenyls	1.81	1,380,384		0.113	0.007	9.6E-02	7.1E-03	-	-	-	-	-	-	-	-	-
Pyrene	1.14	208,930		0.072	0.005	6.4E-02	4.5E-03	6.4E-07	1.1E-06	-	-	-	-	-	-	-
Toluene	4.20	490		0.263	0.017	2.6E-01	1.7E-02	6.9E-06	1.1E-05	6.0E+00	7.5E+02	3.7E+01	9.2E-09	3.1E-07	1.2E-06	1.9E-06
Total mercury (methyl mercury for air emissions)	16.37	348,050	6,961	1.024	0.065	9.0E-01	6.4E-02	3.6E-12	5.9E-12	-	-	3.0E-03	-	2.0E-09	-	-
Trichlorobenzenes	5.94	18,197		0.372	0.024	3.6E-01	2.3E-02	8.1E-06	1.3E-05	-	-	3.7E+00	-	3.6E-06	-	-
Xylene isomers (total)	28.96	1,413		1.812	0.115	1.8E+00	1.1E-01	4.6E-05	7.6E-05	2.7E+00	4.3E+02	4.3E+00	1.1E-07	1.8E-05	1.7E-05	2.8E-05

* An equivalent Koc was computed for metal constituents using the relationship (Koc)equivalent = Kd/foc

ATTACHMENT A

PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 1

SMU (Insert Value: 1 through 7): 1
Selected Dredge Cut (Insert Value e.g. "0-1", "0-2", "0-3"... "0-8"): 0-1
Select Maximum ("M") or Average ("A") Sediment Conc. Values A
Alternative:

Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 45
Total dredge volume in cy: 318000
Dredge cut in feet (either average or to max conc): 2.6
Post-dredge water depth (either average or to max conc.) in feet: 4.2

Dredging Characteristics

Dredge type: Hydraulic
Dredge size (inch): 14
Production rate in cy/hr: 150
Resuspension rate (%): 0.01
Dredging duration in hours: 2120

Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
Specific gravity: 2.36
TOC: 0.02
In Situ Sediment Density (% solids by weight): 0.41
DOC (mg/L): 6

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr): 191,029
% volatilized during mixing: 80.0
% volatilized after 40 days of curing: 100.0
Area of Mixing Pad (acres): 1
Area of Mixing Pad (m2): 4,047

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres): 26
Area of Lagoon (m2): 105,218

Avg Sed Specific gravity: 2.5

Hydraulic Dredging Sediment Handling and SCA

Analyte	Average concentration of dredged material in mg/kg	Average Total Water Quality Constituent Concentration in ug/L			Average Dissolved Water Quality Constituent Concentration in ug/L			Predicted Air Concentration in mg/m ³	Reference Values			Short-term Risk	Air Concentration / Odor
		Influent	Supernatant	Supernatant after Volatilization	Influent	Supernatant	Supernatant after Volatilization	Highest 1-Hour Concentration Outside SCA perimeter (AERMOD)	Res. and Worker	Worker	Max 1-hr Residential	Residential	Residential
Total suspended solids		100,000	100	100,000									
Benzene	2.24	2.2E+02	1.9E+02	190.307	1.9E+02	1.9E+02	1.9E+02	1.6E-02	1.9E+02	3.2E+00	1.3E+00	1.2E-02	8.1E-05
Benzo[a]pyrene	0.61	6.1E+01	9.5E-02	0.095	2.1E-01	7.4E-02	7.3E-02	5.5E-07	-	-	-	-	-
Chlorobenzene	41.26	4.1E+03	2.2E+03	2111.475	2.1E+03	2.2E+03	2.1E+03	1.6E-01	6.0E+00	3.5E+02	-	-	2.7E-02
Dichlorobenzenes (sum) (1,4 Dichlorobenzene for air calculations)	49.36	4.9E+03	8.9E+02	883.267	8.6E+02	8.9E+02	8.8E+02	3.0E-02	7.0E-01	-	3.0E+01	1.0E-03	4.3E-02
Ethylbenzene	2.05	2.0E+02	9.8E+01	96.298	9.4E+01	9.8E+01	9.6E+01	7.4E-03	-	4.3E+02	5.4E+01	1.4E-04	-
Fluorene	1.25	1.3E+02	4.3E+00	4.242	4.4E+00	4.2E+00	4.1E+00	2.5E-04	-	-	-	-	-
Hexachlorobenzenes	0.44	4.4E+01	6.3E-02	0.061	1.5E-01	4.8E-02	4.7E-02	5.7E-06	-	-	-	-	-
Naphthalene	42.24	4.2E+03	7.8E+02	763.023	7.5E+02	7.7E+02	7.6E+02	5.4E-02	2.0E-01	5.2E+01	7.9E+00	6.9E-03	2.7E-01
Phenanthrene	2.03	2.0E+02	5.3E-01	0.516	9.0E-01	4.3E-01	4.2E-01	4.5E-05	-	-	-	-	-
Phenol	1.25	1.3E+02	1.1E+02	108.819	1.0E+02	1.1E+02	1.1E+02	3.9E-04	2.3E-01	2.0E+01	5.8E+00	6.7E-05	1.7E-03
Polychlorinated biphenyls	1.81	1.8E+02	2.6E-01	0.265	6.1E-01	2.0E-01	2.0E-01	-	-	-	-	-	-
Pyrene	1.14	1.1E+02	4.1E-01	0.405	6.1E-01	3.4E-01	3.4E-01	1.3E-05	-	-	-	-	-
Toluene	4.20	4.2E+02	2.2E+02	216.684	2.1E+02	2.2E+02	2.2E+02	1.7E-02	6.0E+00	7.5E+02	3.7E+01	4.6E-04	2.9E-03
Total mercury (methyl mercury for air emissions)	16.37	1.6E+03	4.2E+00	4.217	7.2E+00	3.4E+00	3.4E+00	2.5E-08	-	-	3.0E-03	8.4E-06	-
Trichlorobenzenes	5.94	5.9E+02	1.7E+01	16.864	1.8E+01	1.7E+01	1.6E+01	1.1E-03	-	-	3.7E+00	3.1E-04	-
Xylene isomers (total)	28.96	2.9E+03	7.9E+02	775.406	7.6E+02	7.9E+02	7.7E+02	5.9E-02	2.7E+00	4.3E+02	4.3E+00	1.4E-02	2.2E-02

ATTACHMENT A

PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 1

SMU (Insert Value: 1 through 7): 1
 Selected Dredge Cut (Insert Value e.g. "0-1", "0-2", "0-3"... "0-8") 0-1
 Select Maximum ("M") or Average ("A") Sediment Conc. Values A
 Alternative:

Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 45
 Total dredge volume in cy: 318000
 Dredge cut in feet (either average or to max conc): 2.6
 Post-dredge water depth (either average or to max conc.) in feet: 4.2

Dredging Characteristics

Dredge type: Hydraulic
 Dredge size (inch): 14
 Production rate in cy/hr: 150
 Resuspension rate (%): 0.01
 Dredging duration in hours: 2120

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr) 191,029 Based on dredging production rate and an avg specific gravity for all SMU sediments
 % volatilized during mixing 80.0
 % volatilized after 40 days of curing 100.0
 Area of Mixing Pad (acres) 1
 Area of Mixing Pad (m2) 4,047

Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
 Specific gravity: 2.36
 TOC: 0.02
 In Situ Sediment Density (% solids by weight) 0.41
 DOC (mg/L) 6

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres) 26 Insert acreage associated with Lakewide Alternative
 Area of Lagoon (m2) 105,218

Avg Sed Specific gravity 2.5

Dredging-Area as a CSTR with Dredging and Effluent Discharge

Analyte	Average concentration of dredged material in mg/kg	Avg. SMU Water Column Concentration with 1 Dredge & Primary SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & Enhanced Primary SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & EP + MMF SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & Advanced SCA Effluent (ug/L)	
		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Total suspended solids		347		11		7		7	
Benzene	2.24	0.687	0.687	0.531	0.531	0.531	0.531	0.012	0.012
Benzo[a]pyrene	0.61	0.003	0.001	0.003	0.003	0.003	0.000	0.003	0.000
Chlorobenzene	41.26	7.688	7.662	7.688	7.688	7.689	7.689	0.174	0.173
Dichlorobenzenes (sum) (1,4 Dichlorobenzene for air calculations)	49.36	3.342	3.288	2.030	2.029	1.927	1.927	0.207	0.207
Ethylbenzene	2.05	0.351	0.350	0.063	0.063	0.060	0.060	0.023	0.023
Fluorene	1.25	0.020	0.018	0.005	0.005	0.005	0.005	0.005	0.005
Hexachlorobenzenes	0.44	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Naphthalene	42.24	2.885	2.840	1.852	1.851	1.852	1.852	0.357	0.357
Phenanthrene	2.03	0.010	0.005	0.010	0.009	0.008	0.008	0.008	0.008
Phenol	1.25	0.393	0.393	0.249	0.249	0.176	0.176	0.049	0.049
Polychlorinated biphenyls	1.81	0.008	0.004	0.008	0.008	0.008	0.008	0.008	0.008
Pyrene	1.14	0.006	0.004	0.006	0.006	0.005	0.005	0.005	0.005
Toluene	4.20	0.789	0.786	0.573	0.573	0.528	0.528	0.017	0.017
Total mercury (methyl mercury for air emissions)	16.37	0.079	0.044	0.070	0.068	0.070	0.070	0.067	0.067
Trichlorobenzenes	5.94	0.083	0.075	0.073	0.073	0.055	0.055	0.032	0.032
Xylene isomers (total)	28.96	2.878	2.850	2.850	2.849	2.850	2.850	0.129	0.129

**ONONDAGA LAKE FEASIBILITY STUDY
APPENDIX L**

**ATTACHMENT A
PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 2**

SMU (Insert Value: 1 through 7): 1
 Selected Dredge Cut (Insert Value e.g. "0-1", "0-0-8")
 Select Maximum ("M") or Average ("A") Sediment
 Alternative:
 Notes: Average concentration in dredge cut

Site Characteristics
 Area of dredge site within SMU in acres: 84
 Total dredge volume in cy: 4028000
 Dredge cut in feet (either average or to max con 26)
 Post-dredge water depth (either average or to max 35)

Dredging Characteristics
 Dredge type: Hydraulic
 Dredge size (inch): 14
 Production rate in cy/hr: 150
 Resuspension rate (%): 0.01
 Dredging duration in hours: 26853.3333
 Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics
 Percent fines: 0.92
 Specific gravity: 2.36
 TOC: 0.02
 In Situ Sediment Density (% solids by weight) 0.41
 DOC (mg/L) 6

Mechanical Dredging Sediment Handling and Disposal Characteristics
 Feedrate (kg/hr) 191,029
 % volatilized during mixing 80.0
 % volatilized after 40 days of curing 100.0
 Area of Mixing Pad (acres) 1
 Area of Mixing Pad (m2) 4,047

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics
 Area of Lagoon (acres) 51
 Area of Lagoon (m2) 206,390
 Avg Sed Specific gravity 2.5

Based on dredging production rate and an avg specific gravity for all SMU sediments
Insert acreage associated with Lakewide Alternative

Point of Dredging Impacts - Hydraulic Cutterhead or Clamshell Dredge

Analyte	Sediment concentration of dredged material in mg/kg	Partitioning Coefficients		Average Total Water Quality Constituent Concentration in ug/L		Average Dissolved Water Quality Constituent Concentration in ug/L		Predicted Air Concentration in mg/m ³		Reference Values			Short-term Risk		Odor "HQ" = Air Concentration/Odor Threshold	
								Worker	Short-term Residential	Res. and Worker	Worker	Max 1-hr Residential	Worker	Residential	Worker	Residential
			Koc (mL/g)*	Kd (mL/g)	Around Dredge (1)	Over Dredging Area in SMU	Around Dredge (1)	Over Dredging Area in SMU	Around Dredge (1)	Highest 1-Hour Concentration Outside SMU perimeter (AERMOD)	Odor Threshold (mg/m ³)	OSHA Threshold (mg/m ³)	NY SGC (mg/m ³)	OSHA: Conc / OSHA PEL	HQ-1	Around Dredge (1)
Total suspended solids (mg/L)				7.508	0.347											
Benzene	18.34	100		0.138	0.006	0.138	0.006	-	-	1.9E+02	3.2E+00	1.3E+00	-	-	-	-
Benzo[a]pyrene	6.00	1,096,478		0.045	0.002	0.044	0.002	-	-	-	-	-	-	-	-	-
Chlorobenzene	163.58	500		1.228	0.057	1.228	0.057	-	-	6.0E+00	3.5E+02	-	-	-	-	-
Dichlorobenzenes (sum) (1,4 Dichlorobenzene f	276.12	2,399		2.073	0.096	2.072	0.096	-	-	7.0E-01	-	3.0E+01	-	-	-	-
Ethylbenzene	13.30	588		0.100	0.005	0.100	0.005	-	-	-	4.3E+02	5.4E+01	-	-	-	-
Fluorene	39.69	15,136		0.298	0.014	0.297	0.014	-	-	-	-	-	-	-	-	-
Hexachlorobenzenes	0.51	1,513,561		0.004	0.000	0.004	0.000	-	-	-	-	-	-	-	-	-
Naphthalene	419.63	2,344		3.151	0.146	3.150	0.146	-	-	2.0E-01	5.2E+01	7.9E+00	-	-	-	-
Phenanthrene	80.26	342,748		0.603	0.028	0.593	0.028	-	-	-	-	-	-	-	-	-
Phenol	8.40	100		0.063	0.003	0.063	0.003	-	-	2.3E-01	2.0E+01	5.8E+00	-	-	-	-
Polychlorinated biphenyls	4.23	1,380,384		0.032	0.001	0.031	0.001	-	-	-	-	-	-	-	-	-
Pyrene	45.73	208,930		0.343	0.016	0.339	0.016	-	-	-	-	-	-	-	-	-
Toluene	48.26	490		0.362	0.017	0.362	0.017	-	-	6.0E+00	7.5E+02	3.7E+01	-	-	-	-
Total mercury (methyl mercury for air emissions)	35.85	348,050	6,961	0.269	0.012	0.265	0.012	-	-	-	-	3.0E-03	-	-	-	-
Trichlorobenzenes	181.25	18,197		1.361	0.063	1.358	0.063	-	-	-	-	3.7E+00	-	-	-	-
Xylene isomers (total)	211.91	1,413		1.591	0.074	1.591	0.074	-	-	2.7E+00	4.3E+02	4.3E+00	-	-	-	-

* An equivalent Koc was computed for metal constituents using the relationship (Koc)equivalent = Kd/foc

ATTACHMENT A
PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 2

SMU (Insert Value: 1 through 7): 1
Selected Dredge Cut (Insert Value e.g. "0-1", "0-0-8")
Select Maximum ("M") or Average ("A") Sediment
Alternative:

Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 84
Total dredge volume in cy: 4028000
Dredge cut in feet (either average or to max con 26
Post-dredge water depth (either average or to n 35

Dredging Characteristics

Dredge type: Hydraulic
Dredge size (inch): 14
Production rate in cy/hr: 150
Resuspension rate (%): 0.01
Dredging duration in hours: 26853.3333
Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
Specific gravity: 2.36
TOC: 0.02
In Situ Sediment Density (% solids by weight) 0.41
DOC (mg/L) 6

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr) 191,029
% volatilized during mixing 80.0
% volatilized after 40 days of curing 100.0
Area of Mixing Pad (acres) 1
Area of Mixing Pad (m2) 4,047

Based on dredging production rate and an avg specific gravity for all SMU sediments

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres) 51
Area of Lagoon (m2) 206,390

Insert acreage associated with Lakewide Alternative

Avg Sed Specific gravity 2.5

Hydraulic Dredging Sediment Handling and SCA

Analyte	Average concentration of dredged material in mg/kg	Average Total Water Quality Constituent Concentration in ug/L			Average Dissolved Water Quality Constituent Concentration in ug/L			Predicted Air Concentration in mg/m³	Reference Values			Short-term Risk	Air Concentration / Odor
		Influent	Supernatant	Supernatant after Volatilization	Influent	Supernatant	Supernatant after Volatilization	Highest 1-Hour Concentration Outside SCA perimeter (AERMOD)	Res. and Worker	Worker	Max 1-hr Residential	Residential	Residential
									Odor Threshold (mg/m³)	OSHA Threshold (mg/m³)	NY SGC (mg/m³)		
												HQ-1	1-Hr
Total suspended solids		100,000	100	100									
Benzene	18.34	1.8E+03	1.6E+03	1.5E+03	1.5E+03	1.6E+03	1.5E+03	-	1.9E+02	3.2E+00	1.3E+00	-	-
Benzo[a]pyrene	6.00	6.0E+02	9.3E-01	9.3E-01	2.1E+00	7.2E-01	7.2E-01	-	-	-	-	-	-
Chlorobenzene	163.58	1.6E+04	8.5E+03	8.3E+03	8.2E+03	8.5E+03	8.3E+03	-	6.0E+00	3.5E+02	-	-	-
Dichlorobenzenes (sum) (1,4 Dichlorobenzene f	276.12	2.8E+04	5.0E+03	4.9E+03	4.8E+03	5.0E+03	4.9E+03	-	7.0E-01	-	3.0E+01	-	-
Ethylbenzene	13.30	1.3E+03	6.4E+02	6.2E+02	6.1E+02	6.4E+02	6.2E+02	-	-	4.3E+02	5.4E+01	-	-
Fluorene	39.69	4.0E+03	1.4E+02	1.3E+02	1.4E+02	1.3E+02	1.3E+02	-	-	-	-	-	-
Hexachlorobenzenes	0.51	5.1E+01	7.3E-02	7.0E-02	1.7E-01	5.6E-02	5.4E-02	-	-	-	-	-	-
Naphthalene	419.63	4.2E+04	7.7E+03	7.5E+03	7.5E+03	7.7E+03	7.5E+03	-	2.0E-01	5.2E+01	7.9E+00	-	-
Phenanthrene	80.26	8.0E+03	2.1E+01	2.0E+01	3.6E+01	1.7E+01	1.6E+01	-	-	-	-	-	-
Phenol	8.40	8.4E+02	7.3E+02	7.3E+02	7.0E+02	7.3E+02	7.3E+02	-	2.3E-01	2.0E+01	5.8E+00	-	-
Polychlorinated biphenyls	4.23	4.2E+02	6.2E-01	6.2E-01	1.4E+00	4.8E-01	4.8E-01	-	-	-	-	-	-
Pyrene	45.73	4.6E+03	1.6E+01	1.6E+01	2.5E+01	1.4E+01	1.4E+01	-	-	-	-	-	-
Toluene	48.26	4.8E+03	2.5E+03	2.5E+03	2.4E+03	2.5E+03	2.5E+03	-	6.0E+00	7.5E+02	3.7E+01	-	-
Total mercury (methyl mercury for air emissions)	35.85	3.6E+03	9.2E+00	9.2E+00	1.6E+01	7.5E+00	7.5E+00	-	-	-	3.0E-03	-	-
Trichlorobenzenes	181.25	1.8E+04	5.2E+02	5.1E+02	5.4E+02	5.1E+02	4.9E+02	-	-	-	3.7E+00	-	-
Xylene isomers (total)	211.91	2.1E+04	5.8E+03	5.6E+03	5.6E+03	5.8E+03	5.6E+03	-	2.7E+00	4.3E+02	4.3E+00	-	-

**ONONDAGA LAKE FEASIBILITY STUDY
APPENDIX L**

ATTACHMENT A PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 2

SMU (Insert Value: 1 through 7): 1
Selected Dredge Cut (Insert Value e.g. "0-1", "0-0-8")
Select Maximum ("M") or Average ("A") Sediment
Alternative:

Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 84
Total dredge volume in cy: 4028000
Dredge cut in feet (either average or to max con 26
Post-dredge water depth (either average or to max 35

Dredging Characteristics

Dredge type: Hydraulic
Dredge size (inch): 14
Production rate in cy/hr: 150
Resuspension rate (%): 0.01
Dredging duration in hours: 26853.3333
Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
Specific gravity: 2.36
TOC: 0.02
In Situ Sediment Density (% solids by weight) 0.41
DOC (mg/L) 6

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr) 191,029
% volatilized during mixing 80.0
% volatilized after 40 days of curing 100.0
Area of Mixing Pad (acres) 1
Area of Mixing Pad (m2) 4,047

Based on dredging production rate and an avg specific gravity for all SMU sediments

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres) 51
Area of Lagoon (m2) 206,390

Insert acreage associated with Lakewide Alternative

Avg Sed Specific gravity 2.5

Dredging-Area as a CSTR with Dredging and Effluent Discharge

Analyte	Average concentration of dredged material in mg/kg	Avg. SMU Water Column Concentration with 1 Dredge & Primary SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & Enhanced Primary SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & EP + MMF SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & Advanced SCA Effluent (ug/L)	
		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Total suspended solids		8		0		0		0	
Benzene	18.34	0.118	0.118	0.093	0.093	0.093	0.093	0.007	0.007
Benzo[a]pyrene	6.00	0.002	0.002	0.002	0.002	0.002	0.000	0.002	0.000
Chlorobenzene	163.58	0.657	0.657	0.657	0.657	0.657	0.657	0.058	0.058
Dichlorobenzenes (sum) (1,4 Dichlorobenzene f	276.12	0.452	0.452	0.303	0.303	0.292	0.292	0.097	0.097
Ethylbenzene	13.30	0.049	0.049	0.012	0.012	0.011	0.011	0.007	0.007
Fluorene	39.69	0.023	0.023	0.014	0.014	0.014	0.014	0.014	0.014
Hexachlorobenzenes	0.51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Naphthalene	419.63	0.690	0.689	0.483	0.483	0.483	0.483	0.184	0.184
Phenanthrene	80.26	0.029	0.029	0.029	0.029	0.028	0.028	0.028	0.028
Phenol	8.40	0.056	0.056	0.036	0.036	0.026	0.026	0.009	0.009
Polychlorinated biphenyls	4.23	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Pyrene	45.73	0.017	0.017	0.017	0.017	0.016	0.016	0.016	0.016
Toluene	48.26	0.195	0.195	0.145	0.145	0.135	0.135	0.017	0.017
Total mercury (methyl mercury for air emissions)	35.85	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Trichlorobenzenes	181.25	0.100	0.100	0.094	0.094	0.083	0.083	0.068	0.068
Xylene isomers (total)	211.91	0.480	0.480	0.476	0.476	0.476	0.476	0.076	0.076

ATTACHMENT A

PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 3

SMU (Insert Value: 1 through 7): 1
Selected Dredge Cut (Insert Value e.g. "0-1", "C 0-8")
Select Maximum ("M") or Average ("A") Sediment

Alternative:

Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 84
Total dredge volume in cy: 4028000
Dredge cut in feet (either average or to max cor): 26.3
Post-dredge water depth (either average or to r): 22.15

Dredging Characteristics

Dredge type: Hydraulic
Dredge size (inch): 14
Production rate in cy/hr: 150
Resuspension rate (%): 0.01
Dredging duration in hours: 26853.3333
Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
Specific gravity: 2.36
TOC: 0.02
In Situ Sediment Density (% solids by weight): 0.41
DOC (mg/L): 6

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr): 191,029
% volatilized during mixing: 80.0
% volatilized after 40 days of curing: 100.0
Area of Mixing Pad (acres): 1
Area of Mixing Pad (m2): 4,047

Based on dredging production rate and an avg specific gravity for all SMU sediments

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres): 26
Area of Lagoon (m2): 105,218

Insert acreage associated with Lakewide Alternative

Avg Sed Specific gravity: 2.5

Point of Dredging Impacts - Hydraulic Cutterhead or Clamshell Dredge

Analyte	Sediment concentration of dredged material in mg/kg	Partitioning Coefficients		Average Total Water Quality Constituent Concentration in ug/L		Average Dissolved Water Quality Constituent Concentration in ug/L		Predicted Air Concentration in mg/m ³		Reference Values			Short-term Risk		Odor "HQ" = Air Concentration/Odor Threshold	
		Koc (mL/g)*	Kd (mL/g)	Around Dredge (1)	Over Dredging Area in SMU	Around Dredge (1)	Over Dredging Area in SMU	Worker	Short-term Residential	Res. and Worker	Worker	Max 1-hr Residential	Worker	Residential	Worker	Residential
Total suspended solids (mg/L)				11.862	0.548											
Benzene	3.23	100		0.038	0.002	0.038	0.002	1.0E-06	1.7E-06	1.9E+02	3.2E+00	1.3E+00	3.3E-07	1.3E-06	5.4E-09	8.9E-09
Benz[a]pyrene	0.85	1,096,478		0.010	0.000	0.010	0.000	1.6E-08	2.7E-08	-	-	-	-	-	-	-
Chlorobenzene	11.64	500		0.138	0.006	0.138	0.006	3.5E-06	5.7E-06	6.0E+00	3.5E+02	-	9.9E-09	-	5.8E-07	9.6E-07
Dichlorobenzenes (sum) (1,4 Dichlorobenzene	20.74	2,399		0.246	0.011	0.246	0.011	2.8E-06	4.7E-06	7.0E-01	-	3.0E+01	-	1.6E-07	4.0E-06	6.7E-06
Ethylbenzene	3.85	588		0.046	0.002	0.046	0.002	1.2E-06	1.9E-06	-	4.3E+02	5.4E+01	2.7E-09	3.6E-08	-	-
Fluorene	5.30	15,136		0.063	0.003	0.063	0.003	1.3E-06	2.1E-06	-	-	-	-	-	-	-
Hexachlorobenzenes	0.14	1,513,561		0.002	0.000	0.002	0.000	3.2E-08	5.4E-08	-	-	-	-	-	-	-
Naphthalene	87.26	2,344		1.035	0.048	1.035	0.048	2.5E-05	4.1E-05	2.0E-01	5.2E+01	7.9E+00	4.7E-07	5.2E-06	1.2E-04	2.0E-04
Phenanthrene	7.47	342,748		0.089	0.004	0.086	0.004	1.9E-06	3.2E-06	-	-	-	-	-	-	-
Phenol	3.39	100		0.040	0.002	0.040	0.002	6.2E-08	1.0E-07	2.3E-01	2.0E+01	5.8E+00	3.1E-09	1.8E-08	2.7E-07	4.4E-07
Polychlorinated biphenyls	0.72	1,380,384		0.009	0.000	0.008	0.000	-	-	-	-	-	-	-	-	-
Pyrene	2.88	208,930		0.034	0.002	0.033	0.002	3.3E-07	5.5E-07	-	-	-	-	-	-	-
Toluene	8.39	490		0.100	0.005	0.100	0.005	2.6E-06	4.4E-06	6.0E+00	7.5E+02	3.7E+01	3.5E-09	1.2E-07	4.4E-07	7.3E-07
Total mercury (methyl mercury for air emissions)	9.36	348,050	6,961	0.111	0.005	0.108	0.005	4.3E-13	7.1E-13	-	-	3.0E-03	-	2.4E-10	-	-
Trichlorobenzenes	5.79	18,197		0.069	0.003	0.068	0.003	1.5E-06	2.5E-06	-	-	3.7E+00	-	6.8E-07	-	-
Xylene isomers (total)	54.53	1,413		0.647	0.030	0.647	0.030	1.6E-05	2.7E-05	2.7E+00	4.3E+02	4.3E+00	3.8E-08	6.3E-06	6.1E-06	1.0E-05

* An equivalent Koc was computed for metal constituents using the relationship (Koc)equivalent = Kd/foc

ATTACHMENT A

PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 3

SMU (Insert Value: 1 through 7): 1
Selected Dredge Cut (Insert Value e.g., "0-1", "C 0-8")
Select Maximum ("M") or Average ("A") Sediment A

Alternative:

Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 84
Total dredge volume in cy: 4028000
Dredge cut in feet (either average or to max cor): 26.3
Post-dredge water depth (either average or to r): 22.15

Dredging Characteristics

Dredge type: Hydraulic
Dredge size (inch): 14
Production rate in cy/hr: 150
Resuspension rate (%): 0.01
Dredging duration in hours: 26853.3333
Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
Specific gravity: 2.36
TOC: 0.02
In Situ Sediment Density (% solids by weight): 0.41
DOC (mg/L): 6

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr): 191,029
% volatilized during mixing: 80.0
% volatilized after 40 days of curing: 100.0
Area of Mixing Pad (acres): 1
Area of Mixing Pad (m2): 4,047

Based on dredging production rate and an avg specific gravity for all SMU sediments

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres): 26
Area of Lagoon (m2): 105,218

Insert acreage associated with Lakewide Alternative

Avg Sed Specific gravity: 2.5

Analyte	Average concentration of dredged material in mg/kg	Average Total Water Quality Constituent Concentration in ug/L			Average Dissolved Water Quality Constituent Concentration in ug/L			Predicted Air Concentration in mg/m ³	Reference Values			Short-term Risk	Air Concentration / Odor
		Influent	Supernatant	Supernatant after Volatilization	Influent	Supernatant	Supernatant after Volatilization		Res. and Worker	Worker	Max 1-hr Residential	Residential	Residential
							Highest 1-Hour Concentration Outside SCA perimeter (AERMOD)	Odor Threshold (mg/m ³)	OSHA Threshold (mg/m ³)	NY SGC (mg/m ³)	HQ-1	1-Hr	
Total suspended solids		100,000	100	100									
Benzene	3.23	3.2E+02	2.8E+02	2.7E+02	2.7E+02	2.8E+02	2.7E+02	2.3E-02	1.9E+02	3.2E+00	1.3E+00	1.7E-02	1.2E-04
Benzo[a]pyrene	0.85	8.5E+01	1.3E+01	1.3E-01	2.9E-01	1.0E-01	1.0E-01	7.8E-07	-	-	-	-	-
Chlorobenzene	11.64	1.2E+03	6.1E+02	5.9E+02	5.8E+02	6.1E+02	5.9E+02	4.5E-02	6.0E+00	3.5E+02	-	-	7.5E-03
Dichlorobenzenes (sum) (1,4 Dichlorobenzene	20.74	2.1E+03	3.7E+02	3.7E+02	3.6E+02	3.7E+02	3.7E+02	1.3E-02	7.0E-01	-	3.0E+01	4.2E-04	1.8E-02
Ethylbenzene	3.85	3.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.4E-02	-	4.3E+02	5.4E+01	2.6E-04	-
Fluorene	5.30	5.3E+02	1.8E+01	1.8E+01	1.8E+01	1.8E+01	1.7E+01	1.1E-03	-	-	-	-	-
Hexachlorobenzenes	0.14	1.4E+01	2.1E-02	2.0E-02	4.8E-02	1.6E-02	1.5E-02	1.9E-06	-	-	-	-	-
Naphthalene	87.26	8.7E+03	1.6E+03	1.6E+03	1.6E+03	1.6E+03	1.6E+03	1.1E-01	2.0E-01	5.2E+01	7.9E+00	1.4E-02	5.6E-01
Phenanthrene	7.47	7.5E+02	1.9E+00	1.9E+00	3.3E+00	1.6E+00	1.5E+00	1.6E-04	-	-	-	-	-
Phenol	3.39	3.4E+02	3.0E+02	2.9E+02	2.8E+02	3.0E+02	2.9E+02	1.1E-03	2.3E-01	2.0E+01	5.8E+00	1.8E-04	4.6E-03
Polychlorinated biphenyls	0.72	7.2E+01	1.1E+01	1.1E-01	2.4E-01	8.1E-02	8.1E-02	-	-	-	-	-	-
Pyrene	2.88	2.9E+02	1.0E+00	1.0E+00	1.5E+00	8.7E-01	8.5E-01	3.1E-05	-	-	-	-	-
Toluene	8.39	8.4E+02	4.4E+02	4.3E+02	4.2E+02	4.4E+02	4.3E+02	3.4E-02	6.0E+00	7.5E+02	3.7E+01	9.3E-04	5.7E-03
Total mercury (methyl mercury for air emissions)	9.36	9.4E+02	2.4E+00	2.4E+00	4.1E+00	2.0E+00	2.0E+00	1.4E-08	-	-	3.0E-03	4.8E-06	-
Trichlorobenzenes	5.79	5.8E+02	1.7E+01	1.6E+01	1.7E+01	1.6E+01	1.6E+01	1.1E-03	-	-	3.7E+00	3.0E-04	-
Xylene isomers (total)	54.53	5.5E+03	1.5E+03	1.4E+03	1.4E+03	1.5E+03	1.4E+03	1.1E-01	2.7E+00	4.3E+02	4.3E+00	2.6E-02	4.1E-02

ATTACHMENT A

PREDICTED WATER AND AIR QUALITY IMPACTS ASSOCIATED WITH DREDGING - WORKBOOK 3

SMU (Insert Value: 1 through 7): 1
Selected Dredge Cut (Insert Value e.g. "0-1", "C 0-8"
Select Maximum ("M") or Average ("A") Sediment A

Alternative:
Notes: Average concentration in dredge cut

Site Characteristics

Area of dredge site within SMU in acres: 84
Total dredge volume in cy: 4028000
Dredge cut in feet (either average or to max cor): 26.3
Post-dredge water depth (either average or to r): 22.15

Dredging Characteristics

Dredge type: Hydraulic
Dredge size (inch): 14
Production rate in cy/hr: 150
Resuspension rate (%): 0.01
Dredging duration in hours: 26853.3333
Diameter in feet around dredge head to evaluate water quality (1): 100

Sediment Physical Characteristics

Percent fines: 0.92
Specific gravity: 2.36
TOC: 0.02
In Situ Sediment Density (% solids by weight): 0.41
DOC (mg/L): 6

Mechanical Dredging Sediment Handling and Disposal Characteristics

Feedrate (kg/hr): 191,029
% volatilized during mixing: 80.0
% volatilized after 40 days of curing: 100.0
Area of Mixing Pad (acres): 1
Area of Mixing Pad (m2): 4,047

Based on dredging production rate and an avg specific gravity for all SMU sediments

Hydraulic Dredging Sediment Handling and SCA (Lagoon) Characteristics

Area of Lagoon (acres): 26
Area of Lagoon (m2): 105,218

Insert acreage associated with Lakewide Alternative

Avg Sed Specific gravity: 2.5

Dredging-Area as a CSTR with Dredging and Effluent Discharge

Analyte	Average concentration of dredged material in mg/kg	Avg. SMU Water Column Concentration with 1 Dredge & Primary SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & Enhanced Primary SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & EP + MMF SCA Effluent (ug/L)		Avg. SMU Water Column Concentration with 1 Dredge & Advanced SCA Effluent (ug/L)	
		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Total suspended solids		12		1		1		1	
Benzene	3.23	0.033	0.033	0.026	0.026	0.026	0.026	0.002	0.002
Benzo[a]pyrene	0.85	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chlorobenzene	11.64	0.074	0.074	0.074	0.074	0.074	0.074	0.006	0.006
Dichlorobenzenes (sum) (1,4 Dichlorobenzene	20.74	0.054	0.054	0.036	0.036	0.035	0.035	0.012	0.012
Ethylbenzene	3.85	0.023	0.023	0.005	0.005	0.005	0.005	0.003	0.003
Fluorene	5.30	0.005	0.005	0.003	0.003	0.003	0.003	0.003	0.003
Hexachlorobenzenes	0.14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Naphthalene	87.26	0.227	0.226	0.159	0.159	0.159	0.159	0.060	0.060
Phenanthrene	7.47	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Phenol	3.39	0.035	0.035	0.023	0.023	0.017	0.017	0.006	0.006
Polychlorinated biphenyls	0.72	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pyrene	2.88	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Toluene	8.39	0.054	0.054	0.040	0.040	0.037	0.037	0.005	0.005
Total mercury (methyl mercury for air emissions)	9.36	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Trichlorobenzenes	5.79	0.005	0.005	0.005	0.005	0.004	0.004	0.003	0.003
Xylene isomers (total)	54.53	0.195	0.195	0.194	0.194	0.194	0.194	0.031	0.031