Phase 1 Intermediate Design Report Hudson River PCBs Superfund Site

Attachments

General Electric Company
Albany, New York

August 22, 2005

BBL
BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

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Attachment A – Phase 1 Intermediate Design Remedial Action Monitoring Plan Scope

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Attachment A - Phase 1 Intermediate Design

Remedial Action Monitoring Scope

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1. Introduction

This *Phase 1 Intermediate Design Remedial Action Monitoring Scope* (Phase 1 ID RA Monitoring Scope [Attachment A]) describes the environmental monitoring program that General Electric Company (GE) will carry out during the performance of Phase 1 of the Remedial Action (RA) for the Upper Hudson River to implement, and assess attainment of the criteria set forth in, the Engineering Performance Standards (EPS), the Quality of Life Performance Standards (QoLPS), and substantive water quality requirements (WQ requirements) issued by the United States Environmental Protection Agency (EPA) for Phase 1. The EPS consists of: 1) the Resuspension Performance Standard, 2) the Residuals Performance Standard, and 3) the Productivity Performance Standard, and are set out in a five-volume document titled *Hudson River PCBs Superfund Site Engineering Performance Standards (Hudson EPS)*, issued by EPA in April 2004 (EPA, 2004a).

The QoLPS consist of performance standards governing: 1) air quality, 2) odor, 3) noise, 4) lighting, and 5) navigation, and are set out in a document titled *Hudson River PCBs Superfund Site Quality of Life Performance Standards (Hudson QoLPS)*, issued by EPA in May 2004 (EPA, 2004b).

The WQ requirements consist of: 1) requirements relating to in-river releases of constituents not subject to EPS, as set forth in *Substantive Requirements Applicable to Releases of Constituents not Subject to Performance Standards*; 2) the substantive requirements for discharges to the Hudson River and Champlain Canal, as set forth in *Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharges to Champlain Canal (land cut above Lock 7)*; and 3) *Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharge to the Hudson River.* These three sets of requirements are contained in a single document in the form of a letter to GE with enclosures that EPA issued on January 7, 2005.

This Phase 1 ID RA Monitoring Scope will form the basis for the *Phase 1Environmental Monitoring Plan* (Phase 1 EMP), which will accompany the *Phase 1 Final Design Report* (Phase 1 FDR), and the *Phase 1 Remedial Action Monitoring Quality Assurance Project Plan* (Phase 1 RAM QAPP) to be prepared in accordance with Section 4 of the *Phase 1 Intermediate Design Report* (Phase 1 IDR). The Phase 1 EMP and Phase 1 RAM QAPP will be consistent with this Phase 1 ID RA Monitoring Scope.

This Phase 1 ID RA Monitoring Scope will also form the basis for the Phase 2 EMP to be submitted in conjunction with the *Phase 2 Final Design Report*.

This Phase 1 ID RA Monitoring Scope is organized to cover each of the following major data acquisition programs:

- Water column and fish monitoring;
- Sediment residuals monitoring;
- Air quality and odor monitoring;
- Noise monitoring;
- Lighting monitoring;
- Water discharge monitoring; and
- Special studies.

Collectively, this monitoring program will be referred to as the Remedial Action Monitoring Program (RAMP). The RAMP will replace the Baseline Monitoring Program (BMP; QEA, 2003; QEA and ESI, 2004) during the RA.

The RAMP will not address the standard for navigation, which is included in the QoLPS, since no environmental monitoring requirements pertain to the navigation standard. The activities relating to implementation of the navigation standard will be described in detail in the design documents, the *Remedial Action Community Health and Safety Plan* (Phase 1 RA CHASP), and the *Phase 1 Performance Standards Compliance Plan* (Phase 1 PSCP) to be provided as part of the *Remedial Action Work Plan for Phase 1 Dredging and Facility Operations* (Phase 1 RA Work Plan). Scopes for the Phase 1 RA CHASP and the Phase 1 PSCP are attached to the Phase 1 IDR as Attachments B and C, respectively.

2. Water Column and Fish Monitoring

This section describes the Water Column Monitoring Program that will be carried out in Phase 1 of the Remedial Action to implement the Engineering Performance Standard for Dredging Resuspension (the Resuspension Standard) and the WQ requirements for in-river releases of constituents not subject to performance standards. This section also describes the Fish Monitoring Program that will be performed during Phase 1 of the Remedial Action.

2.1 Objectives, Criteria, and Parameters Subject to Monitoring

2.1.1 Resuspension Standard

The objectives of the Resuspension Standard (as stated in *Hudson EPS*, Volume 1, p. 37) are to:

- Maintain polychlorinated biphenyl (PCB) concentrations in the water column at or below the federal drinking water Maximum Contaminant Level (MCL) of 500 ng/L to protect downstream municipal intakes;

- Minimize the release of PCBs from sediment during remedial dredging; and

- Minimize the export of PCBs to downstream areas, including the Lower Hudson.

The EPA has designated threshold criteria to trigger contingency monitoring and engineering evaluation and controls to reduce the release of PCBs from dredge areas so that the objectives are met. There are three levels of such criteria – known as the Evaluation Level, Control Level, and Resuspension Standard Threshold Level (the Standard Level). These criteria are applied at near-field stations, located within 300 meters (m) of the dredging activities, and at far-field stations, located more than 1 mile downstream of the dredging activity. The applicable criteria are summarized in Table 2-1 of Volume 1 of the EPS and are as follows (specified separately for near-field and far-field stations):

Near-Field Criteria

Evaluation Level

Under the *Hudson EPS* (Section 4.1.1 Volume 2, pp. 87-92), the Evaluation Level would be exceeded if any of the following conditions occurs:

- "The sustained suspended solids concentration above ambient conditions at a location 300 m downstream (i.e., near-field monitoring) of the dredging operation or 150 m downstream from any suspended solids control measure (e.g., silt curtain) exceeds 100 mg/L for River Sections 1 and 3 and 60 mg/L for River Section 2. To exceed this criterion, this condition must exist on average for six hours or for the daily dredging period (whichever is shorter). Suspended solids are measured continuously by surrogate or every three hours by discrete samples."

- "The sustained suspended solids concentration above ambient conditions at the near-field side channel station or the 100 m downstream station exceeds 700 mg/L. To exceed this criterion, this condition must exist for more than three hours on average measured continuously or a confirmed occurrence of a concentration greater than 700 mg/L when suspended solids are measured every three hours by discrete samples."

Control Level

Under the *Hudson EPS* (Section 4.1.2 Volume 2, pp. 93-95), the Control Level would be exceeded if any of the following conditions occurs:

- "The sustained suspended solids concentration above ambient conditions at a location 300 meters downstream (i.e., near-field monitoring) of the dredging operation or 150 meters downstream from any suspended solids control measure (e.g., silt curtain) exceeds 100 mg/L for River Sections 1 and 3 and 60 mg/L for River Section 2. To exceed this criterion, this condition must exist for a period corresponding to the daily dredging period (6 hours or longer) or 24 hours if the operation runs continuously (whichever is shorter) on average. Suspended solids are measured continuously by surrogate or every three hours by discrete samples."

Far-Field Criteria

<u>Evaluation Level</u>

Under the *Hudson EPS* (Section 4.1.1 Volume 2, pp. 87-92), the Evaluation Level would be exceeded if any of the following conditions occurs:

- "The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 300 g/day for a seven-day running average."
- "The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 100 g/day for a seven-day running average."
- "The sustained suspended solids concentration above ambient conditions at a far-field station exceeds 12 mg/L. To exceed this criterion, this condition must exist on average for 6 hours or a period corresponding to the daily dredging period (whichever is shorter). Suspended solids are measured continuously by turbidity (or an alternate surrogate) or every three hours by discrete samples."

<u>Control Level</u>

Under the *Hudson EPS* (Section 4.1.2 Volume 2, pp. 93-95), the Control Level would be exceeded if any of the following conditions occurs:

- "The Total PCB concentration during dredging-related activities at any downstream far-field monitoring station exceeds 350 ng/L for a seven-day running average."
- "The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 600 g/day on average over a seven-day period."
- "The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 200 g/day on average over a seven-day period."
- ""The net increase in PCB mass transport due to dredging-related activities measured at the downstream far-field monitoring stations exceeds 65 kg/year Total PCBs or 22 kg/year Tri+ PCBs."

- "The sustained suspended solids concentration above ambient conditions at a far-field station exceeds 24 mg/L. To exceed this criterion, this condition must exist for a period corresponding to the daily dredging period (six hours or longer) or 24 hours if the operation runs continuously (whichever is shorter) on average. Suspended solids are measured continuously by surrogate or every three hours by discrete samples."

<u>Standard Level</u>

Under the *Hudson EPS* (Section 4.1.3 Volume 2, p. 98), the Standard Level is "a confirmed occurrence of 500 ng/L Total PCBs, measured at any main stem far-field station. To exceed the standard threshold, an initial result greater than or equal to 500 ng/L Total PCBs must be confirmed by the average concentration of four samples collected within 48 hours of the first sample. The standard threshold does not apply to far-field station measurements if the station is within one mile of the remediation."

2.1.2 WQ Requirements

The EPA, in consultation with the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH), has specified water quality standards for a number of constituents that are not subject to the EPS and that will be monitored for compliance during Phase 1 of the Remedial Action. The objectives of these WQ requirements are:

- Protection of aquatic species via Aquatic Acute standards;
- Protection of drinking water supplies via Health (Water Source) standards; and
- Protection of drinking water supplies via New York State Department of Health (NYSDOH) action levels.

Aquatic Acute Water Quality Standards at Near-Field Stations

The *WQC Substantive Requirements* (pp. 1 & 2) set forth the following standards for near-field stations:

- "Aquatic standards (some of which are hardness-dependent) apply to the dissolved form. Hardness varies along the length of the project area and will result in a range of calculated standards. For example, based on limited available data, average hardness values from Corinth and Waterford range from 18 ppm to 55 ppm respectively. The resulting ranges of water quality standards are as follows (where applicable, the formulas for calculating the standards are in brackets):

- cadmium – Aquatic Acute A(A): 0.6 µg/L to 2.0 µg/L [(0.85) exp(1.128[ln (ppm hardness)] – 3.6867)].
- lead – Aquatic Acute A(A): 14.4 µg/L to 50.4 µg/L [{1.46203 – [ln (hardness) (0.145712)]} exp (1.273 [ln (hardness)] – 1.052)].
- chromium – Aquatic Acute A(A): 140 µg/L to 349 µg/L [(0.316) exp (0.819 ln (ppm hardness)) + 3.7256)].
- chromium (hexavalent) – Aquatic Acute A(A): 16 µg/L.
- mercury – Aquatic Acute A(A): 1.4 µg/L."

- "Water quality standards for pH and dissolved oxygen are specified in NYCRR Title 6, Chapter X, Part 703.3.
  - pH will not be less than 6.5 or more than 8.5.
  - Dissolved oxygen for non-trout waters:
    - The minimum daily average will not be less than 5.0 mg/L.
    - At no time will the dissolved oxygen concentration be less than 4.0 mg/L."

Based on review of the historical data, routine monitoring for compliance with the foregoing Aquatic Acute standards for dissolved metals will be limited to analyses for dissolved cadmium and lead, with total cadmium and lead analyses performed as well. It is expected that the monitoring of lead and cadmium should adequately represent the metals associated with sediment resuspension. The EPA, GE, and NYSDEC will evaluate whether mercury and chromium concentrations are adequately represented by lead and cadmium concentrations based on the BMP data, Treatability Study data, any additional sediment data that become available, and/or water column data collected during Phase 1. Based on evaluation of these data, these monitoring requirements may be modified upon agreement of EPA (after consultation with NYSDEC) and GE. Analytical results will be reported for the entire target analyte list (TAL) of metals that are analyzed by EPA Method 200.8 (which exclude mercury and hexavalent chromium, which are analyzed by separate methods – see Section 2.4.4). As discussed further in Section 2.4.4, if monitoring indicates that the dissolved cadmium and/or lead concentrations exceed the above standards, samples will be collected and analyzed (in both dissolved and total form) for the entire suite of metals subject to the Aquatic Acute standards. If, during in-water activities, distressed or dying fish are observed, increased monitoring will be conducted for metals and additional water quality parameters, where appropriate, in accordance with the Phase 1 ID PSCP Scope (Section 7.5) and WQ Substantive Requirements (p.9).

Health (Water Source) Standards at Far-Field Stations

The *WQ Requirements* (p. 2) set forth the following Health (Water Source) standards for cadmium, chromium, and mercury and the following action level for lead. These standards and action levels are based on total form and are not hardness-dependent, and they are not to be exceeded at any of the Schuylerville, Stillwater, or Waterford far-field stations.

- Cadmium (total): 5.0 µg/L.
- Chromium (total): 50 µg/L.
- Mercury (total): 0.7 µg/L.
- Lead (total): 15.0 µg/L (NYSDOH action level).

In addition, the WQ requirements incorporate the NYSDOH's trigger level of 10 µg/L total lead for two far-field stations (Stillwater and Waterford) to protect water suppliers and the public, and state that if that trigger level is exceeded, certain notification and/or response actions must be taken, as described in the Phase 1 PSCP and its Phase 1 IDR Scope.

Determination of an exceedance of the above standards and action level requires a "confirmed occurrence" – i.e., four subsequent samples exceeding the standard/action level, each representing a 6-hour composite, as specified in the *WQ Substantive Requirements* (p. 7).

Based on review of the historical data, routine monitoring for compliance with the foregoing standards and action/trigger levels will be limited to analyses for total cadmium and lead, with dissolved cadmium and lead analyses performed as well. It is expected that the monitoring of lead and cadmium should adequately represent the metals associated with sediment resuspension. EPA, GE, and NYSDEC will evaluate whether mercury and chromium concentrations are adequately represented by lead and cadmium concentrations based on the BMP data, Treatability Study data, any additional sediment data that become available, and/or water column data collected during Phase 1. Based on evaluation of these data, these monitoring requirements may be modified upon agreement of EPA (after consultation with NYSDEC) and GE. Analytical results will be reported for all TAL metals that are analyzed by EPA Method 200.8 (i.e., excluding mercury and hexavalent chromium, which are analyzed by separate methods – see Section 2.4.4). As discussed further in Section 2.4.4, if monitoring indicates that the total cadmium concentration exceeds the cadmium standard or that the total lead concentration exceeds the lead action or trigger level, Samples will be collected and analyzed (in both dissolved and total form) for the entire suite of metals subject to the Health (Water Source) standards. If, during in-water activities, distressed or dying fish are observed, increased monitoring will be conducted for metals and additional water quality parameters, where appropriate, in accordance with the Phase 1 ID PSCP Scope (Section 7.5) and WQ Substantive Requirements (p.9).

2.2 Monitoring Locations and Frequency

Near-field and far-field monitoring locations will be sampled and frequency specified in the *Hudson EPS* Volume 2, Sections 4.2.4, 4.2.5 and 4.2.6, except for modifications approved by EPA and documented herein.

Monitoring will be required for at least the remedial operations listed below. Other operations related to dredging may be included as well (*Hudson EPS* Volume 2 p. 102):

- Dredging;
- Debris removal;
- Resuspension control equipment removal;
- Cap placement;
- Backfill placement;
- Installation of containment devices other than silt curtains (sheet piling and other structural devices requiring heavy equipment operation and disturbance of the river bottom); and
- Shoreline excavation and restoration.

The following remedial operation will not require near-field monitoring:

- Silt curtain placement; and
- Off loading to the processing facility.

2.2.1 Near-Field Monitoring

The locations specified in the *Hudson EPS* (Volume 2, Section 4.2.4.2) will be monitored. Near-field monitoring locations are associated with individual remedial operations and move as the operation moves. Each remedial operation requires five monitoring locations. The locations of the near-field stations are dictated by the near-field criteria. A single background station will be located about 100 m upstream of the dredging activity on the centerline of flow through the area of dredging activity to provide water quality data for the water entering the dredging area. To monitor for resuspension caused by workboats, a single station will be placed adjacent to the dredging activity, in the side channel downstream of the principal location of boat and barge activity supporting the dredging activity. The side channel station will be located reasonably close to workboat activity (approximately 10 m away from the dredging operation), subject to the safety procedures described in the project *Health and Safety Plan* (HASP) (BBL, 2003). Three stations will be placed downstream of the dredging operation in an approximately triangular distribution to provide reasonable assurance that a resuspension plume will not escape the near-field undetected. The station nearest the dredging activity (100 m downstream of the activity or 50 m downstream of the most exterior resuspension control system) will be located along the estimated centerline of flow from the dredging activity. This will be defined as a line beginning at the location of the dredge and running parallel to the centerline of flow. The two stations further downstream will be located to either side of the centerline along a cross-flow transect spaced as appropriate to monitor the plume. These stations will be located approximately 300 m downstream of the dredging operation or 150 m downstream of the most exterior downstream resuspension barrier. The location of the three downstream stations will be assessed daily to maintain their position relative to the centerline of flow through the dredging activities. A boat-mounted Acoustic Doppler Current Profiler (ADCP) or continuous turbidity probe will be used to assess the location of any observable plume to ensure that these downstream compliance stations are located within the plume. In the event that a dredging area is isolated by a resuspension control barrier, a sixth monitoring location will be added within the control barrier. The distances from the remedial operations are approximate and the location of the near-field stations may be changed in the field to better capture the plume, if EPA approves the change.

If remedial operations are located in close proximity to one another, it may not be feasible to maintain all of the locations since there may be safety concerns or the stations may be within the working area for another operation. In such cases, monitoring locations may need to be dropped. The requirements for reduction in the near-field monitoring locations will be followed, specified in the *Hudson EPS* Volume 2, Section 4.2.5. Decisions to drop locations must be documented in the weekly reports.

The near-field monitoring stations will consist of an easily movable device such as a buoy or a mobile platform (e.g., a small pontoon boat) that can be anchored in place. On-board instrumentation will include continuous water column monitoring probes, global positioning system (GPS), navigational lighting, radio communications, and their associated power sources. Additional equipment, such as automated sampling systems, meteorological stations, and other monitoring equipment, will be included on select near-field stations as necessary.

Near-field monitoring will be sufficiently frequent to detect a dredging release with a minimum duration of 1 hour (the minimum number of sub-samples will be identified in the Phase 1 RAM QAPP). To meet this requirement, continuous monitoring will be performed for dissolved oxygen (DO), conductivity, temperature, pH, and turbidity (or other surrogate) at all near-field stations. Each near-field station will have continuous monitoring for turbidity, temperature, and conductivity for one hour prior to beginning remedial operations and for at least two hours after the operation ceases (*Hudson EPS* Volume 2, page 116). This applies to the five stations required if there are no barriers installed and to all six stations if barriers are installed.

One total suspended solid (TSS) sample per station per day will be collected to confirm the surrogate relationship. The ability of the surrogate to adequately predict the suspended solids concentrations will be assessed on a daily basis. The criteria and method for assessing the surrogate relationship will be provided in the Phase 1 RAM QAPP and may differ from that provided in the *Hudson EPS* Volume 2 Section 4.4. If the turbidity (or other surrogate) measurements indicate that a TSS criterion has been exceeded, two TSS samples per day will be collected at the station with the exceedance until such time that the surrogate relationship is confirmed and the station is in compliance.

In the event that a suitable surrogate relationship is not sustainable, vertically-integrated samples will be collected every three hours and analyzed for suspended solids. One sample from each near-field station will be collected one-hour prior to beginning the remedial operations at a location. Corrective measures will be taken to update or change the surrogate relationship to bring it back within the performance metrics set in the Phase 1 RAM QAPP, which will be based on the results of the TSS surrogate study (QEA, 2005a). These measures may include the collection of laser particle size measurements (if applicable) and additional TSS samples, and the evaluation of the performance of automated sampling equipment (if used) and turbidity probes.

Depending on the results of the TSS Surrogate Study, discrete laser particle counters may be used for suspended solids analysis. At both the near-field and far-field stations, pH and DO will be monitored discretely each time a sample is collected (*Hudson EPS* Volume 2, p. 117).

WQ samples for hardness and dissolved and total metals will be collected from the upstream background station and the two stations located 300 m downstream of dredging operations if no resuspension barriers are used or approximately 150 m downstream if resuspension barriers are used. These samples will be collected using an automated sampling system (ISCO or equivalent) from a single, conservative monitoring depth (i.e., at ~ 75% of the water column depth or a minimum of 2 feet off the bottom), as described in Section 2.3.1. The vertical location of the intake may be adjusted based on information gathered during Phase 1. Sample aliquots will be collected at a frequency that is appropriate for the amount of sample required over the sampling period, consistent with the capabilities of the automated sampling equipment. Given that the representativeness of samples will increase as the frequency of collection of sample aliquots increases, the capabilities of the automated samplers will be assessed prior to Phase 1, and the highest sample collection frequency that can be practically achieved on a routine basis will be used. The aliquots from each station will be integrated to form a single daily composite sample for each of the three monitoring stations under routine monitoring. If an automated sampler fails, a minimum of two discrete samples will be collected per station per day and composited; these discrete samples will be depth-integrated using the BMP sampling protocol.

If either of the downstream stations exceeds the WQ Acute Aquatic criteria, the sampling frequency will increase to four aliquots per hour and four composite samples per day at each station and sufficient volume of water will be collected to analyze for total and dissolved metals. If an automated sampler fails while in exceedance, a minimum of four discrete samples will be collected per station per day; these discrete samples will be depth-integrated using the BMP sampling protocol. This sampling frequency will be maintained until such time as the station is in compliance and the EPA has authorized a return to routine monitoring. After the first month, the sampling results will be evaluated and modifications to the monitoring program may be made based on the results of such evaluation subject to EPA approval in consultation with the NYSDEC.

2.2.2 Far-Field Monitoring

The far-field stations will coincide with the stations established for the BMP, except where such stations need to be relocated to accommodate automated sampling. A correction may need to be applied to the baseline data to properly determine compliance with the load-based resuspension criteria. The correction factor will be developed during baseline based on additional data collection and analysis (GE's baseline automated sampler study). The far-field stations include a background station at Bakers Falls and the following five Upper Hudson River stations that will be used to assess achievement of the applicable far-field criteria:

- Rogers Island (River Mile [RM] 194.2);

- Thompson Island (RM 187.5);
- Schuylerville (RM 181.4);
- Stillwater (RM 168.4); and
- Waterford (RM 156.0).

Two additional far-field stations will be located in the Lower Hudson River at Albany (RM 140) and Poughkeepsie (RM 77). A third station at the Mohawk River at Cohoes, which has historically shown low levels of PCB, will be monitored every month; EPA has approved this deviation from the EPS (i.e., contingency monitoring is not required), however, EPA may require higher frequency sampling during Phase 1, if warranted, at the Mohawk River station (e.g., concentrations are greater on average than measured during baseline).

GE is constructing and operating an automated sampling station at Lock 5 (RM 182.3) in 2005 on a pilot basis in accordance with the EPA approved *Scope of Work for Pilot Studies for Automated Near- and Far-Field Water Column Sampling* (QEA, 2005b). This automated station will replace the Schuylerville BMP station after appropriate testing is completed, subject to EPA approval. Automated samplers will also be used at the four remaining Upper Hudson River far-field sampling stations. The precise locations of those automated sampling stations will be determined following completion of the pilot studies, and construction and validation of those stations will be performed in 2006. Each station has been or will be constructed such that water can be automatically sampled from a number of locations along a cross-sectional transect and water quality parameters can be monitored continuously. Once the pilot study has been completed and the other automated stations have been constructed and tested, and EPA has reviewed the test data and approved use of the stations for the BMP, automated sampling techniques will replace manual BMP sampling protocols at these far-field locations. However, the capability to perform manual sampling at the routine monitoring frequency specified in the Resuspension Standard will be maintained, using the BMP sampling protocols, in the event that an automated station fails or is off-line for maintenance.

Monitoring for assessment of the far-field criteria will be conducted at the each downstream far-field station that is a minimum of 1 mile away from the dredging activity. The Thompson Island station will be the nearest representative downstream far-field station for the entire Phase 1 dredging program because this program will terminate at about RM 189.8. The Thompson Island station will serve as a compliance check point for near-field exceedances of TSS at the Evaluation and Control Levels (*Hudson EPS* Volume 2 p. 117, "Exceedance of the Near-Field Resuspension Criteria").

In the event that dredging occurs in more than one river section, effectively creating two nearest far-field stations, this standard is applied in the same manner to both stations. That is, the far-field concentration criteria apply to both stations equally. Given the various uncertainties in load estimation, no pro-rating of the standard for the upper station will be required, although GE could consider doing so, as needed. This means that any of the far-field stations can dictate response actions. In the event that dredging operations move to a location less than one mile upstream of a far-field monitoring point, the next downstream far-field station becomes the representative far-field station for the operation. The nearer far-field station will continue to be monitored at the routine level, not to judge compliance with the standard, but rather to provide data to allow comparison of the far-field station to the new far-field compliance station.

In addition, continuous particle counter measurements may be acquired at these stations if it is determined during the course of the TSS surrogate study (QEA, 2005a) that this technology provides information that will be useful for compliance monitoring. GE will submit recommendations to EPA for the adoption or abandonment of this technology along with the results of the TSS surrogate study.

Rogers Island will serve as the upstream far-field station that will be used to assess PCB load contributions originating upstream of the remediation area. The statistical criteria for this assessment will utilize those described in the *Hudson EPS* (Volume 2, Section 4.1.4.3) and will be included in the Phase 1 PSCP and Phase 1 RAM QAPP.

To provide upstream data for application of some of the resuspension criteria, weekly background samples will be collected at Bakers Falls for PCB, TSS, dissolved organic carbon (DOC), and particulate organic carbon (POC) analysis. These samples will be collected using the manual BMP sampling protocol and discrete measurements of water quality parameters (turbidity, temperature, pH, conductivity and DO) will be taken at the time of sample collection. The sampling frequency at Bakers Falls may be reduced to monthly, with EPA's approval, if the analysis of BMP sampling results indicates that this station has uniformly low PCB concentrations. Daily composite PCB, TSS, DOC, and POC samples will be collected at Rogers Island using the automated sampling system, with sample aliquots collected at a frequency that is appropriate for the amount of sample required over the sampling period, consistent with the capabilities of the automated sampling equipment, subject to EPA approval. Water quality parameters (turbidity, temperature, pH, and conductivity) will be monitored continuously at this station. DO will be measured along with each grab sample collected for suspended solids. A daily discrete sample will be collected for TSS for the purposes of confirming the TSS surrogate relationship. If it is determined that the surrogate relationship is not adequate, samples will be collected for suspended solids every 3 hours, 24 hours per day, with a maximum 24-hour turnaround time, but reasonable efforts will be utilized to reduce the 24-hour turnaround time. If manual sampling is conducted at Rogers Island due to a failure or maintenance of the automated sampling station, daily discrete samples will be collected using the manual BMP sampling protocol. As stated in the *Hudson EPS* (Volume 2, p. 112), the monitoring frequency at Rogers Island may be reduced to weekly, with EPA approval, for all parameters except TSS if the data will not be used to monitor for releases from upstream sources that could be interpreted as releases from the remediation.

Routine monitoring at each of the Thompson Island, Schuylerville, Stillwater, and Waterford stations will be conducted at a frequency sufficient (sub-sampling at once per half hour at a minimum) to verify that short-term (1 hour or more) elevated dredging-induced releases do not pass that far-field station undetected. To meet this requirement, continuous monitoring will be performed for DO, pH, conductivity, temperature, and turbidity. At the Thompson Island station, suspended solids will be continuously monitored with a turbidity monitor. TI Dam will have a surrogate relationship for suspended solids concentrations in place prior to Phase 1. A particle counter may also be used at the TI Dam station if it is determined during the TSS surrogate study that the technology provides useful data for compliance monitoring. If it is determined that the surrogate relationship does not provide a reasonable estimate of TSS, samples will be collected for suspended solids every 3 hours, 24 hours per day, with a maximum 24-hour turnaround time, but reasonable efforts will be utilized to reduce the 24-hour turnaround time. The turnaround time starts at sample receipt by the laboratory. Daily composite PCB, DOC, and POC samples will be collected at these stations under routine monitoring conditions. Modeling indicates that a 1-hour long dredging release that originates from the furthest downstream point of the Phase 1 areas in River Section 1 will result in elevating the concentrations of monitored parameters at the Thompson Island Station for several hours due to dispersion. Sample aliquots will be obtained at a frequency that is appropriate for the amount of sample required over the sampling period, consistent with the capabilities of the automated sampling equipment. Since the representativeness of samples will increase as the frequency of collection of sample aliquots increases, the capabilities of the automated samplers will be assessed prior to Phase 1, and the highest sample collection frequency that can be practically achieved on a routine basis will be used. These aliquots will be used to form 24-hour composites. This sampling frequency will ensure that multiple measurements will occur during the minimum release of interest. If manual sampling is conducted at Thompson Island or Schuylerville due to a failure or maintenance of the automated sampling station, the daily discrete sample will be collected with consideration of time of travel from dredging operations.

If the nearest representative down stream station exceeds the Evaluation Level criteria, the sampling frequency will increase to two 12-hour composite samples per day at Thompson Island and Schuylerville. If the compliance station exceeds the Control or Standard Level criteria, the sampling frequency will increase to three (8-hour) or four (6-hour) composite samples per day, respectively, at Thompson Island and Schuylerville. These increased sampling frequencies will be maintained until the stations are back in compliance as specified in Section 4.3 of the *Hudson EPS* (Reverting to Lower Action Levels) in some cases requiring EPA approval. If the Standard Level has been exceeded at the Thompson Island Dam station or Schuylerville station, the sample collection frequency at Stillwater and Waterford will increase to four composite samples per day and the appropriate, notification, and contingency measures will be implemented in accordance with the Phase 1 PSCP and Phase 1 RA CHASP.

The Lower Hudson River stations at Albany and Poughkeepsie will be sampled every four weeks (*Hudson EPS* Volume 2 p. 115) using the manual BMP sampling protocol (i.e., vertically-integrated sampling at a centroid location). (This low frequency is contingent on the results of the BMP showing Total PCB concentrations less than 100 ng/L on average to allow a margin of safety for the public water supplies [*Hudson EPS* Volume 2 p. 115]). If the 7-day running average total PCB concentration at Waterford or Troy is 350 ng/L (measured or estimated [*Hudson EPS* Volume 2, Section 4.2.6.4]) or greater (Control Level), the sampling frequency will be increased to weekly and maintained at that level until the conditions for reverting to routine monitoring are met as specified in Section 4.3 of the *Hudson EPS* (Reverting to Lower Action Levels). Samples for PCBs, DOC, POC, and suspended solids will be collected. Water quality parameters will be measured on each sample (turbidity, temperature, pH, conductivity, and DO). The results of the analyses will be required within 72 hours (*Hudson EPS* Volume 2, p. 115).

The Mohawk River station will be sampled once per other month from May through November to maintain the historical record; these samples will be collected manually from a centroid location and will be vertically integrated. If the PCB concentrations at Albany are shown to exceed those at Waterford, a grab sample at the Mohawk River at Cohoes will be collected to investigate whether the Mohawk is the source of elevated PCB levels in the Lower Hudson River. If sampling indicates that PCB levels in the Mohawk River have increased significantly, the Mohawk River station will be sampled at the same frequency as the Albany and Poughkeepsie stations during Phase 1.

These monitoring contingencies are for remediation of River Section 1 more than one mile upstream from the Thompson Island monitoring location.

If there were an accidental release in a section that was not undergoing remediation at that time, the two stations at least one mile downstream of the accidental release would be representative until the situation was resolved. Representative stations must always be more than one mile downstream from the source of the resuspended material. In the event that a far-field suspended solids resuspension criterion is exceeded, the far-field station would be monitored for PCBs (*Hudson EPS* Volume 2 p. 113).

To comply with the WQ Health (Water Source) standard, daily composite samples will be collected for metals analysis at Schuylerville, Stillwater, and Waterford, with sample aliquots collected at a frequency of twice per hour. In the event of an exceedance, the sampling frequency will be increased to four composites per day with sufficient volume collected to analyze for dissolved and total metals. If manual monitoring is implemented due to automated station failure or maintenance, discrete sampling will be conducted with consideration of time of travel. The results of TSS samples collected in conjunction with Resuspension Standard monitoring may substitute for those required for WQ requirements, provided that the number of samples and timing of sample collection corresponds to those collected for metals analyses. Continuous turbidity monitoring for the WQ requirements will be performed in conjunction with monitoring for the Resuspension Standard.

2.3 Sampling Methods

The design of the sampling program is based on the need to meet the following objectives:

Objectives for Far-Field Monitoring in the Upper Hudson

- Provide a set of data to demonstrate compliance with the Resuspension Standard Total and Tri+ PCB concentration thresholds.
- Provide a set of data to demonstrate compliance with the WQ requirements.
- Provide a means to rapidly assess water column Total PCB levels so that the EPA can advise public water suppliers when water column concentrations are expected to approach or exceed the federal MCL (i.e., 500 ng/L) during the remediation.
- Provide a set of data to demonstrate compliance with the Total PCB load components of the Resuspension Standard (i.e., 300 g/day and 600 g/day).
- Determine the primary means of PCB release via dredging-related activities.
- Determine the baseline Total PCB levels entering River Section 1 from upstream sources.

- Determine ancillary remediation-related effects on the river (e.g., barge traffic-related resuspension, spillage during transit or off-loading of sediment) that may occur in areas that are not captured by the nearest representative far-field station.

Objectives for Near-Field Monitoring in the Upper Hudson

- Provide a real-time indication of suspended solids release in the near field.
- Provide a set of data to demonstrate compliance with the WQ requirements.
- Determine the amount of suspended solids released by the remedial operations to provide an indication of PCB export.
- Verify that the NYSDEC surface water quality regulations are not violated during the remediation.

Additional Monitoring Objectives

- Monitoring in the Lower Hudson to examine the effect of Upper Hudson dredging activities on Lower Hudson PCB concentrations.
- Verify the selection of the monitoring locations.
- Non-Target Area Monitoring: Determine the degree and extent of contamination resulting from the remedial operations downstream from the target areas. (See Section 8).

Adjustments to the sampling program will be made through corrective action memoranda (CAMs) subject to EPA approval.

No splitting of water samples is permissible for any measurements that must accurately reflect the suspended solids content. If duplicate samples are required, the sample bottles for the duplicate and sample analysis can be deployed at once or in series to generate co-located samples. Sample bottles for PCB and suspended solids analysis should be deployed simultaneously if possible (*Hudson EPS* Volume 2 p. 110).

During the BMP, GE is testing automated sampling systems for both near-field and far-field monitoring. Based on the results of these tests, the Phase 1 RAM QAPP will provide necessary details on the sampling program. In the event that the automated samplers are not able to provide data of adequate quality to address the Resuspension Performance Standards, the Phase 1 RAM QAPP will provide an alternate monitoring method to evaluate compliance with the Resuspension Performance Standards monitoring requirements. In this case, the Phase 1 RAM QAPP will provide for the collection of data required at the routine level and will use best efforts to propose a program to address the objectives of the Resuspension Performance Standards at higher action levels. In addition, the Phase 1 RAM QAPP will specify contingencies in the event of automated sampler failure during dredging.

2.3.1 Near-Field Monitoring

Near-field monitoring requires the collection of continuous water column monitoring data for temperature, specific conductance, pH, DO, and turbidity and the collection of TSS grab samples and metals and hardness composite samples. Continuous water column monitoring data will be acquired using a YSI 6000 Series multi-parameter probe (or equivalent). This probe will be suspended from the monitoring platform at a conservative depth in the water column (i.e., toward the bottom of the water column) at ~ 75% of the water column depth or a minimum of 2 feet off the bottom. Confirmatory TSS samples will be collected at the same depth at which the water quality monitoring probes are deployed, such that these samples may be directly compared to the concurrent continuous turbidity measurements. If the surrogate relationship is not adequate for one or more stations, vertically integrated grab samples for compliance monitoring will be collected. Hardness and metals samples will be collected using an automated sampling system (ISCO or equivalent) with the sampling manifold located at the same depth in the water column as the probe.

As described in Section 2.2.1, the automated sampling system will be configured to draw aliquots at the highest frequency that can be practically achieved. In the event that an automated sampler fails, grab samples for metals and hardness will be collected at 75% of the water depth or a minimum of 2 feet off the bottom at the prescribed daily frequency.

2.3.1.1 Demonstration of Near-Field Automated Samplers during Phase 1

As noted Section 2.3 above, efforts will be made during the BMP to demonstrate the utility of automatic samplers for near-field monitoring. Sampling will be conducted during Phase 1 to verify that the automatic samplers meet the requirements of the EPS and to support modifications or maintenance of the systems that may be needed to meet those requirements. The near-field monitoring will be for continuous water quality parameters and metals. The DQOs and sampling requirements are described below:

Assess the vertical location of the intakes.

Turbidity data will be collected through the water column at each near-field station during remedial operations once a week throughout Phase 1. The data will be assessed to determine if the single intake captures the average (or higher) concentration in the water column. The location of the single intake in the water column may be adjusted based on review of the data.

Determine the long-term calibration and stability of continuous water quality monitoring probes.

The same water parcel will be measured for the continuous water quality parameters (turbidity, DO, pH, conductivity and temperature) using the automated sampler and a calibrated instrument with the probe at the level of the single intake. All stations will be assessed on a weekly basis throughout Phase 1. The data will be assessed using a control chart method (specific thresholds to be defined in the Phase 1 RAM QAPP).

2.3.2 Far-Field Monitoring

At the automated far-field stations, water will be pumped continuously through the system from several sampling inlets located along a cross-river transect. The water from each sampling location will be combined and continuous water quality monitoring measurements will be made on this combined stream using in-line probes located near the automated system's sampling port. In this way, the continuous water quality measurements will be representative of conditions at the time the sample aliquots are collected. As described in Section 2.2.2, sample aliquots will be collected from the combined stream using an automated sampler (ISCO or equivalent) at the highest frequency that can be practically achieved with a minimum of every 30 minutes, to form station composite samples. This departure from the monitoring requirements of the standard is acceptable to EPA as long as the automated samplers are shown to meet the data quality objectives specified in the EPS.

If the surrogate relationship is not adequate for one or more stations, suspended solids samples will be collected every 3 hours, 24 hours per day with a maximum 24-hour turnaround time but reasonable efforts will be utilized to reduce the 24-hour turnaround time. The turnaround time starts at sample receipt by the laboratory. Corrective measures will be taken to update or change the surrogate relationship to bring it back within the performance metrics set in the Phase 1 RAM QAPP which are based on the EPS requirements, the special study to Develop and Maintain of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time

Measurement For the Near-Field and Far-Field Stations (Full Scale), the TSS surrogate study (QEA, 2005a) and subsequent phases of the TSS surrogate study. These measures may include the collection of laser particle size measurements (if applicable) and additional TSS samples, bench-scale TSS studies, and the evaluation of the performance of automated sampling equipment (if used) and turbidity probes.

At the Bakers Falls, Albany, Poughkeepsie, and Mohawk River stations, sampling will be performed at a centroid location using the manual BMP sampling protocol.

2.3.2.1 Demonstration of Far-Field Automated Samplers During Phase 1

As noted Section 2.3 above, efforts will be made during the BMP to demonstrate the utility of automated samplers for far-field monitoring. Sampling will be conducted during Phase 1 to verify that the automated samplers at the far-field stations meet the requirements of the EPS. The results of this sampling may indicate that modifications or maintenance of the systems is required. The DQOs and sampling requirements are described below:

Determine whether the automated samplers collect a sample that is comparable to the vertically integrated grab samples under construction conditions. These samples are necessary to determine if the automated sampler collects a representative sample, even though the samplers do not collect a vertically integrated sample. This sampling is not required if the samplers are located in an area that EPA agrees is likely to be well mixed.

If the TI Dam station is located above the dam, the Phase 1 RAM QAPP will address the issue of vertical integration and comparability with the original TI Dam station. If needed, paired samples may be collected during Phase 1.

Determine the integrity of the samples collected with automated samplers. Determine if the sampling devices are aging or corrupted by biofilms. This test must be completed on each station because construction may differ from one station to another and the degree of biofilm development may differ depending on local conditions such as the location of CSOs.

Samples will be collected from each intake line at the pump house while timing the sample to match discrete samples collected at the intake ports to the automated sampler. Both the pump house samples and the intake point samples will be composited, generating a single sample for the intakes and a single sample from the pump house. All far-field stations will be sampled. The frequency of sampling will be proposed for EPA approval based on review of the automated sampler data collected during baseline. Each sample will be analyzed for TSS, PCB, and metals (where measured for WQ requirements) throughout Phase 1. The results of the sampling will be assessed using a control chart method based on the absolute difference between the measurements and the relative percent difference. If the data appear to have a bias, the sampling apparatus will be modified (such as by increasing the flow) and samples will be collected with the modified sampler.

In addition, pressure testing of the lines will be conducted at a frequency that will be proposed for EPA approval based on review of the automated sampler data collected during baseline.

Assess the performance of the autosamplers.

The performance of the automated samplers will be assessed based on the concentration relationships among far-field monitoring stations on a weekly basis throughout Phase 1. All measured parameters will be considered (Total PCBs, Tri+ PCBs, and all probe measurements). The assessment of the data will be qualitative with comparison of Phase 1 measurements to the baseline monitoring program results.

If the relationships among the far-field stations are not comparable to baseline conditions, it may be necessary to modify the location or number of substations in the cross-section of one or more stations. USGS guidance should be consulted to determine the number of EDI stations required in the cross-section (USGS, 2002. National Field Manual for the Collection of Water-Quality Data, Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Section 4.1.1, http://water.usgs.gov/owq/FieldManual/.). PCB fluxes are expected to remain relatively constant downstream of the dredging operation, with only minor increases, and PCB and TSS concentrations are expected to gradually decline in response to increases in flow (e.g., from tributaries) downstream of the dredging operations.

Determine the long-term calibration and stability of continuous water quality monitoring probes.

During sampling to assess the integrity of the automated samplers over time, water quality data will be collected continuously in the river at each pump intake and in the corresponding pump discharge in the pump house for a minimum of one half hour during the manual sampling to be conducted in conjunction with the automated sampling. The samples will be measured for turbidity, particle distribution, DO, pH, conductivity, and temperature. The results of the sampling will be assessed using a control chart method based on the absolute difference between the measurements and the relative percent difference.

2.3.3 Equipment Maintenance and Calibration

Testing of the near- and far-field sampling equipment, including automatic samplers and continuous water quality monitoring instruments, will be performed during the pilot study. The need for and scope of ongoing evaluations of the ability of the automatic samplers and continuous water quality monitoring equipment to collect representative data will be identified prior to Phase 1. Appropriate operation, maintenance, and calibration procedures will be developed and incorporated into the Phase 1 RAM QAPP.

Near-Field continuous monitors will be checked daily for problems such as bio-fouling and damage (*Hudson EPS* Volume 2 p.106).

2.4 Analytical Methods

Samples will be analyzed according to the requirements of the *Hudson EPS* Volume 2, Section 4.2.6 except for modifications presented herein and unless EPA agrees to other modifications. Adjustments to the sampling program will be made through CAMs subject to EPA approval.

The analytical methods will need to be sensitive enough to measure water column concentrations of PCBs at each station. For Total and Tri+ PCBs, a PCB analytical method with a detection limit low enough to detect expected PCB concentrations at Bakers Falls, Rogers Island, and Waterford is required (*Hudson EPS* Volume 2 p. 103). The current PCB analytical methods specified in the BMP QAPP are expected to meet detection limit requirements during remedial action.

The analytical methods chosen for this program must meet or exceed the specifications of the methods used in the baseline monitoring program in terms of precision, sensitivity, accuracy, representativeness, comparability, completeness and sensitivity. The only exception to this requirement would be in the case that efforts to produce a modified method for TSS to allow a reduced turnaround time are successful. The same analytical methods chosen for each station will be maintained at each station throughout the program for consistency (*Hudson EPS* Volume 2 p. 103).

2.4.1 Suspended Solids

Suspended solids analysis will be conducted using EPA Method 160.2 with modifications to be consistent with American Society for Testing and Materials (ASTM) Method D 3977-97, with a 24-hour turnaround time. However, during non-routine monitoring, reasonable efforts will be made to reduce the 24-hour turnaround time. Any modifications to the method made to reduce turnaround time will be detailed in the Phase 1 RAM QAPP.

2.4.2 PCBs

Analysis of whole water PCBs will be conducted using the modified Green Bay Method (mGBM) and extraction protocols used during the BMP. Under routine monitoring, samples collected at the two nearest far-field stations to the dredging operations (Thompson Island and Schuylerville for Phase 1) will have a 24-hour turnaround time from the time that the last sample is collected at either of these stations until the results are reported from the laboratory, to the extent that such turnaround time is feasible. The time between sample collections at these stations will not exceed four hours. Samples will be processed in batches to provide some daily measure of QA/QC (e.g., laboratory control spikes and continuing calibration standards). However, given the field and laboratory logistics required to provide results within 24 hours, it will not be possible for the initial analytical results to have undergone the standard QA/QC procedures. All PCB samples will be subject to electronic verification and a subset (minimum 5%) will be subject to manual validation. The validation will be frontloaded in order to assess the analyses early in the season. The QA/QC details for PCB analytical samples will be provided in the Phase 1 RAM QAPP.

At stations downstream from the two nearest far-field stations to the dredging operations, Bakers Falls and Rogers Island, PCB results will be reported within 72 hours of collection during routine monitoring. If the Control or Standard Level is exceeded, analyses for samples collected from the stations at Thompson Island, Schuylerville, Stillwater, and Waterford will all have 24-hour turnaround times, to the extent feasible. In this case, reporting of results from the station in exceedance (to confirm the results per the EPS) and Stillwater and Waterford (to be protective of water supplies) will be prioritized. The details of the QA/QC procedure will be provided in the Phase 1 RAM QAPP.

2.4.3 Organic Carbon

Samples will be analyzed for DOC and POC using EPA Method 415.1, as described in the BMP QAPP. Sample turnaround times will be the same as for PCBs at each station.

2.4.4 Metals and Hardness

Metals analysis for the WQ requirements will be conducted using EPA Method 200.8, with the exception of mercury, which will be analyzed using EPA Method 1631, and hexavalent chromium, which will be analyzed using colorimetric Method SW-846 7196A (although Method SW-846 7199 may be used as an alternate procedure for samples when interference exists with the colorimetric Method SW-846 7196A). Each metals composite will be considered a sample upon the collection of the last aliquot. As discussed in Section 2.1.2, samples from near- and far-field stations will be analyzed for total and dissolved cadmium and lead under routine conditions. In the event of an exceedance of an applicable metals standard in either the near field or the far field, the subsequent samples collected for metals analysis from such location(s) will be analyzed for the suite of total and dissolved metals subject to the applicable set of standards, until such time as the metals concentrations fall below the standards. If, during in-water activities, distressed or dying fish are observed, increased monitoring will be conducted for metals (total and dissolved) and additional water quality parameters, where appropriate, in accordance with the Phase 1 ID PSCP Scope (Section 7.5) and WQ Substantive Requirements (p.9). At that time, routine metals monitoring will resume. Hardness analysis will be conducted on near-field samples using EPA Method 130.2.

Initially, the laboratory will be required to report the metals results from the far-field stations within 24 hours of the last sample collected at the far-field stations, to the extent feasible. Given the field and laboratory logistics required to provide results within 24 hours, it will not be possible for the initial analytical results to have undergone standard QA/QC procedures. The amount and type of QA/QC procedures will be delineated in the Phase 1 RAM QAPP.

2.5 Off-Season Water Column Monitoring

In the off-season when dredging activities have ceased, the sampling schedule currently being followed under the BMP will continue, with certain modifications. Specifically, this sampling will include routine weekly sampling for PCBs, TSS, DOC, and POC at the five Upper Hudson River stations (to the extent that weather and river conditions allow), monthly sampling at Bakers Falls and at the Lower Hudson River stations at Albany and Poughkeepsie and every other month at the Mohawk River. Metals sampling will not be conducted during the off-season.

2.6 Public Water Supply Monitoring

When dredging operations are underway, the frequency of monitoring for PCBs will be increased at the public water supply facilities for the Town of Halfmoon and the City of Waterford. This monitoring will augment the already extensive water column sampling to be conducted in the river, which will ensure that PCB levels at the far-field stations remain below the Standard Level set forth in the Resuspension Standard. That Standard Level is a confirmed total PCB concentration of 500 ng/L, which is the same as the National Primary Drinking Water MCL.

The monitoring of the potable water supplies will be on raw and finished water and the analytical method will be EPA Method 508 (PCBs as Aroclors) in accordance with 40 CFR 141.24. This monitoring will be done weekly when dredging operations are underway. The party performing the remedy will work with the water suppliers and the regulatory agencies to implement the plan described above.

2.7 Fish Monitoring

Throughout the RA period, fish collections will continue to be performed in the Upper Hudson River and Lower Hudson River as described below, except that (a) the sampling locations may be modified, if necessary and with EPA approval, to avoid impacts from dredging in that year, and (b) the total number of fish samples collected in each river section each year may be modified upon EPA approval in consultation with the NYSDEC.

2.7.1 Sampling Locations

In the Upper Hudson River, fish sampling will be conducted at locations identified to coincide with the BMP fish sampling locations. Specifically, fish sampling will be conducted in the Upper Hudson River from each of the river sections at the stations listed below:

- Feeder Dam (representative of reference conditions);
- Thompson Island Pool (representative of River Section 1);
- Northumberland/Fort Miller Pools (representative of River Section 2); and
- Stillwater Pool (representative of River Section 3).

In the Lower Hudson River, fish monitoring will be conducted at the following stations:

- Albany/Troy (location will coincide with the BMP fish sampling locations);
- Catskill; and
- Tappan Zee area.

2.7.2 Sampling Frequency

Sampling will be conducted annually at the Upper Hudson River stations. At the Lower Hudson River stations, fish sampling will be conducted annually at Albany/Troy and every two years at Catskill and Tappan Zee.

2.7.3 Species and Sampling Methods

This section specifies the species to be sampled during the remedial action.

2.7.3.1 Upper Hudson River

In the Upper Hudson River, the same species groups as are sampled in the BMP will be collected. These species groups are:

- Black bass (largemouth and/or smallmouth bass, with a goal of half of each species but in whatever combination is available to meet the applicable sample size from Section 2.7.4);
- Ictalurids [bullhead (brown and/or yellow) and/or channel catfish (white and/or channel), with a goal of half of each species but in whatever combination is available to meet the applicable sample size from Section 2.7.4);
- Yellow perch;

- Yearling pumpkinseed; and
- Forage fish (spottail shiner and/or alternative).

Standard sampling methods, including netting, electroshocking, and angling, will be used to collect target species. The samples to be processed for analysis will be standard fillets for bass, bullhead, catfish, and perch; individual whole body samples for yearling pumpkinseed; and whole body composites for spottail shiners or other forage fish species.

2.7.3.2 Lower Hudson River

At the Lower Hudson River stations, the following species will be sampled as part of the fish monitoring program:

- At Albany/Troy: striped bass, black bass (largemouth and/or smallmouth bass, 10 of each, or in whatever combination is available for a total of 20), ictalurids [10 bullhead (brown and/or yellow) and/or 10 catfish (white and/or channel), or in whatever combination is available for a total of 20], and perch (white and/or yellow, 10 of each, or in whatever combination is available), yearling pumpkinseed and forage fish (spottail shiner and/or alternative) - all to be collected annually;
- At Catskill, striped bass, black bass (largemouth and/or smallmouth bass, 10 of each, or in whatever combination is available), and ictalurids [10 bullhead (brown and/or yellow) and/or 10 catfish (white and/or channel), or in whatever combination is available] - all to be collected every 2 years; and
- At Tappan Zee area, striped bass - to be collected every 2 years.
- These samples will be processed as standard fillets.

2.7.4 Sample Size

Sample size within each pool in the Upper Hudson River will be the same as described in the BMP QAPP (QEA 2004). For locations where individual fish will be submitted for analysis, the number of fish to be collected will consist of a maximum (i.e., more of one species may be collected than another in order to achieve the total if one species is present in smaller numbers, or not at all) of: 20 individuals per species group at Feeder Dam; 25 individuals per species group at Northumberland/Fort Miller pool; and 30 individuals per species group at each of the Thompson Island and Stillwater pools. The individuals may be collected from multiple stations within the pool, as necessary to achieve a representative River Section-wide average. In addition, where forage fish will be sampled, 10 whole body composites of forage fish will be collected from each pool (two composites per location).

At each of the Lower Hudson River stations, a maximum of 20 individuals of each species group will be collected.

2.7.5 Measurements

PCBs and percent lipid will be measured to monitor PCB levels in fish. All fish samples will be analyzed for total PCBs using a modification of the EPA Method 8082 Aroclor Sum Method, as specified in the BMP QAPP (QEA 2004), unless EPA determines that the data quality objectives established in the Phase 1 RAM QAPP can no longer be assessed by that method. Analysis by the mGBM will be performed on 5 percent of the total number of samples, during every other sampling event that is conducted at a given sampling location, in order to verify that the Aroclor method is accurately quantifying the Total PCB concentrations in fish, as the contaminant pattern in fish may change as a result of the remediation, which may affect the quantification by the Aroclor method. The weight and length of collected fish also will be measured to assess fish condition. Captured fish will be visually inspected for external abnormalities (e.g., tumors, lesions). Sex of fish will be determined, if possible, prior to processing in the analytical laboratory.

2.8 Reporting

An electronic data export will be provided to the EPA on a weekly basis. The export will contain the most recent version of the data at the time of file creation. Additionally, a “readme” file documenting data additions and corrections will be provided with the database. Changes and/or updates to the project data will be documented by two methods. Data verification and validation changes will be detailed in the automated data verification module (DVM) and validation reports. Other significant changes to the database will be documented in corrective action memoranda provided electronically to the EPA.

The analytical results and continuous water column monitoring data will be reported as follows:

- Continuous water column monitoring data will be made available immediately to the EPA's designated representative in the field and will be submitted to the EPA within 12 hours of collection.
- The reporting system will be designed such that additional sampling can commence within 6 hours of any reported near- or far-field exceedance.
- Analytical results will be made available to the EPA upon receipt from the laboratories. The data package contents will be defined in the Phase 1 RAM QAPP.
- Any exceedances of the 500 ng/L total PCB standard will be reported to the EPA within 3 hours of laboratory reporting.
- Any near-field exceedances of the Acute Aquatic standards will be reported promptly to EPA and NYSDEC, but no later than 3 hours after receipt of the laboratory data.
- Any exceedances of the Health (Water Source) standards or of the NYSDOH action or trigger levels for lead, as defined in Section 2.1.2, will be reported to EPA, NYSDEC, NYSDOH, and the downstream public water suppliers promptly, but no later than 3 hours after receipt of the laboratory data.
- Weekly reports will be submitted that summarize the results of near- and far-field monitoring, exceedances of criteria, and any corrective actions taken.

Such reporting will be facilitated through the use of a data management system that will post results for authorized project personnel in near-real time, allow for the creation of summary reports, and provide notification of exceedances. The project manager or designated representative will submit a weekly report with the requisite information. Further details regarding the reporting will be included in the Phase 1 RAM QAPP.

The data from the off-season water column and fish monitoring programs will be provided to EPA in the monthly reports and monthly database updates under the Consent Decree.

In addition, Data Summary Reports (DSRs) that document the data collected will be provided by April 1 in the year following Phase 1 dredging for both the water column and fish monitoring programs. The Phase 1 DSR will fully document the work, including a summary of the work performed, a tabulation of results, field notes, processing data, chain-of-custody (COC) forms, copies of laboratory audits, data validation results, copies of laboratory reports, and a compact disk version of the project database.

3. Sediment Residuals Monitoring

A residuals sampling and evaluation program will be implemented to monitor the level of PCBs in sediment remaining in dredge areas.

3.1 Objectives and Criteria

The objectives of the Sediment Residuals Monitoring Program are to:

- Verify the removal of the sediment PCB inventory in dredge areas; and
- Determine the concentrations of Tri+ PCBs in sediment residuals (i.e., individual node concentrations, arithmetic average, and median) ; and
- Provide information for evaluation of the Residuals Performance Standard.

This section presents the locations and frequency for sample collection activities pursuant to the Residuals Performance Standard, including:

- Collection of samples to assess Tri+ PCB levels in residuals immediately following dredging;
- Collection of samples to assess Tri+ PCB levels in residuals immediately following re-dredging;
- Collection of samples to assess Tri+ PCB inventory in sediment remaining after dredging; and
- Collection of samples to assess Tri+ PCB levels in backfill.

For clarity, the above activities are referred to herein as "post-dredging residuals sampling," "post-re-dredging residuals sampling," "post-dredging inventory sampling," and "backfill sampling." Residuals sampling will target the top 6 inches of the post-dredging surface.

Residuals sampling will be performed in each certification unit (CU), as described further below, following completion of dredging activities. The sampling results will be evaluated against criteria presented in the Residuals Performance Standard to determine whether the standard has been met or contingency actions are required. Sampling locations, collection methods, and analytical methods for the Sediment Residuals Monitoring Program are described below in Sections 3.2 through 3.4. Contingency actions may require additional sampling and analysis, such as re-dredging sampling activities, etc., depending on the results of the initial sampling effort. These activities are described in Section 3.5 – Contingency Monitoring.

3.2 Monitoring Locations and Frequency

Samples will be collected for residuals characterization following completion of all dredging activities in a given CU. Requirements of *Hudson EPS* Volume 3, Section 4.1 for sampling grid establishment will be complied with. In general, a CU will consist of approximately 5 acres and will be sampled at 40 locations on a triangular grid, except in the following circumstances:

- Isolated dredge areas smaller than 5 acres will be designated as a single CU, and samples will be collected from 40 locations along a proportional grid.
- Non-contiguous dredge areas smaller than 5 acres and within 0.5 mile of one another may be evaluated as a single CU, up to a maximum area of 7.5 acres. For resulting CUs less than 5 acres in size, samples will be collected from 40 locations along a proportional grid while CUs greater than 5 acres will be sampled using a grid with 80-foot spacing (i.e., up to 60 samples for a 7.5-acre area).
- If a number of noncontiguous dredging areas smaller than 5 acres in size are contained within a common silt barrier during dredging, the construction manager must submit a proposal to EPA that explains how the dredging project will be managed to prevent the spread of contamination to the interstitial, non-targeted areas, or propose additional sampling to investigate those areas during residuals sampling in the CUs.
- Contiguous dredging areas up to 7.5 acres in size may be considered a single CU and sampled using a grid with 80-foot spacing (i.e., up to 60 samples for a 7.5-acre area).
- Contiguous dredging areas between 7.5 and 10 acres will be divided into two CUs of equivalent area, and 40 samples collected from each CU along a proportionate grid.
- Contiguous dredging areas larger than 10 acres will be divided equally into approximately 5-acre CUs, and samples collected in each CU using a grid with 80-foot spacing.

Specifics of the CUs and their associated sampling grid will be established following development of the dredge prisms during design and will conform to the above requirements. Sampling points for compliance with the Residuals Performance Standard criteria and Phase 1 ID PSCP Scope Section 3 will be located only in areas where inventory dredging was conducted. If overdredge areas (i.e., side slope areas located laterally outside the areas identified in the *Dredge Area Delineation Reports*) are not backfilled, these locations will also be sampled at the same frequency, and the results will be used to evaluate the residual levels remaining in these areas because the spatial extent of these areas is not known at this time. The size of the CU will be estimated based on the area where inventory dredging was conducted. As noted above, approximately 40 to 60 samples will be collected from each CU along a triangular grid. The grid will be offset from the design support sampling grid used in the Sediment Sampling and Analysis Program (SSAP) such that the residuals sampling nodes are located between 40 and 60% of the distance between SSAP sampling nodes, with the goal being 50% of the nodal distance. If obstructions are encountered at a grid node, the sample will be relocated within a 20-foot radius of the original location.

Sampling in a CU will be completed within 7 days of completion of each dredging attempt in that CU. Samples may be collected prior to completion of the unit as long as the area sampled complies with the requirements of the Phase 1 ID PSCP Scope Section 3.1. Cores will initially be advanced to a depth of 2 feet and samples collected from the 0- to 6-inch interval using the methods discussed in Section 3.3. It may be necessary to re-sample some nodes for deeper samples, if the depth of contamination (DoC) has not been identified and the DoC cannot be estimated through extrapolation. The remainder of the core will be archived according to the same procedures used during the SSAP; archived samples will be stored until EPA permits the samples to be disposed. However upon notification to EPA, GE may dispose of samples one year after collection unless EPA chooses to have GE transfer the samples to EPA or its representative. The core depth may be modified during implementation of the residuals sampling program, with EPA approval, based on the results for CUs sampled early in the program. Such modifications will be made through GE's submission of a CAM for EPA approval.

3.3 Sampling Methods

Sample collection and processing will generally follow the SSAP protocols, with modifications to incorporate requirements from the Residuals Performance Standard. The protocols to be followed for sample collection are presented below, followed by the protocols for processing.

3.3.1 Sample Collection

- Samples will be collected via coring, vibracoring, or manual coring techniques.
- Clear Lexan tubes (or other appropriate semi-transparent tubes) will be used for manual coring. If substrate conditions are such that manual coring is not feasible, cores will be retrieved using vibracoring.
- If vibracoring is employed, the rig will be activated at the sediment-water interface and used throughout the full depth of the core.

- Under conditions where a core cannot be collected, samples will be collected using small ponar-type samplers.
- Core locations will be located using GPS and referenced to an appropriate horizontal coordinate system and vertical datum.
- Sampling locations and all other field data will be recorded.
- Sediment probing will be conducted in an adjacent location prior to core collection to identify the approximate depth and the texture of the sediments.
- Backfill samples and samples from re-dredged nodes will also be collected as 0-to-6-in core samples; and in all respects sample collection, management, and analysis will be identical to residual sediment samples.
- The probing information will be used to determine if a core can be obtained, or if a grab sampler should be deployed instead.
- Design information and probing results will be used to determine the target coring depth.
- Sediment cores will be advanced to a depth of 2 feet (with the objective of collecting a representative surficial 0- to 6-inch sample), or to refusal (if less than 2-foot depth).
- Core recovery will be measured upon collection directly through visual inspection of the sample and confirmed after extraction of the core during processing.
- Actual sample recovery will be calculated by dividing the length of the sediment recovered by the total penetration depth of the core.
- The sampler will document sediment recovery, visually classifying the sediment sample and the thickness of the residuals layer.
- When probing indicates less than 6 inches of sediment over a hard material, at least one attempt will be made to collect a core. A ponar grab sample will be collected when the sediment core cannot be collected.
- If sample recovery is hindered by the presence of bedrock, up to three attempts will be made to retrieve sediments using a coring approach (manual or vibracore) within a 20-foot radius from the proposed sampling location. If that approach is unsuccessful, grab sample collection will be attempted using a ponar-type sampler for up to three additional attempts. Following such attempts, if sediment recovery is still not attainable, presence of bedrock will be noted at the location and the rig will move to the next sampling location.
- If a ponar dredge is used, it will be of sufficient size to penetrate at least 6 inches or the thickness of sediment believed present on the river bottom, whichever is less.
- After collection, the core will be capped, sealed, and labeled. Labeling will include core identification information, date, time, and an arrow to indicate the upper end.

- All other information will be recorded in a field log book.
- The cores will be transported with river water in the headspace to minimize disturbance of the top core layer.
- The cores will be stored on ice on a storage rack in a vertical position and kept in the dark until submitted for processing and analysis.
- Ponar samples will be homogenized in a dedicated, laboratory-decontaminated, stainless steel bowl, transferred to an appropriately selected and labeled sample jar, and stored on ice in a cooler until submitted for processing and analysis.

3.3.2 Sample Processing

- A field processing facility similar to that used in SSAP activities will be used.
- Retrieved core samples will be photographed.
- Field notes will arrive at the processing facility with the core or ponar sample and be entered into the database.
- The initial core processing step will be to drain the excess water, once the fine particles have settled with the goal of minimizing disturbance to the fluff layer.
- The weight of the core tube will then be measured and will be used as an initial estimate of the sediment bulk density.
- Any observed sediment "fluff" layer (the layer the measuring stick will go through to hit the sediment-water interface) will be retained and homogenized with the 0- to 6-inch sample.
- For cores, obvious disturbances to sediment layer created due to the dredge will be documented. Observations including thickness of separate layers of redeposited sediments, disturbed sediment, and undisturbed underlying sediment will be recorded.
- The length of the recovered core will be measured, the core tube will be marked to identify where it will be cut into segments (if more than the 0- to 6-inch segment will be analyzed), and an arrow will be marked on each segment to indicate the upper end.
- The core will be cut into 6-inch segments prior to extrusion. Since the core sections will be separated prior to the extrusion process, the sediment will only be extruded from the section of core tubing that corresponds to the sample to be mixed and analyzed, in most cases, the 0-to-6 in interval. While the core tube is being cut, support will be given to the areas above and below the cut. Once the core tube has been cut through, the core segment will be separated from the rest of the core.

- Sediment will be extruded using a decontaminated stainless steel tool and rigorously homogenized using decontaminated stainless steel or glass equipment.
- Visual descriptions will be recorded into the database, including a description of the physical characteristics of the core segment; general soil type (sand, silt, clay, and organic/other matter such as wood chips, as determined using the Unified Soil type Classification System (USCS); approximate grain size; and presence of observable biota, odor, and color. If Glacial Lake Albany Clay is observed, the presence of clay will be confirmed by a manual test of plasticity. The nature and length of stratigraphy changes will also be noted, if present. Visual texture characterization will be done by a field geologist or equivalent.
- Objects of cultural significance, if present, will be noted in the database, inspected by a qualified geomorphologist or archaeologist, and stored at the processing facility.
- Wood chips will not be separated, but manually pulverized or chopped as necessary to allow homogenization with and inclusion in the sediment samples submitted for laboratory analysis.
- Sample aliquots designated for analysis will be chilled to 4°C and kept in a dark location until sent to the analytical laboratory.

3.4 Analytical Methods and Quality Assurance/Quality Control Procedures

Sediment samples will be analyzed for PCBs using Method GEHR8082, the same method used during the SSAP. To the extent feasible, these analyses will achieve a reporting limit of 0.1 ppm for each PCB Aroclor, with a Method Detection Limit (MDL) of 0.05 ppm or a reporting limit equivalent to 0.1 ppm for Tri+ PCBs over the range of conditions that can be anticipated (e.g., high moisture content). Prior to submittal of the Phase 1 RAM QAPP, GE will submit for EPA review and approval, additional paired analysis using GEHR8082 and the mGBM to refine the regression equation to meet the reporting limit of 0.1 ppm. The information will identify the source and number of samples to be used to develop the conversion and the approach for developing the regression equation. The samples will also be analyzed for moisture content (as part of the PCB analyses) using EPA Method 160.2. If a regression equation is approved by EPA, 4 percent of the samples will be analyzed by the PCB method used to develop the equation, throughout remediation. The paired estimates of Tri+ PCB will be used to assess and maintain the regression throughout the remediation.

If during remediation, a regression equation is used to estimate Tri+ PCBs, a sample with detection(s) of one or more Aroclors that are not included in regression equation, and the concentration of these Aroclors is more than 5 percent of the Total PCB concentration, then a means of calculating Tri+ PCBs will be proposed for this sample for EPA's review and approval, for instance, add any Aroclors not in the regression equation to the 1242 plus 1254 total.

QA/QC procedures for residuals sampling will be described in the Phase 1 RAM QAPP and be approved by EPA. The parties agree that it is critical to generate high quality data with sufficient QA/QC to adequately document CU closure decisions on a timely basis. The parties further agree that results from manual data validation will be a critical component to the overall QA/QC program (particularly in the beginning of the project) and will be used to continuously evaluate and improve analytical procedures, but manual data validation will not be used as a basis to revisit decisions already made regarding actions on a specific CU.

3.5 Contingency Monitoring

Following the initial post-dredging residuals sampling and analysis, the resulting PCB data will be reviewed to determine the appropriate response. Under the Residuals Performance Standard, there are four possible responses:

- Response 1: Backfill and demobilize at a CU (including testing of backfill if necessary).
- Response 2: Jointly evaluate a 20-Acre Average.
- Response 3: Re-dredge or Construct Subaqueous Cap at a CU.
- Response 4: Re-dredging is required.
- Response 5: Capping.

The criteria to be used to determine which of these responses will be implemented during Phase 1 dredging, and the methods used to apply these criteria, will follow the Residuals Performance Standard, as described in the Phase 1 ID PSCP Scope, and will be presented in more detail in the Phase 1 IDR and Phase 1 FDR and the Phase 1 PSCP; these criteria and methods are not discussed herein.

This section describes the additional sampling and analysis associated with one or more of these responses – namely, re-dredging residuals sampling/analysis, inventory re-characterization sampling/analysis, and backfill sampling/analysis. These activities, where performed, will be conducted in accordance with the sampling and analytical methods described in Sections 3.3 and 3.4 and the Phase 1 ID PSCP Scope Section 3.4.

In areas where re-dredging is conducted, residuals samples will be collected following completion of each re-dredge attempt from the re-dredged nodes and analyzed. Re-dredging sample core locations will be offset from the original residuals sample grid by 10 feet. Samples will be collected from the 0- to 6-inch depth interval.

Samples from depths below 6 inches may be analyzed for PCBs to define the depth of contamination as specified in the Phase 1 ID PSCP Scope.

Backfill samples will be collected, when required, along the same grid as the residuals samples. Backfill samples will be collected from the 0- to 6-inch depth interval. Backfill samples will be analyzed for PCBs using the same procedure described for residual samples in Section 3.4 above.

In addition, construction monitoring will be implemented during cap placement activities. This construction monitoring will be described in the *Construction Quality Assurance Plan* for Phase 1 dredging operations, which is discussed in Section 4 of the Phase 1 IDR.

3.6 Data Reporting

Weekly progress reports will be prepared and submitted to the EPA site manager according to an agreed upon schedule with the GE and EPA. The reports will summarize, at a minimum, the following:

- Results of residuals sampling;
- Exceedances of the Residuals Performance Standard by CU and joint 20-acre evaluation area; and
- The course of actions that were undertaken, and rationale.

Also, laboratory data will be made available to the EPA upon receipt from the laboratory.

A CU Completion Report will be prepared and submitted to the EPA, according to an agreed upon schedule. Each CU Completion Report will include:

- CU identification;
- Description of the type(s) of dredging equipment used;
- Description of sediment type(s) encountered;

- Results of residuals sampling;
- Sediment imaging results (if available);
- Written verification that the sampling data were verified in accordance with the procedure described in Section 3.4 above, including a discussion of any data qualifiers applied;
- Results of the required comparisons to action levels for each dredging pass;
- Discussion of any contingency actions taken;
- Number of dredging passes for residuals concentration reduction;
- For each attempt, a map of the CU showing the concentration at each node and the non-compliant area (if any) to be re-dredged or capped;
- A signed verification that the CU was backfilled or capped (as applicable) in accordance with the requirements of the Phase 1 ID PSCP Scope, the Phase 1 PSCP, and the approved remedial design, as well as any other applicable requirements under the Consent Decree; and
- A signed verification that the initial habitat replacement/reconstruction was completed (as applicable) in accordance with the requirements of the approved remedial design, as well as any other applicable requirements under the Consent Decree.

4. Air Quality and Odor Monitoring

An air quality and odor monitoring program will be conducted to assess achievement of the standards set forth in the QoLPS for air quality and, as necessary, for odor. Specific objectives and criteria for air monitoring are described below, organized according to:

- PCBs;
- Criteria Pollutants;
- Opacity; and
- Odor (including hydrogen sulfide [H_2S]).

4.1.1 PCBs

The objective of PCB air quality monitoring is to assess the potential exposure of receptors in the project area to airborne emissions of PCB from the project.

The EPA determined that emissions of PCBs during remediation activities could result in a short-term increase in ambient air levels of these pollutants. The QoLPS for air quality has been established to confirm that this potential impact does not result in unacceptable exposure.

The Air Quality Standards for PCBs, as set forth in the *Hudson QoLPS* (pp. 6-8 & 6-18), are as follows:

- During remedial action, the Residential Standard is:
  24-hour average, total PCBs = 0.11 micrograms per cubic meter (µg/m^3), with a "Concern Level" of 0.08 µg/m^3 (24-hour average) total PCBs.

- During remedial action, the Commercial/Industrial Standard is:
  24-hour average, total PCBs = 0.26 µg/m^3, with a "Concern Level" of 0.21 µg/m^3 (24-hour average) total PCBs.

4.1.2 Criteria Pollutants

In accordance with the *Hudson QoLPS* (pp. 6-9 to 6-1), an assessment will also be made of the following pollutants for which the EPA has promulgated National Ambient Air Quality Standards (NAAQS) (known as "criteria pollutants"): nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter with a median diameter of 10 micrometers or less (PM_{10}), particulate matter with a median diameter of 2.5 micrometers or less ($PM_{2.5}$), and ozone (O_3). Ozone (O_3) is evaluated using its precursors, NO_x and volatile organic compounds (VOCs).

The need for monitoring of these constituents will be determined during remedial design using specific design data. The RD Team will repeat the assessment in EPA's *White Paper – Air Quality Evaluation* analyses (EPA, 2002) using project specific design data. If this project specific information developed during design validates the assumption used in EPA's *White Paper – Air Quality Evaluation* analyses (EPA, 2002), this will be considered a determination of compliance with the QoLPS such that further demonstration by on-site or offsite sampling will not be required. If air quality compliance is not demonstrated as a result of these analyses for any NAAQS, potential design changes that could result in achievement of the NAAQS and/or the need for monitoring for such pollutant(s) will be evaluated, and will submit a proposal on this topic to EPA for review and approval.

4.1.3 Opacity

The Air Quality Standard for opacity, which is based on New York State air regulations (6 NYCRR Title III, Subpart 211.3), is that opacity must be less than 20% (as a 6-minute average), except that there can be one continuous 6-minute period per hour of not more than 57% opacity (*Hudson QoLPS*, p. 6-16).

4.1.4 Odor

The stated objective of the QoLPS for odor is to protect the public from odors that unreasonably interfere with the comfortable enjoyment of life and property (*Hudson QoLPS*, p. 6-18). Odors are difficult to measure because they depend on not only the concentration of the pollutant, but also on the sensitivity of the person exposed to the odor. The QoLPS for odor has two components. The first is a standard for H_2S of 14 $\mu g/m^3$ (0.01 ppm), expressed as a 1-hour average, which applies if an odor identified as H_2S is detected by workers or the public. The second component is that odor complaints will be investigated and mitigated, as appropriate (*Hudson QoLPS*, p. 6-19).

4.2 Monitoring Locations and Frequency

The locations and frequency of the air quality and odor monitoring program are described below. Detailed monitoring plans will be submitted as part of the Phase 1 RAM QAPP.

4.2.1 PCBs

Air monitoring will be conducted, employing samplers operating continuously for 24 hours, to verify the assessment and demonstration of compliance with the QoLPS for PCBs. Such monitoring will be conducted at locations along the dredging corridor, at unloading areas, and around the sediment processing/transfer facility (processing facility), as discussed further below. (Note that the monitoring for unloading areas and processing facility may be combined, depending on final configuration of the processing facility.) In addition, monitoring will be conducted at a permanent background station situated upwind of the Phase 1 dredge areas, the unloading areas, and the processing facility. This station will be situated permanently at a fixed upwind location away from the river and operate throughout the entire term of the remediation program. The specific location for this station will be specified in the design documents. If an approach other than a standard EPA-approved method is being proposed to demonstrate compliance, that approach will require EPA approval and will be specified in the Phase 1 RAM QAPP.

Further, a meteorological station will be established at the processing facility to provide meteorological data for use in this air monitoring program. The specific location for this meteorological station, as well as the equipment to be used at the station, will be specified in the design, which will consider EPA guidance for siting meteorological monitoring stations (EPA, 2000b).

Monitoring Site Selection Process

In selecting locations for the PCB monitoring stations, a three-tiered site selection process will be applied. This process will involve application of the following criteria.

The primary criteria for site selection will involve consideration of the location of the facility perimeter (for monitoring stations that are to be placed on that perimeter), pertinent information on predominant wind direction and wind vectors, and pertinent information on the most likely receptor locations. Information on predominant wind direction and vectors will be obtained through review of the historical meteorological data collected at Albany Airport, in combination with data collected from the meteorological station at the processing facility prior to project start-up. This information will be coupled with dispersion modeling analyses of air emissions to identify the most likely receptor locations.

The secondary criteria for site selection will involve application of the EPA's and U.S. Army Corps of Engineers' (USACE's) guidelines applicable to ambient particulate sampling systems (EPA, 1987; USACE, 1997). These criteria include the following:

- Height of sampler inlet above ground (2 to 15 meters);
- Distance of sampler from trees (> 20 meters);
- Distance from sampler to obstacle at least twice the height of the obstacle above the sampler;
- Unrestricted airflow (270^o arc of unrestricted space around sampler);
- Roof placement > 2 meters from any wall, parapet, penthouse, etc., and no nearby flues that may significantly impact sampling;
- Sufficient separation of the sample inlet from nearby roadways to avoid the effects of dust re-entrainment and vehicular emissions on measured air concentrations; and
- Avoidance of locating particulate matter sampling systems in an unpaved area unless there is vegetative ground cover so that the effect of locally re-entrained fugitive dusts will be kept to a minimum.

The tertiary criteria will consist of logistical considerations, including availability of electrical service, site accessibility, site operator safety considerations, and the availability of site security to mitigate tampering with and/or vandalism of instrumentation.

The details on monitoring locations will be provided in the Phase 1 IDRs and/or Phase 1 IDRs and the Phase 1 RAM QAPP.

Monitoring Frequency

The Phase 1 monitoring for PCBs will be conducted at the following frequencies:

- Stations at the sediment processing facility and unloading areas will be sampled continuously during processing plant operations, and a 24-hour sample will be collected at each station for each day during such operations. Additionally, at least 2 days of baseline data, prior to the start of processing operations, will be collected at the processing facility stations.
- Representative stations within the dredging corridor will be sampled continuously during dredging, and a 24-hour sample will be collected for each day during dredging operations. Additionally, at least 2 days of baseline data, prior to the start of dredging, will be collected at stations that are representative of the first day of dredging.
- The permanent background station will be sampled continuously during dredging or processing plant operations, and a 24-hour sample will be collected for each day during such operations. The sample at this station will be analyzed for PCBs. Additionally, at least 2 days of baseline data will be collected at this station prior to the start of dredging.

During Phase 1 operations, EPA will determine if the objectives of the air monitoring program can be achieved with less frequent monitoring or monitoring at fewer stations (e.g., only selecting the samples collected at the predominantly downwind and upwind stations for analysis).

Meteorological Monitoring

Meteorological data will also be collected at the processing facility. These data will consist of wind speed, wind direction, and ambient temperature collected on a continuous basis during project operations and/or during ambient air monitoring. Data will be collected as 5-minute averages and downloaded for archival storage. The meteorological station will be placed atop a tower and situated so as to meet EPA siting criteria for meteorological monitoring stations (EPA, 2000b).

4.2.2 Criteria Pollutants

As discussed above in Section 4.1.2, sampling for criteria pollutants is not expected to be required. Should the design suggest that this monitoring is required, the details will be specified in the Phase 1 EMP to be submitted with the Phase 1 FDR, as well as reflected in the Phase 1 RAM QAPP.

4.2.3 Opacity

The opacity standard will be applied to vessels, vehicles, and equipment as a performance standard for this project. The locomotives used by rail carriers will not be subject to this opacity standard. These line-haul engines are regulated by EPA's national standards governing opacity (40 CFR Part 92). However, the switcher engine used to operate the on-site rail yard will be subject to the QoLPS for opacity. Vessels and vehicles used for this project will be maintained and operated properly to prevent opacity problems. Also, pollution control systems for process equipment will be designed to prevent opacity concerns. The primary monitoring for opacity will be visual observations. As described in Section 4.3.3, these observations will be made by a certified visual observer using EPA Method 9 documented in field logs. Opacity will be observed at the initial start-up of each piece of equipment permanently assigned to the site that has air emissions. Additional opacity observations will be made if an opacity complaint is received from the public.

4.2.4 Odor

Receptors include residents along the river and users of the river such as boaters. Odor measurement is difficult because no instrument has been found to successfully measure odor and all of its components. The human nose is the most effective instrument to measure odor, but personal preference affects what is considered acceptable or offensive. Instruments can measure some compounds that make up odor (e.g., H_2S), but odor is typically a combination of many compounds. A high or low concentration of just one compound is not generally a good indicator of whether an offensive odor is present.

Although odor measurements are difficult, monitoring can be implemented to demonstrate compliance with the ambient air concentration standards. An assessment of potential activities and conditions that could result in exceeding the H_2S standard or in the detection of other odors will be performed during remedial design. However, if an odor complaint is received or if workers detect an unacceptable odor, and the odor is identified as potentially H_2S, H_2S monitoring will commence. At this time, specific locations and frequency for such monitoring cannot be defined, but it is anticipated that two locations would be monitored – one upwind and one downwind of the suspected source of odors.

4.3 Sampling Methods

4.3.1 PCBs

High-volume air samplers (e.g., Tisch or Andersen PS-1) fitted with a polyurethane foam (PUF) cartridge and a glass-fiber filter will be used for sampling for PCBs in ambient air, where practical. This sampling approach is consistent with EPA Method TO-4A (January 1999). The detection limit for PCBs, expressed as an Aroclor-based total PCB concentration, is expected to be 30 nanograms per cubic meter (ng/m^3) employing this methodology. Lower-volume pumps, which operate with a rechargeable battery, may be used in locations where electricity is not available, provided that a 24-hour sample can be collected. This sampling approach is consistent with EPA Method TO-10A (January 1999). Procedures and modifications, if any, for these methods will be described in the Phase 1 RAM QAPP.

4.3.2 Criteria Pollutants

No sampling for criteria pollutants is anticipated to be required. However, if such sampling is required, the sampling methods will be specified in the Phase 1 EMP and Phase 1 RAM QAPP.

4.3.3 Opacity

A certified observer will visually observe opacity using EPA Method 9 at the point of emission and record this reading using Method 9 datasheets in a field log. A detailed procedure with be provided in the Phase 1 RAM QAPP.

4.3.4 Odor

When sampling for H_2S is warranted, H_2S levels will be measured via direct readings using a hand-held meter (e.g., Arizona Instruments Jerome Meter) or, when this is not possible, via collection in an evacuated Tedlar bag followed by measurement using a hand-held meter. In the latter case, the H_2S meter can be brought to the sample or the sample can be transported in the Tedlar bag to the meter for direct measurement of H_2S. The Tedlar bag will allow multiple samples to be collected simultaneously and will allow more rapid deployment of the sampler. These samples will be collected over a one-hour period using a low-volume sampling pump that draws ambient air into the evacuated bag. These devices will be available at the processing facility, at barge unloading areas, and at shoreline locations, such that pumps and bags can be readily deployed to the site of the odor in the event of a complaint. A detailed procedure with be provided in the Phase 1 RAM QAPP.

4.4 Analytical Methods

4.4.1 PCBs

Air samples will be analyzed for PCBs, using a gas chromatograph fitted with a capillary column in combination with an electron capture detector (GC/ECD). Results will be reported as Aroclor-based PCBs concentrations, consistent with Method TO-4A. However, this analytical method will be optimized for monitoring Hudson-specific PCB air samples collected at the site, so that the results present accurate total PCB quantitation. The procedure to optimize the GC/ECD analysis will be described in the Phase 1 RAM QAPP.

Under routine monitoring conditions, the laboratory will be required to report the PCB results within 72 hours of receipt of the air sample by the laboratory. A shorter turnaround time of 48 hours will be employed during start-up or when changes in operations take place, such as relocation of dredging operations; this shorter turnaround time will be used for the 5 consecutive days of monitoring in such circumstances. Additionally, a turnaround time of 48 hours will be employed in situations where PCB concentrations in any sample exceed the daily average total PCB standards or are greater than the Concern Levels (which represent 80% of the Standard Levels). Such contingency sampling is discussed further below.

4.4.2 Criteria Pollutants

No sampling for criteria pollutants is anticipated to be required. However, if such sampling is required, the analytical methods will be specified in the Phase 1 EMP and Phase 1 RAM QAPP.

4.4.3 Opacity

A certified EPA Method 9 opacity reader will make and record observations for opacity; as such, no analytical methods will be needed.

4.4.4 Odor

H_2S levels will be determined by hand-held direct reading H_2S monitors (e.g., Arizona Instruments Jerome meter). When the Tedlar bag sampling method is used, ambient air samples will be collected over a 1-hour period at the location of an odor complaint, employing an evacuated Tedlar bag fitted with a sampling pump. Measurement of H_2S concentrations in each bag will then be made with a portable meter. In those instances where the odor complaint occurs near the location of the hand-held meter, the Tedlar bag sample may not be necessary as H_2S concentrations can be measured directly with the meter. A detailed procedure will be provided in the Phase 1 RAM QAPP.

4.5 Contingency Monitoring

In the event of an exceedance of the PCB Concern Level or PCB Standard Level or receipt of an odor complaint, contingency monitoring will be performed as outlined below. Details regarding the contingency monitoring will be provided in the Phase 1 RAM QAPP and Phase 1 RA CHASP.

4.5.1 PCBs

If a Concern Level is exceeded (i.e., daily average PCB concentration greater than 80% of the Standard Level), then the following contingency monitoring will occur:

- Examine background PCB concentrations (sampling-event-specific as well as baseline database) and site-specific meteorological data to assist in PCB emissions source identification; and
- Reduce analytical turnaround time to 48 hours from the receipt of the sample at the laboratory.

If the daily average total PCB concentration exceeds the Standard Level, then the following contingency monitoring will occur:

- Establish additional monitoring stations as needed to evaluate cause of increased emissions, utilizing the three-tiered site selection process described above;
- Examine background PCB concentrations (sampling-event-specific as well as baseline data base) and site-specific meteorological data to assist in PCB emissions source identification;
- Reduce laboratory turnaround time to 48 hours; and

- Continue monitoring to confirm compliance with the standard.

4.5.2 Odor

In the event of an odor complaint, the complaint will be recorded and investigated in accordance with the Phase 1 RA CHASP and its Scope. If an odor complaint is received from workers or the public and the odor is identified as potentially H_2S, sampling will be implemented to confirm and measure H_2S concentrations. If the H_2S standard is exceeded or there are recurrent odor complaints, H_2S monitoring will be conducted on a regular basis until compliance with the standard is established. This monitoring will include the use of Tedlar bags for the collection of 1-hour air samples, with subsequent analyses employing a hand-held meter (e.g., Arizona Instruments Jerome). Mitigation measures and associated monitoring will be evaluated and implemented as appropriate, and this action will be recorded in a log.

4.6 Data Reporting

4.6.1 PCBs

Regular weekly progress reports will be submitted to the EPA that include information related to PCB concentrations in air near the processing facility and dredging operations, ambient (background and baseline) PCB levels, and monitoring plan adjustments. These weekly reports will be provided to the EPA in conjunction with the project implementation schedule. Report content and distribution will be described in the Phase 1 RAM QAPP.

The EPA will be notified of an exceedance of the 24-hour PCB standard promptly, but no later than 3 hours following receipt of the analytical data. In the event of an exceedance, a report will be developed that includes an analysis of the reasons for the exceedance and a description of any mitigation measures. The written report will be provided to the EPA within 3 working days of the discovery of the exceedance. This report will include background and baseline monitoring data to help determine whether the project is the source of the exceedance or whether there are external reasons for the exceedance. A summary of data collected at the on-site meteorological station (e.g., wind rose) will also be provided in support of report findings and conclusions regarding the potential source(s) of the PCBs. Contingency report content and distribution will be described in the Phase 1 RAM QAPP.

4.6.2 Odor

During dredging operations, a monthly report will be submitted to the EPA summarizing the monitoring activities for the previous month. The summary will be in tabular format and will include a log of any odor complaints, monitoring, and the necessary information and follow-up actions needed to resolve the complaint. An example of the log will be included in the Phase 1 RAM QAPP and Phase 1 RA CHASP.

The EPA will be notified of odor complaints from the public or of an exceedance of the H_2S performance standard within 24 hours of discovery. A report outlining the reasons for the exceedance and any mitigation measures taken will be submitted to the EPA within 10 days of the event. Report content and distribution will be described in the Phase 1 RAM QAPP and Phase 1 RA CHASP.

5. Noise Monitoring

The purpose of the Noise Monitoring Program is to allow the RA team to make operational changes to mitigate any potential noise impacts.

5.1 Objectives and Criteria

The objectives and criteria of noise monitoring are described in this section, which is organized as follows:

- Noise standards;
- Monitoring locations and frequency;
- Sampling and analytical methods;
- Contingency monitoring; and
- Reporting.

5.2 Noise Standards

The QoLPS criteria for noise that have been developed for the remedial action, as set forth in the *Hudson QoLPS* (p. 6-25), are as follows:

- Short-Term – These criteria apply to facility construction, dredging, and backfilling activities:

    - Residential Control Level (maximum hourly average)
      Daytime = 75 dBA (A-weighted decibels)

    - Residential Standard (maximum hourly average)
      Daytime = 80 dBA
      Nighttime (10:00 pm – 7:00 am) = 65 dBA

    - Commercial/Industrial Standard (maximum hourly average)
      Daytime and nighttime = 80 dBA

- Long-Term – These criteria apply to processing facility and transfer operations:

  - Residential Standard (24-hour average)
    Day-night average = 65 dBA (after addition of 10 dBA to noise levels measured from 10:00 pm to 7:00 am)

  - Commercial/Industrial Standard (maximum hourly average)
    Daytime and nighttime = 72 dBA

The attenuation model will be utilized to predict and evaluate noise levels and the results are presented in the Phase 1 IDR. If there is a predicted exceedance at a receptor location, based on a scaling factor relative to the monitoring point as predicted by an attenuation model, noise controls will be integrated into the design.

During project operations, the attenuation model will be used to evaluate noise levels at the receptor based upon noise levels on the perimeter of the facility or dredging area. A predicted exceedance will trigger additional monitoring at the point of exceedance or, if possible, the nearest possible receptor. If the additional monitoring shows attainment of the standard, the predicted exceedance will be reported with a note that monitoring at the receptor demonstrated attainment. If additional monitoring shows continued exceedances of the standards, the project team will implement a contingency monitoring program, which is discussed later in Section 5.4 - Contingency Monitoring.

5.3 Monitoring Locations and Frequency

Potential noise impacts due to Phase 1 project activities can be divided into short- and long-term impacts for both residential and commercial/industrial environments in the daytime and nighttime. The compliance point for noise monitoring will be at the nearest receptor, either industrial or residential. If it is determined that noise levels are below the standards closer to the source of the noise, then the closer locations will be considered acceptable for demonstrating attainment of the standards. During the design, more accurate information will become available to better specify noise monitoring locations.

Monitoring will be conducted in the slow response mode for continuous equivalent sound level over a 1-hour period (L_{eq}(h)) at the receptor location while the process or activity is at peak load. The L_{eq} monitoring duration can be shortened for sources having steady noise emission levels.

Monitoring will be conducted on a regular basis (at a minimum of every 4 hours) during construction of the processing facility. Potential reduction of the monitoring frequency will be evaluated on an ongoing basis, with reductions implemented if approved by EPA. Once construction has been completed, monitoring will be conducted during the startup of the facility (to validate design assumptions) and on a regular basis during typical facility operations. If noise levels measured at monitoring locations during the remedial action indicate, based upon predictive analyses, that noise levels at a given receptor would exceed the Control Level or limits established by the standard, that receptor location will be monitored, if practical, to demonstrate attainment. Monitoring frequency will be increased if the daytime Control Level or nighttime standard is exceeded. In addition, more frequent monitoring (i.e., hourly monitoring) will be conducted as needed to evaluate changes in operations or to respond to complaints. Background levels will be measured in cases where noise levels approach the standard or to distinguish between project-related and non-project related noise. Where and when possible, routine monitoring locations will be at the fenceline of the processing and unloading facilities and the shoreline of the river, adjacent to dredging operations.

At the beginning of Phase 1, a noise study will be conducted to collect noise level data from the dredging operation at various distances. The noise study will be a 2-week study, which will measure noise emissions from the dredging, barge transport, unloading, and processing operations. This study will measure 1-hour L_{eq} noise for all major operations. There will be approximately 20 full 1-hour sampling events for dredging, barge transport, unloading, and processing facility operations, cumulatively. Data gathered from this study will be used to validate design and to confirm that the operations are attaining the noise standard as set forth in the QoLPS. In addition, based on this information and using calculations for noise attenuation over distance, noise monitoring requirements may be modified, with EPA concurrence, during the dredging of some locations where the nearest receptors are distant or noise levels are consistent. During Phase 1 dredging, monitoring will be conducted on a regular basis (a minimum of every 4 hours) while the dredging and backfilling operations are ongoing if receptors have been determined to be within the impact range of the project (i.e., within the range where the model indicates that there could be an exceedance of the standard.) Potential reduction of the monitoring frequency will be evaluated on an ongoing basis.

Table A5-1 outlines the Noise Monitoring Program for Phase 1 dredging operations.

Table A5-1 – Noise Monitoring Program Summary

Operations	Monitoring Plan	Additional Comments
Background Noise Levels	A 2-week noise monitoring study will be conducted to establish baseline noise levels at the processing facility, as well as at locations that will be representative of receptor locations during Phase 1 dredging operations. A minimum of three 24-hour sampling events will be conducted for the processing facility. A minimum of five 24-hour sampling events will occur along the dredging corridor. This effort will be used to establish 1-hour L_{eq} noise levels at different times of the day for various receptor locations.	Additional background noise data may be needed if background noise levels at receptors are close to or exceed the noise standards.
Phase 1 Noise Study	At the initial startup of Phase 1 dredging operations, a 2-week study will measure noise levels around the dredging, unloading, and processing operations. This study will measure 1-hour L_{eq} noise for all major operations. There will be approximately 20 full 1-hour sampling events making up this noise study. This study will include monitoring data from dredging, barge transport, unloading, and processing facility operations.	
Construction Monitoring	During construction of the processing facilities, noise monitoring will occur at a minimum of every 4 hours. This monitoring will measure 1-hour L_{eq} noise levels.	Should noise monitoring over a 2-week period demonstrate no exceedances of the noise standards, the potential for reducing the frequency of noise monitoring for construction will be reviewed and may propose a modification to the noise monitoring frequency to EPA. Should construction activities exceed the noise standards, additional monitoring will be performed in accordance with Section 5.4 – Contingency Monitoring.
Dredging Operations - Compliance Monitoring	Noise monitoring will be conducted at a minimum of every 4 hours (day and/or nighttime). It is anticipated that many of the noise monitoring locations, for dredging operations, will be located on nearby shorelines.	Should noise monitoring demonstrate no exceedances of the noise standards, the potential for reducing the monitoring frequency will be reviewed and may propose a modification to EPA.

Operations	Monitoring Plan	Additional Comments
Dredging Operations - Contingency Monitoring	Should monitoring results of dredging operations indicate a noise level that exceeds the control level or if a project-related noise complaint is received, monitoring will be conducted for at least 1 hour to demonstrate compliance with noise standards. If the trigger for additional monitoring is a complaint, noise monitoring will be conducted at the location in question from the complaint.	Contingency monitoring is discussed further in Section 5.4 – Contingency Monitoring. Should monitored noise levels demonstrate exceedances of the standards, additional background noise monitoring may be needed to assess the potential impact of non-project-related noise source sensitive receptors.
Processing Operations - Compliance Monitoring	Noise monitoring will be conducted at a minimum of every 4 hours. At a minimum, one monitoring location will be identified for the processing facility and one for unloading operations. The specific locations will be shown in the Phase 1 IDR. The Phase 1 IDR will also show modeled results from processing and unloading operations that will help focus on specific areas adjacent to the processing facility that may be of concern. For each monitoring location, the Phase 1 IDR and *Final Design Reports* will identify the nearest receptors. The distance from the monitoring location to the nearest receptors will be used to model noise levels throughout the day and evening, as measured at the monitoring locations, which would keep project operations within Compliance and Concern Levels.	
Processing Operations - Contingency Monitoring	Should monitoring results of processing/unloading operations indicate a noise level that exceeds the control level, monitoring will be conducted to demonstrate compliance with noise standards. If the trigger for additional monitoring is a complaint, then noise monitoring will be conducted at the location in question from the complaint.	Should monitored noise levels demonstrate exceedances of the standards, additional background noise monitoring may be needed to assess the potential impact of non-project-related noise source.

5.4 Monitoring Methods

A Type 1 or Type 2 sound-level meter, as rated by the American National Standards Institute (ANSI), will be used to measure noise levels.

5.5 Contingency Monitoring

Contingency noise monitoring is described conceptually in this Section. The Concern and Exceedance Levels for the QoLPS for noise are described in the *Hudson QoLPS* (p. 6-38). The triggers for taking action to address noise exceedances and complaints at the Control and Exceedance Levels, as well as potential mitigation efforts, are outlined in the Phase 1 ID PSCP Scope and Phase 1 ID RA CHASP Scope and will be discussed further in the Phase 1 PSCP and Phase 1 RA CHASP, as well as in the Phase 1 design reports.

If a noise complaint is received from the public and is verified as project-related, monitoring will be conducted at the site of the complaint as necessary to determine if the Control Level or standard has been exceeded.

In the event that noise levels above the Control Level or a standard are recorded (whether in response to a complaint or otherwise), additional monitoring will be conducted (as needed) to evaluate the cause of noise increases, and noise monitoring will continue until it confirms that noise levels are below the applicable noise standard. In addition, should monitored noise levels demonstrate exceedances of the noise standard as set forth in the QoLPS, additional background noise monitoring may be needed to assess the potential impact of non-project-related noise source on receptors.

Information related to contingency actions that would be employed to mitigate noise exceedances will be provided as part of the Remedial Design documents as well as in the Phase 1 PSCP and Phase 1 RA CHASP.

5.6 Data Reporting

Records of noise measurements will be maintained, including the measurement location, time of measurement, meteorological conditions, identification of significant sound sources, model and serial numbers of all equipment used, and calibration results. These results will be documented on daily noise monitoring field data sheets or by using automated data loggers during times when noise monitoring is being conducted. Noise complaints will be documented as described in the Phase 1 RA CHASP. A monthly report will be sent to the EPA summarizing the monitoring activities for the previous month. The summary will include (in tabular format) the date, time, location, activity being conducted, and results in dBA. The summary will also include (in tabular format) a log of any noise complaints and the necessary information and follow-up action needed to resolve the complaint. Only noise complaints (as opposed to inquiries), as defined in the Phase 1 RA CHASP and its Scope, will be reported on a routine basis.

The EPA will be notified of any exceedances of the noise standard within 24 hours after the discovery. In the event of any occurrence of the Concern Level (as defined in the QoLPS for noise), a follow-up report will be sent to the EPA describing the response. When there is an occurrence of the Exceedance Level, a report outlining the reasons for the exceedance and any mitigation employed will be submitted to the EPA within 10 days of the event.

6. Lighting Monitoring

To meet the project schedule, nighttime activities may be necessary, which would require artificial lighting. Specifically, artificial lighting may be needed for dredging operations, sediment offloading, processing, and rail loadout activities at night; this lighting may affect nearby receptors. This section describes the Lighting Monitoring Program that will be conducted during Phase 1 to implement the QoLPS for lighting. However, the lighting QoLPS will not supersede worker health and safety lighting requirements established by the Occupational Safety and Health Administration (OSHA).

6.1 Objectives and Criteria

The main objectives of the Lighting Monitoring Program are to monitor and assess lighting impacts. The lighting standards established by the EPA in the *Hudson QoLPS* (p. 6-39) are as follows:

- Rural and suburban residential areas = 0.2 footcandle.
- Urban residential areas = 0.5 footcandle.
- Commercial/industrial areas = 1 footcandle.

Similar to other nuisance impacts, all lighting complaints will be addressed as described in the Phase 1 PSCP and Phase 1 RA CHASP and their Scopes.

6.2 Monitoring Locations and Frequency

Potential lighting impacts due to project activities may occur in various types of areas, which can be divided into rural and suburban residential areas, urban residential areas, and commercial/industrial areas. The primary compliance point for the light standards will be at the receptor. However, if it is determined that light levels closer to the source meet the lighting standards, such locations will be considered acceptable for demonstrating attainment.

Light monitoring will be conducted at the property line of the receptors nearest to the dredging operations that have the potential to experience an exceedance of the lighting standards or at locations closer to the lighting source (e.g., the shoreline). Such monitoring will be conducted three times between 10:00 pm and dawn during the first night of dredging activities at a given area to assess achievement of the standard. Monitoring will be repeated whenever the dredging operation is moved to a different dredge area. Monitoring will also be performed during Phase 1 at the perimeter of the processing facility or at the nearest receptor property line when the facility initially begins activities after dusk and when significant changes in lighting for the facility have been made. Complaints will also trigger additional monitoring, as described below.

6.3 Monitoring Method

A footcandle meter will be used to measure illumination.

6.4 Contingency Monitoring

Contingency light monitoring is described conceptually in this Section. The Concern and Exceedance Levels for the QoLPS for lighting are described in the *Hudson QoLPS* (p. 6-45). The triggers for taking action to address lighting exceedances and complaints at the Control and Exceedance Levels, as well as potential mitigation efforts, are outlined in the Phase 1 ID PSCP Scope and Phase 1 ID RA CHASP Scope and will be discussed further in the Phase 1 PSCP and Phase 1 RA CHASP, as well as in the Phase 1 Design Reports.

If a lighting complaint is received from the public and is verified as project-related, monitoring will be conducted at the site of the complaint as necessary to determine if the lighting standard as set forth in the QoLPS has been exceeded.

In the event that light levels above the applicable standard are recorded (whether in response to a complaint or otherwise), regular light monitoring will be conducted (as needed) to evaluate lighting conditions, and will be continued until achievement of the standard is confirmed.

6.5 Data Reporting

Monitoring results will be documented on light monitoring field data sheets. Records of measurements will be made, including specifics of the measurement location, time of measurement, meteorological conditions during the measurement, identification of significant light sources (including non-project-related sources such as streetlights or moonlight), and model and serial numbers of all equipment used to measure illumination. Lighting complaints will be addressed as described in the Phase 1 RA CHASP and its Scope.

A monthly report summarizing the monitoring activities for the previous month will be submitted to the EPA. The summary will be in a tabular format and will include the monitoring results, as well as a log of any lighting complaints received (including date and time received) and a description of the action taken to resolve the complaint.

The EPA will be notified of any exceedances of the lighting standard within 24 hours after the discovery. In the event of any occurrence of the Concern Level (as defined in the QoLPS for lighting), a follow-up report will be sent to the EPA describing the response. When there is an occurrence of the Exceedance Level, a report outlining the reasons for the exceedance and any mitigation employed will be submitted to the EPA within 10 days of the event.

7. *Monitoring of Discharges to Hudson River and Champlain Canal (Land Cut above Lock 7*

The WQ requirements consist of: 1) requirements relating to in-river releases of constituents not subject to the EPS, as set forth in *Substantive Requirements Applicable to Releases of Constituents not Subject to Performance Standards*; 2) the substantive requirements for discharges to the Hudson River and Champlain Canal, as set forth in *Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharges to Champlain Canal (land cut above Lock 7)* and 3) *Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharge to the Hudson River*. These three sets of requirements are contained in a single document in the form of a letter to GE with enclosures that EPA issued on January 7, 2005.

This section addresses the monitoring requirements for discharges to Hudson River and Champlain Canal (land cut above Lock 7), including the associated monitoring requirements, sample and analytical methods, contingency monitoring, and reporting requirements. Requirements relating to in-river releases are detailed in Section 2.

7.1 Discharge Limitations

Effluent limitations for discharges of water from the sediment processing facility are described in Section 8 of the Phase 1 ID PSCP Scope.

7.2 Monitoring Locations and Frequency, Sampling and Analytical Methods

The following monitoring requirements for the above discharges will be implemented. Additional details will be specified in the Phase 1 EMP and the Phase 1 RAM QAPP.

- Discharge flow will be measured continuously with a flow meter.
- pH will be monitored in the discharge monthly in a grab sample.
- All other parameters will be measured weekly, with PCBs to be measured as a 24-hour runtime composite and the other parameters to be measured in grab samples.

- PCBs will be analyzed by EPA Method 608. The laboratory will be instructed to make all reasonable attempts to achieve a MDL of 0.065 µg/L for each Aroclor.
- Mercury will be analyzed by EPA Method 1631.

7.3 Contingency Monitoring/Response Actions

In the event of an exceedance of the discharge limitations, the response actions described in Section 8.3 of the Phase 1 ID PSCP Scope will be performed. If such actions require additional monitoring, the scope of such monitoring will be set forth in the Engineering Evaluation Report described in that Section of the Phase 1 ID PSCP Scope. If additional testing is proposed, the EPA will be notified of the anticipated additional testing.

7.4 Data Reporting

A monthly report will be submitted to the EPA that includes the routine monitoring results for discharges to the Hudson River and the Champlain Canal (Land Cut above Lock 7). Both concentration (mg/L or µg/L) and mass loadings (lbs/day) will be reported for all parameters except flow and pH. In the event of an exceedance of the discharge limitations or PCB detection, a separate report will be prepared and submitted to the EPA , as described in Section 8.3 of the Phase 1 ID PSCP Scope. Copies of monitoring data and reports submitted to the EPA will be provided to the NYSDEC.

Monitoring data, engineering submissions, and modification requests will be submitted to the EPA with a copy sent to the NYSDEC.

8. Special Studies

This section describes the special studies that will be carried out to provide information to evaluate and refine the implementation of the Resuspension Standard. As stated in the *Hudson EPS* (Vol. 2, p. 118): "The special studies will be conducted for limited periods of time to gather information for specific conditions that may be encountered during the remediation or to develop an alternate strategy for monitoring. Specific conditions may include different dredge types, contaminant concentration ranges, and varying sediment textures. Each of these studies is integral to the Phase 1 evaluation, the development of Phase 2, and is also tied to compliance issues."

The Resuspension Standard (*Hudson EPS*, Vol. 2, pp. 118 *et seq.*) specifies the following special studies:

- Near-field PCB Release Mechanism (Near-field PCB Concentrations);
- Development of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-field and Far-field Stations (Bench Scale);
- Development of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-field and Far-field Stations (Full Scale);
- Non-Target, Downstream Area Contamination; and
- Automated Monitoring (referred to the in *Hudson EPS* as "Phase 2 Monitoring Plan").

As discussed in Section 2 of this Phase 1 ID RA Monitoring Scope, the special study directed to developing a TSS surrogate relationship and the special study on automated monitoring are described in separate work plans (QEA 2005a and 2005b). This section presents the work plans for the special studies of Near-field PCB Release Mechanism and Non-Target Downstream Area Contamination.

8.1 Near-Field PCB Release Mechanism

8.1.1 Objective

The objective of this study is to determine the nature of PCB release during dredging (sediment resuspension/particle-associated or dissolved phase mechanism). If near-field TSS concentrations can be considered a reliable indicator of PCB releases due to dredging-related activities then real-time TSS surrogate measurements that will be taken at near-field stations may be used to identify when modifications of dredging activities to reduce resuspension are needed and to anticipate when elevated PCB concentrations may be expected at far-field monitoring stations.

8.1.2 Study Areas

The study will be carried out at multiple locations so that a range of dredging conditions can be evaluated (e.g., different sediment types (cohesive and non-cohesive), PCB concentration ranges, and the range of dredge types expected to be selected in the Final Design Reports). Five locations have been chosen, four in the Northern Thompson Island Pool (NTIP) and one to the east of Griffin Island (EGIA) (Figures A8-1 and A8-2). The characteristics of these locations are summarized in Table A8-1:

Table A8-1 - Summary Statistics for Special Study Areas

Location (Figures A8-1 and A8-2)	Side-Scan Sonar Designation	Mean % Silt & Clay	Mean % Fine Sand	Mean % Med./Coarse Sand & Gravel	Mean % Organic	Mean T-PCB Conc. (ppm)	Mean DOC (in.)	Mean Tri+ PCB MPA (g/m2)
1	Transitional	24	31	44	1	17	15	8
2	Transitional	18	8	73	1	32	27	18
3	Sand	9	21	68	2	34	25	17
4	Fine	19	45	34	2	50	33	18
5	Fine	73	17	11	0	444	21	24

Notes:
1. Mean DOC and mean tri+ PCB MPA are area-weighted.
2. Mean percent sediment type and the mean total PCB concentration are volume-weighted, and are calculated using measured or extrapolated data down to the average depth of dredging.
3. Average depth of dredging is based on the 6/8/05 version of the married grid which covers both dredge and non-dredge areas.

8.1.3 Monitoring Frequency and Duration

Discrete monitoring of each study area will be performed on three occasions, spaced approximately 2 days apart.

8.1.4 Monitoring Stations

A single background station will be located about 100 m upstream of the dredging activity near the approximate centerline of flow through the area of dredging activity. This station will be coincident with the upstream near-field station used to assess compliance with the Resuspension Standard so that the other parameters measured at this station may be factored into the interpretation of the study results. To monitor the loss of TSS due to settling and the desorption of PCBs that occurs as resuspended sediments are transported downstream, transects will be placed at nominal distances (e.g., 30 m, 100 m, and 300 m) downstream of the dredging activity in the approximate center of the plume. Sampling in close proximity to the near-field stations will provide measurements of PCB phase distribution that directly address the issue of the correlation between near-field TSS surrogate measurements and PCB release. The three downstream transects will be placed within the dredging TSS plume so as to remain within the central two-thirds of the plume based on the increased levels of turbidity and TSS. A boat-mounted Acoustic Doppler Current Profiler (ADCP) or continuous reading turbidity probe will be used to characterize the plume (e.g., location, width). The Phase 1 RAM QAPP will provide justification for the technique to be used to characterize the plume. In the event that the ADCP is not used or is not sufficiently sensitive to TSS conditions, the continuous reading turbidity probe will be used to vertically profile the dredge plume along each cross section. The coordinates of the end points of each transect will be established using GPS and marked using small buoys.

8.1.5 Sampling Methods

The background sample will be a single depth-integrated composite. At locations downstream of the dredging, sampling will be conducted at 0.2 and 0.8 of the water depth at each monitoring station. One sample will be collected at each location per sampling event, compositing the samples from each depth. For PCB samples, water will be pumped from these depths through an in-line filter using a peristaltic pump. The pumping rate will be set at a rate that will result in collecting approximately 8L of water over a one hour period. The sampling vessel will move back and forth laterally across the river along the transect at idle speed during sample collection. The pump intake tubing will be attached to a downrigger or similar device to maintain depth while moving. The level of the intake tubing will be adjusted as the boat is moving to compensate for significant changes in bathymetry. A second pumping system will be used concurrently to collect a sample for TSS analysis. Pumping will be temporarily suspended to allow changing of filters, as required. All of the filters used, and all of the filtrate generated, will be submitted for laboratory analysis. Upon completion of sampling at one transect, the sampling vessel will move downstream and begin sample collection at the next transect.

During the period of sampling, continuous monitoring will be performed at each sampling location for DO, conductivity, temperature, pH, particle distribution, and turbidity; these measurements will be logged at a minimum frequency of one minute. Continuous water column monitoring data will be acquired using a YSI 6000 Series multi-parameter probe, or equivalent. Continuous monitoring data will also be available from the near-field monitoring stations during each sampling event.

8.1.6 Analytical Methods

8.1.6.1 Suspended Solids

The composite water samples will be analyzed for suspended solids using EPA Method 160.2 with modifications to be consistent with American Society for Testing and Materials (ASTM) Method D 3977-97.

8.1.6.2 PCBs

The solids on the filter and the filtrate will be analyzed for PCBs using the modified Green Bay Method (mGBM) and extraction protocols used during the BMP.

8.1.6.3 Organic Carbon

The composite water samples will be analyzed for DOC using EPA Method 415.1, as described in the BMP QAPP and POC via filtration and combustion of the filtered material (Lloyd Kahn method).

8.1.7 Reporting

The procedures and schedule for reporting the results of this special study will be provided in the Phase 1 RAM QAPP.

8.2 Non-Target, Downstream Area Contamination

8.2.1 Objective

The objective of this study is to determine the extent of contamination in terms of spatial extent, concentration and mass of Tri+ PCB contamination deposited downstream from the dredged target areas in non-target areas, that is, to determine the extent to which resuspension induced by dredging activities results in the movement of PCBs to non-target areas. Such movement is expected and is of consequence if the PCB levels in the non-target areas are materially increased. Knowledge of the nature and extent of this movement and its relationship to the type of sediment being dredged, its PCB concentration, and the physical setting may provide a means to assess the need for resuspension controls to prevent the contamination of non-target areas to levels exceeding the mass per unit area (MPA) and surface Tri+ PCB concentration thresholds for dredging.

8.2.2 Study Areas

The study will be carried out at multiple locations so that a range of dredging conditions can be evaluated (e.g., different sediment types (cohesive and non-cohesive), PCB concentration ranges, and the range of dredge types expected to be selected in the Final Design Reports). Three locations have been chosen and are: 1) a location within transitional sediments in NTIP (Location 1 in Table A8-1 and on Figure A8-1); 2) a location within sandy sediments in NTIP (Location 3 in Table A8-1 and on Figure A8-1); and 3) a location within fine sediments in EGIA (Location 5 on Table A8-1 and Figure A8-2).

8.2.3 Monitoring Frequency and Duration

The monitoring period for each study area will extend over the entire time that the study area is being dredged, which will likely be a period of several weeks. Obtaining useful data will be complicated due to changes in the location of the dredging activity in relation to the sampling locations (i.e., to the extent that the distances between the sampling points and the dredging activities vary, it will be difficult to interpret the data). Six rounds of data will be obtained at approximately equal time intervals. The length of these time intervals will be determined by subdividing the estimated time required to dredge the target area by 6. Time intervals are anticipated to be between a few days to a few weeks depending on dredging productivity. The frequency of monitoring may be adjusted during the study to reflect actual dredging progress. At a minimum, the study will consist of approximately 3 weeks per study area unless dredging in a study area is less than 3 weeks in duration. No sampling interval will be less than 3 days to avoid obtaining non-detect results.

8.2.4 Monitoring Stations

Stations will be located within an area extending not more than 300 m downstream of the dredging activity. Because substantial lateral gradients in deposition are expected due to the distribution of TSS in the resuspension plume, stations will be located along transects perpendicular to the plume. Five stations about 15 m apart will be located on each of the first 3 transects. Transects will be set at nominal distances of 15m, 30 m, and 100 m. downstream of the furthest downstream extent of the dredging within the targeted area. Two additional sampling nodes will be placed 300 m downstream, 15 m to either side of the assumed centerline of the plume. The coordinates of the station locations will be established using GPS.

Initially, the locations of these transects will be much further from the dredge than the distances specified above (assuming that the dredging will proceed from upstream to downstream.). Tracking of the dredge position and measuring the accumulation of sediment at the downstream monitoring stations on a temporal basis will provide data to perform an analysis of sediment deposition characteristics for distances greater than 300 m. As the dredging operation approaches the downstream end of the dredge area, data will be obtained at the proper distances to assess the modeling results.

8.2.5 Sampling Methods

Sediment deposition will be monitored by deploying sediment traps at the stations described above. The final design and deployment procedures for the sediment traps will be defined in the RAM QAPP. The sediment traps will be deployed in pairs. Sediment mass will be measured in one of the two traps at each monitoring time interval (primary trap), and redeployed. The secondary traps in each pair will be retrieved upon the completion of the dredging in the target area upstream of the study area. The mass and PCB concentration of the sediment collected in the secondary traps will be measured.

The sediment samples will be removed from the traps by decanting water that overlies the sediment that has accumulated to the extent possible without losing solids. The remaining water and sediment will be poured from the trap into a collection vessel; the traps will then be rinsed with distilled water and the rinsate also placed in the collection vessel. After rinsing, the primary traps will be redeployed.

8.2.6 Analytical Methods

8.2.6.1 Mass of Solids

The mass of solids that is captured in the sediment traps will be determined by filtering, drying, and then reweighing the sample. The specific method will be presented in the Phase 1 RAM QAPP.

8.2.6.2 PCBs

The sediments collected from the traps will be analyzed for Aroclor-based PCBs using Method GEHR8082, with the same target reporting limit and MDL specified in Section 3.4 above. The PCB Aroclor data will be converted from total PCBs to Tri+ PCBs using the EPA-approved regression model to be developed in accordance with Section 3.4; and the results will be reported as Tri+ PCBs.

8.2.6.3 Organic Carbon

The sediments collected from the traps will be analyzed for POC using the Lloyd Kahn method.

8.2.7 Reporting

The procedures and schedule for reporting the results of this special study will be provided in the Phase 1 RAM QAPP.

9. References

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Figures

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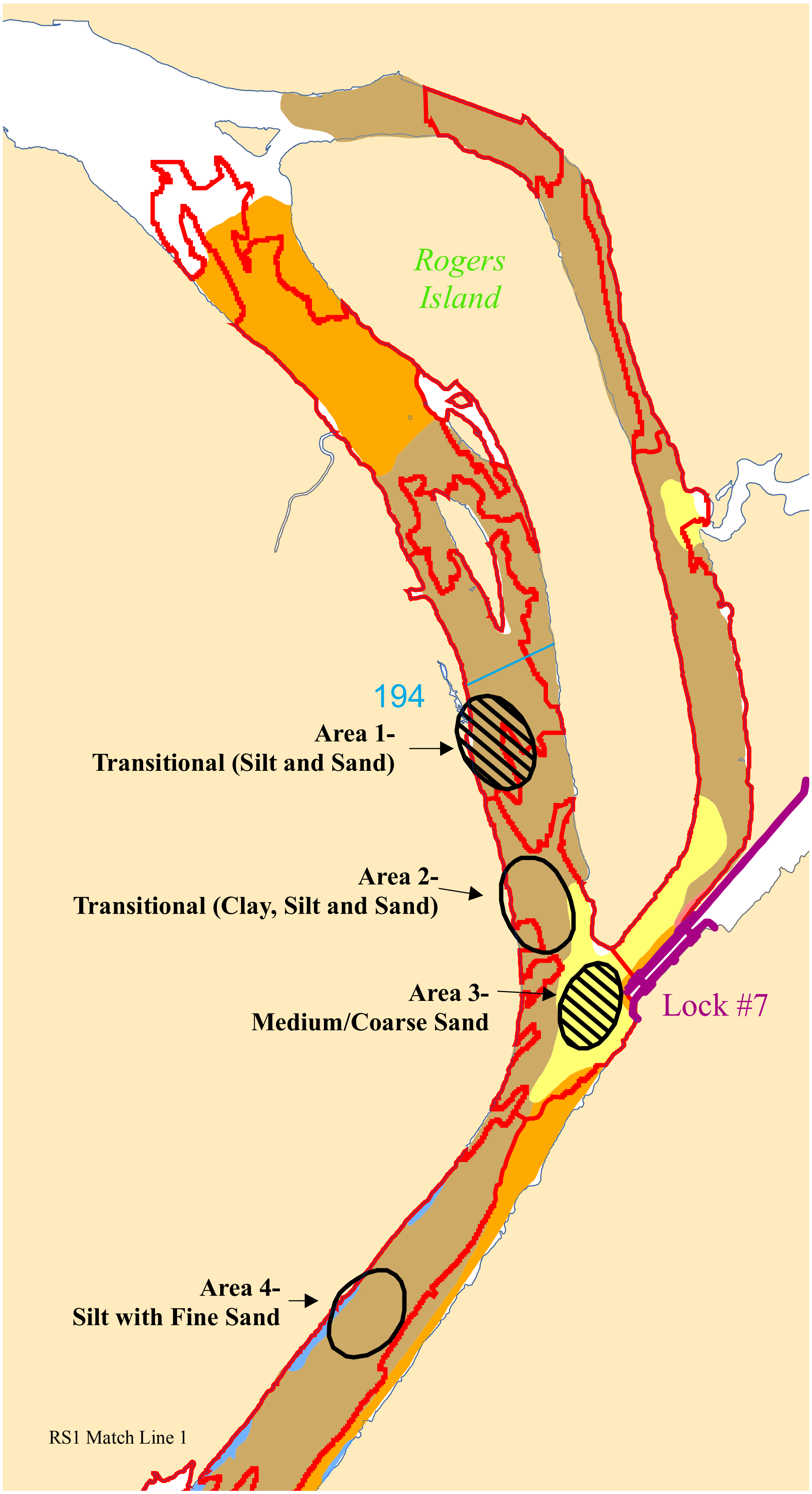
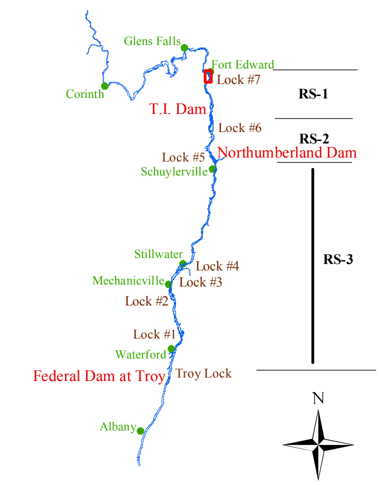


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- Dams and Locks
- River Miles
- Shore Line
- Land

Dredge Areas

- Phase 1 Dredge Areas
- Preliminary Phase 2 Dredge Areas

Special Studies

- Near-Field PCB Release Mechanism Study Areas
- Near-Field PCB Release Mechanism and Non-Target, Downstream Area Contamination Study Areas

Sediment Type

- Type I
- Type II
- Type III
- Type IV
- Type V

FIGURE A8-1

Proposed locations for special studies in NTIP.

QEA Quantitative Environmental Analysis, LLC

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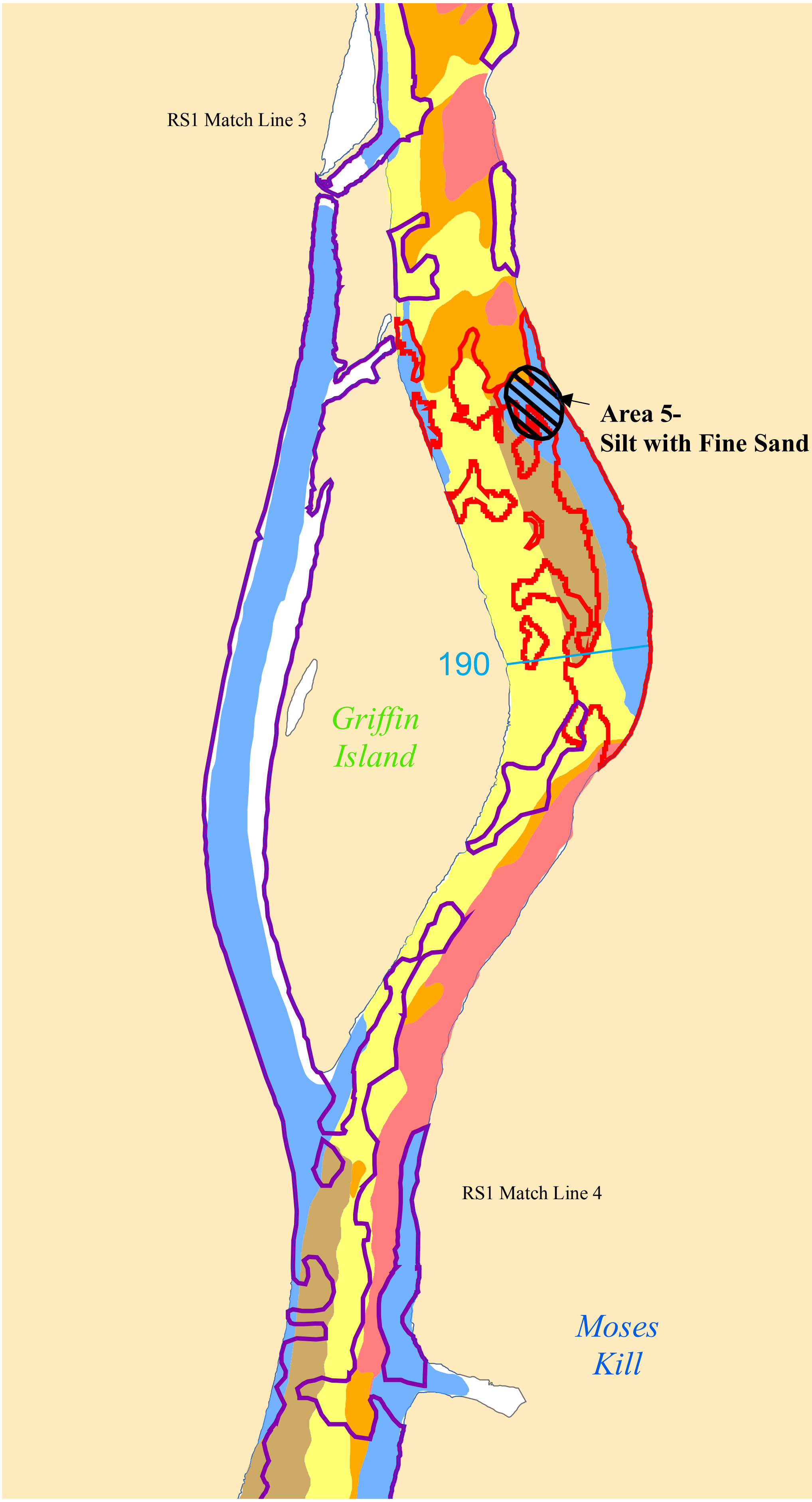
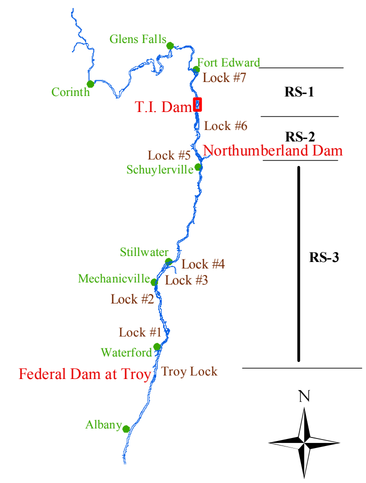


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- Dams and Locks
- River Miles
- Shore Line
- Land

Dredge Areas

- Phase 1 Dredge Areas
- Preliminary Phase 2 Dredge Areas

Special Studies

- Near-Field PCB Release Mechanism Study Areas
- Near-Field PCB Release Mechanism and Non-Target, Downstream Area Contamination Study Areas

Sediment Type

- Type I
- Type II
- Type III
- Type IV
- Type V

FIGURE A8-2

Proposed locations for special studies in EGIA.

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Phase 1 Intermediate Design Report Hudson River PCBs Superfund Site

Attachment B – Phase 1 Intermediate Design Remedial Action Community Health and Safety Program Scope

General Electric Company
Albany, New York

August 22, 2005

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Attachment B - Phase 1 Intermediate Design Remedial Action Community Health and Safety Program Scope

August 22, 2005

Table of Contents

1. Introduction and General Requirements

This *Phase 1 Intermediate Design Remedial Action Community Health and Safety Program Scope* (Phase 1 ID RA CHASP Scope [Attachment B]) provides a description of the elements to be included in the *Phase 1 Remedial Action Community Health and Safety Plan* (Phase 1 RA CHASP) that will be submitted with the *Phase 1 Final Design Report* (Phase 1 FDR) for the Remedial Action (RA) for the Upper Hudson River. This Phase 1 ID RA CHASP Scope also provides a more detailed description of certain key elements of the community health and safety program to be designed and implemented for Phase 1 of the RA. The RA CHASP will be consistent with this Phase 1 ID RA CHASP Scope.

1.1 Background

In August 2003, the General Electric Company (GE) and the United States Environmental Protection Agency (EPA) executed an Administrative Order on Consent for Hudson River Remedial Design and Cost Recovery (RD AOC), effective August 18, 2003 (Index No. CERCLA-02-2003-2027), under which GE agreed to design the RA provided for in the Record of Decision issued by the EPA in 2002 for the Hudson River PCBs Superfund Site. That RA will be conducted in two phases – Phase 1, which will consist of the first year of dredging (at a reduced rate), and Phase 2, which will consist of the remainder of the dredging project. The *Remedial Design Work Plan* (RD Work Plan) that was attached to the RD AOC requires, among other things, that GE submit an RA CHASP with its FDRs for Phase 1 and Phase 2. The RD Work Plan specifies, in Section 4.4, that the Phase 1 RA CHASP will apply to on-site activities and will include a number of specified elements. Each of the elements specified in the RD Work Plan is listed below, along with additional details on the information to be included with each element.

1. Introduction, listing plan objective, site background, and site description, including:

    - Description of the purpose of the Phase 1 RA CHASP;
    - Description of the Phase 1 RA CHASP organization;
    - Summary of associated documents (e.g., Phase 1 FDR, *Phase 1 RA Monitoring Quality Assurance Project Plan* [Phase 1 RAM QAPP], worker *Health and Safety Plan* [HASP]) and their relationship to the Phase 1 RA CHASP;
    - Statement that this is a "stand alone" document and that, where appropriate, information from other documents is presented in an abbreviated form for completeness and readability; and

- Statement that the Phase 1 RA CHASP has taken full account of and has been developed based on the requirements outlined in the Quality of Life Performance Standards (QoLPS), and other relevant documents.

2. Summary of the RA program, including:
   - Description of each major program element and the activities associated with those elements, indicating which activities are associated with river operations (e.g., dredging) and which are associated with facility operations (e.g., transfer/processing); and
   - Description of how these elements provide the basis for the hazard analysis.

3. Project schedule and operations schedule, including:
   - Summary of activities by season;
   - Description of typical hours of operation;
   - Description of duration of activities (e.g., number of days within specific geographic areas);
   - Description of foreseeable reasons why work schedule may change; and
   - Description of notification plans in the event that there are significant changes to the schedule.

4. Description of potential hazards to the surrounding community associated with RA activities, including:
   - For each activity, description of associated hazards (both physical and chemical), potential impacts and measures to be taken to manage the hazards. Hazards will be prioritized based on potential seriousness and relevance to the local community. Information on how these hazards may impact the community will be discussed.

5. Site security plan, including:
   - General information regarding security for project areas, discussing river activities separately from facility activities; and
   - Details regarding access control for the processing site and active dredge areas.

6. Contingency plan for spills and releases during RA field activities, including:
   - Description of requirements for prevention (including best management practices), containment, cleanup, and notification for spills and releases that may affect the community; and
   - Information regarding emergency response (i.e., hospitals, lists of contacts, etc.).

7. Description of how each public hazard will be managed, including actions to be taken if the environmental monitoring indicates the need for corrective action, including:
   - Description of each activity, associated hazards assessed, potential impacts to the community identified, and measures to be taken to manage the hazards, primarily through prevention;
   - Discussion of the relevance and severity of the potential hazard to the community; and
   - Discussion of best management practices for hazard prevention.

8. Overview of the QoLPS as they relate to community health and safety, including:
   - Description of how the Phase 1 RA CHASP is related to the QoLPS.

9. Discussion of protection of water supplies and references to the attendant monitoring program, including:
   - Description of the program for addressing all river water uses (e.g., house water intakes, agricultural intakes, public drinking water intakes); and
   - A listing of all known water intakes.

10. Section identifying the site safety personnel and their qualifications, responsibilities, and contact information, including:
    - Definition of the role and responsibilities of emergency response organizations.

11. Emergency procedures, including emergency contact telephone numbers, hospital directions, medical and fire emergency procedures, and list of emergency equipment located on-site, including:
    - Description of how the emergency contacts and responder information was developed, with appropriate references to the worker HASP.

12. Figures, including:
    - Flow charts of complaint process; and
    - Flow charts of notification process.

In spring 2004, the EPA issued Engineering Performance Standards (EPS) and QoLPS for Phase 1 of the RA. The EPS address resuspension during dredging, residual concentrations of polychlorinated biphenyls (PCBs) in sediments after dredging, and dredging productivity. The QoLPS address impacts related to air quality, odor, noise, lighting, and navigation. In accordance with the QoLPS, the Phase 1 RA CHASP will identify equipment, personnel, and specific procedures for protecting residents and workers, and educating and informing the public on project progress. In addition as the QoLPS state further (page 5-3), the Phase 1 RA CHASP will provide information for the public on the following:

- Worker education and monitoring (including a summary of the HASP);
- Air monitoring (including a summary of routine, control, and exceedance monitoring);
- Contingency plan (including a summary of the design elements intended to control exceedances);
- Complaint management program (including a summary of the program, with flow charts to define the process); and
- Site health and safety personnel contact information.

This Phase 1 ID RA CHASP Scope specifies the required contents of the Phase 1 RA CHASP, as well as some of the key elements to be included in GE's community health and safety program for Phase 1 of the RA.

1.2 General Requirements

The Phase 1 RA CHASP will contain the elements listed in Section 4.4 of the RD Work Plan, as specified above. In addition, the Phase 1 RA CHASP will set forth contingency plans and actions, to be developed during Phase 1 Remedial Design (RD) and to be implemented during Phase 1 of the RA, for responding to and mitigating adverse impacts on air quality, odor, noise, lighting and navigation, which are the subject of the QoLPS. The Phase 1 RA CHASP will also describe a complaint management program for responding to complaints relating to these parameters, as well as to water quality. It will also provide site health and safety personnel contact information as part of a directory of emergency contacts. The Phase 1 RA CHASP will be developed as a stand-alone document, containing relevant information affecting community health and safety. The community will be involved in the development of the Phase 1 RA CHASP.

Where provisions addressing community health and safety are set out in other documents, the information will be summarized or re-iterated in the Phase 1 RA CHASP, as appropriate. Items that will be covered in documents other than the Phase 1 RA CHASP include the following:

- Worker education and monitoring will be addressed in the HASP to be provided as part of the *Phase 1 Remedial Action Work Plan* (Phase 1 RAWP) in accordance with Section 4 of the *Phase 1 Intermediate Design Report* (Phase 1 IDR). The separate standards applicable to workers with regard to issues such as air, lighting, noise, and safe operation of project-related watercraft will be summarized in the HASP.

- Routine, as well as contingency, monitoring requirements for surface water, air quality, hydrogen sulfide (H_2S) odor, noise, and lighting are described in the *Phase 1 Intermediate Design Remedial Action Monitoring Scope* (Phase 1 ID RA Monitoring Scope) provided in Attachment A of the Phase 1 IDR, and will be discussed further in the *Phase 1 Environmental Monitoring Plan* (Phase 1 EMP) and the Phase 1 RAM QAPP.

- Contingency actions (other than increased monitoring) for responding to exceedances of the action levels specified in the Resuspension Performance Standard and the water quality certification (WQC) requirements for in-river releases of constituents not subject to performance standards are described in the *Phase 1 Intermediate Design Performance Standards Compliance Plan Scope* (Phase 1 ID PSCP Scope) provided in Attachment C to the Phase 1 IDR, and will be discussed further in the *Phase 1 Performance Standards Compliance Plan* (Phase 1 PSCP) to be provided as part of the Phase 1 RAWP.

The following sections of this Phase 1 ID RA CHASP Scope provide a further explanation and description of certain components of the Phase 1 community health and safety program. Section 2 describes the design and implementation of contingency plans and actions to address exceedances of the quantitative standards (or Control Levels) set forth in the QoLPS for air quality, odor, noise, and lighting and deviations from the substantive requirements in the QoLPS for navigation. Section 3 describes the community notification program and the process to be followed in managing and responding to public complaints related to air quality, odor, noise, lighting, and navigation, as well as water quality. The Phase 1 design reports (insofar as they address these issues) and the Phase 1 RA CHASP will be consistent with this Scope.

Consistent with the RD Work Plan, this Scope is, and the Phase 1 RA CHASP will be, limited to addressing potential community hazards and impacts that occur in the vicinity of the Upper Hudson Work Area (as defined in the Consent Decree) and are associated with RA activities in this area. Hazards relating to off-site transport and disposal of dredged material, as well as those relating to delivery of raw materials and equipment prior to arrival at the Upper Hudson Work Area, are the responsibility of the transporters and disposal facilities and will not be addressed in the Phase 1 RA CHASP. However, the Phase 1 RA CHASP will include anticipated local traffic routings and a description of the transportation requirements which would apply to these shipments (e.g., DOT regulations, appropriate licensing of carriers/drivers, labeling, and placarding). In addition, GE will work with local first responders in an effort to establish appropriate response protocols to include in the Phase 1 RA CHASP.

In addition, this Scope is, and the Phase 1 RA CHASP will be, related to the activities to be performed during Phase 1 of the RA. If changes or modifications are warranted during Phase 1 (e.g., additional activities or hazards are identified), addenda to the Phase 1 RA CHASP will be developed and submitted to the EPA. Once approved, these addenda will be available for review on site and at public repositories. Following the completion of Phase 1, an evaluation will be conducted to determine whether modifications to the Phase 1 RA CHASP are needed for Phase 2.

2. Contingencies for Exceedances of or Deviations from Quantitative Quality of Life Standards

This section describes the activities that will be performed to address exceedances of the quantitative standards or Control Levels in the QoLPS, or deviations from other substantive requirements in the QoLPS, during Phase 1 of the RA. This section describes both the activities that will be performed during Phase 1 design to plan for such contingencies and the activities that will be performed during implementation of Phase 1 to respond to such contingencies.

As provided in Paragraph 35 of the RD AOC, GE will design Phase 1 of the RA to be consistent with, and fully take account of, the QoLPS (as well as the EPS). The Phase 1 IDR and Phase 1 FDR will document the engineering bases and assumptions for the design to demonstrate that the equipment and processes to be used in Phase 1 are expected to meet the QoLPS, as described in the Phase 1 ID PSCP Scope and to be provided in the Phase 1 PSCP and Phase 1 RA CHASP. The Phase 1 RA CHASP will include a summary of these analyses. The basis of design will be the Concern Level for ambient air concentrations of PCBs, the Control Level for noise, and the quantitative standards for opacity, H_2S, odor, and lighting, all as set forth in the QoLPS, as well as the substantive legal requirements referenced in the QoLPS for navigation.

In addition, during Phase 1 design, contingency plans will be developed for addressing potential exceedances of or deviations from those standards for air quality, odor, noise, lighting, and navigation. The mitigation methods and contingency plans developed during Phase 1 design to manage specific situations (as determined during potential hazard evaluations) will be included in the Phase 1 RA CHASP. These plans will be developed for potential contingencies that are reasonably foreseeable at the time of Final Design, taking into account the degree of confidence that the standards will in fact be achieved. Contingency actions to be planned in design will broadly include:

- Increased monitoring, as needed;
- Routine maintenance;
- Engineering controls;
- Equipment or process modifications;
- Operational modifications;
- Substitution of process components that are readily available and cost-effective; and
- Temporary shutdown of source of the exceedance and inter-related processes.

As noted above, only contingencies for scenarios that may affect the communities surrounding the Upper Hudson Work Area will be addressed in the Phase 1 RA CHASP.

During Phase 1, GE will conduct monitoring to determine whether the various performance standards are being met. The monitoring program and numerical levels of the standards are described in the Phase 1 ID RA Monitoring Scope, with additional details to be provided in the Phase 1 EMP and Phase 1 RAMP QAPP, and will be summarized in the Phase 1 RA CHASP.

During implementation of Phase 1, in the event that there is an exceedance of the quantitative QoLPS or a deviation from other substantive requirements in the QoLPS (i.e., the substantive navigation requirements), contingency actions will be implemented, as set forth in the Phase 1 RA CHASP. Such activities may include routine maintenance, operational changes, equipment or process modifications, additions of equipment, or, in extreme cases, a temporary shutdown of certain operations – all depending on the circumstances. GE will not be required, during the Phase 1 field season to make equipment modifications or additions that are not reasonably available from a schedule or cost standpoint, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event reasonable changes can be made to address achievement of the performance standards during the Phase 1 dredge season, such changes will be proposed to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE's proposals, if any, for modification of the EPA-approved Phase 1 FDR based on field conditions or experience.

The following sections discuss in more detail the contingencies to be considered for air quality, odor, noise, lighting, and navigation.

2.1 Air Quality Contingencies

Potential air quality issues that will be evaluated during the design are:

- PCBs in ambient air;
- The following pollutants subject to National Ambient Air Quality Standards (NAAQS) (criteria pollutants): nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter with a median

diameter of 10 micrometers or less (PM_{10}), particulate matter with a median diameter of 2.5 micrometers or less ($PM_{2.5}$), and ozone (O_3); and

- Opacity.

The EPA established standards for total PCB concentrations in ambient air concentrations are 24-hour average concentrations of 0.11 micrograms per cubic meter ($\mu g/m^3$) for residential areas, with a Concern Level of 0.08 $\mu g/m^3$, and 0.26 $\mu g/m^3$ in commercial/industrial areas, with a Concern Level of 0.21 $\mu g/m^3$. The Phase 1 IDR and Phase 1 FDR will include emission inventories and air dispersion modeling to predict PCB concentrations in ambient air at receptors (e.g., nearby residences or businesses). The results of this design analysis will be summarized in the Phase 1 RA CHASP. If the design predictions exceed the applicable standard at a receptor for any given uncontrolled source, the design will be modified such that predictions are below the applicable standard. The basis of design will assume that the quantitative standards are protective of the health of the community, and therefore, the project will be designed to meet those standards. Scaling or dispersion factors will be developed so that concentrations can be predicted at the receptor (e.g., a residence) based on data from monitoring stations that are closer to the source (e.g., a site fence line). Compliance with the standard will be demonstrated at the monitoring station. In the event that the monitoring station location is not representative of any receptor, conservative modeling will be used to assess compliance at the receptor, with approval of the EPA.

During Phase 1 operations, air monitoring will be conducted as described in the Phase 1 ID RA Monitoring Scope, with additional details to be provided in the Phase 1 EMP and Phase 1 RAM QAPP. In the event that monitoring (or modeling, if used to assess compliance at the receptor, with approval of the EPA) shows an exceedance of a Concern Level, the following steps will be taken: 1) promptly notify the EPA, but no later than 24 hours after receipt of the analytical results; 2) investigate the cause of increased emissions; 3) implement increased monitoring as described in the Phase 1 ID RA Monitoring Scope; and 4) as necessary, implement mitigation measures as outlined in the Phase 1 RA CHASP, provided that any equipment modifications or additions that are part of such measures are reasonably available from a schedule and cost standpoint, recognizing that substitutions for major equipment approved in the Phase 1 FDR and being used in Phase 1 will be impractical.

In the event that the monitoring (or modeling, if used to assess compliance at the receptor) shows an exceedance of a standard, the following steps will be taken: 1) notify the EPA, as well as the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of Health (NYSDOH), immediately upon receipt of the analytical results; 2) investigate the cause of the exceedance; 3) implement increased monitoring as described in the Phase 1 ID RA Monitoring Scope; 4) work with EPA field staff to develop an action plan and implement additional mitigation (subject to the same proviso regarding mitigation measures as noted in the preceding paragraph); 5) continue monitoring and provide daily monitoring reports to the EPA, NYSDEC, and NYSDOH until the standard is achieved; and 6) provide a corrective action report to the EPA in accordance with the Phase 1 RA CHASP.

With respect to criteria pollutants, the design analysis is expected to demonstrate compliance with the NAAQS; therefore, no contingencies for monitoring or control of these pollutants are expected to be provided in the Phase 1 RA CHASP. If the initial design analysis does not demonstrate achievement of the NAAQS, the design will be modified to demonstrate compliance with the NAAQS.

The opacity standard states that opacity must be less the 20% (as a 6-minute average), except that there can be one continuous 6-minute period per hour of not more than 57% opacity. Routine maintenance of diesel engines, generators, and other equipment is expected to achieve the opacity standard. Opacity monitoring will verify this expectation and reasonably foreseeable contingencies will be specified in the Phase 1 RA CHASP in the event of an exceedance.

2.2 Odor Contingencies

For this project, the airborne chemicals that have the potential to be a public health concern via inhalation pathway are PCBs and H_2S. PCBs are odorless, and the EPA has established the air quality standard for PCBs to be protective of public health. As indicated in the QoLPS for odor, the quantitative standards for H_2S have been established to control nuisance odors, and thus also conservatively protect public health. The odor threshold for H_2S is much lower than the level of potential concern to health; therefore adherence to the standard should alleviate both odor and exposure concerns. Odor is not otherwise expected to be a public health concern. The Phase 1 RA CHASP will address H_2S, as well as other odors that "unreasonably interfere with the comfortable enjoyment of life and property" (*Hudson QoLPS*, page 6-18).

The contingency plan for odor will be triggered by the identification of uncomfortable project-related odors by RA workers or by complaints from the public; the complaint process is described in Section 3.2 below. If the odor is identified as H_2S (i.e., rotten eggs), H_2S monitoring will be conducted as described in the Phase 1 ID RA Monitoring Scope, with further details in the Phase 1 EMP and the Phase 1 RAM QAPP. If the monitoring shows an exceedance of the H_2S standard (14 $\mu g/m^3$ as a one-hour average), the following steps will be taken: 1) promptly notify the EPA, but no later than 24 hours after receipt of the analytical data; 2) investigate the cause of the odor to verify that it is project-related; 3) if so, work with EPA field staff to develop an action plan and implement mitigation measures, provided that any equipment modifications or additions that are part of such measures are reasonably available from a schedule and cost standpoint, recognizing that substitutions for major equipment approved in the Phase 1 FDR and being used in Phase 1 will be impractical; 4) continue regular monitoring until the standard is achieved; and 5) provide a corrective action report to the EPA in accordance with the Phase 1 RA CHASP.

Procedures for addressing complaints regarding odors other than H_2S are described in Section 3.2 below.

2.3 Noise Contingencies

The applicable quantitative Control Level and standards for noise are set forth in the QoLPS and listed in Section 5.2 of the Phase 1 ID RA Monitoring Scope. The Phase 1 RD will include an evaluation of noise intensity generated by equipment or processes and traffic associated with site operations. Attenuation modeling will be completed during the design to predict noise intensity at receptors (e.g., nearby residences or businesses), and the results will be summarized in the Phase 1 RA CHASP. If the design predictions exceed the applicable standard at a receptor for any given uncontrolled source, the design will be modified such that predictions are below the applicable standard. The quantitative levels specified in the QoLPS will be assumed to be protective of the community and will be used as the basis of design. Attenuation factors, defined by site-specific conditions, will be developed so that intensities can be predicted at the receptor (e.g., a residence) based on data from monitoring stations that are closer to the source (e.g., a site fence line). These predictions will be validated by a noise study during the startup of RA operations, as described in the Phase 1 ID RA Monitoring Scope. Compliance with the standard will be demonstrated at the monitoring station if the station location is representative of a receptor. In the event that the monitoring station location is not representative of any receptor, temporary monitoring stations may be established at or closer to receptors or modeling may be used to assess compliance at the receptor.

Contingency actions for noise will be triggered by a measurement of noise intensity above a prescribed quantitative limit or by a complaint. The complaint process is described in Section 3.3 below. In the event that monitoring (or modeling, if used to assess compliance at the receptor) shows an exceedance of the Control Level (which applies only to residential areas and only during the daytime), the following steps will be taken: 1) investigate the cause of the noise increases to verify that they are project-related; 2) if so, implement increased monitoring as described in the Phase 1 ID RA Monitoring Scope; and 3) consider mitigation measures, as outlined in the Phase 1 RA CHASP.

In the event that the monitoring (or modeling, if used to assess compliance at the receptor) shows an exceedance of an applicable noise standard, the following steps will be taken: 1) promptly notify the EPA, but no later than 24 hours after discovery of the exceedance; 2) investigate the cause of the exceedance to verify that it is project-related; 3) if so, implement increased monitoring as described in the Phase 1 ID RA Monitoring Scope; 4) work with EPA field staff to develop and implement an action plan for mitigation measures, provided that any equipment modifications or additions that are part of such measures are reasonably available from a schedule and cost standpoint, recognizing that substitution for major equipment approved in the Phase 1 Final Design and being used in Phase 1 will be impractical; 5) continue monitoring and provide daily monitoring reports to the EPA until the standard is achieved; and 6) provide a corrective action report to the EPA in accordance with the Phase 1 RA CHASP.

2.4 Lighting Contingencies

The quantitative lighting standards that the EPA has established are 0.2 footcandle in rural and suburban areas, 0.5 footcandle in residential areas, and 1.0 footcandle in commercial/industrial areas. The Phase 1 RD will include an evaluation of light intensity generated by illumination of active dredge areas, processing areas, loading and staging areas, and administration areas and other work areas on and near the river to provide a safe and secure work place. Light intensity calculations at receptors will be used to assess and confirm compliance. The design basis will assume that the quantitative standards are protective of the community. Lighting will be directed towards work areas and will be compliant with worker safety practices and United States Coast Guard (USCG) and New York State navigation laws.

Contingency actions for lighting impacts, such as position adjustments, will be triggered by a measurement of light intensity (footcandle) above an applicable standard or by a complaint. The complaint process is described in Section 3.3. In the event that monitoring shows an exceedance of the Concern Level (in which lighting levels are above the standard but the exceedance can be easily and immediately mitigated), the following steps will be taken: 1) investigate the cause of the lighting problem to verify that it is project-related; 2) if so, implement increased monitoring as needed; 3) implement mitigation measures as outlined in the RA CHASP, provided that any equipment modifications or additions that are part of such measures are reasonably available from a schedule and cost standpoint, recognizing that substitutions for major equipment approved in the Phase 1 FDR and being used in Phase 1 will be impractical; and 4) submit a follow-up report to the EPA in accordance with the Phase 1 RA CHASP.

In the event that the monitoring shows an exceedance of an applicable lighting standard that is not easily and immediately mitigated, the following steps will be taken: 1) promptly notify the EPA, but no later than 24 hours after discovery of the exceedance; 2) investigate the cause of the exceedance to verify that it is project-related; 3) if so, implement regular monitoring as described in the Phase 1 ID RA Monitoring Scope; 4) develop and implement an action plan for mitigation measures (subject to the same proviso regarding mitigation measures as noted in the preceding paragraph); 5) continue regular monitoring until the standard is achieved; and 6) provide a corrective action report to the EPA in accordance with the Phase 1 RA CHASP.

2.5 Navigation Contingencies

The Phase 1 RD will confirm that the river-based elements of the project comply with the substantive requirements of the federal and New York State regulations governing the navigation of commercial vessels. The New York State Canal Corporation (NYS Canal Corporation) will be consulted during the design and development of the Phase 1 RAWP on issues relating to navigation.

The design basis will assume that compliance with these regulations will constitute compliance with the substantive requirements of the QoLPS for navigation. Hazard analyses will also be conducted to assess potential navigation hazards to the public.

Navigational logistics are not related to health and safety and will not be addressed in the RA CHASP. Navigation-related complaints are addressed in Section 3.4 below.

In the event that on-river operations deviate from the relevant federal and state navigation regulations listed in the QoLPS for navigation or from the design plans relating to navigation and such deviation poses a health or safety hazard, which can be easily and immediately mitigated, the following steps will be taken: 1) promptly notify the EPA and the NYS Canal Corporation, but no later than 24 hours after discovery of the deviation; 2) implement mitigation measures as outlined in the RA CHASP, provided that any equipment modifications or additions that are part of such measures are reasonably available from a schedule and cost standpoint, recognizing that substitutions for major equipment approved in the Phase 1 FDR and being used in Phase 1 will be impractical; and 3) submit a follow-up report to the EPA and NYS Canal Corporation in accordance with the Phase 1 RA CHASP.

In the event that there is a deviation from the relevant federal and state navigation regulations or the design plans relating to navigation and such deviation cannot be easily and immediately mitigated, the following steps will be taken: 1) notify the EPA and NYS Canal Corporation immediately; 2) identify the cause of the deviation; 3) develop and implement an action plan for mitigation measures (subject to the same proviso noted in the preceding paragraph); and 4) provide a corrective action report to the EPA and NYS Canal Corporation in accordance with the Phase 1 RA CHASP.

In addition, contingency plans for navigation accidents related to the project will be included in the Phase 1 RA CHASP. Appropriate emergency response agencies (e.g., police, sheriff, fire departments, etc.) will be worked with during design to establish the contingency plans.

3. Community Notification and Complaint Management Programs

The Phase 1 RA CHASP will include a community notification program and a complaint management program to address community health and safety concerns.

3.1 General

The community notification process summarized in the Phase 1 RA CHASP will consist of notifications to mariners regarding on-river activities, and a website where the general public can obtain project status information, such as information on active dredge areas, anticipated dredge schedule and standard hours of operation, dredged material transport traffic patterns, safety and security information for non-project vessels, monitoring results for QoLPS parameters, and responses to frequently asked questions. In addition, a toll-free phone number, the website, and a mailing address will be established for project inquires and complaints; the phone number will be activated and continuously staffed during processing facility construction and remedial operations. There are also a number of additional sources of specific information for this project. The website will provide references to them. The Phase 1 RA CHASP will summarize the plan for communications with the public.

The complaint management process will address all project-related complaints, including those associated with air quality, odor, noise, lighting, navigation, and water quality. When a phone call, electronic mail communication, or written correspondence is received, it will first be determined whether the individual is making an "inquiry" or a "complaint." For this purpose, an "inquiry" will mean a communication in which the individual is requesting project-related information and is not requesting that corrective action be taken. No regulatory notification or follow-up will be necessary for an inquiry. However, inquiries made through the toll-free phone number, electronic mail, and the mail will be documented in a log noting the time received, subject matter, name of inquiring party, and any follow up required (e.g., if any agencies need to be engaged). A "complaint" will mean a communication in which the individual is requesting that corrective action be taken regarding some aspect of the project, including those associated with a quality-of-life issue (air, odor, noise, lighting, navigation, or water quality).

During Phase 1 of the RA, complaints will be managed in accordance with the following procedure:

- When a complaint is received (as opposed to an inquiry), it will be recorded in a log noting the time the complaint was received, the subject of the complaint, the name of the complainant and how he or she can be reached.

- Following receipt of the complaint, an investigation will be conducted to determine whether the subject of the complaint – i.e., air quality, odor, noise, lighting, navigation, or water quality – is project-related.

- If the complaint is project-related and it pertains to a parameter for which the QoLPS specify numerical standards (or Control Levels) – i.e., PCB concentrations in air, opacity, H_2S concentrations in air, noise, lighting, or surface water concentrations of constituents addressed by the Resuspension Performance Standard or WQC requirements –monitoring (and/or modeling) will be conducted as necessary to determine whether the applicable standard or limit has been exceeded in the area referred to in the complaint.

- If the monitoring (and/or modeling) does not show an exceedance of the applicable numerical standard, any further mitigation action will not be required; however, the party performing the remedy will work with the EPA to evaluate potential mitigation measures, and if both parties agree, such measures will be implemented. Preliminary monitoring results will be reported to regulatory agencies as described in Section 2.

- If the monitoring (and/or modeling) shows an exceedance of the applicable numerical standard or control level, contingency mitigation actions will be implemented in accordance with the procedures and requirements specified in Section 2 of this Phase 1 ID RA CHASP Scope. Preliminary monitoring results will be reported to regulatory agencies as described in Section 2.

- If the complaint is project-related and pertains to a parameter for which the QoLPS do not specify a numerical standard – e.g., odors other than H_2S, navigation impacts, or water quality impacts not addressed by the Resuspension Performance Standard or WQC requirements –the complaint will be evaluated and, if appropriate, take contingency mitigation measures, as described further in subsequent sections of this Phase 1 ID RA CHASP Scope.

- Reporting to EPA regarding complaints, as well as follow-up communications with the complainant to inform him/her of progress in resolving the complaint, will be described in the Phase 1 RA CHASP.

The Phase 1 RA CHASP will describe the reasonably foreseeable contingencies that are likely to generate complaints about air quality, odor, noise, lighting, navigation and water quality and summarize the range of responses to complaints. Where there are numerical standards and project activities have not caused an exceedance of the applicable numerical standard, complaints will be addressed as set out in the above procedure. Additional elements of complaint management applicable to particular types of complaints are set out below and will be described further in the Phase 1 RA CHASP.

3.2 Odor Complaints

If an odor complaint is received and the odor is identified as potentially H_2S, the response procedure discussed in Section 2.2 will be implemented. In the event that an odor complaint is received that is identified as project-related but is not H_2S, the odor will be investigated to determine whether it is uncomfortable, rather than simply discernible. For this purpose, an uncomfortable non- H_2S odor will be defined, in accordance with New York State Law (6 NYCRR § 211.2), as an odor which "unreasonably interfere[s] with the comfortable enjoyment of life or property." In making this investigation, further discussion will be held with the complainant regarding the nature and intensity of the odor, and if necessary, the odor intensity will be objectively assessed. Further details will be provided in the Phase 1 RA CHASP. If a project-related uncomfortable odor is identified, contingency mitigation actions will be taken consistent with those described in Section 2.2. In applying these requirements, multiple complaints regarding the same potential odor source will be treated as one complaint.

The QoLPS for odor defines the Exceedance Level to include "frequent, recurrent odor complaints" related to project activities. For this purpose, "frequent, recurrent odor complaints" will be defined on a case-by-case basis, as will be provided in the Phase 1 RA CHASP. However, the occurrence of "frequent, recurrent odor complaints" will trigger the same responses discussed above.

3.3 Noise and Lighting Complaints

The QoLPS for noise and lighting also define the Exceedance Level to include "frequent, recurrent" complaints related to project activities. For this purpose, "frequent, recurrent" complaints will be defined on a case-by-case basis, as will be provided in the Phase 1 RA CHASP. However, the occurrence of "frequent, recurrent" complaints will trigger the same responses discussed in Section 3.1 above.

3.4 Navigation Complaints

If a navigation complaint relating to health or safety is received from the public relating to the project, an investigation will be conducted to determine whether the project is in compliance with all substantive federal and state navigation regulations and whether and the extent to which the project has interfered with other river traffic. The NYS Canal Corporation will be notified of each complaint and will be consulted if necessary in this investigation. If it is determined that the project is in compliance with all substantive federal and state navigation regulations listed in the QoLPS for navigation and that the appropriate steps have been taken to minimize interference with river traffic consistent with the efficient operation of the project, then no mitigation action will be required to respond to the complaint; however, the party performing the remedy will work with the EPA, in coordination with the NYS Canal Corporation, to evaluate potential mitigation measures, and if both parties agree, such measures will be implemented. If the foregoing criteria are not met, then contingency mitigation actions will be taken as described in Section 2.5.

The QoLPS for navigation defines the Exceedance Level to include "frequent, recurrent complaints indicating project activities are unnecessarily hindering overall non-project-related vessel movement." Such complaints will be handled in the same manner described above.

3.5 Water Quality Complaints

If a water quality complaint is received from the public regarding the quality of river water in the Upper Hudson Work Area, the EPA, NYSDEC and NYSDOH will promptly be notified, but no later than 24 hours after receipt of the complaint, and an investigation will be conducted as to the nature of the complaint. If the complaint relates to resuspended sediments from dredging activities, the available water quality monitoring data will be reviewed to determine whether the complaint is project-related and to determine whether there has been an exceedance of any of the action levels set forth in the Resuspension Performance Standard or the WQC requirements for releases of other constituents. If review of these data indicates an exceedance of such an action level, increased monitoring specified in the Phase 1 ID RA Monitoring Scope and the other contingency actions specified in the Phase 1 ID PSCP Scope will be conducted. If the data do not show such an exceedance, no mitigation action will be required and any further action will be implemented at GE's discretion.

If the complaint investigation identifies a spill, the spill contingency and emergency response actions (including timeframe for such actions), which will be included in the Phase 1 RA CHASP, will be implemented.

Phase 1 Intermediate Design Report Hudson River PCBs Superfund Site

Attachment C – Phase 1 Intermediate Design Performance Standards Compliance Plan Scope

General Electric Company
Albany, New York

August 22, 2005

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Attachment C - Phase 1 Intermediate Design Performance Standards Compliance Plan Scope

August 22, 2005

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Tables (placed in text)

1. Introduction

This *Phase 1 Intermediate Design Performance Standards Compliance Plan Scope* (Phase 1 ID PSCP Scope) provides a general description of the actions that General Electric Company (GE) will undertake during Phase 1 of the Remedial Action (RA) for the Upper Hudson River to implement the Engineering Performance Standards (EPS), the Quality of Life Performance Standards (QoLPS), and the water quality requirements (WQ requirements) issued by the United States Environmental Protection Agency (EPA) for Phase 1 of the RA. The EPS consist of 1) the Resuspension Performance Standard, 2) the Residuals Performance Standard, and 3) the Productivity Performance Standard, and are set out in a five-volume document titled *Hudson River PCBs Superfund Site Engineering Performance Standards*, issued by EPA in April 2004.

The QoLPS consist of performance standards governing 1) air quality, 2) odor, 3) noise, 4) lighting, and 5) navigation, and are set out in a document titled *Hudson River PCBs Superfund Site Quality of Life Performance Standards*, issued by EPA in May 2004.

The WQ requirements consist of: 1) requirements relating to in-river releases of constituents not subject to the EPS, as set forth in *Substantive Requirements Applicable to Releases of Constituents not Subject to Performance Standards;* 2) the substantive requirements for discharges to the Hudson River and Champlain Canal, as set forth in *Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharges to Champlain Canal (land cut above Lock 7)*; and 3) *Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharge to the Hudson River*. These three sets of requirements are contained in a single document in the form of a letter to GE with enclosures that EPA issued on January 7, 2005.

This Phase 1 ID PSCP Scope will form the basis for the *Phase 1 Performance Standards Compliance Plan* (Phase 1 PSCP), to be prepared as part of the *Remedial Action Work Plan for Phase 1 Dredging and Facility Operations* (Phase 1 RA Work Plan). The Phase 1 PSCP will set forth further details as to how the EPS, the QoLPS, and the WQ requirements will be implemented during Phase 1 and will be consistent with this Phase 1 ID PSCP Scope.

This Phase 1 ID PSCP Scope is an attachment to the *Phase 1 Intermediate Design Report* (Phase 1 IDR). Each section provides, for each performance standard or WQ requirement, an overview of the standard or requirement established by EPA, and describes the actions that will be taken to implement that standard or requirement.

Actions that GE will take to implement the EPS, the QoLPS, and the WQ requirements also are set forth in other attachments to the Phase 1 IDR, including the *Phase 1 Intermediate Design Remedial Action Monitoring Scope* (Phase 1 ID RA Monitoring Scope) (Attachment A to the Phase 1 IDR), and the *Phase 1 Intermediate Design Remedial Action Community Health and Safety Program Scope* (Phase 1 ID RA CHASP Scope) (Attachment B to the Phase 1 IDR). Where actions to implement the EPS, the QoLPS or the WQ requirements are specified in those attachments, this Phase 1 ID PSCP Scope incorporates those documents by reference.

During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event that reasonable changes can be made to address achievement of the performance standards during the Phase 1 dredge season, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE's proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

2. Resuspension Performance Standard

This section of the Phase 1 ID PSCP Scope discusses the Resuspension Performance Standard. It provides an overview of the resuspension standard as set forth in the EPS (e.g., Volume 2), and specifies the routine monitoring requirements (Section 4.2 of Volume 2 of the EPS), the contingency monitoring (Section 4.2 of Volume 2 of the EPS) and other responses (Section 4.5 of Volume 2 of the EPS) in the event of an exceedance of an action level, the notification and reporting requirements, and the special studies (Section 4.4 of Volume 2 of the EPS) to be conducted. Some of these requirements are specified in the Phase 1 ID RA Monitoring Scope; in such cases, the requirements are incorporated by reference.

2.1 Overview of Standard

The Resuspension Performance Standard specifies a routine monitoring program and three action levels – Evaluation, Control, and Standard Levels. These action levels apply to polychlorinated biphenyls (PCBs) and/or total suspended solids (TSS) in surface water at either near-field stations (located within 300 meters [m] of the dredging activities) or far-field stations (located more than 1 mile downstream of dredging activities). As described in more detail below, these action levels will be used to trigger additional monitoring or contingency actions during the RA beyond those required by the routine monitoring program. These action levels are also summarized in Table 2-1 of Volume 1 of the EPS and Section 4.0 of Volume 2 of the EPS. The monitoring program is described in the Phase 1 ID RA Monitoring Scope and will be detailed in the *Phase 1 Remedial Action Monitoring Quality Assurance Project Plan* (Phase 1 RAM QAPP) to be prepared as part of the RA work plans.

Evaluation Level

Under the EPS (Section 4.1.1 Volume 2, pp. 87-92), the Evaluation Level would be exceeded if any of the following conditions occurs:

- "The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 300 g/day for a seven-day running average."
- "The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 100 g/day for a seven-day running average."

- "The sustained suspended solids concentration above ambient conditions at a far-field station exceeds 12 mg/L. To exceed this criterion, this condition must exist on average for 6 hours or a period corresponding to the daily dredging period (whichever is shorter). Suspended solids are measured continuously by turbidity (or an alternate surrogate) or every three hours by discrete samples."
- "The sustained suspended solids concentration above ambient conditions at a location 300 m downstream (i.e., near-field monitoring) of the dredging operation or 150 m downstream from any suspended solids control measure (e.g., silt curtain) exceeds 100 mg/L for River Sections 1 and 3 and 60 mg/L for River Section 2. To exceed this criterion, this condition must exist on average for six hours or for the daily dredging period (whichever is shorter). Suspended solids are measured continuously by surrogate or every three hours by discrete samples."
- "The sustained suspended solids concentration above ambient conditions at the near-field side channel station or the 100 m downstream station exceeds 700 mg/L. To exceed this criterion, this condition must exist for more than three hours on average measured continuously or a confirmed occurrence of a concentration greater than 700 mg/L when suspended solids are measured every three hours by discrete samples."

Control Level

Under the EPS (Section 4.1.2 Volume 2, pp. 93-95), the Control Level would be exceeded if any of the following conditions occurs:

- "The Total PCB concentration during dredging-related activities at any downstream far-field monitoring station exceeds 350 ng/L for a seven-day running average."
- "The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 600 g/day on average over a seven-day period."
- "The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 200 g/day on average over a seven-day period."
- "The sustained suspended solids concentration above ambient conditions at a far-field station exceeds 24 mg/L. To exceed this criterion, this condition must exist for a period corresponding to the daily dredging period (six hours or longer) or 24 hours if the operation runs continuously (whichever is shorter) on average. Suspended solids are measured continuously by surrogate or every three hours by discrete samples."
- "The sustained suspended solids concentration above ambient conditions at a location 300 meters downstream (i.e., near-field monitoring) of the dredging operation or 150 meters downstream from any suspended solids control measure (e.g., silt curtain) exceeds 100 mg/L for River Sections 1 and 3 and 60

mg/L for River Section 2. To exceed this criterion, this condition must exist for a period corresponding to the daily dredging period (6 hours or longer) or 24 hours if the operation runs continuously (whichever is shorter) on average. Suspended solids are measured continuously by surrogate or every three hours by discrete samples."

- "The net increase in PCB mass transport due to dredging-related activities measured at the downstream far-field monitoring stations exceeds 65 kg/year Total PCBs or 22 kg/year Tri+ PCBs."

Standard Level

Under the EPS (Section 4.1.3 Volume 2, p. 98), the Standard Level is "a confirmed occurrence of 500 ng/L Total PCBs, measured at any main stem far-field station. To exceed the standard threshold, an initial result greater than or equal to 500 ng/L Total PCBs must be confirmed by the average concentration of four samples collected within 48 hours of the first sample. The standard threshold does not apply to far-field station measurements if the station is within one mile of the remediation."

Adjustments of PCB Load Criteria

The Resuspension Performance Standard (EPS, Section 4.1.3 Volume 2, pp. 97-98) also specifies that adjustments can be made to the allowable total PCB load criteria based on the results of the following:

- "The production rate will be reviewed on a weekly basis. The allowable Total PCB load loss for the season will be adjusted if this target rate is not met…."
- "The allowable seven-day Total PCB load loss thresholds will be revised if the production rate varies from the anticipated value or the operation schedule differs from that assumed for this report. The revision is to be calculated once per dredging season (i.e. the 7-day running average criterion is set once per season)."

The allowable seven-day Total PCB mass load loss will be calculated using the equations in Section 4.1.2.7 (pp. 97-98) of Volume 2 of the EPS. EPA will review the total project mass load (currently set at 650 kg) after the dredge area delineation for Phase 2 is complete. If appropriate, EPA will increase or decrease the total allowable project load proportionally to the total project mass load.

2.2 Routine Monitoring

GE will conduct the routine near-field and far-field monitoring described in Sections 2.2 through 2.4 of the Phase 1 ID RA Monitoring Scope, as such monitoring relates to PCBs, TSS, and other parameters specified in the Resuspension Performance Standard.

2.3 Contingency Monitoring

In the event that the routine monitoring shows an exceedance of the Evaluation Level, the Control Level, or the Standard Level for PCBs or TSS, GE will conduct the contingency monitoring specified for the exceedance at that level in accordance with Sections 2.2, 2.4.1, and 2.5 of the Phase 1 ID RA Monitoring Scope.

2.4 Contingency Actions/Responses

If the monitoring indicates an exceedance of the Evaluation Level, the Control Level, or the Standard Level, GE will undertake the associated contingency actions and engineering responses as outlined below.

Evaluation Level

In the event that the monitoring shows an exceedance of the Evaluation Level, an engineering evaluation as outlined in Section 4.5 of Volume 2 of the EPS will be considered in an effort to determine the cause of the exceedance. If performed, the engineering evaluation will begin upon receipt of data confirming an exceedance of the Evaluation Level. As part of this evaluation, investigative measures may be implemented to determine the cause of the exceedance. If GE determines that such measures are appropriate, it will propose such investigative measures to the EPA field representative. The selection of investigative measures will depend on specific project circumstances and may include one or more the following different actions:

- Visual observations of operations;
- Discussions with project personnel;
- Review of operations records;
- Examination of the integrity of containment barriers (if in use);
- Examination of sediment transport pipeline (if in use);

- Examination of barge loading system and barge integrity;
- Examination of resuspension associated with tugs, barges, and other support vessels; and
- Additional monitoring and/or sampling.

Following the engineering evaluation (where conducted), if the cause of the exceedance can be identified and is project-related, potential engineering solutions will be considered and may be recommended. The engineering evaluation and results will be presented to EPA in an Engineering Evaluation Report. That Engineering Evaluation Report also will include recommendations regarding an engineering solution, if any, to address the cause, except as follows: If the engineering solution involves a refinement in operations or equipment that is consistent with, and would not require a modification of, the EPA-approved design or the RA Work Plan, GE may implement the solution in consultation with the EPA field representative, and then document the implementation of that solution in the Engineering Evaluation Report. In any other case, GE will implement the engineering solution in accordance with the EPA-approved Engineering Evaluation Report.

Control Level

If the monitoring shows an exceedance of the Control Level, an engineering evaluation will be conducted, as outlined in Section 4.5 of Volume 2 of the EPS beginning upon receipt of data confirming the exceedance, in an effort to determine the cause of the exceedance. As specified in the Resuspension Performance Standard (Section 3.4.4 of Volume 2 of the EPS), a Control Level exceedance of a TSS criterion must be confirmed by far field PCB measurements before actions other than increased monitoring are required. If investigative measures are warranted to determine the cause of the Control Level exceedance, such investigative measures will be proposed to the EPA field representative. The selection of investigative measures will depend on specific project circumstances and may include, but are not limited to, the measures described above under *Evaluation Level*.

If the Control Level is exceeded, potential engineering solutions will be evaluated to address the exceedance, and the implementation of an engineering solution will be proposed unless the EPA field representative determines that no engineering solution is necessary to address the Control Level exceedance (for example, if the exceedance is not sustained or is mitigated by implementation of a non-project-related action). The possible engineering solutions to be considered include the following:

- Initiate mandatory engineering evaluation and continual adjustments to dredging operations until the Evaluation Level or better is attained.
- Evaluate and identify any problems.
- Consider changes in resuspension controls, dredge operation, or dredging equipment.
- Consider implementing additional or different resuspension controls.
- Consider changing location and rescheduling more highly contaminated areas for later in the year (applies to May and June only), if other options are not effective.
- Temporarily cease operations if required.

An Engineering Evaluation Report will be prepared and submitted, which contains the results of this engineering evaluation, the proposed engineering solution and a proposed schedule for implementing that solution, except as follows: if the solution involves a refinement in operations or equipment that is consistent with, and would not require a modification of, the EPA-approved design or the RA Work Plan, then GE shall implement the solution in consultation with the EPA field representative and the implementation of that solution will be documented in the Engineering Evaluation Report. In all other cases, the engineering solution will be implemented in accordance with the EPA-approved Engineering Evaluation Report. If the cause of the exceedance was not identified by the engineering evaluation, the Engineering Evaluation Report will include a course of action for continued monitoring and evaluation to determine the cause of the exceedance. GE will consult with EPA on a regular basis until the cause and solution are determined, or until EPA orders a temporary halt to the operation(s) that caused the exceedance or until EPA determines that further evaluation is not necessary.

Standard Level

If the monitoring shows an initial occurrence of a PCB concentration in excess of the Standard Level, GE will promptly notify EPA, but no later than 3 hours after receipt of the data. If subsequent sampling confirms an exceedance of the Standard Level, GE will: 1) again promptly notify EPA, but no later than 3 hours after data receipt; 2) temporarily halt dredging and other river-based operations that caused the exceedance; 3) perform an engineering evaluation; and 4) develop an engineering solution as described above under *Control Level*. GE will also develop a schedule for reinitiating dredging and other river-based operations that were suspended with an objective of minimizing the time that dredging is temporarily shut down. Following such evaluation, GE will present the results of the engineering evaluation to EPA in an Engineering Evaluation Report, along with the proposed engineering solution (or a course of action for continued monitoring and study to further evaluate the cause of the exceedance) and a proposed schedule for implementing that solution and reinitiating dredging, except as follows: if the solution involves a refinement in operations or equipment that is consistent with, and would not require a modification of, the EPA-approved design or the RA Work Plan, GE will implement the solution in consultation with the EPA field representative, and then document the implementation of that solution in the Engineering Evaluation Report, along with a schedule for the reinitiation of dredging. In all other cases, GE will implement the engineering solution in accordance with the EPA-approved Engineering Evaluation Report. Dredging will be reinitiated, upon EPA approval, once the exceedance has been mitigated, in accordance with the schedule in the approved Engineering Evaluation Report. If the cause of the exceedance was not identified during the engineering evaluation, the Engineering Evaluation Report presented to the EPA will include a course of action for continued evaluation to determine the cause of the exceedance. GE will consult with EPA on a regular basis until the cause and solution are determined, or until EPA determines that further evaluation is not necessary.

General

The time frames for engineering evaluations and implementation of engineering solutions in compliance with the Resuspension Standard are discussed in the EPS Volume 2, Section 4.5.1 except as modified below. The time frames to initiate and complete engineering evaluations and implementation of the engineering solutions will be estimated in the remedial design. The time frames for completion of the engineering evaluations and implementation of engineering solutions (if any) will be variable, depending on the circumstances surrounding the exceedance. EPA may modify these time frames during Phase 1 depending on the circumstances surrounding the exceedance. The actual schedule to be implemented in the field will be subject to EPA review. It is anticipated that engineering evaluations will begin immediately upon receipt of data indicating the exceedance of a criterion. It is similarly anticipated that the required engineering contingencies should begin as soon as possible so as to minimize PCB releases. At a minimum, engineering contingency actions should begin within a week of an exceedance, assuming conditions remain in exceedance (EPS, Vol. 2, p. 133). In the case of a temporary halt of the operations, an evaluation should be completed with 5 days. In the event of a temporary cessation, every effort should be made to correct the problem and minimize the length of time of the stoppage (EPS, Vol. 2, p. 132).

During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event reasonable changes can be made to address achievement of the performance standards during Phase 1, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE's proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

During implementation of Phase 1, in the event that there is an exceedance of the Evaluation Level, the Control Level or the Standard Level that requires or warrants an engineering solution (as described above), the engineering solution(s) performed may include routine maintenance, operational changes, equipment or process modifications, additions of equipment, or a temporary halting of certain operations – all depending on the specific circumstances.

2.5 Notifications and Reporting

GE will conduct the notification and reporting activities specified in the Executive Summary of Volume 1 of the EPS and in the Section 2.7 of the Phase 1 ID RA Monitoring Scope and the CHASP that will be developed, subject to EPA review and approval.

2.6 Special Studies

Four special studies related to PCB resuspension and monitoring will be performed. Details for two of the special studies: near-field release mechanism and non-target area downstream contamination are described in Section 8 of the Phase 1 ID RA Monitoring Scope. The third study, to determine the relationship between TSS and turbidity is currently being discussed with EPA and a work plan has been submitted for EPA review and approval. Once approved, GE will perform the study. The results of the study will be provided as part of the Phase 1 RAM QAPP.

The last study is for determining the potential use of automated water samplers at the far-field stations (see Section 2.3 of Phase 1 ID RA Monitoring Scope). A work plan for testing automated samplers has been submitted for EPA review and approval. Upon approval, GE will perform this study. Details on the potential use of automated samplers during Phase 1 dredging will be provided in the Phase 1 RAM QAPP.

3. Residuals Performance Standard

This section of the Phase 1 ID PSCP Scope discusses the Residuals Performance Standard. It provides an overview of the residuals standards as set forth in the EPS (e.g., Volume 3), and specifies the routine monitoring requirements, contingency monitoring and other responses in the event of an exceedance of an action level (Section 3 of Volume 3 of the EPS), the required actions (Section 4.5 of Volume 3 of the EPS), the notification and reporting requirements (Section 4.8 of Volume 3 of the EPS), and the special study (Section 4.7 of Volume 3 of the EPS) under this standard.

3.1 Overview of Standard

The Residuals Performance Standard describes action levels for Tri+ PCBs (PCBs with three or more chlorines) in surface sediment that remains after dredging. The action levels will apply to a Certification Unit (CU), which is described in Section 3.2 of the Phase 1 ID RA Monitoring Scope and in Section 3.3 of this Phase 1 ID PSCP Scope. The action levels in the Residuals Performance Standard are summarized in Table C3-1.

The various actions to be taken based on the results of residual sediment sampling are described in Section 3.4.

Table C3-1 - Summary of the Performance Standard for Dredging Residuals

Case	Certification Unit Arithmetic Average (mg/kg Tri+ PCBs)	No. of Sample Results =15 mg/kg Tri+ PCBs AND < 27 mg/kg Tri+ PCBs	No. of Sample Results ≥ 27 mg/kg Tri+ PCBs	No. of Re-Dredging Attempts Conducted	Required Action (when all conditions are met)*
A	Avg. = 1	= 1	0	N/A	Backfill certification unit (where appropriate); no testing of backfill required.
B	N/A	= 2	N/A	< 2	Re-dredge sampling nodes and re-sample.
C	N/A	N/A	1 or more	< 2	Re-dredge sampling node(s) and re-sample.

Case	Certification Unit Arithmetic Average (mg/kg Tri+ PCBs)	No. of Sample Results =15 mg/kg Tri+ PCBs AND < 27 mg/kg Tri+ PCBs	No. of Sample Results ≥ 27 mg/kg Tri+ PCBs	No. of Re-Dredging Attempts Conducted	Required Action (when all conditions are met)*
D	1 < avg. = 3	= 1	0	N/A	Evaluate 20-acre area-weighted average concentration. If 20-acre area-weighted average concentration = 1 mg/kg Tri+ PCBs, place and sample back-fill. **If 20-acre area-weighted average concentration > 1 mg/kg, follow actions for Case E below.
E	3 < avg. = 6	= 1	0	< 2	Construct sub-aqueous cap immediately OR re-dredge. Construct cap so that arithmetic avg. of uncapped nodes is = 1 mg/kg Tri+ PCBs, no nodes > 27 mg/kg Tri+ PCBs, and not more than one node > 15 mg/kg Tri+ PCBs.
F	avg. > 6	N/A	N/A	0	Collect additional sediment samples to re-characterize vertical extent of contamination and re-dredge. If certification unit median > 6 mg/kg Tri+ PCBs, entire certification unit must be sampled for vertical extent. If certification unit median = 6 mg/kg Tri+ PCBs, additional sampling required only in portions of certification unit contributing to elevated mean concentration.
G	avg. > 6	N/A	N/A	1	Re-dredge. ***
H	avg. > 1 (20-acre avg. > 1)	= 2	= 1	2	Construct sub-aqueous cap (if any of these arithmetic average/sample result conditions are true) as described in Case E and two re-dredging attempts have been conducted OR choose to continue to re-dredge.

Notes:

* Except for Case H, where any of the listed conditions will require cap construction.

** Following placement of backfill, sampling of 0 to 6 inch backfill surface must demonstrate average concentration = 0.25 mg/kg Tri+ PCBs. If backfill surface average concentration is > 0.25 mg/kg, backfill must be dredged and replaced or otherwise remediated with input from EPA.

*** GE shall not install a Cap Type B without receiving EPA approval to cease re-dredging attempts, except for CUs where the average concentration in the CU is less than 6 mg/kg Tri+ PCB and the only non-compliant areas are due to exceedances of the prediction limits.

3.2 Sampling and Analysis Requirements

Following the completion of dredging in a CU, GE will verify that the design cut lines have been achieved and conduct the sampling and analysis of sediment residuals described in Sections 3.3 and 3.4 of the Phase 1 ID RA Monitoring Scope.

3.3 Evaluation of Sampling Data

The sediment sampling results will be used to evaluate the CU by: 1) converting the analytical results for Total PCBs to Tri+ PCBs, using the procedure described in Section 3.4 of the Phase 1 ID RA Monitoring Scope; and then 2) comparing the following values (rounded to whole numbers) to the action levels specified in Section 3.1, above.

- Arithmetic average Tri+ PCB concentration in the CU (or portion of the CU) under evaluation;
- Individual node sample Tri+ PCB concentration in the CU (or portion of the CU) under evaluation;
- Median Tri+ PCB concentration in the CU (or portion of the CU) under evaluation; and
- Area-weighted arithmetic average concentration in a moving 20-acre area consisting of the CU under evaluation, and the two, three, or four most recently dredged CUs within 2 river miles of the current CU (measured along the centerline of the river).

Arithmetic Average of CU

The arithmetic average Tri+ PCB concentration in the CU (or portion of the CU) under evaluation will be calculated by dividing the sum of the individual Tri+ PCB concentrations by the total number of individual sample locations. When calculating the CU arithmetic average, the following procedures will be applied:

- Non-detect sample results will be included in the arithmetic average calculation at a value of ½ the detection limit.
- If no sample is available from a grid node due to field difficulties that cannot be resolved (e.g., outcropping of bedrock), the arithmetic average will be calculated without counting that sample node.
- Following re-dredging of all or part of a CU, the arithmetic average will be subsequently re-calculated by substituting the new sample results from the re-dredged nodes.

- If a subaqueous cap is constructed, the arithmetic average will be calculated using the sample results from the nodes in the uncapped area (i.e., the extent of the capped area and its PCB levels will not be included in the calculation of the arithmetic average).
- The maximum of any duplicate results will be used to determine compliance with the Residuals Performance Standard.
- EPA split sample data will be considered if they are available prior to EPA concurrence on the Dredging Completion Approval Form for the CU under evaluation.

20-Acre Arithmetic Average

The 20-acre arithmetic average Tri+ PCB concentration will be calculated, using the 20-Acre Area-Weighted Average equation on p. 54 of Volume 3 of the EPS, by summing the area-weighted average Tri+ PCB concentrations in the CUs making up the 20 acre area, and dividing the total by the actual total acreage of the CUs.

The 20-acre evaluation unit will be composed of the CU under evaluation and the additional CUs (as necessary to provide a total area of approximately 20 acres) in which dredging was most recently completed, and which are located within 2 miles, measured along the centerline of the river, of the current CU. For purposes of calculating the area of the 20-acre unit, the total areas of these additional CUs will be included regardless of how they were closed. For purposes of calculating the average Tri+ PCB concentration in the 20-acre unit, the pre-backfill arithmetic average for any CU where backfill was placed will be utilized. Similarly, in CUs where a subaqueous cap is placed, for purposes of calculating the average Tri+ PCB concentration in the 20-acre unit, the capped CU's average concentration will be re-calculated based on the sample results from the nodes in the uncapped portion of the CU. The total acreage of the CUs will be used. If a CU is entirely capped, it will not be included in any 20-acre averaging calculations.

3.4 Required Actions

The Residuals Performance Standard requires confirmation that the design dredging cut lines as determined by the procedures described in Section 3.3 of the Phase 1 IDR have been achieved and collection of surface sediment samples has been completed. The need for and type of response actions required to be taken in a CU after confirmation that the design cut lines have been achieved will be based on comparing both the arithmetic average Tri+ PCB concentrations (calculated according to the procedures described above in Section 3.3) and also the individual sample node concentrations to the criteria specified in the Residuals Performance Standard. For the purposes of the response actions that follow, removal to the design cut lines will be defined as those specified in the final design and verified through bathymetric measurement and will comprise the first inventory removal pass. Should average CU concentrations following the first inventory pass exceed 6 mg/kg Tri+ PCB, the dredge cut lines will be revised and a second inventory removal will be made. Following bathymetric verification of the second inventory removal (if required), this will complete the inventory removal steps. Subsequent removal will be referred to as residual re-dredging. Post-inventory sampling results will dictate the appropriate response actions to be undertaken are described below.

The Residuals Performance Standard contains five required actions:

1. Backfill and demobilize (including testing of backfill if necessary).
2. Jointly Evaluate a 20-Acre Average.
3. Re-dredge or Construct Subaqueous Cap at a CU.
4. Re-dredging Required.
5. Capping.

Response 1 – Backfill and Demobilize

As outlined in Section 4.5.3 of Volume 3 of the EPS, if the Tri+ PCB average of a CU is = 1 mg/kg, no node has a Tri+ PCB sample result = 27 mg/kg, and not more than one node has a Tri+ PCB sample result of = 15 mg/kg, backfill will be placed (where appropriate) and equipment will be demobilized. (The criteria for determining when it is appropriate to place backfill, for purposes of the Residuals Performance Standard, are discussed in Section 3.5.) Under this response, backfill testing after placement will not be performed.

In addition, a portion of a contiguous CU may be backfilled after the cut lines are met if: 1) dredging proceeds in a downstream direction in the CU, and EPA has approved the completion of dredging in all CUs that are upstream of the portion of the contiguous CU; 2) the arithmetic average Tri+ PCB concentration of the samples collected from that portion of the CU is 1 mg/kg or less; 3) all nodes sampled within that portion of the CU have Tri+ PCB concentrations less than 15 mg/kg; and (4) GE has determined that it has adequate measures in place to minimize recontamination of that dredged portion of the CU. The EPA field representative will evaluate the adequacy of the measures in place to minimize recontamination and may indicate the need for additional sampling.

Backfill (where appropriate) and Sample Backfill Surface

In CUs where the average Tri+ PCB concentration is > 1 mg/kg and = 3 mg/kg, and the average Tri+ PCB concentration in the 20-acre evaluation area including the CU is = 1 mg/kg, backfill will be placed as described above. After confirmation of proper placement of the backfill, sampling will be conducted as described in Section 3.5 of the Phase 1 ID RA Monitoring Scope (under "Backfill Samples"). If the average surface Tri+ PCB concentration in the backfilled areas is = 0.25 mg/kg, then the CU will be closed. If the average concentration is > 0.25 mg/kg, the EPA field representative will be consulted, the area(s) will either be re-dredged and the backfill replaced, or an additional lift of backfill will be placed in the area(s) causing the average concentration to exceed 0.25 mg/kg, as described in Section 3.4 (Response 2). Where appropriate, backfill will be placed in a CU (or portion of a CU). In general, the backfill thickness will be 12 inches to address residuals; in some instances, no backfill may be placed, and in others, more than one foot may be placed. The details regarding the backfill type and thickness in specific locations will be determined during Final Design.

Response 2 – Jointly Evaluate a 20-Acre Average

As outlined in Section 4.5.3 of Volume 3 of the EPS, if the average Tri+ PCB concentration of samples collected in a CU is > 1 and < 3 mg/kg, no individual node has a Tri+ PCB sample result = 27 mg/kg, and not more than one individual node has a Tri+ PCB sample result = 15 mg/kg, the 20-acre area described above will be evaluated as follows:

For the 20-acre average, if the area-weighted arithmetic average of the individual means from the certification unit under evaluation and the three previously dredge certification units (within two miles of the current unit) is = 1 mg/kg Tri+ PCBs, backfill will be placed where appropriate and sampling performed to confirm that the average backfill surface Tri+ PCB concentration is = 0.25 mg/kg. Sampling of backfill will follow the procedures described in Section 3.5 (under Backfill Samples) of the Phase 1 ID RA Monitoring Scope; the development of an average concentration will follow procedures described in Section 3.3 above. If the concentration of the upper 6 inches of backfill is > 0.25 mg/kg Tri+ PCBs, GE will, in consultation with the EPA field representative, either 1) re-dredge and replace the backfill in the non-compliant area, or 2) place an additional lift of backfill (no less than 6 inches in thickness) in those areas that caused the average concentration to exceed 0.25 mg/kg, considering hydraulic conditions. Following actions 1) or 2) above, the backfill will be sampled again and the area-weighted concentration of the CU under evaluation will be recalculated.

If the area-weighted arithmetic average of the individual means from the certification unit under evaluation and the three previously dredge certification units (within two miles of the current unit) is > 1 mg/kg, the area will be re-dredged or a subaqueous cap will be placed at the specific areas within the CU that caused the non-compliant average concentration. GE will decide whether to re-dredge or to cap a non-compliant area based on engineering judgment in the field and evaluation of the sediment data for that CU. GE's decision shall take into account potential impacts on dredging productivity as appropriate, consistent with Section 3.5, Volume 3 of EPS).

For the startup of Phase 1, the cumulative mean can be calculated using the area-weighted average equation provided in EPS Volume 3, Section 4.5.2 in lieu of the 20-acre area-weighted arithmetic average, given that the first three CUs will not have a sufficient number of previously dredged CUs to allow for calculation of such 20-acre area-weighted arithmetic average (see Attachment A of Volume 3 of the EPS).

Response 3 – Re-dredge or Construct Subaqueous Cap at a CU

As outlined in Section 4.5.3 of Volume 3 of the EPS, if the Tri+ PCB average is > 3 mg/kg but = 6 mg/kg, no Tri+ PCB sample result is = 27 mg/kg, and not more than one Tri+ PCB sample result is = 15 mg/kg, the non-compliant area will be re-dredged or a subaqueous cap will be constructed. The process for determining whether a non-compliant area will be re-dredged or capped will be as described above under Response 2.

If re-dredging is selected, the surface sediment of the re-dredged area will be sampled in accordance with the re-dredging residuals sampling procedures in Section 3.5 of the Phase 1 ID RA Monitoring Scope (if concentrations are high, the core should be advanced a depth of 2 feet, where possible) and the CU will be re-evaluated. If subaqueous capping is selected, the capped area will be selected such that the arithmetic average Tri+ PCB concentration of the uncapped nodes is 1 mg/kg or less and no individual node has a Tri+ PCB concentration = 15 mg/kg.

Response 4 – Re-dredging is Required

1. Specific Nodes with Discrete Exceedances

   Regardless of the average Tri+ PCB concentration, if two or more samples within a CU have Tri+ PCB concentrations = 15 mg/kg, the non-compliant area will be re-dredged and the non-complaint nodes re-sampled in accordance with Section 4.5.3 of Volume 3 of the EPS. If one or more sample(s) has Tri+ PCB concentration = 27 mg/kg, such sampling node(s) will be re-dredged and re-sampled. Any re-sampling will comply with the re-dredging residuals sampling procedures in Section 4 of Volume 3 of the EPS and Section 3.5 of the Phase 1 ID RA Monitoring Scope. Under this response, no more than two residual re-dredging attempts will be required. After these node-specific re-dredging efforts are completed, the CU will be re-evaluated as described in Section 3.3 of this Phase 1 ID PSCP Scope.

2. CU Average > 6 mg/kg

   If two inventory removal attempts have been completed and the Tri+ PCB average for a CU is still > 6 mg/kg, up to two residual re-dredging attempts will be performed in the non-compliant areas. If after two residual passes the average is still > 6 mg/kg, GE will petition EPA to place a cap over the non-compliant area.

Response 5 – Capping

As outlined in Section 4.5.3 of Volume 3 of the EPS, if after two re-dredging attempts, a CU has a Tri+ PCB average > 1 mg/kg (and the 20-acre area-weighted arithmetic average is > 1 mg/kg), two or more samples show Tri+ PCB concentrations = 15 mg/kg, or one or more samples show Tri+ PCB concentration = 27 mg/kg, a subaqueous cap may be constructed, where conditions allow. In such a case, the area to cap will be selected such that the arithmetic average concentration of the uncapped nodes is 1 mg/kg Tri+ PCB or less and no individual uncapped node has a concentration = 15 mg/kg Tri+ PCB.

Extent of Non-Compliant Area

To determine the extent of the non-compliant area subject to further response action (e.g., re-dredging, capping) as described above, the procedures set forth in Section 4.5.5 of Volume 3 of the EPS and further discussed below will be followed. The extent of a non-compliant area around a single node sample will be determined using the following equation (repeated for each surrounding node) (as set forth in the EPS, Volume 3, pp. 58 to 59):

$$d_r = \frac{d*(C_1 - 1)}{(C_2 - C_1)}$$

where:

d_r = the distance (in feet) to the edge of the non-compliant area (i.e., from the C_1 to C_2 nodes)

d = the distance (in feet) between nodes (typically 80 feet)

C_1 = the concentration (in mg/kg Tri+ PCBs) at the elevated node under consideration

C_2 = the concentration (in mg/kg Tri+ PCBs) at a compliant node surrounding C_1

When calculating the extent of the non-compliant area using the preceding formula, the following procedures will apply:

- The distance which defines the non-compliant area will be at least half the distance between the nodes.
- The non-compliant area will be contained within a boundary that has sides perpendicular to the axes between the sampled nodes.
- The non-compliant area will not extend beyond the polygon created by connecting the surrounding nodes.
- The non-compliant area will not extend beyond the boundary of the CU.

Where the arithmetic average Tri+ PCB concentration in a CU following a dredging pass exceeds an applicable action level, the procedures for determining the extent of the non-compliant area will depend on whether the post-dredging data indicate the average Tri+ PCB concentration in the CU is greater than 6 mg/kg.

Where the arithmetic average Tri+ PCB concentration in the CU is > 1 mg/kg but < 6 mg/kg, the horizontal extent of non-compliant areas subject to further response action will be delineated by applying the criteria set forth in the preceding paragraph to the individual sample nodes with the highest Tri+ PCB concentrations (ensuring removal of those = 27 mg/kg and 15 mg/kg and others as necessary), and then recalculating the average Tri+ PCB concentration in the CU, until that average concentration is = 1 mg/kg. In making these recalculations, the concentration at nodes to be re-dredged will be considered to be at the average Tri+ PCB concentration of the nodes in the CU that will not be re-dredged or capped, and nodes to be capped will not be considered in calculating the average. The vertical extent of non-compliant areas will be determined based on the dredge equipment, thickness of the disturbed layer, and other pertinent information. The minimum vertical extent of non-compliant areas in this situation will be no less than 6 inches for purposes of establishing dredge cut lines for re-dredging purposes. If the disturbed layer is thicker than 6 inches, the vertical extent of dredging will be determined based on analysis of samples from depths greater than 6 inches, unless the cut lines will require dredging to bedrock or glacial clay.

Where the arithmetic average concentration in a CU exceeds 6 mg/kg Tri+ PCB, the following procedures will be followed in accordance with Section 4.5.3 of Volume 3 of the EPS: First, as described in Section 3.5 of the Phase 1 ID RA Monitoring Scope, deeper core samples (> 6 inches) will be taken from the archived samples (or collected if not archived) in successive 6-inch segments and analyzed for PCBs as necessary to characterize the depth to the first 6-inch sediment layer with = 1 mg/kg Total PCBs. This depth will be the vertical extent of contamination used as the basis for developing the dredge prism for further removal in the area surrounding that node. If the median concentration also exceeds 6 mg/kg Tri+ PCB, these deeper samples will be taken from areas throughout the CU. However, upon EPA approval, only a subset of the CU could be re-sampled if Tri+ PCB levels in the sampled nodes within the excluded portion if the CU are < 1 mg/kg. In this case, this discrete area will be considered a compliant area, and the remainder of the CU will be considered the non-compliant area subject to further dredging to remove the additional PCB inventory.

If the average Tri+ PCB concentration in the CU exceeds 6 mg/kg but the median concentration is < 6 mg/kg Tri+ PCBs, the deeper samples will be taken only from the sampling locations where the 0-6 inch concentration is greater than 1 mg/kg Tri+ PCBs. In this case, the latter locations will constitute the non-compliant area.

Based on physical conditions encountered in the field (e.g., bedrock, glacial clay), the extent of the non-compliant area may be modified subject to the approval of EPA.

3.5 Reporting

GE will submit the weekly progress reports and the individual CU-specific reports (to follow EPA approval of the backfill/cap installation at that CU) described in Sections 4.8 of Volume 3 of the EPS and Section 3.6 of the Phase 1 ID RA Monitoring Scope.

3.6 Special Study

The data that will be collected to address the special study to characterize residual sediment strata and thickness in accordance with the EPS Volume 3 Attachment B is described in Section 3.3 of the Phase 1 ID RA Monitoring Scope.

4. Productivity Performance Standard

This section discusses the Productivity Performance Standard. It provides an overview of the productivity standards as set forth in the EPS, describes how the design will establish a production schedule, specifies the monitoring and reporting requirements (Section 4.2 of Volume 4 of the EPS), and outlines the responses in the event that the production schedule is not being met (Section 4.3 of Volume 4 of the EPS).

4.1 Overview of Standard for Phase 1

The Productivity Performance Standard specifies the following annual minimum and target cumulative volumes of sediment (*in situ* volumes, exclusive of re-dredging volumes) to be removed, processed, and shipped off-site each year during Phase 1 (EPS, Section 4.1 of Volume 4, see also Table 4-1 of Volume 4):

- "The minimum volume of sediment to be removed, processed, and shipped off site during Phase 1 shall be 200,000 [cubic yards (cy)]. Phase 1 must be designed and scheduled to meet the target removal of 265,000 cy."
- "For a period of at least one month during Phase 1, the minimum production rate shall be the rate required to meet the Phase 2 Performance Standard in order to demonstrate the capabilities of the dredging equipment and the sediment processing and transportations systems." (For Phase 2, the standard specifies a required annual removal volume of 490,000 cy and a target annual removal volume of 530,000 cy.)
- "Stabilization of shorelines and backfilling of areas dredged during Phase 1, as appropriate, shall be completed by the end of the calendar year and prior to the spring high flow period on the river. Processed sediment shall not be stockpiled and carried over to Phase 2 for disposal."

The Productivity Performance Standard includes three action levels: Concern, Control, and Standard. These action levels are to be based on a comparison of the actual production rate to what is referred to as the scheduled productivity. The scheduled productivity for a dredging season will be defined in the RA Work Plan for that season, as described in Section 4.2.

Concern Level

The Concern Level is defined in the EPS (Volume 4, p. 30) as a situation during dredging operations in which "the monthly dredging productivity falls below the scheduled productivity for that month by 10 percent or more."

Control Level

The Control Level is defined in the EPS (Volume 4, p. 30) as a situation during dredging operations in which "the monthly productivity falls below scheduled productivity by 10 percent or more for two or more consecutive months."

Standard Level

The Standard Level is defined in the EPS (Volume 1, p. 69) as a situation in which the "[a]nnual cumulative volume fails to meet production requirements."

4.2 Design Activities to Establish Production Schedule

A production schedule has been developed for Phase 1 using the target annual removal volumes described for Phase 1 in Section 4.1 above. Specifically, as discussed in Section 3.3.1, Phase 1 is being designed to meet the Phase 1 target removal volume of 265,000 cy, and includes in the design a minimum of one month of dredging at the anticipated Phase 2 production rate – namely, 530,000 cy/yr. This monthly volume may be revised during Phase 1 Final Design considering the Phase 2 target removal volume and the number of operational days during the construction season (including hours per day and days per week).

The RD will use the dredge areas and target removal volumes from the EPA-approved Dredge Area Delineation Reports, as modified in the IDRs and FDRs, to develop dredging production schedules, which will be documented in the RA Work Plans. For purposes of developing the production schedules in the RD, the overall production schedule for a dredging season will include the removal of sediment as specified in the dredge prisms shown in the FDR, along with the installation of backfill and caps and stabilization of impacted shorelines prior to the end of the dredging season, which will be weather-dependent. The production schedule will also include a schedule for sediment processing and shipment off-site for disposal prior to the end of the calendar year. This production schedule may be subject to further revision by the contractor selected to perform the dredging; any revised production schedule will be provided in proposed revisions to the Phase 1 RA Work Plans, as the case may be, and will be subject to EPA approval. However, changes in the production schedule made by the contractor will not result in a revision in the volume to be dredged in any construction season as indicated in the Final Design Reports (FDRs). The actual dredging production rate during each phase of the project will be compared to the production schedule provided in the relevant RA Work Plan to determine whether the Concern, the Control, or the Standard Level has occurred. For purposes of establishing whether the Concern, the Control, or the Standard Level has occurred, the following rules will apply:

- The dredging production rate will be based on the actual volume dredged, which will be measured as *in situ* cy and will include the volume of sediment removed to achieve the removal limits specified in design, including any volume associated with overcut, side slope removal, overdredging allowance, and dredging for navigational purposes. For purposes of the Productivity Performance Standard, the volume dredged will not include sediment removed outside the dredge cut lines shown or specified in the Final Design, sediment removed during re-dredging to capture dredging residuals, additional material removed solely to facilitate cap/backfill placement, sediment removed from non-target areas (if any), or non-compliant backfill that is removed.
- For comparisons to monthly production schedule, the actual *in situ* volume dredged that month will be compared to the *in situ* volume scheduled for that month in the production schedule to be included in the RA Work Plan for the dredging season.
- For comparisons to the annual production schedule, the actual *in situ* volume dredged and processed will be compared to the *in situ* volume scheduled for that season in the production schedule to be included in the RA Work Plan for that season.

4.3 Routine Monitoring and Reporting

The specific activities to monitor the actual dredging productivity will be provided in the FDR. The monitoring activities also will be specified in the *Construction Quality Assurance Plan* (Construction QA Plan), which will be part of the RA Work Plan. Reporting will be in accordance with Section 4.2 of Volume 4 of the EPS and will include daily, weekly, monthly and annual reports, providing the volume of sediment dredged, which will be measured or estimated as *in situ* cy, as described above.

- Data for daily dredging operations will be maintained to evaluate productivity performance. The data to be collected will be relevant to the design, the specific equipment, and the contracting approach used for the project, and will include the following for each dredge: dredge operating hours and shifts per day; downtime for repairs to the dredge plant; downtime waiting for support equipment (e.g., barge, clogged pipeline, pipeline booster pump malfunction, etc.); downtime due to project and non-project vessel traffic; downtime to re-set the dredge and the number of re-sets per day; downtime associated with EPS-related shutdowns; downtime associated with QoLPS-related shutdowns; and the estimated average width, length, and depth of the dredge cut to estimate the volume of *in situ* sediment removed. The actual report form to be used will be provided in the FDRs and Phase 1 Construction QA Plan, and will include records of productivity data (e.g., estimated total cy of material processed, shipped off-site, and staged on-site), and be available on site.

- Weekly reports will be prepared providing information on the following:
  - Locations dredged;
  - Number of hours of actual dredging time per dredge and gross volume dredged each day and each week;
  - Cumulative amount dredged for the season;
  - Number of barges loaded and transported for off-loading, and approximate volume in each;
  - Time required for off-loading barges (if used);
  - Information on re-dredging efforts (locations, approximate volume, and time expended);
  - Total tonnage of material processed, shipped off-site, and stored on-site;
  - Concentration and mass of PCBs in processed sediments;
  - Volume of water treated and returned to river; and
  - Delays encountered in the project, the reasons for the delays, and the hours lost to production due to the delays.

- Monthly summaries will be prepared and submitted to EPA by the 15th of the following month, providing the same information listed above for each week during the month, season, and overall project. The monthly reports will also compare productivity on a weekly, monthly, seasonal, and project-total basis to the production schedule specified in the relevant RA Work Plan.
- Following the completion of Phase 1, GE will submit a report to EPA that compiles the relevant data from Phase 1.

- On-site records will also be kept of the following:
  - Locations of backfill and sediment caps placed;
  - Volumes of backfill or capping material placed and hours spent in placing backfill and sediment caps; and
  - Locations and details of shoreline work, including shoreline dredging and restoration rates.

4.4 Required Response Actions

If monitoring indicates an occurrence of the Concern or Control Level, GE will take the response actions required in Section 2.3.2.2 of Volume 1 of the EPS and described below.

During implementation of Phase 1, in the event that the production rate falls below the scheduled productivity, measures to make up the shortfall (in whole or in part) will be evaluated, including but not limited to increasing the hours and/or days of operation or utilizing available equipment to increase throughput.

During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event reasonable changes can be made to address achievement of the performance standards during Phase 1, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE’s proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

Concern Level

In the event that the Concern Level occurs, GE will: 1) notify EPA in its monthly report; 2) complete an assessment to determine the cause of the shortfall and whether there are any practical means to make up the shortfall or otherwise increase productivity within the next 2 months; and 3) present the results of that assessment and, if warranted, a proposal for such measures to EPA. GE will implement measures, as approved by EPA, to make up the shortfall or otherwise increase productivity, to the extent practical and subject to the general considerations described above. Activities that GE will consider for increasing productivity will include increasing work schedule, if not already operating 24 hours a day, 7 days a week, modifying the dredge plan, staging additional sediment at the processing facility, and other contingencies that are specified in the FDR.

Control Level

In the event that the Control Level occurs, GE will: 1) notify EPA; and 2) provide a report/action plan to EPA explaining the reasons for the shortfall and describing the steps underway or to be taken to increase production, subject to the general considerations described above. The objective will be to erase the shortfall by the end of the dredging season, if the shortfall can practically be erased. GE will implement measures, as approved by EPA, to make up the shortfall or otherwise increase productivity, to the extent practical and subject to the general considerations described above. Activities to be considered for increasing productivity will include increasing work schedule, if not already running 24 hours a day, 7 days a week, modifying the dredge plan, staging additional sediment at the processing facility, and other contingencies that are specified in the FDR.

5. Performance Standards for Air Quality, Odor, Noise, and Lighting

This section discusses the QoLPS for air quality, odor, noise, and lighting. It provides an overview of the quality-of-life standards as set out in the QoLPS, describes the design analyses to be performed to assess achievement of the standards, and specifies the routine monitoring requirements, contingency monitoring and other responses in the event of an exceedance of an applicable standard or other trigger level, requirements for responding to complaints, and notification and reporting requirements. Most of these requirements are specified in the Phase 1 ID RA Monitoring Scope and/or the Phase 1 ID RA CHASP Scope, and thus this section consists, in large part, of a roadmap with cross-references to those documents. (Note that the average concentrations described in this section for given time periods are block averages for that discrete time period, not running averages.)

5.1 Overview of Standards

Air Quality Performance Standard

The standards for total PCB concentrations in ambient air are 24-hour average concentrations of 0.11 micrograms per cubic meter (µg/m3) in residential areas and 0.26 µg/m3 in commercial/industrial areas, with "Concern Levels" at 80% of those values (0.08 µg/m3 in residential areas and 0.21 µg/m3 in commercial/industrial areas) (QoLPS, pp. 6-8 and 6-18).

The air quality standard for opacity, based on New York State regulations (6 NYCRR 211.3), is that opacity during project operations must be less than 20% as a 6-minute average, except that there can be one 6-minute period per hour of not more than 57% (QoLPS, p. 6 to 16).

In addition, the Air Quality Performance Standard requires an assessment during design of the following pollutants for which EPA has promulgated National Ambient Air Quality Standards (NAAQS): nitrogen oxides, sulfur dioxide, carbon monoxide, particulate matter with a median diameter of 10 micrometers or less, particulate matter with a median diameter of 2.5 micrometers or less, and ozone (QoLPS, pp. 6-9 to 6-11).

The need for monitoring of these constituents will be determined during Final Design using specific design data. The RD Team will repeat the assessment in EPA's *White Paper – Air Quality Evaluation* analyses (EPA, 2002) using project specific design data. If this project specific information developed during design validates the assumption used in EPA's *White Paper – Air Quality Evaluation* analyses (EPA, 2002), this will be considered a determination of compliance with the QoLPS such that further demonstration by on-site or off-site sampling will not be required. If air quality compliance is not demonstrated as a result of these analyses for any NAAQS, GE will evaluate potential design changes that could result in achievement of the NAAQS and/or the need for monitoring for such pollutant(s), and will submit a proposal on this topic to EPA for review and approval.

Odor Performance Standard

The odor standard has two components: 1) a numerical standard for hydrogen sulfide (H2S), which is 0.01 ppm (14 $\mu g/m^3$) over 1 hour; and 2) a standard for odor complaints, which is that the complaints are investigated and mitigated (QoLPS, p. 6-19).

Noise Performance Standard

The noise standards are as follows (QoLPS, p. 6-25):

Short-term criteria – applicable to facility construction, dredging, and backfilling:

- Residential Control Level (maximum hourly average):
  - Daytime = 75 dBA (A-weighted decibels)
- Residential Standard (maximum hourly average):
  - Daytime = 80 dBA
  - Nighttime (10:00 pm – 7:00 am) = 65 dBA
- Commercial/Industrial Standard (maximum hourly average):
  - Daytime and nighttime = 80 dBA

Long-term criteria – applicable to the processing facility and transfer operations:

- Residential Standard (24-hour average):
  - Day-night average = 65 dBA (after addition of 10 dBA penalty to night levels from 10:00 p.m. to 7:00 a.m.)

- Commercial/Industrial Standard (maximum hourly average):
  - Daytime and nighttime = 72 dBA

Lighting Performance Standard

The numerical lighting standards for light emissions attributable to the project are as follows (QoLPS, p. 6-39):

- Rural and suburban residential areas = 0.2 footcandle;
- Urban residential areas = 0.5 footcandle; and
- Commercial/Industrial areas = 1 footcandle.

In addition to these numerical standards, the Lighting Performance Standard references certain statutory and regulatory requirements pertaining to lighting. These include the following (QoLPS, p. 6-42):

- 33 CFR 154.570, which requires adequate fixed lighting for bulk transfer facilities at nighttime and states that lighting will be located or shielded so as not to mislead or otherwise interfere with navigation; and
- 33 USC §§ 2020 through 2024 (specifying various lighting requirements for vessels).

The project will comply with these requirements, as well as 33 CFR §§ 84-88, Annex I and Annex V, and the other requirements specified in the Navigation Performance Standard governing lighting on vessels.

As noted in the QoLPS, the Lighting Performance Standard will not supersede worker safety lighting requirements established by the Occupational Safety and Health Administration (OSHA) (QoLPS, p. 6-40).

5.2 Design Analysis

Section 3.11.2 of the Phase 1 IDR documents the engineering bases and assumptions to date to demonstrate that the equipment and processes to be used in Phase 1 are expected to meet the above quantitative standards as required by the QoLPS. Final analyses will be provided in the Phase 1 FDR.

5.3 Routine Monitoring

The following monitoring will be conducted:

- Routine and baseline air quality monitoring for PCBs in accordance with the requirements set forth in Section 6.1 of the QoLPS and Sections 4.2.1, 4.3.1, and 4.4.1 of the Phase 1 ID RA Monitoring Scope;
- Opacity monitoring in accordance with the requirements set forth in Section 6.1 of the QoLPS and Sections 4.2.3, 4.3.3, and 4.4.3 of the Phase 1 ID RA Monitoring Scope;
- Odor monitoring in accordance with the requirements set forth in Section 6.2 of the QoLPS and Sections 4.2.4, 4.3.4, and 4.4.4 of the Phase 1 ID RA Monitoring Scope;
- A 2-week noise study at the beginning of Phase 1 dredging operations, as described in Section 5.3 of the Phase 1 ID RA Monitoring Scope;
- Routine noise monitoring in accordance with the requirements set forth in Table 6-8 and Section 6.3 of the QoLPS and Sections 5.3 and 5.4 of the Phase 1 ID RA Monitoring Scope; and
- Lighting monitoring in accordance with the requirements set forth in Section 6.4 of the QoLPS and Sections 6.2 and 6.3 of the Phase 1 ID RA Monitoring Scope.

5.4 Contingency Monitoring and Responses

Ambient Air Concentrations of PCBs

In the event that air quality monitoring for PCBs shows an exceedance of an applicable Concern Level (defined in Section 5.1 above) or of a PCB air quality standard, the required actions, specified in Table 6-2 of the QoLPS will be taken. GE will provide the notifications specified in Section 4.6.1 of the Phase 1 ID RA Monitoring Scope, conduct the contingency monitoring specified for such exceedances in Section 4.5.1 of the Phase 1 ID RA Monitoring Scope, and take the other response actions specified for such exceedances in Section 2.1 of the Phase 1 ID RA CHASP Scope.

Opacity

In the event that opacity monitoring shows an exceedance of the opacity standard, GE will: 1) notify EPA and the New York Department of Environmental Conservation (NYSDEC); 2) undertake the contingency actions, to be specified for this situation in the RA CHASP; and 3) submit to EPA a report on the reasons for the exceedance and measures taken to prevent further exceedances.

Odor

The Odor Performance Standard defines the "Concern Level" as the presence of uncomfortable project-related odors identified by RA workers or an odor complaint from the public; and it defines the "Exceedance Level" as an exceedance of the H2S standard or "[f]requent, recurrent odor complaints related to project activities" (QoLPS, p. 6-24). If the Concern Level occurs and the odor is identified as potentially H2S, the required actions specified in Table 6-4 of the QoLPS will be taken. GE will provide the notification specified in Section 4.6.2 of the Phase 1 ID RA Monitoring Scope and conduct H2S monitoring as described in Sections 4.2.4 and 4.5.2 of the Phase 1 ID RA Monitoring Scope. If that monitoring shows an exceedance of the H2S standard, GE will continue monitoring on a regular basis until the standard is met, and will take the response actions specified in Section 2.2 of the Phase 1 ID RA CHASP Scope. In addition, if the Control or Exceedance Level is triggered by an odor complaint, GE will provide the notification specified in Section 4.6.2 of the Phase 1 ID RA Monitoring Scope and will respond to the complaint in accordance with the procedures set forth in Section 3 of the Phase 1 ID RA CHASP Scope, as noted in Section 5.5 below. The specified responses differ depending on whether the odor is identified as H2S.

Noise

The Noise Performance Standard defines the "Concern Level" as an exceedance of the residential control level, or an exceedance of an applicable noise standard that can be easily and immediately mitigated, or receipt of a project-related noise complaint (QoLPS, p. 6-38). It defines the "Exceedance Level" as an exceedance of an applicable noise standard that cannot be easily and immediately mitigated, or "[f]requent, recurrent noise complaints related to project activities" (QoLPS, p. 6-38). If there is an occurrence of the Concern Level or the Exceedance Level, the required actions specified in Table 6-9 of the QoLPS will be taken. GE will provide the notifications specified in Section 5.6 of the Phase 1 ID RA Monitoring Scope and will conduct the contingency monitoring specified in Sections 5.3 and 5.5 of that Scope. In addition, if noise levels are measured above the residential control level or an applicable noise standard, GE will conduct the response actions specified for such contingencies in Section 2.3 of Phase 1 ID RA CHASP Scope. The process for responding to complaints shall be as set forth in Section 3 of the Phase 1 ID RA CHASP Scope, as noted in Section 5.5 below.

Lighting

The Lighting Performance Standard defines the “Concern Level” as an exceedance of an applicable numerical standard that can be easily and immediately mitigated, or receipt of a project-related lighting complaint (QoLPS, p. 6-45). It defines the “Exceedance Level” as an exceedance of an applicable numerical lighting standard that cannot be easily and immediately mitigated, or “[f]requent, recurrent complaints related to project activities” (QoLPS, p. 6-45). If there is an occurrence of the Concern Level or the Exceedance Level, the required actions specified in Table 6-11 of the QoLPS will be taken. GE will provide the notifications specified in Section 6.5 of the Phase 1 ID RA Monitoring Scope and will conduct the contingency monitoring specified in Section 6.4 of that Scope. In addition, if lighting levels are measured above an applicable numerical standard, GE will conduct the response actions specified for the relevant level (Control or Exceedance) in Section 2.3 of the Phase 1 ID RA CHASP Scope. The process for responding to complaints shall be as set forth in Section 3 of the Phase 1 ID RA CHASP Scope, as noted in Section 5.5 below. Further, in the event of a deviation from a lighting requirement applicable to lighting on vessels, GE will follow the procedures for deviations from the navigation requirements, as specified in Section 2.5 of the Phase 1 ID RA CHASP Scope. These procedures for deviations from the standard include notifying the EPA and the New York State Canal Corporation (NYS Canal Corporation) promptly but no later than 24 hours after discovery of the deviation, identifying the cause of the deviation, implementing an action plan for mitigation measures and providing a corrective action report to the EPA in accordance with the RA CHASP.

During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event reasonable changes can be made to address achievement of the performance standards during Phase 1, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE’s proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

5.5 Response to Complaints

The process to be followed for handling and responding to complaints from the public relating to quality-of-life issues will be as set forth in Section 3 of the Phase 1 ID RA CHASP Scope. If a complaint is received relating to air quality, odor, noise, or lighting, GE will follow the procedure specified in that section for recording and responding to the complaint.

5.6 Notifications and Reporting

GE will conduct the recordkeeping, reporting, and notification activities specified in the following:

- For air quality, Section 6.1 of the QoLPS, Section 2.1 of the Phase 1 ID RA CHASP Scope and Section 4.6.1 of the Phase 1 ID RA Monitoring Scope;
- For odor, Section 6.2 of the QoLPS, Section 2.2 of the Phase 1 ID RA CHASP Scope and Section 4.6.2 of the Phase 1 ID RA Monitoring Scope;
- For noise, Section 6.3 of the QoLPS, Section 2.3 of the Phase 1 ID RA CHASP Scope and Section 5.6 of the Phase 1 ID RA Monitoring Scope; and
- For lighting, Section 6.4 of the QoLPS, Section 2.4 of the Phase 1 ID RA CHASP Scope and Section 6.5 of the Phase 1 ID RA Monitoring Scope.

In addition, reporting on the handling of complaints will be conducted as illustrated in Figure 6-1 of the QoLPS and as described in Section 3 of the Phase 1 ID RA CHASP Scope and in the Phase 1 RA CHASP.

6. Navigation Performance Standard

This section discusses the QoLPS for navigation during dredging operations. It sets forth the general requirements of the standard, describes the design analyses to be performed to assess achievement of the standard, and specifies the routine notice and monitoring requirements, contingency actions in the event of a deviation from the applicable requirements, requirements for responding to complaints, and notification and reporting requirements. Some of these requirements are specified in the Phase 1 ID RA CHASP Scope; these requirements are incorporated by reference in this section.

6.1 General Requirements

GE will comply with the following requirements of the Navigation Performance Standard:

- **Obstructions:** GE will, to the extent practical consistent with meeting the goals of the project and complying with the other performance standards, comply with 33 U.S.C. Ch. 9 § 409, which prohibits tying up or anchoring vessels or other craft in navigable channels in such a manner as to prevent or obstruct the passage of other vessels or craft.

- **Lighting on Vessels:** GE will comply with the following requirements relating to the type, size, location, color, and use of lighting on all ships:
  - 33 CFR §§ 84-88, Annex I – requirements for positioning and spacing of lights, location of direction-indicating lights for dredges, and screens, color, shape, and intensity of lights;
  - 33 CFR §§ 84-88, Annex V – additional requirements for lighting of moored barges and dredge pipelines; and
  - NYS Canal Corporation regulations at 21 NYCRR 151.11 – lighting requirements for moored floats.

- **Signals on Vessels:** GE will comply with the following requirements relating to the type, intensity, and use of lighting and sound for signaling on all ships:
  - 33 CFR § 86, Annex III – requirements for technical details of sound signals;
  - 33 CFR § 87, Annex IV – requirements for distress signals; and
  - NYS Canal Corporation regulations at 21 NYCRR 151.6 (draft marking on floats), 151.15 (buoys and lights displaced), 151.23 (warning signals approaching bends), and 151.26 (aids to navigation).

- **Piloting:** GE will comply with the following requirements regarding the piloting and movement of vessels:
  - 33 CFR § 88, Annex V – requirements for public safety activities, obtaining copies of rules, and law enforcement vessels; and
  - NYS Canal Corporation regulations at 21 NYCRR 151.7, 151.8, 151.9, 151.17. 151.18, 151.19, 151.20, 151.21, and 151.24 – piloting requirements.

As stated in the QoLPS (Section 7: Finalizing the Standards, p. 7-1): "If during design EPA determines that adjustments to the quality of life performance standards are warranted, EPA may adjust the standards and will involve the public in any such adjustment." The Navigation Performance Standard is modified herein to be consistent with the recent revisions to the navigational regulations of the NYS Canal Corporation (21 NYCRR Part 151), which were identified after release of the QoLPS.

In addition to the above, GE will comply with the following:

- **Restricting Access:** Access to work areas undergoing remediation will be restricted where necessary in coordination with the NYS Canal Corporation. Where access is restricted, necessary steps will be taken, to the extent practical, to provide an adequate buffer zone for safe passage of commercial and recreational vessels in the navigational channel. In any event, channel encroachment requirements will be established in consultation with the NYS Canal Corporation.
- **Scheduling Activities and Use of Locks:** Project-related river traffic will be controlled and scheduled so that interference with non-project-related vessels is not unnecessarily hindered, while at the same time allowing efficient performance of the project. Where locks are used, remedial operations will be coordinated with the NYS Canal Corporation and its lock operators. Project-related vessels will be considered commercial vessels for purposes of navigation.
- **Temporary Aids to Navigation:** Temporary aids to navigation (e.g., lighting, signs, buoys) in areas of active work may be necessary and will consist of items specified by the NYS Canal Corporation or United States Coast Guard (USCG).

The navigation performance standard includes two action levels – Concern and Exceedance Levels, as described below.

- The Concern Level occurs if there is a deviation from the requirements described above and the deviation can be easily mitigated, or if a project-related navigation complaint is received from the public.

- The Exceedance Level occurs if remedial activities unnecessarily hinder overall non-project related vessel movement and create project-related navigation interferences, or if there are frequent recurrent complaints from the public that project activities are unnecessarily hindering non-project vessel movement.

6.2 Design Analysis

Section 3.11.2.5 of the Phase 1 IDR documents the bases and assumptions for the design to demonstrate that the vessels and other equipment to be used in Phase 1 are expected to meet the Performance Standard for Navigation. Further details will be provided in the Phase 1 FDR. The NYS Canal Corporation will be consulted during RD on issues relating to navigation.

6.3 Routine Notices

In accordance with the Performance Standard for Navigation (Sections 6.5.6 and 6.5.7 of QoLPS), GE will provide routine notices during dredging, which will include the following:

- The NYS Canal Corporation will be notified when in-river project activities are anticipated. This will be done by both verbal and written notice. Information will be provided to allow the NYS Canal Corporation and/or USCG to issue Notices to Mariners.
- The public will be provided with a schedule of anticipated project activities. Methods for informing the public of anticipated actions may include the following, where appropriate:
  - Communications with lock operators during lock usage;
  - Broadcasting on appropriate marine frequencies during in-river activities to notify lock operators and other mariners of transient activities that may affect navigation;
  - Posting notices at marinas, public boat launches, and locks;
  - Providing interested commercial and recreational user groups with a summary of anticipated activities on an annual basis prior to initiating in-river activities; and
  - Posting information about in-river activities on a publicly accessible website.

Further details regarding the provision of notices to the public will be provided in the Phase 1 FDR.

6.4 Routine Monitoring

In accordance with the Performance Standard for Navigation (Section 6.5.6 of QoLPS), a routine monitoring program will be implemented to assess in-river activities associated with the project and non-project vessel traffic in the vicinity of the in-river activities. The routine monitoring will include the following:

- Periodic monitoring of in-river activities that may have an impact on navigation of the river by commercial and recreational watercraft; and
- Monitoring vessel traffic and compiling daily logs of river navigation activities in the vicinity of in-river project activities along with any resulting navigation issues.

Further details regarding the routine monitoring will be provided in the Phase 1 FDR.

6.5 Contingency Actions/Responses

In the event that the Concern or Exceedance Level occurs in the form of a deviation from the navigation requirements specified in Section 6.1, GE will take the required actions specified in Table 6-13 of the QoLPS. GE will conduct the contingency response actions specified for such level in Section 2.5 of the Phase 1 ID RA CHASP Scope.

During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event reasonable changes can be made to address achievement of the performance standards during Phase 1, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE's proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

6.6 Specific Requirements for Handling Complaints

If a navigation complaint is received from the public, GE shall follow the procedure specified in Sections 3.1 and 3.3 of the Phase 1 ID RA CHASP Scope, which shall describe the system for managing navigation complaints at and around the project site.

6.7 Notifications and Reporting

In accordance with the Performance Standard for Navigation (Sections 6.5.8 and 6.5.9 of the QoLPS), GE will make the following notifications and reports:

- A monthly navigation monitoring report summarizing monitoring activities for the previous month shall be submitted to EPA and NYS Canal Corporation. This report will include the daily record logs of river navigation activities and issues. The report will be in a tabular format and include a log of navigation complaints and follow-up actions taken to resolve the complaint.
- If there is a deviation from the navigation requirements specified in Section 6.1, GE will notify EPA and the NYS Canal Corporation verbally within 24 hours for deviations at the Concern Level and immediately upon knowledge of the deviation for deviations at the Exceedance Level.
- In the event of an occurrence of the Concern Level, GE will provide a follow-up report to EPA and the NYS Canal Corporation with a summary of the navigation issue and any mitigation conducted. In the event of an occurrence of the Exceedance Level, GE will submit daily navigation reports to the EPA and NYS Canal Corporation until compliance is achieved, and will submit a corrective action report within 10 days of discovery of the deviation, describing the cause of the problem and the mitigation measures implemented.

The required contents of these reports will be provided in the Phase 1 FDR. In addition, reporting on the handling of complaints will be conducted as described in Section 3 of the Phase 1 ID RA CHASP Scope, and in the Phase 1 RA CHASP.

7. WQC Requirements for In-River Releases of Constituents Not Subject to Performance Requirements

This section discusses the WQ requirements for in-river releases of constituents not subject to the EPS. It provides an overview of the substantive standards as set forth in the EPA's WQ requirements, and specifies the routine monitoring requirements, contingency monitoring and other responses in the event of an exceedance of an applicable standard or an observation of distressed or dying fish, and notification and reporting requirements. Where these requirements are specified in the Phase 1 ID RA Monitoring Scope and Phase 1 ID RA CHASP Scope, this section incorporates those requirements by reference.

7.1 Overview of Standard

The WQ requirements for in-river releases are divided into acute water quality standards to be met at near-field stations and health-based standards to be met at far-field stations.

Aquatic acute water quality standards at near-field stations

The WQ requirements issued by EPA in January 2005 (pp. 1 & 2) set forth the following standards for near-field stations:

- "Aquatic standards (some of which are hardness-dependent) apply to the dissolved form. Hardness varies along the length of the project area and will result in a range of calculated standards. For example, based on limited available data, average hardness values from Corinth and Waterford range from 18 ppm to 55 ppm respectively. The resulting ranges of water quality standards are as follows (where applicable , the formulas for calculating the standards are in brackets):
  - cadmium – Aquatic Acute A(A): 0.6 µg/L to 2.0 µg/L [(0.85) exp(1.128[ln (ppm hardness)] – 3.6867)].
  - lead – Aquatic Acute A(A): 14.4 µg/L to 50.4 µg/L [{1.46203 – [ln (hardness) (0.145712)]} exp (1.273 [ln (hardness)] – 1.052)].
  - chromium – Aquatic Acute A(A): 140 µg/L to 349 µg/L [(0.316) exp (0.819 ln (ppm hardness)) + 3.7256)].

- chromium (hexavalent) – Aquatic Acute A(A): 16 µg/L.
- mercury – Aquatic Acute A(A): 1.4 µg/L."

- "Water quality standards for pH and dissolved oxygen are specified in NYCRR Title 6, Chapter X, Part 703.3.
  - pH shall not be less than 6.5 or more than 8.5.
  - Dissolved oxygen for non-trout waters:
    - The minimum daily average shall not be less than 5.0 mg/L.
    - At no time shall the dissolved oxygen concentration be less than 4.0 mg/L."

Health (water source) standards at far-field stations

The WQ requirements (pp. 2 & 8) set forth the following standards for far-field stations:

- The following water quality standards, which apply to the total form and are not hardness dependent, should not be exceeded at any of the Schuylerville, Stillwater, or Waterford fixed far-field stations:
  - Cadmium (total): 5 µg/L;
  - Chromium (total): 50 µg/L;
  - Mercury (total): 0.7 µg/L; and
  - Lead (total): 15 µg/L (New York State Department of Health [NYSDOH] action level), with a "trigger level" of 10 µg/L at Stillwater and Waterford.

- Determination of an exceedance requires a "confirmed occurrence" prior to any changes in operation, though the potential changes will be formulated after one exceedance – i.e., four subsequent samples, each representing a 6-hour composite, as specified in the WQ requirements.

7.2 Routine Monitoring

GE will conduct the routine near-field and far-field monitoring for metals and water quality parameters (i.e., pH, DO, temperature, turbidity, suspended solids, hardness, and conductivity as described in the WQ requirements (pp. 2-7) as modified in Sections 2.2, 2.3, and 2.4.4 of the Phase 1 ID RA Monitoring Scope.

7.3 Contingency Monitoring

In the event that the routine monitoring shows an exceedance of an applicable standard (or the trigger level for total lead), GE will conduct the contingency monitoring specified for the relevant exceedance in the WQ requirements (pp. 2-7) as modified in Sections 2.2, 2.4.4, and 2.5 of the Phase 1 ID RA Monitoring Scope. As described in Section 7.2 above, lead and cadmium will be used initially as a surrogate for the metals RA monitoring program. Monitoring requirements may be modified to include the additional metals as identified in the WQ requirements and section 7.1 above.

7.4 Contingency Actions/Responses

If any of the above standards is exceeded at a near-field or far-field station, GE will promptly notify EPA and NYSDEC (and, for exceedances of the health standards at far-field stations, the NYSDOH and the public water suppliers), but no later than 3 hours after receipt of the laboratory data, evaluate the cause(s) of the exceedance, and propose an appropriate response to EPA for approval. GE will make these laboratory data available to EPA, NYSDEC, NYSDOH and the water suppliers.

The selection of investigative measures will depend on specific project circumstances and may include one or more the following different actions:

- Visual observations of operations;
- Discussions with project personnel;
- Review of operations records;
- Examination of the integrity of containment barriers (if in use);
- Examination of sediment transport pipeline (if in use);
- Examination of barge loading system and barge integrity;
- Examination of resuspension associated with tugs, barges, and other support vessels; and
- Additional monitoring and/or sampling.

GE will consider and evaluate potential responses and propose an appropriate response to EPA. Such responses may include additional studies, increased monitoring, and/or implementation of engineering controls. GE will consider potential engineering controls including:

- Initiate engineering evaluation and continual adjustments to dredging operations until concentrations are in compliance with the WQ requirements.
- Evaluate and identify any problems.
- Changes in resuspension controls, dredge operation, or dredge type.
- Implementing additional resuspension controls.
- Temporarily cease operations if required.

GE will prepare and submit an Engineering Evaluation Report, which contains the results of this engineering evaluation, the proposed engineering solution, and a proposed schedule for implementing that solution, except as follows: if the solution involves a refinement in operations or equipment that is consistent with, and would not require a modification of, the EPA-approved design or the RA Work Plan, then GE will implement the solution in consultation with the EPA field representative and will document the implementation of that solution in the Engineering Evaluation Report. In all other cases, GE will implement the engineering solution in accordance with the EPA-approved Engineering Evaluation Report. If the cause of the exceedance was not identified by the engineering evaluation, the Engineering Evaluation Report will include a course of action for continued monitoring and evaluation to determine the cause of the exceedance. GE will consult with EPA on a regular basis until the cause and solution are determined, or until EPA orders a temporary halt to the operation(s) that caused the exceedance or until EPA determines that further evaluation is not necessary. During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event that reasonable changes can be made to address achievement of the performance standards during Phase 1, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE's proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

In addition, if a trigger level of 10 µg/L total lead (~ 70% of the action level) is exceeded by a single water column sample at the Stillwater or Waterford Stations, GE will promptly notify EPA, NYSDEC, NYSDOH and the water suppliers, but no later than 3 hours after receipt of the laboratory results. If that exceedance is confirmed by the next 24-hour sample, GE will evaluate the cause of the exceedance and propose an appropriate response to EPA. Such response may include increased monitoring and/or implementation of engineering controls, as described in the preceding paragraph.

7.5 Responses to Observations of Distressed or Dying Fish

If, during in-water activities, distressed or dying fish are observed, GE will promptly notify EPA. GE will also assess the cause(s) of the situation; and if the cause can be determined and is project-related, GE will conduct increased monitoring for metals and additional water quality parameters, where appropriate, in accordance with the WQ requirements (p. 9) and the Phase 1 ID RA Monitoring Scope, and will propose an appropriate response to EPA, following the same requirements and subject to the same qualifications specified in Section 7.4 for an exceedance of water quality standards.

7.6 Notifications and Reporting

In addition to the notifications and reporting described above in this section, GE will conduct the notification and reporting activities specified in Section 2.7 of the Phase 1 ID RA Monitoring Scope.

8. Substantive WQC Requirements for Discharges to Hudson River and Champlain Canal (Land Cut above Lock 7)

This section addresses the substantive WQ requirements for discharges to Hudson River and Champlain Canal (land cut above Lock 7), as well as the associated monitoring requirements, response actions, and notification and reporting requirements.

8.1 Effluent Limitations

The following (Table C8-1) are effluent limits for the potential discharge from dredged sediment dewatering facilities to the Champlain Canal (land cut portion) above Lock 7 for the Hudson River PCB Site Remedial Action.

Table C8-1 – Effluent Limits for Potential Discharge from Dredged Sediment Dewatering Facilities to the Champlain Canal (Land Cut Portion) Above Lock 7

Parameter	Treatment Plant Discharge Flow Rate	Water Quality Based Effluent Limits
PCBs	Any Assumed Flow Rate	0.3 µg/l, goal of 0.065 µg/l (same as for discharge to Hudson River)
Mercury	Any Assumed Flow Rate	(same as for discharge to Hudson River)
Chromium	0.1 MGD	0.21 mg/l (0.175 lb/day)
	Discharge Flow rate greater than 0.1 MGD	18.9 lb/day (maximum mass flow rate)
Cadmium	0.1 MGD	0.04 mg/l (0.033 lb/day)
	Discharge Flow rate greater than 0.1 MGD	0.62 lb/day (maximum mass flow rate)
Lead	0.1 MGD	0.038 mg/l (0.03 lb/day)
	Discharge Flow rate greater than 0.1 MGD	0.31 lb/day (maximum mass flow rate)
Copper	0.1 MGD	0.136 mg/l (0.11 lb/day)
	Discharge Flow rate greater than 0.1 MGD	0.75 lb/day (maximum mass flow rate)

Note: The accompanying table lists concentrations and associated mass loading rates for Cadmium, Chromium, Lead and Copper for discharge flow rates between 0.1 and 15 MGD.

All other parameters and conditions included in the substantive requirements of a State Pollutant Elimination Discharge Elimination System permit for potential discharge to the Hudson River from dredged sediment dewatering facilities as listed below (Table C8-2) would also be applicable to discharges to the Champlain Canal.

Table C8-2: Other Parameters and Conditions Included In the Substantive Requirements of a State Pollutant Elimination Discharge Elimination System Permit

Flow, MGD	Cr	Load	Cd	Load	Pb	Load	Cu	Load
0.100	0.210	0.175	0.040	0.033	0.038	0.032	0.136	0.113
0.300	0.210	0.525	0.040	0.100	0.038	0.095	0.136	0.340
0.500	0.210	0.876	0.040	0.167	0.038	0.158	0.136	0.567
0.700	0.210	1.226	0.040	0.234	0.038	0.222	0.128	0.750
0.900	0.210	1.576	0.040	0.300	0.038	0.285	0.100	0.750
1.100	0.210	1.927	0.040	0.367	0.034	0.310	0.082	0.750
1.300	0.210	2.277	0.040	0.434	0.029	0.310	0.069	0.750
1.500	0.210	2.627	0.040	0.500	0.025	0.310	0.060	0.750
1.700	0.210	2.977	0.040	0.567	0.022	0.310	0.053	0.750
1.900	0.210	3.328	0.039	0.620	0.020	0.310	0.047	0.750
2.100	0.210	3.678	0.035	0.620	0.018	0.310	0.043	0.750
2.300	0.210	4.028	0.032	0.620	0.016	0.310	0.039	0.750
2.500	0.210	4.379	0.030	0.620	0.015	0.310	0.036	0.750
2.700	0.210	4.729	0.028	0.620	0.014	0.310	0.033	0.750
2.900	0.210	5.079	0.026	0.620	0.013	0.310	0.031	0.750
3.000	0.210	5.254	0.025	0.620	0.012	0.310	0.030	0.750
3.500	0.210	6.130	0.021	0.620	0.011	0.310	0.026	0.750
4.000	0.210	7.006	0.019	0.620	0.009	0.310	0.022	0.750
4.500	0.210	7.881	0.017	0.620	0.008	0.310	0.020	0.750
5.000	0.210	8.757	0.015	0.620	0.007	0.310	0.018	0.750
5.500	0.210	9.633	0.014	0.620	0.007	0.310	0.016	0.750
6.000	0.210	10.508	0.012	0.620	0.006	0.310	0.015	0.750
6.500	0.210	11.384	0.011	0.620	0.006	0.310	0.014	0.750
7.000	0.210	12.260	0.011	0.620	0.005	0.310	0.013	0.750
7.500	0.210	13.136	0.010	0.620	0.005	0.310	0.012	0.750
8.000	0.210	14.011	0.009	0.620	0.005	0.310	0.011	0.750
8.500	0.210	14.887	0.009	0.620	0.004	0.310	0.011	0.750
9.000	0.210	15.763	0.008	0.620	0.004	0.310	0.010	0.750
9.500	0.210	16.638	0.008	0.620	0.004	0.310	0.009	0.750
10.000	0.210	17.514	0.007	0.620	0.004	0.310	0.009	0.750
10.500	0.210	18.390	0.007	0.620	0.004	0.310	0.009	0.750
11.000	0.206	18.900	0.007	0.620	0.003	0.310	0.008	0.750
11.500	0.197	18.900	0.006	0.620	0.003	0.310	0.008	0.750
12.000	0.189	18.900	0.006	0.620	0.003	0.310	0.007	0.750
12.500	0.181	18.900	0.006	0.620	0.003	0.310	0.007	0.750
13.000	0.174	18.900	0.006	0.620	0.003	0.310	0.007	0.750
13.500	0.168	18.900	0.006	0.620	0.003	0.310	0.007	0.750
14.000	0.162	18.900	0.005	0.620	0.003	0.310	0.006	0.750

Flow, MGD	Cr	Load	Cd	Load	Pb	Load	Cu	Load
14.500	0.156	18.900	0.005	0.620	0.003	0.310	0.006	0.750
15.000	0.151	18.900	0.005	0.620	0.002	0.310	0.006	0.750

Note: Mass Loadings, in lb/day, and Concentrations, in mg/l, for Chromium (Cr), Cadmium (Cd), Lead (Pb), and Copper (Cu) for Various Discharge Flow Rates to the Champlain Canal

Calculations: The mass equivalent of the listed concentrations for Cadmium, Chromium, Lead, and Copper, respectively, may be discharged up to the maximum mass flow rate listed. For example, 0.21 mg/l of Chromium may be discharged at any discharge flow rate up to 10.8 MGD, which equates to 18.9 lb/day at 0.21 mg/l. At discharge flow rates greater than 10.8 MGD, no more than 18.9 lb/day of Chromium may be discharged (resulting in proportionally lower concentrations). The mass flow rate is determined using the calculation:

Load = [flow, MGD] x [concentration, mg/l] x [8.34]

Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharge to the Hudson River

During the period beginning with the effective date of discharge (EDD) and lasting until the completion of the project, the discharges from the treatment facility to water index number H, Class B/C, Hudson River will be limited and monitored as specified in Table C8-3 below.

Table C8-3: Limits to Discharges from the Treatment Facility
to Water Index Number H, Class B/C, Hudson River

Outfall Number and Parameter	Discharge Limitations		Units	Minimum Monitoring Requirements		Foot-note
	Daily Avg.	Daily Max		Measurement Frequency	Sample Type	
Outfall 001 - Treated Remediation Discharge for Hudson River PCB Site:						
Flow	Monitor	Monitor	GPD	Continuous	Meter	
pH (range)	6.0 to 9.0		SU	Monthly	Grab	
Solids, Total Suspended	Monitor	50	mg/l	Weekly	Grab	8
Total Organic Carbon	Monitor	Monitor	mg/l	Weekly	Grab	8
PCBs, Aroclor 1016	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8

Outfall Number and Parameter	Discharge Limitations		Units	Minimum Monitoring Requirements		Foot-note
	Daily Avg.	Daily Max		Measurement Frequency	Sample Type	
Outfall 001 - Treated Remediation Discharge for Hudson River PCB Site:						
PCBs, Aroclor 1221	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8
PCBs, Aroclor 1232	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8
PCBs, Aroclor 1242	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8
PCBs, Aroclor 1248	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8
PCBs, Aroclor 1254	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8
PCBs, Aroclor 1260	Monitor	0.3	µg/l	Weekly	Runtime composite	1,8
PCBs, Total	Monitor	Monitor	µg/l	Weekly	Runtime composite	1,8
Cadmium, Total	Monitor	0.04	mg/l	Weekly	Grab	2,8
Chromium, Total	Monitor	0.21	mg/l	Weekly	Grab	2,8
Copper, Total	Monitor	0.136	mg/l	Weekly	Grab	2,8
Lead, Total	Monitor	0.038	mg/l	Weekly	Grab	2,8
Mercury, Total	Monitor	0.0002	mg/l	Weekly	Grab	2,3,8
Dissolved Oxygen	Monitor	Monitor	mg/l	Weekly	Grab	8

<u>Additional Conditions and Footnotes:</u>

(1) PCBs:

a. GE must monitor this discharge for PCBs using EPA laboratory Method 608. The laboratory must make all reasonable attempts to achieve the Minimum Detection Levels (MDLs) of 0.065 µg/l for each of the subject Aroclors. Monitoring requirements may be modified in the future if the EPA approves a method different from Method 608

b. Non-detect at the MDL of 0.065 µg/l is the discharge goal. GE shall report all values above the MDL. If the level of any Aroclor is above its listed MDL, GE must evaluate the treatment system and identify the cause of the detectable level of PCBs in the discharge. Following three consecutive months that include analytical results above any MDL, GE shall prepare an approvable report identifying the measures undertaken to eliminate the detections and propose additional steps to be taken to eliminate the recurrence of such detections. This report shall be submitted to the EPA within 28 days following receipt of sampling results from the third monitoring period.

c. If EPA determines that effluent monitoring results above the MDL of 0.065 µg/l can be prevented by implementation of additional measures as proposed by GE, GE shall implement such additional measures.

d. The treatment technology for this discharge shall be the maximum feasible treatment technology for treatment of PCBs. As treatment technology improvements become available, GE shall, at its own initiative or the EPA's request, review the available technology and submit for EPA approval, plans to improve the treatment technology and/or Best Management Practices employed to remove maximum feasible amount of PCBs from the wastewater discharge.

e. This limit is a phased Total Maximum Daily Loading limit, prepared in accordance with 6 NYCRR 702.16(b). Discharge is not authorized until such time as an engineering submission showing the method of treatment is approved by the EPA. The discharge rate may not exceed the effective or design treatment system capacity.

(2) Mass based effluent limits for these metals will be developed when the final effluent flow rate is determined.

(3) Mercury, Total shall be analyzed using EPA Method 1631.

(4) All monitoring data, engineering submissions and modification requests must be submitted to:

Doug Garbarini
Hudson River Team
EPA
290 Broadway, 19th Floor
New York, NY 10007
(212) 637-3952

With a copy sent to:

William Daigle, Hudson River Unit
Division of Environmental Remediation
NYSDEC, 625 Broadway, Albany, New York 12233-7010
(518) 402-9770

(5) Only site generated wastewater related to the Hudson River PCB Site Remedial Action is authorized for treatment and discharge.

(6) Both concentration (mg/l or µg/l) and mass loadings (lbs/day) must be reported for all parameters except flow and pH.

(7) Any use of corrosion/scale inhibitors or biocidal-type compounds used in the treatment process must be approved by EPA prior to use.

(8) In accordance with CERCLA Sections 121(d)(2) and 121(e), no permits are required for on-site CERCLA response actions.

With respect to Footnote 1, GE will not be required to make any modification to the PCB method or treatment technologies that is not being required at other facilities by NYSDEC. During Phase 1, equipment modifications or additions that are not reasonably available from a schedule or cost standpoint will not be required, recognizing that substitutions for major equipment approved in the Phase 1 Final Design or being used in Phase 1 may be impractical. However, in the event that reasonable changes can be made to address achievement of the performance standards during Phase 1, GE will propose such changes to equipment or operations for EPA review and approval. During Phase 1, EPA will consider any information that GE may submit regarding impacts to schedule and project costs when the Agency reviews GE's proposals, if any, for modification of the EPA-approved Phase 1 Final Design based on field conditions or experience.

8.2 Discharge Monitoring

GE will monitor the above discharges in accordance with the discharge monitoring requirements set forth in the WQ requirements and Section 8 of the Phase 1 ID RA Monitoring Scope. Further details will be specified in the Phase 1 RAM QAPP to be prepared as part of the RA Work Plans.

The monitoring will be consistent with the substantive requirements identified in EPA's letter to GE dated January 7, 2005.

8.3 Response Actions

In the event of an exceedance of the discharge limitations (which include a detection of Aroclors above the MDL), GE will perform an engineering evaluation and propose, for EPA approval, appropriate corrective action in an Engineering Evaluation Report to be submitted to EPA and NYSDEC. The corrective action may include additional testing to assess the problem, carbon (or other media) changeout, repairs to equipment, operational modifications (e.g., modifying additive dosages, more frequent backwashing, lead/lag changes of activated carbon, reducing flow rate), modifications to or replacement of treatment equipment, or, if necessary, temporary cessation of operations. In addition, if the level of any PCB Aroclor is above the MDL, GE will perform an investigation into the cause of the detectable level of PCBs in the discharge and provide the results in a report to EPA. If 3 consecutive months include PCB results above the MDL, GE will prepare and submit to the EPA a report that identifies the corrective measures undertaken and proposes additional steps to eliminate the recurrence of such detections. GE will submit the report to the EPA within 28 days from GE's receipt of the sampling results from the third monitoring period. GE will implement any additional corrective measures in accordance with the EPA-approved report recommending such corrective measures.

8.4 Notifications and Reporting

GE will submit to the EPA and NYSDEC a monthly report that includes the routine monitoring results for discharges to the Hudson River and the Champlain Canal (Land Cut above Lock 7). Both concentration [mg/L or µg/L] and mass loadings [lbs/day] will be reported for all parameters except flow and pH. In the event of an exceedance of the discharge limitations or PCB detection, GE will prepare and submit to the EPA and NYSDEC a separate report, as described in Section 8.3 of this Phase 1 ID PSCP Scope. Monitoring data, engineering submissions and modification requests will be submitted to EPA with a copy sent to NYSDEC.

Quantitative Environmental Analysis, LLC

Hudson River PCBs Site

Phase 1 Intermediate Design Report
Attachment D – Determination of Depth of Contamination

Prepared by:

Quantitative Environmental Analysis, LLC

Montvale, NJ

Prepared for:

General Electric Company

Albany, NY

August 22, 2005

Hudson River PCBs Site

Phase 1 Intermediate Design Report
Attachment D – Determination of Depth of Contamination

Prepared by:

Quantitative Environmental Analysis, LLC

Montvale, NJ

Prepared for:

General Electric Company

Albany, NY

Job Number:

GENdes:232

August 22, 2005

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List of Acronyms

CL	Confidence Level
DAD	Dredge Area Delineation
DoC	Depth of Contamination
GIS	Geographic Information System
IDL	Interactive Data Language
IDW	Inverse Distance Weighting
LWA	Length-Weighted Average
MAE	Mean Absolute Error
ME	Mean Error
MPA	Mass per Unit Area
NAVD88	North American Vertical Data 1988
OSI	Oceans Surveys, Inc.
PCB	Polychlorinated Biphenyl
RM	River Mile
RMSE	Root Mean Squared Error
SEDC	Supplemental Engineering Data Collection
SFSP	Supplemental Field Sampling Plan
SSAP	Sediment Sampling and Analysis Program
TIN	Triangulated Irregular Network
USEPA	United States Environmental Protection Agency

SECTION 1
INTRODUCTION

In accordance with the RD Work Plan (BBL 2003), the objective of Phase 1 dredge area delineation (DAD) was to identify those sediments within the Phase 1 Areas that meet the criteria for removal specified in the Record of Decision, as well as those specified in the United States Environmental Protection Agency's (USEPA's) Final Decision (USEPA 2004). These objectives are outlined in more detail in the Phase 1 DAD Report (DAD Report), which was approved by USEPA on March 30, 2005 (QEA 2005). In relation to the depth of dredging, a specific objective of the DAD was to determine depths of removal required to capture the PCB-containing sediments meeting the removal criteria within the delineated dredge areas. The DAD Report provided a detailed description of the methodology for establishing the horizontal and vertical boundaries of those areas meeting the criteria for removal, volume of contaminated sediments, and PCB inventory within those areas. The depth of contamination (DoC) was defined as the depth of sediment below which Total PCB concentrations are consistently less than 1 mg/kg. The DoC for each core was based on the measured Total PCB concentration data, Total PCB concentration extrapolations, or the doubled depth of the recovery of the core, as defined in the DAD Report. Kriging was performed on DoC estimates of each available core and resulted in a continuous surface over the river, indicating the thickness of sediment that met the criteria for removal, as per the definition of DoC.

Kriging, and most other interpolation schemes, use a weighted average of values at nearby sampled locations as the estimate of the value at each unsampled location. Thus, interpolated values fall inside the range of the neighboring measured values, always greater than the lowest value and less than the highest value. This behavior has two consequences: 1) the interpolated surface is smoother than the data from which it was derived; and 2) the interpolated values tend to exceed local measured values that are at the lower end of the distribution of measured values and to be less than local measured values that are at the upper end of the distribution of measured values. These consequences can be problematic if the measured values exhibit discontinuities (i.e., abutting regions where the within region variance is small in comparison to the cross-region variance) and if the region of interest is characterized by measured values at one end of the distribution. The kriging of DoC for purposes of dredge delineation was degraded by both of these factors. The boundaries between dredge areas and non-dredge areas tend to be boundaries between shallow sediments and deeper sediments and the DoC values inside dredge areas are at the upper end of the distribution of values within an interpolation domain. An illustration of this problem is shown in Figure D-1-1. This figure shows interpolated DoC contours established by kriging along with measurements of DoC for an area in the vicinity of Griffin Island. A clear discontinuity in DoC is seen between the non-dredge and dredge areas. Because of the influence of the low DoC values in the non-dredge area, the interpolated results in the dredge areas consistently underestimate the measured DoC values for individual cores. This is not a consequence of uncertainty associated with the DoC values within the dredge area. In fact, the data show that the DoC values within the dredge area are consistent such that DoC is known with good confidence. Rather, the under prediction by kriging is a consequence of including DoC values from the non-dredge area in the interpolation equation estimating DoC values within the dredge area when the data show a clear separation between these populations of data (i.e., the DoC data within the dredge area are not correlated with the data outside the dredge area).

Various alternatives to DoC kriging were examined in an effort to produce a DoC surface that exhibited less bias relative to the measured values. Unfortunately, all of the spatial interpolation models we examined were deficient to some extent because of the discontinuities mentioned above and the absence of a stationary spatial correlation structure over the domain of the interpolation. This latter issue is a general problem throughout the river. Spatial correlation appears to be very local and varies considerably from location to location. Furthermore, DoC is controlled by variables that cannot effectively be included in interpolation. For example, it was found that in certain areas, the DoC coincided with the top of the Glacial Lake Albany clay layer. However, attempts at cokriging DoC with the top of the clay layer and other variables did not materially improve performance of the interpolator.

The method to produce a DoC surface that appeared to have the least bias was to interpolate the Total PCB concentration in discrete depth intervals, overlay the interpolation results and define DoC by the top of the shallowest depth interval at which Total PCB concentration was less than 1 mg/kg and was also less than 1 mg/kg at all deeper intervals. Figure D-1-2 shows the results of this method (using Inverse Distance Weighting [IDW] as the interpolation model) for the same area near Griffin Island for which DoC kriging results are shown in Figure D-1-1. The interpolation of 1 mg/kg does a better job of matching the gradient in DoC that exists between the dredge area and the non-dredge area. Moreover, it provides a better match to the high DoC values found at the easternmost section of the area shown in the figures. On the basis of these types of comparisons, interpolation of Total PCB concentration at depth was chosen as the methodology to develop a DoC surface for use in intermediate design for Phase 1 Areas.

In addition, this Attachment presents an analysis to determine where DoC appears to extend to Glacial Lake Albany clay, the approach used to map the elevation of the surface of the clay layer, and the combining of the DoC surface and the clay surface to form a final DoC boundary for use in Phase 1 intermediate design. This Attachment summarizes the development and application of these two methods.

SECTION 2
DATA TREATMENTS

2.1 PCB DATA

All available data from the Sediment Sampling and Analysis Program (SSAP) and Supplemental Field Sampling Plan (SFSP), as well as all available data from data gap programs (i.e., QEA 2002, QEA 2003) were incorporated into the interpolation method (referred to as the 1 mg/kg interpolator throughout this document). In conducting the interpolation, data treatment was dependent on the Confidence Level (CL) of the core (as defined in the DAD Report [QEA 2005]):

- CL1, 2A, 2B, 2E, 2F, 2G: The Total PCB concentrations for all measured and extrapolated sections were used to the maximum depth (two times recovery depth). The Total PCB concentrations below the maximum depth were set equal to 0 mg/kg.
- CL2C and 2R: The Total PCB concentrations for measured sections were used to the depth to top of rock or clay. If there were no measured Total PCB concentrations from the recovery depth to the top of the rock or clay layer, the Total PCB concentrations reflects the absence of data. The Total PCB concentrations below the rock or clay layer were set equal to 0 mg/kg.
- CL2D: Total PCB concentrations for all measured sections were used. Below the last measured section, Total PCB concentrations were set equal to no data.
- CL2H: No measured Total PCB concentrations were used. Below probing depth Total PCB concentrations were set equal to 0 mg/kg.
- CL2I: Not used in the 1 mg/kg interpolator.
- CL2J: Below probing depth, Total PCB concentrations were set equal to 0 mg/kg.
- CL2K: Below probing depth, Total PCB concentrations were set equal to 0 mg/kg.
- CL2L: Not used in the 1 mg/kg interpolator.

Special considerations for some of these CLs are described in more detail in Section 3.2. The extrapolation applied to the Total PCB concentration in incomplete cores is described in Section 2.2.3 of the DAD Report (QEA 2005). In addition, in relation to the data gap data, agreed upon language (e.g., USEPA 2004) detailed the criteria to apply in order to determine whether the original core, the data gap core, or both cores would be used in the dredge area delineation and subsequent design. However, these criteria assumed that the pertinent information for delineation and design was surface PCB concentrations, MPA, and DoC. This new method for determining a depth of dredging surface does not directly consider each core's DoC. Instead, the focus of this method is on Total PCB concentrations within a pre-set number of depth intervals. As a result, in all cases, the measured Total PCB data for the original core and its paired data gap core were incorporated into the 1 mg/kg interpolation. Only the measured sections for the previously "dropped" core were used, while all measured and extrapolated (if applicable) sections of the kept core were used as per the rules described above.

2.2 RESPONSE TO USEPA'S MARCH 30, 2005 COMMENTS

On March 30, 2005, USEPA provided, along with the DAD Report approval letter, comments to be considered during dredge prism development in the Phase 1 intermediate design and preparation of the Phase 2 DAD. The following section addresses are the comments related to Phase 1 intermediate design. Although this Attachment is focused on determination of DoC, the following section addresses all comments from the USEPA's March 30, 2005 letter that pertain to Phase 1 intermediate design.

Comment 1: East Rogers Island Interpolation and Areal Extent of Dredge Delineation

USEPA recommended that separate interpolations be conducted for the northern, central and southern portions of East Rogers Island in order to honor the changes in flow direction as the river proceeds downstream. In response to this comment, the interpolation of the 1 mg/kg interpolation areas for East Rogers Island was conducted separately for the northern, central, and southern portions of this channel. However, the MPA and surface PCB interpolations were not adjusted and the areal extent of NTIP01 remained unchanged from the DAD Report.

USEPA recommended modifying the areal boundaries of the dredge area delineation near the Fort Edward Terminal Wall (i.e., the northernmost portion of NTIP02a). However, based on engineering considerations as described in Section 3.3 of the Phase 1 Intermediate Design Report, this area has been removed from the dredging program.

Comment 2: West Rogers Island Areal Extent of Dredge Delineation

USEPA recommended extending the dredge area in the northern portion of West Rogers Island to the shoreline. No adjustment has been made because the existing delineation is consistent with the delineation rule specifying that the results of the interpolator be followed unless ancillary data or PCB data that would support moving the boundary away from the interpolated boundary exist at an acceptable density. Moreover, the recommended extension would cover a shallow area with a bottom consisting of rocks and cobbles. In consultation with USEPA oversight personnel at the beginning of the 2002 field program, much of this area was deemed inaccessible for coring (Figure D-2-1).

Comment 3: Core RS1-9392-AR100 Meeting Select Criteria

USEPA requested that surrounding cores be considered to determine whether a core in the vicinity of River Mile 193 (Core RS1-9392-AR100) meeting the "Select" criteria should be treated as a "Select" core. USEPA noted that this core has a double peak and therefore might not be indicative of an area of burial. The data from this core do meet the Select criteria, as interpreted by USEPA (i.e., maximum Total PCB concentration in the top 12 inches below 5 mg/kg and a peak buried below 24 inches) and has been treated as such. All of the Total PCB concentrations in samples from this core are below 10 mg/kg, thus the double peak results from Total PCB concentrations of 3.9 mg/kg in the 0-2 in. segment and 7.9 mg/kg in the 36-42 in. segment and do not provide strong evidence that this area is not an area of burial.

Comment 4: Depth of Contamination

GE assigned a DoC of 6 in. to all samples with probing depths that were less than or equal to 6 in. However, as indicated by the USEPA, these locations could have DoC set to their probing depth. As a result, the samples shown in Table 1 of USEPA's comments were incorporated into the 1 mg/kg interpolator with the measured Total PCB concentration assigned to a depth interval from the surface to the probing depth. Below the probing depth for these locations, the Total PCB concentration was assumed to be 0 mg/kg.

USEPA also discussed three cores that have reporting limit issues (USEPA Table 2) and indicates the DoC of these cores can be adjusted for intermediate design. However, given the new method for establishing DoC (i.e., Total PCB concentration interpolation at depth), this adjustment is unnecessary. The Total PCB concentrations for all sections that had reporting limit issues were adjusted as per USEPA's Final Decision (USEPA 2004) and the data were used in the 1 mg/kg interpolation.

The final portion of USEPA's Comment 4 relates to uncertainty. As discussed in Section 1 of this Attachment, the DoC surface derived from kriging is inadequate for dredge prism development and this Attachment presents the approach used instead. The uncertainty estimates of DoC provided by the kriging model do not provide a means to improve the kriging DoC surface because they are subject to the limitations caused by differences in the spatial structure of the data and the assumptions of the model. Thus, these estimates cannot be used to provide a reliable estimate of a "conservative" DoC surface. As discussed in Section 3.4.2 of the Phase 1 Intermediate Design Report, the data are inherently conservative and it is likely that a DoC surface consistent with the data is conservative. The approach used to develop dredge prisms produces such a surface and no adjustment of the surface to depths greater than that indicated by the data is warranted.

Comment 5: Other Comments Related to Dredge Area Delineation

USEPA indicated that two exceedances on the east shoreline below Lock 7 should be included in a dredge area. However, these two points are surrounded by cores below the criteria and are considered isolated. Therefore, the dredge area was not revised.

USEPA indicated that the DAD Report did not provide the "requested level of justification" regarding historical cores and those cores identified as "inconsistent". Section 2.7

of the DAD Report details the evaluation of the historical core data and the arguments supporting the treatment of these data, while Section 2.2.4.1 of the DAD Report discusses the analyses conducted that led to labeling of certain data as "inconsistent". In addition to the justification provided in the Phase 1 DAD (QEA 2005), we note that excluding historical data from the dredge delineation has no material effect on the delineation. Of the six historical cores in the Northern Thompson Island Pool for which MPAs could be confidently calculated, five are within dredge areas and do not provide an indication that areas outside the dredge areas met the removal criteria at the time the historical cores were collected. Similarly, all of the four historical cores in East Griffin Island are within dredge areas. Additionally, the historical cores within dredge areas would not have significantly influenced the boundaries established by interpolation because most have MPAs similar to the values for neighboring SSAP cores and tend to be overwhelmed by the large number of SSAP cores in the local area. Regarding the inconsistent cores, in the February 3, 2005 letter from GE to USEPA, GE agreed to relax the tolerance for the classification of cores with inconsistent data to be cores where the lab recovery is more than five inches greater than the penetration depth and the lab recovery is more than five inches greater than the field recovery, because of USEPA's concerns related to the potential for measurement errors in the field recovery. The differences in the Total PCB concentrations and the textural descriptions between the core identified as containing inconsistent data and the 2004 data gap core support the use of the data from the data gap core only.

The last comments relevant to the Phase 1 intermediate design received from USEPA on March 30, 2005 were related to data gap core pairs, in which the DoC and MPA of a paired core were not used in delineation. Specifically, USEPA found 10 core pairs in which the dropped core has a measured end depth that is greater than the DoC of the core that was used; USEPA found 22 core pairs in which the dropped data gap core has a higher MPA than that of the core that was used.

For the method presented here for DoC determination, the measured Total PCB data for both the data gap core and the dropped core were used in the interpolation of Total PCB at depth. However, a response to USEPA's comment is provided here for completeness. USEPA provided a list of 13 core pairs (3 additional than the original 10 mentioned in the March 30, 2005 comments) in a follow up email received on May 20, 2005. Of those 13 cores, 6 of the dropped cores have been reintegrated into the intermediate design (see Table D-2-1), including 2 cores that are located within "clay areas", and 7 are still dropped for the reasons given Table D-2-1.

Table D-2-1. Dropped data gap cores highlighted in USEPA's March 30, 2005 comments.

Core ID	New Treatment	Comments
RS1-9089-ET063	None	Core in "Clay Area". Original core had clay at 6 in.; data gap core had clay at 5 in. and DoC at 2 in. Data treatment correct.
RS1-9392-IN067	None	Peak TPCB concentration at the bottom of new core. DoC for old extrapolated to 14 in. This is equal to the depth of the last measured section in the new core.
RS1-9392-WT071	CL2F	Core extrapolated.
RS1-9392-WT127	CL2F	Core extrapolated.
RS1-9392-WT228	CL2F	Core extrapolated.
RS1-9392-WT286	None	Original core had only one sample (0-2 in.). Data gap core has a DoC and the clay layer at 2 in.
RS1-9493-WS110	CL2F	Old core has a nearly classic PCB profile. Core extrapolated.
RS1-9493-WS111	CL2F	Old core has a nearly classic PCB profile. Core extrapolated.
RS1-9493-WS603	None	GE identified this as a clay core with the DoC at 9 in. USEPA extrapolated the DoC to 34 in. Core in "Clay Area". Data treatment correct.
RS1-9493-WT256	None	DoC in data gap core is 2 in. Original core only sampled from 0-2 in. Data treatment correct.
RS1-9594-WS603	None	GE identified this as a clay core with the DoC at 9". USEPA extrapolated the DoC to 34 in. Core in "Clay Area". DoC determined by top of clay layer.
RS1-9594-WT086	None	Old core is a short core with an inconsistent profile. GE does not propose to use the data from the old core for determining the DoC.
RS1-9594-WT171	CL2F	Old core has a nearly classic PCB profile with the exception of the bottom layer (30-34 in.). Core extrapolated.

In addition, the areal interpolation and delineation were not redone to accommodate the 22 incomplete cores not used in delineation that have measured MPAs greater than their paired core that was used in delineation. For some of the 22 dropped data gap cores, our calculations result in different MPAs than those shown in the file provided by USEPA on May 20, 2005. In many of the cases, the dropped data gap core would not have a significant impact on the dredge delineation because the core is located well within the dredge area boundaries and/or the difference in MPA between the dropped core and the kept core is not significant. However, GE will reconsider the unextrapolated MPAs of these dropped data gap cores when making any adjustment to the areal delineation in the Phase 1 Areas during the analysis of the 2005 data gap sampling results.

2.3 IDENTIFICATION OF THE INTERFACE BETWEEN SEDIMENT AND GLACIAL LAKE ALBANY CLAY

As described in Section 1 of this Attachment, it was determined that in certain portions of the river, the DoC extends to the top of the Glacial Lake Albany clay layer. Glacial Lake Albany was formed approximately 15,000 years ago when water melting from the edge of a glacier was dammed by glacial debris (http://www.skidmore.edu/sssg4/environment/geology.htm). Glacial Lake Albany occupied the Hudson River Valley from Poughkeepsie to Glens Falls. Clay and sand were deposited on floor of the glacial lake. Seasonal variations during deposition resulted in the varved or rhythmically bedded clays and silts, although this layering is not present in all locations and throughout the entire thickness of the clay deposits (Cadwell 2005).

The top of the glacial clay at each sample location was determined by looking at the textural and general descriptions from the SSAP core or Supplemental Engineering Data Collection (SEDC) boring at that location. This was done using the following systematic approach:

- Cores with Clay "CL" as the primary textural description were identified. The top of the segment was noted.
- If the textural description also contained gravel, organics, coarse sand or medium sand, the core was flagged and the core profile was reviewed in detail to evaluate if the clay could be determined to be Glacial Lake Albany clay.
- Cores with Clay or "CL" in the general description were identified. Any depth associated with the indication of clay was noted. The core profile for each of these cores was reviewed in detail.
- For cores with clay in both the general description and the primary textural description, the associated depths were compared. If the depths did not match, the core profile was reviewed in detail.
- The depth to the top of clay was determined. If it could not be definitively determined that a core contained the Glacial Lake Albany clay, the core was flagged as uncertain, and no information was used from this core.

- If there was no indication of clay in a given core, the bottom of the last segment in the database was identified as the depth which the clay layer could not be above for that location.

2.4 CREATION OF BATHYMETRY SURFACE

A 1 by 1 ft. grid of bathymetry elevations was required to convert depths below the sediment surface from the 1 mg/kg interpolator (see Section 3) to elevations. Ocean Surveys, Incorporated (OSI) conducted a bathymetric survey of East Rogers Island in July 2005 which included both multi-beam and single-beam data. OSI provided this data binned into a 1 by 1 ft. grid. However, this grid does not cover all of East Rogers Island; there are some gaps between grid cells and near the shoreline.

To fill in gaps, elevations (in NAVD88) were assigned to the GIS layer shoreline that was digitized from aerial photography of flow conditions in spring 2002. This Hudson River shoreline represents a flow rate of approximately 5,000 cfs at Fort Edward (QEA 2005) which corresponds to a flow rate of approximately 5216 cfs at Thompson Island Dam based upon tributary contributions (QEA 1999). It was assumed that at the shoreline, the water depth approaches zero which means the shore elevation is equal to the water surface elevation. The flow rate is linked to water-surface elevation by the equations below:

$$\text{At Fort Edward}: Elevation\,[ft] = 117.2 + 0.123 * (FlowRate[cfs])^{0.406} \qquad (2\text{-}1)$$

$$\text{At Thompson Island Dam}: Elevation[ft] = 117.2 + 0.062 * (FlowRate[cfs])^{0.441} \qquad (2\text{-}2)$$

The elevation of the shoreline between Fort Edward and Thompson Island Dam was approximated using linear interpolation. To calculate distance from Fort Edward, a Hudson River centerline was drawn. This line was divided into 10-ft. segments each with an associated distance to Fort Edward. The shoreline was converted into points and each point was assigned a distance from Fort Edward based on the distance associated with the closest Hudson River 10-ft. centerline segment.

A Triangulated Irregular Network (TIN; i.e., linear interpolation) of elevations was used to fill in gaps using both the bathymetry data from OSI and the approximate shoreline elevations. The gridded data from OSI and the filled in gaps were combined to create a complete grid of elevations.

SECTION 3
INTERPOLATION OF TOTAL PCB AT DEPTH

3.1 REVIEW OF IDW

Interpolations were performed to determine the areal extent of Total PCB concentrations at depth using the IDW deterministic interpolator with a specified optimization procedure. These interpolations are referred to as "1 mg/kg interpolations" because a Total PCB concentration of 1 mg/kg is the threshold that determines depth of contamination in a core. The steps involved in completing the 1 mg/kg interpolation are: 1) assigning Total PCB concentrations at depth; 2) transforming the assigned Total PCB concentrations; 3) delineating interpolation areas; 4) optimizing the IDW parameters; and 5) performing final IDW interpolation. Complete discussions of Steps 2 through 5 are available in Section 3 of the DAD Report. Only those aspects of each step pertinent to this particular analysis are discussed herein.

IDW was used rather than kriging because the data set was not amenable to the development of experimental variograms. The zero values in the data set, which constitute a significant portion at depth, tend to corrupt the variogram.

3.2 ASSIGNMENT OF TOTAL PCB AT DEPTH

The DAD Report categorized each available SSAP core with a CL, indicating the confidence in MPA estimations and in some cases, confidence in DoC. Further detailed discussion on CLs can be found in the DAD Report (QEA 2005). Each core with CL 1, 2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2J, 2K, or 2R was partitioned into 18 vertical slices at 2, 12, 24, 30, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 108, and 114 inches. The length-weighted average Total PCB concentration for each slice was determined using the equation:

$$LWA = \sum_i \frac{TPCB_i(L_i)}{L_s} \qquad (3\text{-}1)$$

where: LWA is the length-weighted average of the Total PCB concentration of the slice, TPCB is the measured or extrapolated Total PCB concentration of section *i*, L is the length of the portion of section *i* that is greater than or equal to the top of the slice and less than or equal to the bottom of the slice, and L_s is the length of the slice.

Where appropriate, the straddle core protocol as defined in USEPA Final Decision (USEPA 2004, Appendix A) was used to calculate the Total PCB concentration in the portion above 12 in. of a core section whose top and bottom straddle 12 in. For cores that have a section straddling 12 in. (e.g., 2-24 in. section) and a Total PCB concentration in the section below the straddle section that is less than the straddle section, the Total PCB concentration in the portion of the straddle section above 12 in. was calculated assuming that all of the PCB mass in the straddle section was in that portion of the section. In these cases, correct mathematics requires that the Total PCB concentration in the portion of the straddle section below 12 in. be set to zero. To be conservative, this was not done. The Total PCB concentration below the 12 in. horizon was set equal to the measured concentration in the straddle section. This results in "double counting" of Total PCB concentrations. For example, if a 2-24 in. section had a Total PCB concentration of 10 mg/kg that was adjusted to 20 mg/kg using USEPA's equation for the 2-12 in. layer, the Total PCB concentration in the 12-24 in. layer was assumed to still be equal to 10 mg/kg.

In addition to the adjustments discussed above and data treatments discussed in Section 2.1, some special conditions were applied when assigning the slice Total PCB concentration values:

- Sections with Total PCB concentrations of non-detect were assigned concentrations of 0 mg/kg.
- Slices whose start depths were greater than or equal to the depth to the confining layer in CL 2C and 2R cores were assigned concentrations of 0 mg/kg. The confining layers in 2C and 2R cores are the clay and rock layers, respectively and were determined by reviewing the field notes of those cores. Slices in 2C and 2R cores where at least 25% of

the slice is deeper than the bottom of the last measured section and shallower than the confining layer were considered to have no data.

- Slices in CL 2H, 2J, and 2K cores whose start depths were above the depth of contamination were considered to have no data and those whose start depths were below the depth of contamination were assigned concentrations of 0 mg/kg.
- All final slice concentrations between 0 and 0.0001 mg/kg were assigned a value of 0 mg/kg in order to avoid complications in the data transformation.

If a slice did not meet any of the above criteria, did not include a straddle core section, included sections with measured or extrapolated concentrations, and included sections with no data, then the concentration of the slice was calculated as the LWA of the available concentrations.

3.3 INTERPOLATION AREAS

The Phase 1 Areas were divided into seven interpolation areas with approximately uniform flow direction. The division process was described in detail in the DAD Report, Section 3.2 (QEA 2005), and the interpolation areas used in this analysis are the same as the variogram areas used in the DAD Report, except RM192 was not included. In addition, East Rogers Island was divided into three different interpolation areas, as per USEPA's March 30, 2005 comments (see Section 2.2 of this Attachment). The interpolation areas are listed, along with the interpolation area flow direction, in Table D-3-1 and shown in Figure D-3-1. Interpolations were carried out separately for each slice in each interpolation area.

Table D-3-1. Interpolation areas for Phase 1 intermediate design and related flow direction.

Subarea	Flow Direction (degrees)
West_RI	150
East_RIa	100
East_RIb	165
East_RIc	40
Lock7	35
NE_GI	170
SE_GI	20

3.4 TRANSFORMATION OF SLICE LWA TOTAL PCB CONCENTRATIONS

The Total PCB concentration of each slice in each core was transformed using the same procedure as in the DAD Report: the Box-Cox transformation was applied in order to arrive at an optimal λ value that generally resulted in a distribution visually closest to linear on a normal probability scale. Normality was evaluated using the Shapiro-Wilk Test. The Box-Cox transformation and Shapiro-Wilk Test are described in detail in the DAD Report (Section 3.3, QEA 2005).

3.5 OPTIMIZATIONS

Using a similar procedure as described in the DAD Report (QEA 2005), the IDW parameters were optimized in an effort to minimize errors. Each layer was optimized independently, around the decision criterion of 1 mg/kg (i.e., the accuracy of the model in predicting whether the point is above or below 1 mg/kg). The parameters that were optimized were:

1. azimuth;
2. IDW power;
3. major semiaxis; and
4. anisotropy ratio.

Optimization was performed using a computer program written in Interactive Data Language (IDL; a programming environment for statistical and graphical data analysis; www.rsinc.com/idl/) and is described in detail in the DAD Report (Section 3.4.1.3, QEA 2005). The optimized parameters were chosen, primarily, to minimize the Type 2 errors (false negatives) with a secondary priority of minimizing total errors. The optimized IDW parameters for the 18 slices in the six Phase 1 variogram areas are summarized in the Tables D-3-2, D-3-3, and D-3-4. A table for azimuth is not included because that parameter is the flow direction in the given variogram area (Table D-3-1).

Table D-3-2. Optimized anisotropy for 1 mg/kg interpolation.

Subarea	0 to 2 in.	2 to 12 in.	12 to 24 in.	24 to 30 in.	30 to 36 in.	36 to 42 in.	42 to 48 in.	48 to 54 in.	54 to 60 in.	60 to 66 in.	66 to 72 in.	72 to 78 in.	78 to 84 in.	84 to 90 in.	90 to 96 in.	96 to 102 in.	102 to 108 in.	108 to 114 in.
West_RI	5	5	5	2	2.9	2.5	2	2	2	2	2	2	2	2	2	2	2	2
East_RIa	5	2	10	1.5	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2
East_RIb	7	2.5	2.5	7	10	2	2.5	2	2	2.9	2	2	2	2	2	2	2	2
East_RIc	2	5	5	5	5	5	2	2	2	2	2	2.9	2	3	2	2	2	2
Lock7	2.5	1	1.5	2.5	2.9	2	1.5	2	2	2.5	2	2	2.5	2	2	2	2	2
NE_GI	5	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SE_GI	3	2	2.5	2.9	2	2.5	2.9	2.9	2	2	2.9	2	2	2	2	2	2	2

Table D-3-3. Optimized major semiaxis for 1 mg/kg interpolation.

Subarea	0 to 2 in.	2 to 12 in.	12 to 24 in.	24 to 30 in.	30 to 36 in.	36 to 42 in.	42 to 48 in.	48 to 54 in.	54 to 60 in.	60 to 66 in.	66 to 72 in.	72 to 78 in.	78 to 84 in.	84 to 90 in.	90 to 96 in.	96 to 102 in.	102 to 108 in.	108 to 114 in.
West_RI	540	540	540	200	310	310	200	200	200	200	200	200	200	200	200	200	200	200
East_RIa	540	200	1000	140	140	200	200	200	200	200	200	200	200	200	200	200	200	200
East_RIb	770	1000	540	770	1000	200	310	200	200	310	200	200	200	200	200	200	200	200
East_RIc	200	540	540	540	540	540	310	200	200	200	200	310	200	540	200	200	200	200
Lock7	770	540	890	310	1000	200	140	200	200	540	200	200	310	200	200	200	200	200
NE_GI	540	1000	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
SE_GI	540	770	540	310	200	540	310	310	200	200	310	200	200	200	200	200	200	200

Table D-3-4. Optimized power for 1 mg/kg interpolation.

Subarea	0 to 2 in.	2 to 12 in.	12 to 24 in.	24 to 30 in.	30 to 36 in.	36 to 42 in.	42 to 48 in.	48 to 54 in.	54 to 60 in.	60 to 66 in.	66 to 72 in.	72 to 78 in.	78 to 84 in.	84 to 90 in.	90 to 96 in.	96 to 102 in.	102 to 108 in.	108 to 114 in.
West_RI	2.5	1.5	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
East_RIa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
East_RIb	1	1.5	2.5	3	4.5	4.5	5	3.5	4	1	1	1	1.5	1.5	1	1	1	1
East_RIc	1	1	2.5	1.5	4	1	3.5	1	1	1	1	1	1	2	1.5	1	1	1
Lock7	1	1	3	5	3.5	5	5	4.5	1	3.5	1	1	1	1	1	1	1	1
NE_GI	3	1	3.5	2.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SE_GI	1	1	5	3.5	1	4	1	1	1	1	5	1	1	1	1	1	1	1

3.6 FINAL INTERPOLATION PARAMETERS AND RESULTS

Interpolations were performed in each interpolation area for each of the 18 slices. The grid cells within the interpolation area were then assigned depth values equal to the bottom of the deepest slice for which the interpolated Total PCB concentration value was greater than or equal to 1 mg/kg. This grid is the dredge depth surface as defined by the IDW interpolator. The final interpolated surfaces showing the depth at which Total PCB concentrations go below 1 mg/kg are presented in Figures D-3-2a through D-3-2c.

SECTION 4
DEVELOPMENT OF ELEVATION OF CLAY SURFACE

4.1 ASSIGNMENT OF ELEVATION OF DATA POINTS

Both SSAP cores and SEDC borings were assigned elevations based on the 1 by 1 ft. grid of July 2005 multi-beam bathymetry data provided by OSI. Each core was assigned an elevation from the nearest bathymetry grid cell. In addition, statistics on all bathymetry grid cells within 1.6 ft. of each core were examined to check that core elevations were not influenced by features such as fallen trees or debris.

4.2 DEVELOPMENT OF ELEVATION OF CLAY SURFACE

The following steps were used to develop the elevation of clay surface: 1) determine the depth to clay at each core; 2) convert the depths to elevations; 3) manually draw 5-ft. clay surface contours based on clay elevations and the elevations of the bottom of cores where the clay is not present; 4) create 1-ft. clay surface contours based upon TINs; 5) manually adjust the 1-ft. contours; and 6) create a surface based upon the 1-ft. contours.

The depth to Glacial Lake Albany clay in each core is determined as described in Section 2.3. The elevation of clay layer was calculated by subtracting the depth to clay from the elevation assigned to the core. Next, 5-ft. contours of the top of clay were hand-drawn based on clay elevations and the bottom elevation of cores without clay. In locations where there are cores without clay, the elevation of the clay surface must be deeper than or equal to the bottom elevation of these cores.

One-foot top of clay contours were then created by creating two TINs. The first TIN is based upon the 5-ft. contours and the clay elevations from cores with Glacial Lake Albany clay. The second TIN is based upon all the information used in the first TIN and the bottom elevation of cores without clay. These two TINs were converted into 1 by 1 ft. grids. One-foot contours were created from the minimum value of the two grids based upon TINs and the bathymetry data. This ensures that the top of clay surface honors cores with clay and cores without clay, and does not exceed the elevation of the river bottom bathymetry. The 1-ft. contours were manually adjusted, as necessary, and a TIN was created based only upon these 1-ft. contours. A grid was created from the TIN and if the elevation of any grid cells exceed the elevation of the river bottom bathymetry, the elevation of these grid cells was set equal to the bathymetry elevation. This clay elevation grid was then converted to a point GIS file to be used in the next step in defining the dredge surface. The final surface showing the elevation of clay in East Rogers Island is presented in Figure D-4-1.

4.3 DEVELOPMENT OF AREA WHERE CLAY SURFACE GOVERNS DOC

Areas in which the top of clay appeared to define the DoC were delineated by plotting the difference between the DoC and the depth to clay for each individual location. Figure D-4-2 shows the data from the east side of Rogers Island. If the DoC is equal to the depth to clay the location is shown as a pink colored dot; cores where the DoC is above the clay are colored red, and locations where the DoC extends into the clay are colored blue. From these data, the areas where the DoC appears to coincide with the top of clay were delineated. A weight of evidence approach was used to establish these areas. In general, cores that had the DoC 2 in. or less above the top of the clay layer were included in the "clay areas". The clay areas were not extrapolated to the shoreline because the near shore areas likely have been depositional since before PCB usage and would contain clean sediments on top of the clay surface. Figure D-4-3a and Figure D-4-3b show the areas where the clay layer was used to establish the DoC over the entire Phase 1 Area of the river.

SECTION 5
DEVELOPMENT OF FINAL DOC SURFACE

5.1 TRANSFORMATION OF 1 mg/kg INTERPOLATION RESULTS TO ELEVATIONS

As discussed in Section 3.6, the 1 mg/kg interpolation results assign a depth of dredging to each 10 by 10 ft. grid cell. In order to define a dredge surface it was necessary to convert these 10 ft. grid cells into 1 ft. grid cells and convert depths to elevations. The 10 ft. grid cells were converted to 1 ft. grid cells using a TIN. These 1 ft. grid cells were then converted to elevations by subtracting the 1 mg/kg interpolation grid from the bathymetry grid provided by OSI (see Section 2.4 of this Attachment). Each 1 ft. square grid cell in the 1 mg/kg interpolation grid was aligned with the corresponding bathymetry cell and the depth was subtracted from the elevation resulting in a new "1 mg/kg elevation" grid. The 1 mg/kg elevation grid was then converted to a GIS point file to be used in the next step in defining the dredge surface. Each point of the 1 mg/kg elevation point shapefile was geographically located at the center point of each grid cell and the value of the point was the elevation of the cell.

5.2 COMBINING OF INTERPOLATION WITH ELEVATION OF CLAY INFORMATION

The 1 mg/kg elevation point shapefile was combined with the clay elevation point file in order to define the final dredge surface. The areas where the clay surface governs DoC, which is described in Section 4.3, were used to query out the points in the clay elevation point file with these areas and the points in the 1 mg/kg elevation point file outside of these areas. The results of these two queries were merged together to create a 'married' point file. The final surface for East Rogers Island is shown in Figure D-5-1.

SECTION 6
CROSS-VALIDATION OF FINAL RESULTS

6.1 BACKGROUND

On May 20, 2005, GE received a memo from USEPA, detailing suggested elements of for the Phase 1 Intermediate Design Report (Kern 2005). The memo details uncertainties in determining the depth of dredging and argues for cross validation and statistical testing of any proposed depth of contamination method. Pursuant to the recommendations of this memo, a cross-validation of the 1 mg/kg interpolator was conducted and is reported below. It should be noted that a number of the statistics that are recommended by Kern (2005) as a measure of the methods performance require a set "decision criteria" (e.g., sensitivity, specificity, false positives [Type 1 errors], and false negatives [Type 2 errors]). However, there are no set decision criteria for DoC and these statistics are not calculable for the final surface. Although the statistics could be calculated for each layer around 1 mg/kg, it was felt that this level of effort (there are 18 layers in the 1 mg/kg interpolation) is unwarranted. Instead, statistical measures that were calculable are presented below with plots and other analyses documenting the performance of the method.

Kern (2005) also stated that the uncertainty of the estimated DoC surface "…should be evaluated quantitatively to provide EPA with the estimates of the likelihood of success and the range of potential outcomes of the remedial performance" and suggested the following be calculated:

- projected re-dredging rate;
- proportion of inventory expected to remain in place;
- proportion of remediated sediment expected to be below criteria;
- uncertainty in total volume estimates;
- percentage of certification units expected to fail the residual standard; and
- implications to projected schedule.

As indicated above, GE believes that the uncertainty derived from kriging cannot be used to infer the true uncertainty of the DoC surface so that the bulleted information above can be calculated with confidence. Furthermore, the uncertainty of the DoC surface is influenced by data quality issues that tend to force overestimates of the DoC. These issues are discussed in Section 3.4.2.2 of the Intermediate Design Report and include: 1) a high bias of the PCB analytical results; 2) downward mixing of PCBs due to the coarse sectioning of cores; 3) downward smearing of contaminated sediments as a core tube is pushed through the sediments; and 4) use of a conservative equation to extrapolate PCB concentrations downward for incomplete cores. Moreover, uncertainty in the DoC surface is not the only factor contributing to the need for redredging. Imperfect bottom coverage by the dredge, sloughing of sediments at the edges of the dredge prism, fallback of sediments disturbed but not captured by the dredge, and the presence in some places of a rough hard bottom all contribute to the need for redredging. Consequently, GE has not attempted to calculate the information in the bulleted list. It is GE's view that such an attempt would be meaningless and the only reasonable way to obtain this information is through the Phase 1 dredging program. The data obtained in Phase 1 will allow an assessment of the uncertainty associated with the data and modeling used to establish the DoC surface that can be used to make inferences for Phase 2 dredging that can be used to refine the approach to DoC estimation to the extent that the applied approach is inadequate for design.

6.2 CROSS-VALIDATION METHODS APPLIED

For the 1 mg/kg interpolator, a leave-one-out cross-validation was performed. One point was removed from the data set and the remaining data points were used to predict total PCB concentrations in each layer at the removed point's location. This information was used to compare predicted dredge depth (the bottom of the deepest layer with a predicted total PCB concentration greater than or equal to 1 mg/kg) with measured DoC. Differences in predicted and measured DoC were quantified using root mean squared error (RMSE), mean error (ME), and mean absolute error (MAE) as calculated by the equations below.

$$RMSE = \sqrt{\frac{\sum_{n}(predicted - measured)^2}{n}} \tag{6-1}$$

$$ME = \frac{\sum_{n}(predicted - measured)}{n} \tag{6-2}$$

$$MAE = \frac{\sum_{n}(|predicted - measured|)}{n} \tag{6-3}$$

6.3 CROSS-VALIDATION RESULTS FOR EAST ROGERS ISLAND

The East Rogers Island area is characterized by widely varying DoC and poor spatial correlation. Cores (excluding CL2D cores) spaced at less than about 40 ft. apart have differences in DoC that range from zero to 16 inches and at some locations individual cores have DoC values that are radically different from neighboring cores about 80 to 160 ft. away. For example, at the point where the East Rogers Island channel bends to the west, a single location with deep DoC (extrapolated depth on the order of 100 inches) confirmed by data gap sampling is surrounded by cores with DoC of 48 inches or less. This variability is not well described by mathematical interpolation and the interpolated DoC surface likely is the least accurate in this area of the river.

Cross validation results for the 1 mg/kg interpolator are presented for the portion of East Rogers Island that is oriented North-South, starting north of the Bond Creek confluence and ending just before the channel turns to the southwest (see Figure D-3-1). This portion contains the bulk of the data and provides the best ability to compare measured and predicted DoC values. Figure D-6-1 presents the results in two ways. The left panel in the figure shows a cross-plot of predicted DoC from the 1 mg/kg interpolator and measured DoC (i.e., DoC as determined from core information, including extrapolations). The different symbols on the left hand plot indicate whether the core is CL1 (complete) or CL2 (extrapolated) and the different colors indicate whether the core is located in an area that will be governed by the 1 mg/kg interpolator (red) or the elevation of Glacial Lake Albany clay (blue). The right panel shows the distribution of differences between predicted and measured DoC for each of the predicted DoC increments. The left panel indicates that there is significant variability in the ability to predict DoC at locations where data have been removed from the interpolation. The right panel shows that the model does a reasonable job on average. The horizontal bars in the center of each rectangle indicate the median difference between the predicted and measured DoC values. In most of the depth increments, the median is close to zero. The variability is large with the range of 75% of the data (indicted by the limits of the rectangles) extending about +/-10 inches for predicted DoCs up to 24 inches and slightly larger for greater predicted DoCs. This characterization of the comparison is supported by the error statistics. The mean error is essentially zero, whereas the mean absolute error is about 14 inches and the root mean square error is about 20 inches. Further information is provided in a statistical summary of the cross validation that is presented in Table D-6-1. This table shows that the median measured DoC at a predicted DoC about equals the predicted DoC but that the maximum and minimum measured values are much different from that predicted by the model. In cases where the difference between the measured and predicted DoC values is large, the core removed from the data set tends to have a DoC that is much different from the values of surrounding cores on which the interpolator relies to predict the DoC at the location of the removed core. In addition, the majority of the underpredictions from the 1 ppm interpolator occur with CL2 cores. This may be an indication of the conservative nature of the extrapolation technique, as discussed in the Phase 1 DAD (QEA 2005).

Table D-6-1. Statistics on measured DoC for each predicted DoC value in East_RIb.

Predicted DoC (inches)	Measured DoC (inches)				
	Number of cores	Minimum	Maximum	Median	Mean
2	9	0	24	3	6
12	20	0	36	12	11
24	25	2	106	30	32
30	20	0	68	24	28
36	9	2	54	24	24
42	10	8	57	42	38
54	3	30	69	56	52
78	1	36	36	36	36
102	1	48	48	48	48

Notes:
Confidence level 2D cores are not included.
All predicted values in this table are based on the 1 mg/kg interpolator, even in dredge to clay areas.

The cross validation provides some sense of the uncertainty of the interpolated DoC surface but it probably overestimates uncertainty since, by removing a core from the data set, it looks at the uncertainty of predicting DoC at distances of 80 ft. from the nearest core, whereas the interpolated surface relies on interpolations at distances of 40 ft. from the nearest core. Nonetheless, cross-validation demonstrates the weakness of the interpolator as a predictive tool. The conservative nature of the measured DoCs and the ability to use Glacial Lake Albany clay as a DoC marker in some areas of the river compensate for this weakness, but the interpolated DoC surface must be used with care, ensuring that dredge prisms are revised as necessary to account for data at variance with the interpolator results (see Step 8 of the Dredge Prism Development Process presented in the Phase 1 Intermediate Design Report). In the absence of significant and stationary spatial correlation, the data themselves provide the only reliable means available to characterize DoC. Mean errors from cross validation or some central tendency characterization of the variability in DoC among closely spaced cores do not provide reasonable estimates of the uncertainty of individual DoC measurements or the interpolated DoC values in between those measurements. This conclusion applies throughout the Phase 1 Areas. Although the East Rogers Island area is the most difficult within which to characterize DoC, the concerns with the predictive ability of interpolation extend through all the dredge areas.

SECTION 7
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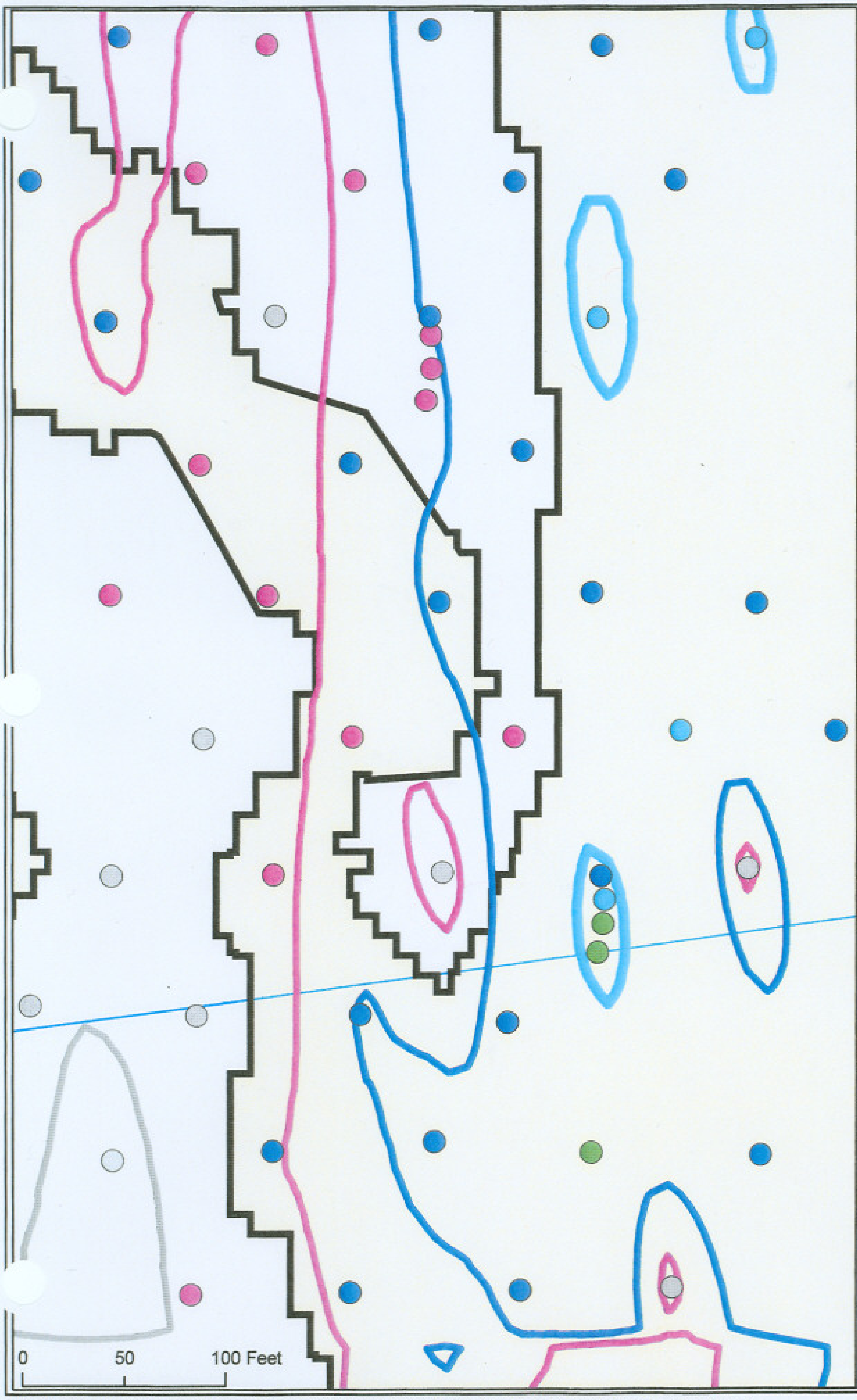
FIGURES

Quantitative Environmental Analysis, LLC



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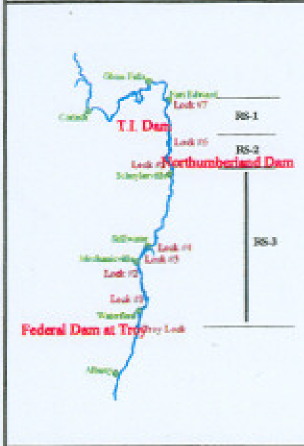

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Dredge Areas
- DOC = 0 - 2
- DOC = 2 - 12 in.
- DOC = 12 - 24 in.
- DOC = 24 - 30 in.
- DOC = 30 - 36 in.
- DOC = 36 - 42 in.
- DOC = 42 - 48 in.
- DOC = 48 - 54 in.
- DOC = 54 - 60 in.
- DOC = 66 - 85 in.
- DOC = 85 - 96 in.
- DOC = 96 - 102 in.
- DOC = 96 - 102
- DOC = 102 - 108

Contours

- DOC = 2 in.
- DOC = 12 in.
- DOC = 16 in.
- DOC = 24 in.
- DOC = 30 in.

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Figure D-1-1.

50th percentile results of kriging DoC from Phase 1 DAD in the vicinity of the Griffin Island and associated data, indicating discontinuity in DoC data.

QEA Quantitative Environmental Analysis, LLC

GENdes 232 July 2005

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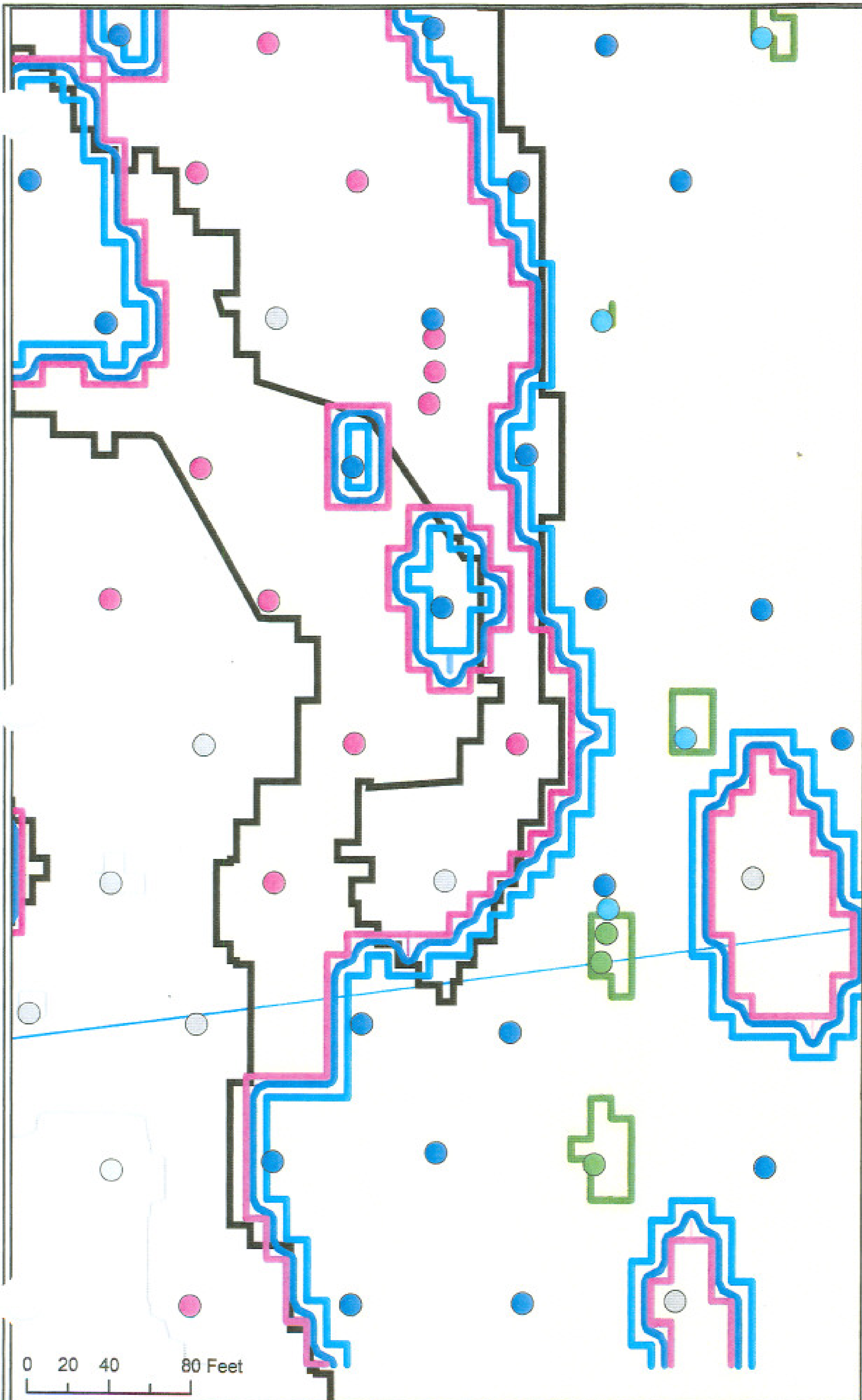

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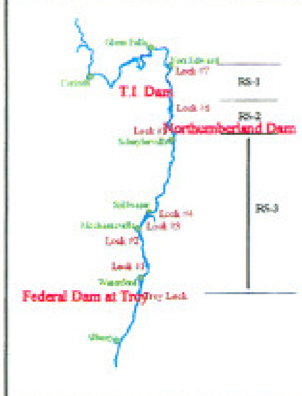

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Dredge Areas
- DOC = 0 - 2
- DOC = 2 - 12 in.
- DOC = 12 - 24 in.
- DOC = 24 - 30 in.
- DOC = 30 - 36 in.
- DOC = 36 - 42 in.
- DOC = 42 - 48 in.
- DOC = 48 - 54 in.
- DOC = 54 - 60 in.
- DOC = 60 - 66 in.
- DOC = 66 - 96 in.
- DOC = 86 - 96 in.
- DOC = 96 - 108 in.
- DOC > 108 in.

Contours

- DOC = 2 in.
- DOC = 12 in.
- DOC = 16 in.
- DOC = 24 in.
- DOC = 30 in.

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Figure D-1-2.

Results of depth of contamination as determined by interpolating Total PCB concentrations at depth in the vicinity of Griffin Island.

QEA

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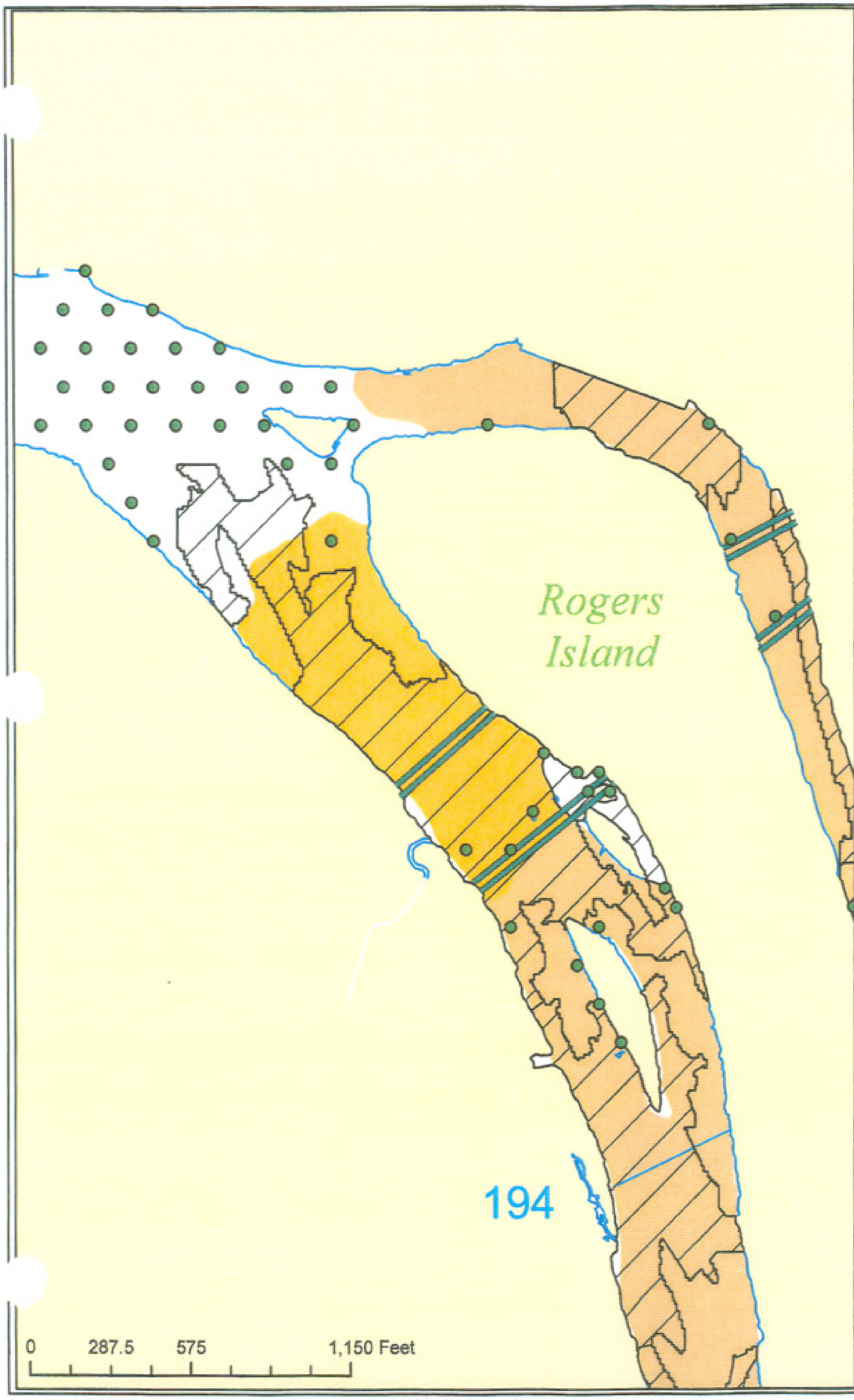

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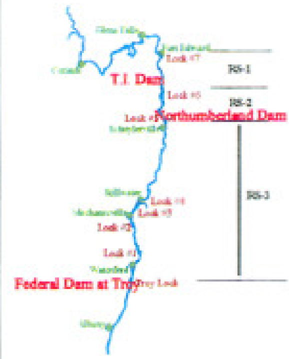

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Bridges
- Inaccessible areas
- Dredge Areas
- Type I sediment
- Type II sediment
- Type III sediment
- Type IV sediment
- Type V sediment

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Figure D-2-1.

Inaccessible locations in Northern West Rogers Island

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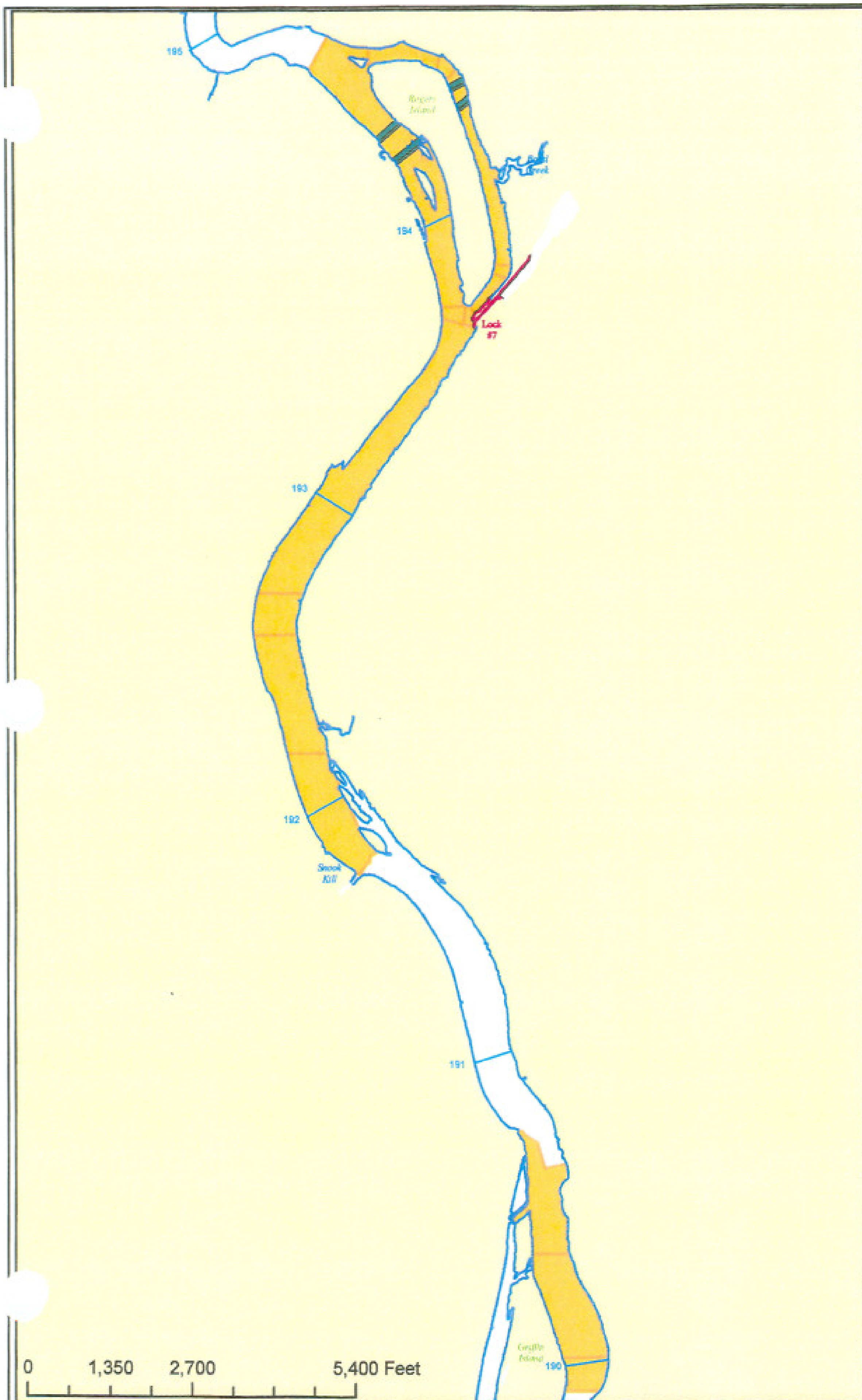
HC - \\hendrix\V_Drive\Genrem\Working\Chou\analysis\gis\project\GENdes232\Fig_2_1_inaccess_areas_20050728.mxd



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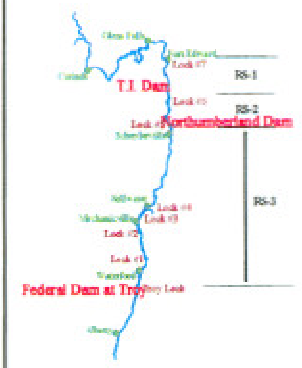

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Bridges
- IDW interpolation areas

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Figure D-3-1.

Interpolation areas for Phase 1 Areas used for interpolation of Total PCB concentrations at depth.

QEA Quantitative Environmental Analysis, LLC

GENdes 232 July 2005

HC - \\hendrix\V_Drive\Genrem\Working\Chou\analysis\gis\project\GENdes232\Fig_3_1_int_areas_20050728.mxd

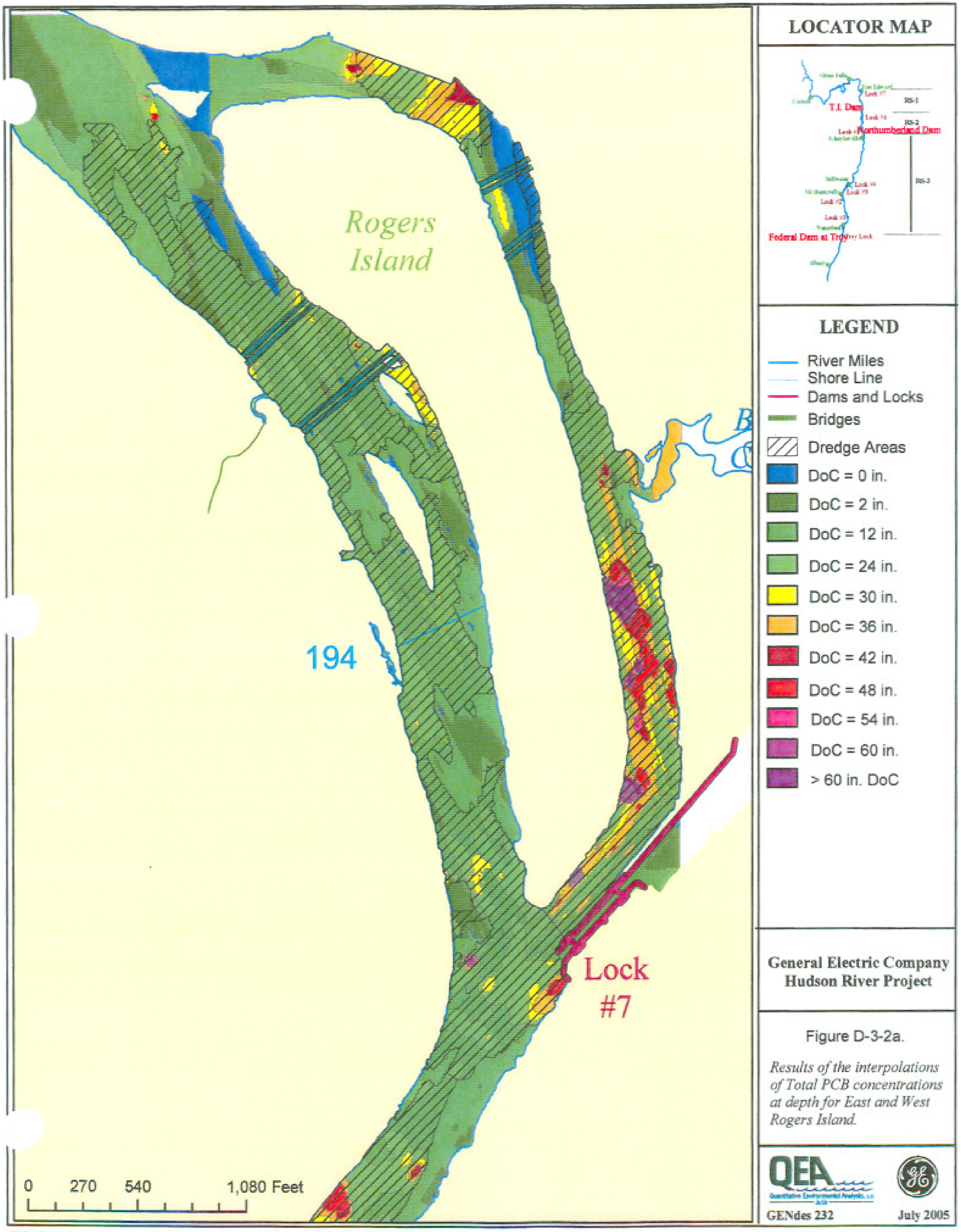

Figure D-3-2a.

Results of the interpolations of Total PCB concentrations at depth for East and West Rogers Island.

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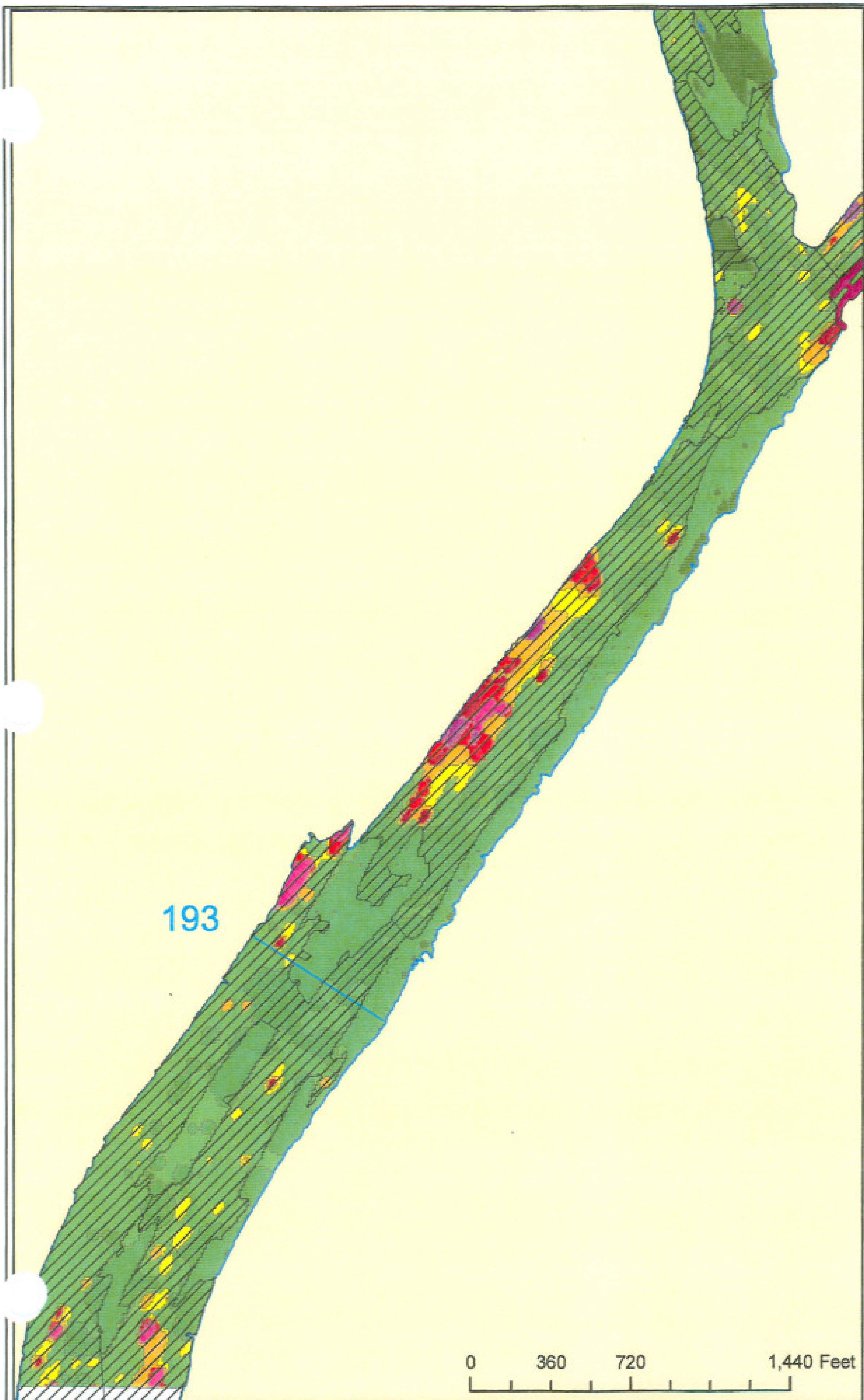

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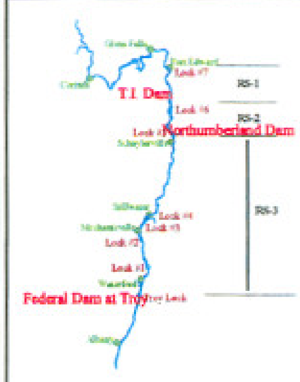

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Figure D-3-2b.

Results of the interpolations of Total PCB concentrations at depth for the Lock 7 area.

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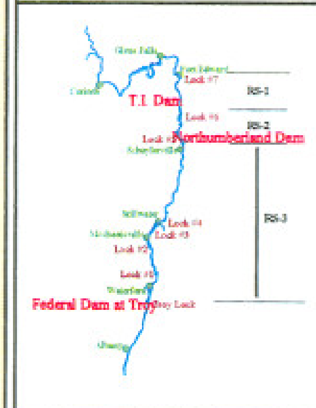
HC - \\hendrix\V_Drive\Genrem\Working\Chou\analysis\gis\project\GENdes232\Fig_3_2b_interp_tot_pcb_20050728.mxd

LOCATOR MAP



LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Bridges
- Dredge Areas
- DoC = 0 in.
- DoC = 2 in.
- DoC = 12 in.
- DoC = 24 in.
- DoC = 30 in.
- DoC = 36 in.
- DoC = 42 in.
- DoC = 48 in.
- DoC = 54 in.
- DoC = 60 in.
- > 60 in. DoC

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Figure D-3-2c.

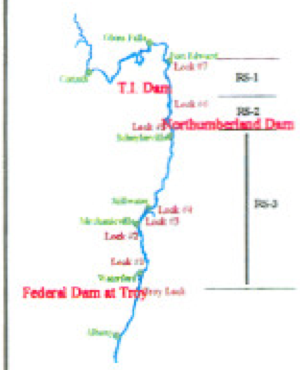
Results of the interpolations of Total PCB concentrations at depth for the East Griffin Island area.

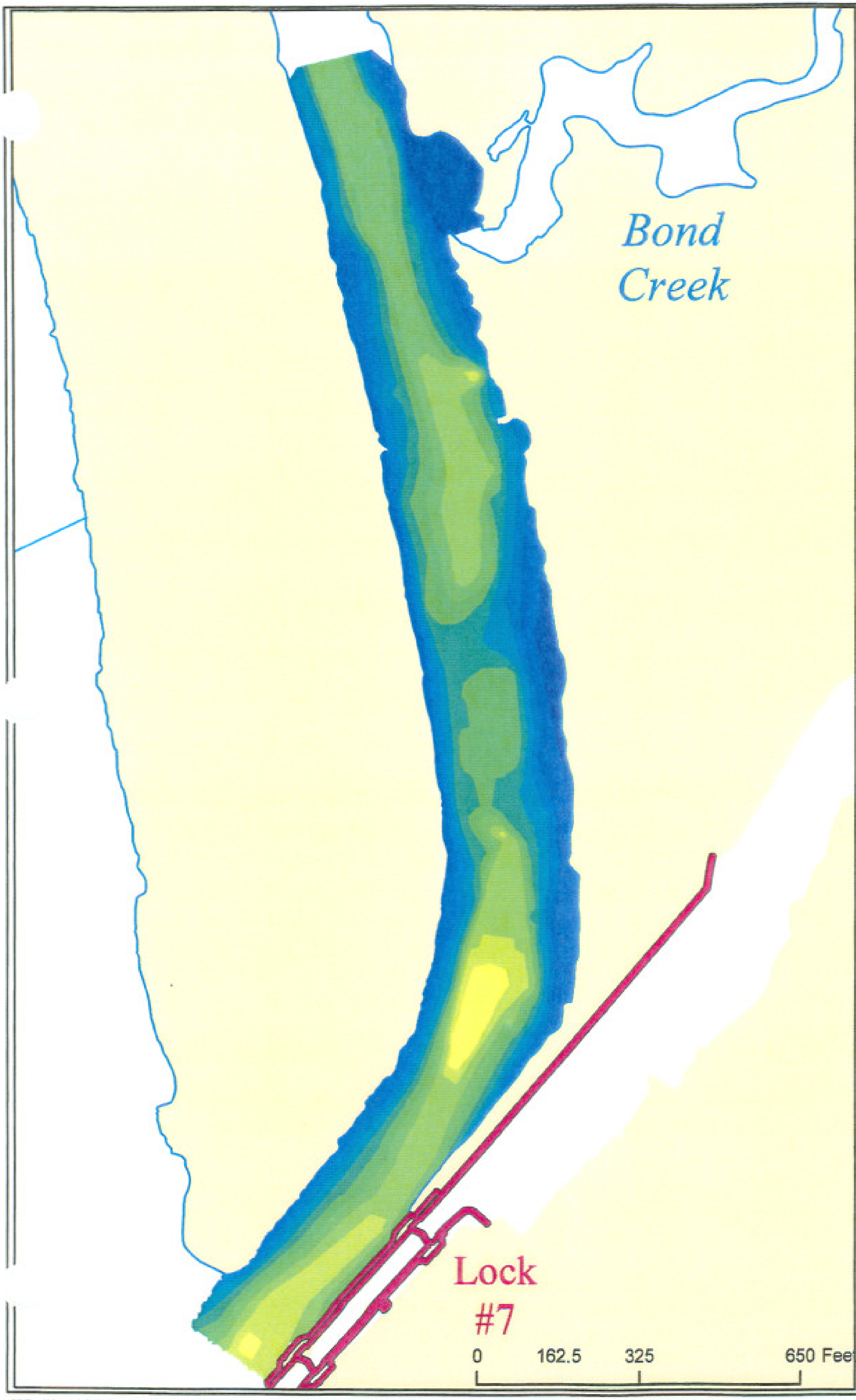
QEA Quantitative Environmental Analysis, LLC

GENdes 232 July 2005

HC - \\hendrix\V_Drive\Genrem\Working\Chou\analysis\gis\project\GENdes232\Fig_3_2c_interp_tot_pcb_20050728.mxd

LOCATOR MAP





LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Bridges

Elevation of Clay (ft.)

- 96 - 97.95
- 97.95 - 99.62
- 99.62 - 101.09
- 101.09 - 102.67
- 102.67 - 104.08
- 104.08 - 105.61
- 105.61 - 107.26
- 107.26 - 109.03
- 109.03 - 110.84
- 110.84 - 112.99

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Figure D-4-1.

Elevation of clay in East Rogers Island

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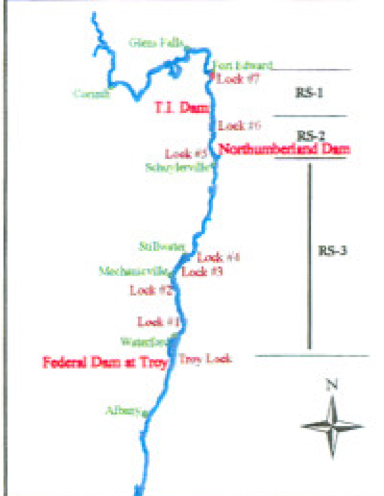
GENdes 232 July 2005

HC - \\hendrix\V_Drive\Genrem\Working\Chou\analysis\gis\project\GENdes232\Fig_4_1_elev_of_clay_20050729.mxd

LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 150 300 Feet

LEGEND

- DoC extends into the clay layer
- DoC and clay are at the same depth
- DoC is shallower than the top of clay layer
- Dredge to Clay Area

Figure D-4-2

Comparison of Depth to Clay and DoC in East Rogers Island

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GENdes: 214

Aug 17, 2005

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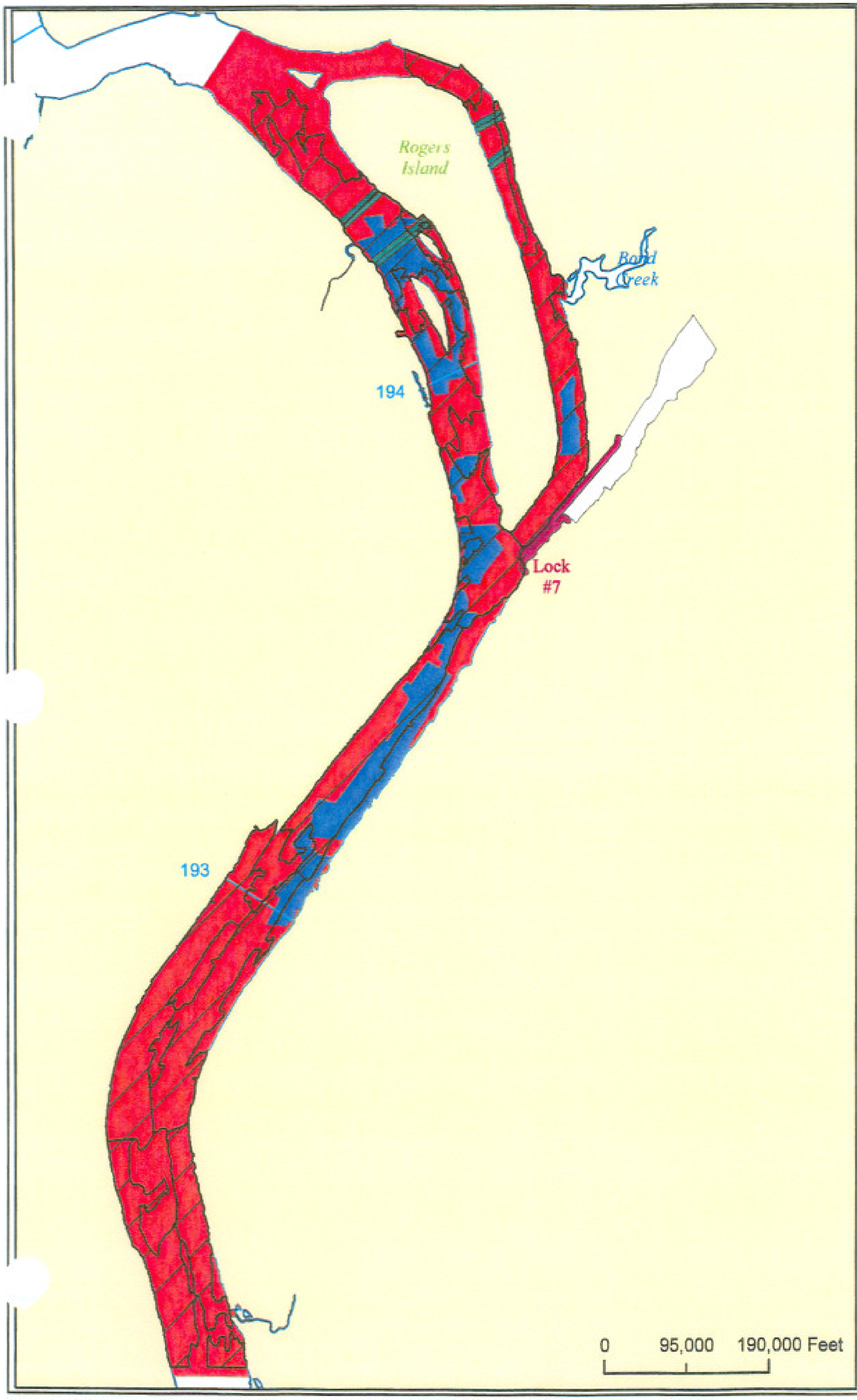

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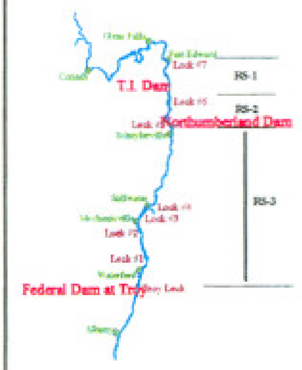

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Bridges
- Dredge Areas
- Clay areas
- 1ppm areas

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Figure D-4-3a.

Dredge to clay and dredge to 1 mg/kg areas.

GENdes 232

July 2005

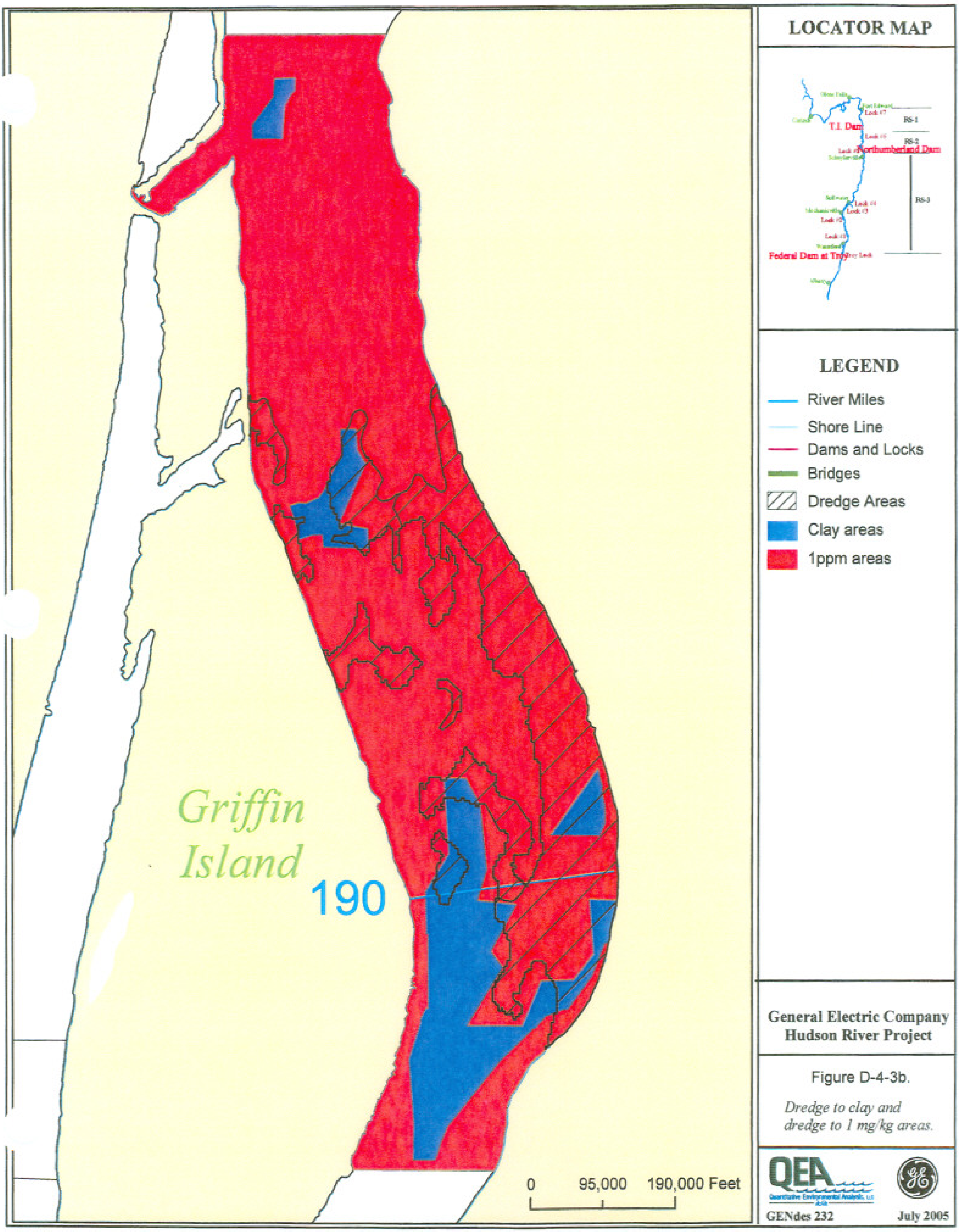

Figure D-4-3b.

Dredge to clay and dredge to 1 mg/kg areas.

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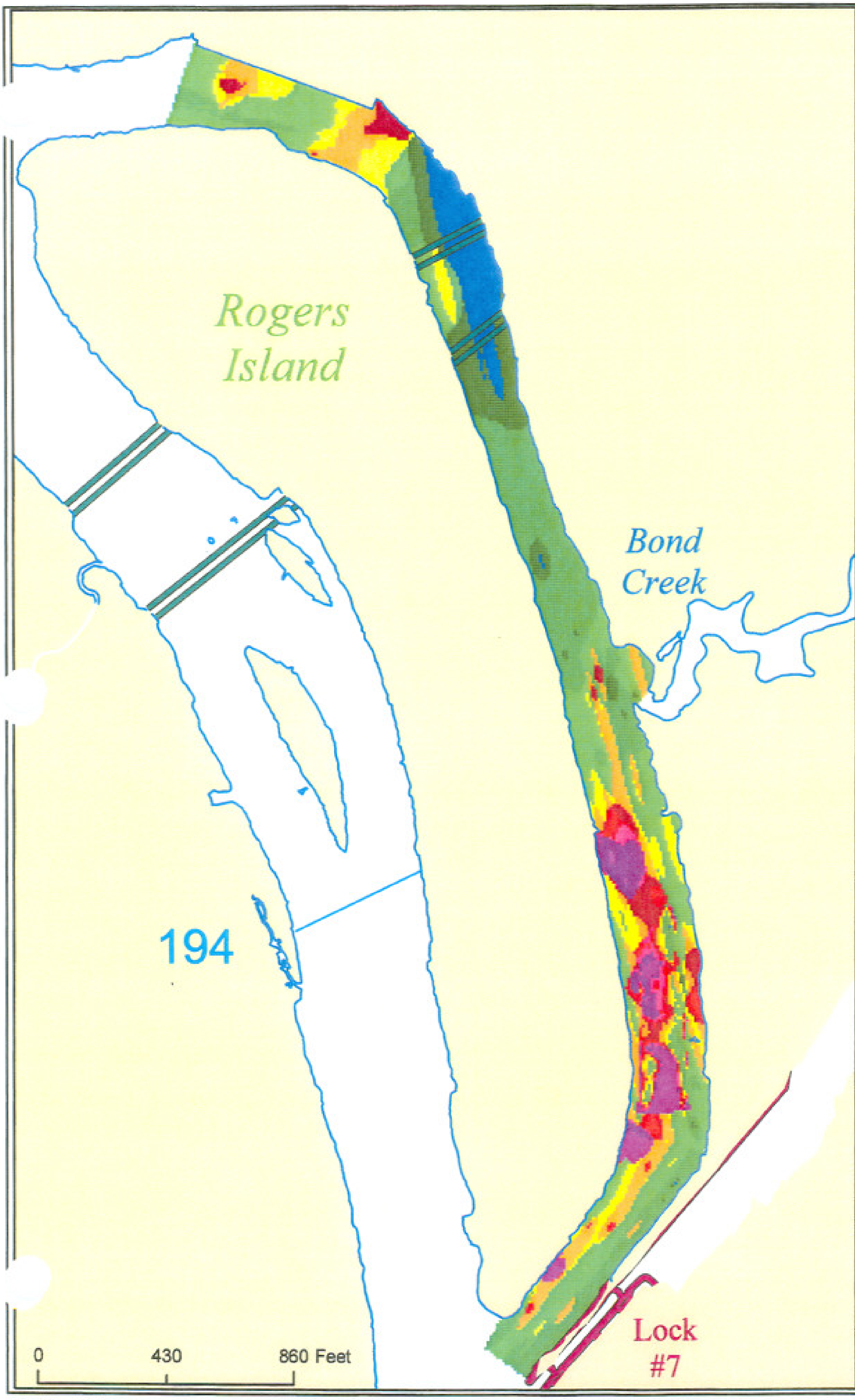

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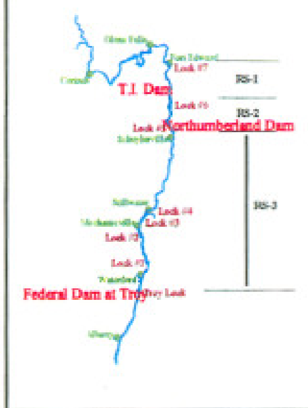

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Bridges

- DoC = 0 in.
- DoC = 2 in.
- DoC = 12 in.
- DoC = 24 in.
- DoC = 30 in.
- DoC = 36 in.
- DoC = 42 in.
- DoC = 48 in.
- DoC = 54 in.
- DoC = 60 in.
- > 60 in. DoC

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Figure D-5-1.

Depth of Contamination surface in East Rogers Island

QEA Quantitative Environmental Analysis, LLC

GENdes 232

July 2005

HC - \\hendrix\V_Drive\Genrem\Working\Chou\analysis\gis\project\GENdes232\Fig_5_1_DoC_surface_ERI_20050729.mxd

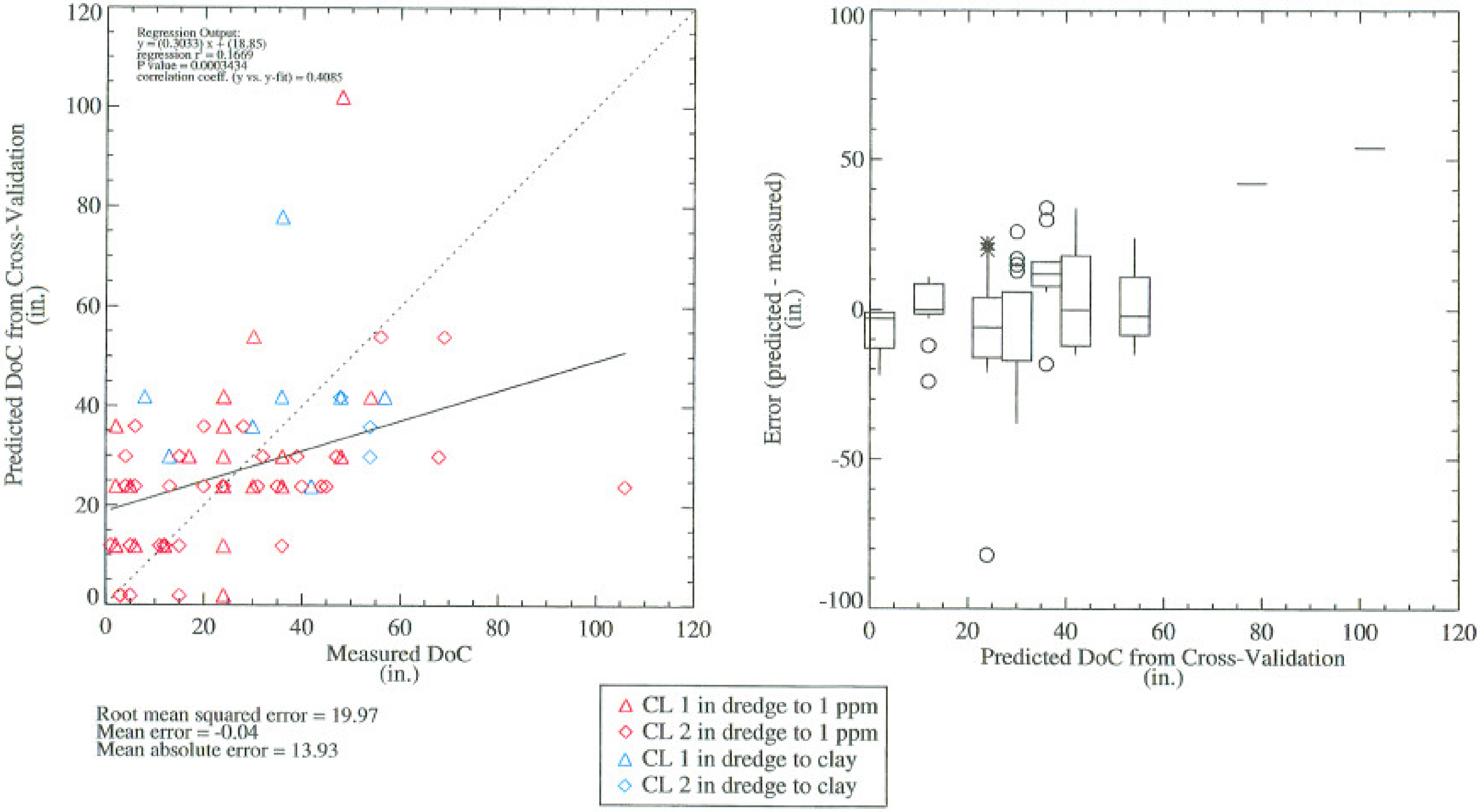

Figure D-6-1. Cross-validation results for 1 mg/kg IDW interpolation for depth of contamination (DoC): East_RIb.

Confidence Level 2D cores are not included. All predicted values on this plot are based on the 1 mg/kg interpolator, even in dredge to clay areas. Black dashed line is the one-to-one line. Solid black line represents linear regression. The right panel contains Tukey box-plots.

Hudson River PCBs Site

Phase 1
Intermediate Design Report
Attachment E - Dredge Resuspension Modeling

Prepared by:

Quantitative Environmental Analysis, LLC

Montvale, NJ

Prepared for:

General Electric Company

Albany, NY

August 22, 2005

Hudson River PCBs Site

Phase 1
Intermediate Design Report
Attachment E - Dredge Resuspension Modeling

Prepared by:

Quantitative Environmental Analysis, LLC

Montvale, NJ

Prepared for:

General Electric Company

Albany, NY

Job Number:

GENdes:232

August 22, 2005

Table of Contents

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List of Acronyms

ADCP	acoustic Doppler current profiler
BMP	Baseline Monitoring Program
EFDC	Environmental Fluid Dynamics Code
EGIA	East Griffin Island Area
EPS	Engineering Performance Standards
HRM	Hudson River Monitoring
NTIP	Northern Thompson Island Pool
PCB	polychlorinated biphenyls
RM	River Mile
ROD	Record of Decision
RPS	Resuspension Performance Standard
SSAP	Sediment Sampling and Analysis Program

TID	Thompson Island Dam
TIP	Thompson Island Pool
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

E.1 INTRODUCTION

E.1.1 Background

In the Record of Decision for the Hudson River (ROD; USEPA 2002), the United States Environmental Protection Agency (USEPA) required establishment of performance standards for, among other things, resuspension during dredging. USEPA undertook responsibility for development of the standards and issued the standards in 2004 (Malcolm Pirnie and TAMS 2004). The Performance Standard for resuspension, hereafter referred to as the Resuspension Performance Standard or RPS, establishes limits for concentrations of polychlorinated biphenyls (PCBs) in river water and downstream transport of PCBs.

The RPS includes a primary standard of a not-to-exceed river water PCB concentration of 500 ng/L and two action levels (Evaluation and Control) meant to trigger efforts to identify and correct remediation-related problems that might result in an exceedence of the standard. The action levels are defined by far-field (more than 1 mile downstream of dredging activities) and near-field (within 300 m of the dredging activities) criteria. The far-field criteria include PCB and total suspended solids (TSS) concentrations and PCB mass flux. The near-field criteria consist of TSS concentrations at specified distances from the dredging activities. These action level criteria as they apply to Phase 1 dredging in River Section 1 are listed in Tables E-1-1 and E-1-2.

Table E-1-1. Resuspension standard criteria for far-field stations[3].

Parameter	Evaluation Level	Control Level
7-d Running Average Total PCB Concentration		350 ng/L
7-d Running Average Total PCB Load	300 g/d	600 g/d
7-d Running Average Tri+ PCB Load	100 g/d	200 g/d
Dredging Season Cumulative Total PCB Load		65 kg
Dredging Season Cumulative Tri+ PCB Load		22 kg
TSS (6 hr average or average of day's dredging period if less)	12 mg/L[1]	24 mg/L[2]

Notes: [1]*6-hour running average or average of day's dredging period if less.*
[2]*24-hour running average or average of day's dredging period if less.*
[3]*PCB load and TSS are net above baseline conditions.*

Table E-1-2. Resuspension standard criteria for near-field stations[4].

Parameter	Evaluation Level	Control Level
TSS @ 100 m (or channel side of dredging)	700 mg/L[1]	
TSS @ 300 m	100 mg/L[2]	100 mg/L[3]

Notes: [1]*3-hour running average.*
[2]*6-hour running average or average of day's dredging period if less.*
[3]*24-hour running average or average of day's dredging period if less.*
[4]*TSS values are net above baseline conditions.*

E.1.2 Technical Approach

Evaluation of the effects of sediment and PCB releases during dredging operations on water column concentrations at near-field and far-field locations is accomplished through application of a mathematical model. This modeling framework is used to simulate the transport and fate of resuspended sediment and PCBs in River Section 1 (i.e., Thompson Island Pool or TIP) during the five-month dredging season, which extends from May through November. Predicted TSS at the near-field stations (100 and 300 m downstream of the dredging operation) and TSS and PCB concentrations (and PCB loads) at the far-field station (Thompson Island Dam or TID) are compared to the Evaluation, Control, and Standard Levels of the RPS. The approach makes it possible to quantitatively analyze the effects of various dredging plans on TSS and PCB concentrations, and associated PCB loads, at the far-field station. Thus, the potential for a specific dredging plan to exceed the RPS criteria can be estimated prior to implementing that plan. As part of the design of the dredging project it is necessary to determine where engineered resuspension control or containment systems (i.e., silt curtains, silt barriers, sheet piling, or other physical barriers) may be needed during dredging to maintain resuspension levels at or below the Control Level of the RPS. The modeling provides a means to evaluate the ability of various control options to reduce downstream transport and water column concentrations to levels at or below the Control Level of the RPS.

E.1.3 Overview of Modeling Framework

This analysis involves use of a mathematical model, which consists of three sub-models that are linked together: 1) hydrodynamics; 2) sediment transport; and 3) PCB fate and transport (see Figure E-1-1). The hydrodynamic model predicts depth-averaged current velocity, water depth (or stage height), and bottom shear stress, which is the frictional force that moving water exerts on the sediment bed. The sediment transport model predicts water column concentrations of suspended sediment, and deposition onto the sediment bed. The PCB fate and transport model predicts water column concentrations of dissolved and particle-associated PCBs, and deposition of particle-associated PCBs to the bed. For this application, erosion of sediment and particle-associated PCBs from the bed are not considered.

Figure E-1-2 shows a generalized conceptual diagram of the modeling framework. The primary fate and transport mechanisms considered are:

- resuspension of sediment and particulate-bound PCBs due to dredging;
- hydrodynamic advection and dispersion of suspended sediment and PCBs;
- deposition of suspended sediment and associated sorbed PCBs;
- sorption and desorption of PCBs; and
- volatilization of dissolved phase PCBs.

This model is only concerned with the fate and transport of resuspended material as a result of dredging activity. Moreover, the dredge resuspension simulated is only that sediment released to the water column from direct dredge operation and does not include other dredge-related sources such as debris removal and barge movement. High-flow event resuspension (erosion) is not considered as dredging activities will not be taking place during such river conditions. Other non-dredging related sources of sediment and PCBs known to be present in the river (e.g. upstream and tributary inputs) are also not considered as the focus is material resulting from dredge activity. This approach is in accordance with the RPS standards because most standards are based on net increase of suspended sediment and PCBs as a result of dredging. For the far-field absolute PCB concentration standard, a baseline concentration resulting from the Baseline Monitoring Program (BMP) data and added to the dredge resuspension PCBs predicted by modeling.

E.2 SEDIMENT RESUSPENSION DURING DREDGING

E.2.1 Summary of USEPA Findings

The Feasibility Study (USEPA 2000), the Responsiveness Summary released with the ROD (USEPA 2002), and the Engineering Performance Standards (EPS; Malcolm Pirnie and TAMS 2004) present evaluations of dredging-induced resuspension. In these evaluations resuspension is normalized to the rate of dredging to yield a fractional resuspension rate (i.e., kg resuspended/kg dredged) expressed as a percentage.

The Feasibility Study reviews field and modeling studies of resuspension and concludes that resuspension rates at the dredge head of 0.35% (hydraulic - cutterhead) and 0.30% (mechanical - environmental bucket) represent conservative estimates of the resuspension likely to occur during the dredging of the Upper Hudson River. The value of 0.35% was derived from field studies of resuspension during cutterhead dredging of fine sediments in Calumet Harbor and Lavaca Bay. The value of 0.30% was derived from a field study of an enclosed bucket dredge operating in Boston Harbor. The sediments at all of these sites are dominated by small particles capable of being resuspended, thus the release rate essentially represents percentage of resuspendable sediment dredged that is released to the water column.

The Responsiveness Summary presents additional reviews of field and modeling studies and affirms the use of the values of 0.30% and 0.35% at the dredge head. In addition, it presents the results of calculations to estimate the dredging release rate at a distance of 10 meters from the dredge head. Mass-weighted average release rates were reported to be 0.13% for and environmental bucket dredge and 0.065% for a conventional hydraulic cutterhead dredge[1]. The report concludes that these values "... represent conservative estimates of the potential releases due to dredging and are consistent with direct observations made on several sites." (USEPA 2002).

[1] These percentages were presented as kg of fine sediment transported downstream per kg of total sediment dredged. Given that the rates at the dredge head were based on the dredging of fine sediments, kg of fine sediment dredged and kg of total sediment dredged are roughly equivalent.

The EPS provides further affirmation of the Feasibility Study release rates, using a dredge head release rate of 0.3% as the starting point for near-field and far-field resuspension modeling (Malcolm Pirnie and TAMS 2004). However, it appears that this rate was applied incorrectly for purposes of modeling. First, it is adjusted upward to 0.5% based on the incorrect assumption that the fine sediment fraction of Upper Hudson River sediments should be used to convert the rate from bulk sediment based resuspension to fine sediment based resuspension. In fact, the fine sediment fraction of the sediments from which the estimate was derived (i.e., Boston Harbor, Calumet Harbor, or Lavaca Bay) should be used for such a conversion. Since the fine sediment fractions of the field study sites were all close to one, the Feasibility Study values essentially represent kg fine sediment released/kg fine sediment dredged and the conversion does not alter the rate. Second, the dredge head release rate is applied 10 m downstream of the dredge without downward adjustment to account, as was done in the Responsiveness Summary, for the solids losses that occur in the first 10 m.

E.2.2 Assumptions Used in Predictive Modeling

On the basis of the USEPA findings, a value of 0.35% was used as the dredging-induced sediment resuspension rate at the dredge head. This rate was interpreted to represent the kg of resuspendable sediment resuspended/kg of resuspendable sediment dredged.

Given the uncertainty inherent in reliance on extrapolation from other sites as a means to determine the need for resuspension controls, a resuspension release rate of 0.70% was evaluated to identify those areas for which controls would be necessary if the release rate was twice that used for design. This 0.70% release rate was used to evaluate the need for resuspension control measures to be included in design as a contingency measure.

E.3 HYDRODYNAMIC MODELING

E.3.1 Model Description

The hydrodynamic model used in this study is the Environmental Fluid Dynamics Code (EFDC), which was originally developed by Dr. John Hamrick (Hamrick 1992). EFDC is a general purpose hydrodynamic model capable of simulating flow in rivers, lakes, reservoirs, estuaries and coastal oceans. This model solves the conservation of mass and momentum equations, which are the fundamental equations governing the movement of water in a river. A complete description of the model is given in Hamrick (1992).

The Upper Hudson River is relatively shallow and its flow is unstratified. These conditions make it reasonable to assume that the water column is vertically well-mixed. Thus, the two-dimensional, vertically-averaged equations are an accurate approximation to the general three-dimensional equations of motion for an incompressible fluid. The conservation of mass and momentum equations applied to TIP are (Ziegler et al. 2000):

$$\frac{\partial \eta}{\partial t} + \frac{\partial (uh)}{\partial x} + \frac{\partial (vh)}{\partial y} = 0 \quad \text{(E-3-1)}$$

$$\frac{\partial (uh)}{\partial t} + \frac{\partial (u^2 h)}{\partial x} + \frac{\partial (uvh)}{\partial y} = -gh\frac{\partial \eta}{\partial x} - C_f qu + \frac{\partial}{\partial x}\left(hB_H \frac{\partial u}{\partial x}\right) + \frac{\partial}{\partial y}\left(hB_H \frac{\partial u}{\partial y}\right) \quad \text{(E-3-2)}$$

$$\frac{\partial (vh)}{\partial t} + \frac{\partial (uvh)}{\partial x} + \frac{\partial (v^2 h)}{\partial y} = -gh\frac{\partial \eta}{\partial y} - C_f qv + \frac{\partial}{\partial x}\left(hB_H \frac{\partial v}{\partial x}\right) + \frac{\partial}{\partial y}\left(hB_H \frac{\partial v}{\partial y}\right) \quad \text{(E-3-3)}$$

where: h is total water depth ($h_o+\eta$); h_o is reference water depth; η is water surface displacement with respect to reference depth; u, v are velocities along the x- and y-axes, respectively; $q = (u^2 + v^2)^{1/2}$; C_f is bottom friction factor; and B_H is horizontal eddy viscosity.

Note that the x-axis is oriented in the longitudinal (along-channel) direction and the y-axis is oriented in the lateral (cross-channel) direction. Equations E-3-1 to E-3-3 were transformed from Cartesian coordinates to orthogonal, curvilinear coordinates (see Hamrick (1992) for detailed discussion) in order to resolve the complex geometry and bathymetry of TIP more accurately.

An important variable in the hydrodynamic and sediment transport models is bottom shear stress (τ_b), which represents the frictional force exerted on the sediment bed by moving water in the river. The bottom shear stress is related to depth-averaged current velocity by the quadratic stress law:

$$\tau_b = \rho \, C_f \, q^2 \tag{E-3-4}$$

where: ρ is water density.

The bottom friction factor in Equation (E-3-4) is dependent on the local water depth and effective bottom roughness (Ziegler et al. 2000).

$$C_f = MAX\left[\frac{\kappa^2}{\left(\ln \frac{h}{2z_o} \right)^2} \quad , \quad C_{f,min} \right] \tag{E-3-5}$$

where: κ is von Karman's constant (0.4); z_o is the effective bottom roughness; and $C_{f,min}$ is the minimum bottom friction factor (typically, set at 0.0025).

E.3.2 Model Development

Development of the hydrodynamic model of the TIP involved four main tasks: 1) specification of the geometry of the study area; 2) generation of a numerical grid; 3) projection of river bathymetry onto the numerical grid; and 4) specification of boundary conditions.

The region of the Upper Hudson River considered in this modeling evaluation extends from a location approximately 1,300 feet upstream of Rogers Island to TID. The location of the river shoreline within this region was determined using aerial photography information obtained during Spring 2002. The approximate flow rate at the time the aerial photographs were taken was 5,000 cfs at the United States Geological Survey (USGS) gauging station at Fort Edward).

A curvilinear, boundary-fitting numerical grid was generated to represent the study area, which is approximately six miles long. The river channel within the TIP is discretized using 230 longitudinal (i.e., along channel) and 22 lateral (i.e., cross channel) grid cells (Figure E-3-1). Average longitudinal cell size is 160 ft. and typical lateral cell size is about 30 ft. The grid resolution was chosen such that a plume resulting from resuspension of sediment and PCBs during dredging operations can be adequately simulated. Note that all three sub-models (i.e., hydrodynamic, sediment transport, and PCB fate and transport) use the same numerical grid.

Bathymetry data used to specify model inputs were obtained during two studies: 1) single-beam bathymetry data collected during a 2001 survey; and 2) supplemental water depth data obtained during the Sediment Sampling and Analysis Program (SSAP) in 2002 and 2003. The 2001 bathymetry data were collected along cross-channel transects, with a typical distance between transects of 125 ft. Bathymetry data from this survey were reprocessed during Spring 2003 and contoured at 1-ft. intervals to support the remedial design. The reprocessed data form the 2001 survey was included in the Hudson River GIS database. The reprocessed bathymetry data were projected onto the numerical grid, with the water depth (or bed elevation) in a specific grid cell representing the average water depth (bed elevation) within the area encompassed by that grid cell. A graphical representation of the TIP bathymetry is shown on Figure E-3-2 (a through e).

Two boundary conditions are needed for the hydrodynamic model: 1) incoming flow rate at the upstream boundary; and 2) water surface elevation (stage height) at the downstream boundary, which is location at TID. Flow rate collected at the USGS gauging station at Fort Edward is used to specify incoming flow at the upstream boundary of the model. Discharge from the TIP tributaries (e.g., Snook Kill, Moses Kill) is not included in these simulations because the tributary flow is small compared to the river discharge (i.e., about 4% of the total flow rate at TID, on average). Neglecting tributary flows has negligible effect on model results.

Water surface elevation (or stage height) at TID is specified as a function of river flow rate. Stage heights measured by Champlain Canal personnel at Crockers Reef, which is located at the entrance to the canal near River Mile (RM) 189, were used to develop this relationship between flow rate and stage height at TID (QEA 1999).

$$\eta_{dam} = 117.2 + 3.57\left(\frac{Q}{10000}\right)^{0.44} \qquad \text{(E-3-6)}$$

where: η_{dam} is stage height [ft. with respect to NAVD 88] and Q is flow rate [cfs].

E.3.3 Calibration and Validation

Assessment of the predictive capability of the hydrodynamic model is achieved through comparisons of predicted and measured stage height (water surface elevation) and current velocity. The model parameter that is adjusted to achieve the optimum agreement between model predictions and observed values is the effective bottom roughness (z_o). The model calibration exercise indicated that an effective bottom roughness of 1 cm is appropriate for the study area. Horizontal eddy viscosity was set at a value of 0.06 m^2/s, which is the minimum value that ensures numerical stability. No adjustment of horizontal eddy viscosity was made during model calibration and validation.

Model calibration was conducted using stage height data obtained during the 1983 spring flood at Gauge 119, which is located near the entrance to the Champlain Canal lock at Fort

Edward. This flood had a maximum daily-average flow rate at Fort Edward of 34,100 cfs, which represents a return period of approximately 10 years. An effective bottom roughness of 1 cm produced the best agreement between observed and predicted stage heights during the 1983 flood (Figure E-3-3). These results indicate that the model adequately predicts stage height in the study area.

Model validation was accomplished using acoustic Doppler current profiler (ADCP) data collected during June 2004 (QEA 2004). Sampling locations are shown on Figures E-3-4 through E-3-7. No model parameters were adjusted during the validation exercise. Comparisons between predicted and measured current velocities at stations BMP1 and SEDC1 to SEDC5 are shown on Figures E-3-8 through E-3-13. These results indicate that the model is able to adequately reproduce observed current velocities in the TIP.

E.3.4 Application

Simulation of suspended sediment and PCB transport in the river due to resuspension during dredging operations requires specification of a hydrograph during the six-month dredging season. An analysis of historical flow rate data was conducted to develop hydrographs that are representative of a range of discharge conditions during the dredging season. Developing representative hydrographs requires that seasonal variations in flow conditions are incorporated into the analysis. For example, discharge during May is typically higher than discharge during August.

Representative hydrographs were developed by analyzing historical flow rate data at the Fort Edward gauging station that were collected during the six-month period from May through October. The 6-month dredging season is divided into 18 sub-periods, with each sub-period being 10 or 11 days long. A statistical analysis of the flow data, which were analyzed for each of the 18 sub-periods, produced estimates of median (50 percentile) flow rates, as well as 10 and 90 percentile flows, for each sub-period during the dredging season. The 10 and 90 percentile flows are assumed to represent lower- and upper-bound estimates, respectively.

The bounding flows, together with the median flow, are used to develop three hydrographs for the dredge season: 1) low-flow (i.e., 10 percentile); 2) typical flow (i.e., 50 percentile); and 3) high-flow (i.e., 90 percentile). For a specific hydrograph associated with a hydrodynamic simulation, flow rate is assumed to be constant during each sub-period. The hydrographs for the six-month dredging season are listed in Table E-3-1. These hydrographs are designed to approximate seasonal variations in discharge, as well as represent the range of flow rates that may be reasonably expected to occur during the dredging season.

Table E-3-1. Inflow hydrographs for six-month dredging season.

Month	Sub-Period Dates	10 Percentile Flow Rate (cfs)	50 Percentile Flow Rate (cfs)	90 Percentile Flow Rate (cfs)
May	1-10	3,000	6,800	16,700
	11-20	2,400	5,600	16,700
	21-31	2,400	4,600	11,400
June	1-10	2,200	3,800	8,800
	11-20	2,200	3,600	7,700
	21-30	1,900	3,200	6,000
July	1-10	1,500	2,400	4,600
	11-20	1,700	2,800	4,100
	21-31	1,900	2,800	4,100
August	1-10	1,900	2,800	4,100
	11-20	1,700	2,800	4,600
	21-31	1,700	2,800	4,400
September	1-10	1,900	2,600	4,100
	11-20	1,900	2,800	3,800
	21-30	2,200	2,800	4,900
October	1-10	2,200	3,000	5,300
	11-20	2,200	3,400	5,600

The hydrodynamic model was used to estimate average velocity in the TIP for a range of flow conditions. Simulations were conducted with inflows corresponding to high-flow events with these return periods: 2, 5, 10, 20, 50, and 100 years (see Table E-3-2). Results of these simulations were used to determine the area-weighted average velocities for the TIP for each high-flow event (see Table E-3-2 and Figure E-3-14).

Table E-3-2. Average TIP velocity for various high-flow conditions.

High-Flow Event Return Period (years)	Flow Rate (cfs)	Average Velocity (m/s)
2	23,000	0.71
5	30,000	0.86
10	34,500	0.95
20	38,000	1.01
50	44,000	1.11
100	47,300	1.17

E.4 SEDIMENT TRANSPORT MODELING

E.4.1 Overview of Sediment Transport Processes

Sediment released to the water column during dredging operations is composed of a mixture of clay, silt, sand and gravel, with the relative amounts of each sediment type depending on local bed conditions. The amount of released sediment that is transported away from the dredge-head is dependent on the sediment type. Coarser sediment, i.e., coarse sand and gravel (which are typically transported as bed load), will be redeposited within the immediate vicinity of the dredge-head because of the high settling speed of this type of sediment. Fine and medium sands, which are transported as suspended and bed load in rivers, may have the following fates after being released during dredging: 1) redeposition within the immediate vicinity dredge-head; and/or 2) carried downstream of the dredge-head as suspended load and redeposited on the bed. Clay and silt that are released during dredging will tend to behave as flocculating cohesive sediment that is transported as suspended load. Typically, this fine sediment type will be transported significantly further downstream from the dredge-head than fine/medium sand.

E.4.2 Model Description

The sediment transport model used in this study is based on the SEDZL algorithm (Ziegler et al. 2000). This model is capable of simulating the transport, resuspension and deposition of cohesive (muddy) and non-cohesive (sandy) sediments. A description of the model is provided in Ziegler et al. (2000). This model has been applied to approximately 20 sediment transport studies in rivers, including: Upper Hudson River (New York), Lower Fox River (Wisconsin), Tennessee River, Grasse River (New York), Saginaw River (Michigan), and Upper Mississippi River (Minnesota). Water-column transport of suspended sediment is governed by a conservation of mass equation. For this analysis, erosion from the sediment bed is not considered because it does not affect simulation of sediment released during dredging operations, and dredging will not take place during high flow events.

Suspended sediment particles in a river have a large range of sizes, from less than 1 µm clays to medium sands on the order of 400 µm. Simulation of the entire particle size spectrum is impractical. Therefore, particles were broadly segregated into two groups: silt and clay that may interact and form flocs and sand that is transported as discrete particles. The model uses this approach to approximate the particle size spectrum. Class 1 particles include all flocculating particles, i.e., clays and silts, with disaggregated particle diameters of less than 62 µm. Suspended sands are separated into two size classes. Class 2 particles correspond to very fine sand, which ranges in size from 75 to 150 µm. Class 3 particles represent fine and medium sands, with a size range of 150 to 425 µm.

A two-dimensional, vertically-averaged sediment transport equation for size-class k is used (Ziegler et al. 2000).

$$\frac{\partial(hC_k)}{\partial t}+\frac{\partial(uhC_k)}{\partial x}+\frac{\partial(vhC_k)}{\partial y}=\frac{\partial}{\partial x}\left(hE_x\frac{\partial C_k}{\partial x}\right)+\frac{\partial}{\partial y}\left(hE_y\frac{\partial C_k}{\partial y}\right)+R_k-D_k \qquad \text{(E-4-1)}$$

where: C_k is concentration of suspended sediment of size-class k; E_x, E_y are horizontal eddy diffusivities along the x- and y-axes, respectively; R_k is resuspension (erosion) flux of size-class k; and D_k is deposition flux of size-class k.

Results from the hydrodynamic model provide information about the transport field in Equation E-4-1, i.e., u, v, and h. Similar to the hydrodynamic equations, Equation E-4-1 has been transformed into an orthogonal, curvilinear coordinate system and solved numerically. The hydrodynamic and sediment transport models use the same numerical grids.

Deposition Processes

Flocculating sediments in the water column range from clay particles smaller than 1 µm up to ~62 µm silts. The discrete particles aggregate and form flocs that can vary greatly in size and effective density. Variations in concentration and shear stress affect both floc diameter and settling speed (Burban et al. 1990). Previous modeling studies (Ziegler and Nisbet 1994, 1995; Gailani et al. 1996; Ziegler et al. 2000) indicate that an effective approximation is to treat suspended flocculating sediments as a single class. This approach assumes that the settling and depositional characteristics of flocculating sediments can be represented by average values of a distribution of properties. Using this approximation, the deposition flux of flocculating (Class 1) sediments to the sediment bed is expressed as (Ziegler et al. 2000).

$$D_1 = P_1 \, W_{s,1} \, C_1 \qquad \text{(E-4-2)}$$

where: $W_{s,1}$ is flocculating sediment settling speed and P1 is probability of deposition for flocculating sediments.

Settling speeds of cohesive flocs have been measured over a large range of concentrations and shear stresses in freshwater (Burban et al. 1990). The Burban settling speed data for cohesive flocs in freshwater were analyzed to develop a formulation to approximate the effects of flocculation on settling speed (Ziegler et al. 2000). This analysis indicates that the settling speed is dependent on the product of the concentration (C_1) and the water column shear stress (G) at which the flocs are formed, resulting in the following relationship:

$$W_{s,1} = 2.5\,(C_1 G)^{0.12} \qquad \text{(E-4-3)}$$

where: the units of $W_{s,1}$, C_1, and G are m/day, mg/l and Pa, respectively (Figure E-4-1). For a depth-averaged model, as used in this study, the relevant shear stress for use in Equation (E-4-3) is the bottom shear stress (i.e., $G = \tau_b$, see Equation E-3-4).

Modeling suspended flocculating sediments as a single class, with an effective $W_{s,1}$ given by Equation E-4-3 makes it necessary to use a probability of deposition (P_1) to parameterize the effects of particle/floc size heterogeneity and near-bed turbulence on the deposition rate. The complex interactions occurring in the vicinity of the sediment-water interface cause only a certain fraction of the settling flocculating sediments, represented by P_1, to become incorporated into the bed (Krone 1962, Partheniades 1992). An experimentally-based formulation that represents the effects of variable floc size on probability of deposition was developed by Partheniades (1992) (Figure E-4-2).

$$P_1 = 1 - (2\pi)^{-1/2} \int_{-\infty}^{Y} e^{-\frac{w^2}{2}} dw \qquad \text{(E-4-4)}$$

where:

$$Y = 2.04 \ln\left[0.25\left(\frac{\tau_b}{\tau_{b,\min}} - 1\right) e^{1.27\tau_{b,\min}}\right] \qquad \text{(E-4-5)}$$

and: $\tau_{b,min}$ is bottom shear stress below which P_1=1.

A value of 0.01 Pa is used for $\tau_{b,min}$ (Ziegler et al. 2000). This value is consistent with $\tau_{b,min}$. values reported by Partheniades (1992).

Class 2 and 3 particles, i.e., fine and medium sand, suspended in the water column have an effective settling speed ($W_{s,k}$) that depends on the effective particle diameter (d_k). The relationship between $W_{s,k}$ and d_k was developed by Cheng (1997). The depositional flux for this sediment class is estimated as:

$$D_2 = P_2 W_{s,2} \Gamma C_2 \qquad \text{(E-4-6)}$$

where: P_k is probability of deposition for non-cohesive sediment class k and Γ_k is stratification correction factor for class k.

Significant vertical stratification can occur in the water column due to the high settling speeds of fine and medium sand. This characteristic means that accurate calculation of sand deposition flux requires use of the near-bed concentration ($C_{a,k}$), where $C_{a,k} = \Gamma_k C_k$ and $\Gamma_k > 1$. Note that Γ_k is dependent upon $W_{s,k}$, τ_b, bottom roughness, and local depth.

The settling speed of a sand particle is related to the particle diameter, representing class k sediment, as follows (Cheng 1997):

$$W_{s,k} = \frac{\nu}{D_k}\left[\left(25 + 1.2D_*^2\right)^{1/2} - 5\right]^{1.5} \qquad \text{(E-4-7)}$$

where: D* = non-dimensional particle parameter.

$$D_* = D_k\left[\frac{(s-1)g}{\nu^2}\right]^{1/3} \qquad \text{(E-4-8)}$$

where: s is specific density of particle (assumed to be 2.65 for sand particles) and v is kinematic viscosity of water.

The settling speeds of suspended sand particles (i.e., 62< Dk < 500 μm) range from about 200 to 5,000 m/day (Figure E-4-3).

Most sediment transport models applied to riverine systems have used a vertically-averaged approximation of the vertical distribution of sediment in the water column (e.g., Ziegler et al. 2000). This approach assumes that particles are uniformly distributed throughout the water column, which is a good approximation for cohesive sediments due to their lower settling velocities (~1 to 10 m/day). The high settling speeds of suspended sands cause significant stratification to occur, with order of magnitude increases in concentration typically occurring between the top and bottom of the water column. Thus, simulation of suspended sand transport with a vertically-averaged model necessitates the use of a correction factor (Γ_k) to account for effects of concentration stratification.

This correction factor will relate the vertically-averaged sediment concentration of class k sediment (C_k), which is calculated by the sediment transport model, to the near-bed concentration ($C_{a,k}$). The vertical distribution of non-cohesive sediment in the water column can be calculated using (van Rijn 1984):

$$C_2(z) = \begin{cases} C_{a,2}\left[\left(\dfrac{a}{h-a}\right)\left(\dfrac{h}{z}-1\right)\right] & , \quad \dfrac{z}{h} < 0.5 \\ C_{a,2}\left(\dfrac{a}{h-a}\right)^{\zeta} e^{-4\zeta\left(\frac{z}{h}-0.5\right)}, & \dfrac{z}{h} \geq 0.5 \end{cases} \qquad \text{(E-4-9)}$$

where: a is the near-bed reference height (where a = MAX[$11z_o$, 0.01 h]); z is vertical coordinate (z = 0 at sediment-water interface and z = h at water surface); and ζ is the suspension parameter defined by (van Rijn 1984):

$$\zeta = \frac{W_{s,2}}{\beta \kappa u_*} \qquad \text{(E-4-10)}$$

where: κ is von Karman constant (assumed to be 0.4) and the β-factor, which is related to the vertical diffusion of particles, is given by (van Rijn 1984):

$$\beta = 1 + 2\left(\frac{W_{s,2}}{u_*}\right)^2 \quad , \quad 0.1 < \frac{W_{s,2}}{u_*} < 1 \qquad \text{(E-4-11)}$$

The vertically-averaged concentration, C_k, is defined as:

$$C_2 = \frac{1}{h}\int_a^h C_2(z)\, dz \qquad \text{(E-4-12)}$$

Using Equation E-4-9 in the above integral yields:

$$C_2 = \frac{C_{a,2}}{h}\left(\frac{a}{h-a}\right)^{\zeta}\left\{\int_a^{0.5h}\left(\frac{h}{z}-1\right)^{\zeta}dz + \int_{0.5h}^{h} e^{-4\zeta\left(\frac{z}{h}-.05\right)}dz\right\} \quad \text{(E-4-13)}$$

The integrals in this equation will be evaluated separately. The first integral does not have a closed form solution. Approximating the solution using the trapezoidal rule and three segments between z = a and z = 0.5 h, i.e., δz = (0.5 h – a)/3, yields:

$$\int_a^{0.5h}\left(\frac{h}{z}-1\right)^{\zeta}dz = \frac{1}{3}\left[0.5\left(\frac{h}{a}-1\right)^{\zeta} + \left(\frac{h}{a+2\delta z}-1\right)^{\zeta} + 0.5\right] \quad \text{(E-4-14)}$$

The second integral has the following solution:

$$\int_{0.5h}^{h} e^{-4\zeta\left(\frac{z}{h}-0.5\right)}dz = \frac{h}{4\zeta}\left(1-e^{-2\zeta}\right) \quad \text{(E-4-15)}$$

Inserting Equations E-4-14 and E-4-15 into Equation E-4-13 and solving for $C_{a,k}$ produces:

$$C_{a,2} = \Gamma C_2 \quad \text{(E-4-16)}$$

where:

$$\Gamma = \left(\frac{h}{a}-1\right)^{\zeta}\left\{\frac{1}{4\zeta}\left(1-e^{-2\zeta}\right) + \frac{1}{3}\left(0.5-\frac{a}{h}\right)\left[0.5\left(\frac{h}{a}-1\right)^{\zeta} + \left(\frac{h}{a+\delta z}-1\right)^{\zeta} + \left(\frac{h}{a+2\delta z}-1\right)^{\zeta} + 0.5\right]\right\}^{-1}$$

(E-4-17)

The dependence of Γ_k on h, a, $W_{s,k}$ and Γ_b is shown on Figure E-4-4.

The probability of deposition parameter (P_k) in Equation E-4-6 accounts for the effects of near-bed turbulence and particle size variations on deposition of fine sand. In quiescent water, the bottom shear stress will be zero and P_k will equal one. As the bottom shear stress increases, the probability of deposition decreases. The dependence of P_k on bottom shear stress was investigated by Gessler (1967), who determined that P_k could be described by a Gaussian distribution:

$$P_2 = \frac{1}{(2\pi)^{1/2}} \int_{-\infty}^{Y} e^{-\frac{1}{2}x^2}\, dx \qquad \text{(E-4-18)}$$

where:

$$Y = \frac{1}{\sigma}\left(\frac{\tau_{c,2}}{\tau_b} - 1\right) \qquad \text{(E-4-19)}$$

and: $\tau_{c,k}$ is critical shear stress for class k sand and σ is standard deviation of the Gaussian distribution for incipient motion. Based upon experimental results, Gessler (1967) determined that σ was equal to 0.57. The relationship between P_k, particle diameter and bottom shear stress is illustrated on Figure E-4-5.

Lateral Dispersion Coefficient

Suspended sediment and PCBs in the water column will be transported downstream by river currents. In addition, these solids and chemicals will be dispersed laterally across the river channel by turbulent diffusion and dispersion processes in the river. The rate at which the sediment and chemical transport models disperse suspended or dissolved material across the channel is determined by the lateral diffusion coefficient ($E_{lateral}$); this coefficient determines the rate and extent of cross-channel spreading of a plume. Based on data collected in various rivers, the following relationship is valid (Rutherford 1994):

$$E_{lateral} = \alpha\ U^*\ h \qquad \text{(E-4-20)}$$

where: α is an empirical constant and U^* is bed shear velocity.

For slightly meandering rivers, such as the Upper Hudson River, the value of α ranges between about 0.1 and 1.1, with an average value of 0.45 (Figure E-4-6). For this study, α was set at 0.45 for all simulations. This approach provides an objective, data-based method for estimating lateral dispersion in the Upper Hudson River.

E.4.3 Model Development

Development of the sediment transport model required specification of these model inputs: 1) bed map, which delineates areas of cohesive and non-cohesive sediment; 2) effective particle diameter for the two sand classes (i.e., Classes 2 and 3); and 3) magnitude and composition of dredge resuspension loads.

Side-scan sonar data were obtained for the TIP during 2002. These data were analyzed and used to broadly separate sediment bed types into three classes: 1) cohesive; 2) non-cohesive; and 3) hard bottom. The bed map for TIP resulting from this analysis is presented on Figure E-4-7.

The effective diameters for Classes 2 and 3 (i.e., fine and medium sand) were estimated using grain size distribution data collected from the TIP. This analysis suggests that representative effective diameters for Classes 2 and 3 are 113 and 267 μm, respectively. The settling speeds corresponding to these effective diameters are about 600 and 2,400 m/day, respectively. Note that the settling speed of flocculating cohesive sediment (i.e., Class 1) ranges between 1 and 10 m/day. An effective diameter of 26 μm is used for Class 1 sediment.

Magnitude and Composition of Dredge Releases

The composition of sediment to be dredged in each grid cell was estimated based on the primary visual texture description of the SSAP core segments. Each sediment core was associated with a volume of sediment that was defined by overlaying Thiessen polygons developed from the locations of the cores on the areal dredge delineation. The volume associated with each core was the product of its Thiessen polygon area (truncated at the dredge area boundaries) and a dredging depth equal to the volume-weighted average dredge depth for the dredge area under the Thiessen polygon. Each texture description in a core was assigned a fraction of the core's associated dredge volume based on it relative length over the dredging depth. If the dredge depth was deeper than the last core section, then it was assumed that the texture description for the last core section extends down to the average dredge depth. The Thiessen polygon-based sediment composition was mapped onto the model grid using an area-weighted approach.

In order to translate the qualitative visual sediment classifications into quantitative estimates of the volume fractions of the three sediment classes used in the model, correlations were developed between primary visual texture description and measured grain size. These correlations were based on a subset of approximately 5% of the SSAP data that were analyzed for grain size distribution. The average grain size distribution of each of the primary visual textures is shown on Figure E-4-8. The estimated grain size distribution is aggregated into the three sediment classes. Class 1 is composed of clay and silt. Class 2 represents very fine sand. Class 3 consists of fine and medium sand. Transport of very coarse material (i.e., coarse sand and gravel) is not simulated because this type of sediment is only transported as bed load. Figures E-4-9 through E-4-11 show the average sediment composition of dredged areas for the three sediment classes.

The mass of sediment released during dredging operations is based on the dredging plan. For a particular grid cell, the mass of dredged sediment and the duration of dredging are specified. These two quantities are used to calculate the sediment mass removal rate during dredging in a grid cell:

$$W_{ij,k} = M_{ij} \, f_{ij,k} \, / \, T_{ij} \qquad \text{(E-4-21)}$$

where: $W_{ij,k}$ is the mass loading rate for sediment class k in grid cell (i,j); M_{ij} is total mass of dredged sediment in grid cell (i,j); $f_{ij,k}$ is fraction of sediment class k in the bed in grid cell (i,j); and T_{ij} is the duration of dredging grid cell (i,j).

E.4.4 Application

Effects of Grid Resolution on Near-Field Transport

The numerical grid used in this study has a relatively high spatial resolution for a far-field model. Typical grid cell dimensions are about 160 ft. in the longitudinal (along channel) direction and about 30 ft. in the lateral (cross-channel) direction. This grid resolution is adequate for simulating plume structure and transport outside the immediate vicinity of the dredge-head (i.e., the far-field).

Sediment released during dredging is input as a water column load to the grid cell in which the dredge is operating. Deposition and transport of sediment within that grid cell are simulated using the far-field model. The immediate vicinity of the dredge-head corresponds to the near-field region, which has a spatial extent of approximately 30 ft. (10 m). The near-field region is smaller than a typical grid cell. Thus, the far-field model cannot resolve sediment transport processes within the near-field region. The far-field model, however, does provide an approximate simulation of transport processes within the near-field region.

An investigation was conducted to determine the extent that approximating near-field transport processes, through specification of the dredge release load as described above, affects sediment transported away from the immediate vicinity of the dredge-head. A typical far-field grid cell has dimensions of about 30 ft. in the lateral direction by about 160 ft. in the longitudinal direction, with the water column represented by one vertical layer because of the use of a vertically-averaged model. This far-field grid cell is assumed to encompass the near-field region.

To investigate the effects of grid resolution on near-field transport processes, a single two-dimensional (2-D), far-field grid cell was represented as a three-dimensional (3-D), high-resolution grid with approximately 6-ft. square grid cells and 10 layers in the vertical (Figure E-4-12). The 3-D grid was used to evaluate whether the 2-D model provides a reasonable approximation of the near-field sediment transport processes. The effects of the following model input parameters on sediment transport within the 2-D (far-field) and 3-D (near-field) grids were evaluated: 1) river flow rate; 2) longitudinal location within 3-D grid of sediment load release; and 3) location of far-field grid cell (i.e., sediment load release location) in TIP channel. In addition, the effect of vertical location in the water column of load release was evaluated for all three input parameters; sediment loads were released at bottom, mid-depth and surface points.

For these simulations, only two classes of sediment were used: flocculating cohesive sediment (Class 1) and very fine sand with an effective diameter of 113 μm (Class 2). Model simulations were set up such that the total inflow rate along the upstream boundary of the 3-D grid matched the inflow rate to the 2-D grid cell; the total inflow rate was uniformly distributed along the 3-D inflow boundary. In the vertical, the velocity distribution at the 3-D inflow boundary was assumed to be uniform.

A 2-D grid cell located near RM 193 was chosen to investigate the effects of flow rate and longitudinal location within the 3-D grid (Figure E-4-12). Water depth at this grid cell is approximately 3 m. The impact of flow rate on the flux of suspended sediment transported across the downstream boundary of the near-field region (which is located at the downstream face of the 2-D grid cell) is shown on Figure E-4-13, which presents the ratio of the 3-D flux to the 2-D flux. These results indicate that more sediment is transported out of the near-field region by the 2-D model than the 3-D model, with the 3-D:2-D flux ratio increasing as flow increases. The 3-D model predicts that more sediment is deposited within the near-field region (Figure E-4-14). Additional insights from these results are: 1) deposition decreases with increasing flow rate due to probability of deposition effects; 2) more sediment is deposited when the load release is at the bottom than at the surface location; and 3) sand deposition is more sensitive to flow rate than deposition of fine (Class 1) sediment 1.

For the 2-D far-field model, sediment loading from releases during dredging is input to a single grid cell, such that the load is uniformly distributed over the entire cell. In contrast, the 3-D near-field model has 70 grid cells in the longitudinal (along channel) direction, such that the sediment load can be specified at any of those 70 grid cells. For the 3-D simulation results discussed above (see Figures E-4-13 and E-4-14), the sediment load was specified in the center of the 3-D grid (i.e., halfway between the upstream and downstream boundaries of the grid). The longitudinal location of the sediment release affects the transport of sediment out of the near-field region and the impacts of this location were evaluated (see Figures E-4-15 and E-4-16). Generally, the amount of sediment transported out of the near-field region increases as the release location gets closer to the downstream boundary.

The relative location of the far-field grid cell where the sediment release occurs in the channel may also affect the transport of solids within the near-field region of the dredge-head. Variation of solids release location within the channel was investigated at two general areas in the TIP: 1) in the northern TIP near RM 193; and 2) near Griffin Island. At each of these two areas, model sensitivity to channel location was evaluated by specifying the solids release point at three locations: 1) near-shore; 2) approximate mid-point between the shore and edge of navigation channel; and 3) edge of navigation channel. Results of the analysis in the northern TIP near RM 193 are presented on Figures E-4-17 and E-4-18. Similarly, results for the area near Griffin Island are shown on Figures E-4-19 and E-4-20. At both locations, differences between the 2-D far-field and 3-D near-field predictions of the downstream transport of released sediment tend to decrease as the release point moves from the near-shore area to the navigation channel.

The results of this analysis suggest that the 2-D far-field model tends to overpredict the transport of released sediment from the immediate vicinity of the dredge-head, i.e., the 2-D grid cell in which sediment loading is specified. Increasing the grid resolution within the immediate vicinity of the dredge-head through use of a 3-D model results in redeposition of more sediment, particularly coarser sediment (sand), than is predicted by the 2-D far-field model. The effects of increased grid resolution on model predictions are complex, as indicated on Figures E-4-13 through E-4-20. This complexity makes it difficult to generalize the results and develop an algorithm that might be used to adjust the 2-D model in the grid cell where dredge releases are specified such that better agreement is achieved between the 2-D and 3-D models within the immediate vicinity of the dredge-head. Additional work may make it possible to develop an adjustment algorithm for the 2-D far-field model at the location of dredge releases.

While these results indicate that the 2-D far-field model tends to overpredict transport of sediment within the immediate vicinity of the dredgehead, examination of the comparisons of the 2-D and 3-D model results shows that the overprediction is primarily related to coarse sediment (i.e., sands). Differences in cohesive (Class 1) sediment transport between the 2-D and 3-D models are generally minor. Thus, simulation of the transport of particle-associated PCBs within the immediate vicinity of the dredgehead may be minimally affected because the PCBs tend to be concentrated in the cohesive sediment fraction. Additionally, the 2-D model predicts that most of the PCBs associated with the coarse sediments do not desorb before redeposition, thus any overprediction of sand transport does not impact PCB levels predicted at far-field locations.

Linking of Sediment Transport and PCB Fate Models

Sediment transport model results are used in the PCB fate model as follows. The two models are run in parallel within the model framework. Predicted water column concentrations and deposition fluxes for all three sediment classes are calculated in each grid cell. This sediment transport information is then used to calculate PCB partitioning and deposition fluxes.

E.5 PCB FATE AND TRANSPORT MODELING

E.5.1 PCB Metric

The RPS specifies criteria for Total PCB concentration and Total and Tri+ PCB flux. The Tri+ PCB flux criterion was "… derived from the Total PCB criterion and the observation that the Total PCB to Tri+ PCB ratio in the sediments is approximately 3:1. Since sediments are the main form of release of PCBs, it is expected that the net addition of Tri+ PCBs will be one-third that of Total PCBs …" (Malcolm Pirnie and TAMS 2004). Given the derivative nature of the Tri+ PCB flux and the desire to keep the resuspension modeling effort tractable, modeling was conducted for Total PCBs. Compliance with the Total PCB flux criteria was presumed to ensure compliance with the Tri+ PCB flux criteria.

E.5.2 Overview of PCB Fate and Transport Processes

The purpose of the PCB modeling is to assess the fate and transport of resuspended material as a result of dredging activity. For this reason, the only sources of PCBs considered are those caused by resuspension during dredging. Other sources, such as resuspension due to other dredging-related activities (e.g., barge movement, debris removal, control structure placement), upstream loadings, flow-induced resuspension (i.e., bed erosion), and diffusional loads from the sediment bed are not included in the simulations. As shown in Figure E-1-2, the relevant PCB kinetic processes are sorption/desorption and volatilization. The PCB desorption process is integral to predicting the fate of resuspended PCBs as a result of dredging because sorbed PCBs will be transported with sediment particles while dissolved PCBs will be transported with the water. Volatilization from the river, while not expected to be a major loss mechanism of PCBs, is also included in order to assess the amount of PCBs released to the atmosphere as a result of dredging.

E.5.3 Model Description

Desorption Kinetics Sub-Model

In the analyses of organic compounds in natural waters, it is common practice to assume equilibrium partitioning between the aqueous and sediment-sorbed chemical phases. This implies that the kinetics of adsorption and desorption are much faster than the processes affecting PCBs. Sorption has fast and slow stages (Pignatello and Xing 1996). The fast stage has a time scale of minutes to hours, whereas the slow stage's time scale is weeks to months. The conventional conceptual model of biphasic sorption includes a reversibly sorbing component with fast stage kinetics and a resistantly bound component with slow stage kinetics.

It appears that sediments have a limited capacity for resistant sorption. Studies with field contaminated Hudson River sediments (Carroll et al. 1994) and laboratory-contaminated sediments (Kan et al. 1997) indicate a saturation of the resistant compartment at environmentally relevant concentrations of sorbed contaminant. Carroll et al. (1994) found that about 1000 ug Total PCB/g organic carbon was resistantly bound in Hudson River sediments with total sorbed PCB concentrations ranging from 2500 to 8700 ug Total PCB/g organic carbon. Kan et al. (1997) found that the resistant component on a river sediment saturated at about 2400 ug naphthalene/g organic carbon and about 70 ug 2,2',5,5' tetrachlorobiphenyl/g organic carbon.

Ignoring biphasic sorption by assuming instantaneous equilibrium introduces error in the PCB fate model. The equilibrium model over-estimates desorption of PCBs from resuspended sediment depending on the time scales of slow desorption. This will result in over-estimation of PCB flux from sediments and downstream transport of PCBs. The significance of this over-estimation depends on the magnitude of resuspension and the fraction of the sediment PCB that is resistantly sorbed.

In dredging analyses, the transport of contaminated sediments occurs on relatively short time scales (i.e., minutes to hours). For environmental analyses that occur on such short scales, comparable to that of labile desorption, the kinetics of desorption cannot be ignored. Equilibrium partitioning is not a good approximation. Any accurate modeling analysis of the fate and transport of sediment-sorbed organic contaminants introduced into the water column as a result of dredging must consider the dynamics of chemical desorption.

It has been proposed that the differential rates of organic compound desorption arise from the disparate diffusional rates of adsorbed chemical from swollen and condensed phases of organic matter (Pignatello 1990). Another common conceptual model is the radial diffusion model proposed by Wu and Gschwend (1986). A conceptual model that considers both disparate phases and radial diffusion was proposed by Famularo et al. (1980). This model assumes that the particle consists of two compartments, an outer shell and an inner core. Instantaneous equilibrium is assumed between the bulk aqueous phase chemical and the immediate surface of the outer shell. Diffusional processes are responsible for the transport from the surface of the shell to the interior of the shell as well as the transport from the shell interior to the inner core. Figure E-5-1 shows the conceptual model. Desorption from the outer shell is responsible for the fast labile phase of PCB desorption, while diffusion from the inner core to the outer shell controls the slow refractory phase desorption. This model was successfully applied to the desorption of the pesticide Kepone from resuspended sediments (Connolly et al. 1983).

Using this model and assuming constant particulate density and organic carbon content, the transfer rate of labile to dissolved PCB is given by:

$$\frac{dC_d}{dt} = -\left(\frac{3 * K_f * m}{1000 * R * \rho}\right) * \left(C_d - \frac{r_s * 1000}{f_{oc} * K_{ow}}\right) \qquad \text{(E-5-1)}$$

The transfer rate of the refractory to labile phase of PCB is given by:

$$\frac{dC_c}{dt} = \left(\frac{3 * K_c * ratio_R * m}{R}\right) * (r_s - r_c) \qquad \text{(E-5-2)}$$

where: C_d = dissolved chemical concentration (mg/L)

C_c = core (refractory) chemical concentration (mg/L)

r_c = core (refractory) chemical concentration on a mass basis (mg/g)

r_s = shell (labile) chemical concentration (mg/g)

m = solids concentration (g/L)

K_f = diffusion rate constant for the shell (cm/s)

K_c = diffusion rate constant for the core (cm/s)

f_{oc} = fraction organic carbon

K_{ow} = octanol-water partition coefficient (L/kg)

ρ = particle density (g/cc)

R = radius of shell (particle radius) (cm)

$ratio_R$ = ratio of core/shell radius (<1)

With this model, most parameters depend on properties of the sediment particles; the only chemical-dependent property is the octanol-water partition coefficient.

Volatilization

Volatilization is the process by which PCBs are transported across the air-water interface. A chemical's tendency to volatilize is determined by the ratio of its equilibrium activities in air and water (Henry's Constant). This ratio is a fundamental property of the chemical that is defined by Henry's Law. The value of Henry's Constant may be calculated from the vapor pressure of the chemical and its solubility in water (i.e., Henry's Constant equals the vapor pressure divided by the solubility) or it may be calculated from the equilibrium ratio of gas phase and water phase concentrations in a laboratory experiment. A high Henry's Constant is indicative of a volatile chemical that preferentially accumulates in the air phase. A low Henry's Constant is indicative of a non-volatile chemical that preferentially accumulates in the water phase. Values of Henry's Constant are presented either in units of partial pressure per unit aqueous concentration (e.g., atm-m^3/mol) or as a dimensionless ratio of concentrations (e.g., (mol/m^3)/(mol/m^3)). The dimensionless ratio is derived from the dimensioned ratio by dividing by the product of the universal gas constant and absolute temperature, i.e., RT, thus converting pressure into concentration using the ideal gas law.

Volatile chemicals have dimensionless Henry's Constants greater than about 0.1 (0.0025 atm-m^3/mol). As points of reference, the highly volatile chemicals vinyl chloride and oxygen have Henry's Constants at 20°C of about 4 and 21 (0.1 and 0.5 atm-m^3/mol), respectively. Numerous experimental determinations of Henry's Constants for PCBs have been published (e.g., Bopp 1983, Burkhard et al. 1985, Murphy et al. 1987, Dunnivant and Elzerman 1988, Brunner et al. 1990). These studies have used various methodologies that have yielded differing estimates. Values range from about 0.05 to 0.0005. They are highest for the lowest chlorinated congeners and decrease as chlorination increases. Values for Aroclors 1242 and 1254, as reported by Murphy et al. (1987) are about 0.1 and 0.008, respectively. While all of the reported PCB Henry's Constants are below the level of volatile chemicals, they are of sufficient magnitude to make volatilization a significant process, particularly in systems with large surface areas and long residence times.

The PCB Henry's Constants have a positive dependency on temperature. Laboratory data indicate an approximate doubling of the Henry's Constant for every 10°C temperature increase (Tateya et al. 1988, ten Hulscher et al. 1992), however, for this modeling application, the Henry's Constant was held constant at the 25°C value

The rate at which volatilization occurs is dependent on the mass transfer coefficient at the air-water interface and the concentration of PCBs in the water column. Only freely-dissolved PCB can be transported across the interface and sorption to particulate or dissolved organic carbon reduces volatilization. The equation used to describe PCB flux due to volatilization is as follows:

$$S_v = \frac{k_L}{h}\left(c - \frac{c_{air}}{H}\right) \tag{E-5-3}$$

where: S_v is the PCB volatilization flux; k_L is volatilization mass transfer coefficient; h is the water depth; c is the dissolved phase PCB concentration in water; c_{air} is vapor-phase PCB concentration in air; and H is dimensionless Henry's Constant.

The mass transfer coefficient (k_L) is dependent on the rates of mass transfer through relatively thin layers of water and air at the interface, which are in turn dependent on the concentration gradients in the layers, and the diffusivity of PCBs in the layers (O'Connor 1983, 1984).

$$k_L = \frac{k_g k_l}{k_g + \frac{k_l}{H}} \qquad \text{(E-5-4)}$$

where: k_g is vapor-phase mass transfer coefficient and k_l is water-phase mass transfer constant.

E.5.4 Model Development

Development of the PCB fate model required specification of model inputs associated with the dredge resuspension loads, desorption, and volatilization.

Resuspension PCB Loads

Total PCB concentrations in the sediment bed are calculated in the following manner. Sediment volumes, based on primary texture description, are calculated for Thiessen polygons and grid cells as described in Section E.4.3. Using core data, a volume-weighted average concentration by primary texture description is calculated down to the average dredge depth for each Thiessen polygon. Both measured Total PCB concentrations and extrapolated Total PCB concentrations are used for CL 1A, 2A, 2B, 2E, 2F, and 2G. Only measured concentrations are used for CL 2C, 2R, 2D, and 2H. Abandoned locations are not included. The average Total PCB concentrations for each primary texture description in a Thiessen polygon are used to calculate a volume-weighted average Total PCB concentration for each grid cell by texture description.

In order to estimate PCB concentrations for the three sediment classes used in the model, the correlations developed in Section E.4.3 (Figure E-4-8) are used to calculate the average PCB concentration for each of the sediment classes. These estimated concentrations are weight-averaged for the three sediment classes. Figures E-5-2 through E-5-4 show the average PCB concentrations for the three sediment classes used in the modeling.

Desorption

The experiments performed by Carroll et al. (1994) was used to calibrate the PCB desorption parameters. These experiments were considered to be the most appropriate source of published data as it used field contaminated Hudson River sediments. Recent experiments performed by Schneider et al. at the University of Maryland also have used field contaminated Hudson River sediments. Some results of these experiments have been presented (Schneider 2004); however, the results have yet to be published.

Carroll's experiments observed both short-term (days) and long-term (months) desorption of PCBs from Hudson River sediments for a range of contaminant levels from 25 to 205 mg/kg. The short-term portion of the desorption curve was chosen as the main calibration target. This was chosen since the relevant time scales of transport between dredging locations and monitoring stations (near and far-field) are on the order of minutes to hours. Moreover, the desorption of 25 mg/kg contaminated sediment was used as it was felt that that level was representative of the average levels found in the TIP. Figure E-5-5 shows the portion of this data set that was used for calibration.

Inspection of Equations E-5-1 and E-5-2 shows a number of parameters are needed for calibration. The organic carbon content was measured at 0.96%. The average particle radius was estimated to be 220 μm. Particle density was assumed at 2.65 g/cc based on typical values for sand. The octanol/water partition coefficient, $K_{ow,}$ has been shown to be approximately linearly related to laboratory determined K_{oc} values (Karickhoff 1981, 1984; Baker et al. 1997) and it is common to assume that K_{oc} is equal to K_{ow}. Since K_{ow} values of PCBs range over 3 orders of magnitude, increasing with increasing chlorination, the appropriate K_{oc} value to describe partitioning of PCBs as a group (Total PCB in the model) will depend on congener composition. Paired dissolved and particulate water data collected in the Upper Hudson River at Thompson Island and Schuylerville in 2004 and 2005 (BMP, QEA and ESI 2004) yield an average total PCB K_{oc} of $10^{5.4}$. Using the data shown in Figure E-5-5, the model was calibrated (also shown) with a very high degree of agreement between model and data. The calibrated parameters are given in Table E-5-1.

Table E-5-1. Desorption sub-model calibration parameters.

Parameter	Value	Units
K_f	0.25	cm/min
K_c	$1.0x10^{-7}$	cm/min
$ratio_R$	0.75	
f_{ref}	0.47	

To assess the validity of the desorption sub-model, the model was compared to the results of the Treatability Studies (DRET) performed by General Electric Company as described in the main body of the Intermediate Design Report. These experiments investigated the settling and PCB desorption of sediment by adding water to sediments, thoroughly agitating for one hour, and then allowing to sit for one hour. After this, the overlying water was analyzed for sediment and PCB. Although the intense and prolonged agitation of the sediments is not representative of field conditions during dredging, these data were used a semi-quantitative validation of the desorption model. Figure E-5-6 shows the dissolved PCB concentration predicted by the model compared to the DRET results. Generally, the model fell within the range of the observed data. There seems to be a slight underprediction of desorption of the model, however, this may be a result of increased desorption due to the intense agitation of these sediments.

The desorption sub-model also agrees with the results (as yet unpublished) of experiments conducted by Schneider et al. (2004). During these experiments, contaminated Hudson River sediments were resuspended with very low turbulence in large tanks. The resuspension 'event' lasted for three days. This was repeated three times with a one-day quiescent phase in between each resuspension phase. The sediment and PCB concentrations were monitored during each simulated event. For the purposes of predicting desorption due to dredging, only the first simulated resuspension event is appropriate. During this event 20% of total PCBs desorbed during the first hour and 40% desorbed during the first six hours. The six hour desorption is most representative of the labile portion of the PCB desorption. Assuming this value represents the entire labile phase desorption, it can be compared to the desorption sub-model calibration parameter, f_{ref}, from Table E-5-1. The initial fraction labile in the model is therefore 53% (1-f_{ref}), and is generally comparable to the 40% found by Schneider et al.

Volatilization

The overall volatilization mass transfer coefficient was calculated from water phase and vapor phase mass transfer coefficients and from Henry's Constant as indicated in Equation E-5-4 The Henry's Constant for Total PCBs used in the model calculations was estimated as the average of the values for the di-chlorinated congeners reported by Brunner et al. (1990) at 25ºC. Both experimentally determined and calculated Henry's Constants were included in the average to yield a Henry's Constant of 23.7 Pa-m3/mol (0.0136 unitless). Brunner's predictive equation calculates Henry's Constants based on the number of chlorine atoms and number of chlorine atoms in the ortho position:

$$\text{Log } H' = -1.38-0.32(\text{no. of Cl}) + 0.18(\text{no. of o-Cl}) \qquad \text{(E-5-5)}$$

Using an average Henry's Constant for di-chlorinated PCBs is a conservative estimate for Total PCBs which allows for the evaluation of the importance of volatilization losses during dredging.

E.6 SIMULATION OF DREDGING OPERATIONS

E.6.1 Development of a Dredge Plan

The details of the development of the dredging plan are given in the main body of the Intermediate Design Report. The dredging schedule was based on same the numerical grid that was used for the resuspension modeling. The sediment volumes to be dredged were divided into discrete volumes that reside below each corresponding river grid element. The total sediment mass removed, dredge ID number, dredge start time, and dredge end time were specified for each of these grid cells A base dredging plan was developed assuming no structural resuspension controls. The planned dredging utilizes four dredges and covers the period from May 21, 2007 to October 2, 2007. Table E-6-1 presents the schedule used for the dredging simulations. Figures E-6-1a and E-6-1b show graphical representations of the dredging schedule.

Table E-6-1. Dredging schedule for May 21 to October 2, 2007.

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
20	20	NTIP01	1	22.5	0.7	05/21/07 00:00	05/21/07 00:43
20	21	NTIP01	1	421.8	11.7	05/21/07 00:43	05/21/07 12:24
20	22	NTIP01	1	536.2	17.3	05/21/07 12:24	05/22/07 05:45
20	23	NTIP01	1	63.8	2.1	05/22/07 05:45	05/22/07 07:48
21	19	NTIP01	1	130.9	4.2	05/22/07 07:48	05/22/07 12:02
21	20	NTIP01	1	1380.7	44.6	05/22/07 12:02	05/24/07 08:41
21	21	NTIP01	1	2096.3	117.8	05/24/07 08:41	05/31/07 06:30
21	22	NTIP01	1	1603.3	105.1	05/31/07 06:30	06/05/07 15:39
22	19	NTIP01	1	6.9	0.2	06/05/07 15:39	06/05/07 15:52
22	20	NTIP01	1	928.3	60.9	06/05/07 15:52	06/08/07 04:45
22	21	NTIP01	1	1207.1	67.9	06/08/07 04:45	06/12/07 00:36
22	22	NTIP01/NTIP02A	1	1051.4	68.9	06/12/07 00:36	06/14/07 21:33
22	23	NTIP01/NTIP02A	1	423.2	20.5	06/14/07 21:33	06/15/07 18:05
23	22	NTIP02A	1	3.4	0.3	06/16/07 00:00	06/16/07 00:16
23	23	NTIP02A	1	0.3	0.0	06/16/07 00:16	06/16/07 00:17
24	21	NTIP02A	1	0.5	0.0	06/16/07 00:17	06/16/07 00:18
24	22	NTIP02A	1	2.3	0.2	06/16/07 00:18	06/16/07 00:32
24	23	NTIP02A	1	0.0	0.0	06/16/07 00:32	06/16/07 00:32
25	21	NTIP02A	1	29.7	1.6	06/16/07 00:32	06/16/07 02:05
25	22	NTIP02A	1	101.0	9.9	06/16/07 02:05	06/16/07 12:01
25	23	NTIP02A	1	3.8	0.1	06/16/07 12:01	06/16/07 12:09
26	21	NTIP02A	1	126.9	3.5	06/16/07 12:09	06/16/07 15:40
26	22	NTIP02A	1	314.8	20.6	06/16/07 15:40	06/18/07 12:18

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
26	23	NTIP02A	1	38.2	1.9	06/18/07 12:18	06/18/07 14:09
27	20	NTIP02A	1	44.4	1.4	06/18/07 14:09	06/18/07 15:36
27	21	NTIP02A	1	257.0	14.4	06/18/07 15:36	06/19/07 06:02
27	22	NTIP02A/NTIP02B	1	402.3	39.6	06/19/07 06:02	06/20/07 21:37
27	23	NTIP02A	1	18.4	0.9	06/20/07 21:37	06/20/07 22:30
28	19	NTIP02B	1	14.0	0.3	06/21/07 00:00	06/21/07 00:20
28	20	NTIP02B	1	474.6	15.3	06/21/07 00:20	06/21/07 15:40
28	21	NTIP02B	1	560.1	15.5	06/21/07 15:40	06/22/07 07:12
28	22	NTIP02B	1	621.0	20.1	06/22/07 07:12	06/23/07 03:16
28	23	NTIP02B	1	58.9	1.4	06/23/07 03:16	06/23/07 04:42
29	19	NTIP02B	1	138.1	3.4	06/23/07 04:42	06/23/07 08:03
29	20	NTIP02B	1	572.4	28.2	06/23/07 08:03	06/25/07 12:12
29	21	NTIP02B	1	906.5	18.8	06/25/07 12:12	06/26/07 07:02
29	22	NTIP02B	1	737.0	17.9	06/26/07 07:02	06/27/07 00:54
29	23	NTIP02B	1	783.6	19.0	06/27/07 00:54	06/27/07 19:55
30	19	NTIP02B	1	563.7	13.7	06/27/07 19:55	06/28/07 09:35
30	20	NTIP02B	1	906.2	44.6	06/28/07 09:35	06/30/07 06:10
30	21	NTIP02B	1	791.9	16.5	06/30/07 06:10	06/30/07 22:37
30	22	NTIP02B	1	41.5	1.7	06/30/07 22:37	07/02/07 00:22
30	23	NTIP02B	1	64.2	1.6	07/02/07 00:22	07/02/07 01:55
31	19	NTIP02B	1	838.2	41.2	07/02/07 01:55	07/03/07 19:09
31	20	NTIP02B	1	1174.9	24.4	07/03/07 19:09	07/05/07 19:34
31	21	NTIP02B	1	963.0	20.0	07/05/07 19:34	07/06/07 15:35
31	22	NTIP02B	1	824.6	30.0	07/06/07 15:35	07/07/07 21:34
31	23	NTIP02B	1	44.0	1.1	07/07/07 21:34	07/07/07 22:38
32	18	NTIP02B	1	221.9	5.4	07/07/07 22:38	07/09/07 04:01
32	19	NTIP02B	1	3893.0	94.4	07/09/07 04:01	07/13/07 02:24
32	20	NTIP02B	1	2971.2	61.7	07/13/07 02:24	07/16/07 16:09
32	21	NTIP02B	1	1532.8	31.9	07/16/07 16:09	07/18/07 00:00
32	22	NTIP02B	1	1295.3	47.1	07/18/07 00:00	07/19/07 23:07
32	23	NTIP02B	1	227.1	8.3	07/19/07 23:07	07/20/07 07:22
33	18	NTIP02B	1	67.3	2.4	07/20/07 07:22	07/20/07 09:49
33	19	NTIP02B	1	1320.3	48.0	07/20/07 09:49	07/23/07 09:50
33	20	NTIP02B	1	2109.1	76.7	07/23/07 09:50	07/26/07 14:32
33	21	NTIP02B	1	1555.1	56.6	07/26/07 14:32	07/28/07 23:06
33	22	NTIP02B	1	1389.8	50.6	07/28/07 23:06	08/01/07 01:41
33	23	NTIP02B	1	27.7	1.0	08/01/07 01:41	08/01/07 02:41
34	19	NTIP02B	1	1196.3	29.0	08/01/07 02:41	08/02/07 07:41
34	20	NTIP02B	1	1839.4	38.2	08/02/07 07:41	08/03/07 21:55
35	19	NTIP02B	1	905.8	22.0	08/03/07 21:55	08/04/07 19:52
35	20	NTIP02B	1	2155.4	44.8	08/04/07 19:52	08/07/07 16:40
36	19	NTIP02B	1	1581.7	38.3	08/07/07 16:40	08/09/07 07:01
36	20	NTIP02B	1	3125.2	64.9	08/09/07 07:01	08/12/07 23:58
37	18	NTIP02B	1	9.5	0.2	08/12/07 23:58	08/13/07 00:12
37	19	NTIP02B	1	713.1	17.3	08/13/07 00:12	08/13/07 17:29
37	20	NTIP02B	1	1168.7	24.3	08/13/07 17:29	08/14/07 17:46
38	17	NTIP02B	1	169.5	4.1	08/14/07 17:46	08/14/07 21:53
38	18	NTIP02B	1	651.0	15.8	08/14/07 21:53	08/15/07 13:40
38	19	NTIP02B	1	735.0	17.8	08/15/07 13:40	08/16/07 07:29

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
39	16	NTIP02B	1	67.3	1.6	08/16/07 07:29	08/16/07 09:07
39	17	NTIP02B	1	704.6	17.1	08/16/07 09:07	08/17/07 02:12
39	18	NTIP02B	1	610.1	14.8	08/17/07 02:12	08/17/07 17:00
40	15	NTIP02B/NTIP02F	1	260.8	9.5	08/17/07 17:00	08/18/07 02:29
14	8	NTIP02C	2	31.5	1.3	06/18/07 00:00	06/18/07 01:18
15	2	NTIP02C	2	92.0	3.8	06/18/07 01:18	06/18/07 05:08
15	3	NTIP02C	2	186.3	7.7	06/18/07 05:08	06/18/07 12:52
15	4	NTIP02C	2	170.4	7.1	06/18/07 12:52	06/18/07 19:57
15	5	NTIP02C	2	210.7	17.8	06/18/07 19:57	06/19/07 13:43
15	6	NTIP02C	2	203.7	8.5	06/19/07 13:43	06/19/07 22:11
16	1	NTIP02C	2	167.3	8.1	06/19/07 22:11	06/20/07 06:18
16	2	NTIP02C	2	355.7	35.0	06/20/07 06:18	06/21/07 17:18
16	3	NTIP02C	2	251.1	10.4	06/21/07 17:18	06/22/07 03:44
16	4	NTIP02C	2	149.1	6.2	06/22/07 03:44	06/22/07 09:56
16	5	NTIP02C	2	148.9	6.2	06/22/07 09:56	06/22/07 16:07
16	6	NTIP02C	2	258.3	10.7	06/22/07 16:07	06/23/07 02:51
17	0	NTIP02C	2	25.8	1.3	06/23/07 02:51	06/23/07 04:06
17	1	NTIP02C	2	148.9	7.2	06/23/07 04:06	06/23/07 11:20
17	2	NTIP02C	2	162.1	6.7	06/23/07 11:20	06/23/07 18:04
17	3	NTIP02C	2	70.5	2.9	06/23/07 18:04	06/23/07 21:00
17	4	NTIP02C	2	60.3	2.5	06/23/07 21:00	06/23/07 23:30
17	5	NTIP02C	2	347.5	29.3	06/23/07 23:30	06/26/07 04:48
17	6	NTIP02C	2	300.6	12.5	06/26/07 04:48	06/26/07 17:17
18	3	NTIP02C	2	77.4	3.2	06/26/07 17:17	06/26/07 20:30
18	4	NTIP02C	2	293.8	12.2	06/26/07 20:30	06/27/07 08:43
18	5	NTIP02C	2	314.0	13.0	06/27/07 08:43	06/27/07 21:46
19	0	NTIP02C	2	30.5	1.5	06/27/07 21:46	06/27/07 23:15
19	1	NTIP02C	2	101.9	4.9	06/27/07 23:15	06/28/07 04:11
19	2	NTIP02C	2	161.7	6.7	06/28/07 04:11	06/28/07 10:55
19	3	NTIP02C	2	319.3	26.9	06/28/07 10:55	06/29/07 13:50
19	4	NTIP02C	2	347.2	14.4	06/29/07 13:50	06/30/07 04:16
20	0	NTIP02C	2	26.8	1.3	06/30/07 04:16	06/30/07 05:34
20	1	NTIP02C	2	227.9	11.1	06/30/07 05:34	06/30/07 16:37
20	2	NTIP02C	2	310.9	26.2	06/30/07 16:37	07/02/07 18:50
20	3	NTIP02C	2	353.5	14.7	07/02/07 18:50	07/03/07 09:31
20	4	NTIP02C	2	371.6	15.4	07/03/07 09:31	07/05/07 00:58
21	0	NTIP02C	2	0.0	0.0	07/05/07 00:58	07/05/07 00:58
21	1	NTIP02C	2	192.2	18.9	07/05/07 00:58	07/05/07 19:52
21	2	NTIP02C	2	346.5	29.2	07/05/07 19:52	07/07/07 01:05
21	3	NTIP02C	2	399.9	33.7	07/07/07 01:05	07/09/07 10:49
21	4	NTIP02C	2	415.7	35.0	07/09/07 10:49	07/10/07 21:51
21	5	NTIP02C	2	413.9	34.9	07/10/07 21:51	07/12/07 08:45
22	0	NTIP02C	2	2.3	0.2	07/12/07 08:45	07/12/07 08:55
22	1	NTIP02C	2	291.2	21.2	07/12/07 08:55	07/13/07 06:06
22	2	NTIP02C	2	627.3	45.6	07/13/07 06:06	07/16/07 03:44
22	3	NTIP02C	2	410.5	60.6	07/16/07 03:44	07/18/07 16:18
22	4	NTIP02C	2	442.0	32.1	07/18/07 16:18	07/20/07 00:27
22	5	NTIP02C	2	457.5	33.3	07/20/07 00:27	07/21/07 09:43
23	0	NTIP02C	2	59.3	2.2	07/21/07 09:43	07/21/07 11:53

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
23	1	NTIP02C	2	488.3	17.8	07/21/07 11:53	07/23/07 05:39
23	2	NTIP02C	2	462.2	19.5	07/23/07 05:39	07/24/07 01:08
23	3	NTIP02C	2	380.7	7.9	07/24/07 01:08	07/24/07 09:03
23	4	NTIP02C	2	537.0	11.2	07/24/07 09:03	07/24/07 20:13
23	5	NTIP02C	2	547.1	11.4	07/24/07 20:13	07/25/07 07:35
24	0	NTIP02C	2	20.9	0.5	07/25/07 07:35	07/25/07 08:05
24	1	NTIP02C	2	444.7	10.8	07/25/07 08:05	07/25/07 18:53
24	2	NTIP02C	2	544.2	11.3	07/25/07 18:53	07/26/07 06:11
24	3	NTIP02C	2	684.1	14.2	07/26/07 06:11	07/26/07 20:24
24	4	NTIP02C	2	364.4	15.4	07/26/07 20:24	07/27/07 11:46
24	5	NTIP02C	2	430.1	8.9	07/27/07 11:46	07/27/07 20:42
25	0	NTIP02C	2	31.2	1.1	07/27/07 20:42	07/27/07 21:50
25	1	NTIP02C	2	371.7	13.5	07/27/07 21:50	07/28/07 11:21
25	2	NTIP02C	2	684.8	50.5	07/28/07 11:21	07/31/07 13:53
25	3	NTIP02C	2	1084.9	39.5	07/31/07 13:53	08/02/07 05:20
25	4	NTIP02C	2	523.6	19.0	08/02/07 05:20	08/03/07 00:22
25	5	NTIP02C	2	102.2	6.0	08/03/07 00:22	08/03/07 06:24
26	0	NTIP02C	2	12.8	0.3	08/03/07 06:24	08/03/07 06:43
26	1	NTIP02C	2	257.8	6.3	08/03/07 06:43	08/03/07 12:58
26	2	NTIP02C	2	466.4	11.3	08/03/07 12:58	08/04/07 00:17
26	3	NTIP02C	2	179.1	3.7	08/04/07 00:17	08/04/07 04:00
26	4	NTIP02C	2	269.2	5.6	08/04/07 04:00	08/04/07 09:36
26	5	NTIP02C	2	434.3	9.0	08/04/07 09:36	08/04/07 18:37
27	0	NTIP02C	2	78.6	1.9	08/04/07 18:37	08/04/07 20:32
27	1	NTIP02C	2	312.3	7.6	08/04/07 20:32	08/06/07 04:06
27	2	NTIP02C	2	507.2	10.5	08/06/07 04:06	08/06/07 14:38
27	3	NTIP02C	2	140.8	2.9	08/06/07 14:38	08/06/07 17:34
27	4	NTIP02C	2	12.3	0.3	08/06/07 17:34	08/06/07 17:49
27	5	NTIP02C	2	182.8	4.4	08/06/07 17:49	08/06/07 22:15
28	0	NTIP02C/NTIP02E	2	150.3	3.6	08/06/07 22:15	08/07/07 01:54
28	1	NTIP02C/NTIP02E	2	492.6	11.9	08/07/07 01:54	08/07/07 13:51
28	2	NTIP02C/NTIP02E	2	140.0	2.9	08/07/07 13:51	08/07/07 16:45
28	4	NTIP02E	2	10.4	0.3	08/08/07 00:00	08/08/07 00:15
28	5	NTIP02E	2	8.7	0.2	08/08/07 00:15	08/08/07 00:27
29	0	NTIP02E	2	237.5	8.6	08/08/07 00:27	08/08/07 09:06
29	1	NTIP02E	2	304.2	7.4	08/08/07 09:06	08/08/07 16:29
29	2	NTIP02E	2	315.5	6.6	08/08/07 16:29	08/08/07 23:02
29	3	NTIP02E	2	79.4	1.6	08/08/07 23:02	08/09/07 00:41
29	4	NTIP02E	2	226.2	5.5	08/09/07 00:41	08/09/07 06:10
29	5	NTIP02E	2	210.0	10.3	08/09/07 06:10	08/09/07 16:30
30	1	NTIP02E	2	350.6	8.5	08/09/07 16:30	08/10/07 01:00
30	2	NTIP02E	2	458.1	22.5	08/10/07 01:00	08/10/07 23:32
30	3	NTIP02E	2	200.3	4.2	08/10/07 23:32	08/11/07 03:42
30	4	NTIP02E	2	336.5	8.2	08/11/07 03:42	08/11/07 11:51
30	5	NTIP02E	2	458.6	11.1	08/11/07 11:51	08/11/07 22:59
31	1	NTIP02E	2	194.2	4.7	08/11/07 22:59	08/13/07 03:41
31	2	NTIP02E	2	348.5	8.5	08/13/07 03:41	08/13/07 12:08
31	3	NTIP02E	2	27.0	0.9	08/13/07 12:08	08/13/07 13:03
31	4	NTIP02E	2	330.2	13.9	08/13/07 13:03	08/14/07 02:58

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
31	5	NTIP02E	2	666.1	16.1	08/14/07 02:58	08/14/07 19:07
32	1	NTIP02E	2	269.0	6.5	08/14/07 19:07	08/15/07 01:39
32	2	NTIP02E	2	460.0	11.2	08/15/07 01:39	08/15/07 12:48
32	3	NTIP02E	2	370.0	7.7	08/15/07 12:48	08/15/07 20:29
32	4	NTIP02E	2	534.9	11.1	08/15/07 20:29	08/16/07 07:36
32	5	NTIP02E	2	556.5	11.6	08/16/07 07:36	08/16/07 19:10
33	1	NTIP02E	2	326.4	7.9	08/16/07 19:10	08/17/07 03:05
33	2	NTIP02E	2	607.4	14.7	08/17/07 03:05	08/17/07 17:49
33	3	NTIP02E	2	572.9	11.9	08/17/07 17:49	08/18/07 05:43
33	4	NTIP02E	2	476.9	9.9	08/18/07 05:43	08/18/07 15:38
33	5	NTIP02E	2	385.7	8.0	08/18/07 15:38	08/18/07 23:39
33	6	NTIP02E	2	1636.0	34.0	08/18/07 23:39	08/21/07 09:39
34	0	NTIP02E	2	25.6	0.6	08/21/07 09:39	08/21/07 10:16
34	1	NTIP02E	2	320.9	7.8	08/21/07 10:16	08/21/07 18:03
34	2	NTIP02E	2	541.1	13.1	08/21/07 18:03	08/22/07 07:10
34	3	NTIP02E	2	597.1	25.2	08/22/07 07:10	08/23/07 08:21
34	4	NTIP02E	2	252.3	5.2	08/23/07 08:21	08/23/07 13:35
34	5	NTIP02E	2	166.0	3.5	08/23/07 13:35	08/23/07 17:02
34	6	NTIP02E	2	1939.3	40.3	08/23/07 17:02	08/25/07 09:20
35	1	NTIP02E	2	216.2	5.2	08/25/07 09:20	08/25/07 14:35
35	2	NTIP02E	2	451.7	22.2	08/25/07 14:35	08/27/07 12:48
35	3	NTIP02E	2	524.7	10.9	08/27/07 12:48	08/27/07 23:42
35	4	NTIP02E	2	474.2	9.9	08/27/07 23:42	08/28/07 09:34
35	5	NTIP02E	2	26.0	0.5	08/28/07 09:34	08/28/07 10:06
35	7	NTIP02E	2	26.9	0.6	08/28/07 10:06	08/28/07 10:40
36	1	NTIP02E/NTIP02F	2	141.9	5.2	08/28/07 10:40	08/28/07 15:50
36	2	NTIP02E/NTIP02F	2	268.7	6.5	08/28/07 15:50	08/28/07 22:20
36	3	NTIP02E/NTIP02F	2	99.7	2.1	08/28/07 22:20	08/29/07 00:25
36	4	NTIP02E	2	132.2	2.7	08/29/07 00:25	08/29/07 03:10
36	5	NTIP02E	2	20.7	0.4	08/29/07 03:10	08/29/07 03:35
36	7	NTIP02F	2	89.7	1.9	08/30/07 00:00	08/30/07 01:51
37	1	NTIP02F	2	160.2	3.9	08/30/07 01:51	08/30/07 05:44
37	2	NTIP02F	2	267.8	6.5	08/30/07 05:44	08/30/07 12:14
37	3	NTIP02F	2	335.6	14.1	08/30/07 12:14	08/31/07 02:23
37	4	NTIP02F	2	73.9	1.5	08/31/07 02:23	08/31/07 03:55
37	5	NTIP02F	2	25.9	0.5	08/31/07 03:55	08/31/07 04:27
37	6	NTIP02F	2	195.6	4.1	08/31/07 04:27	08/31/07 08:31
38	0	NTIP02F	2	7.7	0.3	08/31/07 08:31	08/31/07 08:48
38	1	NTIP02F	2	305.0	11.1	08/31/07 08:48	08/31/07 19:54
38	2	NTIP02F	2	264.7	6.4	08/31/07 19:54	09/01/07 02:19
38	3	NTIP02F	2	226.5	4.7	09/01/07 02:19	09/01/07 07:01
38	4	NTIP02F	2	299.9	6.2	09/01/07 07:01	09/02/07 13:15
38	5	NTIP02F	2	375.5	7.8	09/02/07 13:15	09/02/07 21:03
38	6	NTIP02F	2	498.9	10.4	09/02/07 21:03	09/04/07 07:25
39	0	NTIP02F	2	1.1	0.0	09/04/07 07:25	09/04/07 07:28
39	1	NTIP02F	2	137.6	5.0	09/04/07 07:28	09/04/07 12:28
39	2	NTIP02F	2	305.9	15.0	09/04/07 12:28	09/05/07 03:31
39	3	NTIP02F	2	311.8	6.5	09/05/07 03:31	09/05/07 09:59
39	4	NTIP02F	2	447.2	9.3	09/05/07 09:59	09/05/07 19:17

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
39	5	NTIP02F	2	376.0	7.8	09/05/07 19:17	09/06/07 03:06
39	6	NTIP02F	2	355.0	7.4	09/06/07 03:06	09/06/07 10:29
39	7	NTIP02F	2	383.3	8.0	09/06/07 10:29	09/06/07 18:27
40	1	NTIP02F	2	10.6	0.4	09/06/07 18:27	09/06/07 18:50
40	2	NTIP02F	2	22.7	0.5	09/06/07 18:50	09/06/07 19:23
40	3	NTIP02F	2	33.6	0.7	09/06/07 19:23	09/06/07 20:04
40	4	NTIP02F	2	41.7	0.9	09/06/07 20:04	09/06/07 20:56
40	5	NTIP02F	2	187.8	3.9	09/06/07 20:56	09/07/07 00:51
40	6	NTIP02F	2	314.4	13.3	09/07/07 00:51	09/07/07 14:06
40	7	NTIP02F	2	352.9	7.3	09/07/07 14:06	09/07/07 21:26
40	8	NTIP02F	2	434.8	9.0	09/07/07 21:26	09/08/07 06:28
41	1	NTIP02F	2	63.4	2.3	09/08/07 06:28	09/08/07 08:47
41	2	NTIP02F	2	196.7	4.8	09/08/07 08:47	09/08/07 13:33
41	3	NTIP02F	2	113.5	4.8	09/08/07 13:33	09/08/07 18:20
41	4	NTIP02F	2	17.6	0.4	09/08/07 18:20	09/08/07 18:42
41	5	NTIP02F	2	21.5	0.4	09/08/07 18:42	09/08/07 19:09
41	6	NTIP02F	2	70.4	1.5	09/08/07 19:09	09/08/07 20:37
41	7	NTIP02F	2	125.3	2.6	09/08/07 20:37	09/08/07 23:13
41	8	NTIP02F	2	194.9	4.1	09/08/07 23:13	09/10/07 03:16
41	9	NTIP02F	2	191.7	4.0	09/10/07 03:16	09/10/07 07:15
41	10	NTIP02F	2	57.0	1.9	09/10/07 07:15	09/10/07 09:10
41	11	NTIP02F	2	178.2	3.7	09/10/07 09:10	09/10/07 12:53
41	12	NTIP02F	2	323.0	6.7	09/10/07 12:53	09/10/07 19:35
41	13	NTIP02F	2	406.5	17.1	09/10/07 19:35	09/11/07 12:43
41	14	NTIP02F	2	431.8	9.0	09/11/07 12:43	09/11/07 21:42
41	15	NTIP02F	2	295.5	6.1	09/11/07 21:42	09/12/07 03:50
42	0	NTIP02F	2	0.0	0.0	09/12/07 03:50	09/12/07 03:50
42	1	NTIP02F	2	179.7	6.5	09/12/07 03:50	09/12/07 10:22
42	2	NTIP02F	2	173.2	4.2	09/12/07 10:22	09/12/07 14:34
42	3	NTIP02F	2	305.0	6.3	09/12/07 14:34	09/12/07 20:55
42	4	NTIP02F	2	345.7	14.6	09/12/07 20:55	09/13/07 11:29
42	5	NTIP02F	2	262.1	5.4	09/13/07 11:29	09/13/07 16:56
42	6	NTIP02F	2	206.7	4.3	09/13/07 16:56	09/13/07 21:13
42	7	NTIP02F	2	240.0	5.0	09/13/07 21:13	09/14/07 02:13
42	8	NTIP02F	2	213.1	4.4	09/14/07 02:13	09/14/07 06:38
42	9	NTIP02F	2	290.3	6.0	09/14/07 06:38	09/14/07 12:40
42	10	NTIP02F	2	368.6	7.7	09/14/07 12:40	09/14/07 20:20
42	11	NTIP02F	2	380.6	7.9	09/14/07 20:20	09/15/07 04:14
42	12	NTIP02F	2	285.3	5.9	09/15/07 04:14	09/15/07 10:10
42	13	NTIP02F	2	309.4	6.4	09/15/07 10:10	09/15/07 16:36
43	0	NTIP02F	2	3.7	0.1	09/15/07 16:36	09/15/07 16:44
43	1	NTIP02F	2	206.0	7.5	09/15/07 16:44	09/17/07 00:13
43	2	NTIP02F	2	82.3	2.0	09/17/07 00:13	09/17/07 02:13
43	3	NTIP02F	2	27.7	0.7	09/17/07 02:13	09/17/07 02:54
43	4	NTIP02F	2	105.1	2.2	09/17/07 02:54	09/17/07 05:05
43	5	NTIP02F	2	126.2	2.6	09/17/07 05:05	09/17/07 07:42
43	6	NTIP02F	2	222.2	4.6	09/17/07 07:42	09/17/07 12:19
43	7	NTIP02F	2	224.4	4.7	09/17/07 12:19	09/17/07 16:59
43	8	NTIP02F	2	172.9	3.6	09/17/07 16:59	09/17/07 20:34

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
43	9	NTIP02F	2	237.9	4.9	09/17/07 20:34	09/18/07 01:31
43	10	NTIP02F	2	201.5	4.2	09/18/07 01:31	09/18/07 05:42
43	11	NTIP02F	2	157.6	3.3	09/18/07 05:42	09/18/07 08:59
44	1	NTIP02F	2	6.7	0.2	09/18/07 08:59	09/18/07 09:13
44	2	NTIP02F	2	77.3	2.8	09/18/07 09:13	09/18/07 12:02
44	3	NTIP02F	2	214.3	5.2	09/18/07 12:02	09/18/07 17:14
44	4	NTIP02F	2	221.9	4.6	09/18/07 17:14	09/18/07 21:51
44	5	NTIP02F	2	93.0	1.9	09/18/07 21:51	09/18/07 23:47
44	6	NTIP02F	2	85.7	1.8	09/18/07 23:47	09/19/07 01:33
44	7	NTIP02F	2	143.3	3.0	09/19/07 01:33	09/19/07 04:32
44	8	NTIP02F	2	175.1	3.6	09/19/07 04:32	09/19/07 08:10
44	9	NTIP02F	2	202.0	4.2	09/19/07 08:10	09/19/07 12:22
44	10	NTIP02F	2	163.9	3.4	09/19/07 12:22	09/19/07 15:47
45	0	NTIP02F	2	0.0	0.0	09/19/07 15:47	09/19/07 15:47
45	1	NTIP02F	2	19.5	0.7	09/19/07 15:47	09/19/07 16:29
45	2	NTIP02F	2	64.2	2.3	09/19/07 16:29	09/19/07 18:49
45	3	NTIP02F	2	83.2	2.0	09/19/07 18:49	09/19/07 20:50
45	4	NTIP02F	2	144.1	3.5	09/19/07 20:50	09/20/07 00:20
45	5	NTIP02F	2	47.7	1.0	09/20/07 00:20	09/20/07 01:20
45	6	NTIP02F	2	0.7	0.0	09/20/07 01:20	09/20/07 01:21
46	3	NTIP02G	2	0.0	0.0	09/21/07 00:00	09/21/07 00:00
46	4	NTIP02G	2	73.4	1.5	09/21/07 00:00	09/21/07 01:31
46	5	NTIP02G	2	217.5	9.2	09/21/07 01:31	09/21/07 10:41
46	6	NTIP02G	2	368.3	7.7	09/21/07 10:41	09/21/07 18:20
47	0	NTIP02G	2	0.0	0.0	09/21/07 18:20	09/21/07 18:20
47	1	NTIP02G	2	22.0	0.5	09/21/07 18:20	09/21/07 18:52
47	2	NTIP02G	2	52.3	1.3	09/21/07 18:52	09/21/07 20:08
47	3	NTIP02G	2	64.7	1.6	09/21/07 20:08	09/21/07 21:43
47	4	NTIP02G	2	114.1	2.8	09/21/07 21:43	09/22/07 00:28
47	5	NTIP02G	2	121.9	2.5	09/22/07 00:28	09/22/07 03:00
47	6	NTIP02G	2	137.5	5.8	09/22/07 03:00	09/22/07 08:48
47	7	NTIP02G	2	132.7	2.8	09/22/07 08:48	09/22/07 11:34
47	8	NTIP02G	2	164.2	3.4	09/22/07 11:34	09/22/07 14:59
48	1	NTIP02G	2	49.4	1.2	09/22/07 14:59	09/22/07 16:10
48	2	NTIP02G	2	85.4	2.1	09/22/07 16:10	09/22/07 18:15
48	3	NTIP02G	2	120.8	2.9	09/22/07 18:15	09/22/07 21:10
48	4	NTIP02G	2	137.5	5.8	09/22/07 21:10	09/24/07 02:58
48	5	NTIP02G	2	154.2	3.2	09/24/07 02:58	09/24/07 06:10
48	6	NTIP02G	2	118.5	2.5	09/24/07 06:10	09/24/07 08:38
48	7	NTIP02G	2	144.6	3.0	09/24/07 08:38	09/24/07 11:38
48	8	NTIP02G	2	234.2	4.9	09/24/07 11:38	09/24/07 16:30
48	9	NTIP02G	2	334.8	7.0	09/24/07 16:30	09/24/07 23:28
48	10	NTIP02G	2	284.1	5.9	09/24/07 23:28	09/25/07 05:22
48	11	NTIP02G	2	299.6	6.2	09/25/07 05:22	09/25/07 11:36
49	0	NTIP02G	2	0.0	0.0	09/25/07 11:36	09/25/07 11:36
49	1	NTIP02G	2	156.3	3.8	09/25/07 11:36	09/25/07 15:23
49	2	NTIP02G	2	235.6	5.7	09/25/07 15:23	09/25/07 21:06
49	3	NTIP02G	2	231.1	5.6	09/25/07 21:06	09/26/07 02:42
49	4	NTIP02G	2	263.0	5.5	09/26/07 02:42	09/26/07 08:10

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
49	5	NTIP02G	2	215.9	4.5	09/26/07 08:10	09/26/07 12:39
49	6	NTIP02G	2	198.5	4.1	09/26/07 12:39	09/26/07 16:47
49	7	NTIP02G	2	193.2	4.0	09/26/07 16:47	09/26/07 20:48
50	0	NTIP02G	2	11.7	0.3	09/26/07 20:48	09/26/07 21:05
50	1	NTIP02G	2	259.5	6.3	09/26/07 21:05	09/27/07 03:23
50	2	NTIP02G	2	379.0	9.2	09/27/07 03:23	09/27/07 12:34
50	3	NTIP02G	2	374.8	7.8	09/27/07 12:34	09/27/07 20:21
50	4	NTIP02G	2	288.3	6.0	09/27/07 20:21	09/28/07 02:21
50	5	NTIP02G	2	289.6	6.0	09/28/07 02:21	09/28/07 08:22
50	6	NTIP02G	2	347.4	7.2	09/28/07 08:22	09/28/07 15:35
51	0	NTIP02G	2	0.0	0.0	09/28/07 15:35	09/28/07 15:35
51	1	NTIP02G	2	199.4	4.8	09/28/07 15:35	09/28/07 20:25
51	2	NTIP02G	2	336.5	8.2	09/28/07 20:25	09/29/07 04:35
51	3	NTIP02G	2	362.3	8.8	09/29/07 04:35	09/29/07 13:22
51	4	NTIP02G	2	284.3	5.9	09/29/07 13:22	09/29/07 19:16
51	5	NTIP02G	2	310.9	6.5	09/29/07 19:16	10/01/07 01:44
51	6	NTIP02G	2	297.5	6.2	10/01/07 01:44	10/01/07 07:55
52	1	NTIP02G	2	145.0	3.5	10/01/07 07:55	10/01/07 11:26
52	2	NTIP02G	2	332.4	8.1	10/01/07 11:26	10/01/07 19:30
52	3	NTIP02G	2	364.0	8.8	10/01/07 19:30	10/02/07 04:19
52	4	NTIP02G	2	372.2	7.7	10/02/07 04:19	10/02/07 12:03
52	5	NTIP02G	2	397.1	8.3	10/02/07 12:03	10/02/07 20:19
14	9	NTIP02C	3	50.6	4.3	06/18/07 00:00	06/18/07 04:16
14	10	NTIP02C	3	0.1	0.0	06/18/07 04:16	06/18/07 04:16
15	7	NTIP02C	3	180.4	7.5	06/18/07 04:16	06/18/07 11:46
15	8	NTIP02C	3	224.7	18.9	06/18/07 11:46	06/19/07 06:42
15	9	NTIP02C	3	196.3	8.2	06/19/07 06:42	06/19/07 14:52
15	10	NTIP02C	3	51.8	2.2	06/19/07 14:52	06/19/07 17:01
16	7	NTIP02C	3	282.1	11.7	06/19/07 17:01	06/20/07 04:45
16	8	NTIP02C	3	282.8	11.8	06/20/07 04:45	06/20/07 16:30
16	9	NTIP02C	3	249.0	10.3	06/20/07 16:30	06/21/07 02:51
16	10	NTIP02C	3	208.0	17.5	06/21/07 02:51	06/21/07 20:23
16	11	NTIP02C	3	257.8	21.7	06/21/07 20:23	06/22/07 18:07
16	12	NTIP02C	3	188.0	7.8	06/22/07 18:07	06/23/07 01:56
16	13	NTIP02C	3	32.8	1.4	06/23/07 01:56	06/23/07 03:18
17	7	NTIP02C	3	281.8	11.7	06/23/07 03:18	06/23/07 15:00
17	8	NTIP02C	3	424.6	17.6	06/23/07 15:00	06/25/07 08:39
17	9	NTIP02C	3	378.5	15.7	06/25/07 08:39	06/26/07 00:23
17	10	NTIP02C	3	324.5	13.5	06/26/07 00:23	06/26/07 13:52
17	11	NTIP02C	3	240.2	10.0	06/26/07 13:52	06/26/07 23:51
17	12	NTIP02C	3	6.9	0.3	06/26/07 23:51	06/27/07 00:08
18	6	NTIP02C	3	190.2	16.0	06/27/07 00:08	06/27/07 16:11
18	7	NTIP02C	3	191.3	8.0	06/27/07 16:11	06/28/07 00:08
18	8	NTIP02C	3	143.8	6.0	06/28/07 00:08	06/28/07 06:06
18	9	NTIP02C	3	7.3	0.3	06/28/07 06:06	06/28/07 06:25
19	5	NTIP02C	3	358.2	30.2	06/28/07 06:25	06/29/07 12:37
19	6	NTIP02C	3	321.0	27.1	06/29/07 12:37	06/30/07 15:41
19	7	NTIP02C	3	73.3	6.2	06/30/07 15:41	06/30/07 21:52
19	8	NTIP02C	3	41.6	2.8	06/30/07 21:52	07/02/07 00:40

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
19	9	NTIP02C	3	10.0	0.4	07/02/07 00:40	07/02/07 01:05
20	5	NTIP02C	3	390.9	33.0	07/02/07 01:05	07/03/07 10:03
20	6	NTIP02C	3	295.0	12.3	07/03/07 10:03	07/03/07 22:18
21	6	NTIP02C	3	307.7	25.9	07/03/07 22:18	07/06/07 00:15
21	7	NTIP02C	3	159.8	7.8	07/06/07 00:15	07/06/07 08:00
21	8	NTIP02C	3	81.2	5.9	07/06/07 08:00	07/06/07 13:54
22	6	NTIP02C	3	569.9	41.4	07/06/07 13:54	07/09/07 07:21
22	7	NTIP02C	3	839.7	123.9	07/09/07 07:21	07/14/07 11:15
22	8	NTIP02C	3	277.2	20.2	07/14/07 11:15	07/16/07 07:26
23	6	NTIP02C	3	791.3	16.4	07/16/07 07:26	07/16/07 23:52
23	7	NTIP02C	3	736.1	31.0	07/16/07 23:52	07/18/07 06:54
23	8	NTIP02C	3	396.2	29.2	07/18/07 06:54	07/19/07 12:08
23	9	NTIP02C	3	66.9	1.6	07/19/07 12:08	07/19/07 13:45
24	6	NTIP02C	3	746.5	36.7	07/19/07 13:45	07/21/07 02:28
24	7	NTIP02C	3	656.3	32.3	07/21/07 02:28	07/23/07 10:45
24	8	NTIP02C/NTIP02D	3	672.7	33.1	07/23/07 10:45	07/24/07 19:50
24	9	NTIP02C/NTIP02D	3	426.5	10.3	07/24/07 19:50	07/25/07 06:11
25	6	NTIP02C	3	267.7	9.7	07/25/07 06:11	07/25/07 15:55
25	7	NTIP02C	3	257.2	9.4	07/25/07 15:55	07/26/07 01:16
25	8	NTIP02C/NTIP02D	3	304.8	22.5	07/26/07 01:16	07/26/07 23:45
26	6	NTIP02C	3	412.1	8.6	07/26/07 23:45	07/27/07 08:19
26	7	NTIP02C	3	441.4	9.2	07/27/07 08:19	07/27/07 17:29
26	8	NTIP02C	3	155.9	6.1	07/27/07 17:29	07/27/07 23:37
26	9	NTIP02C	3	101.0	2.4	07/27/07 23:37	07/28/07 02:04
27	6	NTIP02C	3	330.9	8.0	07/28/07 02:04	07/28/07 10:06
27	7	NTIP02C	3	191.1	4.0	07/28/07 10:06	07/28/07 14:04
27	8	NTIP02C	3	144.4	3.0	07/28/07 14:04	07/28/07 17:04
27	9	NTIP02C	3	444.9	9.2	07/28/07 17:04	07/30/07 02:19
27	10	NTIP02C/NTIP02D	3	256.5	6.2	07/30/07 02:19	07/30/07 08:32
27	11	NTIP02C/NTIP02D	3	622.2	30.6	07/30/07 08:32	07/31/07 15:08
28	8	NTIP02C/NTIP02E	3	133.0	3.2	07/31/07 15:08	07/31/07 18:21
28	9	NTIP02C/NTIP02E	3	493.8	10.3	07/31/07 18:21	08/01/07 04:37
28	10	NTIP02C	3	386.1	9.4	08/01/07 04:37	08/01/07 13:59
28	11	NTIP02C	3	392.5	9.5	08/01/07 13:59	08/01/07 23:30
29	10	NTIP02C	3	129.4	3.1	08/01/07 23:30	08/02/07 02:38
29	11	NTIP02C	3	165.4	4.0	08/02/07 02:38	08/02/07 06:39
25	9	NTIP02D	3	543.0	19.7	08/03/07 00:00	08/03/07 19:44
25	10	NTIP02D	3	954.2	70.4	08/03/07 19:44	08/07/07 18:08
25	11	NTIP02D	3	387.8	28.6	08/07/07 18:08	08/08/07 22:45
26	10	NTIP02D	3	303.3	7.4	08/08/07 22:45	08/09/07 06:06
26	11	NTIP02D	3	622.4	15.1	08/09/07 06:06	08/09/07 21:13
29	7	NTIP02E	3	212.5	5.2	08/10/07 00:00	08/10/07 05:09
29	8	NTIP02E	3	598.9	29.5	08/10/07 05:09	08/11/07 10:36
29	9	NTIP02E	3	27.6	0.6	08/11/07 10:36	08/11/07 11:11
30	6	NTIP02E	3	14.8	0.4	08/11/07 11:11	08/11/07 11:32
30	7	NTIP02E	3	667.4	16.2	08/11/07 11:32	08/13/07 03:43
30	8	NTIP02E	3	785.3	16.3	08/13/07 03:43	08/13/07 20:02
30	9	NTIP02E	3	218.0	9.2	08/13/07 20:02	08/14/07 05:14
31	6	NTIP02E	3	939.4	22.8	08/14/07 05:14	08/15/07 04:00

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
31	7	NTIP02E	3	1176.5	57.9	08/15/07 04:00	08/17/07 13:52
31	8	NTIP02E	3	385.0	8.0	08/17/07 13:52	08/17/07 21:52
32	6	NTIP02E	3	1139.2	23.7	08/17/07 21:52	08/18/07 21:33
32	7	NTIP02E	3	1167.1	24.3	08/18/07 21:33	08/20/07 21:48
32	8	NTIP02E	3	76.4	1.6	08/20/07 21:48	08/20/07 23:23
33	7	NTIP02E	3	2164.3	45.0	08/20/07 23:23	08/22/07 20:22
33	8	NTIP02E	3	1445.2	35.0	08/22/07 20:22	08/24/07 07:24
33	9	NTIP02E	3	238.5	5.8	08/24/07 07:24	08/24/07 13:11
34	7	NTIP02E	3	1819.1	37.8	08/24/07 13:11	08/27/07 02:59
34	8	NTIP02E	3	1033.1	25.0	08/27/07 02:59	08/28/07 04:02
34	9	NTIP02E	3	488.0	11.8	08/28/07 04:02	08/28/07 15:52
36	8	NTIP02F	3	915.7	33.3	08/29/07 00:00	08/30/07 09:18
36	9	NTIP02F	3	541.4	13.1	08/30/07 09:18	08/30/07 22:25
37	7	NTIP02F	3	1237.3	25.7	08/30/07 22:25	09/01/07 00:08
37	8	NTIP02F	3	865.0	18.0	09/01/07 00:08	09/02/07 18:07
38	7	NTIP02F	3	575.2	24.2	09/02/07 18:07	09/04/07 18:21
38	8	NTIP02F	3	368.3	7.7	09/04/07 18:21	09/05/07 02:01
38	9	NTIP02F	3	214.3	7.8	09/05/07 02:01	09/05/07 09:48
38	10	NTIP02F	3	20.7	0.5	09/05/07 09:48	09/05/07 10:18
39	8	NTIP02F	3	406.2	8.4	09/05/07 10:18	09/05/07 18:45
39	9	NTIP02F	3	432.1	15.7	09/05/07 18:45	09/06/07 10:28
39	10	NTIP02F	3	479.8	17.4	09/06/07 10:28	09/07/07 03:55
39	11	NTIP02F	3	369.6	13.4	09/07/07 03:55	09/07/07 17:21
39	12	NTIP02F	3	21.1	0.8	09/07/07 17:21	09/07/07 18:07
40	9	NTIP02F	3	282.2	5.9	09/07/07 18:07	09/07/07 23:59
40	10	NTIP02F	3	118.7	4.3	09/07/07 23:59	09/08/07 04:18
40	11	NTIP02F	3	197.2	4.8	09/08/07 04:18	09/08/07 09:05
40	12	NTIP02F	3	319.2	7.7	09/08/07 09:05	09/08/07 16:49
40	13	NTIP02F	3	238.6	5.8	09/08/07 16:49	09/08/07 22:36
40	14	NTIP02F	3	282.6	6.9	09/08/07 22:36	09/10/07 05:27
41	16	NTIP02F	3	287.3	6.0	09/10/07 05:27	09/10/07 11:26
41	17	NTIP02F	3	251.4	5.2	09/10/07 11:26	09/10/07 16:39
41	18	NTIP02F	3	203.4	4.2	09/10/07 16:39	09/10/07 20:53
41	19	NTIP02F	3	180.7	3.8	09/10/07 20:53	09/11/07 00:38
41	20	NTIP02F	3	148.0	3.1	09/11/07 00:38	09/11/07 03:43
41	21	NTIP02F	3	177.0	6.4	09/11/07 03:43	09/11/07 10:09
41	22	NTIP02F	3	138.0	5.0	09/11/07 10:09	09/11/07 15:10
41	23	NTIP02F	3	680.3	24.7	09/11/07 15:10	09/12/07 15:55
42	14	NTIP02F	3	310.7	6.5	09/12/07 15:55	09/12/07 22:22
42	15	NTIP02F	3	227.6	4.7	09/12/07 22:22	09/13/07 03:06
42	16	NTIP02F	3	231.2	4.8	09/13/07 03:06	09/13/07 07:54
42	17	NTIP02F	3	248.4	5.2	09/13/07 07:54	09/13/07 13:04
42	18	NTIP02F	3	203.7	4.2	09/13/07 13:04	09/13/07 17:18
42	19	NTIP02F	3	157.4	3.3	09/13/07 17:18	09/13/07 20:34
42	20	NTIP02F	3	135.5	2.8	09/13/07 20:34	09/13/07 23:23
42	21	NTIP02F	3	132.2	2.7	09/13/07 23:23	09/14/07 02:08
42	22	NTIP02F	3	99.3	2.1	09/14/07 02:08	09/14/07 04:12
42	23	NTIP02F	3	1488.3	36.1	09/14/07 04:12	09/15/07 16:17
43	12	NTIP02F	3	128.3	2.7	09/15/07 16:17	09/15/07 18:57

Grid ID I	Grid ID J	Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
43	13	NTIP02F	3	136.0	2.8	09/15/07 18:57	09/15/07 21:46
43	14	NTIP02F	3	160.4	3.3	09/15/07 21:46	09/17/07 01:06
43	15	NTIP02F	3	117.3	2.4	09/17/07 01:06	09/17/07 03:32
43	16	NTIP02F	3	128.6	2.7	09/17/07 03:32	09/17/07 06:13
43	17	NTIP02F	3	149.6	6.3	09/17/07 06:13	09/17/07 12:31
43	18	NTIP02F	3	126.0	2.6	09/17/07 12:31	09/17/07 15:08
43	19	NTIP02F	3	87.6	1.8	09/17/07 15:08	09/17/07 16:58
43	20	NTIP02F	3	76.5	1.6	09/17/07 16:58	09/17/07 18:33
43	21	NTIP02F	3	59.1	1.2	09/17/07 18:33	09/17/07 19:47
43	22	NTIP02F	3	34.3	0.7	09/17/07 19:47	09/17/07 20:29
43	23	NTIP02F	3	203.7	4.9	09/17/07 20:29	09/18/07 01:26
44	11	NTIP02F	3	189.8	3.9	09/18/07 01:26	09/18/07 05:23
44	12	NTIP02F	3	202.6	4.2	09/18/07 05:23	09/18/07 09:35
44	13	NTIP02F	3	224.6	4.7	09/18/07 09:35	09/18/07 14:15
44	14	NTIP02F	3	187.5	7.9	09/18/07 14:15	09/18/07 22:10
44	15	NTIP02F	3	142.7	3.0	09/18/07 22:10	09/19/07 01:07
44	16	NTIP02F	3	88.3	1.8	09/19/07 01:07	09/19/07 02:58
44	17	NTIP02F	3	63.0	1.3	09/19/07 02:58	09/19/07 04:16
44	18	NTIP02F	3	49.6	1.0	09/19/07 04:16	09/19/07 05:18
44	19	NTIP02F	3	38.4	0.8	09/19/07 05:18	09/19/07 06:06
44	20	NTIP02F	3	16.3	0.3	09/19/07 06:06	09/19/07 06:26
44	21	NTIP02F	3	0.8	0.0	09/19/07 06:26	09/19/07 06:27
45	8	NTIP02F/NTIP02G	3	240.7	5.0	09/19/07 06:27	09/19/07 11:27
45	9	NTIP02F/NTIP02G	3	174.4	3.6	09/19/07 11:27	09/19/07 15:05
45	10	NTIP02F/NTIP02G	3	103.2	2.1	09/19/07 15:05	09/19/07 17:13
45	11	NTIP02F/NTIP02G	3	70.5	1.5	09/19/07 17:13	09/19/07 18:41
45	12	NTIP02F/NTIP02G	3	44.6	0.9	09/19/07 18:41	09/19/07 19:37
45	13	NTIP02F	3	40.2	0.8	09/19/07 19:37	09/19/07 20:27
45	14	NTIP02F	3	43.1	1.8	09/19/07 20:27	09/19/07 22:16
45	15	NTIP02F	3	0.6	0.0	09/19/07 22:16	09/19/07 22:17
46	7	NTIP02G	3	344.1	7.2	09/20/07 00:00	09/20/07 07:09
46	8	NTIP02G	3	319.4	6.6	09/20/07 07:09	09/20/07 13:47
46	9	NTIP02G	3	195.8	4.1	09/20/07 13:47	09/20/07 17:51
46	10	NTIP02G	3	86.9	3.7	09/20/07 17:51	09/20/07 21:31
46	11	NTIP02G	3	48.2	1.6	09/20/07 21:31	09/20/07 23:08
46	12	NTIP02G	3	21.0	0.7	09/20/07 23:08	09/20/07 23:51
46	13	NTIP02G	3	0.7	0.0	09/20/07 23:51	09/20/07 23:52
47	9	NTIP02G	3	195.3	4.1	09/20/07 23:52	09/21/07 03:56
47	10	NTIP02G	3	122.1	2.5	09/21/07 03:56	09/21/07 06:28
47	11	NTIP02G	3	131.8	5.6	09/21/07 06:28	09/21/07 12:01
47	12	NTIP02G	3	157.9	3.3	09/21/07 12:01	09/21/07 15:18
47	13	NTIP02G	3	140.0	2.9	09/21/07 15:18	09/21/07 18:13
47	14	NTIP02G	3	124.4	2.6	09/21/07 18:13	09/21/07 20:48
47	15	NTIP02G	3	49.0	1.0	09/21/07 20:48	09/21/07 21:49
47	16	NTIP02G	3	19.2	0.4	09/21/07 21:49	09/21/07 22:13
47	17	NTIP02G	3	2.4	0.0	09/21/07 22:13	09/21/07 22:16
48	12	NTIP02G	3	351.6	7.3	09/21/07 22:16	09/22/07 05:34
48	13	NTIP02G	3	392.4	8.2	09/22/07 05:34	09/22/07 13:44
48	14	NTIP02G	3	416.5	8.7	09/22/07 13:44	09/22/07 22:23

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
48	15	NTIP02G	3	305.5	6.3	09/22/07 22:23	09/24/07 04:44
48	16	NTIP02G	3	227.3	4.7	09/24/07 04:44	09/24/07 09:27
48	17	NTIP02G	3	77.1	1.6	09/24/07 09:27	09/24/07 11:03
49	8	NTIP02G	3	168.2	3.5	09/24/07 11:03	09/24/07 14:33
49	9	NTIP02G	3	157.1	3.3	09/24/07 14:33	09/24/07 17:49
49	10	NTIP02G	3	192.4	4.0	09/24/07 17:49	09/24/07 21:49
49	11	NTIP02G	3	175.4	3.6	09/24/07 21:49	09/25/07 01:28
49	12	NTIP02G	3	182.0	3.8	09/25/07 01:28	09/25/07 05:15
49	13	NTIP02G	3	183.5	3.8	09/25/07 05:15	09/25/07 09:03
49	14	NTIP02G	3	187.8	3.9	09/25/07 09:03	09/25/07 12:58
49	15	NTIP02G	3	172.8	3.6	09/25/07 12:58	09/25/07 16:33
49	16	NTIP02G	3	106.0	2.2	09/25/07 16:33	09/25/07 18:45
49	17	NTIP02G	3	29.0	0.6	09/25/07 18:45	09/25/07 19:21
50	7	NTIP02G	3	260.1	5.4	09/25/07 19:21	09/26/07 00:46
50	8	NTIP02G	3	255.3	5.3	09/26/07 00:46	09/26/07 06:04
50	9	NTIP02G	3	225.1	4.7	09/26/07 06:04	09/26/07 10:45
50	10	NTIP02G	3	148.0	3.1	09/26/07 10:45	09/26/07 13:49
50	11	NTIP02G	3	125.5	2.6	09/26/07 13:49	09/26/07 16:26
50	12	NTIP02G	3	140.0	2.9	09/26/07 16:26	09/26/07 19:20
50	13	NTIP02G	3	146.6	3.0	09/26/07 19:20	09/26/07 22:23
50	14	NTIP02G	3	261.9	5.4	09/26/07 22:23	09/27/07 03:50
50	15	NTIP02G	3	215.8	4.5	09/27/07 03:50	09/27/07 08:19
50	16	NTIP02G	3	54.2	1.1	09/27/07 08:19	09/27/07 09:26
51	7	NTIP02G	3	235.8	4.9	09/27/07 09:26	09/27/07 14:20
51	8	NTIP02G	3	239.9	5.0	09/27/07 14:20	09/27/07 19:19
51	9	NTIP02G	3	200.5	4.2	09/27/07 19:19	09/27/07 23:29
51	10	NTIP02G	3	189.4	3.9	09/27/07 23:29	09/28/07 03:26
51	11	NTIP02G	3	192.3	4.0	09/28/07 03:26	09/28/07 07:25
51	12	NTIP02G	3	266.8	5.5	09/28/07 07:25	09/28/07 12:58
51	13	NTIP02G	3	289.7	6.0	09/28/07 12:58	09/28/07 18:59
51	14	NTIP02G	3	243.7	5.1	09/28/07 18:59	09/29/07 00:03
51	15	NTIP02G	3	140.5	2.9	09/29/07 00:03	09/29/07 02:58
51	16	NTIP02G	3	12.3	0.3	09/29/07 02:58	09/29/07 03:14
51	17	NTIP02G	3	1.7	0.0	09/29/07 03:14	09/29/07 03:16
52	7	NTIP02G	3	256.6	5.3	09/29/07 03:16	09/29/07 08:36
52	8	NTIP02G	3	265.0	5.5	09/29/07 08:36	09/29/07 14:06
52	9	NTIP02G	3	286.4	6.0	09/29/07 14:06	09/29/07 20:03
52	10	NTIP02G	3	277.7	5.8	09/29/07 20:03	10/01/07 01:49
52	11	NTIP02G	3	230.2	4.8	10/01/07 01:49	10/01/07 06:37
52	12	NTIP02G	3	218.6	4.5	10/01/07 06:37	10/01/07 11:09
52	13	NTIP02G	3	224.9	4.7	10/01/07 11:09	10/01/07 15:50
52	14	NTIP02G	3	194.6	4.0	10/01/07 15:50	10/01/07 19:52
52	15	NTIP02G	3	123.3	2.6	10/01/07 19:52	10/01/07 22:26
52	16	NTIP02G	3	42.6	0.9	10/01/07 22:26	10/01/07 23:19
53	8	NTIP02G	3	290.1	6.0	10/01/07 23:19	10/02/07 05:21
53	9	NTIP02G	3	314.4	6.5	10/02/07 05:21	10/02/07 11:53
173	10	EGIA01A	4	0.9	0.0	06/04/07 00:00	06/04/07 00:01
173	11	EGIA01A	4	58.2	1.2	06/04/07 00:01	06/04/07 01:13
173	12	EGIA01A	4	56.6	1.2	06/04/07 01:13	06/04/07 02:24

Grid ID I	Grid ID J	Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
173	13	EGIA01A	4	0.8	0.0	06/04/07 02:24	06/04/07 02:25
174	8	EGIA01A	4	6.4	0.1	06/04/07 02:25	06/04/07 02:33
174	9	EGIA01A	4	28.6	1.0	06/04/07 02:33	06/04/07 03:30
174	10	EGIA01A	4	53.9	2.3	06/04/07 03:30	06/04/07 05:47
174	11	EGIA01A	4	209.4	8.8	06/04/07 05:47	06/04/07 14:36
174	12	EGIA01A	4	54.9	1.1	06/04/07 14:36	06/04/07 15:45
175	7	EGIA01A	4	22.3	0.5	06/04/07 15:45	06/04/07 16:13
175	8	EGIA01A	4	211.1	4.4	06/04/07 16:13	06/04/07 20:36
175	9	EGIA01A	4	245.9	10.4	06/04/07 20:36	06/05/07 06:58
175	10	EGIA01A	4	194.1	4.0	06/05/07 06:58	06/05/07 11:00
175	11	EGIA01A	4	189.8	3.9	06/05/07 11:00	06/05/07 14:57
175	12	EGIA01A	4	102.5	2.1	06/05/07 14:57	06/05/07 17:04
175	13	EGIA01A/EGIA01B	4	25.0	0.5	06/05/07 17:04	06/05/07 17:35
175	14	EGIA01A/EGIA01B	4	39.4	0.8	06/05/07 17:35	06/05/07 18:25
176	6	EGIA01A	4	17.5	0.4	06/05/07 18:25	06/05/07 18:46
176	7	EGIA01A	4	105.4	2.2	06/05/07 18:46	06/05/07 20:58
176	8	EGIA01A	4	229.8	4.8	06/05/07 20:58	06/06/07 01:44
176	9	EGIA01A	4	237.6	4.9	06/06/07 01:44	06/06/07 06:41
176	10	EGIA01A	4	131.0	2.7	06/06/07 06:41	06/06/07 09:24
176	11	EGIA01A	4	130.3	2.7	06/06/07 09:24	06/06/07 12:07
176	12	EGIA01A	4	192.4	4.0	06/06/07 12:07	06/06/07 16:07
176	13	EGIA01A/EGIA01B	4	146.5	3.0	06/06/07 16:07	06/06/07 19:09
177	11	EGIA01A	4	95.3	2.0	06/06/07 19:09	06/06/07 21:08
177	12	EGIA01A/EGIA01B	4	41.3	0.9	06/06/07 21:08	06/06/07 22:00
173	20	EGIA01B	4	2.9	0.1	06/07/07 00:00	06/07/07 00:03
173	21	EGIA01B	4	136.3	3.3	06/07/07 00:03	06/07/07 03:21
173	22	EGIA01B	4	90.9	2.2	06/07/07 03:21	06/07/07 05:34
173	23	EGIA01B	4	2.5	0.1	06/07/07 05:34	06/07/07 05:37
174	20	EGIA01B	4	43.5	0.9	06/07/07 05:37	06/07/07 06:32
174	21	EGIA01B	4	169.5	4.1	06/07/07 06:32	06/07/07 10:38
174	22	EGIA01B	4	97.2	2.4	06/07/07 10:38	06/07/07 13:00
174	23	EGIA01B	4	2.8	0.1	06/07/07 13:00	06/07/07 13:04
175	15	EGIA01B	4	58.1	1.2	06/07/07 13:04	06/07/07 14:16
175	16	EGIA01B	4	53.8	1.1	06/07/07 14:16	06/07/07 15:23
175	17	EGIA01B	4	48.0	1.0	06/07/07 15:23	06/07/07 16:23
175	18	EGIA01B	4	15.0	0.3	06/07/07 16:23	06/07/07 16:42
175	19	EGIA01B	4	70.1	1.5	06/07/07 16:42	06/07/07 18:09
175	20	EGIA01B	4	159.9	3.3	06/07/07 18:09	06/07/07 21:29
175	21	EGIA01B	4	118.8	2.9	06/07/07 21:29	06/08/07 00:22
175	22	EGIA01B	4	26.1	1.0	06/08/07 00:22	06/08/07 01:19
176	14	EGIA01B	4	86.4	1.8	06/08/07 01:19	06/08/07 03:07
176	15	EGIA01B	4	131.7	2.7	06/08/07 03:07	06/08/07 05:51
176	16	EGIA01B	4	177.4	3.7	06/08/07 05:51	06/08/07 09:32
176	17	EGIA01B	4	194.7	4.0	06/08/07 09:32	06/08/07 13:35
176	18	EGIA01B	4	338.2	7.0	06/08/07 13:35	06/08/07 20:36
176	19	EGIA01B	4	324.7	6.7	06/08/07 20:36	06/09/07 03:21
176	20	EGIA01B	4	307.6	6.4	06/09/07 03:21	06/09/07 09:45
176	21	EGIA01B	4	320.4	7.8	06/09/07 09:45	06/09/07 17:31
176	22	EGIA01B	4	136.5	5.0	06/09/07 17:31	06/09/07 22:29

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
177	13	EGIA01B	4	164.1	3.4	06/09/07 22:29	06/11/07 01:54
177	14	EGIA01B	4	275.5	5.7	06/11/07 01:54	06/11/07 07:37
177	15	EGIA01B	4	273.5	5.7	06/11/07 07:37	06/11/07 13:18
177	16	EGIA01B	4	106.1	2.2	06/11/07 13:18	06/11/07 15:30
177	17	EGIA01B	4	2.4	0.0	06/11/07 15:30	06/11/07 15:33
177	18	EGIA01B	4	121.4	2.5	06/11/07 15:33	06/11/07 18:05
177	19	EGIA01B	4	324.9	6.8	06/11/07 18:05	06/12/07 00:50
177	20	EGIA01B	4	344.3	7.2	06/12/07 00:50	06/12/07 07:59
177	21	EGIA01B	4	465.2	11.3	06/12/07 07:59	06/12/07 19:16
177	22	EGIA01B	4	363.0	8.8	06/12/07 19:16	06/13/07 04:04
178	12	EGIA01B	4	110.2	2.3	06/13/07 04:04	06/13/07 06:22
178	13	EGIA01B	4	157.7	3.3	06/13/07 06:22	06/13/07 09:38
178	14	EGIA01B	4	114.6	2.4	06/13/07 09:38	06/13/07 12:01
178	15	EGIA01B	4	24.8	0.5	06/13/07 12:01	06/13/07 12:32
178	16	EGIA01B	4	39.6	0.8	06/13/07 12:32	06/13/07 13:22
178	17	EGIA01B	4	150.1	3.1	06/13/07 13:22	06/13/07 16:29
178	18	EGIA01B	4	294.4	6.1	06/13/07 16:29	06/13/07 22:36
178	19	EGIA01B	4	386.6	8.0	06/13/07 22:36	06/14/07 06:38
178	20	EGIA01B	4	476.3	9.9	06/14/07 06:38	06/14/07 16:32
178	21	EGIA01B	4	537.4	13.0	06/14/07 16:32	06/15/07 05:34
178	22	EGIA01B	4	538.3	13.1	06/15/07 05:34	06/15/07 18:37
178	23	EGIA01B	4	37.2	0.9	06/15/07 18:37	06/15/07 19:31
179	16	EGIA01B	4	61.9	1.3	06/15/07 19:31	06/15/07 20:48
179	17	EGIA01B	4	158.7	3.3	06/15/07 20:48	06/16/07 00:06
179	18	EGIA01B	4	279.6	5.8	06/16/07 00:06	06/16/07 05:54
179	19	EGIA01B	4	531.7	11.0	06/16/07 05:54	06/16/07 16:57
180	17	EGIA01B	4	43.5	0.9	07/02/07 00:00	07/02/07 00:54
180	18	EGIA01B	4	563.1	11.7	07/02/07 00:54	07/02/07 12:36
180	19	EGIA01B	4	615.7	22.4	07/02/07 12:36	07/03/07 10:59
181	17	EGIA01B	4	197.6	4.1	07/03/07 10:59	07/03/07 15:06
181	18	EGIA01B	4	654.5	27.6	07/03/07 15:06	07/05/07 18:41
181	19	EGIA01B	4	700.6	14.6	07/05/07 18:41	07/06/07 09:15
181	20	EGIA01B	4	601.0	21.9	07/06/07 09:15	07/07/07 07:06
182	16	EGIA01B/EGIA01C	4	178.1	3.7	07/07/07 07:06	07/07/07 10:48
182	17	EGIA01B	4	508.2	21.4	07/07/07 10:48	07/09/07 08:13
182	18	EGIA01B	4	846.2	17.6	07/09/07 08:13	07/10/07 01:48
182	19	EGIA01B	4	643.5	27.1	07/10/07 01:48	07/11/07 04:56
182	20	EGIA01B	4	564.4	11.7	07/11/07 04:56	07/11/07 16:40
182	21	EGIA01B	4	814.3	60.1	07/11/07 16:40	07/14/07 04:45
182	22	EGIA01B	4	922.3	33.5	07/14/07 04:45	07/16/07 14:17
182	23	EGIA01B	4	124.7	3.0	07/16/07 14:17	07/16/07 17:19
179	20	EGIA01B	4	558.6	20.3	07/17/07 00:00	07/17/07 20:18
179	21	EGIA01B	4	416.4	8.7	07/17/07 20:18	07/18/07 04:58
179	22	EGIA01B	4	372.1	13.5	07/18/07 04:58	07/18/07 18:30
179	23	EGIA01B	4	27.5	1.0	07/18/07 18:30	07/18/07 19:30
180	20	EGIA01B	4	611.9	22.3	07/18/07 19:30	07/19/07 17:45
180	21	EGIA01B	4	661.7	16.0	07/19/07 17:45	07/20/07 09:47
180	22	EGIA01B	4	523.0	19.0	07/20/07 09:47	07/21/07 04:50
180	23	EGIA01B	4	0.0	0.0	07/21/07 04:50	07/21/07 04:50

Grid ID		Dredge Area	Dredge ID (1,2,3,4)	Eng. Consideration Dredge Weight (tons)	Design Factored Time (hr)	Start Time	Finish Time
I	J						
181	21	EGIA01B	4	624.0	22.7	07/21/07 04:50	07/23/07 03:31
181	22	EGIA01B	4	728.5	26.5	07/23/07 03:31	07/24/07 06:02
34	21	NTIP02B	4	1028.5	21.4	07/25/07 00:00	07/25/07 21:22
34	22	NTIP02B	4	1319.4	48.0	07/25/07 21:22	07/27/07 21:23
34	23	NTIP02B	4	8.0	0.3	07/27/07 21:23	07/27/07 21:41
35	21	NTIP02B	4	1905.0	46.2	07/27/07 21:41	07/30/07 19:52
35	22	NTIP02B	4	1032.5	37.5	07/30/07 19:52	08/01/07 09:25
35	23	NTIP02B	4	31.3	1.1	08/01/07 09:25	08/01/07 10:33
36	21	NTIP02B	4	2380.9	49.5	08/01/07 10:33	08/03/07 12:02
36	22	NTIP02B	4	1584.2	38.4	08/03/07 12:02	08/06/07 02:26
36	23	NTIP02B	4	425.5	15.5	08/06/07 02:26	08/06/07 17:56
37	21	NTIP02B	4	1145.6	23.8	08/06/07 17:56	08/07/07 17:44
37	22	NTIP02B	4	911.0	44.8	08/07/07 17:44	08/09/07 14:32
38	20	NTIP02B	4	658.7	13.7	08/09/07 14:32	08/10/07 04:14
38	21	NTIP02B	4	641.5	15.6	08/10/07 04:14	08/10/07 19:47
38	22	NTIP02B	4	488.8	17.8	08/10/07 19:47	08/11/07 13:33
38	23	NTIP02B	4	14.5	0.5	08/11/07 13:33	08/11/07 14:05
39	19	NTIP02B	4	465.0	9.7	08/11/07 14:05	08/11/07 23:45
39	20	NTIP02B	4	459.7	19.4	08/11/07 23:45	08/13/07 19:08
39	21	NTIP02B	4	426.4	18.0	08/13/07 19:08	08/14/07 13:06
39	22	NTIP02B	4	299.6	22.1	08/14/07 13:06	08/15/07 11:12
39	23	NTIP02B	4	50.3	1.8	08/15/07 11:12	08/15/07 13:02
40	16	NTIP02B/NTIP02F	4	309.7	15.2	08/15/07 13:02	08/16/07 04:16
40	17	NTIP02B/NTIP02F	4	343.6	8.3	08/16/07 04:16	08/16/07 12:36
40	18	NTIP02B/NTIP02F	4	307.1	6.4	08/16/07 12:36	08/16/07 18:59
40	19	NTIP02B/NTIP02F	4	278.4	5.8	08/16/07 18:59	08/17/07 00:46
40	20	NTIP02B/NTIP02F	4	288.8	6.0	08/17/07 00:46	08/17/07 06:46
40	21	NTIP02B/NTIP02F	4	211.0	7.7	08/17/07 06:46	08/17/07 14:27
40	22	NTIP02B/NTIP02F	4	44.4	1.6	08/17/07 14:27	08/17/07 16:03

E.6.2 Incorporation of a Dredge Plan into a Simulation

The total sediment mass removed and dredge duration were used to calculate the average sediment mass removal rate for each grid cell. The fraction of the sediment volume attributable to each of the three suspendable sediment fractions was used to calculate the individual sediment class mass removal rates. The sediment mass removal rates were then multiplied by the overall dredge resuspension loss rate (0.35% for the base case) to calculate the rate of sediment resuspended. The Total PCB concentrations of each sediment fraction (computed as described in Section E.5.3) were applied to estimate the mass rate of PCB resuspended for each sediment class. These mass loading rates were input to the water column grid cell above the sediment being dredged. The loading rates for each grid cell were applied with the exact duration and timing as specified in the dredge plan.

E.6.3 Overview of Control Systems

Various control systems have been considered as possible methods for reducing the downstream transport of solids and PCBs released during dredging operations. The control systems presently being investigated are "hard" control structures that offer physical barriers to the transport of resuspended material. Two types of control structures are considered: sheet piling and silt curtains. Sheet piling involves construction of a hard barrier that is designed to cut off flow and prevent transport of solids and PCBs. A silt curtain is a flexible barrier that reduces flow and transport; a silt curtain is not as effective as a rigid barrier (i.e., sheet piling) at reducing flow and transport of solids and PCBs.

Currently, control structures are being considered for use at two TIP locations. A combination of sheet piling and silt curtains are planned for use in the East Channel at Rogers Island (Figure E-6-2). At this location, one sheet pile structure is proposed at the northern entrance to the East Channel, with structure length of 220 ft. This structure will block flow from entering the East Channel, diverting it to the West Channel. A silt curtain, approximate length of 230 ft., is proposed at the southern end of the East Channel (Figure E-6-2) to reduce downstream transport of resuspended sediment. The second control structure is proposed along the eastern shoreline near Griffin Island (Figure E-6-3). A sheet pile and three silt curtains are being considered at this location. The sheet pile will extend approximately 125 ft. into the channel from the shoreline and encloses about 1.7 acres; about 6% of the total flow in the river will be diverted by the structure. Silt curtains are proposed to extend an additional approximately 100 ft into the channel from the sheet pile, continue approximately 600 ft. parallel to the river channel, then extend back to the shoreline to fully enclose an area of about 2.9 acres (Figure E-6-3).

The dredging schedule, which extends from May through October, specifies the following schedule for the use of control structures. The Rogers Island sheet pile will be in place for 122 days, from May 21 to September 19. The Rogers Island silt curtain will be in place for

91 days, from May 21 to August 19. The sheet pile in the vicinity of Griffin Island will be place for 40 days, from July 17 to August 25. The East Griffin Island silt curtains will be placed for 9 days, from July 17 to July 25. Note that silt curtains are taken down shortly after completion of dredging of enclosed sediments. Sheet piles remain in place for an additional month to ensure ample time for settling of residual sediment and PCB.

E.6.4 Simulation of Control Structure Effects

The effects of control structures on flow and transport are incorporated into the model as follows. At the location of a sheet pile structure, the grid cells along the boundary of the structure are treated as a solid boundary, with zero flow and transport across that boundary. At the location of a silt curtain, flow is allowed across the grid cells at the structure boundary; flow is conserved at a silt curtain boundary. The flux of suspended sediment across a silt curtain boundary is modified, with the flux of cohesive (Class 1) sediment being reduced by 70% of the flux encountering the structure. It is assumed that the flux of coarse (Classes 2 and 3) sediment is zero across the silt curtain. The transport of dissolved PCBs is unaffected by the silt curtain structure, but the transport of PCBs sorbed to sediment is adjusted in the same manner as the suspended sediment fluxes.

E.7 RESULTS OF MODEL SIMULATIONS

E.7.1 Baseline Far-Field Concentrations

The RPS threshold and control levels for far-field PCB concentration criteria are absolute concentrations. In order to evaluate the ability of proposed dredging alternatives to maintain PCB levels below these standards, it was necessary to estimate the value of the baseline concentration that would exist in addition to the PCB concentrations resulting from dredging. For the Phase 1 dredging of River Section 1, the location of the far-field station is at the TID. In June 2004, the BMP was set up with the purpose of establishing these non-dredging related PCB concentrations. Inspection of this data as well as the previous Hudson River Monitoring (HRM) Program in the West Channel of Thompson Island shows a strong seasonal dependence of the levels. For this reason the BMP data were analyzed on a monthly basis and average monthly Total PCB concentrations were used to establish the baseline concentration. These values are given in Table E-7-1. These concentrations were added to the PCB concentrations predicted by the resuspension modeling to estimate absolute Total PCB at the TID for comparison to RPS standards.

Table E-7-1. Baseline TID Total PCB concentration.

Month	PCB Concentration (ng/L)
May	34.5
June	63.1
July	52.5
August	21.3
September	29.0
October	58.5

E.7.2 Overview of Model Simulations

Two basic model simulations are presented here. The base dredging plan with no control systems was initially run to evaluate the ability to meet RPS criteria without such structures. The results of this simulation were used to identify time periods (and the associated dredge locations) when RPS criteria were exceeded. After analysis of this base case, control systems were proposed that would address and confine the releases from dredging of areas that are responsible for the exceedance of RPS criteria. The other primary model simulation includes the final set of control systems chosen and serves to demonstrate the ability of such controls to maintain levels below the standards.

For these base scenarios, assumptions were made regarding the dredging loss rate and river flow conditions. The loss rate was assumed to be 0.35% of resuspendable material. The river flow conditions were considered to be median values for the particular time of year based on ten-day intervals. Sensitivity runs are also presented to show the effects on PCB and TSS levels of variations of river flow, resuspension loss rate, as well as desorption capacity.

E.7.3 General Results and Insights

Plume Characteristics

The plume of suspended sediment and PCBs downstream of an operating dredge exhibits certain common characteristics. Near the dredge head, the plume width is relatively narrow and water column concentrations are at maximum levels. Moving downstream from the dredge head, the plume widens as suspended sediment and PCBs are dispersed in the lateral (cross-channel) direction. Water column concentrations decrease due to dispersive dilution and deposition of suspended sediment. Figure E-7-1 shows the development of a typical PCB plume during dredge operation.

The relative location of the dredge head in the channel (e.g., shallow near-shore area or deeper navigation channel) affects the general structure of the plume. Figure E-7-2 demonstrates the form of a fully developed dredge plume of Total PCBs for a mid-channel dredge operation near the southern end of Rogers Island. The plume quickly disperses across the channel within a mile of the dredge head. When the plume reaches the TID, the PCBs are well mixed with only small lateral gradients. By contrast, the plume from a near-shore dredge operation (Figure E-7-3) exhibits much higher cross-channel gradients. These gradients persist for a much longer distance downstream and retain significant lateral variations at the TID. It is also evident from comparison of these two figures that for a given distance downstream, the maximum plume concentration of a near-shore release can be much higher than for a mid-channel release.

Sediment Transport

Under median flow conditions, only fine sediments (Class 1 – clay and silt) are carried in suspension to the far-field station. The resuspended sand (Classes 2 and 3) settles out in the near-field. Figure E-7-4 shows the normalized suspended sediment concentration of the three classes as the plume travels downstream from a near-shore dredging operation. Class 3 sediment settles out within approximately 50 m of the dredge (i.e., within the grid cell in which dredging occurs). The Class 2 sediment travels a longer distance, nearly twice as far, but it is typically redeposited within 100 m of the dredge. The normalized suspended sediment profile for a mid-channel dredge operation is shown in Figure E-7-5. Class 3 sediment travels further but still deposits within a relatively short distance (100 m). Similarly, Class 2 sediments also travel further. The longer travel distance of these two classes is due to the higher velocities and deeper depths associated with the navigation channel. Under high-flow conditions, these sediments can remain in suspension for a considerable distance downstream. Some fraction of Class 2 sediment can often reach the far-field station.

Class 1 sediment deposits much more slowly and a significant portion will stay in suspension for miles from the dredge. Redeposition of fine (Class 1) sediment varies widely; it is largely dependent on the flow conditions and location of the release. Anywhere from 0% to 75% of the resuspended fine sediment redeposits before reaching the far-field station. Generally, redeposition is highest for near-shore releases under low flow conditions and lowest for releases near or in the navigational channel under high flow conditions. For example, a typical dredge release was simulated in the near-shore region just below Rogers Island using average sediment composition, 0.35% release rate, and median flow conditions. Under these conditions, 58% of the resuspended fine sediment and 0% of the resuspended sand reach the far-field station.

TSS concentrations at the far-field station are relatively low under all conditions as a result of the lateral mixing and dilution of the plume and the redeposition of resuspended sediments. Even with relatively high resuspension rates, the far-field TSS concentrations remain below 5 mg/L.

PCB Transport

The contribution of each sediment class to PCB transport differs significantly due to the interplay between redeposition rates, particle size and the magnitude of the labile and refractory components of sorbed PCB. Nearly all of the PCBs associated with resuspended Class 3 sediments do not reach the far-field station. These PCBs redeposit because the sediments settle much quicker than the time scales of either labile or refractory desorption. Class 2 sediment, while not generally reaching the far-field station, does contribute to the PCBs downstream as a result of the longer time that this sediment spends in suspension as well as the higher rates of desorption (compared to Class 3) due to smaller particle diameters. Nearly all of this contribution comes from the labile sorbed PCBs. The refractory component on this sediment does not have sufficient time to desorb. The extent of labile desorption depends on local conditions which determine the amount of time sediments spend in suspension. Fine sediment is the main source of PCBs reaching the far-field station. Nearly the entire labile component desorbs from these particles and transports downstream as dissolved PCBs. Much of the refractory component remains sorbed, but contributes to the far-field PCB levels due to the significant transport of fine sediments to the far-field station. During a typical near-shore dredge release just below Rogers Island using average PCB concentrations, 0.35% loss rate, and median flow, 78% of PCBs initially sorbed to Class 1 sediment were transported past the TID, whereas only 7.6% and 1.7% of the PCBs initially sorbed to Class 2 and 3 sediment, respectively, passed the TID.

The bulk of the desorption occurs in the vicinity of the dredge operation. Figure E-7-6 shows the spatial profile of a typical mid-channel dredge PCB plume. After the first initial decline in total PCB in the first approximately 200 m due to dilution and deposition, the PCB concentration declines much more slowly, primarily as a result of fine sediment deposition. The dissolved PCB component shows that a rapid desorption occurs in the first 100 m, a slower portion continues to desorb until about 0.5 mi. after which the fraction of the PCBs that are dissolved remains relatively constant. For a typical release as described above, nearly two-thirds of the PCB flux at TID is in the dissolved phase.

E.7.4 Dredging With No Control Structures

The modeling indicates that far-field PCB levels will vary greatly during the course of Phase 1 dredging due to variations in the PCB concentration and grain size distribution of the sediment being dredged. Distinct peaks in PCB release are predicted to occur during mid-June, the first half of July and the first half of August. The first peak is associated with dredging in the East Griffin Island area. The second peak primarily comes from dredging in the East Channel at Rogers Island with a smaller contribution from the East Griffin Island area. The third peak is produced by the dredging occurring in the East Channel at Rogers Island. The East Channel at Rogers Island contribution to the second peak results from dredging in just downstream of Bond Creek, whereas the third peak occurs due to dredging further downstream just above where the channel bends to the west. All of these areas contain high PCB concentrations and high percentages of fine grained sediments.

The design resuspension loss rate (0.35%) produces Total PCB concentrations at TID that remain below the Control Level (seven-day average concentration of 350 ng/L) and the Primary Standard (24-hour average of 500 ng/L) for the entire season. The seven-day average Total PCB concentration at TID fluctuates between about 25 ng/L and 200 ng/L (Figure E-7-7). The 24-hour average concentration at this location ranges between 25 ng/L and 260 ng/L.

The seven-day average net PCB flux at TID resulting from 0.35% release varies from near zero to about 1,030 g/d (Figure E-7-8). It exceeds the Evaluation Level of 300 g/d for about 34% of the dredging season. The Control Level of 600 g/d is exceeded for about 18% of the dredging season. Despite the period of elevated seven-day average fluxes, the total flux over the dredging season remains below the Control Level of 65 kg (Figure E-7-9). The total downstream flux is about 40 kg.

The elevated Total PCB concentrations and fluxes at TID are not associated with elevated TSS. The model indicates that six-hour average net TSS concentrations never exceed 1 mg/L

(Figure E-7-10). Similarly, near-field net TSS concentrations remain relatively low and always below the RPS criteria. At the station 300 m downstream of the dredging, TSS concentrations are typically less than 10 mg/L (Figure E-7-11). The highest concentration of about 20 mg/L occurs when dredging fine sediments along the western shore in NTIP02G (Dredge 2 in Figure E-7-11) and in East Griffin Island (Dredge 4 in Figure E-7-11). At the station 100 m downstream of the dredging, TSS concentrations do not exceed about 50 mg/L (Figure E-7-12).

E.7.5 Dredging With Control Structures

The addition of the resuspension controls in East Channel at Rogers Island and East Griffin Island that are described in Section E.6.3 reduces downstream PCB fluxes by about a quarter. The flux of Total PCBs past TID over the entire Phase 1 program declines from about 40 kg to about 31 kg (Figure E-7-15) with the reduction about equally attributable to the two areas where controls are deployed. The seven-day average Total PCB concentration at TID remains below 170 ng/L for the entire season, whereas it reached about 200 ng/L without controls (Figure E-7-13). The 24-hour average concentration exhibits a greater reduction overall and exhibits less variability than was predicted to occur without controls. For the entire season the 24-hour average is below 200 ng/L.

The resuspension controls are predicted to be moderately effective in reducing the seven-day average net PCB flux at TID resulting from 0.35% release to levels below the Control Level (Figure E-7-14). The maximum flux is reduced from about 1,030 g/d to about 700 g/d and the peaks associated with dredging in the East Channel at Rogers Island are greatly reduced, but the fluxes remain above the Evaluation Level for about 26% of the dredging season and above the Control Level for about 7% of the dredging season. This is largely because reducing flow through the East Channel at Rogers Island by cutting off of the upstream entrance reduces the PCB flux from the channel only by about a third because the lower flow is compensated by a buildup of PCB concentrations within the channel. The remaining low flow carrying this more highly contaminated water remains a significant flux. In contrast, the elimination of flow in the sheet piled area at East Griffin Island reduces the flux from this area by about 75%.

The ability of the dredge plan with control structures to keep PCB levels under the standards was evaluated assuming higher loss rate of dredged material. For a loss rate of 0.70%, the seven-day average concentration past TID varied from about 40 ng/L to about 220 ng/L, well below the Control Level (Figure E-7-16). The daily average remained below the 500 ng/L threshold throughout the season, only reaching a maximum of about 330 ng/L.

The seven-day average net PCB flux at TID resulting from 0.70% release varies from about 50 g/d to about 1,400 g/d (Figure E-7-17). It exceeds the Evaluation Level for about 43% of the dredging season and the Control Level for about 29% of the dredging season. Despite these elevated fluxes, the total flux for the dredging season reaches only 56 kg, remaining below the Control Level (Figure E-7-18).

E.7.6 Sensitivity Analysis

Model runs were conducted to access the sensitivity of the model to river flow conditions and desorption capacity. While the median flow was used in the development of the dredge plan, low flow and high flow conditions were also evaluated. The dredge plan with the control structures in the East Channel at Rogers Island and East Griffin Island were run using low and high flow values at the 10 and 90 percentile from the historical flow distribution for each of the ten day intervals. Under high flow conditions, the total predicted PCB flux past the TID is increased by about 3 kg (Figure E-7-19). Conversely, low flow conditions decreased the seasonal flux by about 3 kg due to the increased settling of suspended sediment resulting from lower water velocities and bottom shear stresses. This represents about +/-10% about the median flow. It should be noted that the dredge plan shown in Figure E-7-19 is different than the dredge plan presented in Section E.7.5 and is only meant to show the relative sensitivity of the model.

Sensitivity to the desorption capacity of the sediments was evaluated by varying the initial labile/refractory split of sorbed PCBs. As presented in Section E.5.4, the calibrated value of the initial fraction labile was 53%. Assuming that the sorbed PCBs were much less labile at 20%, the overall season flux of PCB past the TID would be reduced by about 5 kg (Figure E-7-20). Although the labile component is reduced by more than 50%, the overall transport is only reduced by about 16% because of the desorption of some refractory PCBs and because a significant portion of the flux is from PCB sorbed to fine grained sediment. Again, it should be noted that these runs are for a different dredge plan as presented in Section E.7.5, but the relative sensitivity will be the same.

E.8 SUMMARY AND CONCLUSIONS

A mathematical modeling framework, consisting of linked hydrodynamic, sediment transport and PCB fate and transport sub-models, has been developed and it is used to simulate the transport and fate of sediment and PCBs released during dredging operations. The two-dimensional, vertically-averaged hydrodynamic model predicts stage height and current velocity in the TIP, over a range of flow rates, with good accuracy. The sediment transport model simulates the transport and deposition of three classes of suspended sediment: 1) flocculating sediment (clay and silt); 2) very fine sand; and 3) fine and medium sands. The PCB fate and transport model incorporates these chemical transport processes into the modeling framework: 1) water column transport of dissolved and particle-associated PCBs; 2) deposition of particle-associated chemical; 3) sorption and desorption; and 4) volatilization.

Application of the sediment transport model to the simulation of the fate of sediment released during dredging operations provides the following general insights. First, coarse sediment (i.e., sand, which is represented as Class 2 and 3 sediment in the model) settles quickly and redeposits relatively close to the dredge head. This behavior is caused by two factors: 1) relatively high settling speed of sands (typically greater than 500 m/d); and 2) high probability of deposition for flow conditions in the river during typical dredging operations. Second, fine sediment (i.e., flocculating clay and silt, which is represented by Class 1 sediment in the model) settles slowly and is transported long distances downstream of the dredge head. In contrast to sand, fine sediment has a relatively low settling speed (i.e., range of 1 to 10 m/d) and the probability of deposition is relatively low.

Model results were used to evaluate PCB concentrations in the river caused by releases during dredging operations without and with control structures. For dredging with no control structures and 0.35% resuspension loss rate, the following conclusions are developed from the model results:

- Total PCB concentrations at TID remain below the Control Level (seven-day average concentration of 350 ng/L) and the Primary Standard (24-hour average of 500 ng/L) for the entire dredging season.
- The total flux over the dredging season (40 kg) is below the Control Level (65 kg).
- The PCB flux at TID consists on average of about two-thirds dissolved phase and one third particulate phase PCB.
- The seven-day average net PCB flux at TID exceeds the Evaluation Level (300 g/d) for about 34% of the dredging season. The Control Level (600 g/d) is exceeded for about 18% of the dredging season.
- Elevated Total PCB concentrations and fluxes at TID are not associated with elevated TSS concentrations.

For dredging with control structures (i.e., controls at East Channel at Rogers Island and East Griffin Island) and 0.35% resuspension loss rate, model results indicate that:

- The addition of resuspension controls reduces downstream PCB releases by about 25%. The flux of Total PCBs past TID during the dredging seasons declines from about 40 kg with no controls to about 31 kg with controls.
- The resuspension controls are moderately effective in reducing the seven-day average net PCB flux at TID to levels below the Control Level. The fluxes remain above the Evaluation Level for about 26% of the dredging season and above the Control Level for about 7% of the dredging season.
- Higher loss rates of dredge material will result in higher net PCB fluxes at TID. The season flux increases by 80% from 31 kg to 56 kg as the loss rate doubles from 0.35 to 0.70%.
- High flow conditions will result in higher net PCB fluxes at TID of about 10%. Similarly, low flow conditions will decrease net PCB fluxes by about 10%.
- Lower desorption capacity of the dredged sediments will result in lower PCB fluxes at TID. The overall season flux is reduced by about 16% as the labile PCB component is reduced from 53% to 20%.

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FIGURES

Quantitative Environmental Analysis, LLC
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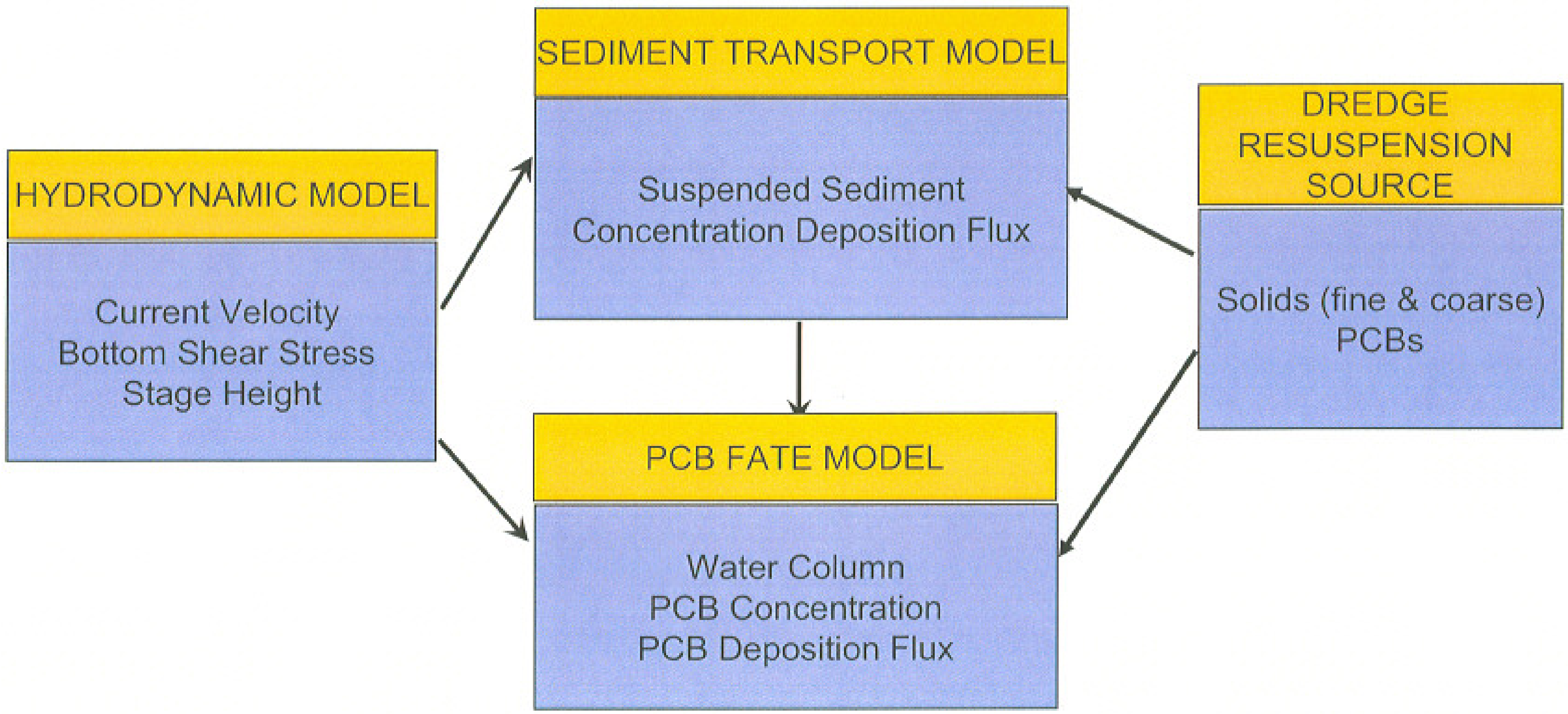

Figure E-1-1. Structure of dredge resuspension modeling framework.

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8/18/2005 10:00 AM

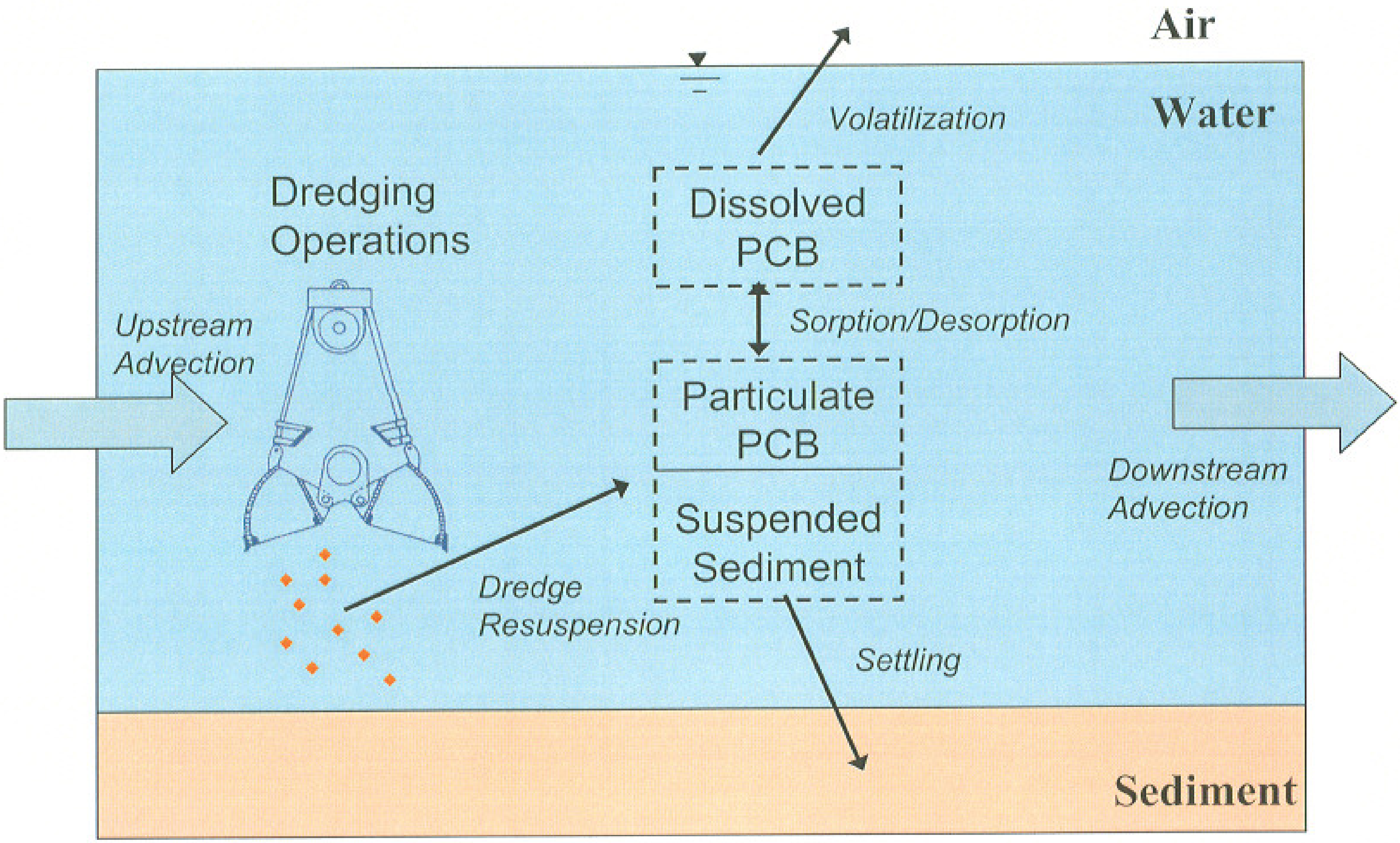

Figure E-1-2. Generalized conceptual diagram of resuspension modeling.

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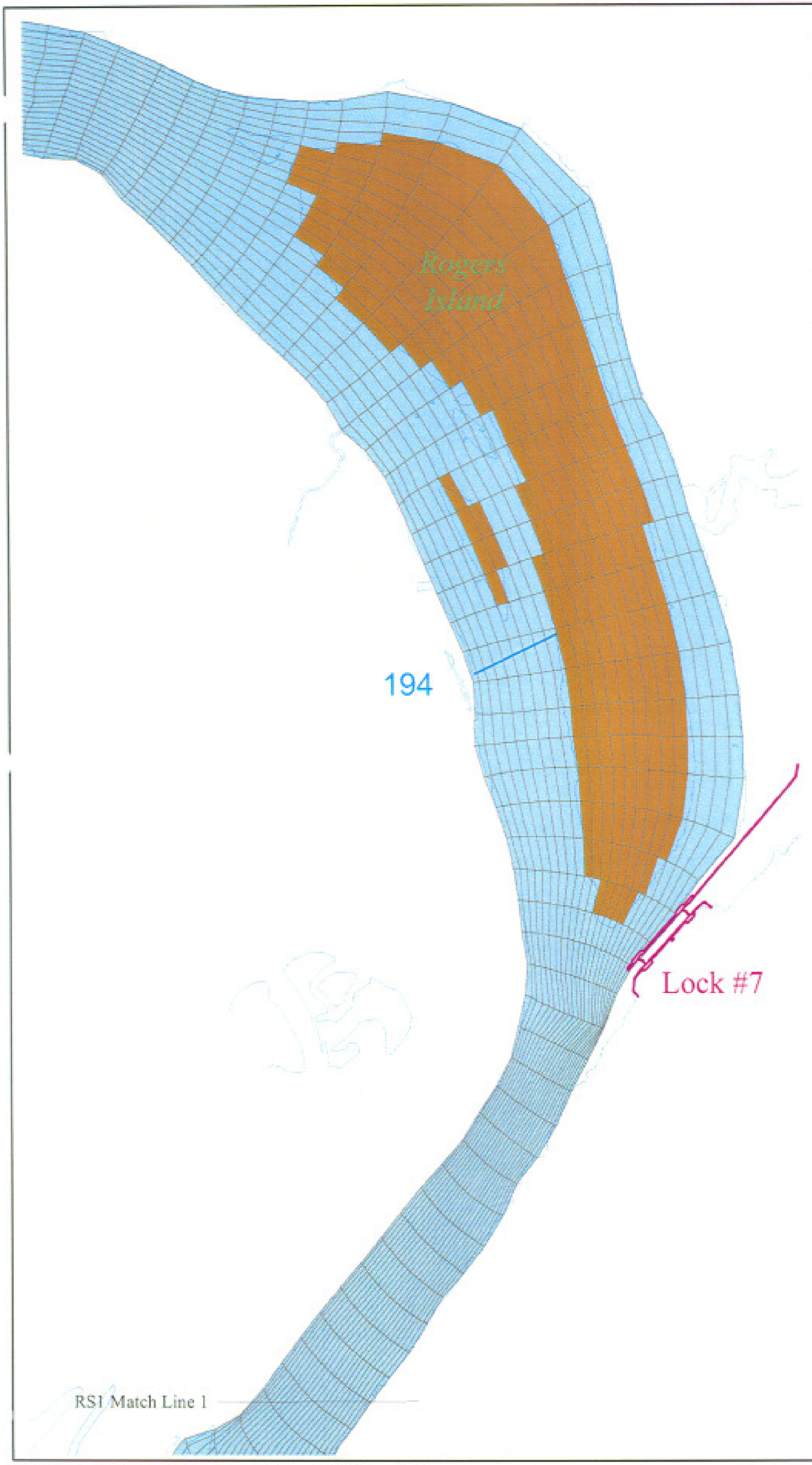
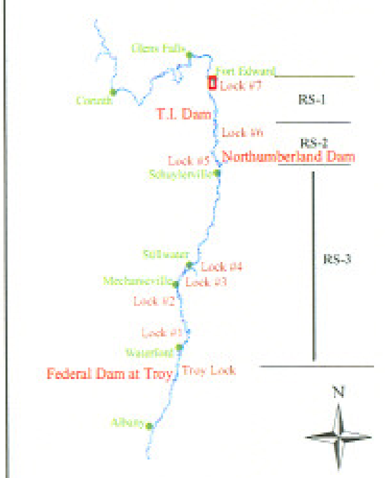


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements

UPPER HUDSON RIVER STUDY AREA

Figure E-3-1a. Numerical grid for Thompson Island Pool.

RM193 to RM194

QEA Quantitative Environmental Analysis, LLC

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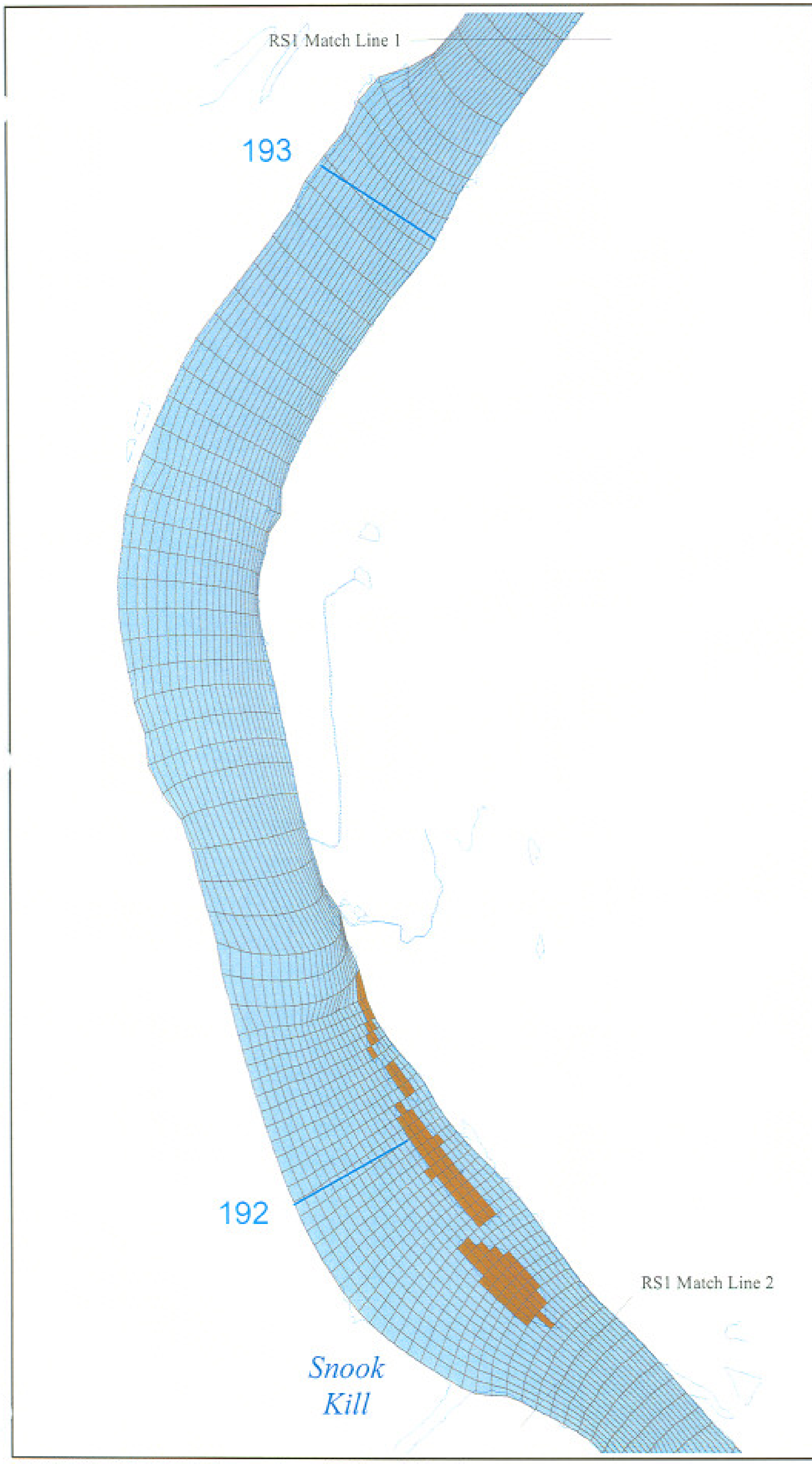
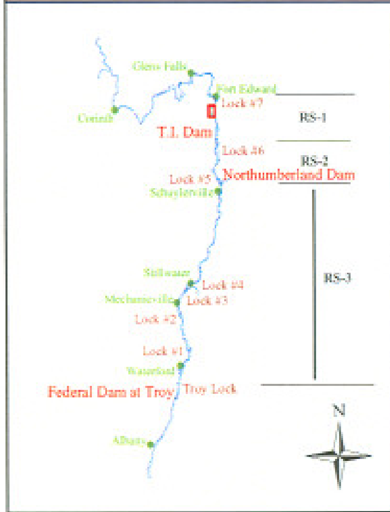


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements

UPPER HUDSON RIVER STUDY AREA

Figure E-3-1b. Numerical grid for Thompson Island Pool.

RM191 to RM193

QEA Quantitative Environmental Analysis, LLC

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Jul 29, 2005.

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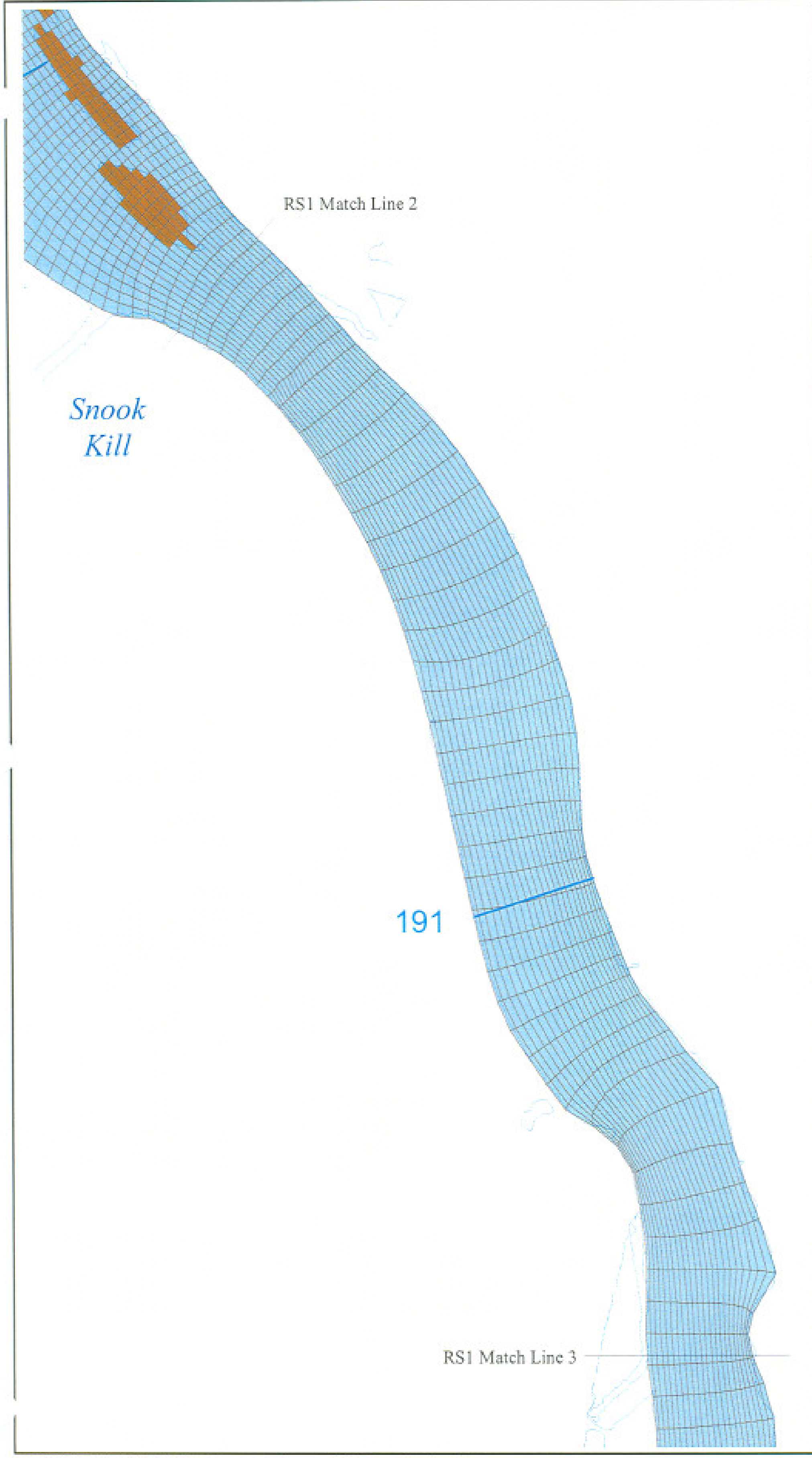
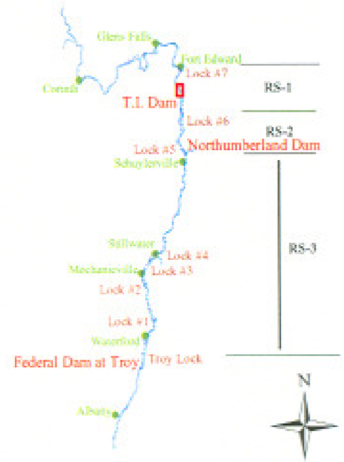


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements

UPPER HUDSON RIVER STUDY AREA

Figure E-3-1c. Numerical grid for Thompson Island Pool.

RM190 to RM191

QEA Quantitative Environmental Analysis, LLC

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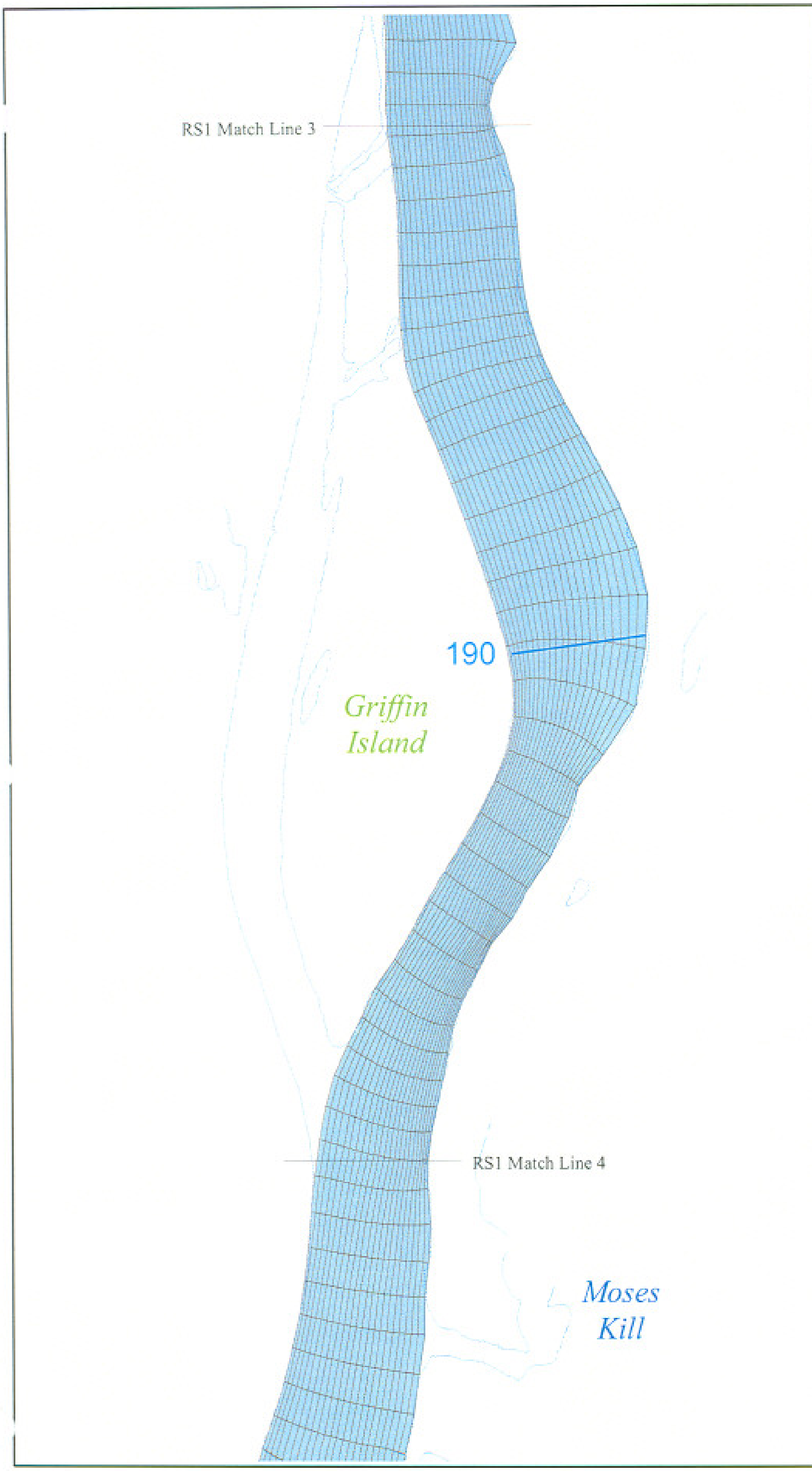
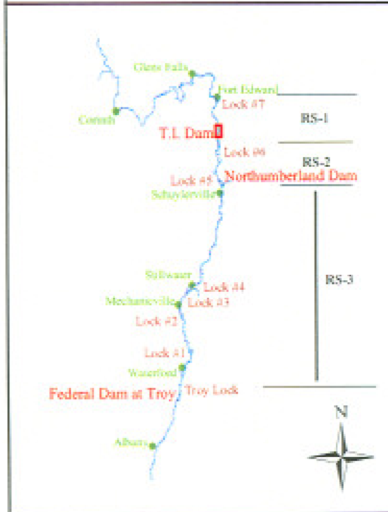


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements

UPPER HUDSON RIVER STUDY AREA

Figure E-3-1d. Numerical grid for Thompson Island Pool.

RM189 to RM190

Quantitative Environmental Analysis, LLC

GENdes Jul 29, 2005.

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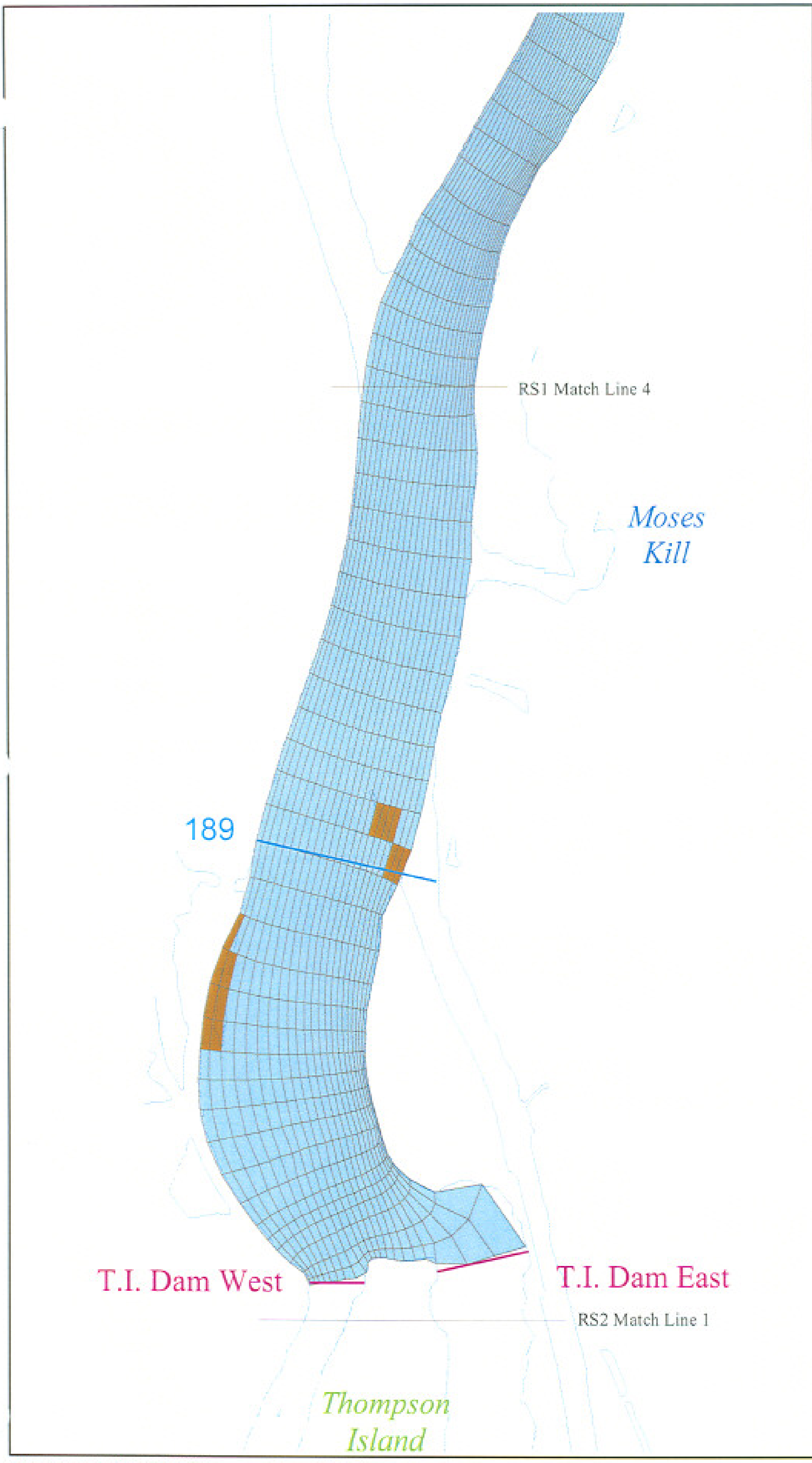
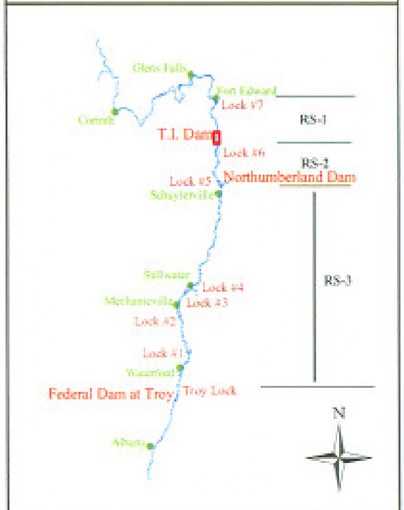


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements

UPPER HUDSON RIVER STUDY AREA

Figure E-3-1e. Numerical grid for Thompson Island Pool.

RM188 to RM189

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

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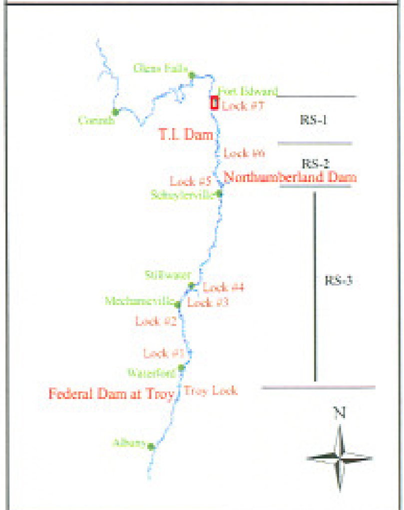
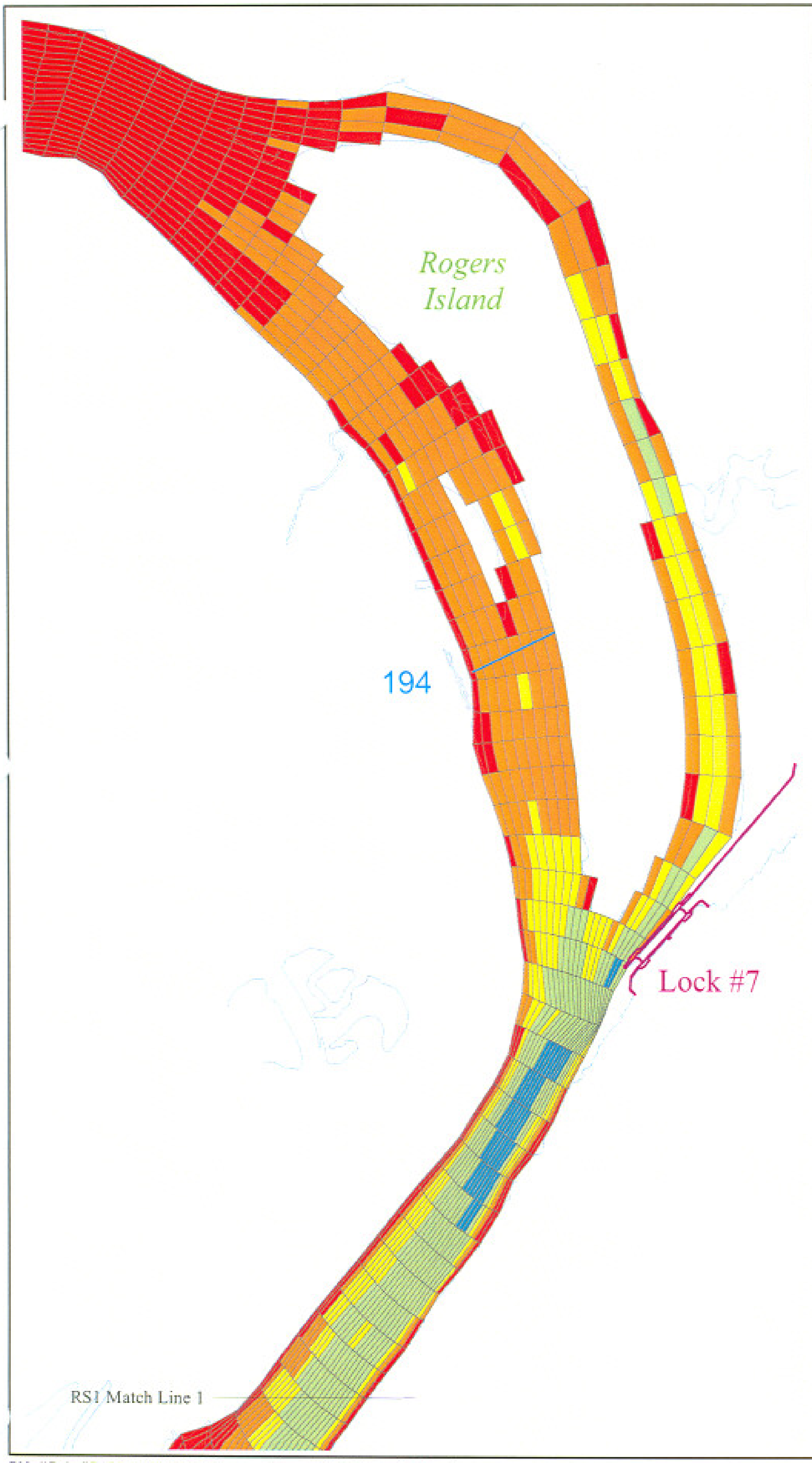
LOCATOR MAP OF THE UPPER HUDSON RIVER





GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks

Sediment Elev. (ft NAVD88)

- < 90
- 90 - 95
- 95 - 100
- 100 - 105
- 105 - 110
- 110 - 115
- > 115

UPPER HUDSON RIVER STUDY AREA

Figure E-3-2a. Bathymetry for Thompson Island Pool.

RM193 to RM194

QEA Quantitative Environmental Analysis, LLC

GENdes Jul 29, 2005.

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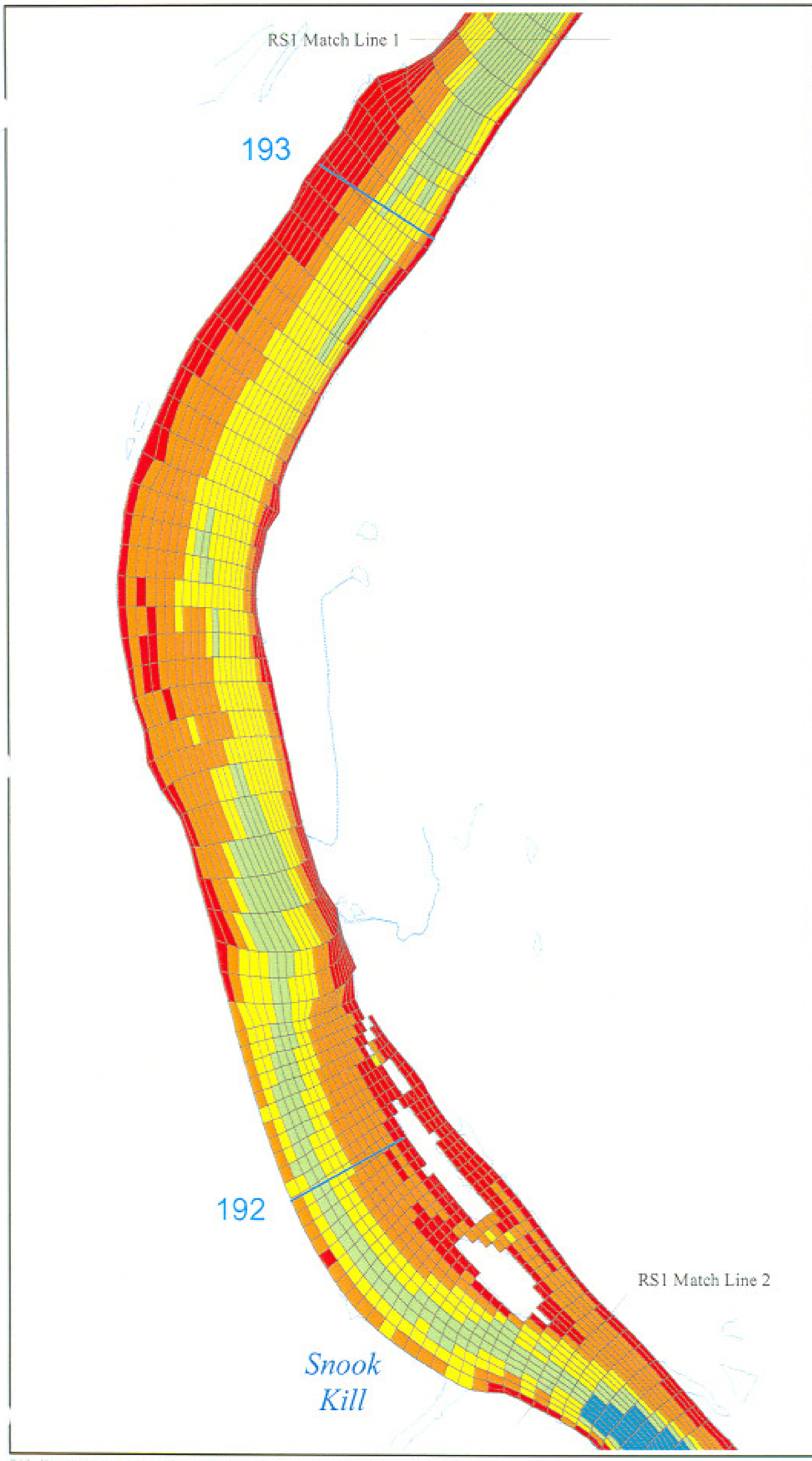
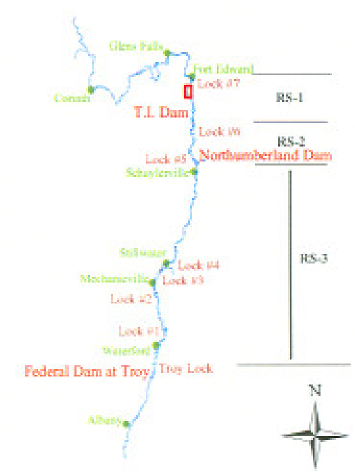


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

River Miles

Shore Line

Dams and Locks

Sediment Elev. (ft NAVD88)

< 90

90 - 95

95 - 100

100 - 105

105 - 110

110 - 115

> 115

UPPER HUDSON RIVER STUDY AREA

Figure E-3-2b. Bathymetry for Thompson Island Pool.

RM191 to RM193

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

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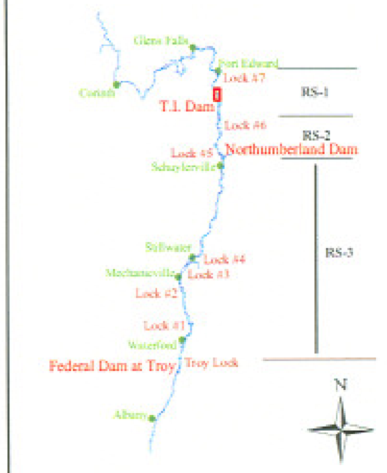
LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks

Sediment Elev. (ft NAVD88)

- < 90
- 90 - 95
- 95 - 100
- 100 - 105
- 105 - 110
- 110 - 115
- > 115

UPPER HUDSON RIVER STUDY AREA

Figure E-3-2c. Bathymetry for Thompson Island Pool.

RM190 to RM191

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

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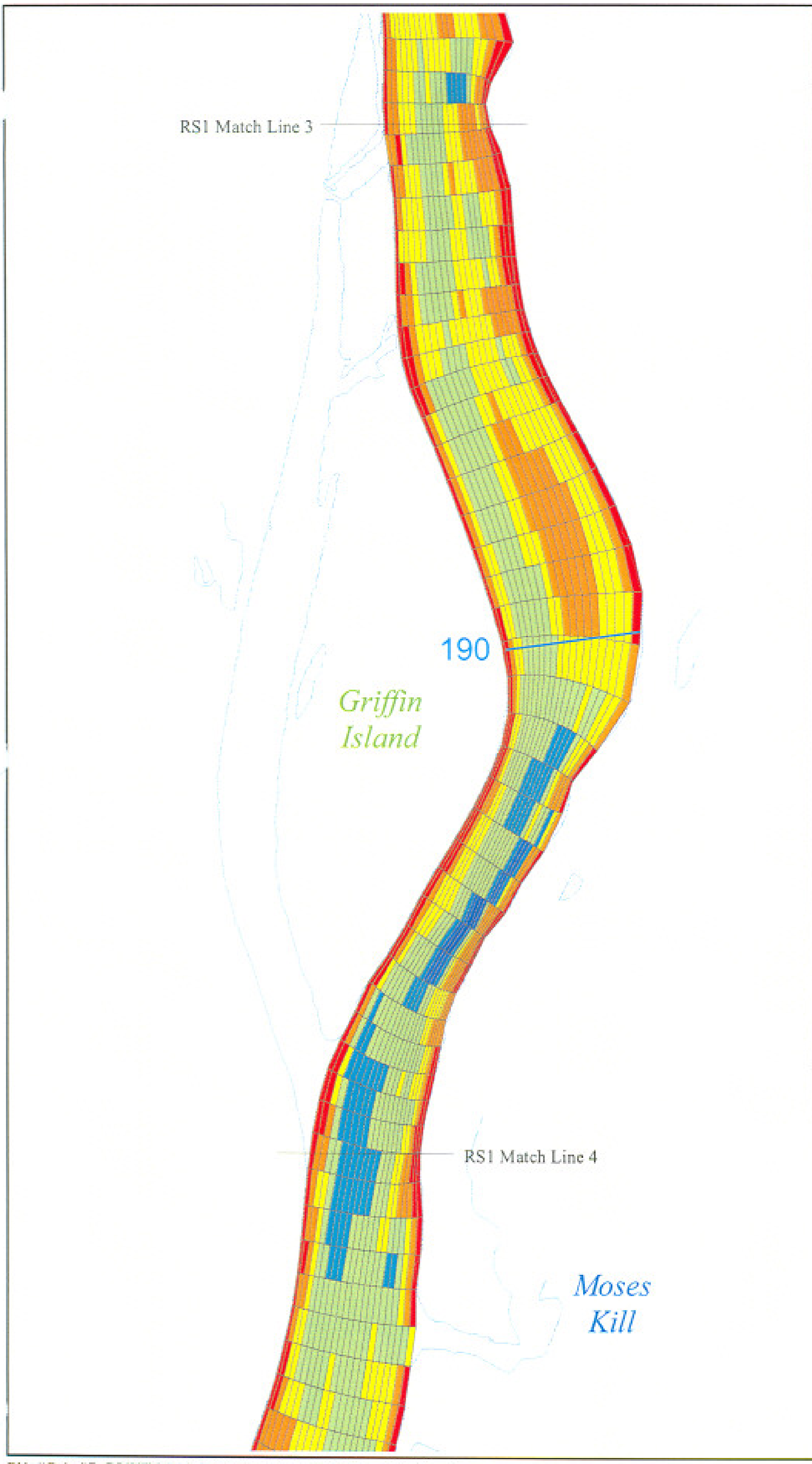
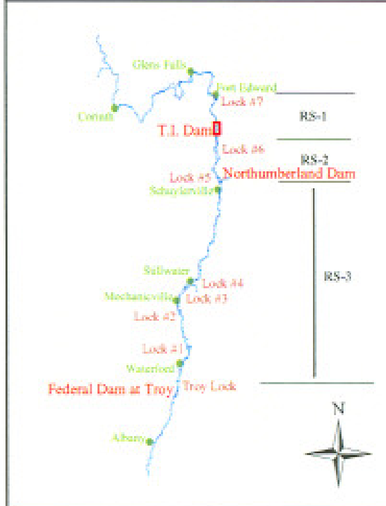


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks

Sediment Elev. (ft NAVD88)

- < 90
- 90 - 95
- 95 - 100
- 100 - 105
- 105 - 110
- 110 - 115
- > 115

UPPER HUDSON RIVER STUDY AREA

Figure E-3-2d. Bathymetry for Thompson Island Pool.

RM189 to RM190

QEA Quantitative Environmental Analysis, LLC

GENdes Jul 29, 2005.

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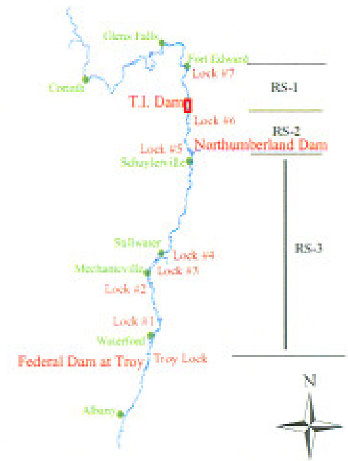
LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks

Sediment Elev. (ft NAVD88)

- < 90
- 90 - 95
- 95 - 100
- 100 - 105
- 105 - 110
- 110 - 115
- > 115

UPPER HUDSON RIVER STUDY AREA

Figure E-3-2e. Bathymetry for Thompson Island Pool.

RM188 to RM189

QEA Quantitative Environmental Analysis, LLC

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Jul 29, 2005.

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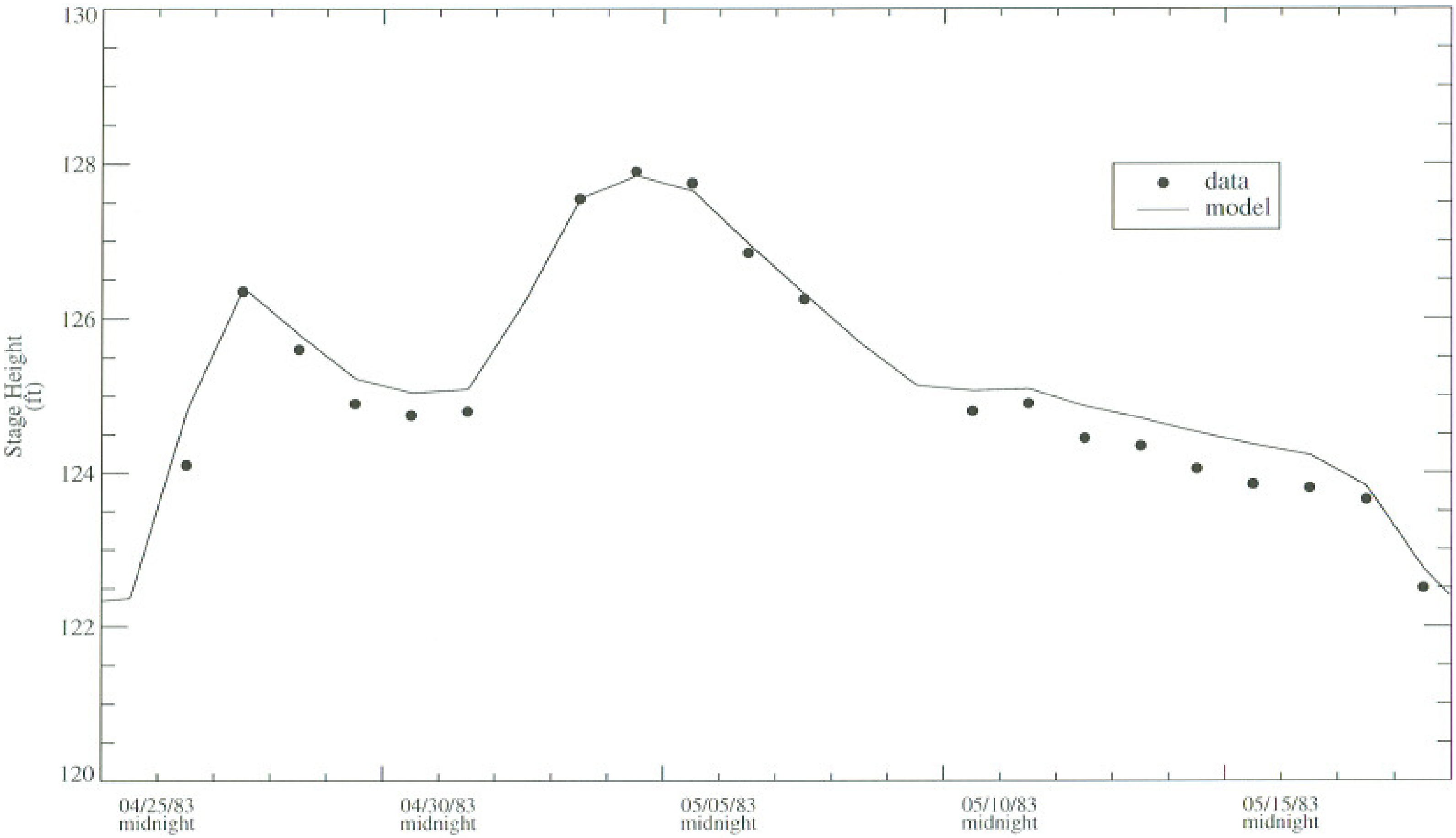

Figure E-3-3. Comparison of predicted and observed stage height at gauge 119 (at the entrance to Lock 7) during Spring 1983 flood.

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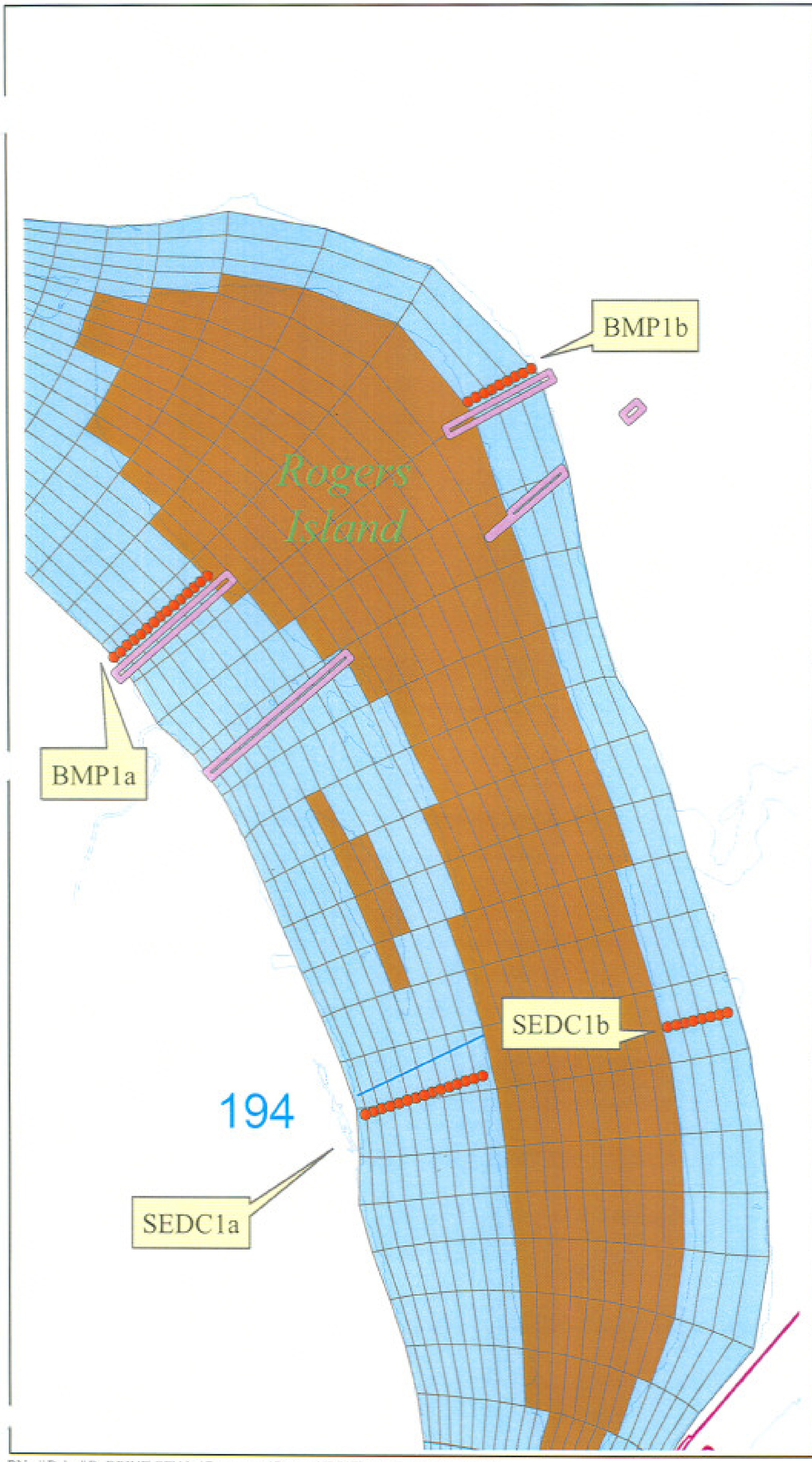
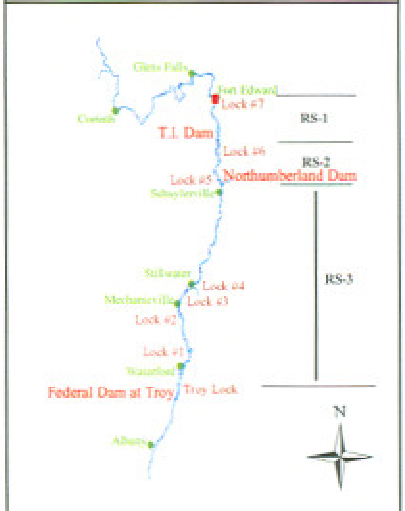
Thu Aug 18 13:21:37 2005



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- ADCP Data
- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements
- Bridges

UPPER HUDSON RIVER STUDY AREA

Figure E-3-4. Locations of transects BMP1 and SEDC1 at which ADCP data were collected during June 2004.

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GENdes

Jul 29, 2005.

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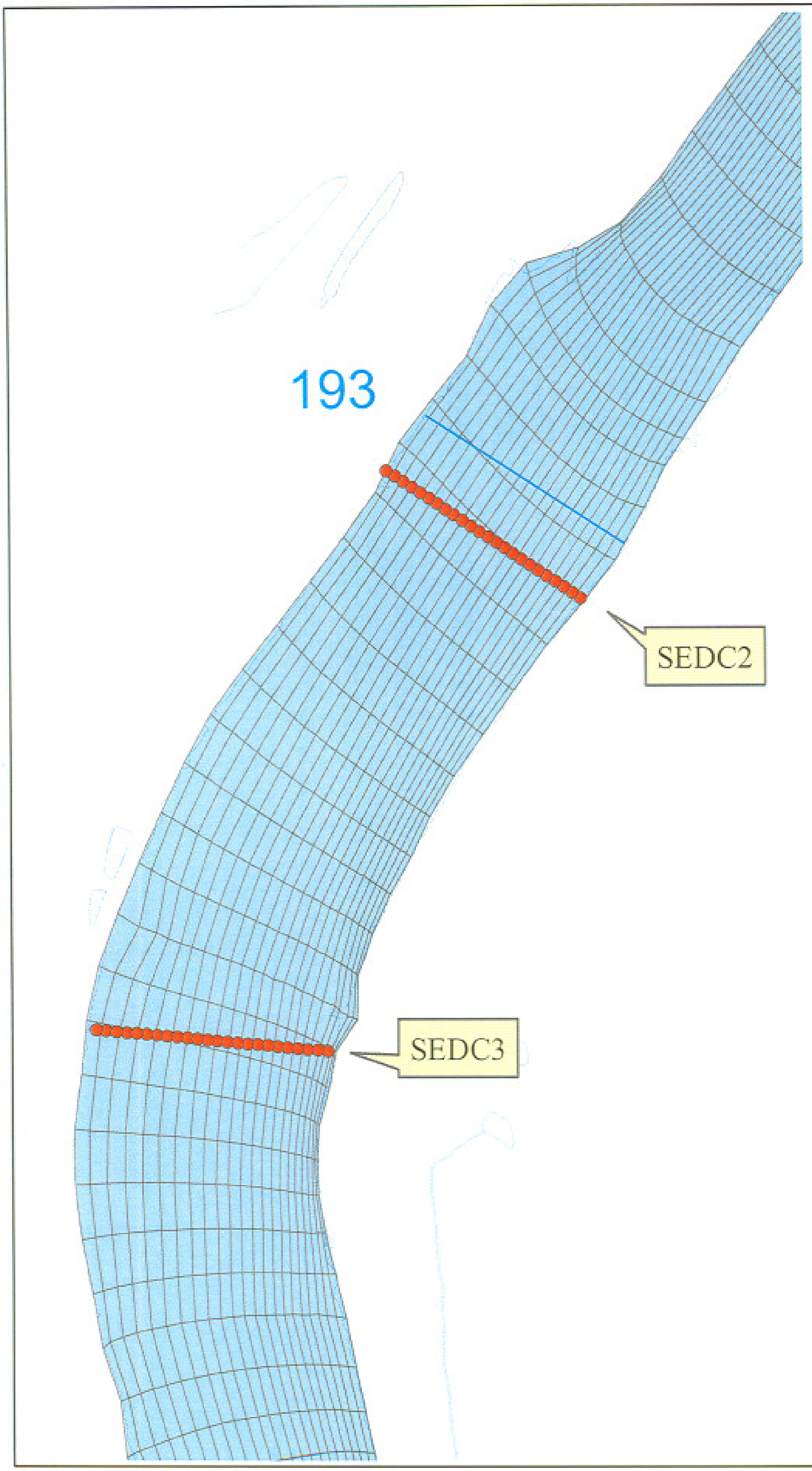
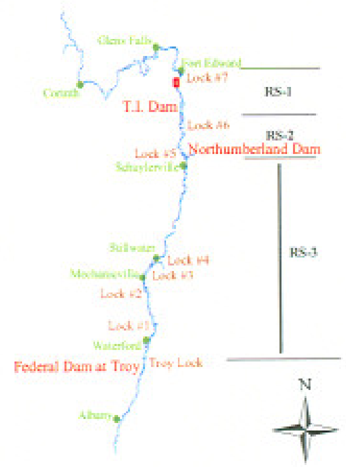


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- ADCP Data
- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements
- Bridges

UPPER HUDSON RIVER STUDY AREA

Figure E-3-5. Locations of transects SEDC2 and SEDC3 at which ADCP data were collected during June 2004.

QEA Quantitative Environmental Analysis, LLC

GENdes Jul 29, 2005.

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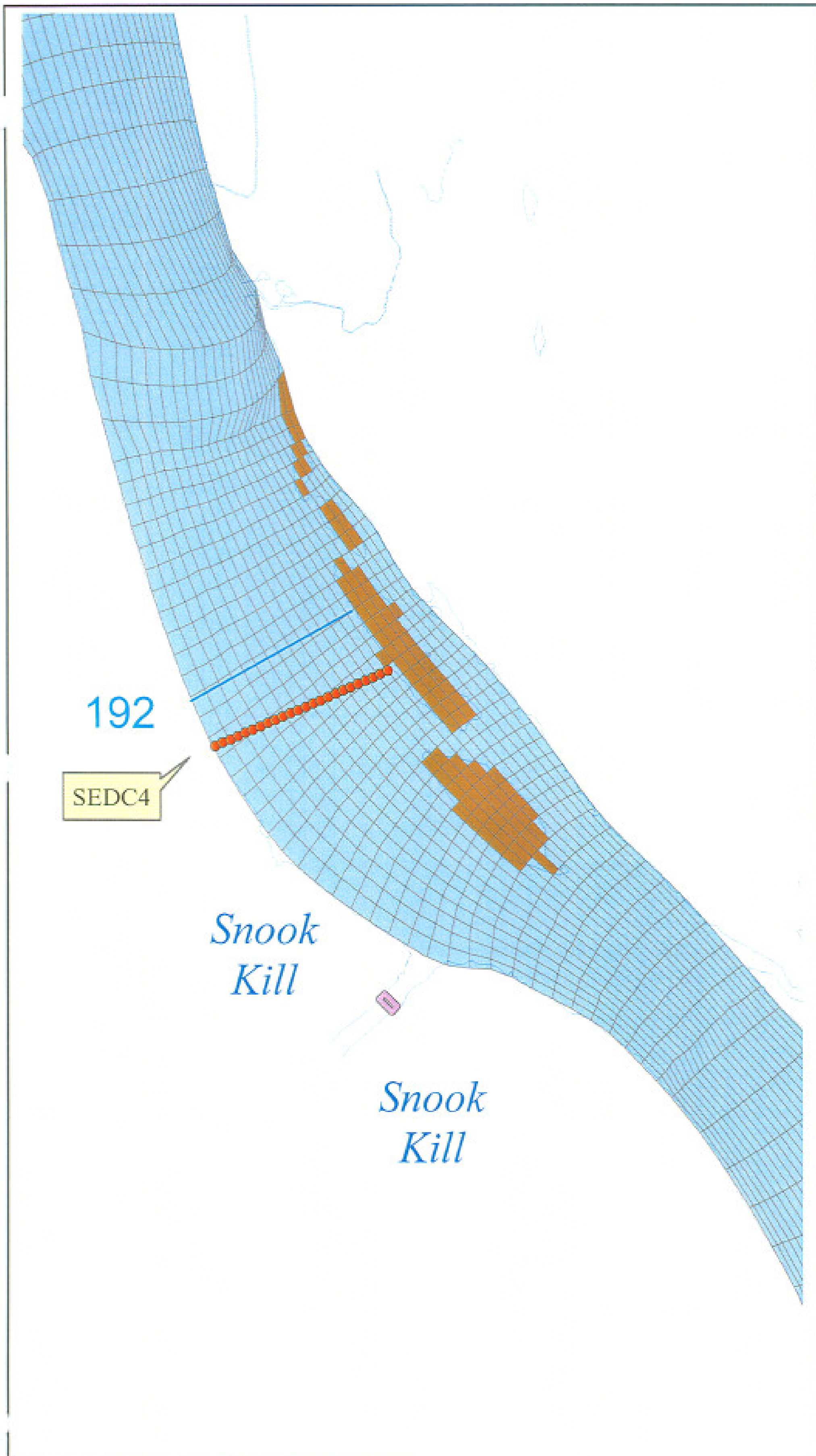
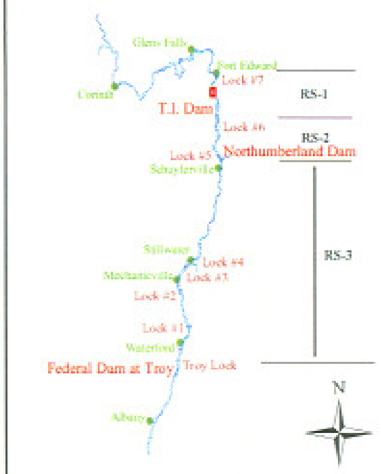


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- ADCP Data
- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements
- Bridges

UPPER HUDSON RIVER STUDY AREA

Figure E-3-6. Location of transect SEDC4 at which ADCP data were collected during June 2004.

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

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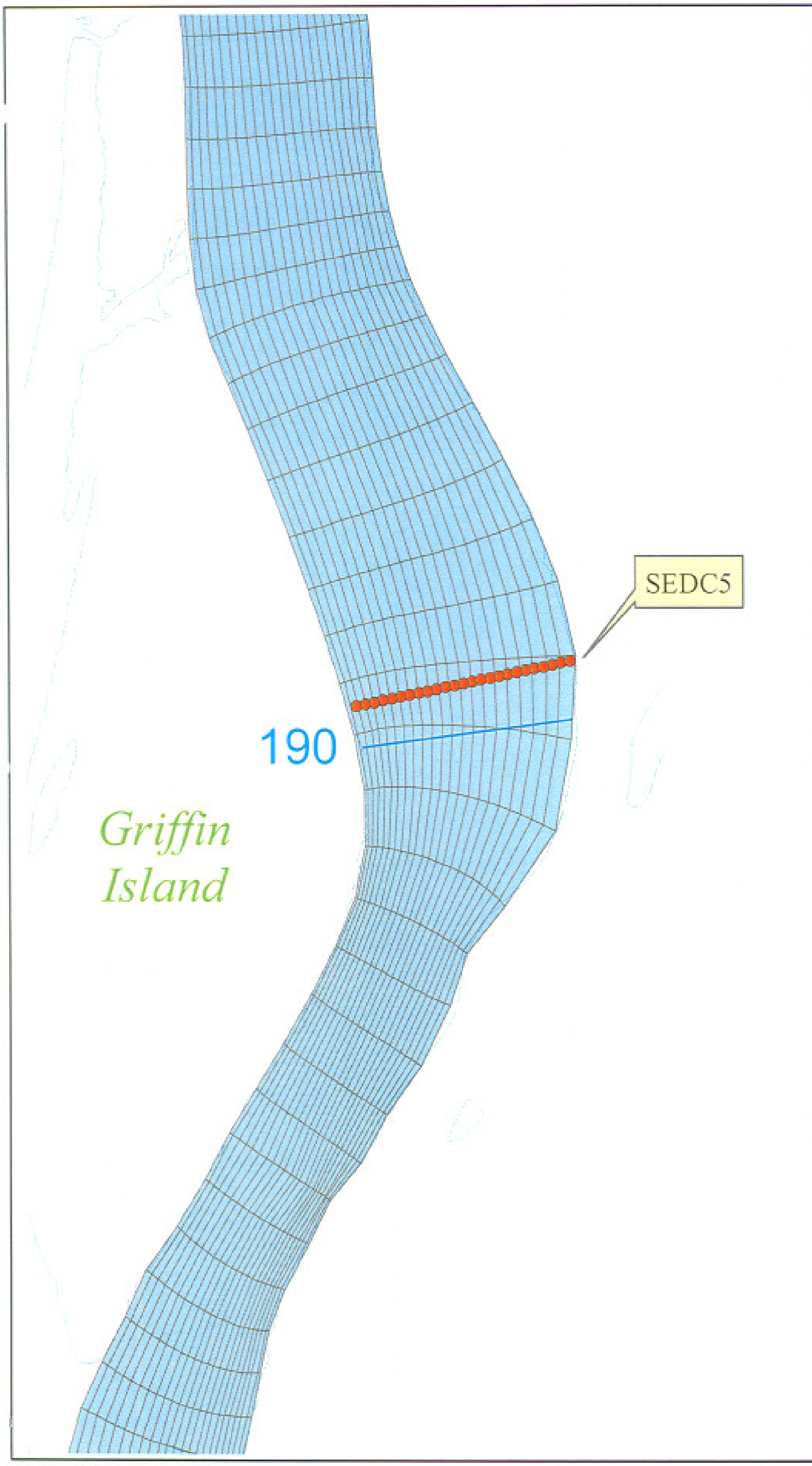
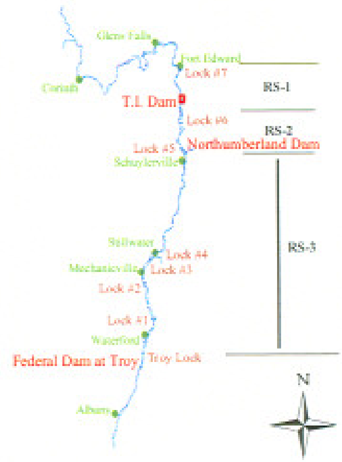


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- ADCP Data
- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements
- Bridges

UPPER HUDSON RIVER STUDY AREA

Figure E-3-7. Location of transect SEDC5 at which ADCP data were collected during June 2004.

QEA Quantitative Environmental Analysis, LLC

GENdes Jul 29, 2005.

DN - \\Daleel\D_DRIVE\GENdes\Documents\Reports\IDR\Figure_E-3-4_5_6_7.mxd

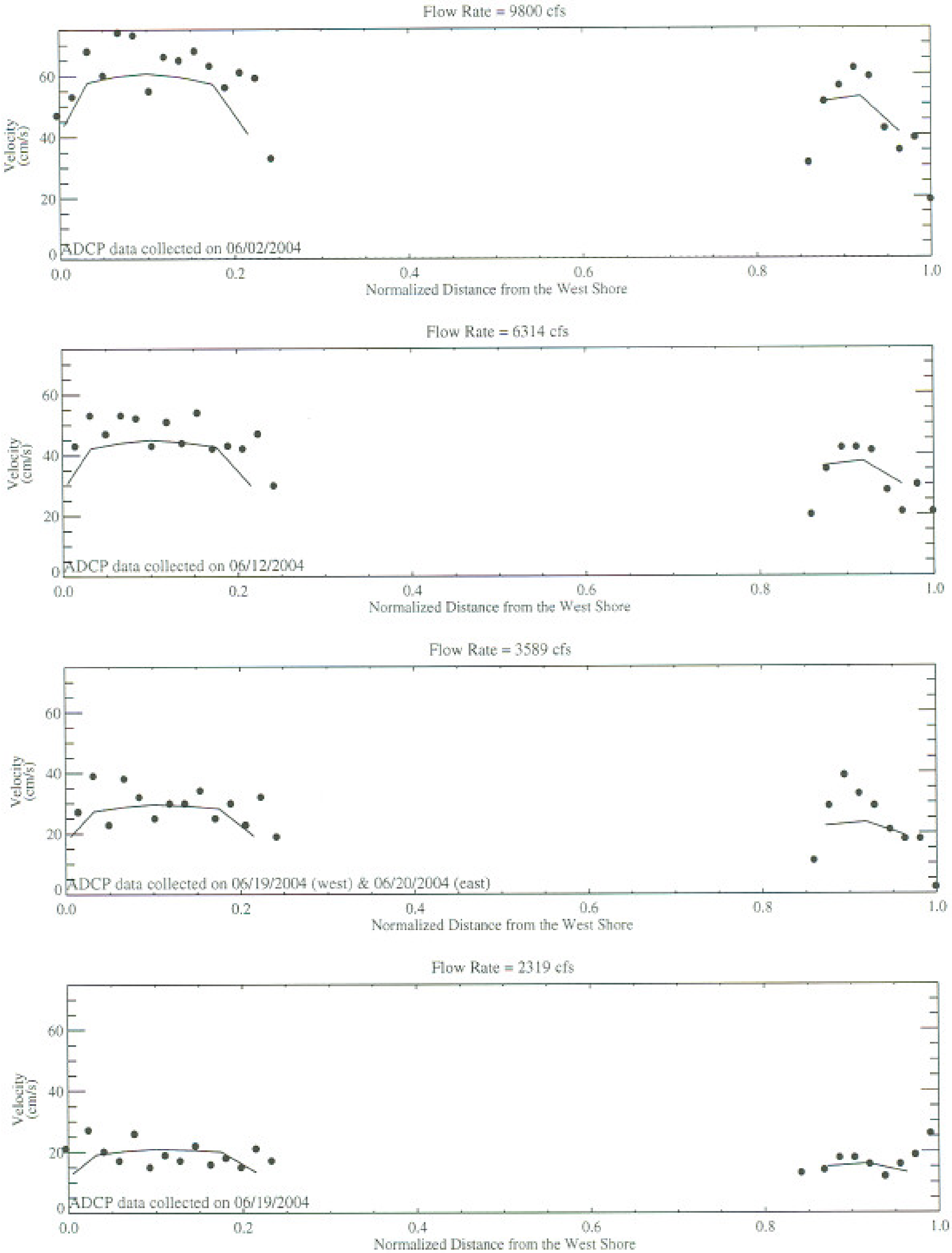


Figure E-3-8. Comparison of predicted and measured current velocity at transect BMP1 during June 2004.

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Wed Oct 27 11:07:35 2004

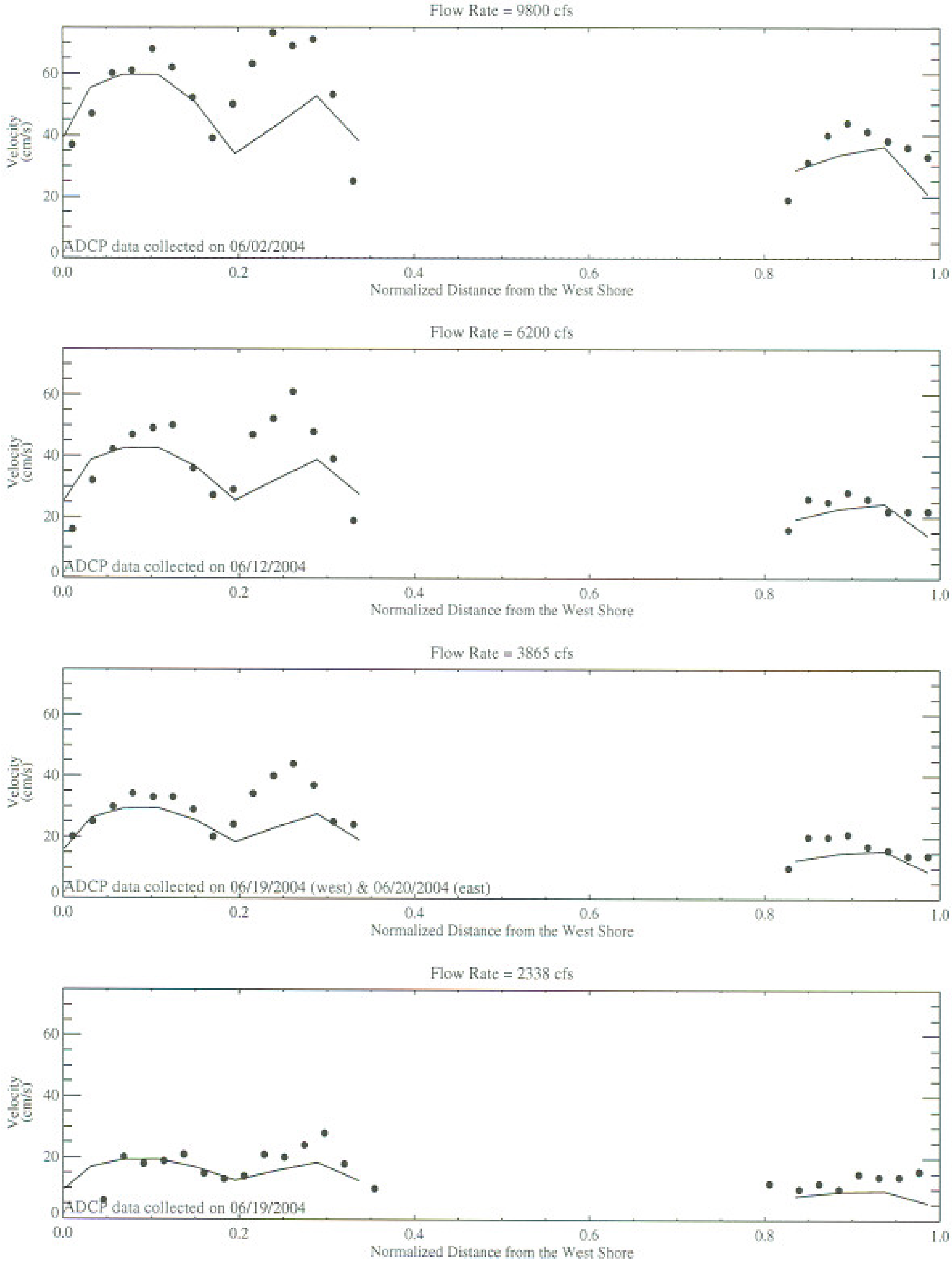

Figure E-3-9. Comparison of predicted and measured current velocity at transect SEDC1 during June 2004.

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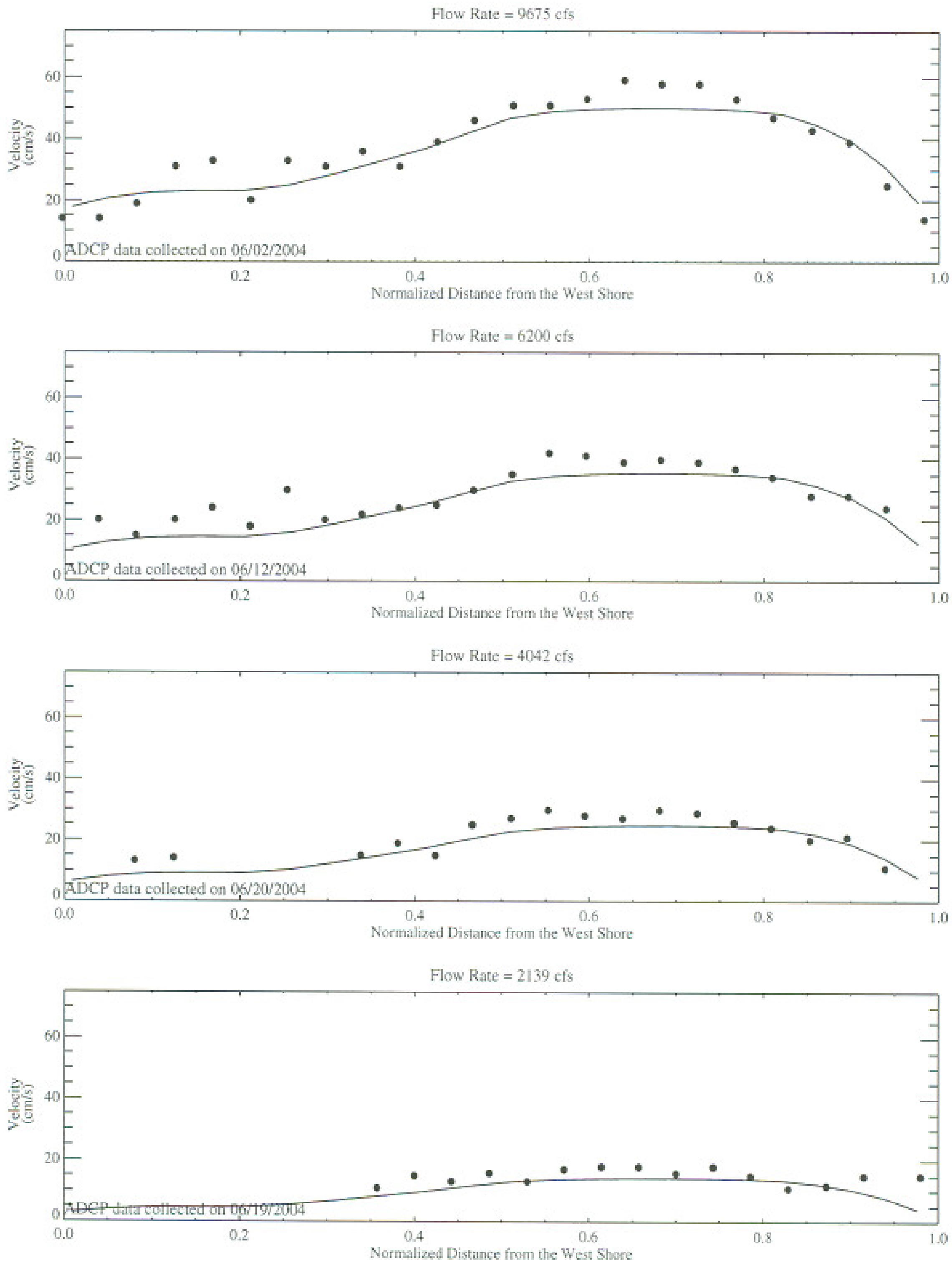

Figure E-3-10. Comparison of predicted and measured current velocity at transect SEDC2 during June 2004.

cfo - C:\GENdes\Analysis\Model\plot_vel_adcp.pro
Wed Oct 27 11:07:35 2004

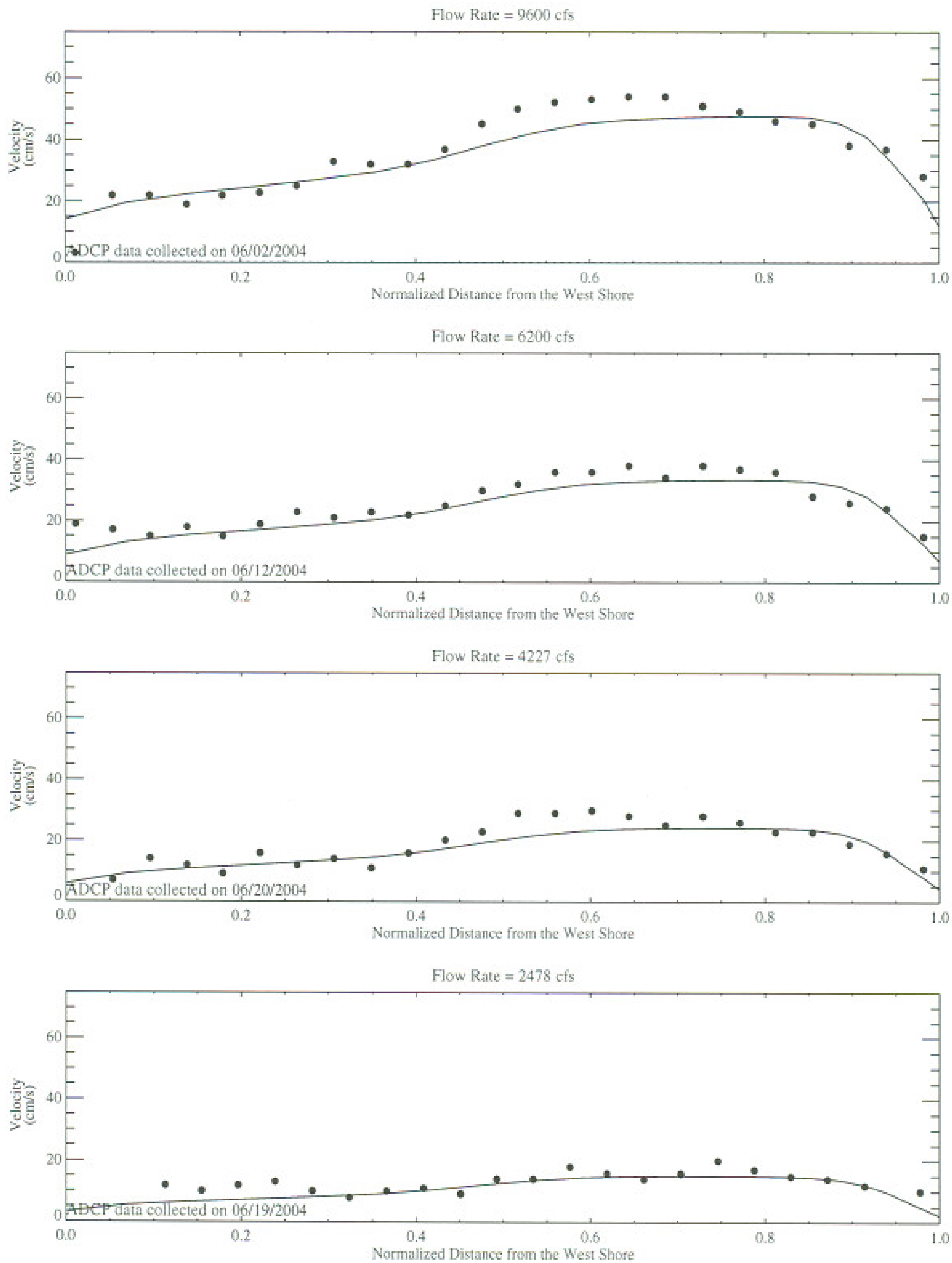

Figure E-3-11. Comparison of predicted and measured current velocity at transect SEDC3 during June 2004.

cfo - C:\GENdes\Analysis\Model\plot_vel_adcp.pro
Wed Oct 27 11:07:35 2004

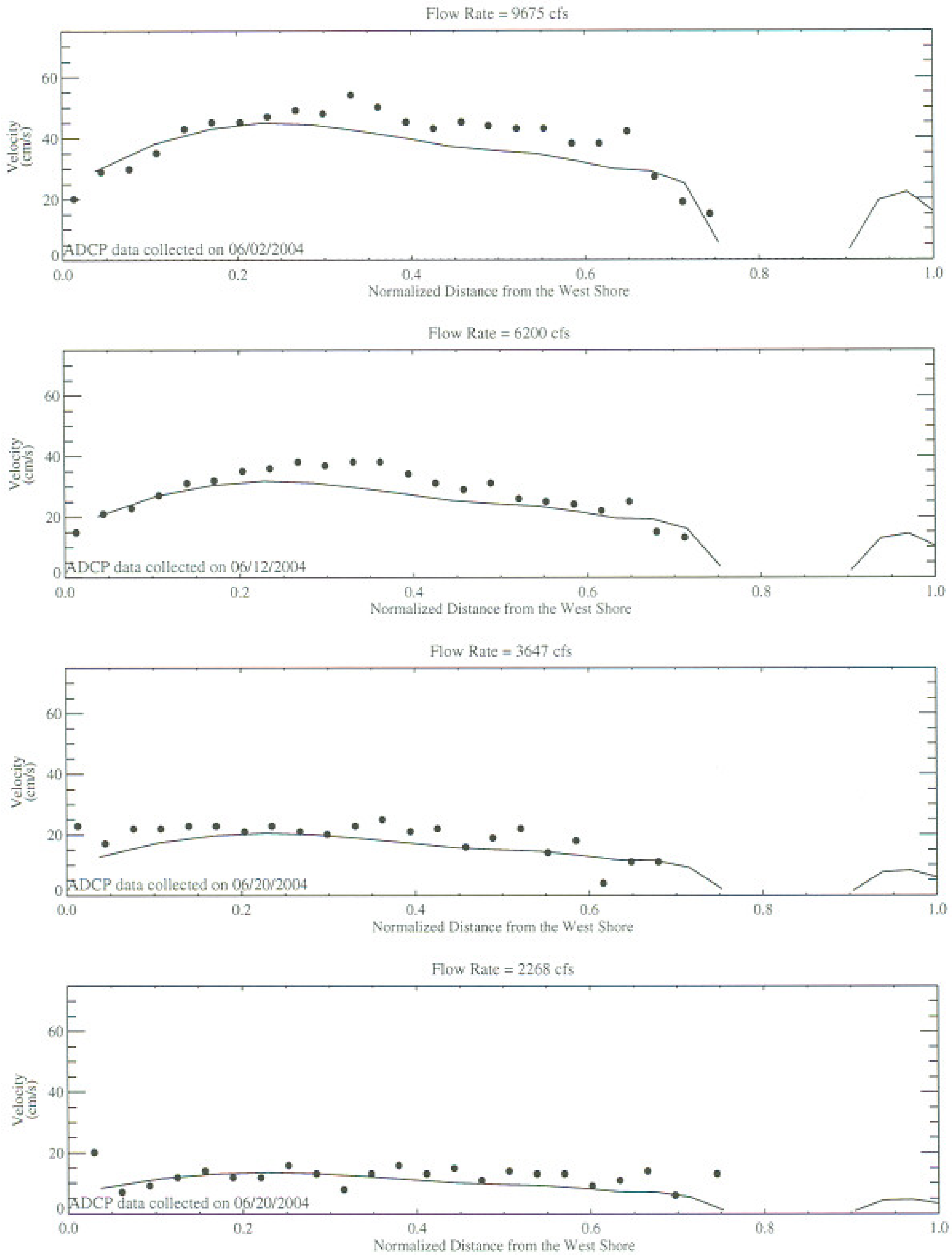

Figure E-3-12. Comparison of predicted and measured current velocity at transect SEDC4 during June 2004.

cfo - C:\GENdes\Analysis\Model\plot_vel_adcp.pro
Wed Oct 27 11:07:35 2004

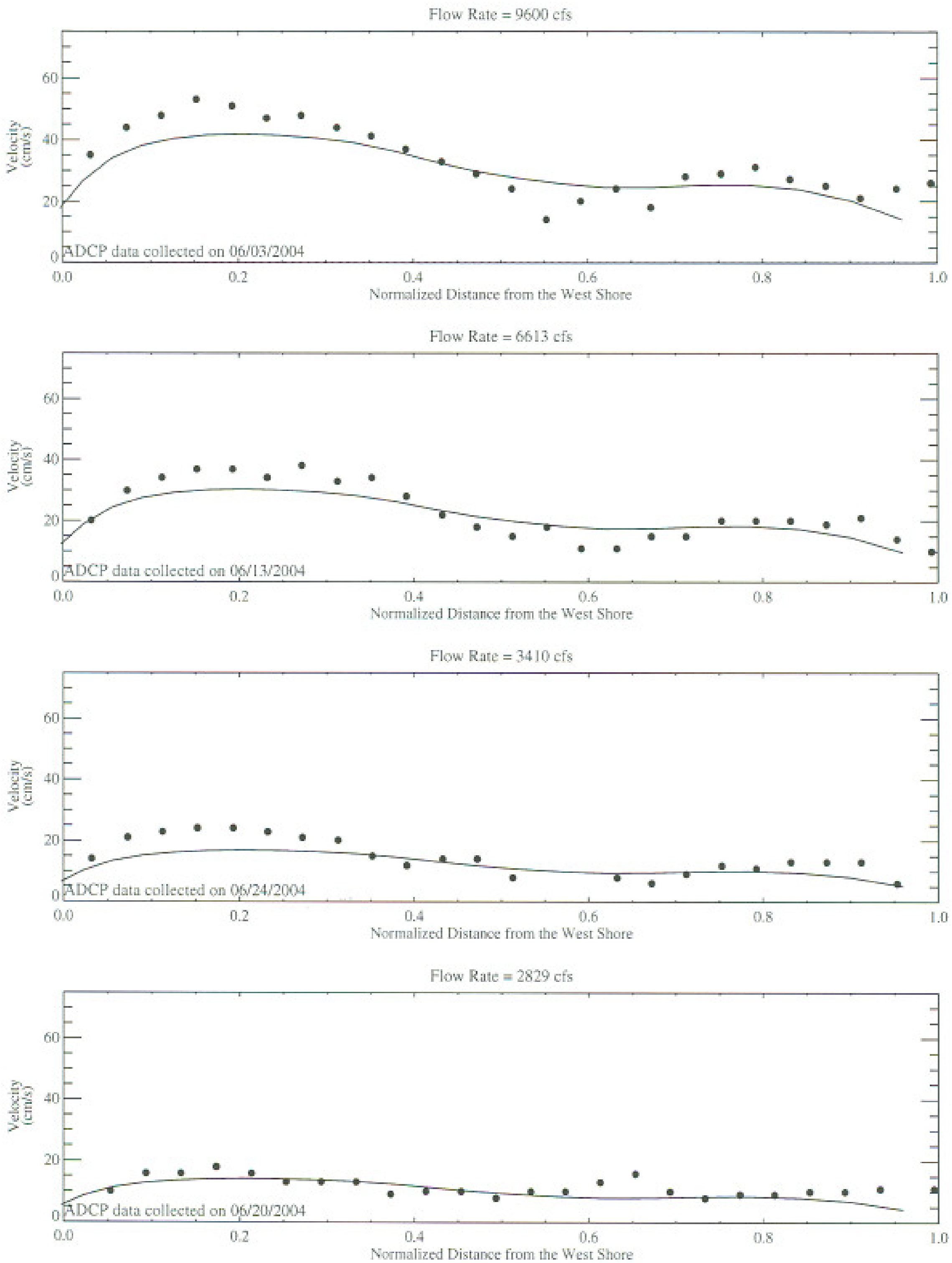

Figure E-3-13. Comparison of predicted and measured current velocity at transect SEDC5 during June 2004.

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Wed Oct 27 11:07:36 2004

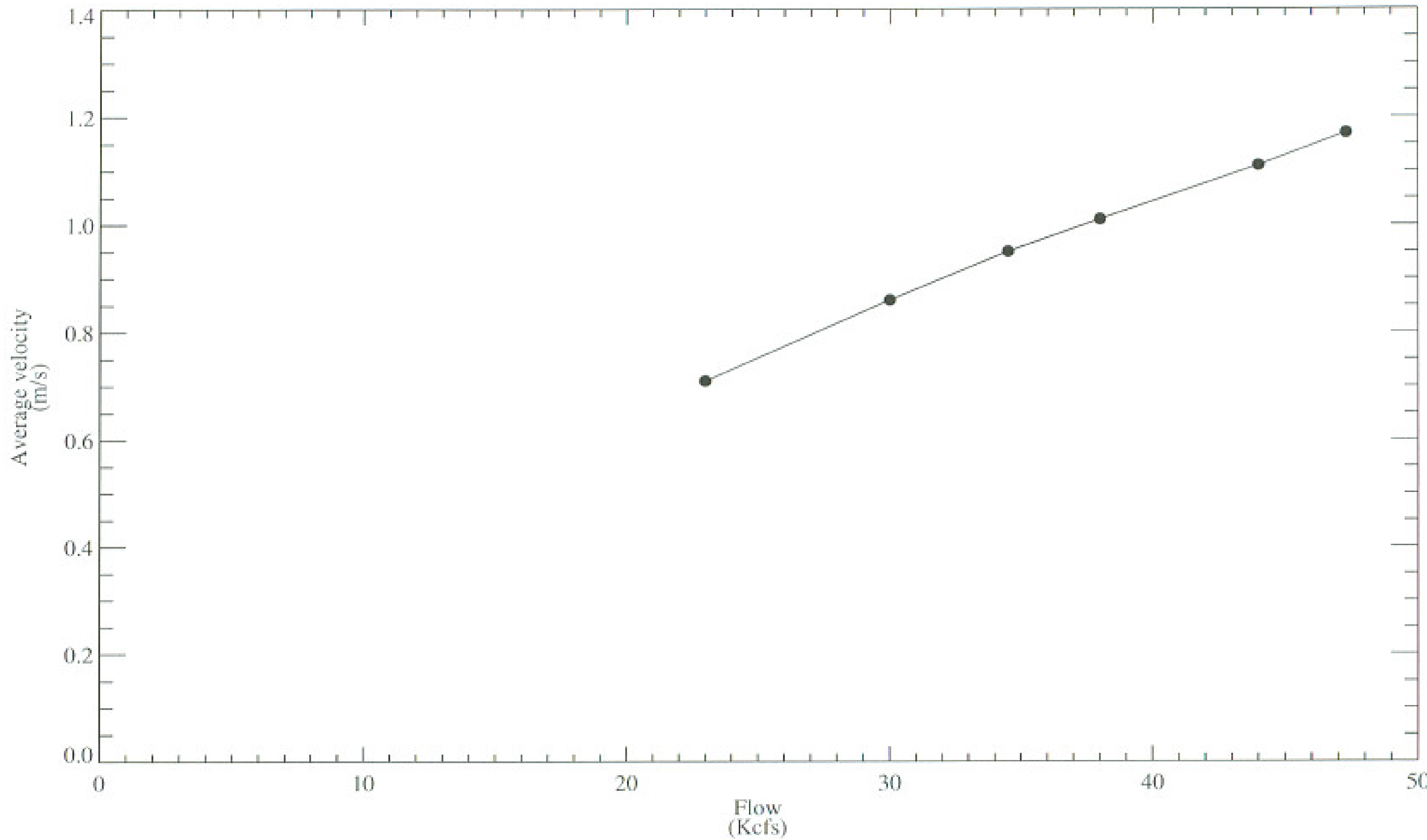

Figure E-3-14. Average current velocity in TIP as a function of flow rate at Fort Edward.

lz - D:\GENdes\Analysis\Model_Outputs\EFDC_Outputs\Get_ave_vel\plot_ave_vel.pro
Wed Aug 17 16:34:14 2005

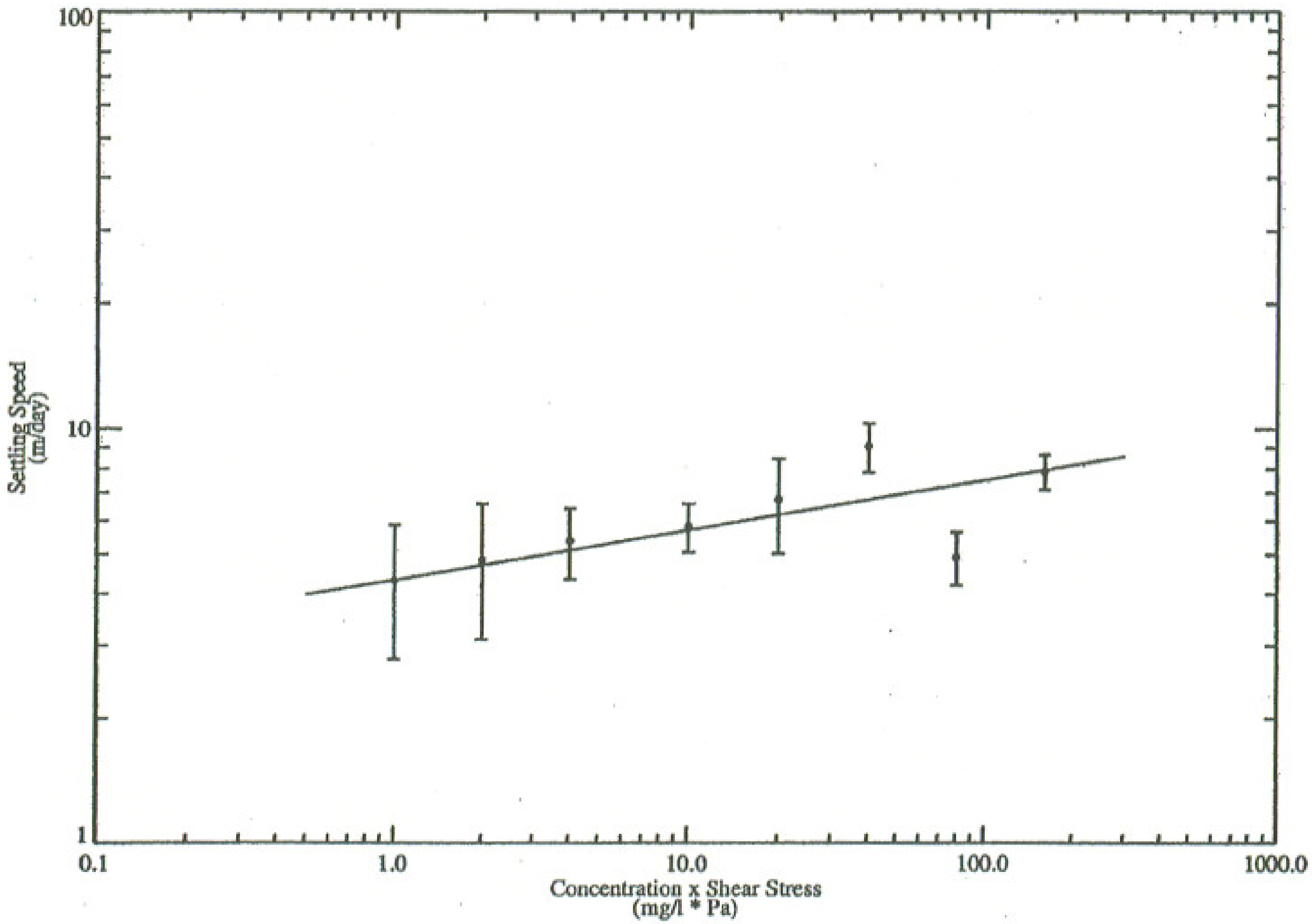

Figure E-4-1. Settling speed of flocculating cohesive (class 1) sediment (solid line) and floc settling speed data (mean + 95% confidence interval, Burban et al. 1990) as a function of sediment concentration and shear stress.

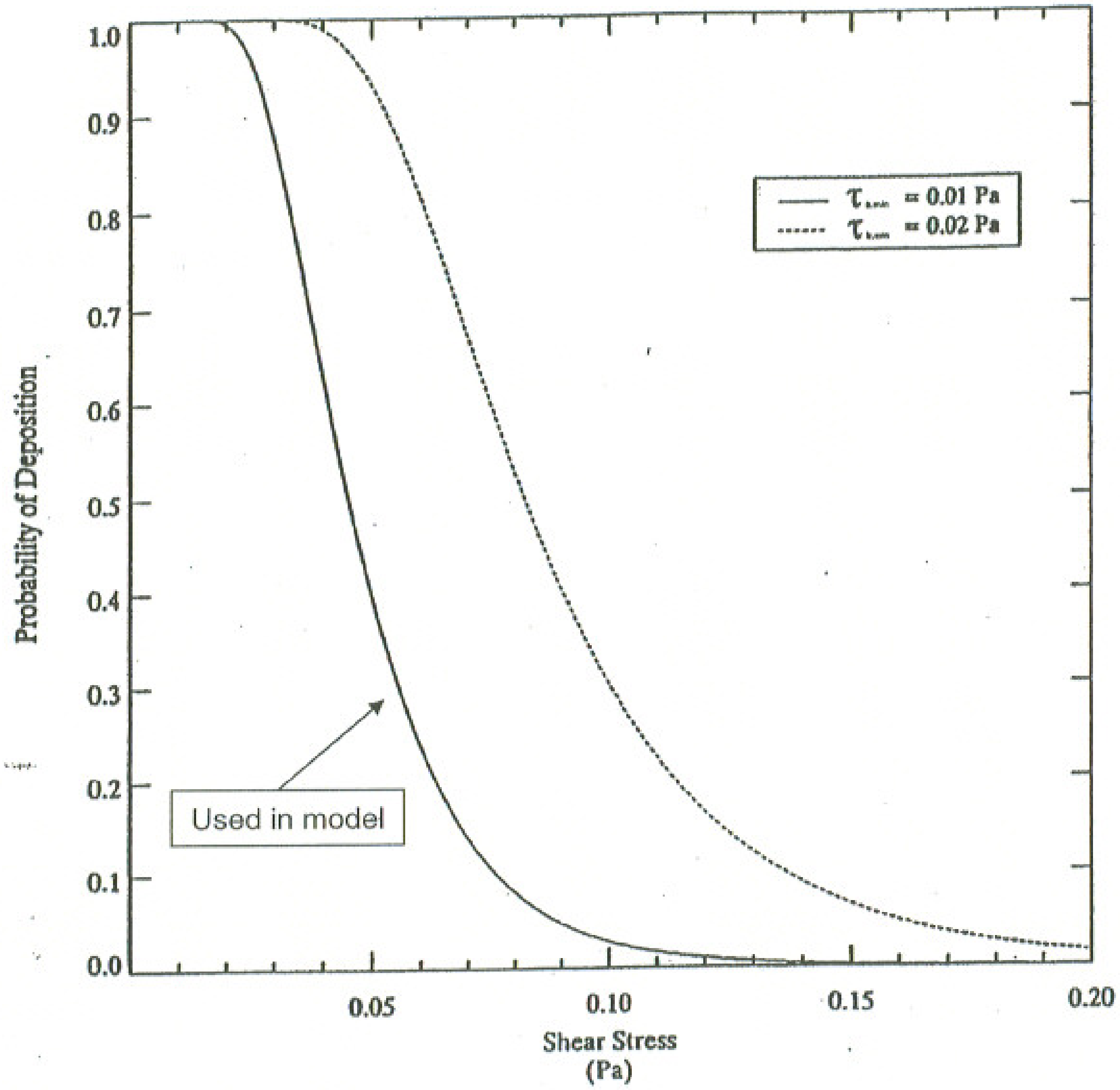

Figure E-4-2. Probability of deposition of cohesive (class 1) sediment as a function of bottom shear stress.

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6/18/2005 10:33 AM

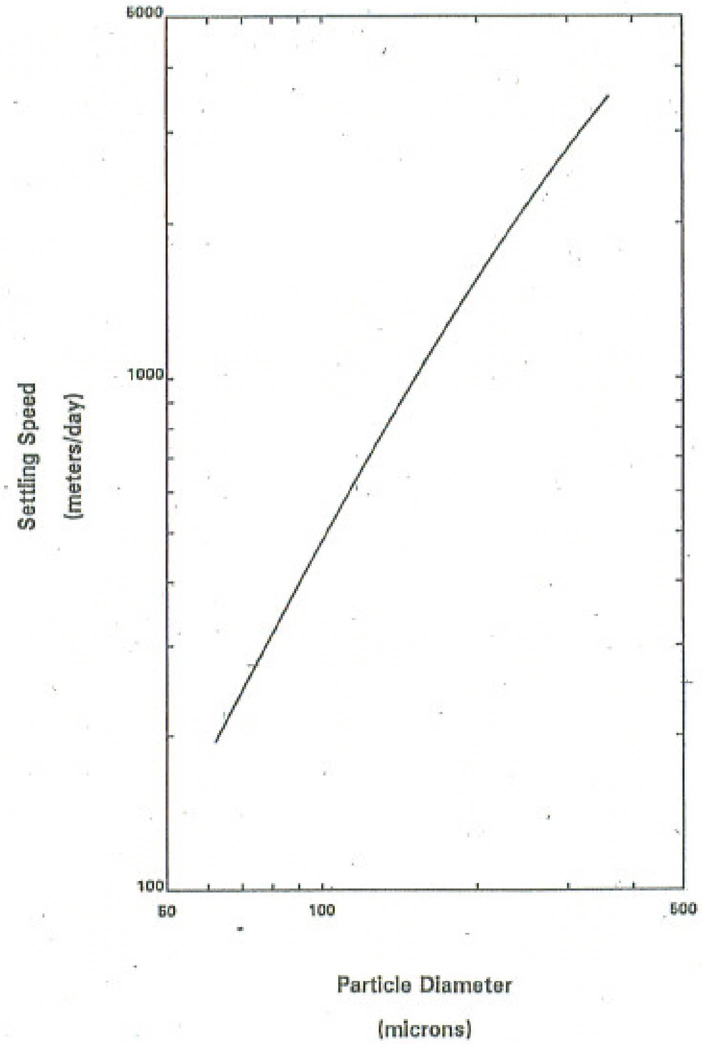

Figure E-4-3. Settling speed of noncohesive (classes 2 and 3) sediment as a function of particle diameter (Cheng 1997).

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8/18/2005 10:33 AM

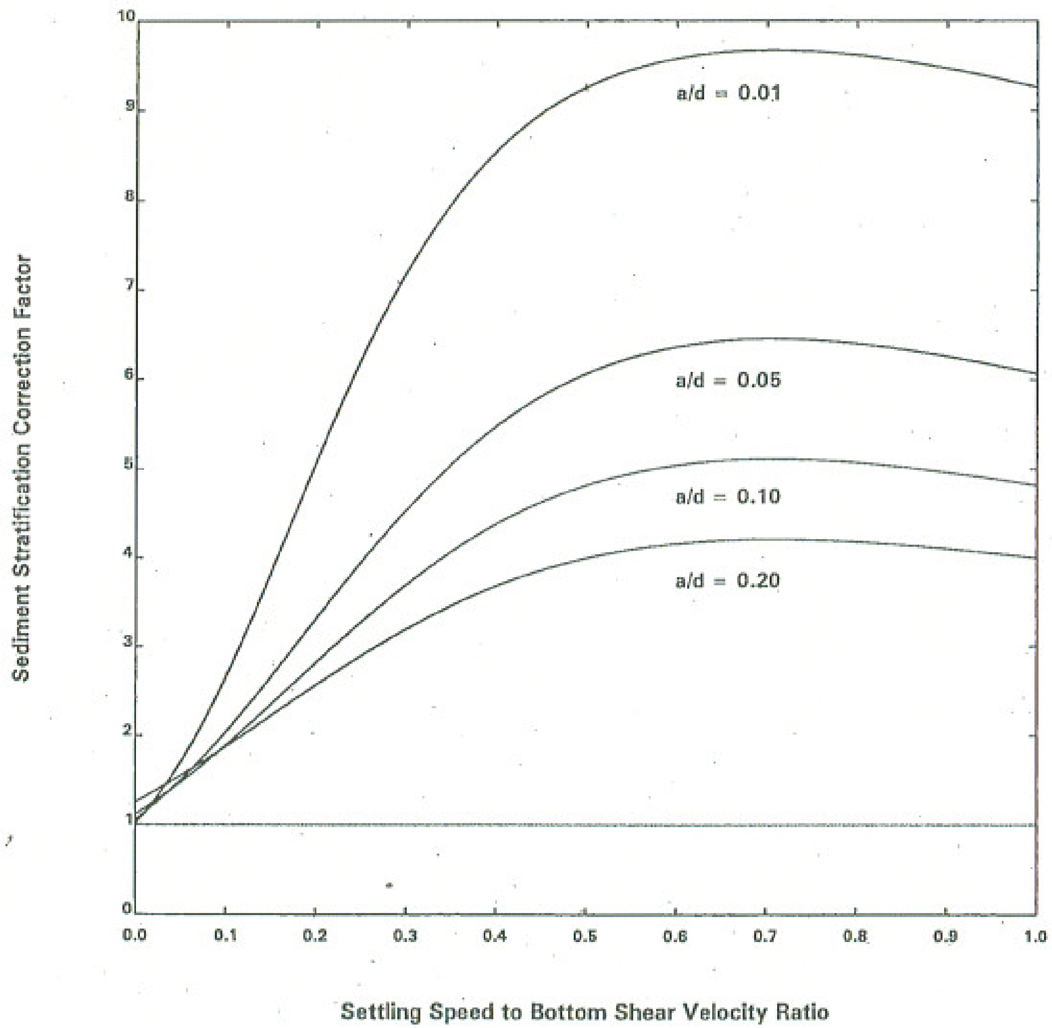

Figure E-4-4. Stratification correction factor (Γ) for noncohesive (classes 2 and 3) sediment as function of W_s/u^* for various reference heights (normalized with respect to water depth).

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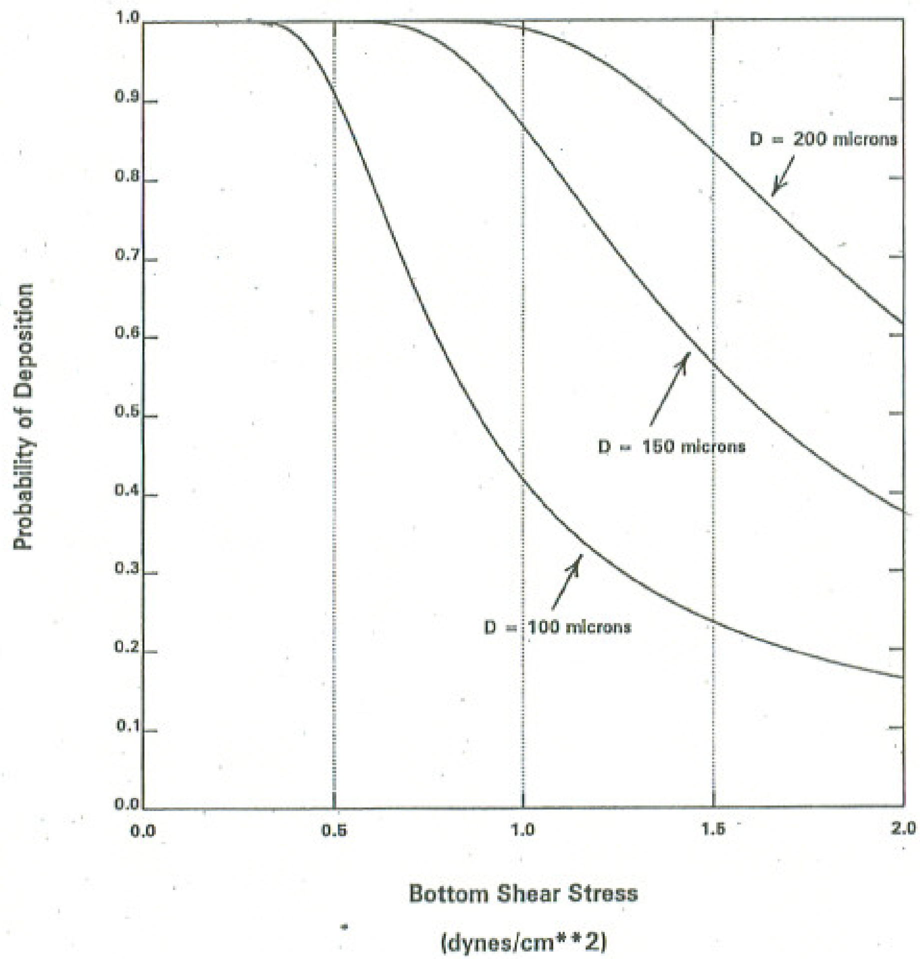

Figure E-4-5. Probability of deposition of noncohesive (classes 2 and 3) sediment as function of bottom shear stress for different particle diameters.

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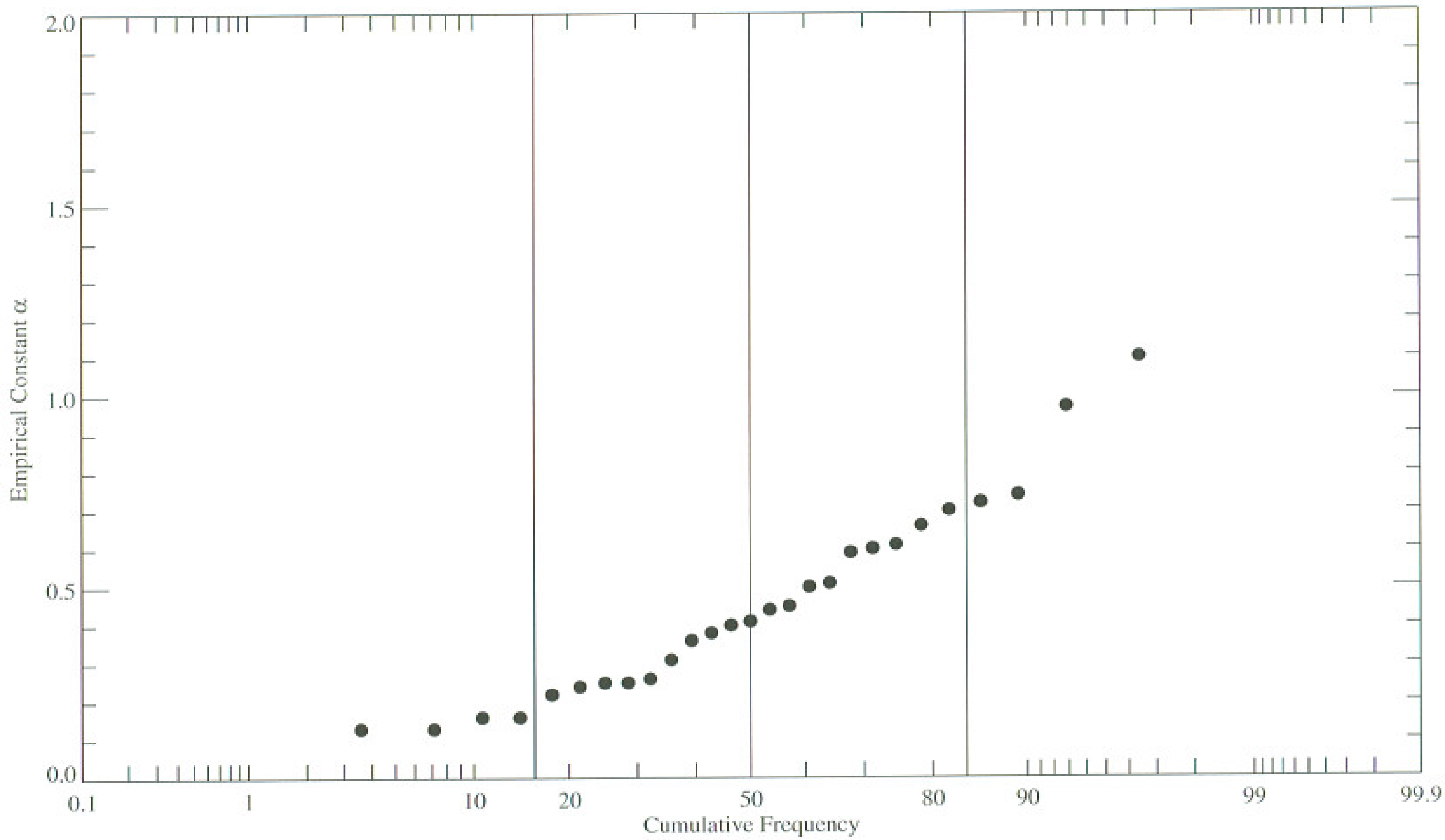
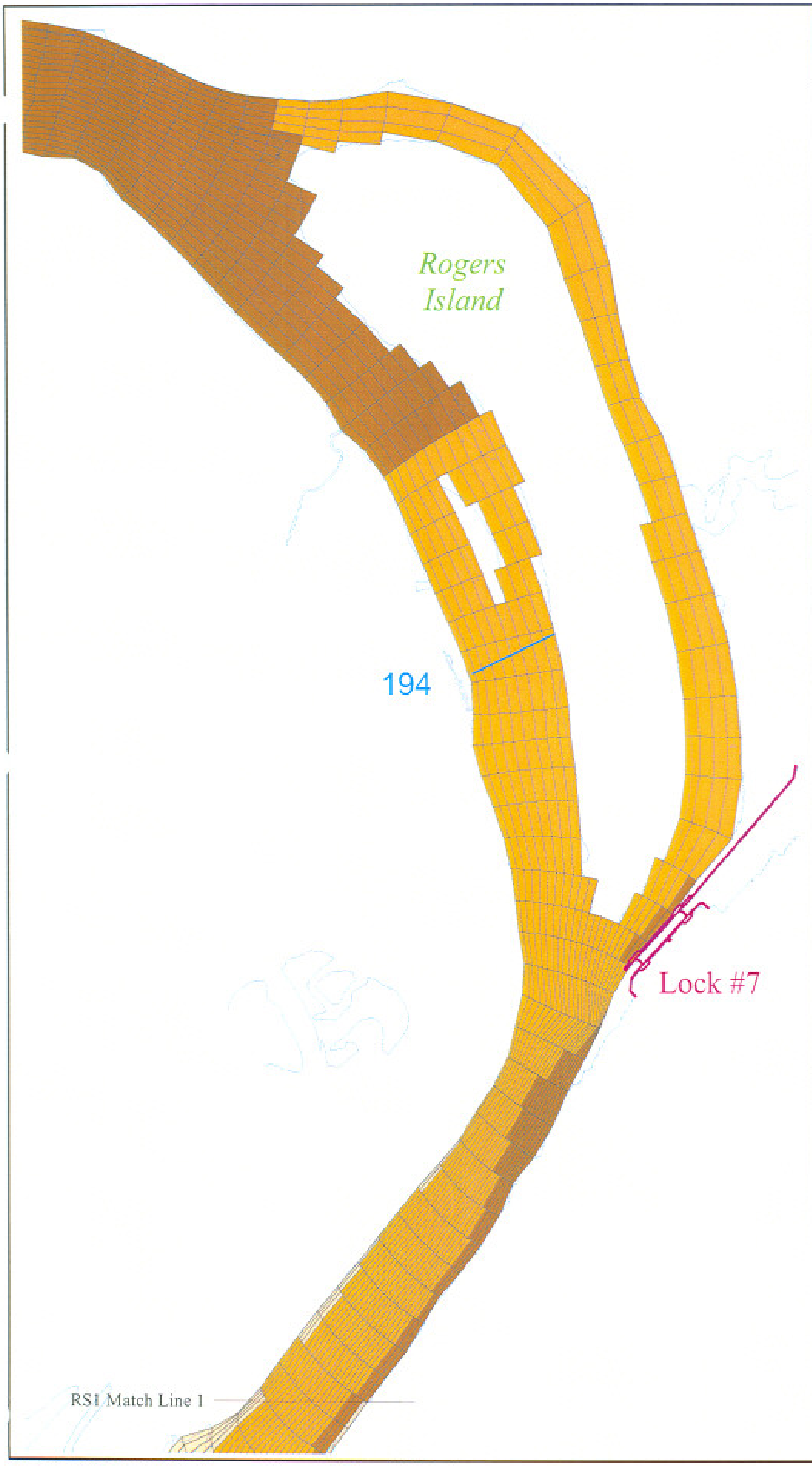
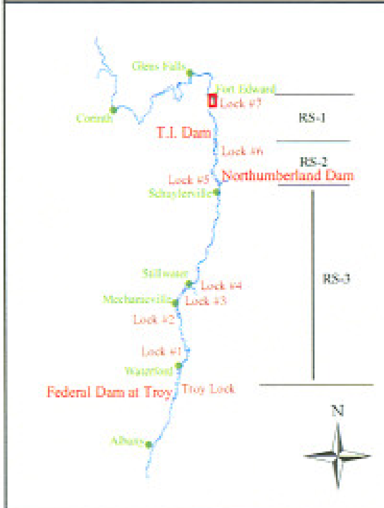


Figure E-4-6. Frequency distribution of empirical constant (α) in lateral dispersion coefficient formulation. Empirical constant values based on data cited in Rutherford (1994).

lz - D:\GENdes\Data\Tran_dispersion_coef\probplot_tran_disp_coef_meander.pro
Wed Aug 17 16:38:56 2005



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Hard-Bottom
- Cohesive Sediment
- Non-Cohesive Sediment

UPPER HUDSON RIVER STUDY AREA

Figure E-4-7a. Sediment bed map for Thompson Island Pool.

RM193 to RM194

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

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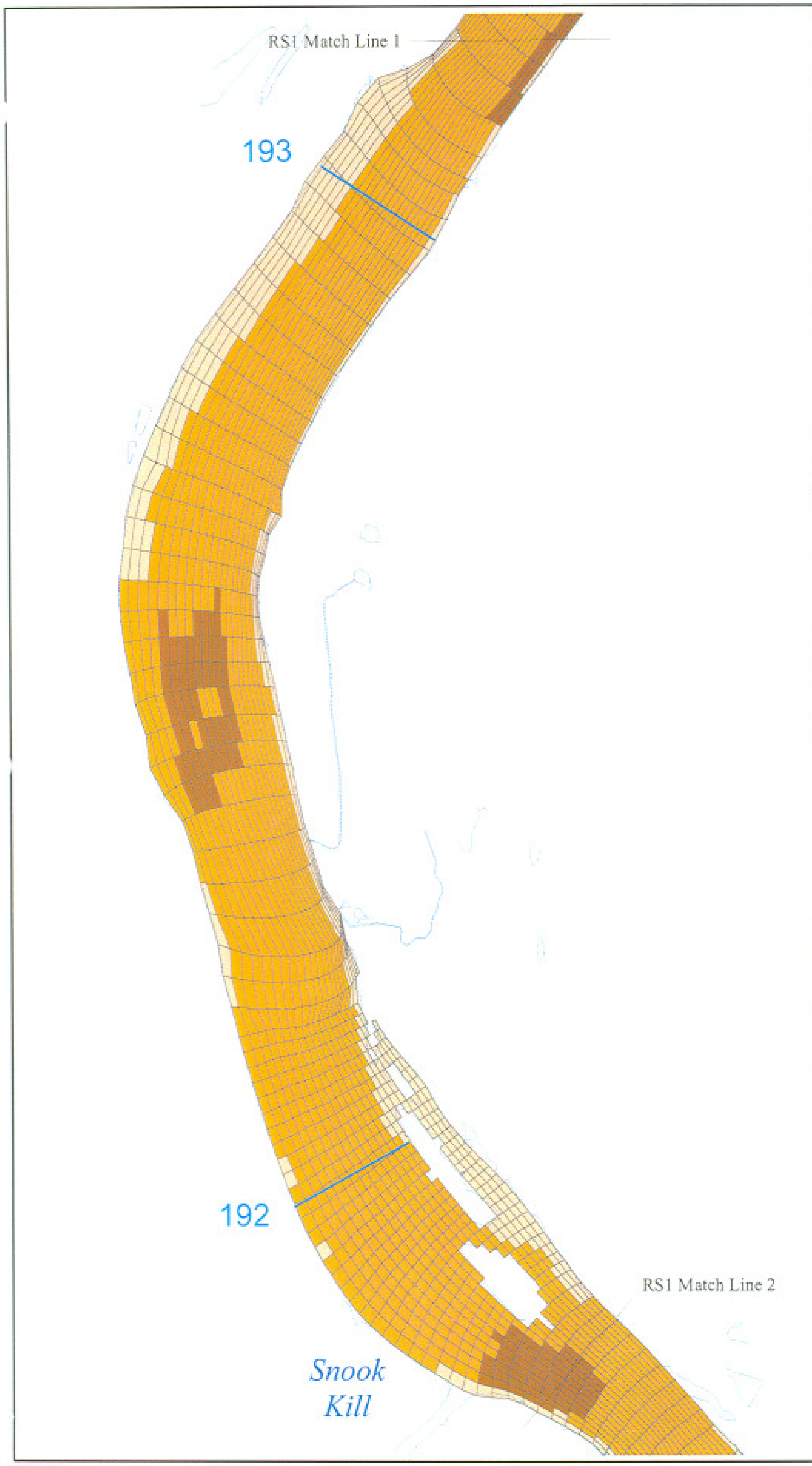
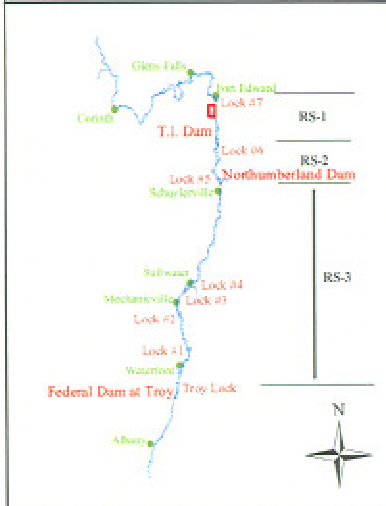


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Hard-Bottom
- Cohesive Sediment
- Non-Cohesive Sediment

UPPER HUDSON RIVER STUDY AREA

Figure E-4-7b. Sediment bed map for Thompson Island Pool.

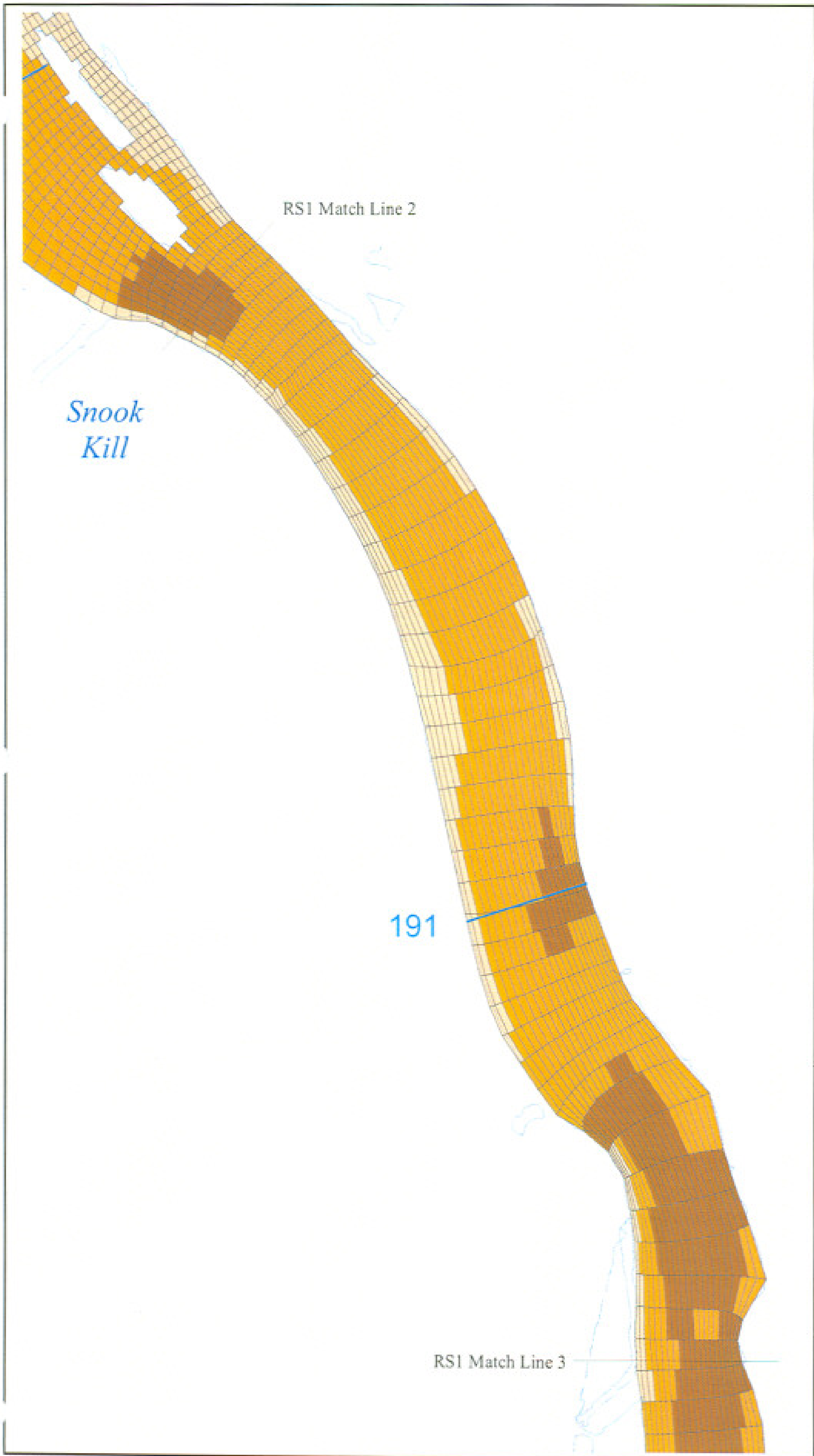
RM191 to RM193

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

DN - \\Daleel\D_DRIVE\GENdes\Documents\Reports\IDR\Figure_E-4-7.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER

GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Hard-Bottom
- Cohesive Sediment
- Non-Cohesive Sediment

UPPER HUDSON RIVER STUDY AREA

Figure E-4-7c. Sediment bed map for Thompson Island Pool.

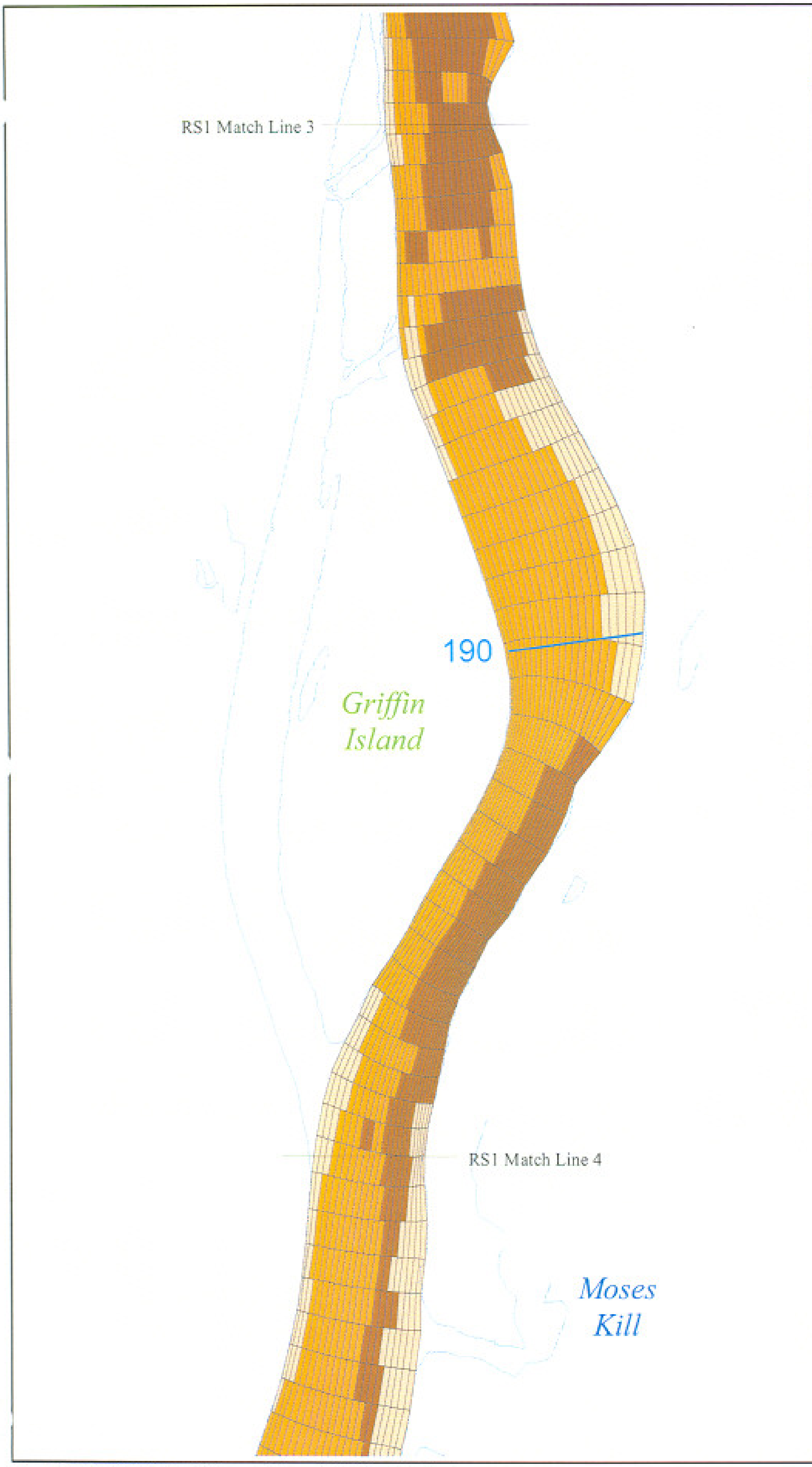
RM190 to RM191

QEA
Quantitative Environmental Analysis, LLC

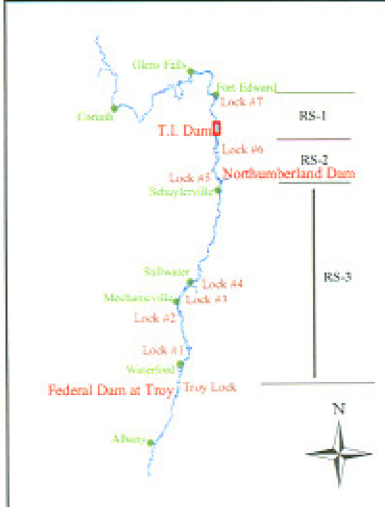
GENdes

Jul 29, 2005.

DN - \\Daleel\D_DRIVE\GENdes\Documents\Reports\IDR\Figure_E-4-7.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Hard-Bottom
- Cohesive Sediment
- Non-Cohesive Sediment

UPPER HUDSON RIVER STUDY AREA

Figure E-4-7d. Sediment bed map for Thompson Island Pool.

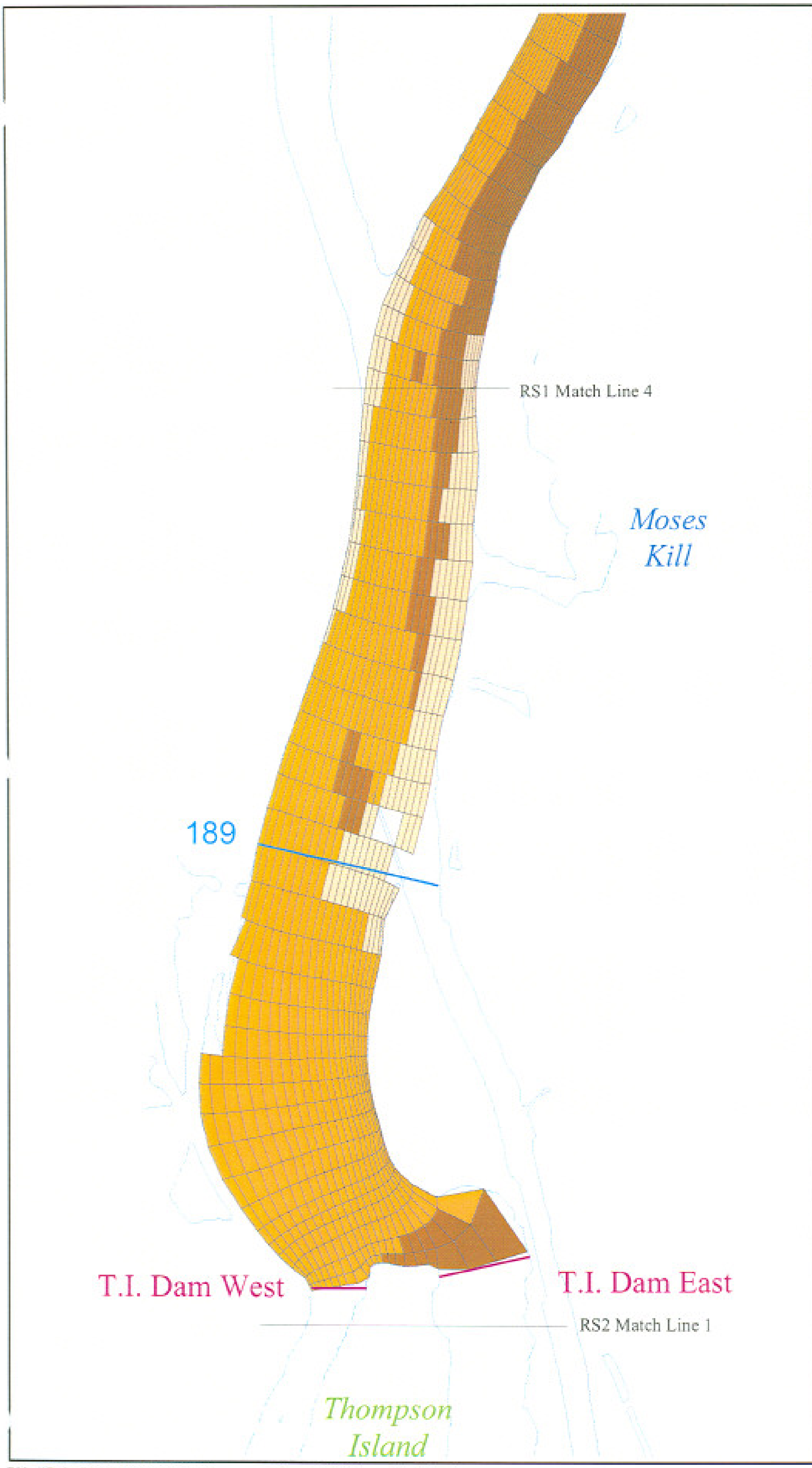
RM189 to RM190

QEA Quantitative Environmental Analysis, LLC

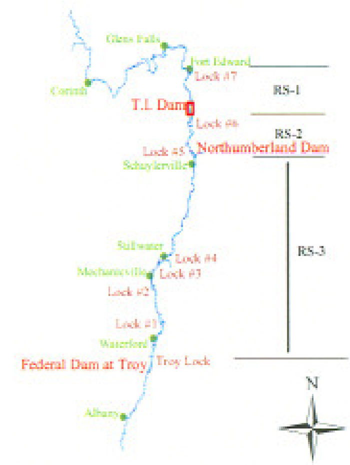
GENdes

Jul 29, 2005.

DN - \\Daleel\D_DRIVE\GENdes\Documents\Reports\IDR\Figure_E-4-7.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Hard-Bottom
- Cohesive Sediment
- Non-Cohesive Sediment

UPPER HUDSON RIVER STUDY AREA

Figure E-4-7e. Sediment bed map for Thompson Island Pool.

RM188 to RM189

QEA Quantitative Environmental Analysis, LLC

GENdes Jul 29, 2005.

DN - \\Daleel\D_DRIVE\GENdes\Documents\Reports\IDR\Figure_E-4-7.mxd

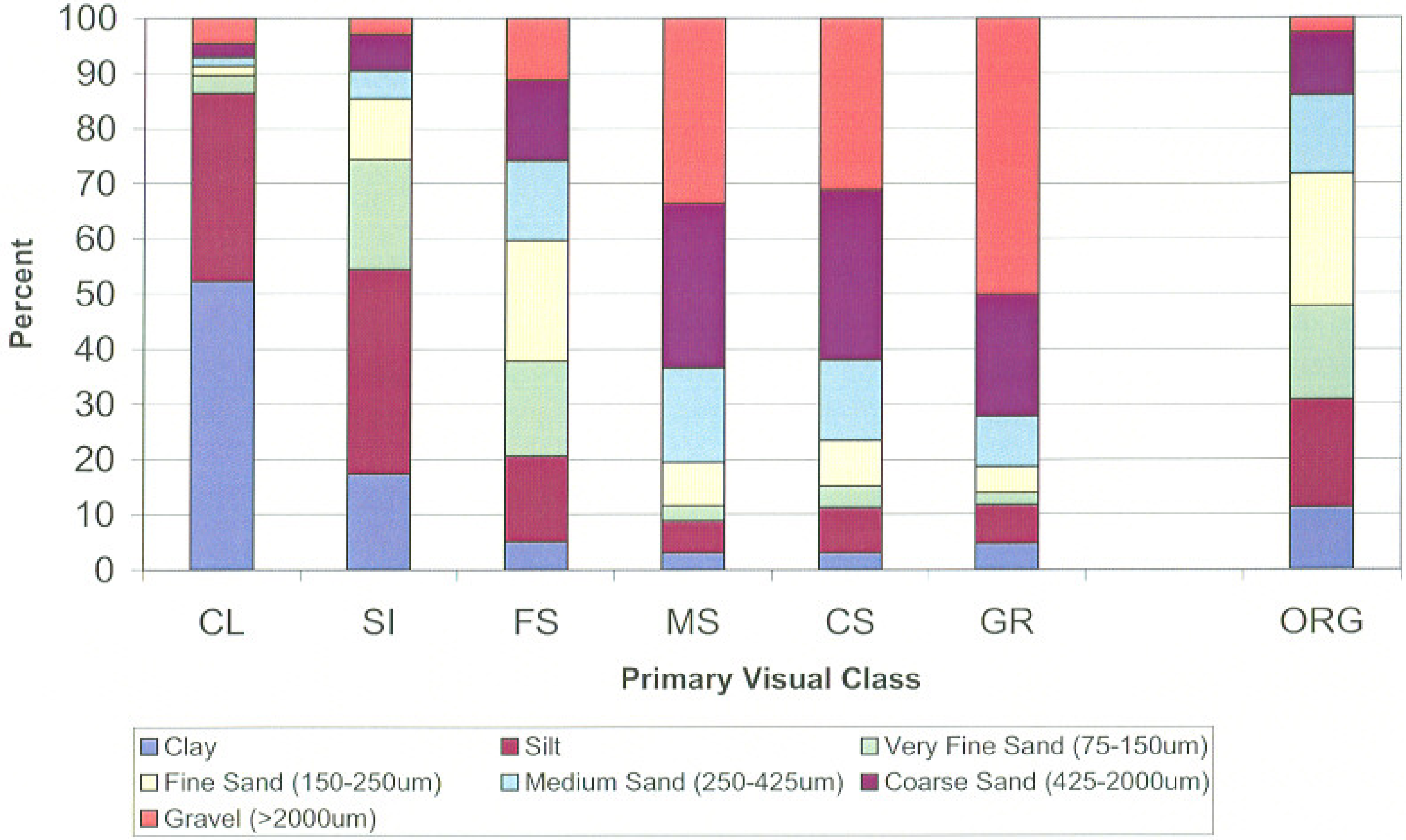
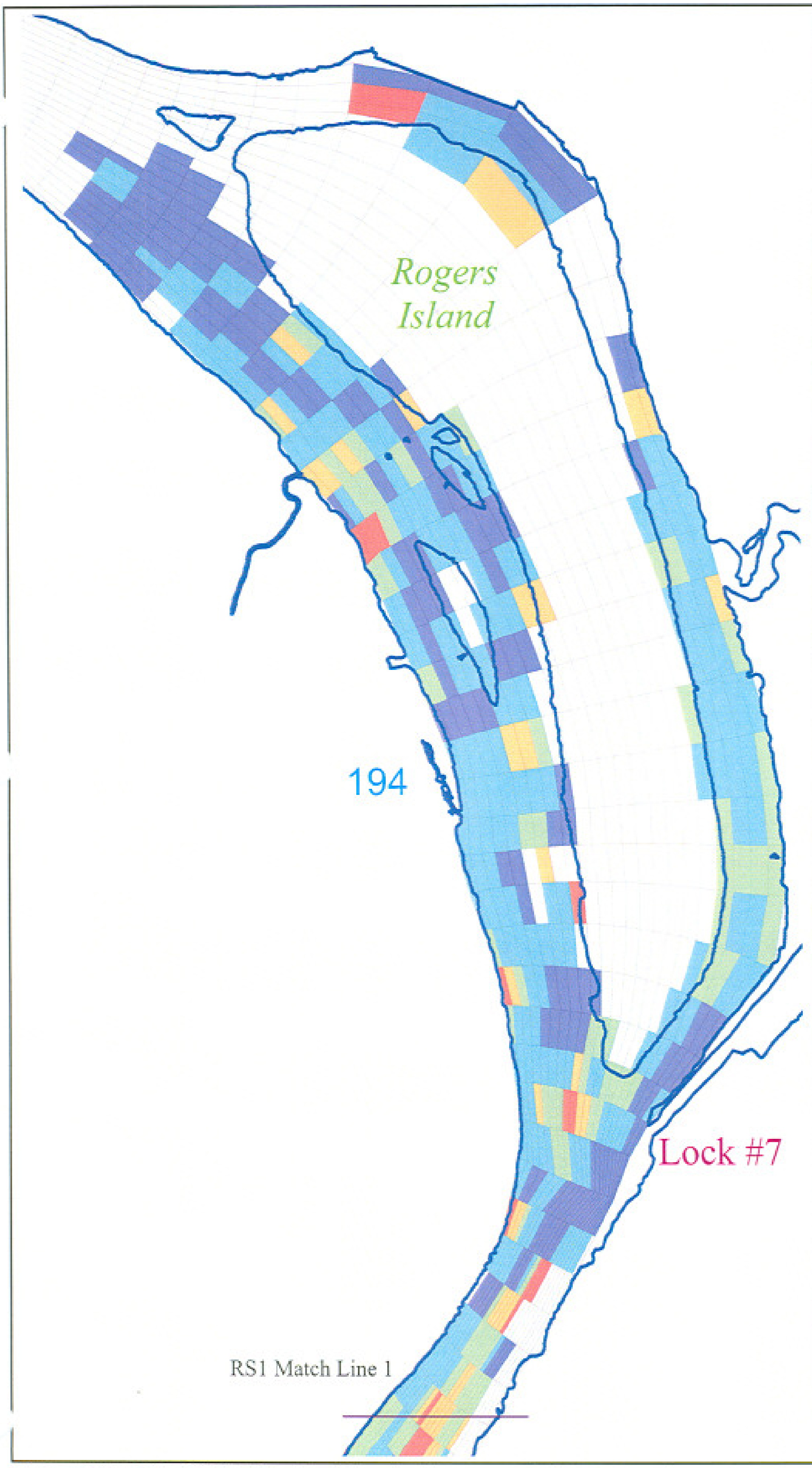
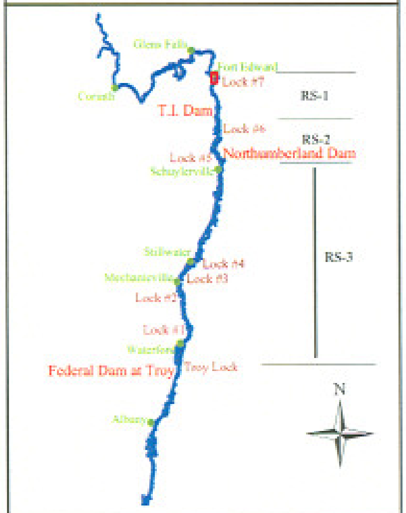


Figure E-4-8. Average Grainsize Composition of SSAP Primary Visual Classes

\\dalee\\d_drive\\GENdes\\Documents\\Reports\\IDR\\Figure_E-4-8_Phase1_GS_VIS_Results_050505.xls



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Percent Clay and Silt

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60
- Shoreline
- Model Grid

Figure E-4-9a.

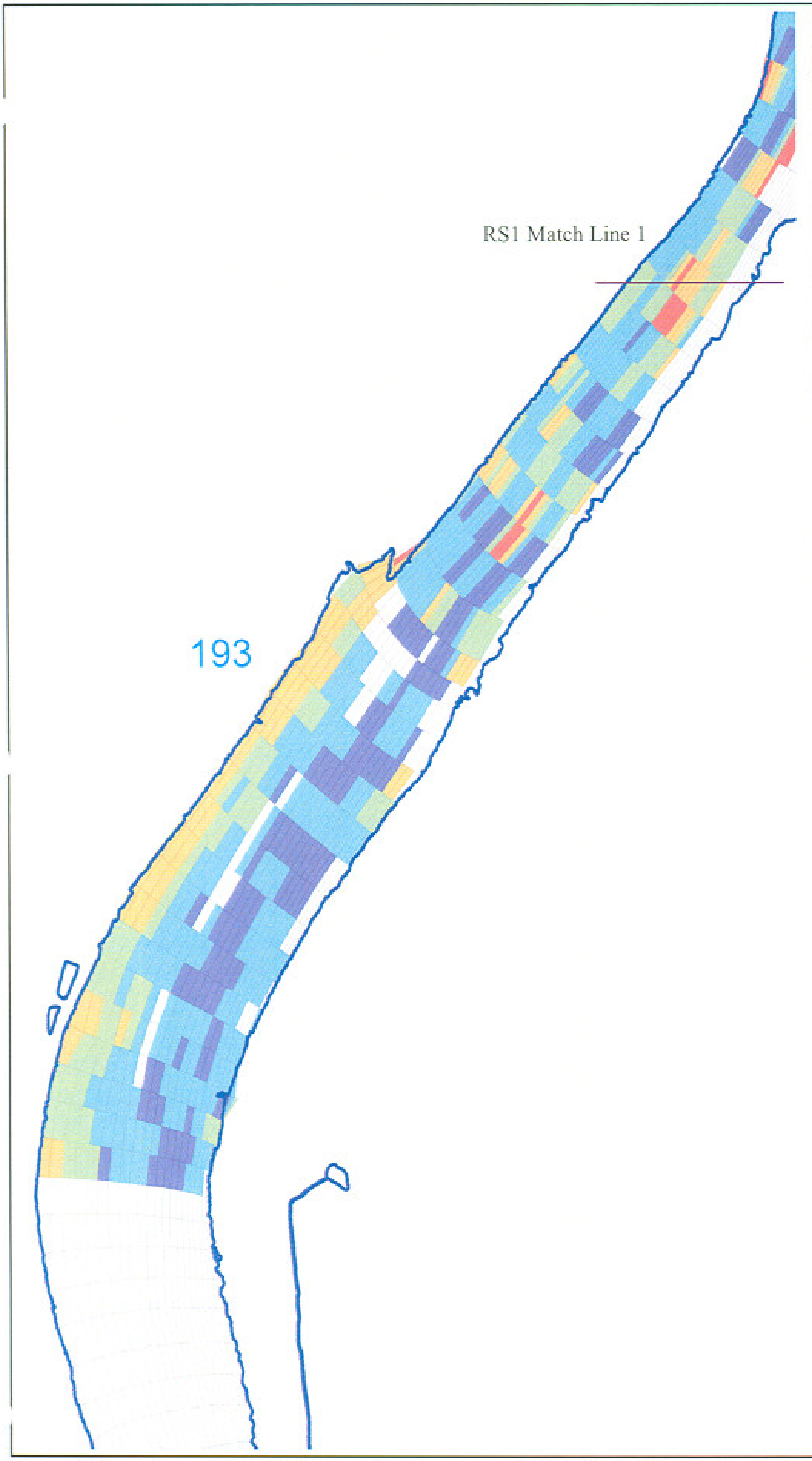
Percent Clay and Silt in Total Sediment Bed by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

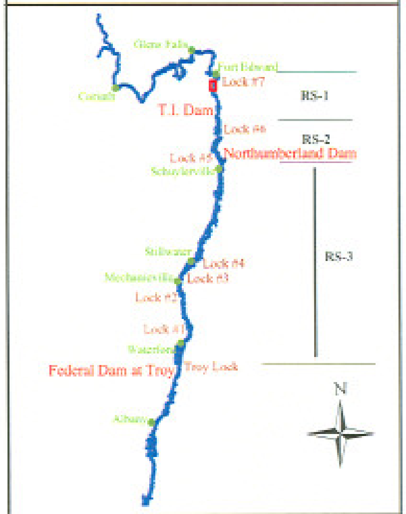
GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Percent Clay and Silt

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60
- Shoreline
- Model Grid

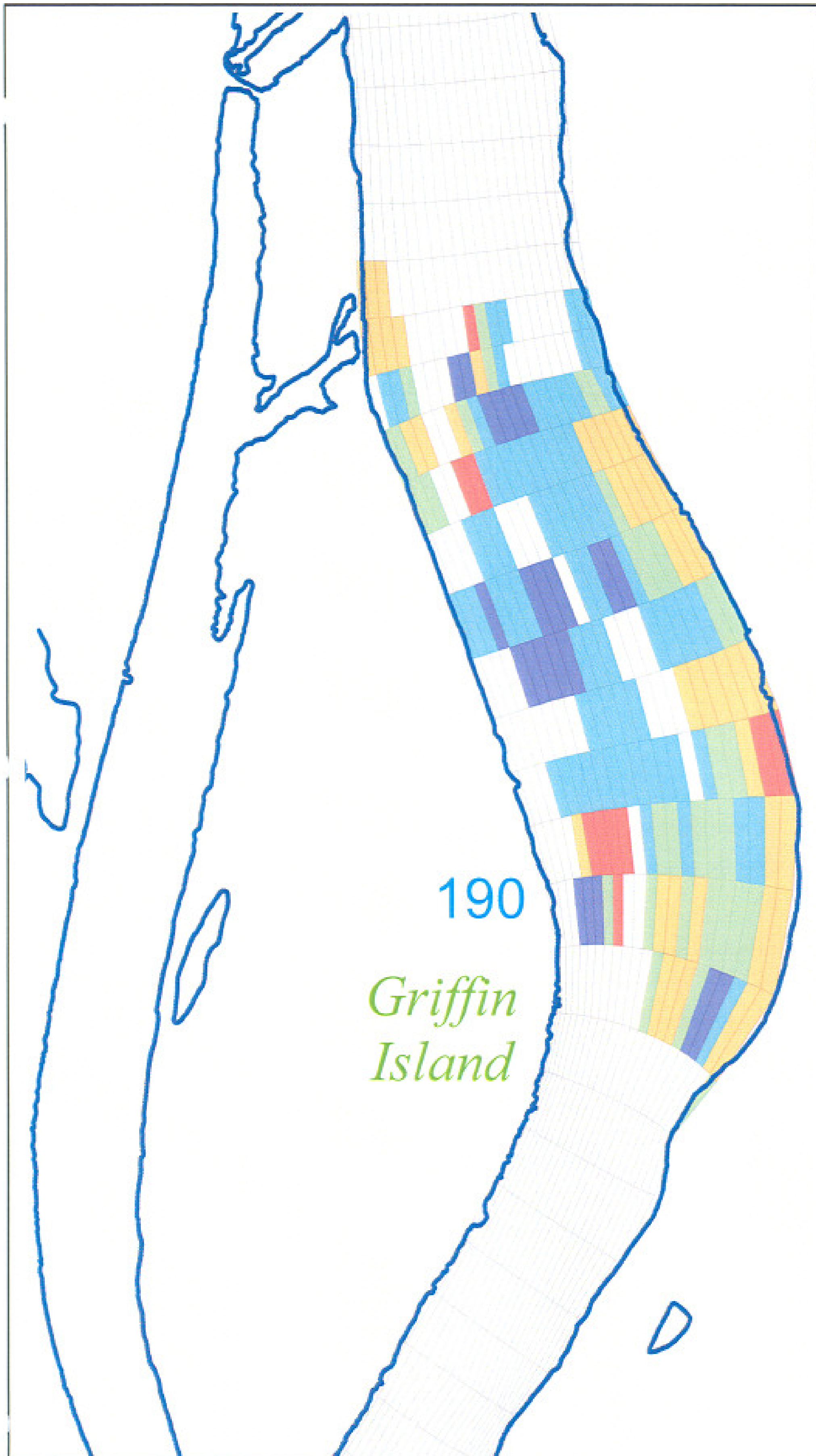
Figure E-4-9b.

Percent Clay and Silt in Total Sediment Bed by Model Grid Cell.

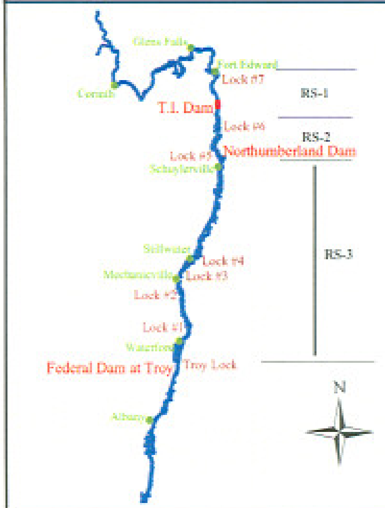
QEA Quantitative Environmental Analysis, LLC

GENdes: 232 Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrcm\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Percent Clay and Silt

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60
- Shoreline
- Model Grid

Figure E-4-9c.

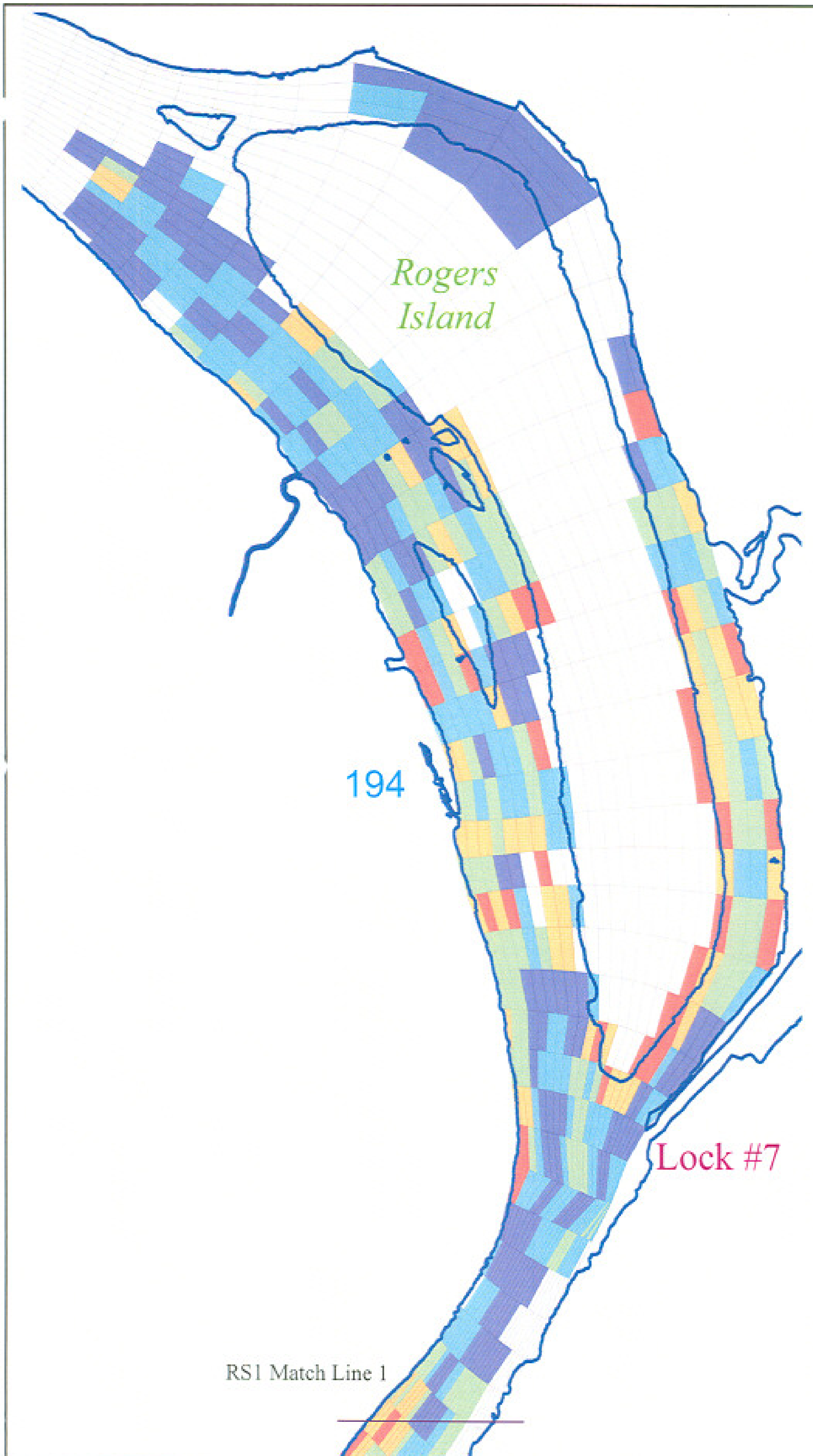
Percent Clay and Silt in Total Sediment Bed by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

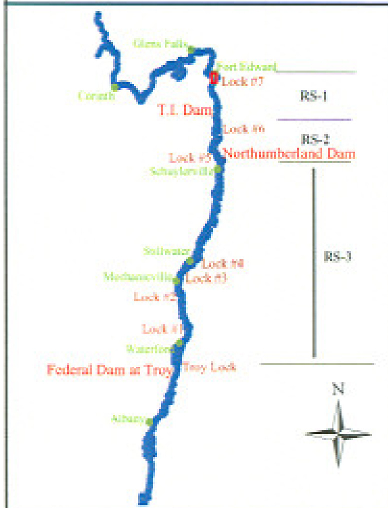
GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Percent Very Fine Sand

- 0 - 4
- 4 - 8
- 8 - 12
- 12 - 16
- 16 - 20
- Shoreline
- Model Grid

Figure E-4-10a.

Percent Very Fine Sand in Total Sediment Bed by Model Grid Cell.

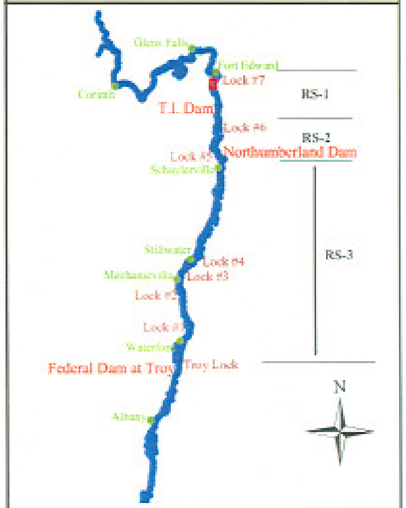
QEA Quantitative Environmental Analysis, LLC

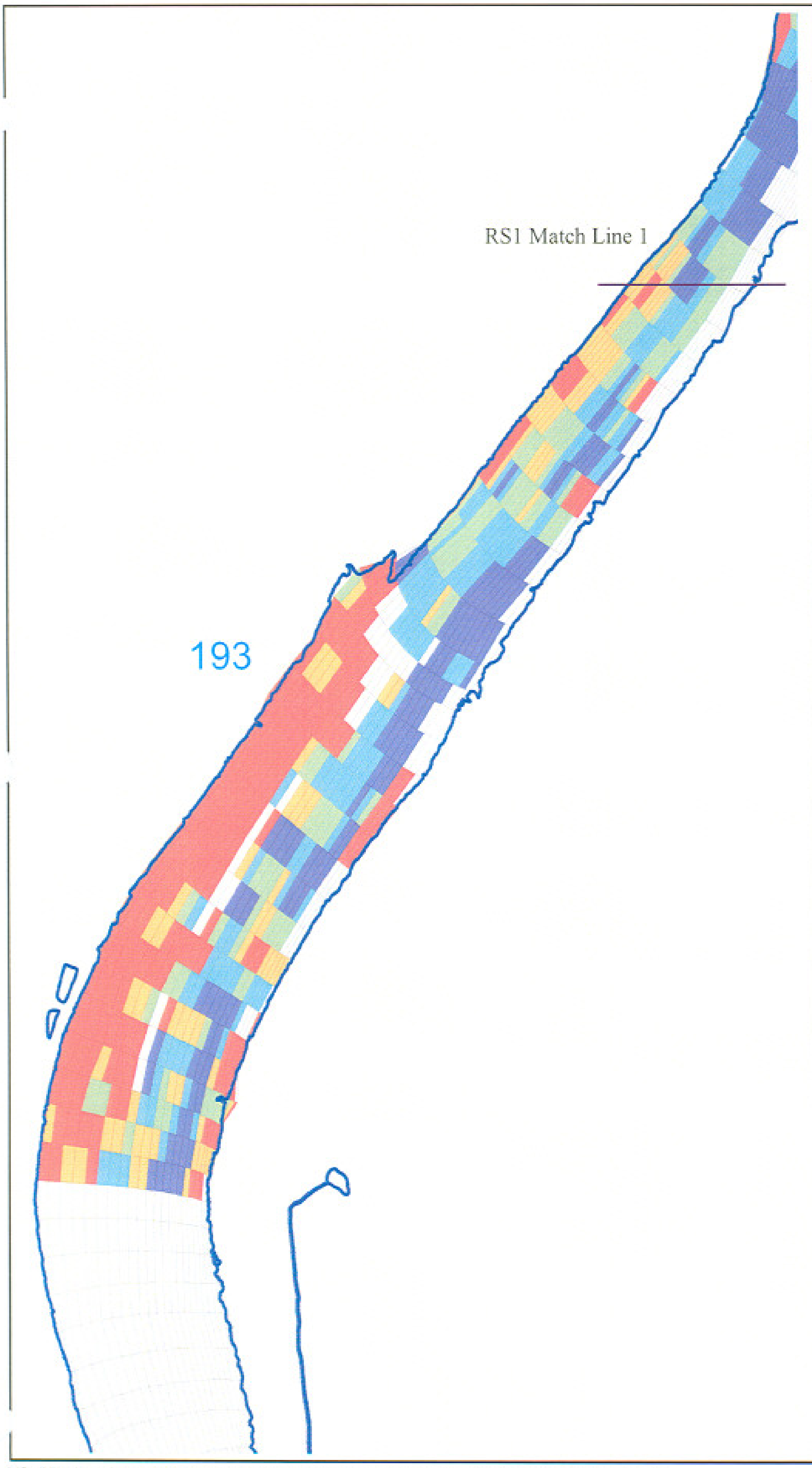
GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

LOCATOR MAP OF THE UPPER HUDSON RIVER





GRAPHIC SCALE

0 250 500 Feet

LEGEND

Percent Very Fine Sand

- 0 - 4
- 4 - 8
- 8 - 12
- 12 - 16
- 16 - 20
- Shoreline
- Model Grid

Figure E-4-10b.

Percent Very Fine Sand in Total Sediment Bed by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

GENdes: 232 Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

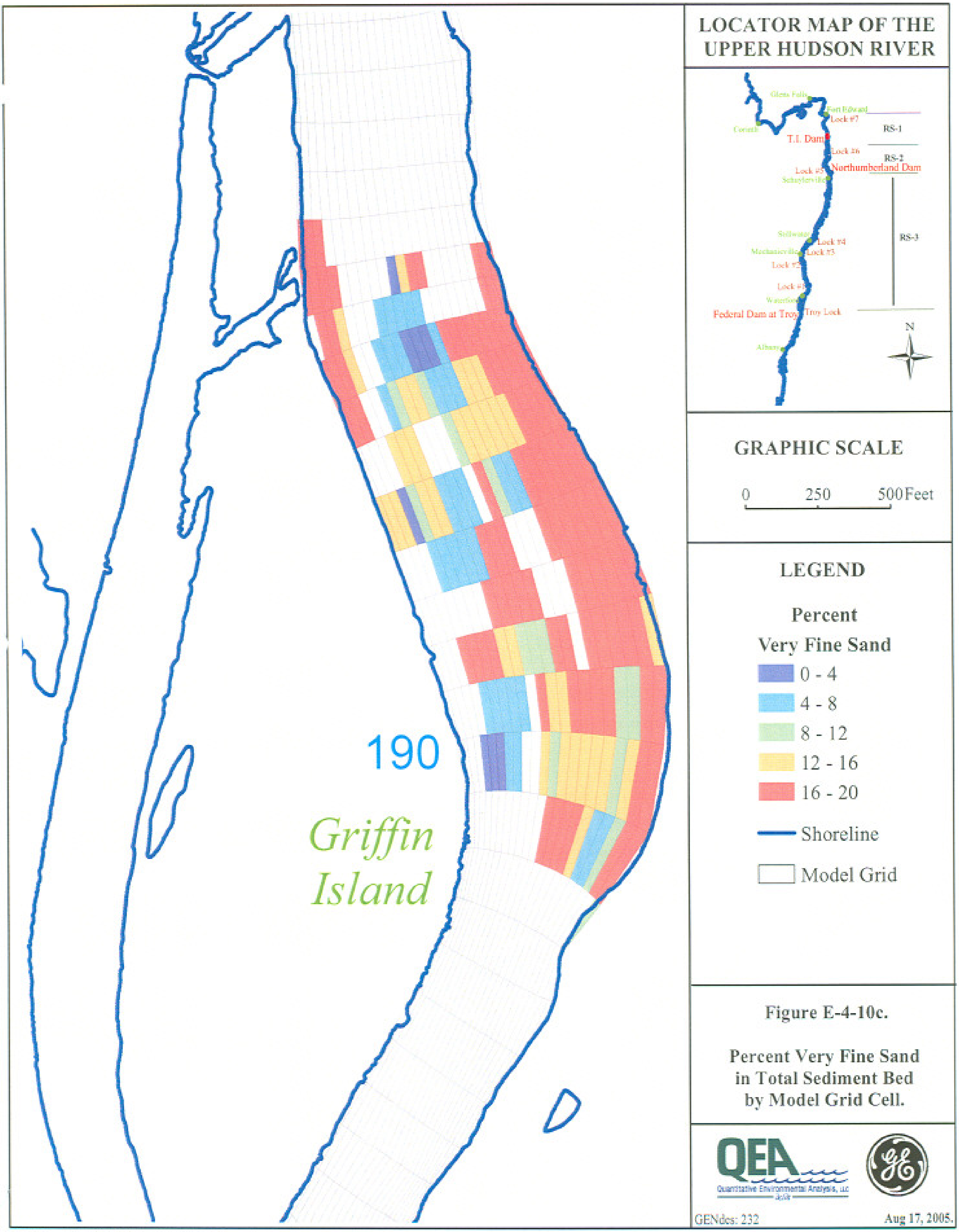


Figure E-4-10c.

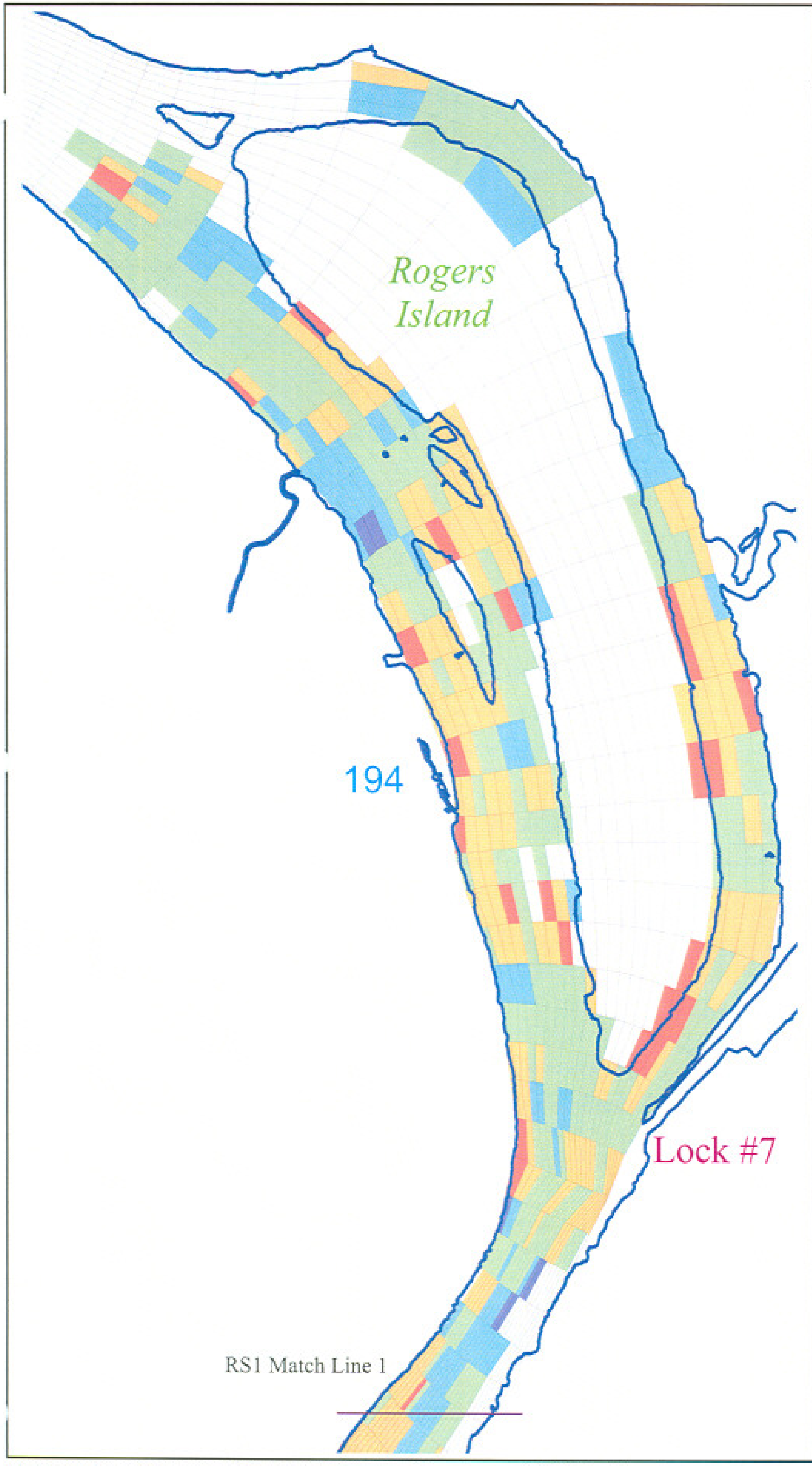
Percent Very Fine Sand in Total Sediment Bed by Model Grid Cell.

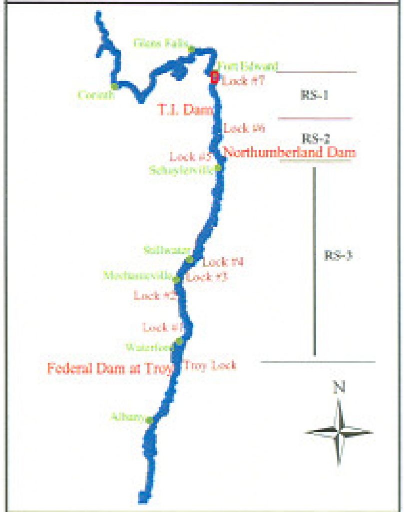
QEA Quantitative Environmental Analysis, LLC

GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd





GRAPHIC SCALE

0 250 500Feet

LEGEND

Percent

Fine and Medium Sand

- 0 - 8
- 8 - 16
- 16 - 24
- 24 - 32
- 32 - 40
- Shoreline
- Model Grid

Figure E-4-11a.

Percent Fine and Medium Sand in Total Sediment Bed by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

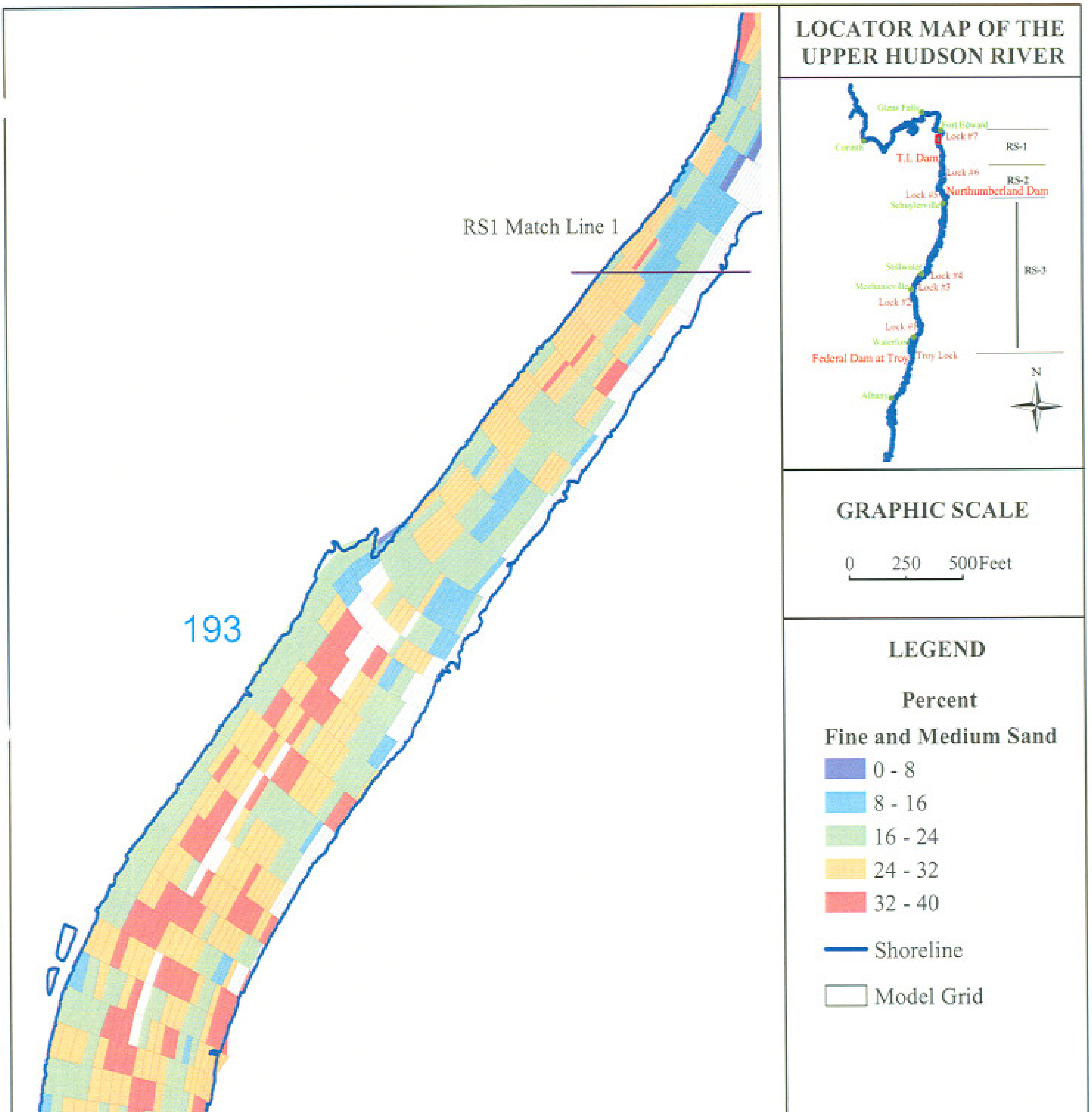


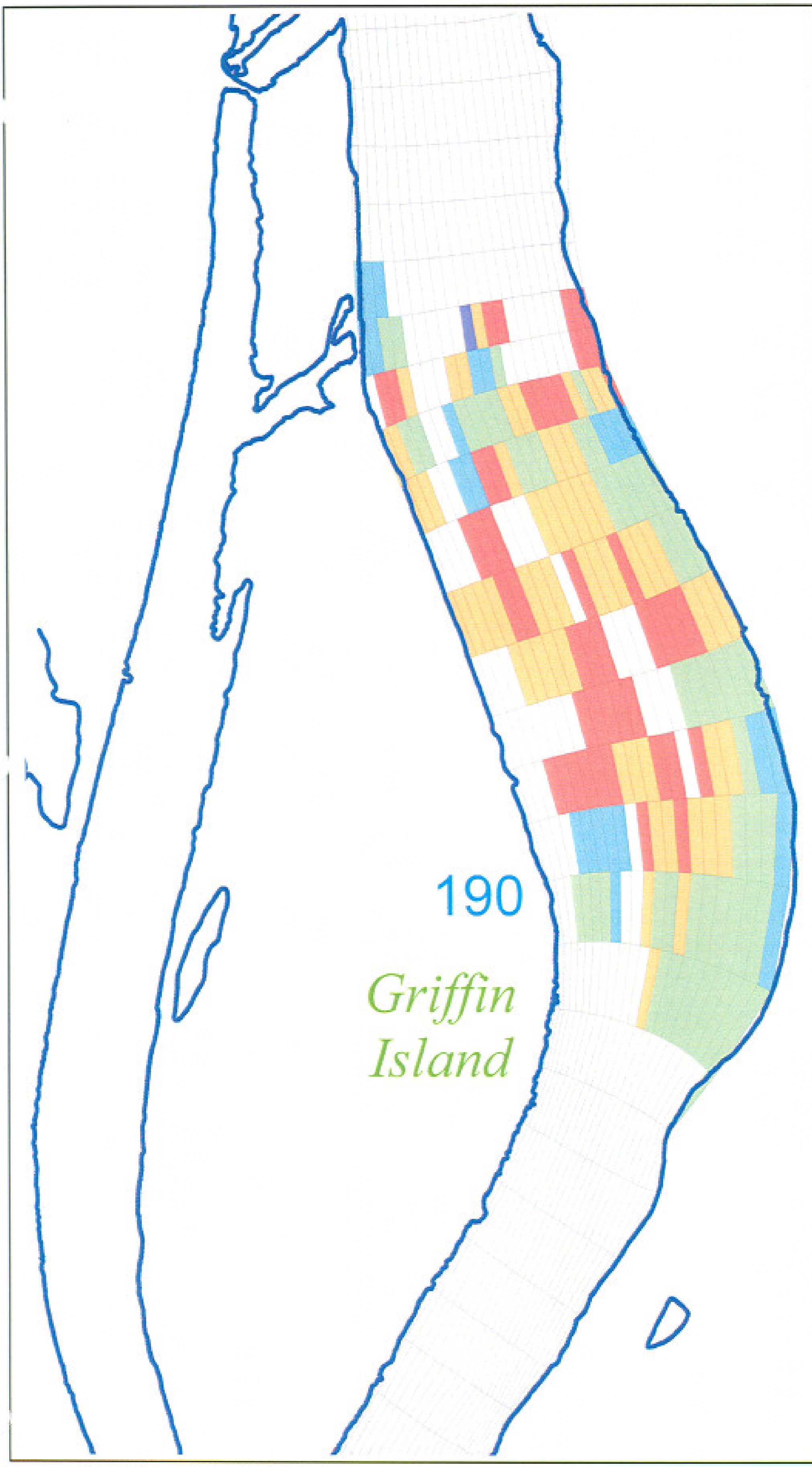
Figure E-4-11b.

Percent Fine and Medium Sand in Total Sediment Bed by Model Grid Cell.

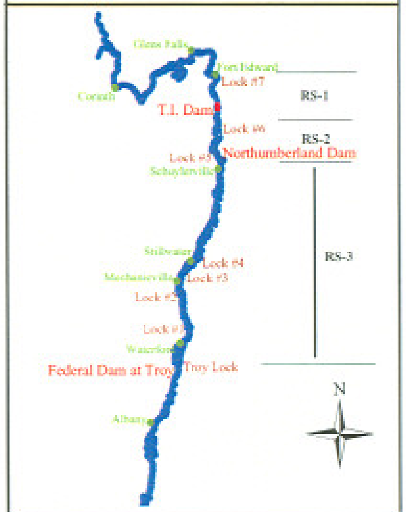
GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Percent Fine and Medium Sand

- 0 - 8
- 8 - 16
- 16 - 24
- 24 - 32
- 32 - 40
- Shoreline
- Model Grid

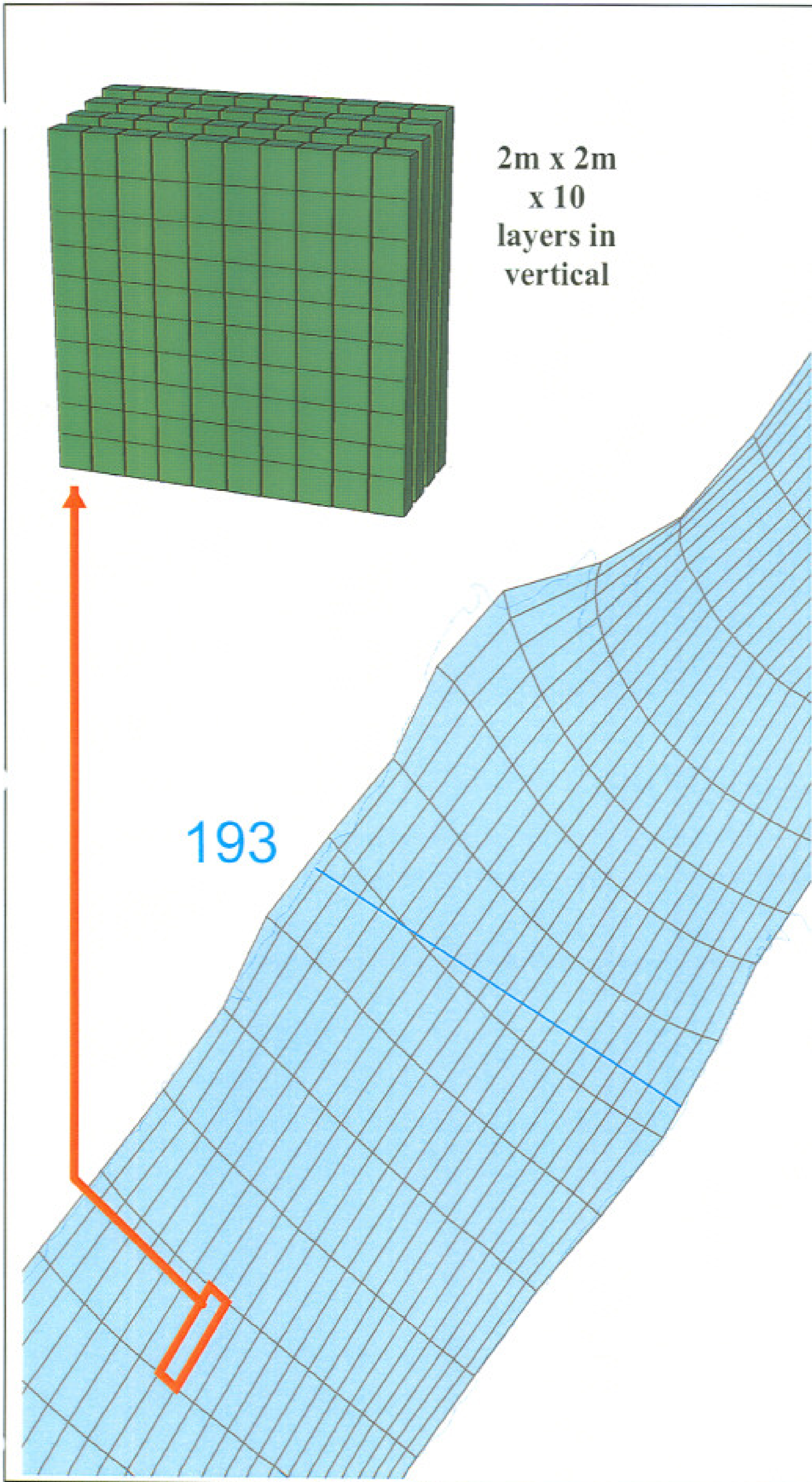
Figure E-4-11c.

Percent Fine and Medium Sand in Total Sediment Bed by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

GENdes: 232 Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER

GRAPHIC SCALE

0 100 200 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements

UPPER HUDSON RIVER STUDY AREA

Figure E.4-12.

Relationship between numerical grids used for 2-D far-field and 3-D near-field models.

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GENdes Jul 29, 2005.

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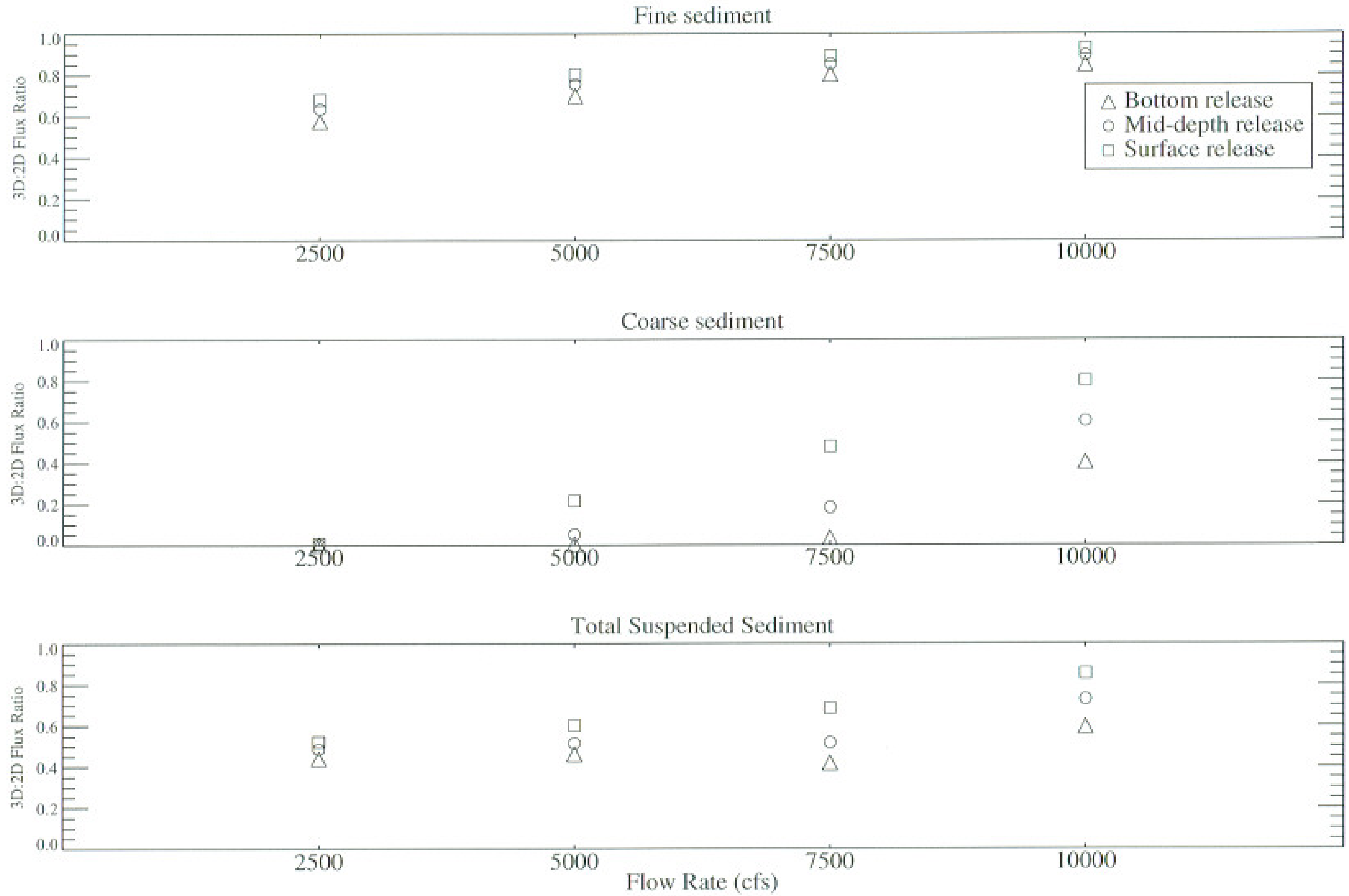

Figure E-4-13. Effect of river flow rate on 2-D/3-D model results: ratio of 3-D to 2-D sediment flux transported out of 2-D grid cell.

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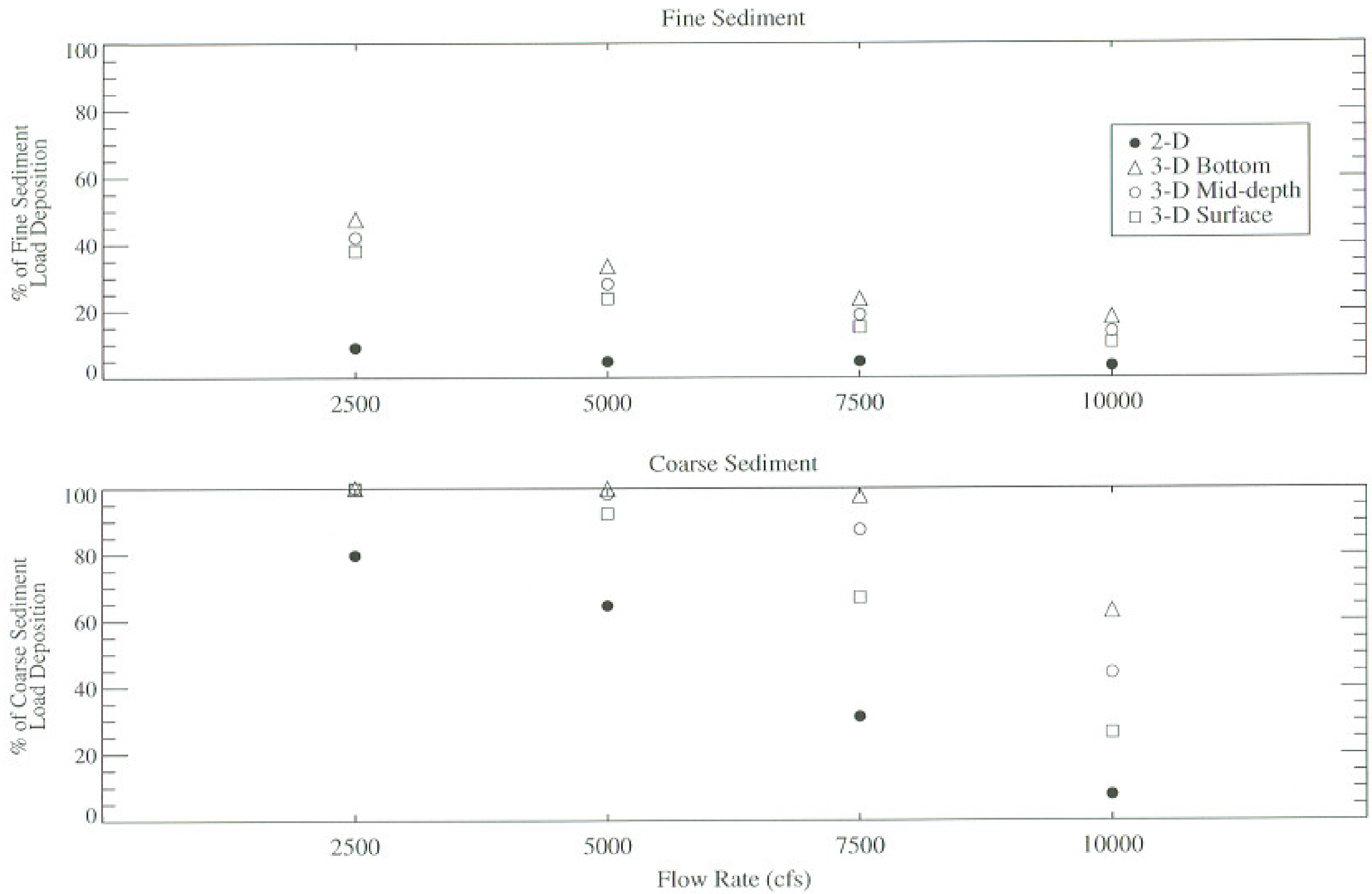

Figure E-4-14. Effect of river flow rate on 2-D/3-D model results: percent of released load deposited within 2-D grid cell.

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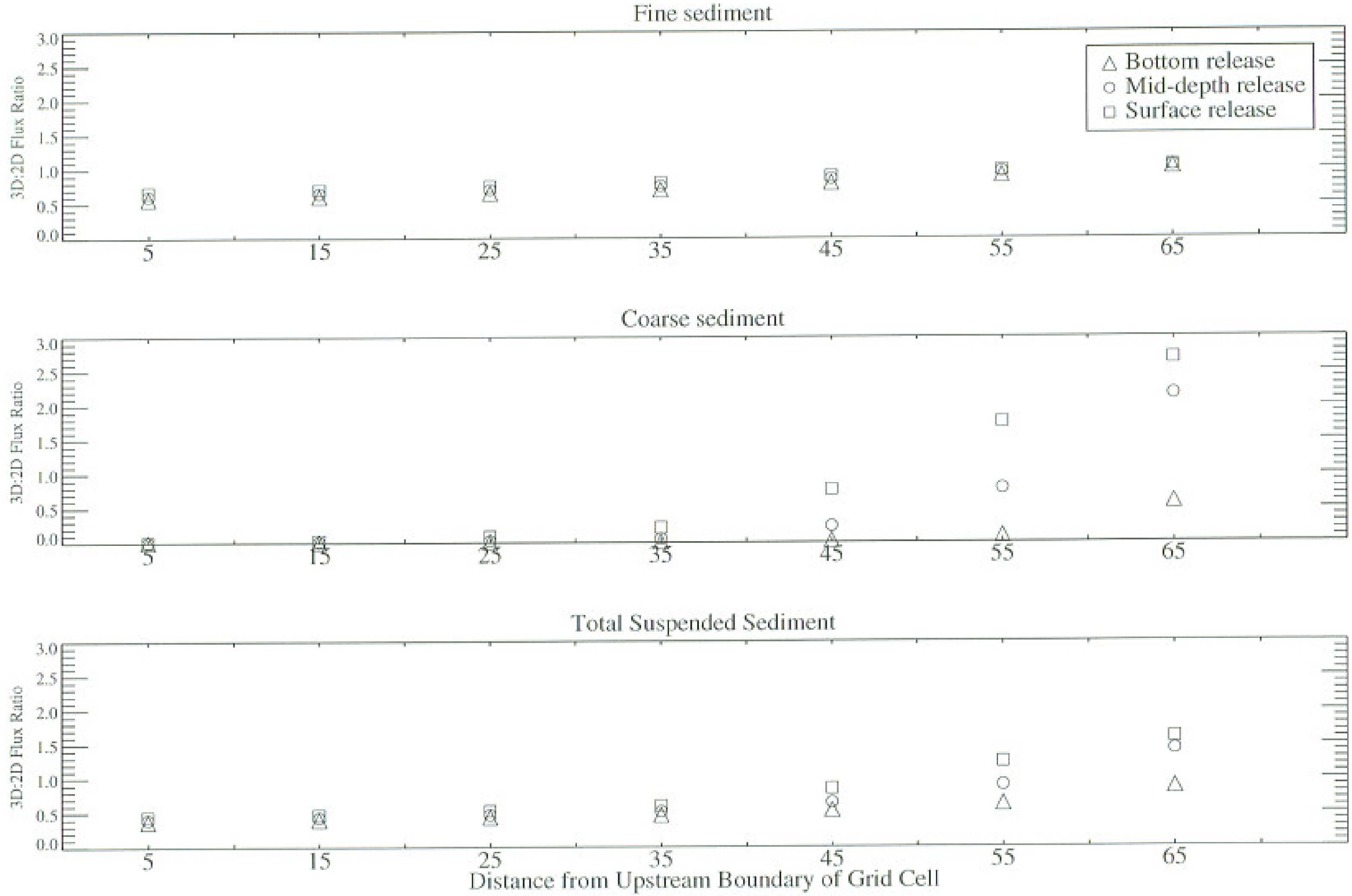

Figure E-4-15. Effect of load release location in 3-D grid on 2-D/3-D model results: ratio of 3-D to 2-D sediment flux transported out of 2-D grid cell.

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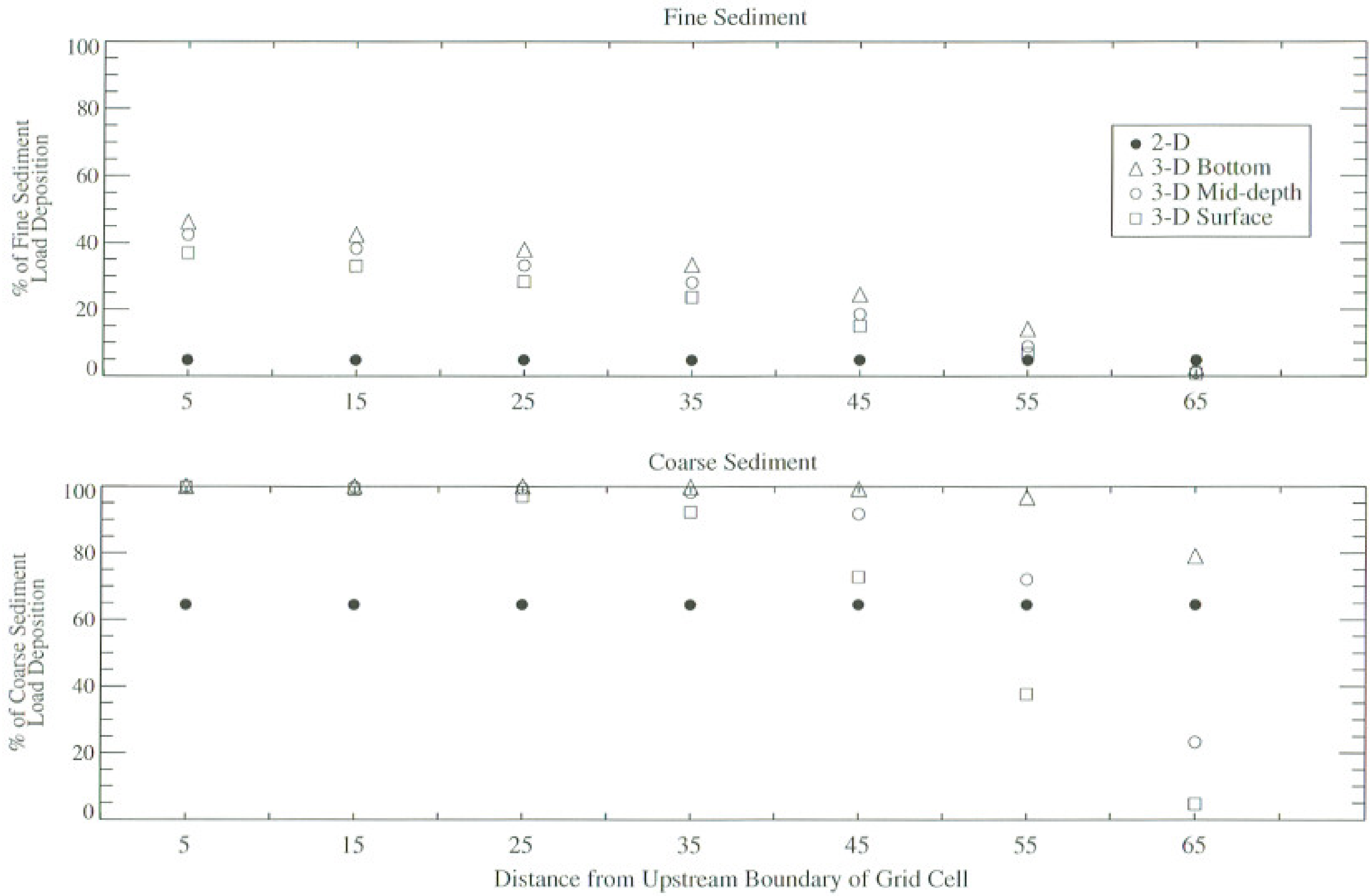

Figure E-4-16. Effect of load release location in 3-D grid on 2-D/3-D model results: percent of released load deposited within 2-D grid cell.

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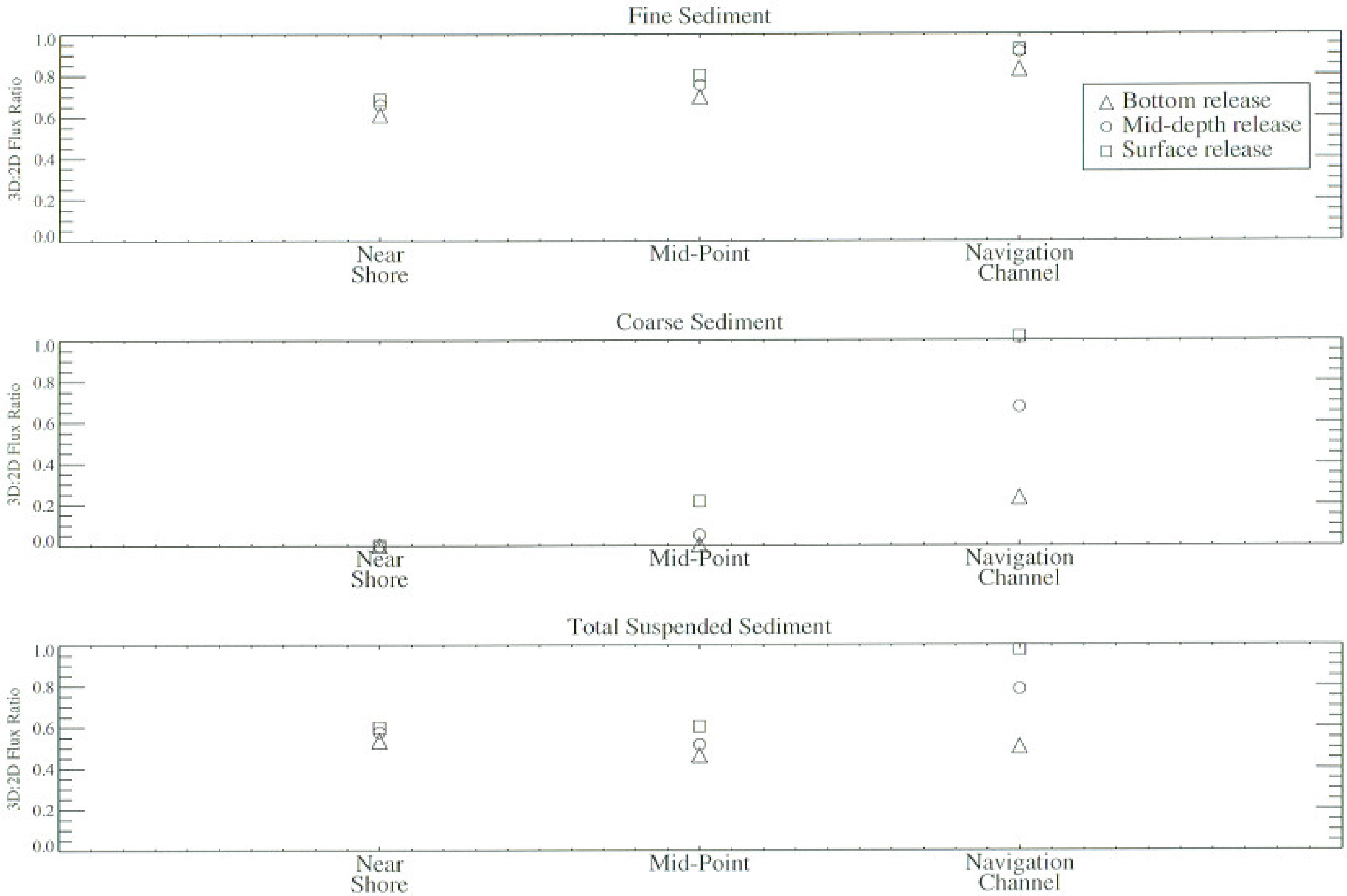

Figure E-4-17. Effect of 2-D grid cell location in the TIP channel (near RM 193) on 2-D/3-D model results: ratio of 3-D to 2-D sediment flux transported out of 2-D grid cell.

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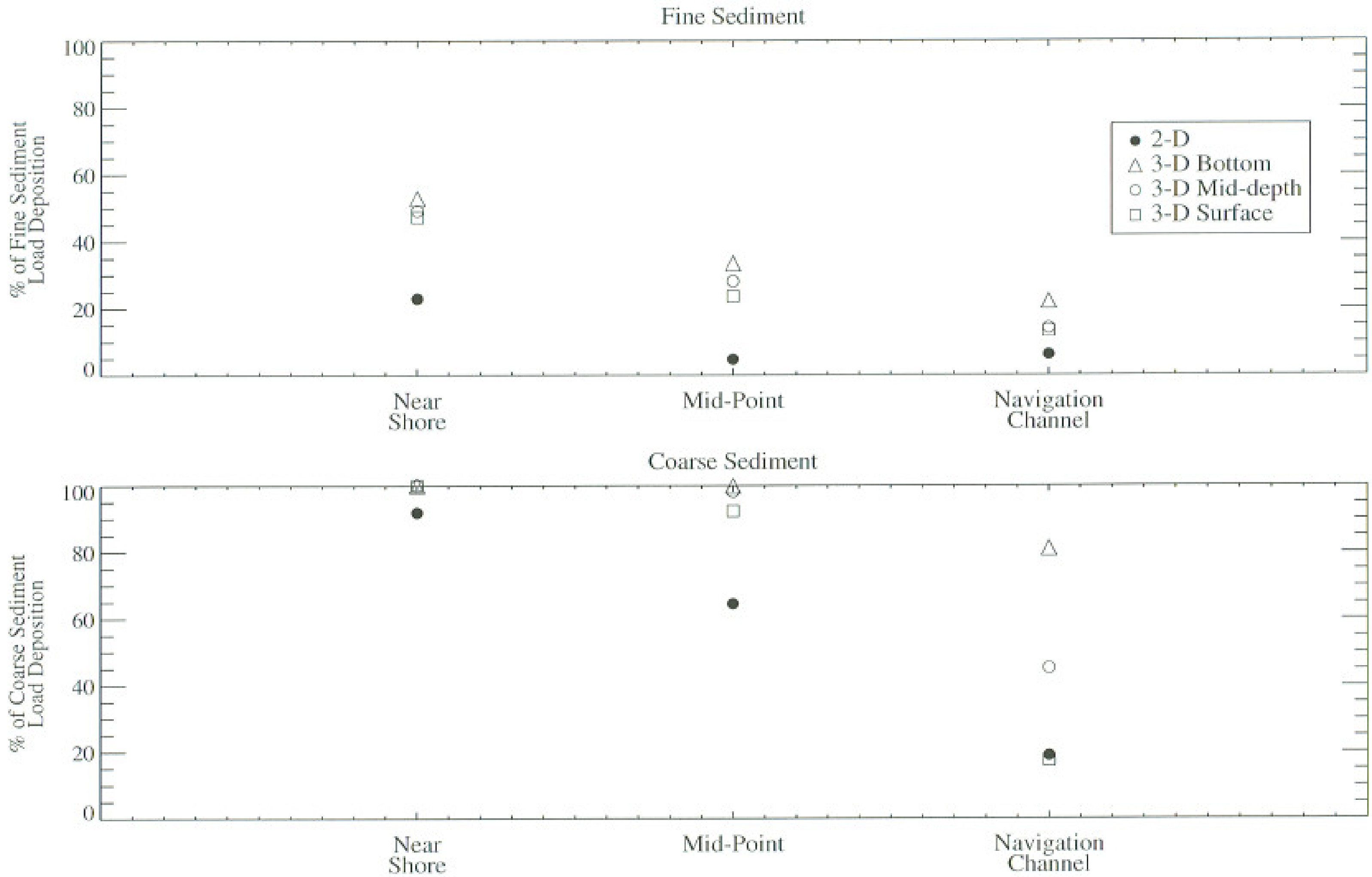

Figure E-4-18. Effect of 2-D grid cell location in the TIP channel (near RM 193) on 2-D/3-D model results: percent of released load deposited within 2-D grid cell.

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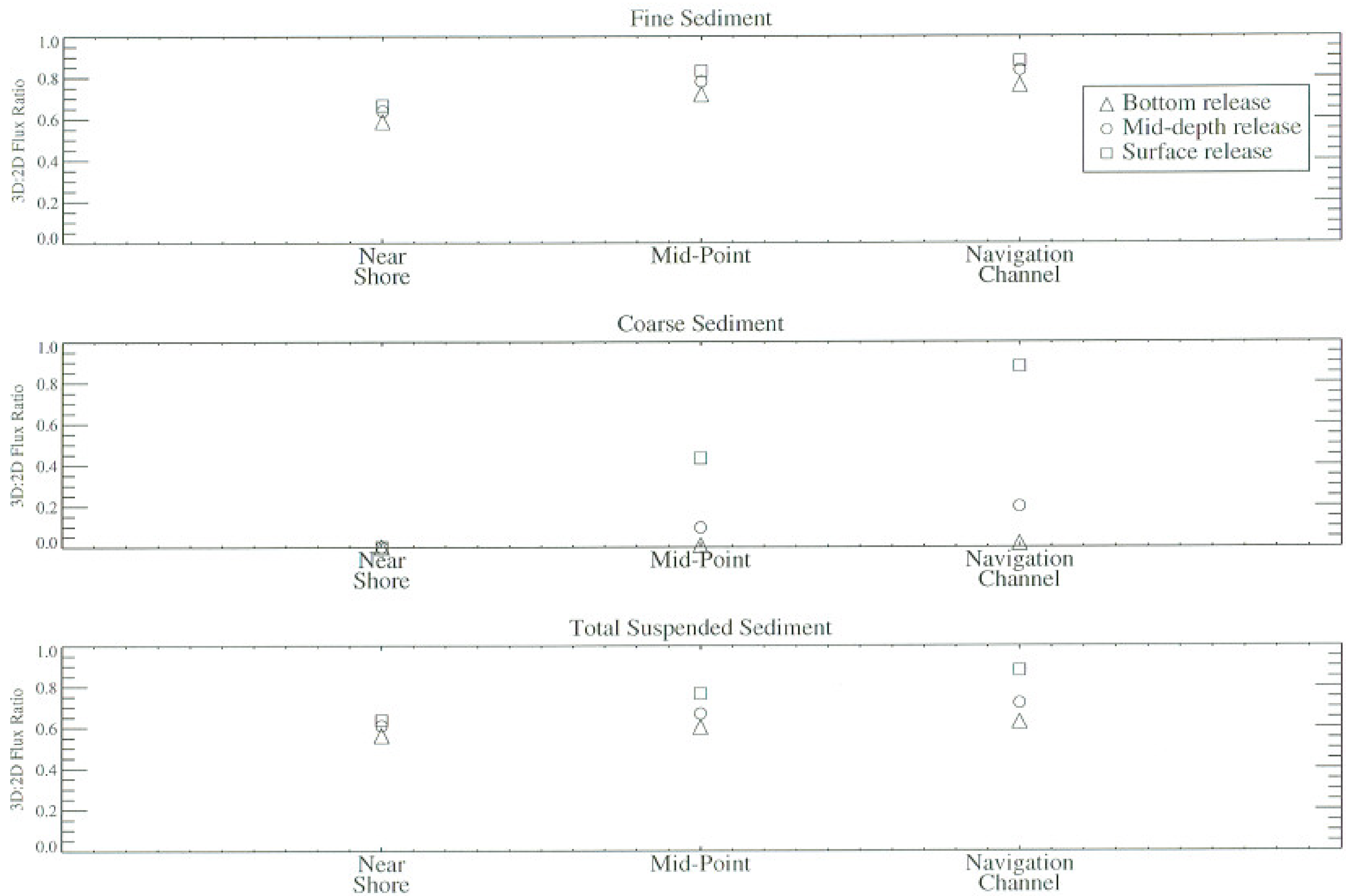

Figure E-4-19. Effect of 2-D grid cell location in the TIP channel (near Griffin Island) on 2-D/3-D model results: ratio of 3-D to 2-D sediment flux transported out of 2-D grid cell.

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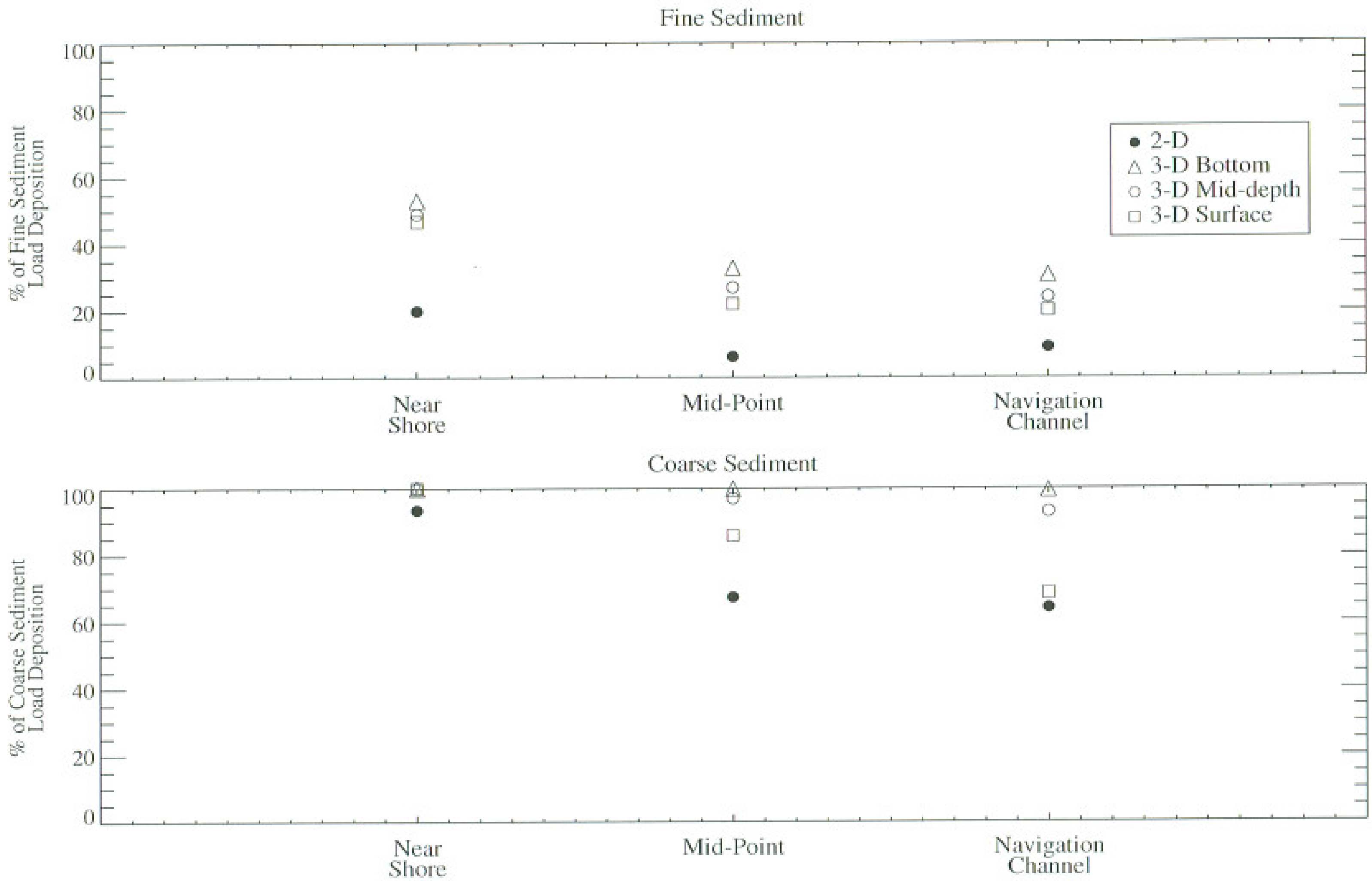

Figure E-4-20. Effect of 2-D grid cell location in the TIP channel (near Griffin Island) on 2-D/3-D model results: percent of released load deposited within 2-D grid cell.

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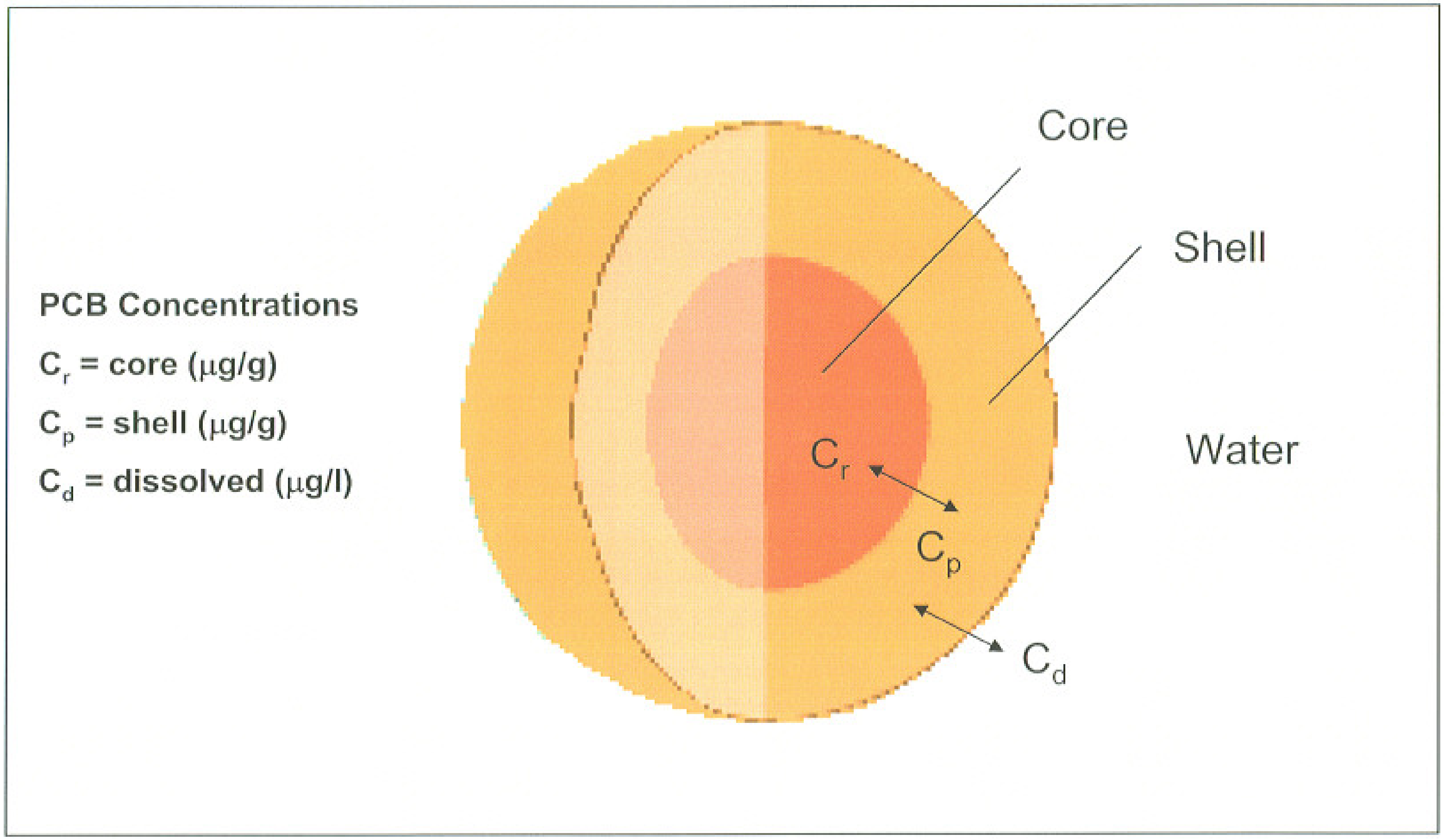
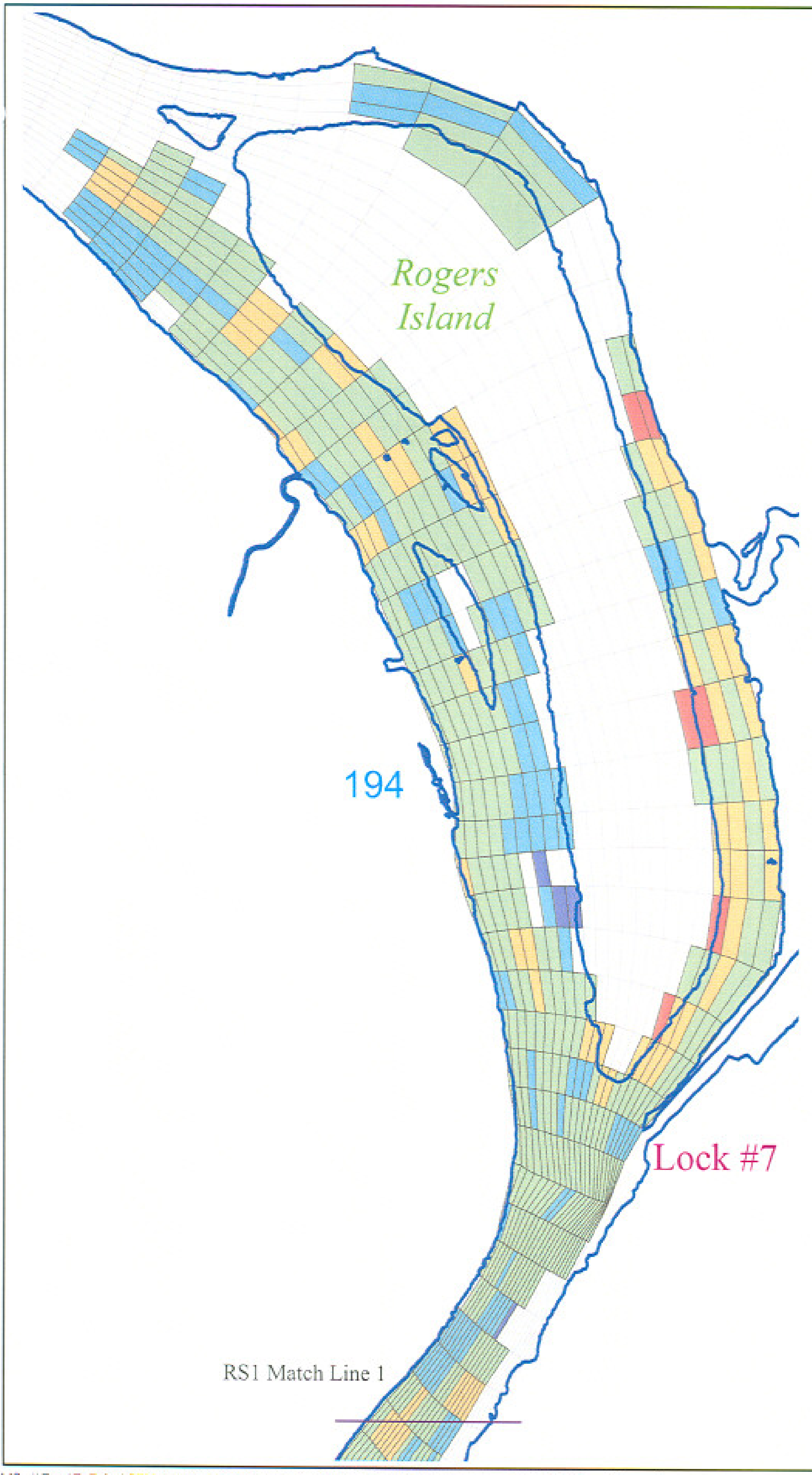
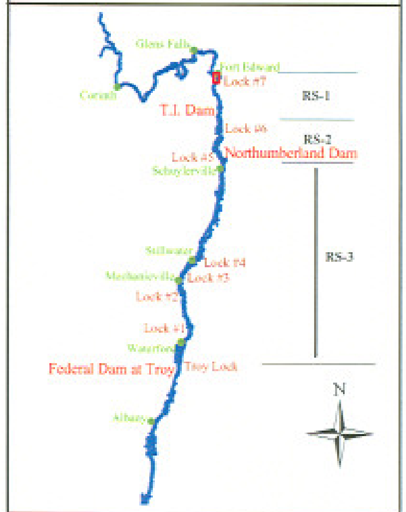


Figure E-5-1. Conceptual diagram of dual compartment radial diffusive PCB sorption sub-model



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Clay and Silt

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

Figure E-5-2a.

Average Total PCB Concentration in Clay and Silt by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

GENdes: 232

Aug 17, 2005.

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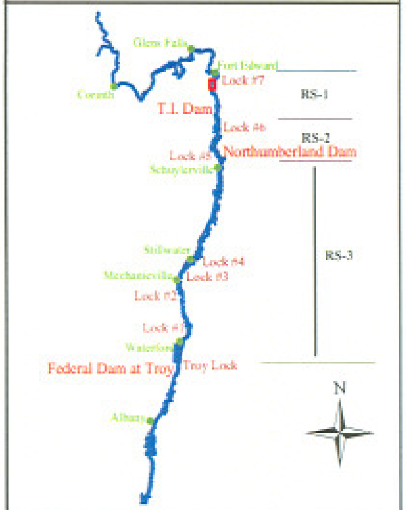
LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Clay and Silt

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

Figure E-5-2b.

Average Total PCB Concentration in Clay and Silt by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

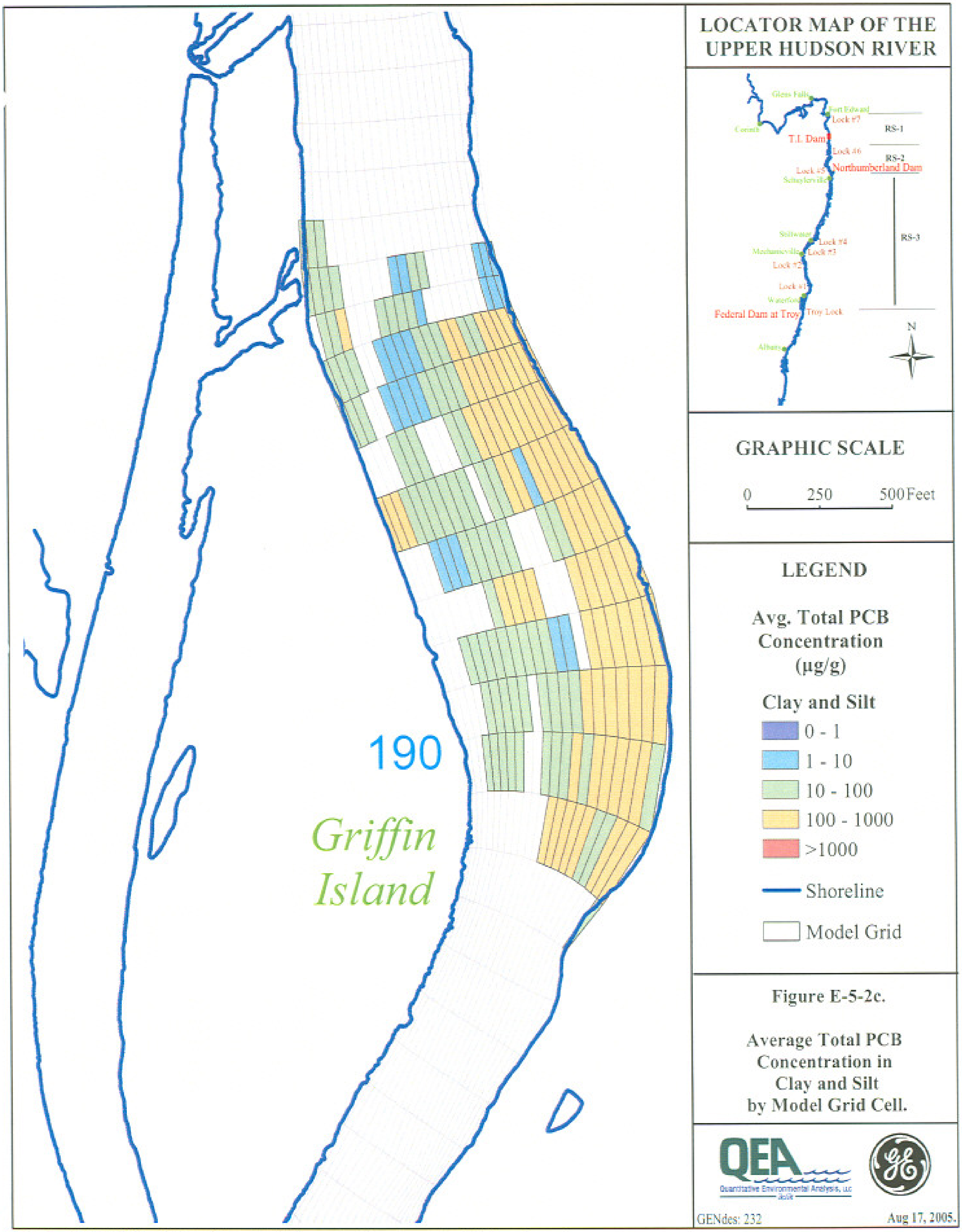
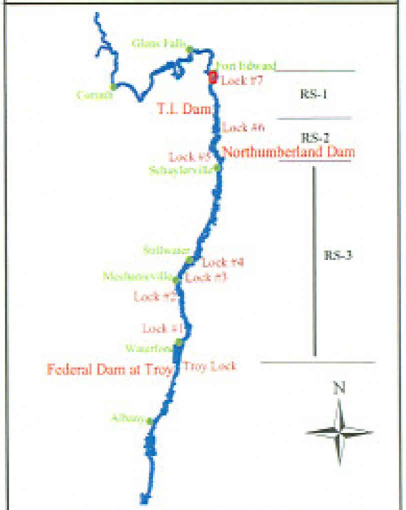


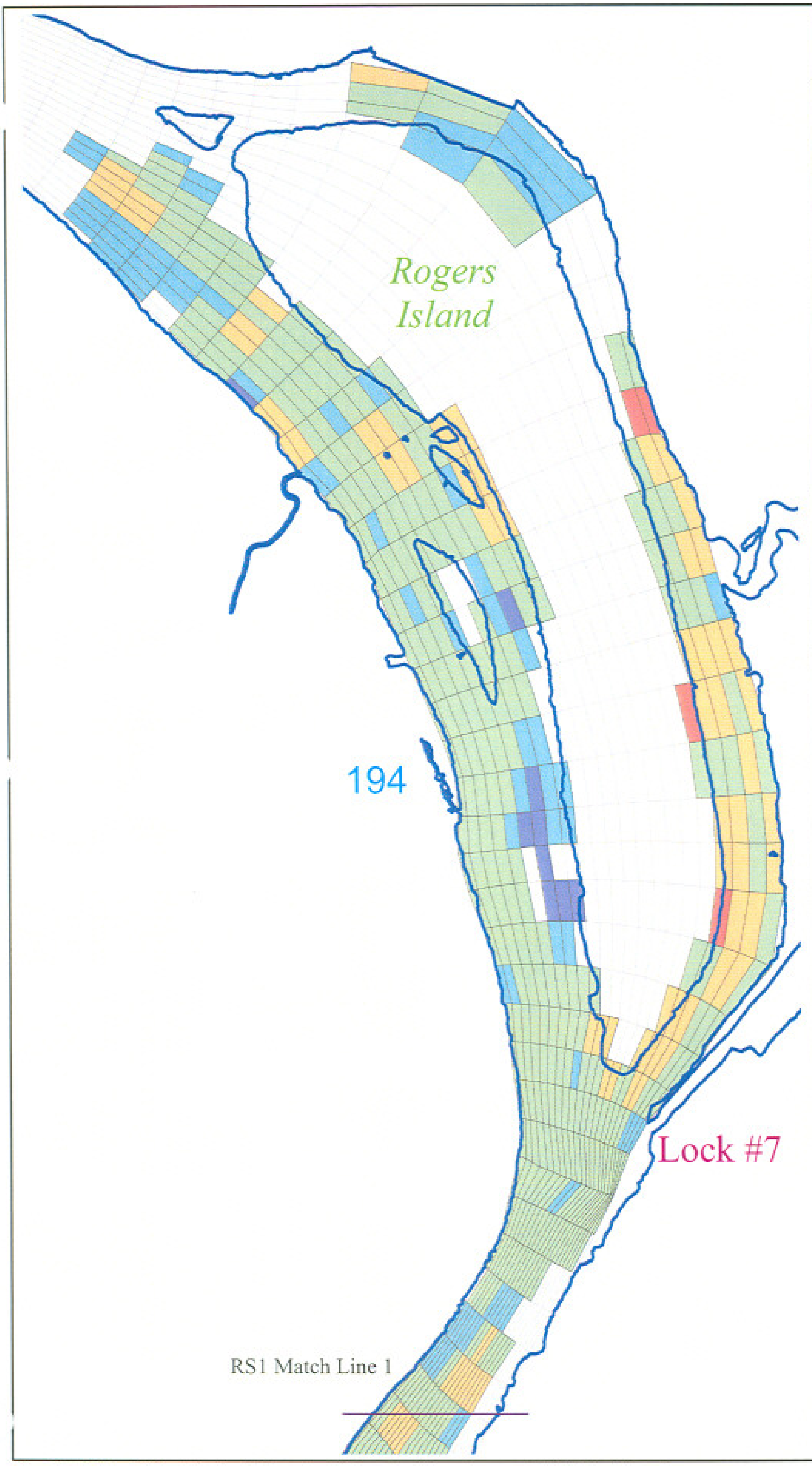
Figure E-5-2c.

Average Total PCB Concentration in Clay and Silt by Model Grid Cell.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

LOCATOR MAP OF THE UPPER HUDSON RIVER





GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Very Fine Sand

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

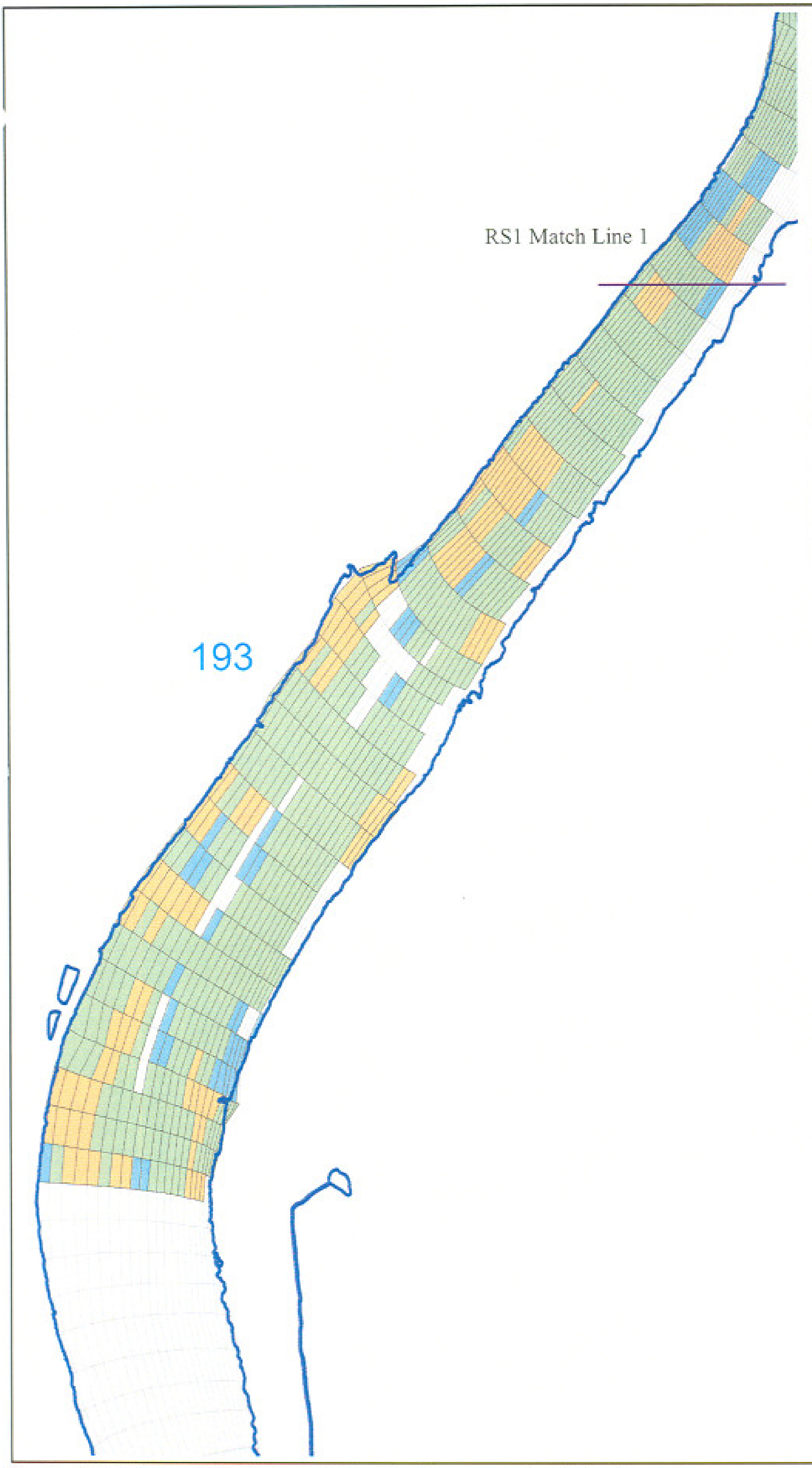
Figure E-5-3a.

Average Total PCB Concentration in Very Fine Sand by Model Grid Cell.

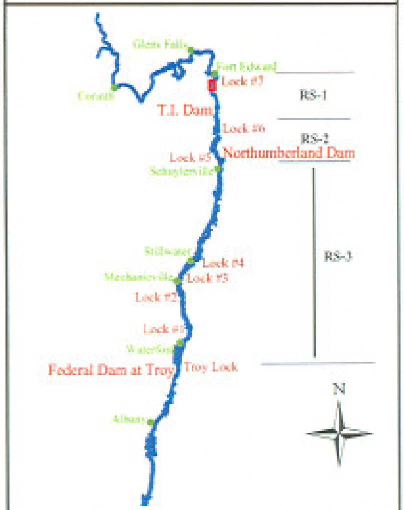
QEA Quantitative Environmental Analysis, LLC

GENdes: 232 Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (μg/g)

Very Fine Sand

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

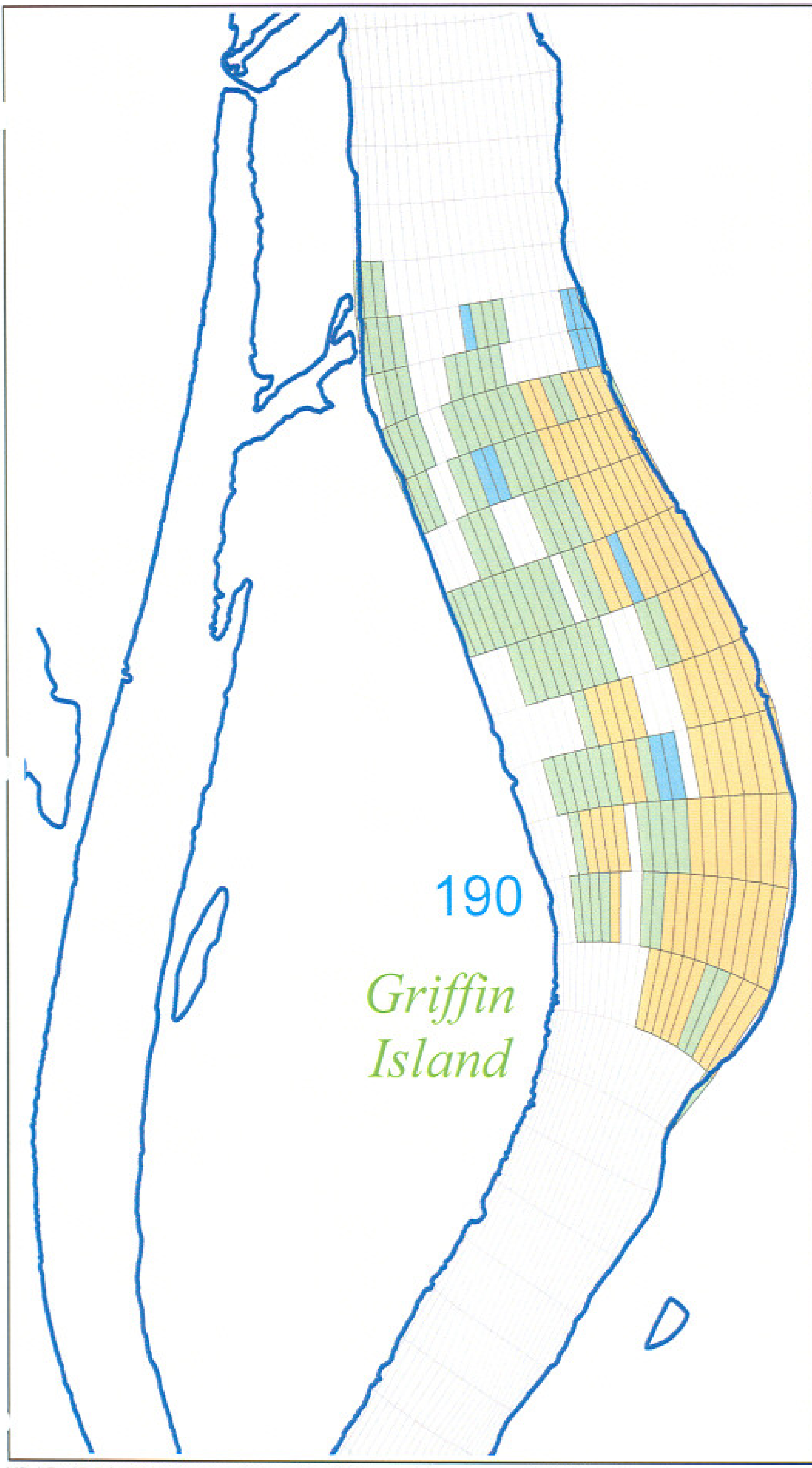
Figure E-5-3b.

Average Total PCB Concentration in Very Fine Sand by Model Grid Cell.

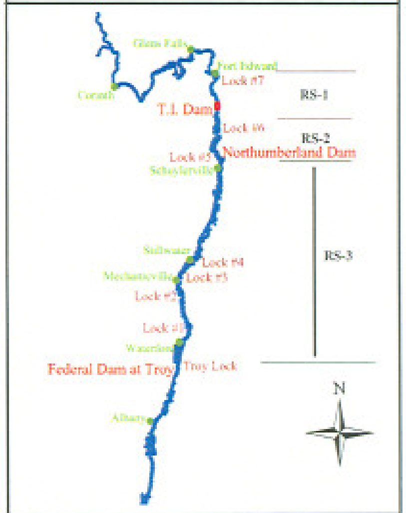
QEA Quantitative Environmental Analysis, LLC

GENdes: 232 Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Very Fine Sand

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

Figure E-5-3c.

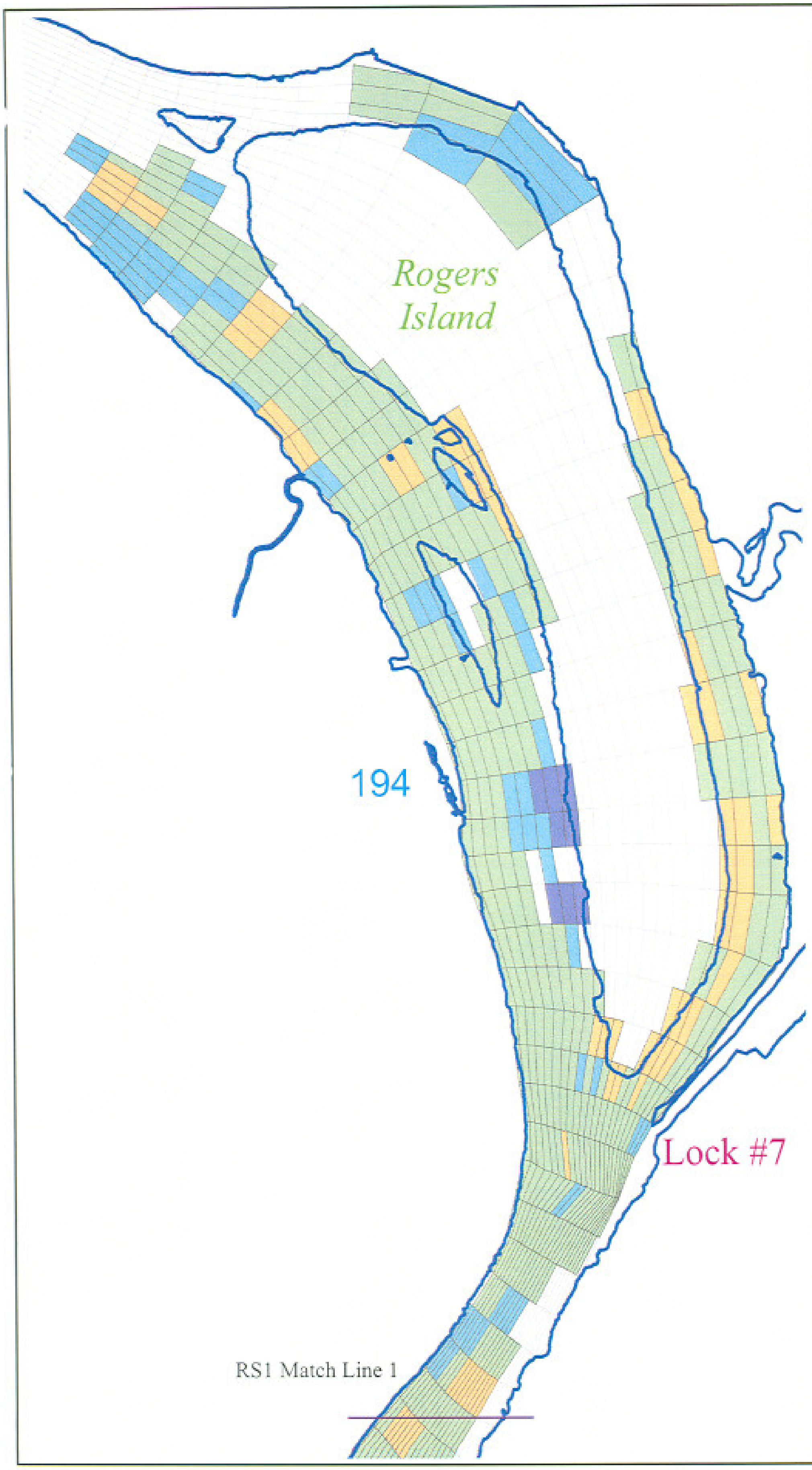
Average Total PCB Concentration in Very Fine Sand by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

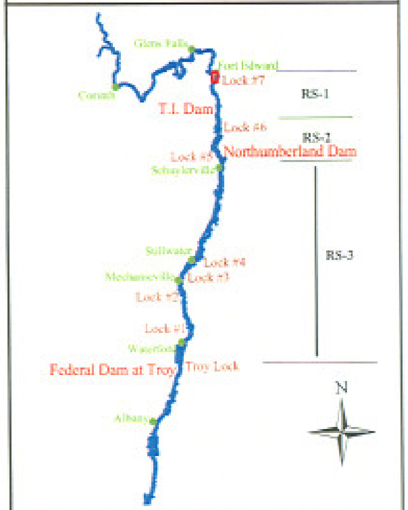
GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Fine and Medium Sand

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

Figure E-5-4a.

Average Total PCB Concentration in Fine and Medium Sand by Model Grid Cell.

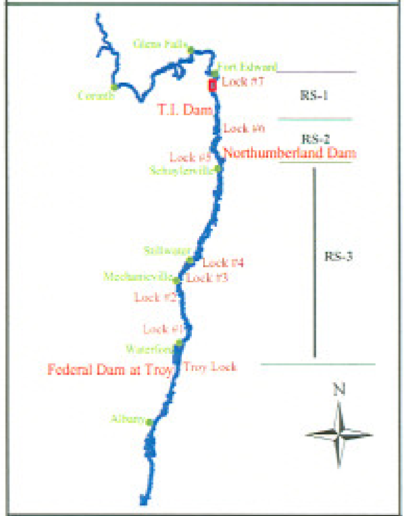
QEA Quantitative Environmental Analysis, LLC

GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Fine and Medium Sand

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

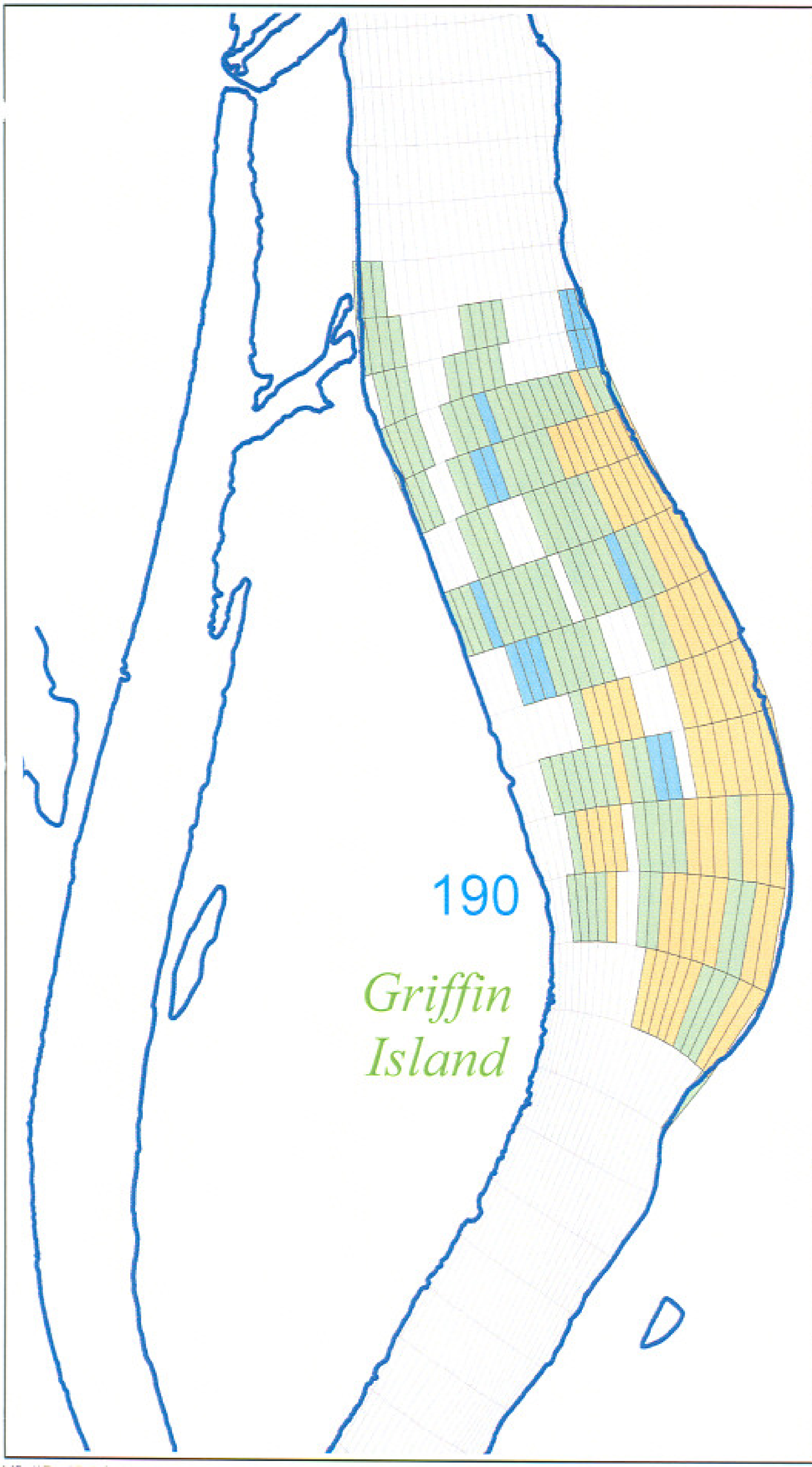
Figure E-5-4b.

Average Total PCB Concentration in Fine and Medium Sand by Model Grid Cell.

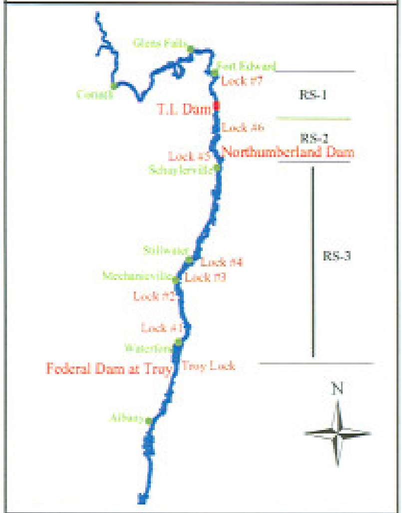
QEA Quantitative Environmental Analysis, LLC

GENdes: 232 Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

Avg. Total PCB Concentration (µg/g)

Fine and Medium Sand

- 0 - 1
- 1 - 10
- 10 - 100
- 100 - 1000
- >1000
- Shoreline
- Model Grid

Figure E-5-4c.

Average Total PCB Concentration in Fine and Medium Sand by Model Grid Cell.

QEA Quantitative Environmental Analysis, LLC

GENdes: 232

Aug 17, 2005.

MS - \\Zeus\E_Drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\PCB_Frac_Map.mxd

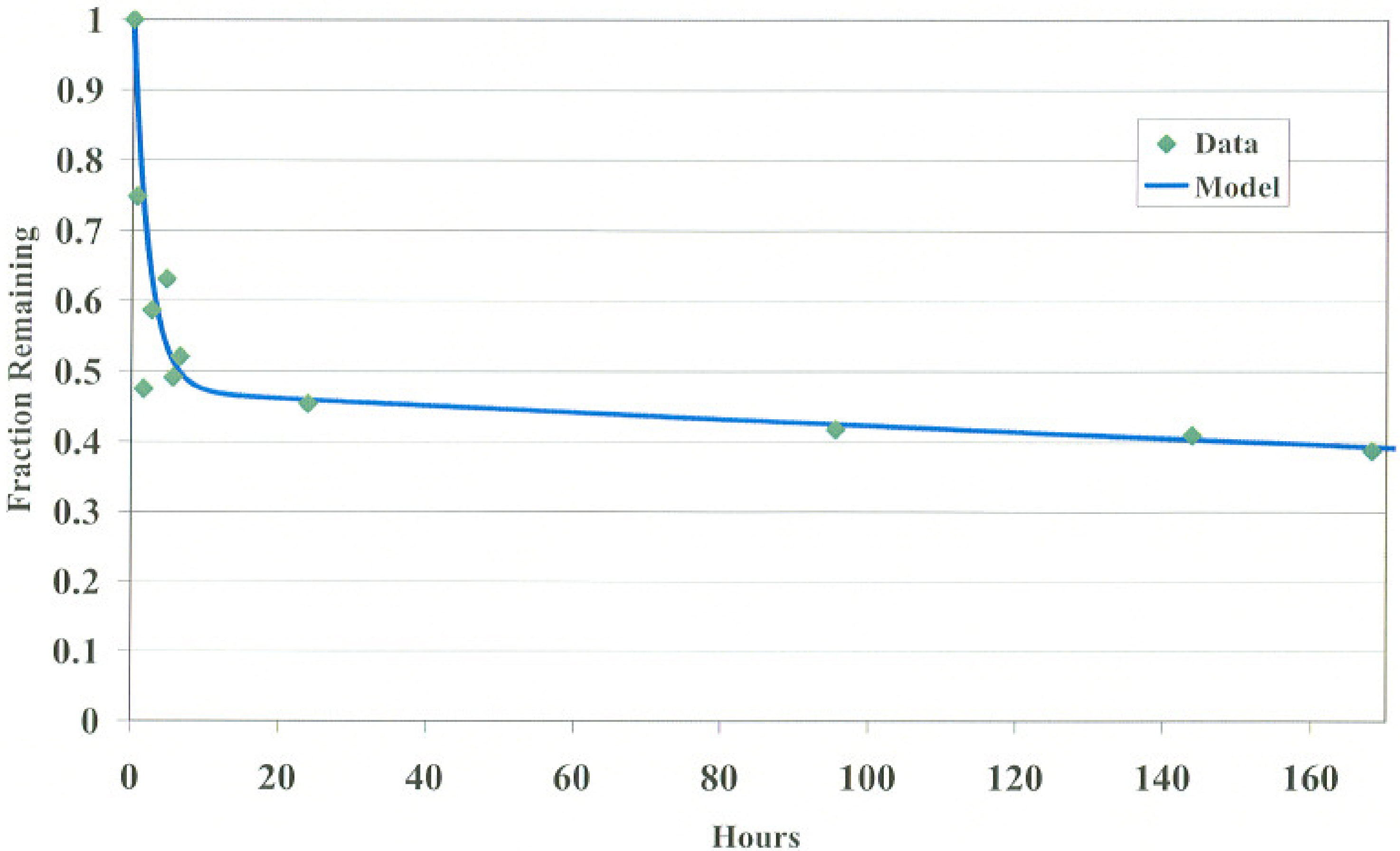


Figure E-5-5. Hudson River Sediment PCB desorption. Comparison of results of Carroll, et.al. (1994) and desorption sub-model calibration

\\dalee\\d_drive\\GENdas\\Documents\\Reports\\IDR\\Figure_E-5-5_model.xls

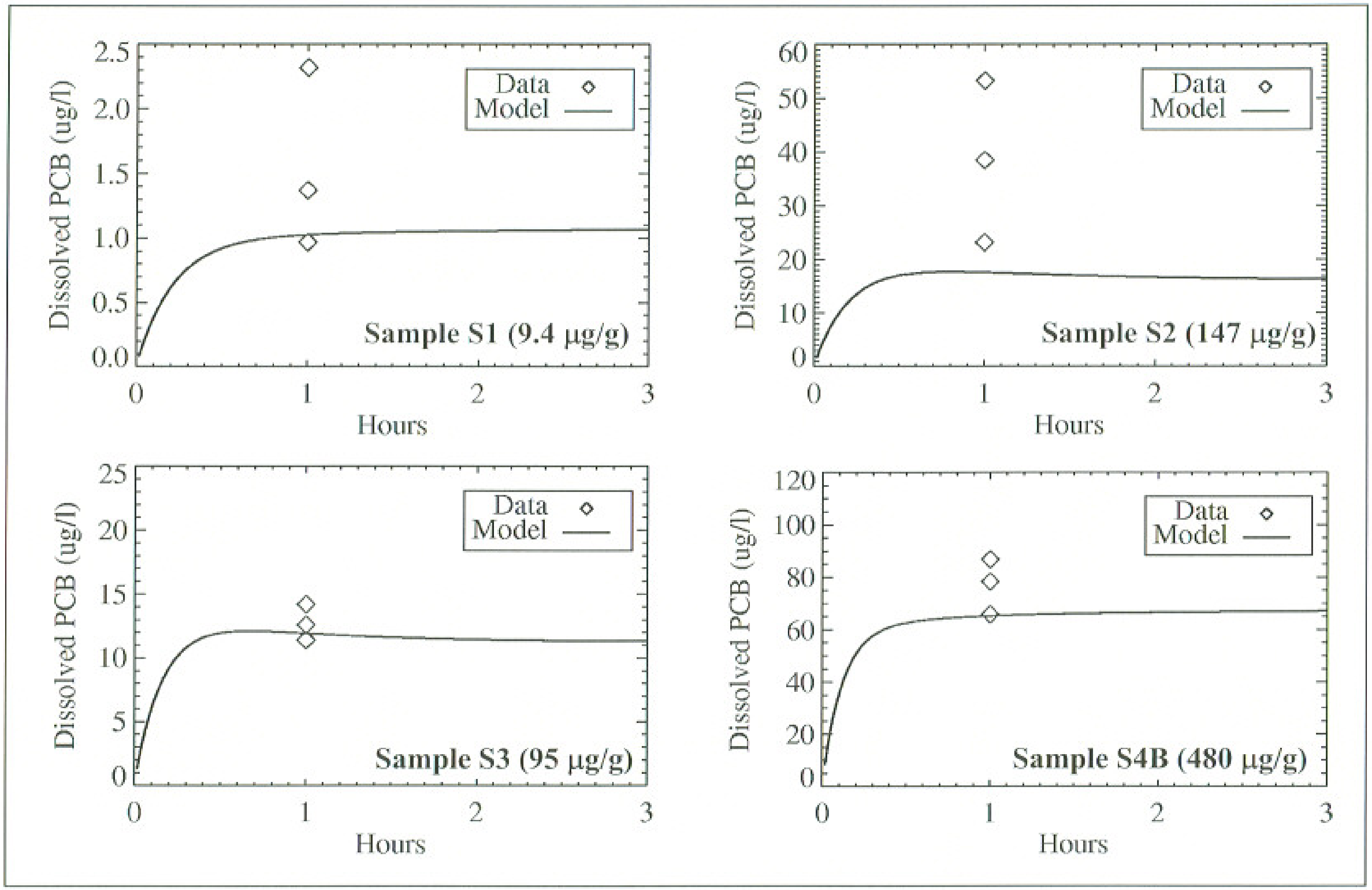
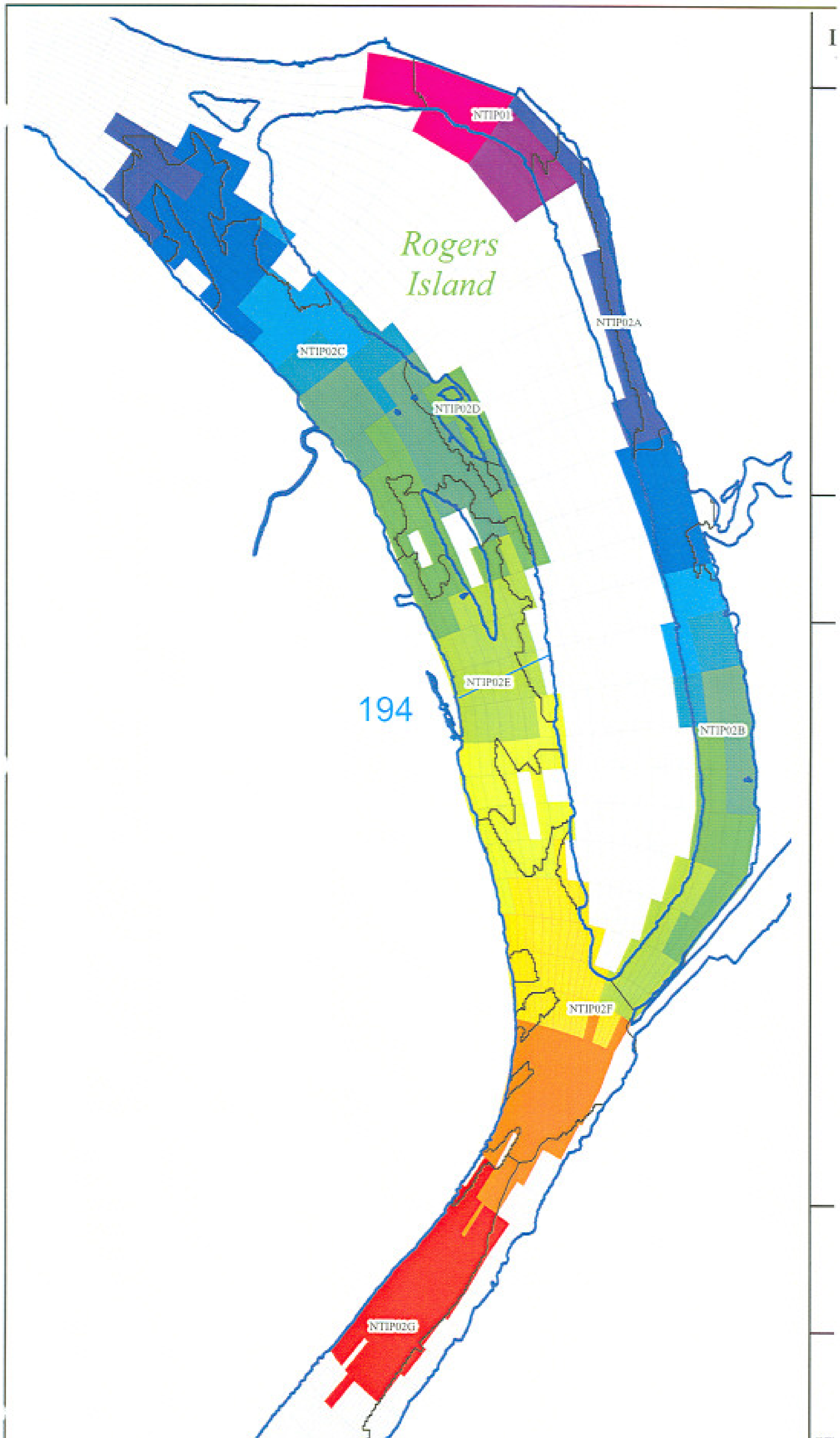
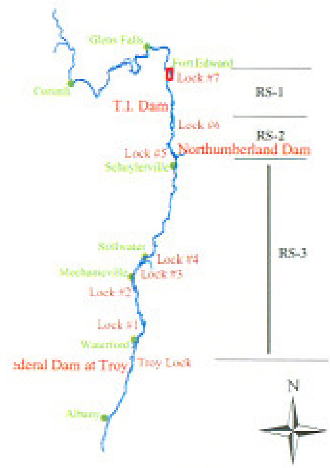


Figure E-5-6. Comparison of DRET Study results to desorption sub-model predictions

\\daleel\d_drive\GENdes\Documents\Reports\IDR\Figure_E-5-6_dret_simulation.ppt



I)CATOR MAP OF THE PPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

2007 Dredge Dates

- May 21 - May 31
- June 1 - June 10
- June 11 - June 20
- June 21 - June 30
- July 1 - July 10
- July 11 - July 20
- July 21 - July 31
- Aug 1 - Aug 10
- Aug 11 - Aug 20
- Aug 21 - Aug 31
- Sep 1 - Sep 10
- Sep 11 - Sep 20
- Sep 21 - Oct 2
- Dredge Areas

Figure E-6-1a.

Phase 1 Dredging Schedule Northern TIP

QEA

GE| es:221

Aug 17, 2005

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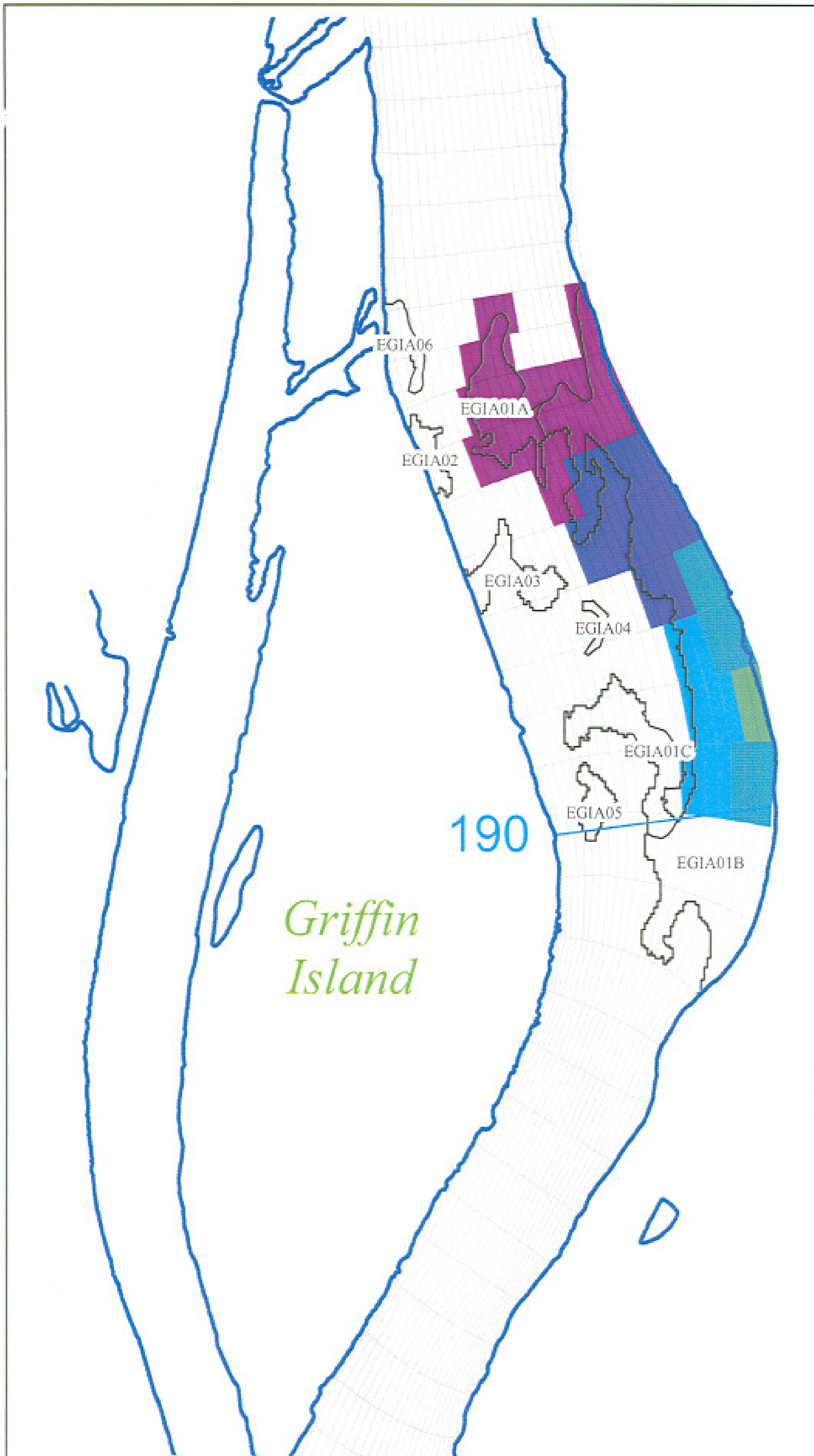
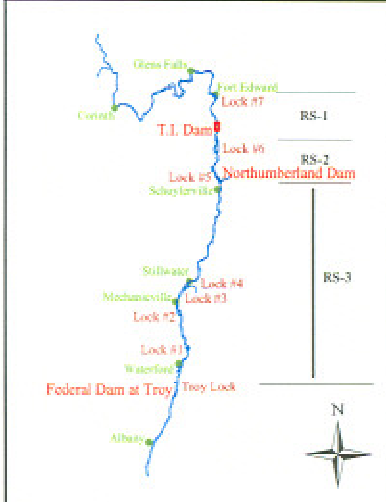


LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

2007 Dredge Dates

- May 21 - May 31
- June 1 - June 10
- June 11 - June 20
- June 21 - June 30
- July 1 - July 10
- July 11 - July 20
- July 21 - July 31
- Aug 1 - Aug 10
- Aug 11 - Aug 20
- Aug 21 - Aug 31
- Sep 1 - Sep 10
- Sep 11 - Sep 20
- Sep 21 - Oct 2

Dredge Areas

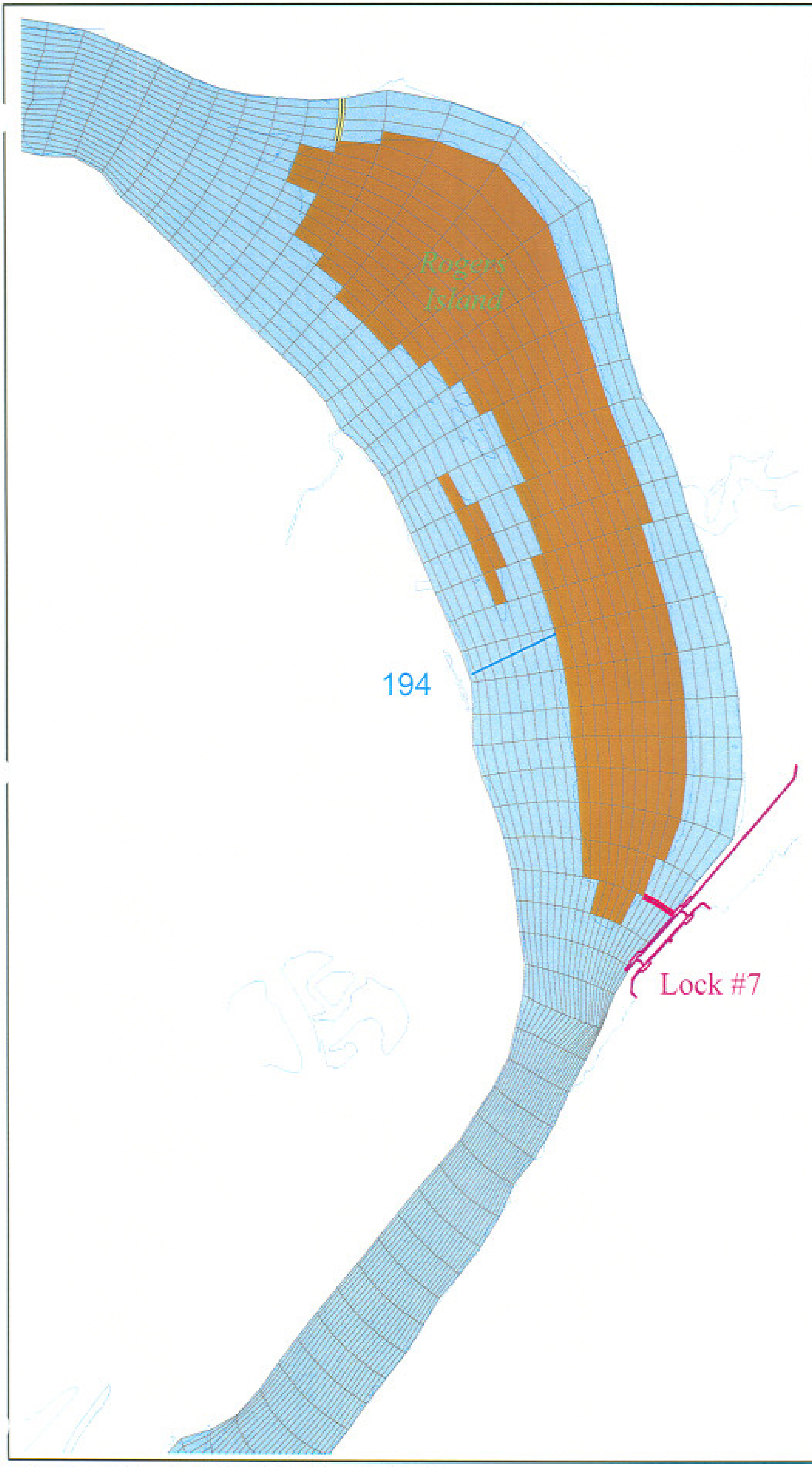
Figure E-6-1b.

Phase 1 Dredging Schedule Griffin Island

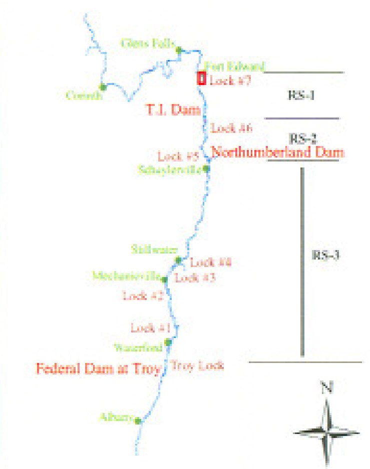
QEA Quantitative Environmental Analysis, LLC

GENdes:221 Aug 17, 2005

MS - \\Zeus\e_drive\GENrem\Working\GIS\maps\ArcGIS8_maps\model\maps\resuspension\Dredge_schedule_for_report_20050808.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements
- Silt Curtain
- Sheetpile

UPPER HUDSON RIVER STUDY AREA

Figure E-6-2.

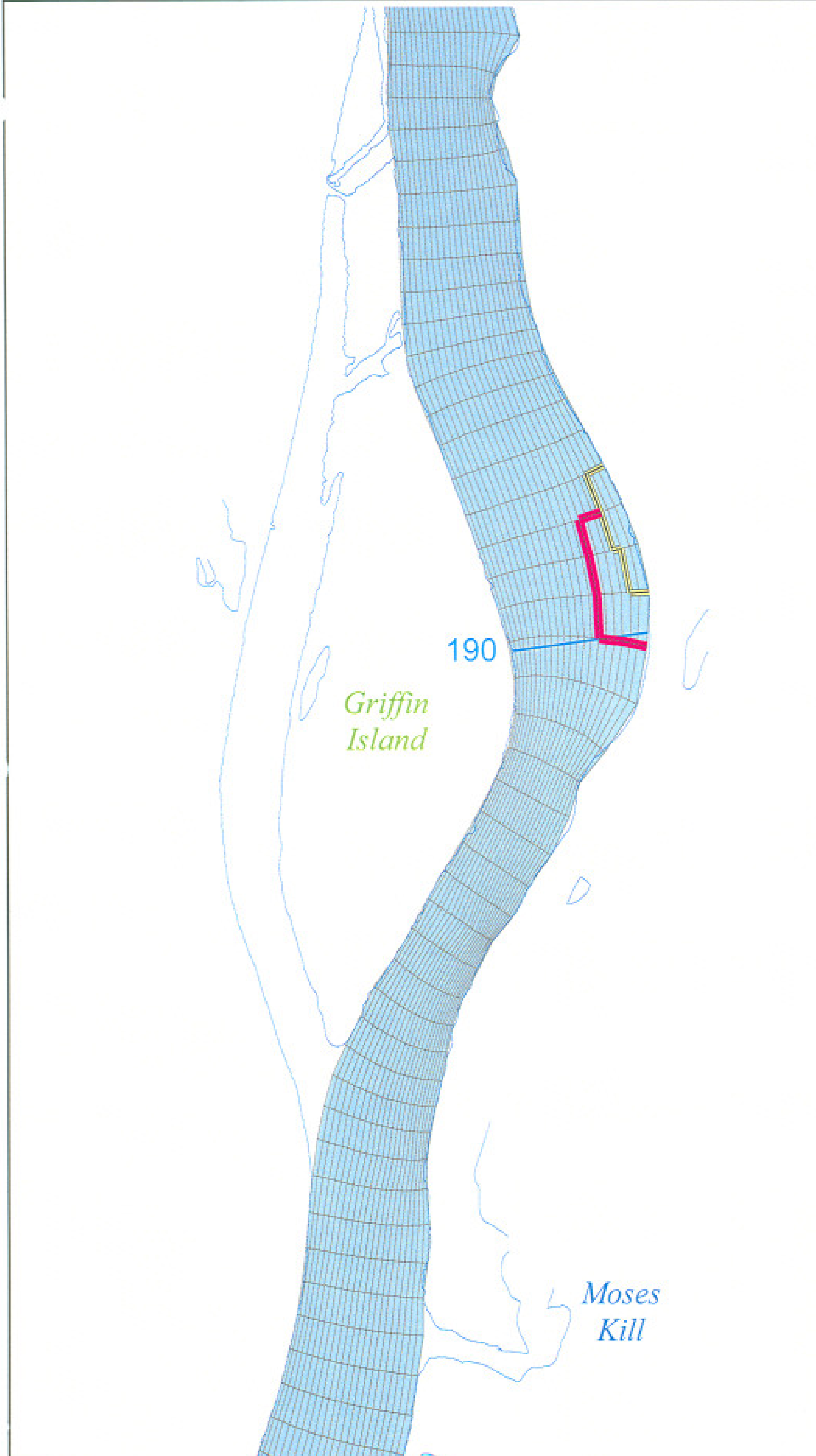
Model Implementation of the Sheet Pile and Silt Curtain near Rogers Island

QEA Quantitative Environmental Analysis, LLC

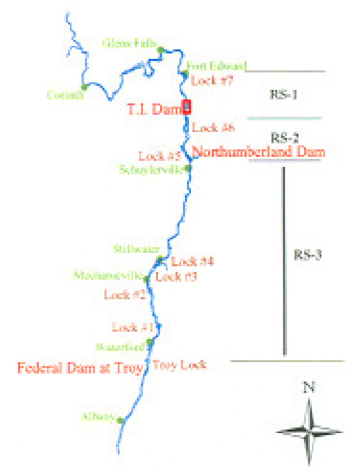
GENdes

Jul 29, 2005.

DN - \\daleel\d_drive\GENdes\Documents\Reports\IDR\Figure_E-6-2.mxd



LOCATOR MAP OF THE UPPER HUDSON RIVER



GRAPHIC SCALE

0 250 500 Feet

LEGEND

- River Miles
- Shore Line
- Dams and Locks
- Island/Land Elements
- Channel Elements
- Sheetpile
- Silt Curtain

UPPER HUDSON RIVER STUDY AREA

Figure E-6-3.

Model Implementation of the Sheet Pile and Silt Curtain near Griffin Island

QEA Quantitative Environmental Analysis, LLC

GENdes

Jul 29, 2005.

DN - \\Daleel\D_DRIVE\GENdes\Documents\Reports\IDR\Figure_E-6-3.mxd

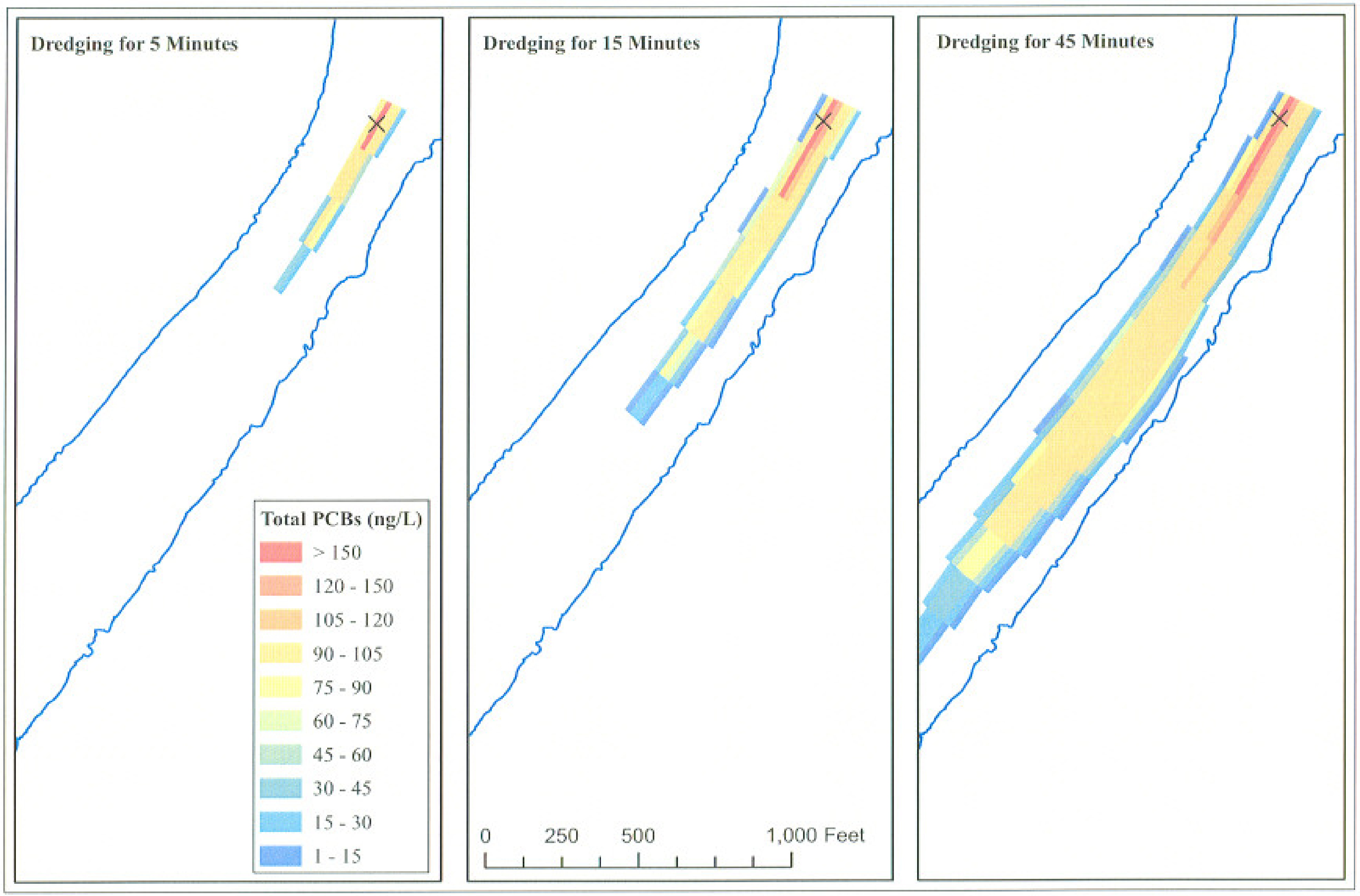


Figure E-7-1. Development of Typical Dredge Resuspension PCB Plume.

Location of dredge head is mid-channel and denoted by 'X'

\\Sam\d_drive\jobs\gendes\analysis\plume_figures\gis\plume_development.mxd

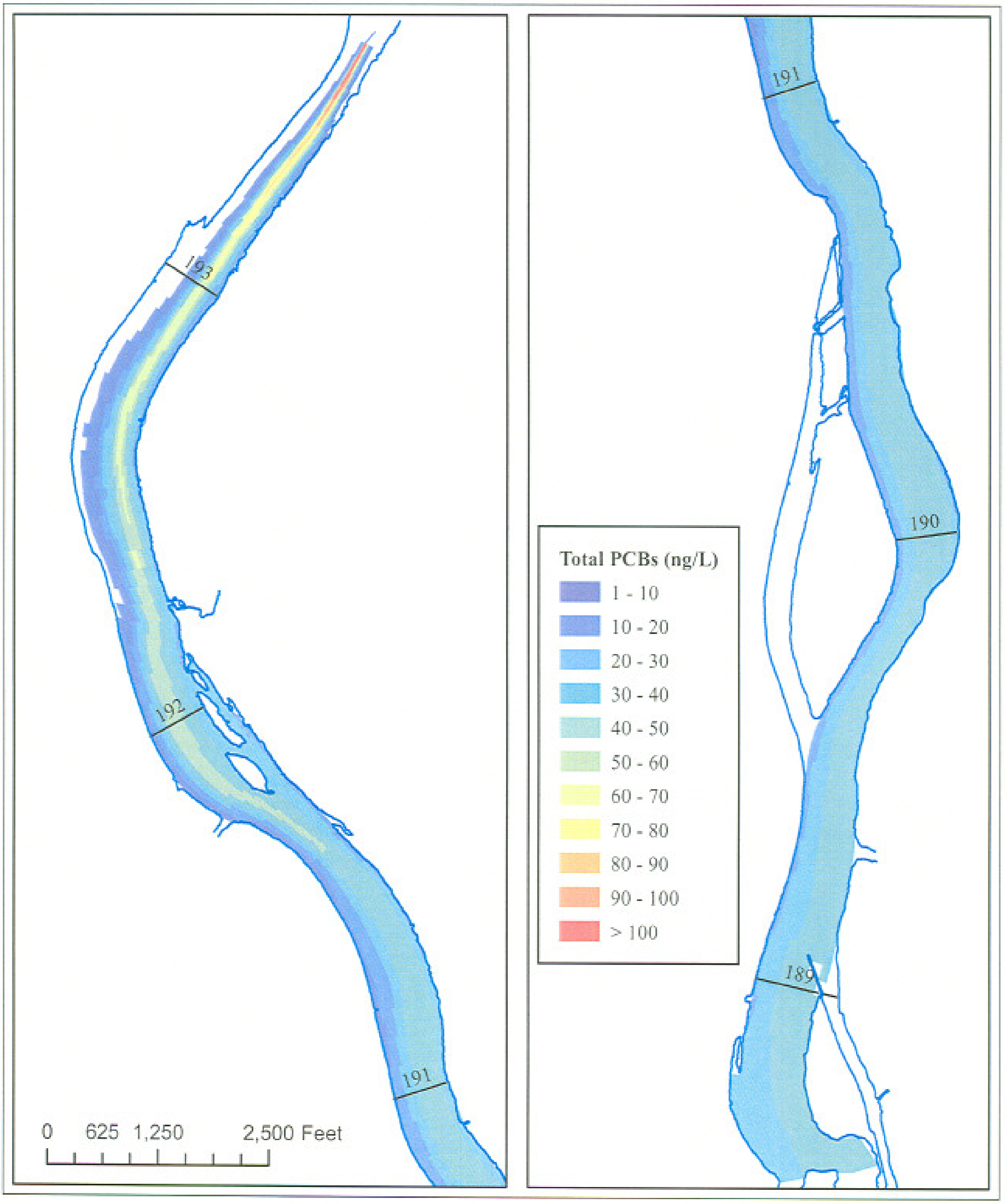


Figure E-7-2. Fully Developed Dredge Resuspension PCB Plume for a Mid-Channel Operation.

\\Sam\d_drive\jobs\gendes\analysis\plume_figures\gis\plume_steady_state_bank_release.mxd

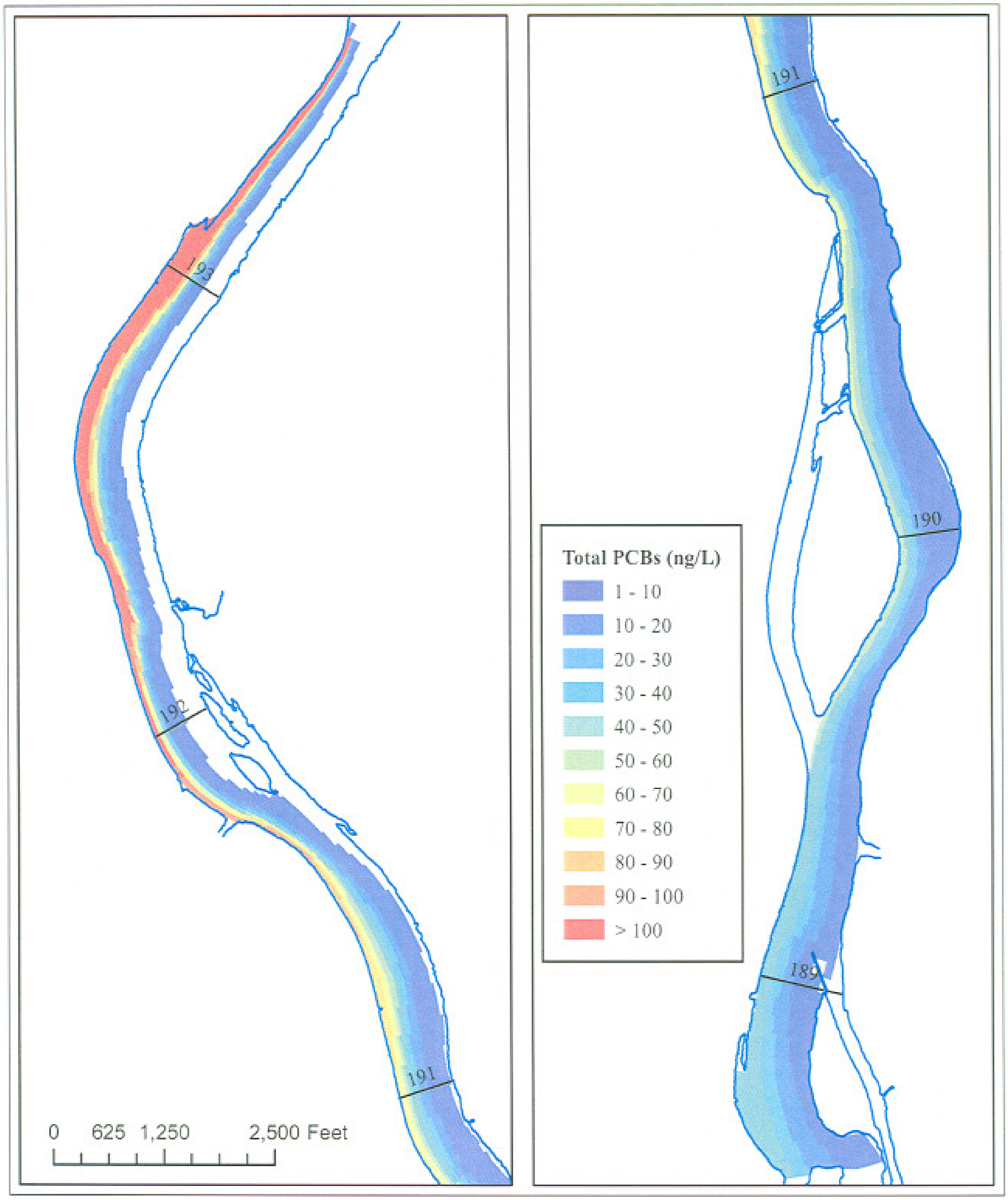


Figure E-7-3. Fully Developed Dredge Resuspension PCB Plume for a Near-Shore Operation.

\\Sam\d_drive\jobs\gendes\analysis\plume_figures\gis\plume_steady_state_bank_release.mxd

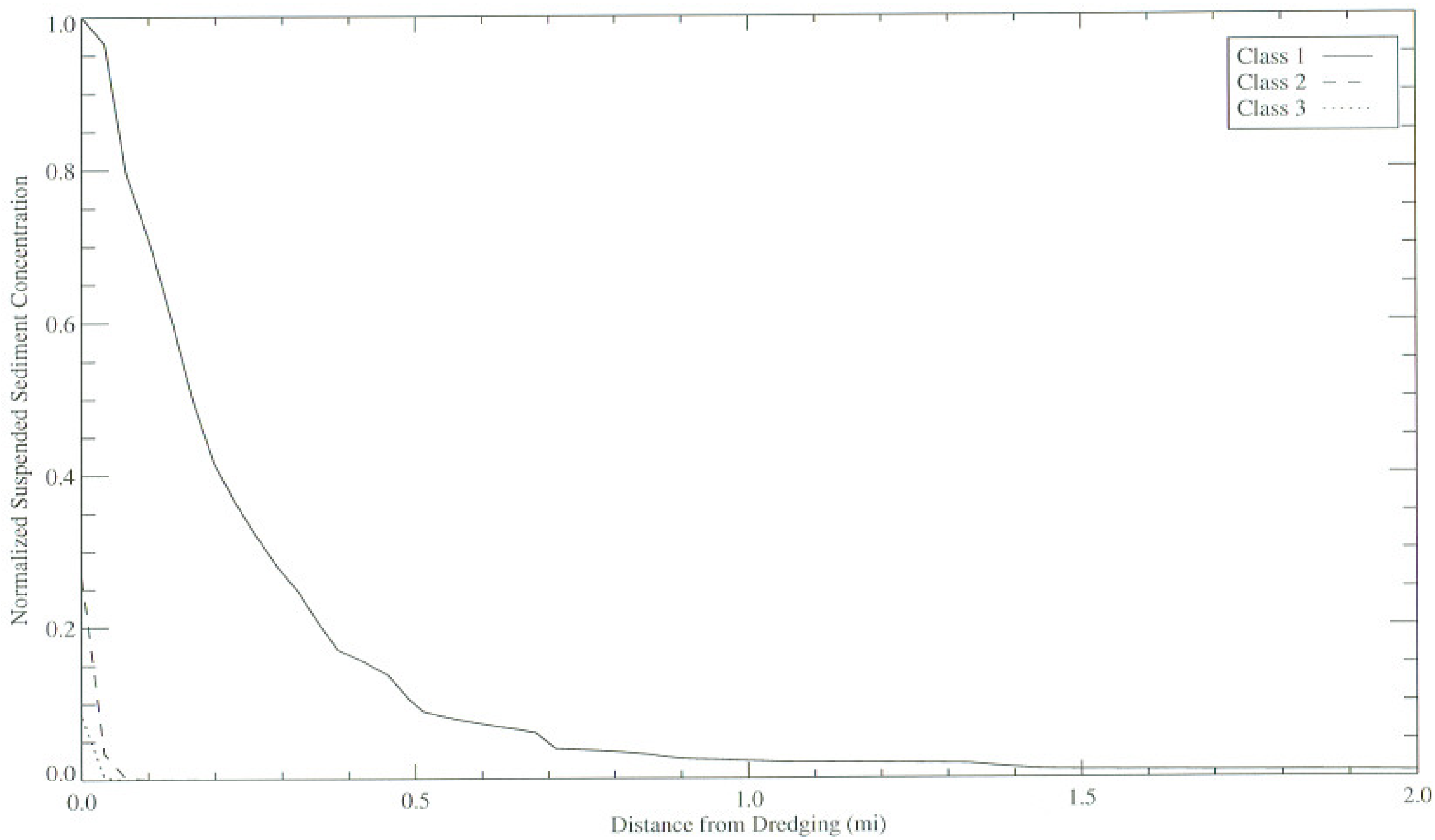


Figure E-7-4. Typical Suspended Sediment Dredge Plume Centerline Concentrations for Near-Shore Release and Median Flow (2,800 cfs)

model runs: doc0508-06a

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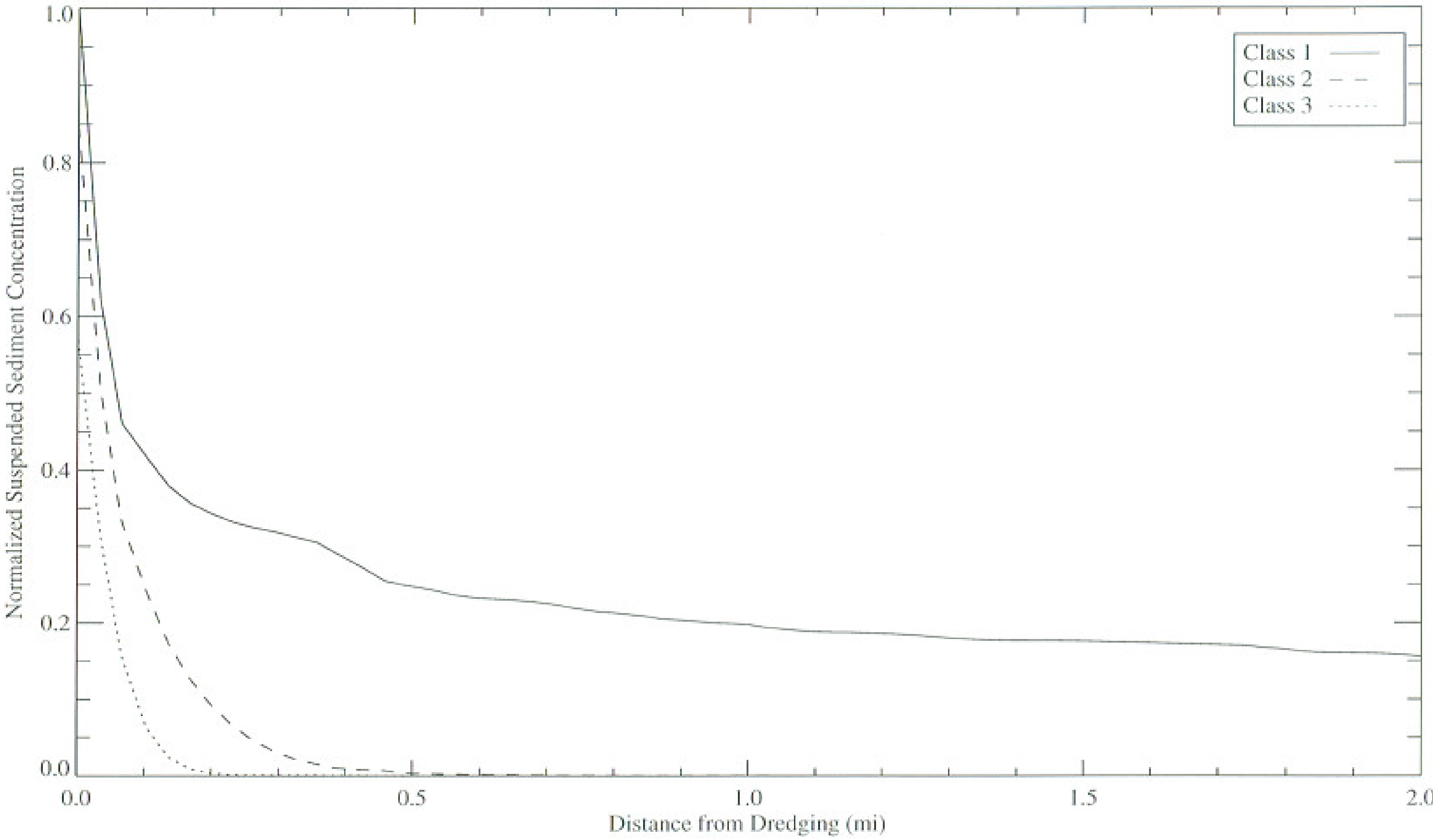

Figure E-7-5. Typical Suspended Sediment Dredge Plume Centerline Concentrations for Mid-Channel Release and Median Flow (2,800 cfs)

model runs: doc0508-05a

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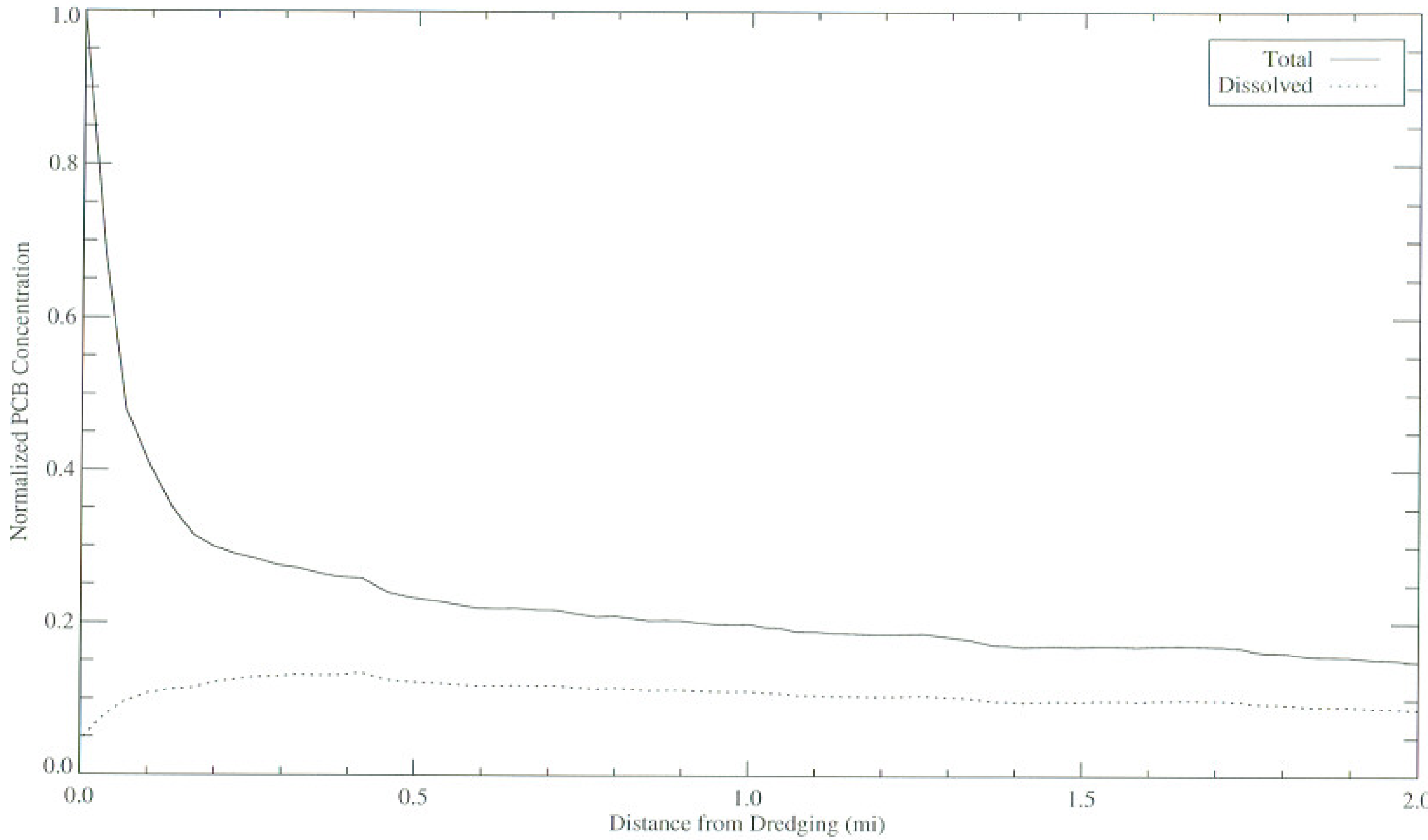

Figure E-7-6. Typical PCB Dredge Plume Centerline Concentrations for Mid-Channel Release and Median Flow (2,800 cfs)

model runs: doc0508-05a

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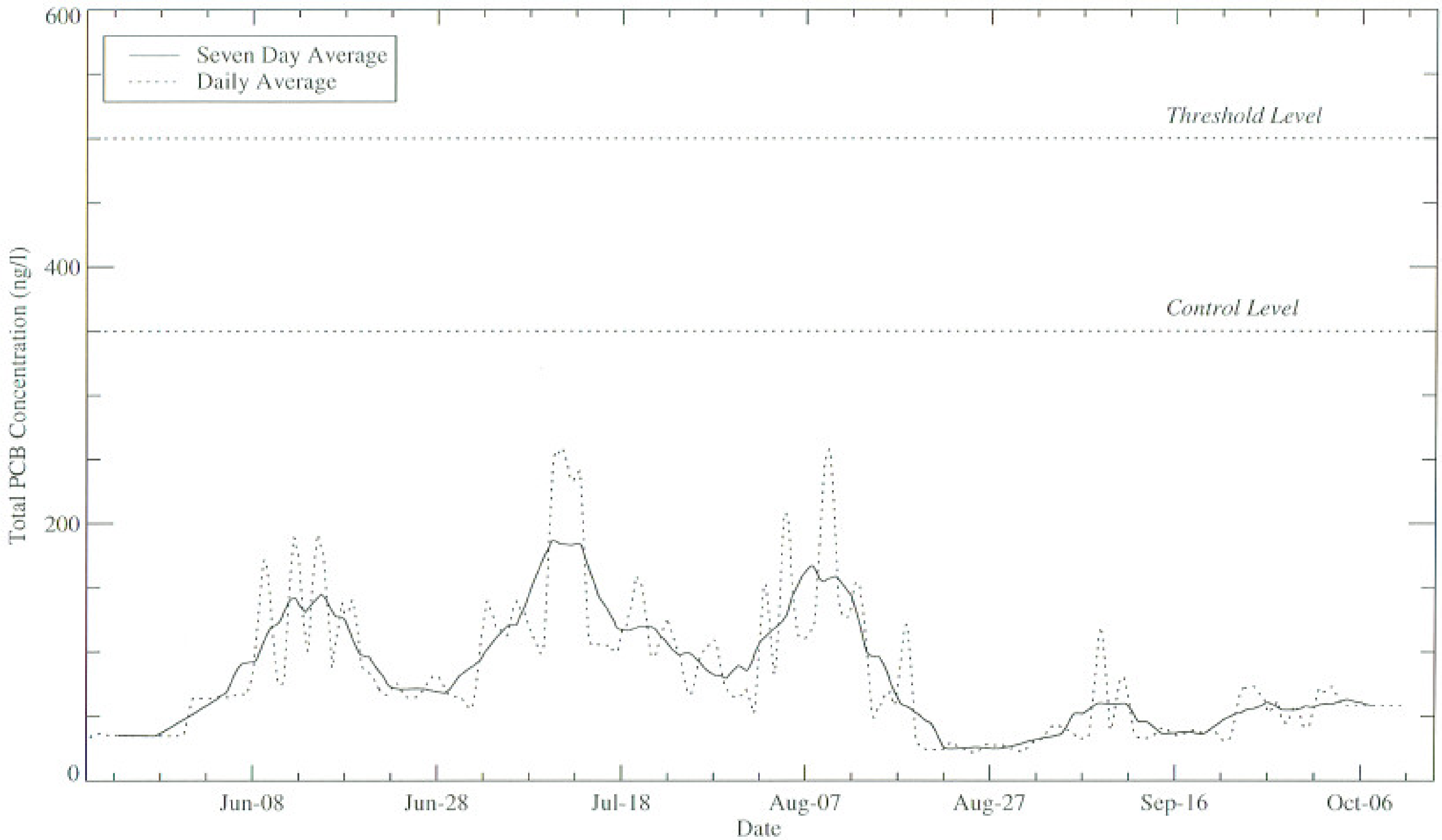

Figure E-7-7. Average TID Total PCB Concentration (including baseline) for Dredging with No Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-04

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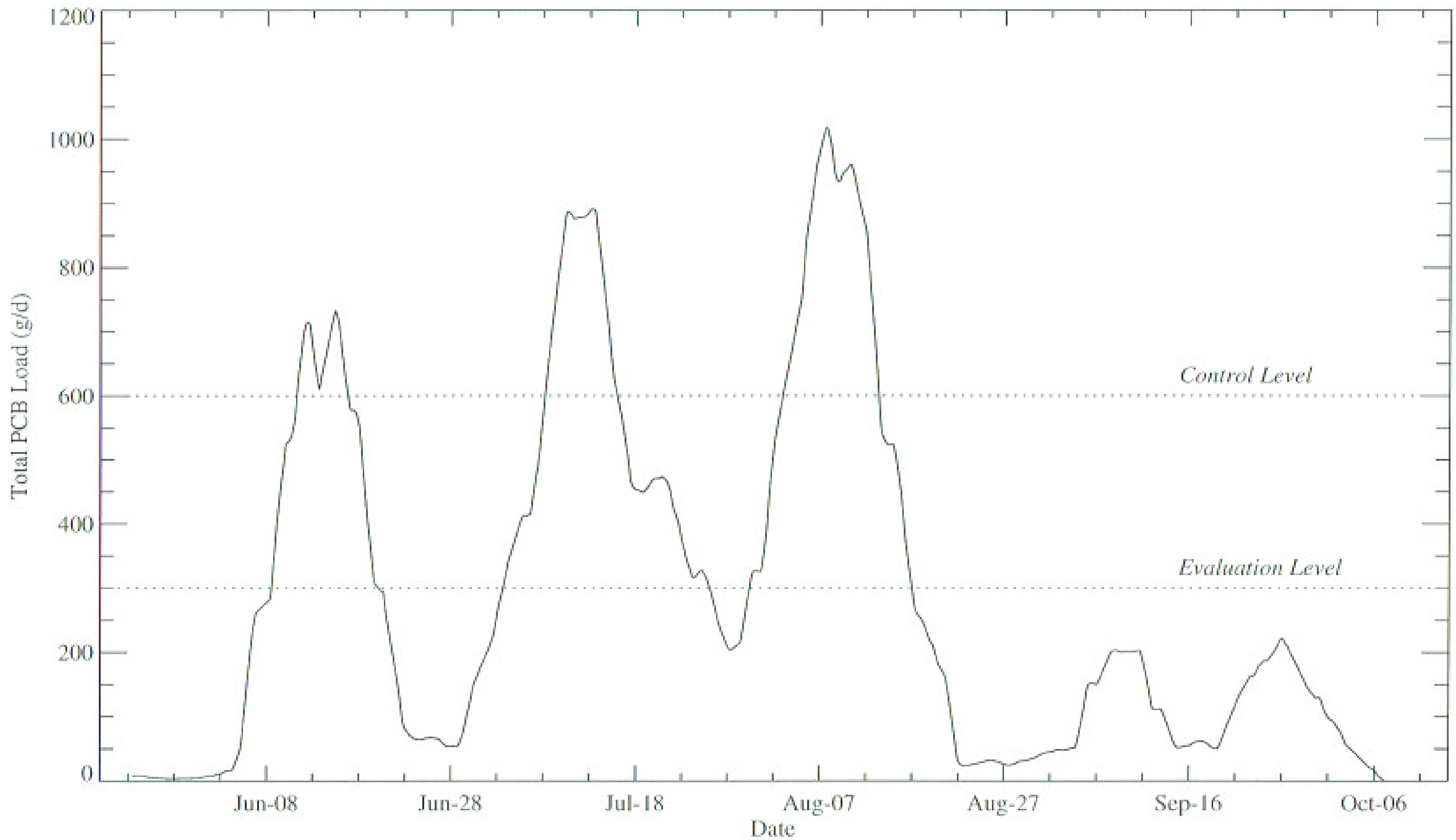

Figure E-7-8. Seven-Day Average TID Total PCB Load Above Baseline for Dredging with No Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-04

haz - D:\Harry\GENdes\Report\tid_pcb_load_7day.pro
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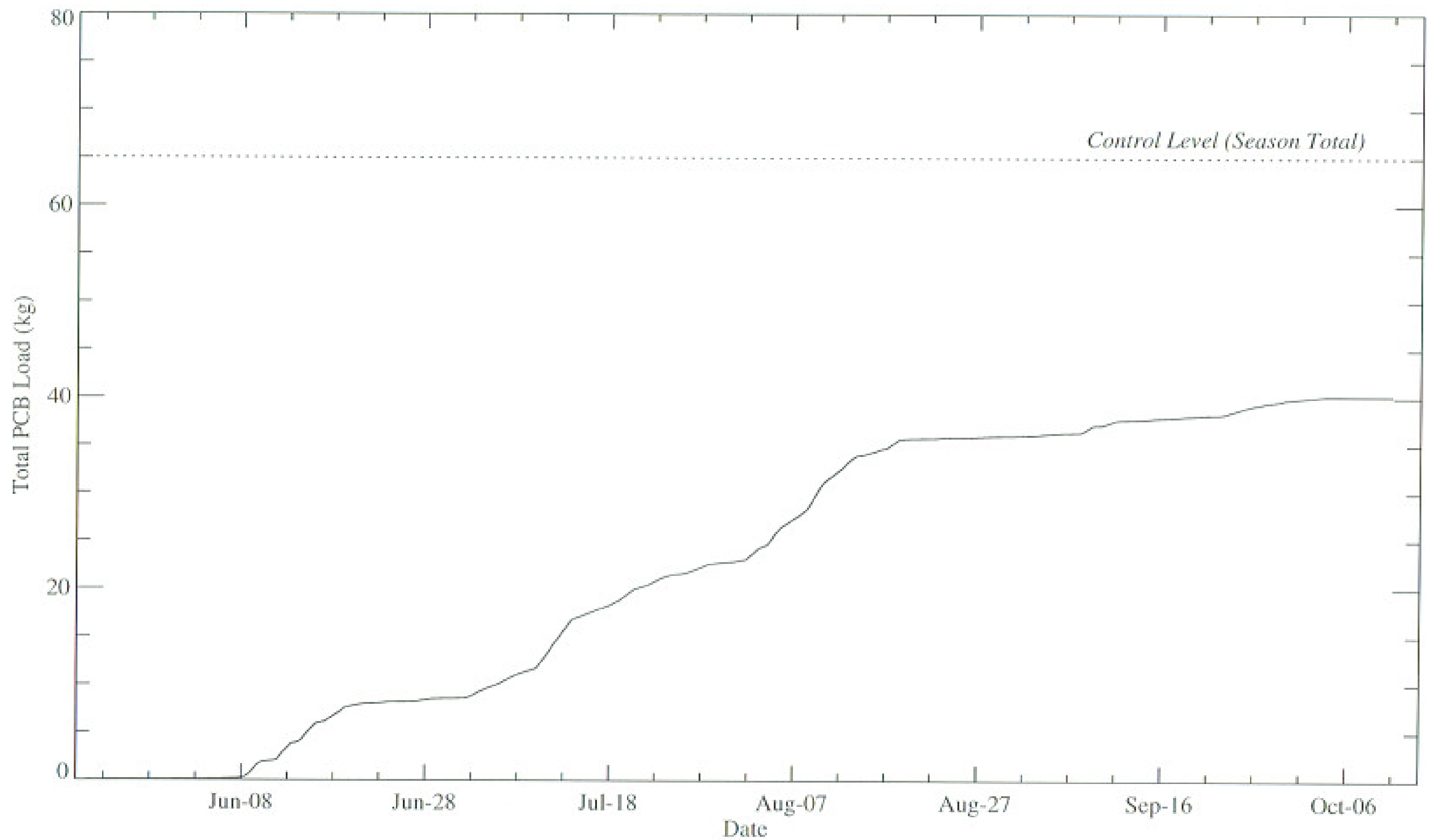

Figure E-7-9. Cumulative TID Total PCB Load Above Baseline for Dredging with No Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-04

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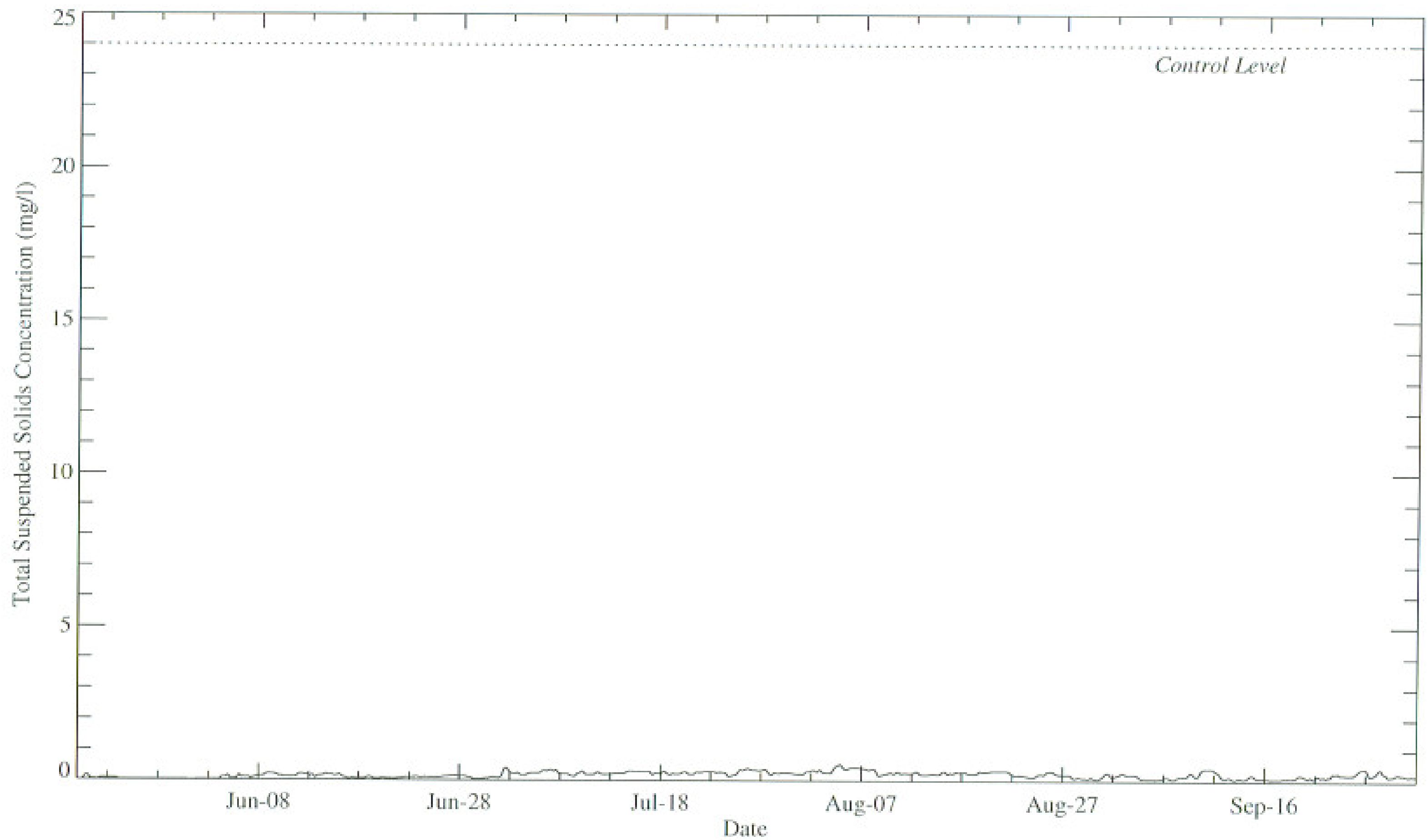

Figure E-7-10. Six Hour Average TID Total TSS Concentration Above Baseline Dredging with No Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-04

haz - D:\Harry\GENdes\Report\tid_avg_tss_6hour.pro
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ATTORNEY WORK PRODUCT
PREPARED AT REQUEST OF COUNSEL

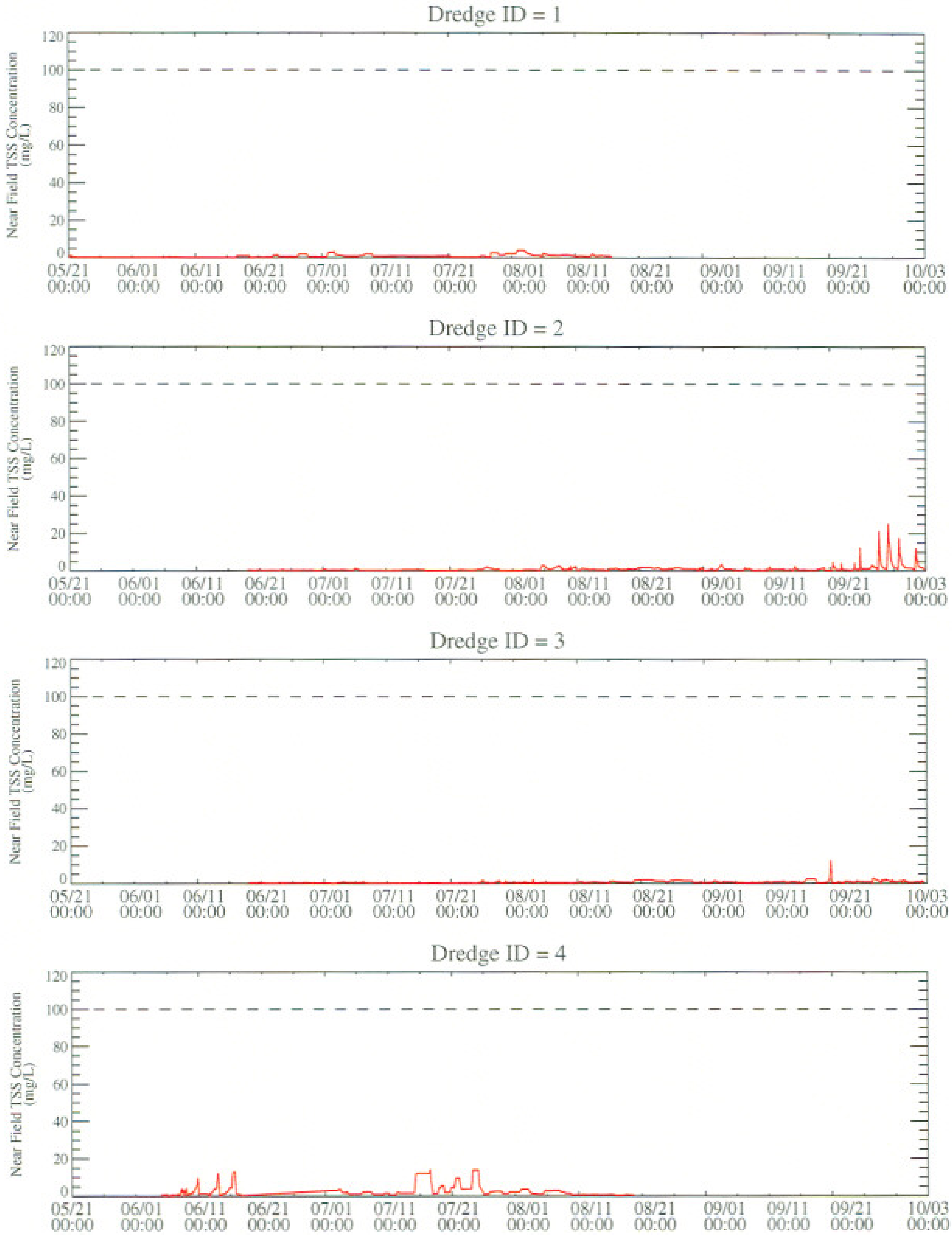

Figure E-7-11. Six-hour average TSS at near field monitoring stations (300 m downstream) with no control structures.

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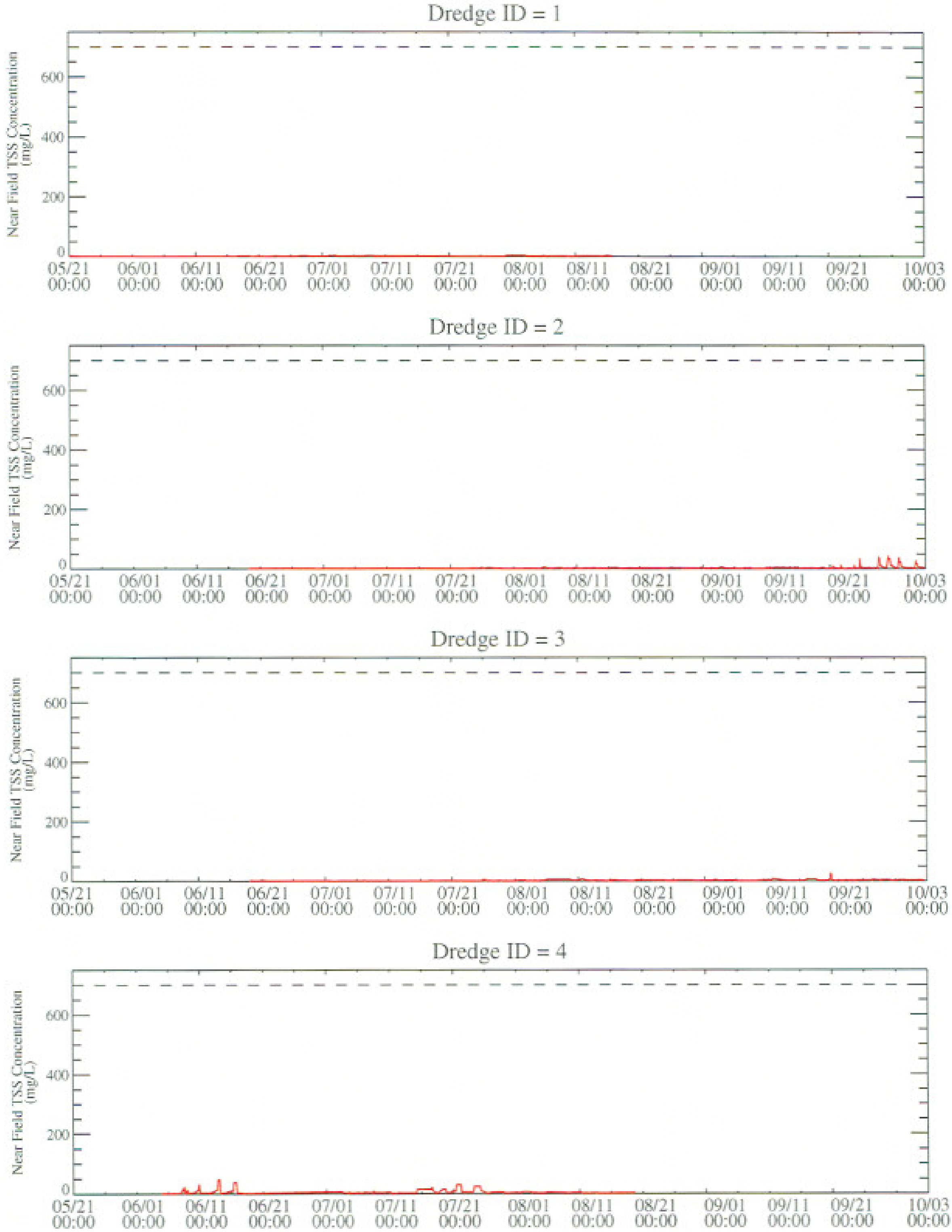

Figure E-7-12. Three-hour average TSS at near field monitoring stations (100 m downstream) with no control structures.

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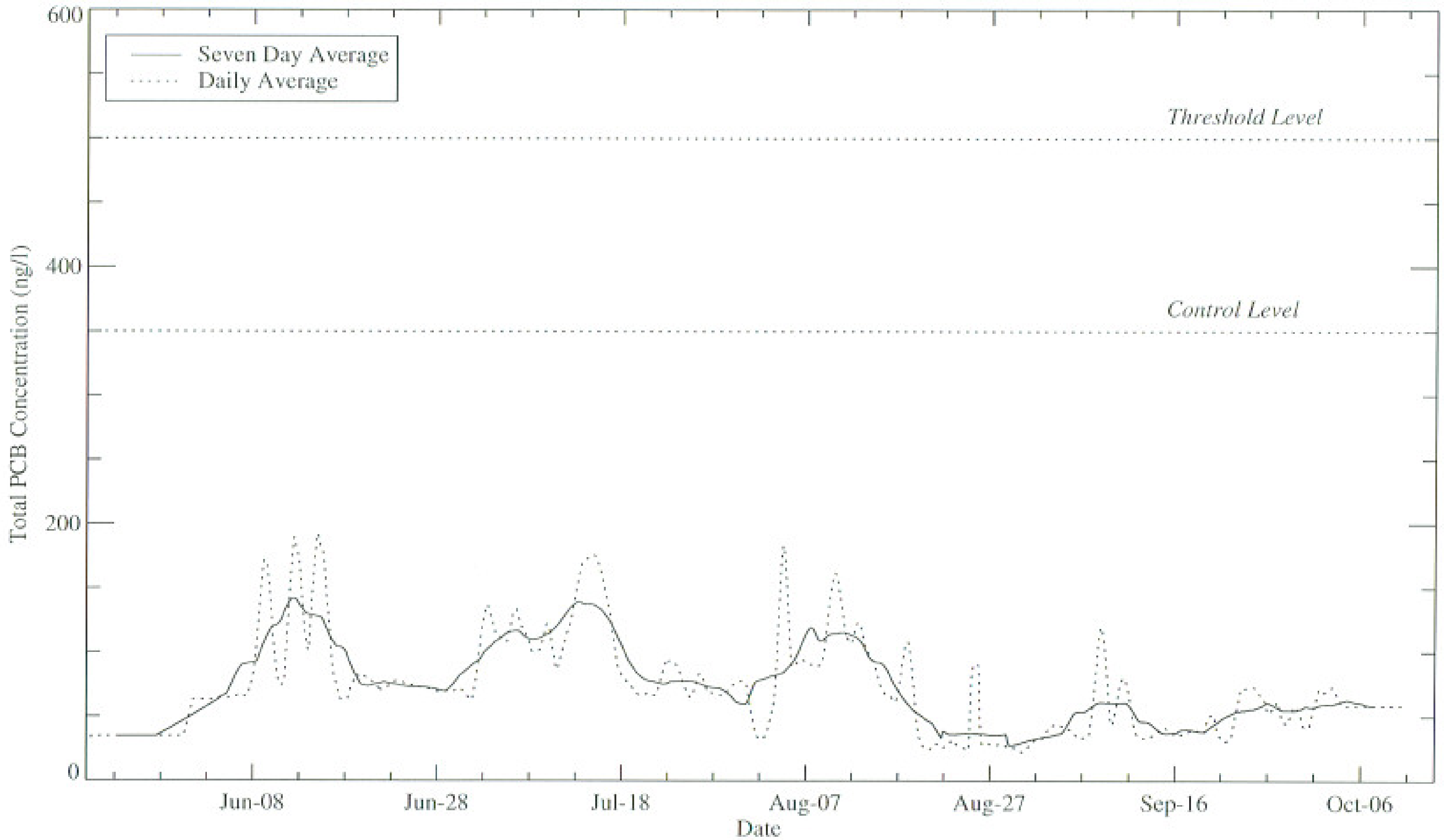

Figure E-7-13. Average TID Total PCB Concentration (including baseline) for Dredging with NTIP and EGIA Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-05

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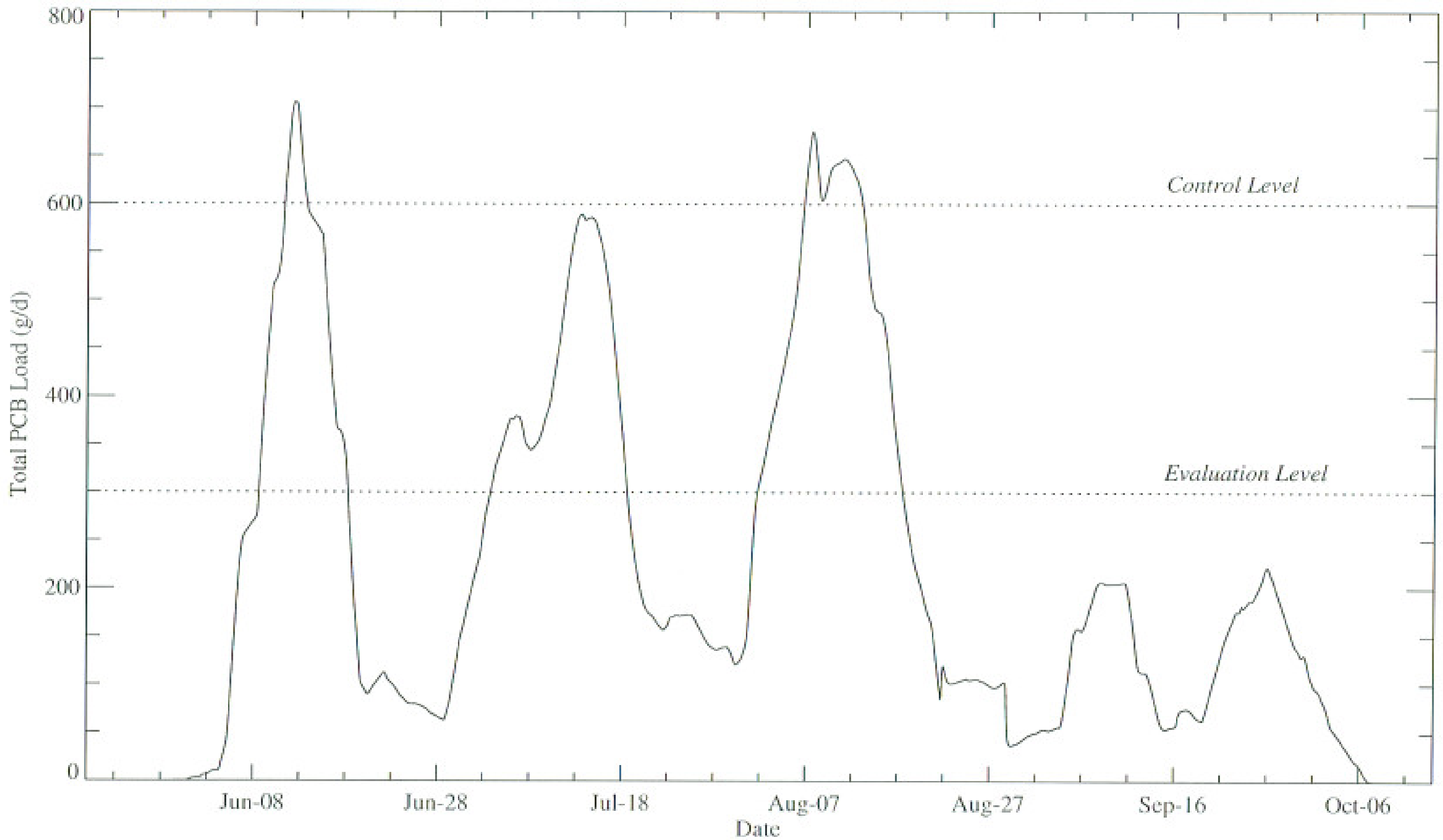

Figure E-7-14. Seven-Day Average TID Total PCB Load Above Baseline for Dredging with NTIP and EGIA Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-05

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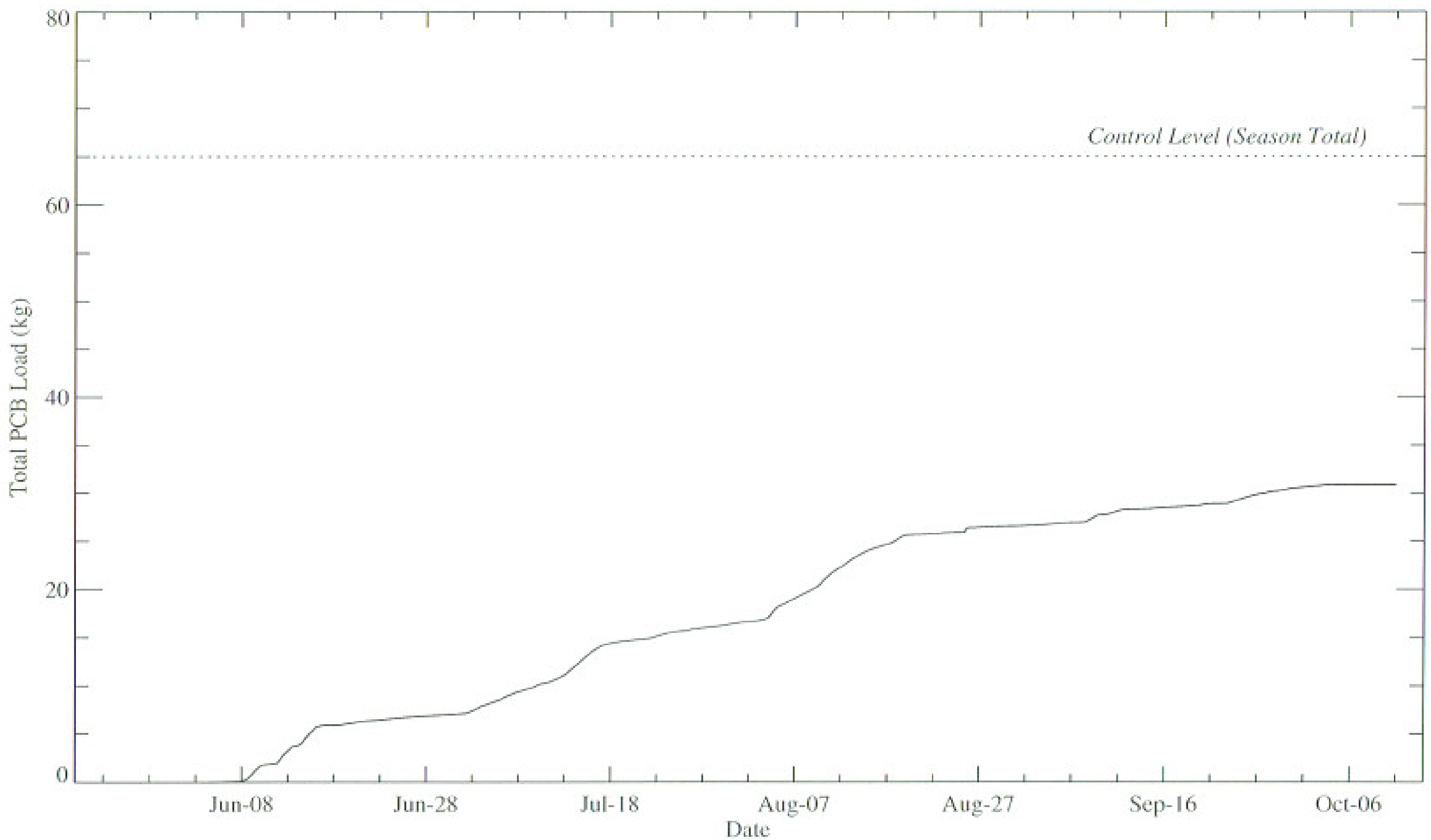

Figure E-7-15. Cumulative TID Total PCB Load Above Baseline for Dredging with NTIP and EGIA Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-05

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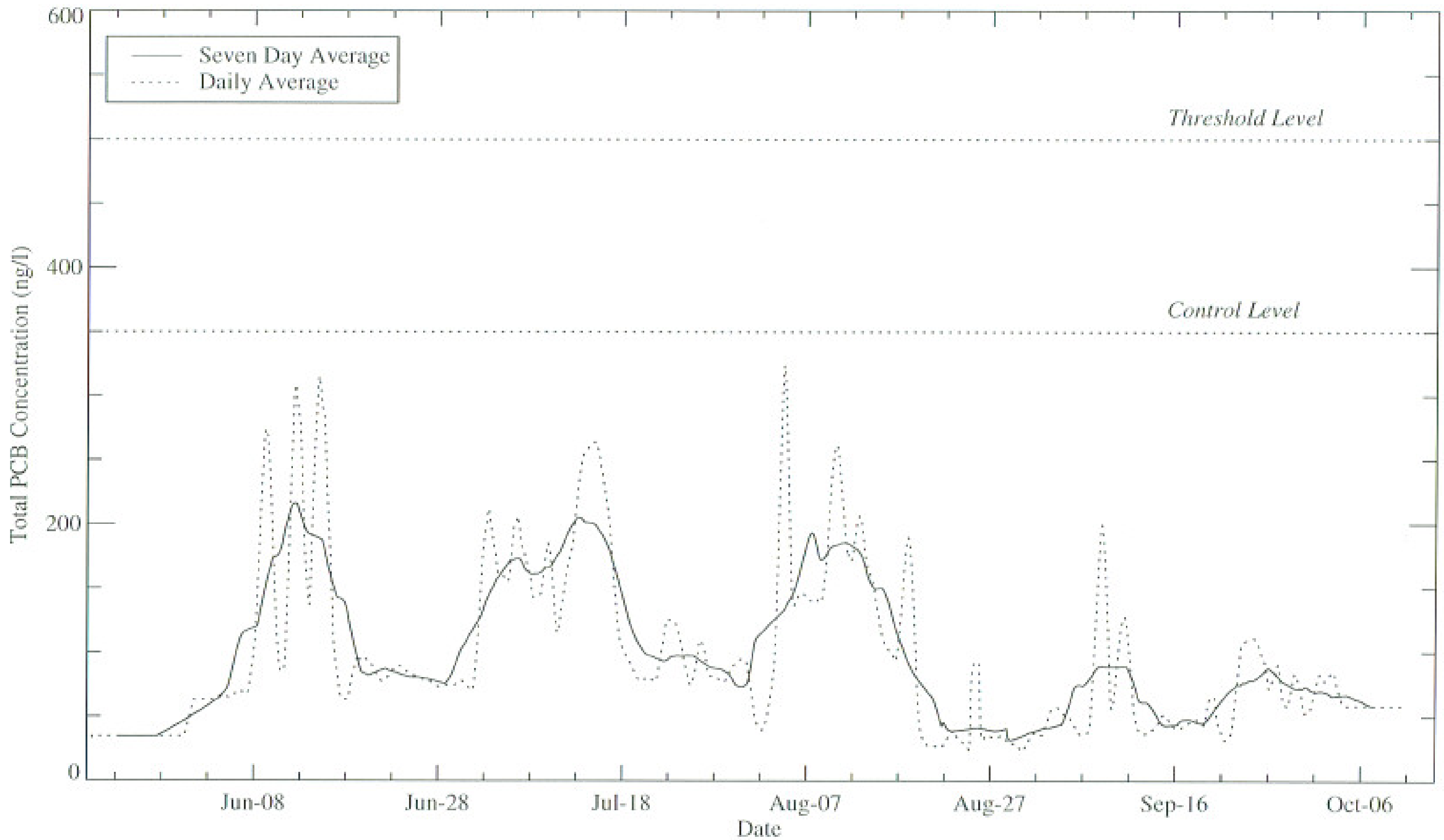

Figure E-7-16. Average TID Total PCB Concentration (including baseline) for Dredging with NTIP and EGIA Control Structures, 0.70% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-06

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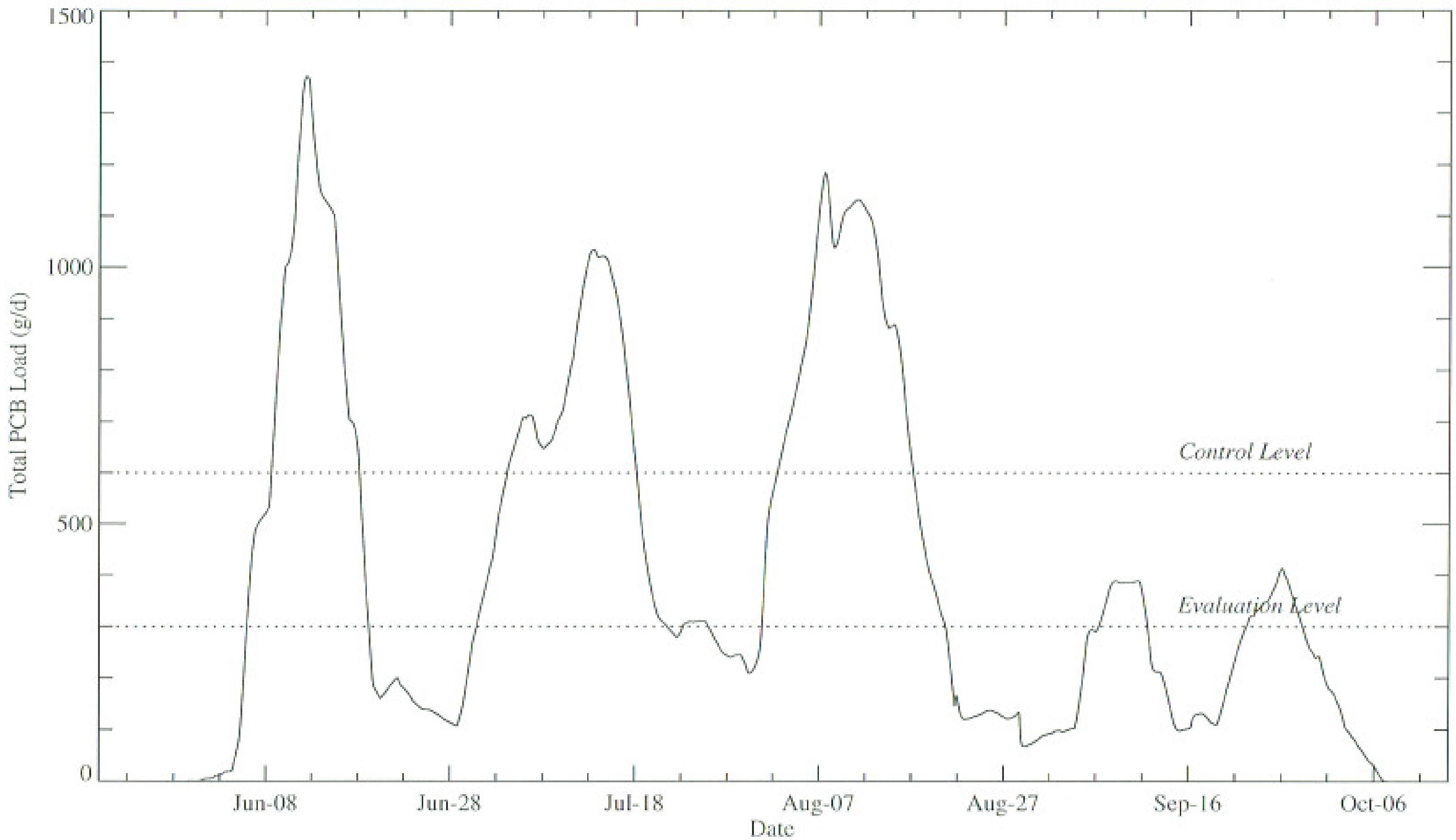

Figure E-7-17. Seven-Day Average TID Total PCB Load Above Baseline for Dredging with NTIP and EGIA Control Structures, 0.70% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-06

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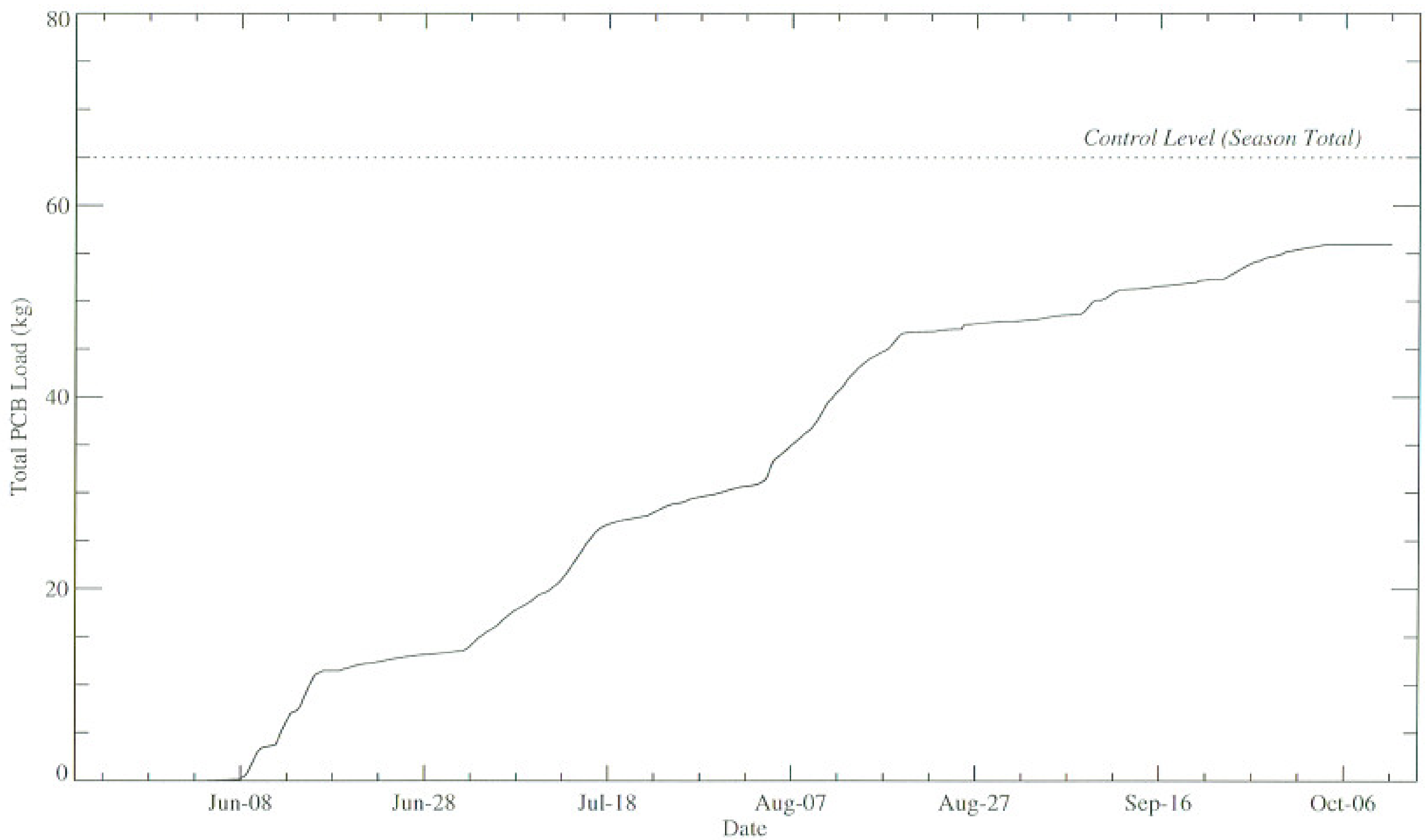

Figure E-7-18. Cumulative TID Total PCB Load Above Baseline for Dredging with NTIP and EGIA Control Structures, 0.70% Loss and Median Flow

Dredge Plan 050805

model run: plan0508-06

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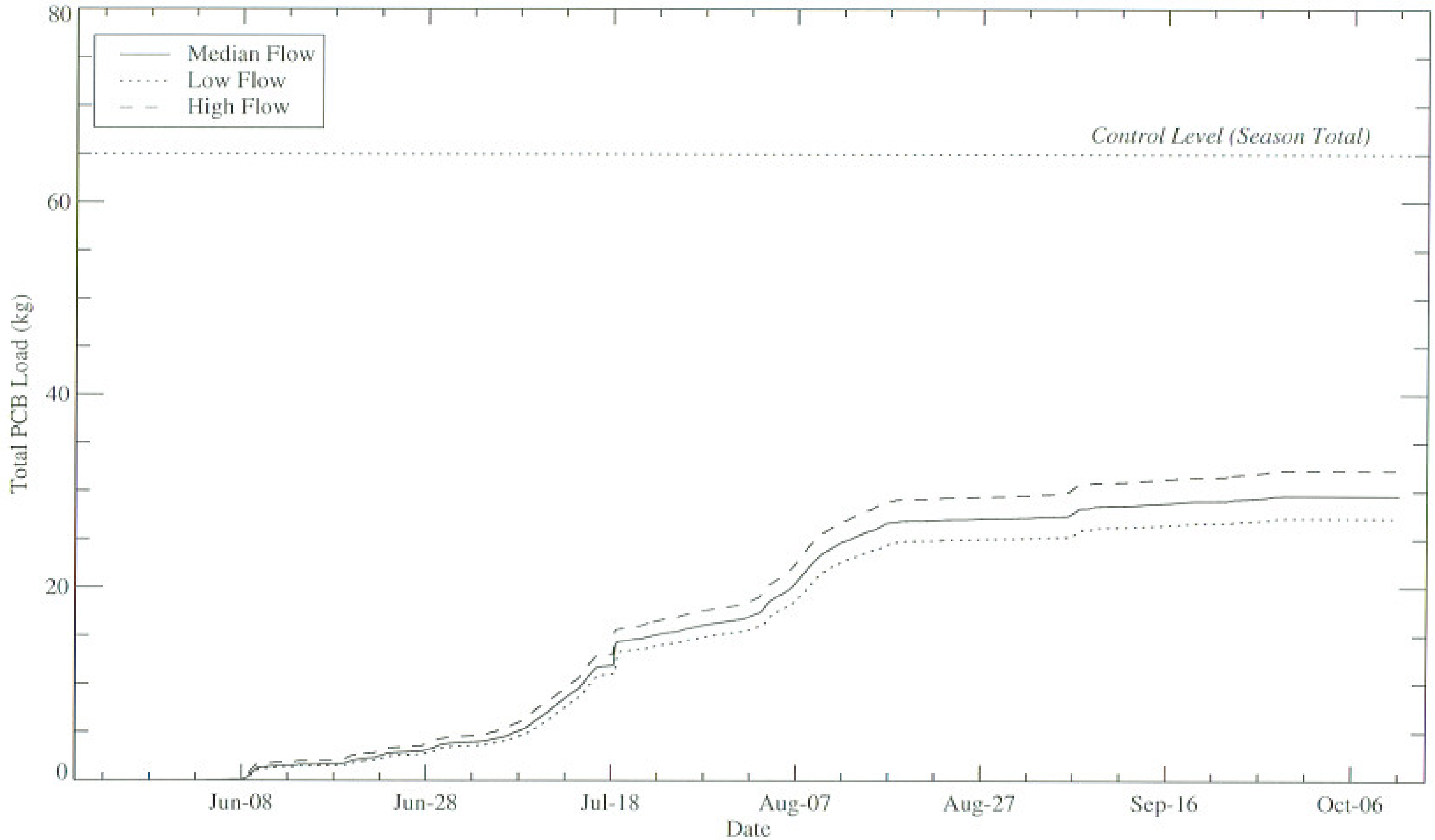

Figure E-7-19. Model Flow Rate Sensitivity of Cumulative TID Total PCB Load Above Baseline for Dredging with NTIP and EGIA Control Structures and 0.35% Loss

Dredge Plan 050701

model run: plan0507-09, plan0507-12, plan0507-11

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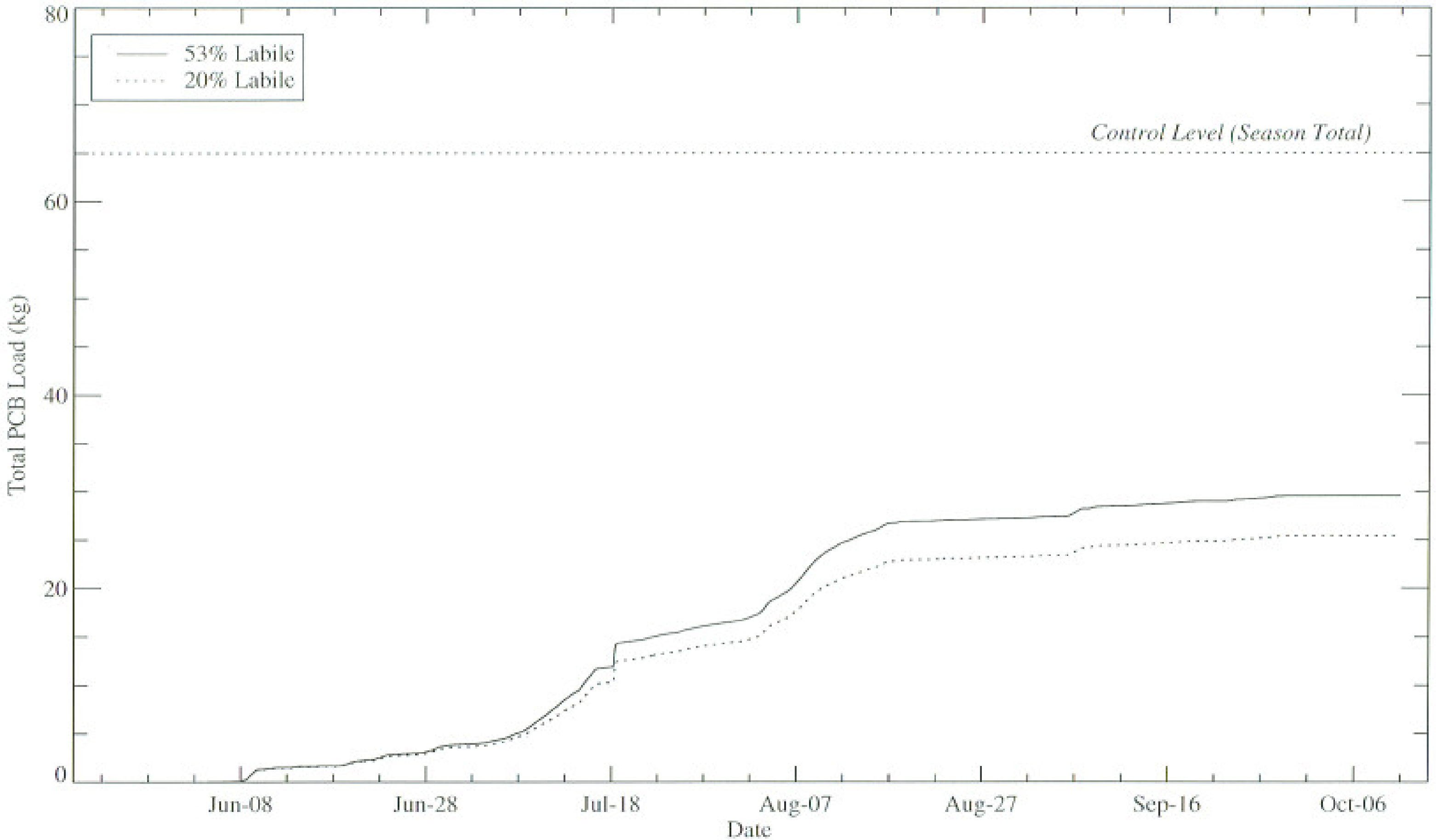

Figure E-7-20. Model Desorption Capacity Sensitivity of Cumulative TID Total PCB Load Above Baseline Dredging with NTIP and EGIA Control Structures, 0.35% Loss and Median Flow

Dredge Plan 050701

model run: plan0507-09, plan0508-02

haz - D:\Harry\GENdes\Report\tid_pcb_load_cum.pro
Thu Aug 18 14:19:17 2005

Phase 1 Intermediate Design Report
Hudson River PCBs Superfund Site

Attachment F – Design Analysis:
Unloading and Waterfront Facilities

General Electric Company
Albany, New York

August 22, 2005

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Attachment F – Design Analysis: Unloading and Waterfront Facilities

1. General

This attachment documents the project objectives and criteria for the design of the unloading and waterfront facilities. The analysis lists the applicable design standards, reference information available, assumptions made during design, relevant site information, and construction materials scheduled to be used for the unloading and waterfront facilities.

Project objectives for designing the unloading and waterfront facilities for Phase 1 include the following:

1. Design a structure for a 200-foot long dredged material barge to berth and be unloaded. The wharf may also need to accommodate berthing of two smaller 100-foot long barges, if needed.
2. The unloading structure must include an impervious wearing surface and be capable of supporting a track mounted crane or hydraulic excavator.
3. The unloading structures must accommodate the unloading of one dredged material barge for Phase 1. The site is capable of supporting a second wharf and unloader for Phase 2 with some additional modifications. The need for a second wharf and unloader for Phase 2 operations will be evaluated during the Phase 1 Final Design.
4. The barge berth must not encroach into the navigation channel.
5. Material removed for the berth construction can be used onsite.
6. Widening of the channel for the berth must include an area for support vessel docking and tug turn-around.

Design standards include the following:

- New York State Building Code, 2000 International Building Code;
- SEI/ASCE 7 Minimum Design Loads For Buildings And Other Structures;
- ACI 318 Building Code And Commentary;
- AISC Manual of Steel Construction, LRFD, Third Edition;
- AWS Structural Welding Code – Steel;
- NY State Canal Corporation Design Standards;
- ASTM A36: Steel Grade (36ksi material); and
- ASTM A572: Steel Grade (50ksi material).

Design survey controls include:

- Vertical Control: NAVD-88.
- Horizontal Control: NAD-83 / New York State Plane – East Zone.

Additional information on the site, design loads, and materials for the waterfront and unloading facilities is provided in the Tables F1 to F3 below.

Table F1 - Relevant Site Information for Design of Unloading and Waterfront Facilities

Existing Conditions and Proposed Elevations	Channel Width (Approximately)	75 feet
	Bottom of Channel Elevation	+117.0 feet +/-
	Low Water Surface (LWS)	+129.0 feet +/-
	Existing Grade Elevation	+133.0 feet +/-
	Proposed Dock Elevation	+136.0 feet

Table F2 - Design Loads for Unloading and Waterfront Facilities

Live Load	Surcharge	800 psf
	Vehicular	N/A
	Equipment	140-ton crane
	Wave	N/A
	Basic Wind Speed	90 mph
	Seismic	Site determined
	Ice/Snow	50 psf deck loading
	Breasting	N/A
	Mooring	N/A
Design Vessel Information	Vessel Type	Unpowered jumbo barge
	Displacement	1,900 tons (loaded)
	Approach Velocity	0.5 ft/s
	Beam	40 feet
	LOA	200 feet
	Draft	9 feet (loaded)
	Freeboard	3 to 10 feet
	Ballast	No
	Site Current	N/A

Table F3 - Material Information for Unloading and Waterfront Facilities

Wharf Structures	Cast-In-Place Concrete	Compressive stress, f'c = 4000 psi
	Steel Reinforcing	Yield stress, Fy = 60,000 psi
	Steel Framing	ASTM A36/A572
	HP-Piles	ASTM A572
	Steel Sheet Pile	ASTM A328/A572

Notes:
f'c is the minimum required compressive strength of concrete after 28 days.
Fy is the yield strength of reinforcing steel for cast-in-place concrete.

2. Dredged Material Barge Staging Requirements

Phase 1 barge staging will require that the waterfront facilities be able to moor up to three barges. The number of barges is predicated upon the following:

- One barge is empty;
- One barge is being unloaded; and
- One barge is full.

A tugboat will bring a loaded barge to the unloading facility through Lock 7, and the barge will be secured. The tugboat will reverse direction and pick up the empty barge for transit back through Lock 7 to the dredge areas.

During the Phase 1 Final Design, a determination will be made as to the need for two barges to be unloaded at any one time and a second wharf for Phase 2. This would be accomplished using two cranes on two unloading wharves that will discharge into two hoppers for processing. An expanded design of the unloading wharves would allow for two barges to be secured to the wharves, a loaded barge to be secured to the dolphins to the north, an empty/full barge to be staged between the wharves, and an empty barge to be secured to the dolphins to the south. A barge haul system will move the barges from the north berth to the south berth, stopping at the unloading wharves.

Although the wharf layout assumes the maximum size barge, actual barges will vary in size and capacity.

3. Offloading Crane Requirements – Productivity

To develop requirements for the offloading crane, assumptions to estimate productivity rates for offloading barges at the unloading and processing facility were developed. Based on these assumptions, a series of spreadsheets was produced. The purpose of the analysis was to evaluate and size a crane and boom, determine the appropriate clamshell bucket size, estimate the number of times the barge will be moved while offloading, and predict the maximum time to unload barges of varying capacity. Assumed sediment volumes are 1,050 cy (for larger barge) and 500 cy (for smaller barge) for inventory dredging. For residuals dredging, sediment volumes are assumed to be 656 cy (for larger barge) and 313 cy (for smaller barge). Free water, over and above these volumes, will also be present in the barges. The free water will be pumped out of the barge while the barge is staged, waiting to be unloaded. "Trash pump" suction hoses would be draped into the barge. The excess water would be pumped ashore to the processing plant for processing.

For the analysis, three periods of downtime were investigated (0, 1, and 2 hours). This rate accounts for breaks for workers and miscellaneous work stoppages that occur during operation over a 24-hour work day. A spill plate will be fixed on the wharf deck to capture spillage during off-loading. Therefore, no time is required to be allotted to shift the position of the spill plate. A 5-cy bucket was assumed for the analysis performed, and an efficiency rate for material captured by the bucket per scoop was assumed to be 90%. This 90% includes consideration of partially filled buckets when the level of material drops within the barge. The swing time for the crane was defined as the time required for the crane operator to scoop material, swing 180°, offload the material into a hopper, and swing back 180° for a new load.

Loading on the cranes was calculated for the crane operating with a clamshell bucket scooping dredged material with a unit weight of 90 pounds per cubic foot (lbs/ft^3). A 5-cy bucket weighs approximately 7,400 lbs empty and 19,550 lbs fully loaded.

Various barge combinations (large, small and debris) are expected to arrive at the facility in a 24-hour period. An analysis was performed in which variables were changed in order to determine the most likely maximum number of barges that could be accommodated at a single wharf with a single crane. Results show that 10 barges (three large barges and seven small barges, with a total volume of 4,668 cy) could be unloaded in a 24-hour period. Taking into account the above variables for the highest number of barges, it would take 18.3 to 24.0 hours to unload 10 barges assuming 1 hour of downtime and 15 minutes to relocate the barges (see Table F4). For a 50-second cycle time (swing time), it will take approximately 21.2 hours to unload the material barges. Taking into account the above variables for the peak daily volume (from the Dredge Plan) of material to be unloaded (5,106 cy), and a mix of large and small barges, it would take 19.1 to 25.4 hours to unload nine barges assuming 1 hour of downtime and 15 minutes to relocate the barges (see Table F5). For a 50-second cycle time (swing time), it will take approximately 22.3 hours to unload the material barges.

4. Offloading Crane Requirements – Equipment

Based on the analysis for bucket sizing, four major crane manufacturers were identified as possible suppliers for the appropriate crane size to offload the barges. The design for live loading by the cranes was calculated assuming the crane would operate with a 5-cy clamshell bucket. Two types of unloading equipment could be used – lattice boom crawler cranes and excavators (see attached Figures F1 and F2). Although the lattice boom crawler crane is more commonly used, some dredged material processing facilities within the Port of New York and New Jersey use hydraulic excavators for unloading barges (see attached Figure F3). The two options for offloading the material are discussed below.

Option 1

Option 1 is to offload the barges using a lattice boom crawler crane. During operation, the lattice boom crane will be positioned on the upland edge of the unloading wharf with the crawlers parallel to the face of the wharf.

Three lattice boom crane manufacturers were researched: Manitowoc Cranes, Terex/American Cranes, and Liebherr Cranes. Crane selection was based on the bucket weight plus the dredged material weight (19,550 lbs or 9.8 short tons) and the radius required for the boom. The boom of the crane will be required to have a radius that will extend from the crane center pin, over the width of the wharf to the extents of the barge width. Location of the crane with relationship to the barge will also affect the radius required. The unloading wharf, including the fender system, is 32 feet wide and the maximum width of the barge is 40 feet. Distance from the edge of the crawler to the crane center pin varies depending on the crane manufacturer and size.

Optimum positioning for the two lattice boom cranes (needed for Phase 2) was determined to be 51 feet 9 inches from the east and west extents of the unloading wharf to the crane center pin. Based on this positioning and a limit of two barge moves, the required working radius for the cranes would be 80 feet.

Considering the above criteria, the following three cranes have been selected as feasible options to unload the barges:

- **Liebherr HS 855 HD Litronic** – The Liebherr HS 855 HD Litronic is a 143.3-ton capacity crane. The Liebherr crane center pin would be located on the wharf 8 feet from the wharf's upland edge.

- **American HC 165** – The American HC 165 is a 165-ton capacity crane. The American crane center pin would be located on the wharf 10.4 feet from the wharf's upland edge. The American is the largest of the three cranes, with a base dimension of approximately 21 feet by 25 feet.

- **Manitowoc Model 1015** – The Manitowoc Model 1015 is a 132-ton capacity crane. The Manitowoc crane center pin would be located on the wharf, approximately 8 feet from the upland edge.

Some movement of all three types of cranes will be required during operation. The movement will be up to 20 feet parallel to the fender line, aligned with the crawler treads. It is anticipated that this movement would be small, not have a significant impact on production times and be necessary only to reach the further extents of material within the barge.

Option 2

Option 2 is to use Hitachi excavators to offload the barges. An excavator would be located on the water-edge of the unloading wharf with the crawlers parallel to the face of the wharf. Hitachi excavators with 5-cy clamshell buckets were considered for this option. As in Option 1, the loading on the excavator was calculated to be 9.8 short tons. It is anticipated the excavator would be located landward of the wharf curb. Radius requirements were calculated by adding 2 feet for the fenders and 40 feet for the width of the barge, which results in a required excavator radius of approximately 44 feet. Additional reach would be required to dig material off the bottom of the barge; therefore, sizing for the excavator was determined assuming a maximum reach of at least 60 feet.

The Hitachi EX1900 would be a suitable excavator for this application. The excavator is capable of carrying a 24,300-lb load at a maximum reach of 62 feet at an elevation 15 feet below the ground level. The excavator has greater mobility than the lattice boom crawler. Some movement of the excavator will be necessary to offload the barge with two barge moves.

Both a lattice boom crawler crane and an excavator are viable solutions to offload dredged material. Manufacturers of such equipment beyond those mentioned here are also available. Of concern in either case is loading on the wharf structure. Preliminary member sizing for the structure assumed an 800 psf live load on the deck (heavy-duty working wharf). The above-mentioned lattice boom cranes produce in excess of 2,000 psf live load and the hydraulic excavator produces approximately 3,600 psf live load under the treads. However, since both of these options preclude the 800 psf live load occurring over the entire structure, further analysis will be conducted in the Phase 1 FDR to determine how and if the current design needs to be refined to accommodate these loads. The most probable refinement will be to strengthen only the area of the wharf deck under which the crane will be located.

Tables

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Table F4: Crane Cycle Time Study (10 barges)

	CYCLE TIME - MINIMUM		CYCLE TIME - MEDIAN		CYCLE TIME - MAXIMUM	
	MINUTES	HOURS	MINUTES	HOURS	MINUTES	HOURS
LARGE BARGE						
MOVE IN	15.0	0.25	15.0	0.25	15.0	0.25
RELOCATE	15.0	0.25	15.0	0.25	15.0	0.25
MOVE OUT	15.0	0.25	15.0	0.25	15.0	0.25
TOTAL	45.0	0.75	45.0	0.75	45.0	0.75
SMALL BARGE						
MOVE IN	15.0	0.25	15.0	0.25	15.0	0.25
RELOCATE	0.0	0.00	0.0	0.00	0.0	0.00
MOVE OUT	15.0	0.25	15.0	0.25	15.0	0.25
TOTAL	30.0	0.50	30.0	0.50	30.0	0.50
UNLOAD						
TOTAL	691.6	11.53	864.4	14.41	1037.3	17.29
DEBRIS BARGE						
MOVE IN	15.0	0.25	15.0	0.25	15.0	0.25
UNLOAD	60.0	1.00	60.0	1.00	60.0	1.00
RELOCATE	0.0	0.00	0.0	0.00	0.0	0.00
UNLOAD	0.0	0.00	0.0	0.00	0.0	0.00
MOVE OUT	15.0	0.25	15.0	0.25	15.0	0.25
TOTAL	90.0	1.50	90.0	1.50	90.0	1.50

TOTAL TIME TO UNLOAD	MINIMUM	MEDIAN	MAXIMUM
LARGE BARGES	2.3	2.3	2.3
SMALL BARGES	3.5	3.5	3.5
DEBRIS BARGES	0.0	0.0	0.0
UNLOAD	11.5	14.4	17.3
DOWN TIME	1.0	1.0	1.0
TOTAL HOURS	18.3	21.2	24.0

Notes:
1. From BBL Dredging Day 85
2. 5 cy Bucket at 90% capacity.
3. Fixed drip plate (no relocation).
4. Full barge staged, waiting to be moved into position for unloading.
5. Empty barge staging area clear to accept barge from wharf.
6. Cycle time varies w/MED. DT & MED. RT.

Daily Capacity:	Large Barge:	3	
	Small Barge:	7	
	Debris Barge:	0	
	Total	10	4,668 CY

Crane Cycle Time:	Minimum	40 seconds
	Median	50 seconds
	Maximum	60 seconds
Down Time:	Minimum	0 hour
	Median	1 hour
	Maximum	2 hours
Relocation Time:	Minimum	0 minute
	Median	15 minutes
	Maximum	30 minutes

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Phase 1 Intermediate Design Report

Table F5: Crane Cycle Time Study (9 barges)

	CYCLE TIME - MINIMUM		CYCLE TIME - MEDIAN		CYCLE TIME - MAXIMUM	
	MINUTES	HOURS	MINUTES	HOURS	MINUTES	HOURS
LARGE BARGE						
MOVE IN	15.0	0.25	15.0	0.25	15.0	0.25
RELOCATE	15.0	0.25	15.0	0.25	15.0	0.25
MOVE OUT	15.0	0.25	15.0	0.25	15.0	0.25
TOTAL	45.0	0.75	45.0	0.75	45.0	0.75
SMALL BARGE						
MOVE IN	15.0	0.25	15.0	0.25	15.0	0.25
RELOCATE	0.0	0.00	0.0	0.00	0.0	0.00
MOVE OUT	15.0	0.25	15.0	0.25	15.0	0.25
TOTAL	30.0	0.50	30.0	0.50	30.0	0.50
UNLOAD						
TOTAL	756.4	12.61	945.6	15.76	1134.7	18.91
DEBRIS BARGE						
MOVE IN	15.0	0.25	15.0	0.25	15.0	0.25
UNLOAD	60.0	1.00	60.0	1.00	60.0	1.00
RELOCATE	0.0	0.00	0.0	0.00	0.0	0.00
UNLOAD	0.0	0.00	0.0	0.00	0.0	0.00
MOVE OUT	15.0	0.25	15.0	0.25	15.0	0.25
TOTAL	90.0	1.50	90.0	1.50	90.0	1.50

TOTAL TIME TO UNLOAD	MINIMUM	MEDIAN	MAXIMUM
LARGE BARGES	3.0	3.0	3.0
SMALL BARGES	2.5	2.5	2.5
DEBRIS BARGES	0.0	0.0	0.0
UNLOAD	12.6	15.8	18.9
DOWN TIME	1.0	1.0	1.0
TOTAL HOURS	19.1	22.3	25.4

Notes:
1. From BBL Dredging Day 75
2. 5 cy Bucket at 90% capacity.
3. Fixed drip plate (no relocation).
4. Full barge staged, waiting to be moved into position for unloading.
5. Empty barge staging area clear to accept barge from wharf.
6. Cycle time varies w/MED. DT & MED. RT.

Daily Capacity:	Large Barge:	4	
	Small Barge:	5	
	Debris Barge:	0	
	Total	9	5,106 CY

Crane Cycle Time:	Minimum	40 seconds
	Median	50 seconds
	Maximum	60 seconds
Down Time:	Minimum	0 hour
	Median	1 hour
	Maximum	2 hours
Relocation Time:	Minimum	0 minute
	Median	15 minutes
	Maximum	30 minutes

Figures

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ATTACHMENT F - DESIGN ANALYSIS: UNLOADING AND WATERFRONT FACILITIES

LIEBHERR LATTICE BOOM CRANE

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FIGURE F-1

08/20/05 SYR-D85-DJH-KLS
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HITACHI HYDRAULIC EXCAVATOR

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FIGURE F-2

08/20/05 SYR-D85-DJH-KLS
N:20437703/20437G09.cdr (pg. 2 of 3)

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UNLOADING CRANE

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FIGURE
F-3

08/20/05 SYR-D85-DJH-KLS
N:20437703/20437G09.cdr (pg. 3 of 3)

Phase 1 Intermediate Design Report
Hudson River PCBs Superfund Site

Attachment G – Design Analysis: Processing Facilities

General Electric Company
Albany, New York

August 22, 2005

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Attachment G – Design Analysis: Processing Facilities

1. General

This attachment and the associated tables and calculations (Exhibits G-1.1 through G-8.1) present the rationale for the selection and sizing of the various pieces of equipment and individual facilities that will collectively comprise the sediment and water processing facilities at the Energy Park site. It presents the basis and results of calculations used in the design, and incorporates the results of treatability studies, where appropriate.

The overall process flow diagram for the processing facility is presented in Sections 3.6.4.1 and 3.6.4.2 and shown on Contract Drawings P-2002 and P-2003. This attachment presents the assumptions and calculations used to size those components in the general order they are discussed in Section 3.6, but the reader is referred to that section for a complete narrative of how the components interact with each other.

The Phase 1 Intermediate Design and treatability studies were both developed using examples of four dredged sediment types, illustrating a range of conditions encountered horizontally and vertically in the river. Particle size distributions were determined for samples or sample segments during the Year 1 and Year 2 SSAP programs. The sample results were sorted by percent fines (% passing 0.074 millimeter [mm]) and the data set was separated into four equal quadrants. The analyses within each quadrant were averaged and reported as sediment types S1, S2, S3, and S4 (see Exhibit G-1.1). The particle size distributions for the Year 1 and Year 2 SSAP data are combined and presented in Exhibit G-1.1, while separate particle size distributions for the Year 1 and Year 2 data sets are displayed in Exhibit G-1.2.

During the treatability studies (see Treatability Study Appendix), samples of Hudson River sediments were collected from areas where PSDs and PCB concentrations were representative of sediment types S1, S2, S3, and S4. Summary analyses of these baseline sediment samples are shown in Exhibits G-1.3 and G-1.4.

The four different sediment types represent the range of properties that the processing facilities must be capable of handling. It is not expected that equal quantities of each sediment type will be dredged. Estimated quantities of each sediment type that will need to be processed will be developed during Phase 1 Final Design.

2. Size Separation

Mechanical Unloader (Clam Shell)

Barge unloader configurations are presented in Attachment F (Design Analysis: Unloading and Waterfront Facilities), along with unloading calculations and discussion of unloader sizes.

Hopper with Pipe Grizzly

Details pertaining to selection of bar screen (pipe grizzly), belt feeder, and inclined conveyor are presented in Exhibit G-2.1.

Trommel Screen

Loading calculations, trommel component sizing, and selection of a fixed stack conveyor are presented in Exhibit G-2.1. A screen opening size of 3/8 inch is the smallest size recommended by equipment suppliers.

Sediment Slurry Tank

The sediment slurry tank will be used to adjust the solids content of the trommel screenings to within the range of 20 to 30% (w/w) solids. This will form the feed to the hydrocyclones, as discussed below. Recycle water will be applied to both the trommel spray bars and the sediment slurry tank. The portion of recycle water added to the slurry tank will be added in response to a mass analyzer signal from within the slurry tank. The trommel sprays will add half or more of the required dilution water, so the recycle water added to the slurry tank will be a final trim. The slurry tank hydraulic residence time of 5 to 8 minutes is a compromise between the need for tankage large enough to equalize large short-term fluctuations in concentrations and a desire to minimize settling of coarse material within the slurry tank. A residence time of 5 to 8 minutes will represent a mixture of the contents of four to six clamshell swings.

Hydrocyclone System

The hydrocyclone system is sized to treat a continuous flow of sediment slurry. Type S1 sediments will create the highest solids loadings to the system, as shown in Table 3-35 (Material Balances). Sizing calculations were prepared by Krebs Engineers (Tucson, AZ), and are included in Exhibit G-2.1.

Treatability testing was performed to evaluate size separation technologies and the chemical properties of the separated solid fractions. Samples of four sediment types were wet screened in sufficient quantity to analyze the screened fractions for a number of parameters, including PCB, TOC, solids, pH, and specific gravity. Results are presented in Exhibit G-2.2. Other properties of the separated size fractions are presented on pages 227 to 238 of the appended *Treatability Studies Report*. These results show how solids and PCBs separate differently by particle size for different sediment types. The amount of PCB in coarse fractions was likely associated with the woody material observed in these samples.

Two hydrocyclone treatability testing campaigns were performed in August 2004 and December 2004. The August 2004 tests applied sediment S4 (28% fines) at feed concentrations of 10 and 15% (w/w), while the December 2004 tests applied sediments S2-2 (17% fines) and S3-4 (36% fines) at feed concentrations of 15 and 25% (w/w), respectively. Hydrocyclone testing in the December 2004 tests used a cyclostack and higher solid feed concentration. In general, these runs achieved better performance than observed in the August 2004 hydrocyclone testing. Hydrocyclone testing results and material balances are shown in Exhibit G-2.3.

Based on the results of these tests and advice from Joseph Keene of KD Engineering (Tucson, AZ) and Krebs Engineers, a hydrocyclone feed solids content in the neighborhood of 25% (w/w) was established as a target, with a range of 20 to 30% considered acceptable.

<u>Vibratory Dewatering Screens</u>

For purposes of Phase 1 Intermediate Design, 120 square feet (ft^2) of vibratory dewatering screens (to recover -40 mesh x +400 mesh) was recommended by Derrick Corporation for dewatering the estimated 300 tons of solids per day of hydrocyclone underflow resulting from the treatment of sediments generated from dredging 4,300 cy/day of type S1 material.

Treatability studies evaluated the drainage characteristics of the coarse fraction. Coarse settled solids (79% solids) from S1 sediment gravity drained to 86% after 24 hours, while coarse solids (71% solids) from S2 sediment drained to 73% after 24 hours. Coarse solids (42% solids) from hydrocyclone underflow testing of sediment S4 drained to 77% solids after 24 hours. Drainage results are summarized in Exhibit G-2.5. Some of the water loss was likely due to evaporation. While this testing showed that separated coarse solids will release additional water, the test was not representative of dryness that may be attained by vibratory dewatering screens. For purposes of completing the Intermediate Design, it was assumed that hydrocyclone underflow will dewater on a vibratory screen to a solids content of 85% by weight. This will be refined after further consultation with the equipment vendors.

Process Water Storage Tanks

The size separation process water storage tank will receive and store recycle water from solids processing for use in trommel screen washing and addition to the sediment slurry tank. This tank, located at the waterfront, will provide 1-hour residence time when type S1 sediment is processed, as presented in Exhibit G-2.1.

The treated water storage tank, also located at the waterfront, will provide treated water (from process filtration and GAC treatment) for use as decontamination wash water, as presented in Exhibit G-2.1.

3. Thickening and Dewatering

Hydrocyclone overflow will be directed to the hydrocyclone wet well, where it will be pumped to the solids thickening and dewatering system. The slurry pumps and piping from the hydrocyclone wet well are sized in Exhibit G-3.1.

Dredge Slurry Holding Tanks

The dredge slurry holding tanks serve as flow equalization prior to thickening of the hydrocyclone underflow. As developed in Exhibit G-3.1, two tanks with a storage volume of 700,000 gallons each will provide a storage capacity for 8 hours of hydrocyclone underflow generated by processing type S1 sediment. Eight hours of storage would also provide a buffer period of offloaded storage in the event a portion of the thickening or dewatering facilities was under repair or maintenance. More importantly, these tanks are required to cope with water imbalances that will likely occur when changes in sediment types are delivered for processing, and especially when processing needs change as a result of intermixing inventory barge loads followed by residuals barge loads (or vice versa).

Mixing energy studies were performed to determine the mixing energy needed to keep slurries in suspension. Results of mixer studies in 5-gallon and 55-gallon containers are presented on pages 331 to 337 of the Treatability Studies Appendix. The range of velocity gradients (G) from 200 to 800 sec^{-1} all kept solids in suspension for gravity-decanted fines from slurry types S1 to S4B. Vendors have recommended five 75-hp mixers for each 700,000-gallon tank. These mixers can provide a velocity gradient of 205 sec^{-1} when the tank is at full capacity.

The sizing of dredge slurry holding tank transfer pumps is included in Exhibit G-3.1.

Thickener Conditioning Tanks

Chemical screening tests were performed on 100 milliliter (mL) samples to evaluate the effects of polymer treatment on thickening fine solids (<#200 sieve) from sediment S2-2-07. Coagulant polymer (GE Betz Developmental E) doses of 9.7 pounds per dry ton (lbs/dry T solids) achieved the fastest settling rates. See Exhibit G-3.2a.

Additional settling tests with polymer screening were performed using 2 liter (L) samples of hydrocyclone overflows from treatment of sediment type S2-2. The screening used combinations of cationic polymer coagulants with cationic and anionic polymer flocculants. The results, shown in Exhibit G-3.2b, led to the tentative selection of cationic coagulant GE Betz Developmental E at a dose of 6 lb/dry T combined with anionic flocculant GE Betz AE1115 at a dose of 3 lb/dry T.

Polymer preparation and addition systems will be developed to permit chemical-enhanced thickening, as described above, for cationic and anionic polymer treatment. These details will be developed during Phase 1 Final Design, or in accordance with performance specifications.

Gravity Thickener System

Gravity thickener sizing calculations are presented in Exhibit G-3.1, using results of the 2-L cationic and anionic polymer treatments with hydrocyclone overflow from treating S2-2-07 <#200 samples. These calculations indicate the need for two 60-foot diameter thickeners. A water depth of 12 feet is recommended by vendors.

Dewatering Conditioning Tanks

Dewatering polymer screening and confirmation tests were performed to select polymers for use in filter press testing. Screening test results are shown in Exhibits G-3.4 and G-3.5. These results indicated that various cationic coagulant products performed similarly within dosage ranges of 2 to 13 lbs/dry T for gravity-desanded slurries. Optimum cake solids ranged between 60 to 70% at 4 to 9 lbs/dry T polymer doses, with no strong trend from S1 to S4.

Comparison of thickened vs. unthickened filter press feeds and feed solids of 3 to 25% suggests some improvement of cake solids concentrations with increasing feed solids concentrations. Polymer coagulant doses of 6 to 10 lbs/dry T solids were required for thickening.

A mixing sub-study was performed to evaluate mixing needs and floc sensitivity to mixing or shear (see page 451 of the appended *Treatability Studies Report*. The results indicated that 3 minutes of over-mixing at 100 revolutions per minute (rpm) resulted in a loss of 10 to 12 % cake solids. This is typical of performance losses that might be expected from excessive floc shear.

The polymer conditioning facilities at the processing facility should be designed with variable mixing speed capability to allow the operator to avoid excessive mixing conditions.

Based on the results of polymer screening and the pilot scale tests described below, a cationic coagulant such as GE Betz Developmental E will be used for Phase 1 dewatering within a dosage range of 7 to 19 lbs/dry T. This dosage range may be modified if polymer treatment will be used in the gravity thickeners. Additional testing of thickened sediments will continue during Phase 1 Final Design.

Polymer preparation and addition systems will be developed to permit chemical-enhanced dewatering, as described above, for cationic polymer treatment. These details will be developed during Phase 1 Final Design or in accordance with performance specifications.

Recessed Chamber Filter Press Dewatering System

Dewatering treatability studies included bench-scale filter press simulations (BFPs or “hockey pucks”) using a test apparatus from US Filter. These bench-scale tests were used to evaluate the effects of several variables. The program also included tests using a 1 ft^2 pilot-scale plate and frame filter press (PFP). The PFP tests were conducted to generate water for water treatment pilot tests. The main variable that changed for the PFP tests was the feed sediment types. Exhibit G-3.6 is a listing of all the bench-scale and pilot-scale tests.

Exhibit G-3.7a lists results of treatments with GE Betz Developmental E polymer, 100 psi and 30- 60-minute runs. The data were then divided into BFP and PFP for each matrix. For the BFP runs, the results were selected for the dosage that produced highest cake solids when a series of dosages was performed. For PFP, it was assumed that all dosages were close to optimal. The pilot-scale results did not significantly differ from similar bench-scale tests. In general, it is expected that sediments can be dewatered to 55 to 65% solids (see comparisons in Exhibit G-3.7b).

The filter press tests used "simulated" hydrocyclone overflow as feed. This simulated feed was produced by settling the sediment slurry for 1 to 2 minutes to simulate the coarse solids removal expected during hydrocyclone separation. Bench-scale filter press tests were also run on actual hydrocyclone overflow from pilot tests (Exhibit G-3.8). The actual hydrocyclone overflows appear to require polymer doses higher than the simulated feeds and produce cake solids of 45 to 55%, as compared to 55 to 65% for the simulated feeds. When freshly-diluted sediment samples were passed across a #400 screen, the resulting fines required high polymer doses and produced BFP cakes in the 45 to 55% range, similar to the hydrocyclone overflows.

Several BFP runs evaluated cake release screening for alternative fabric porosities. See Exhibit G-3.9. The tests included fabrics with porosities ranging from 0.5 to 15 cubic feet per minute (cfm). All of the tested fabrics had good release and clear filtrate; cake solids and filtrate volumes were similar within each of the two sediments tested. Specific filter press vendors may need to perform similar testing for other media.

Most BFP runs and all PFP runs were conducted at filter feed pressures of 100 psi. Within tests BFP-82 to BFP-92, several feed pressures of 125 and 225 psi were performed. Improvements of cake solids at the higher pressures were inconsistent. Run BFP-84 at 125 psi had cake solids of 71.5% vs 67.1% for BFP-83 at 100 psi. However, curiously, BFP-88 at 100 psi produced cake solids of 59.2%, compared to BFP-90 at 125 psi, which had cake solids of 58.9% and BFP-91at 225 psi, which had cake solids of 54.6%.

Cake solids vs. time were evaluated in runs BFP-144, BFP-133, and BFP-145. Cake solids improved around 10% solids points from 45 to 60 minutes, with little further cake dryness achieved by increasing the time to 60 to 90 min. Similar time trends can be observed by plotting filtrate volumes from individual BFP and PFP tests (no BFP tests went beyond 90 minutes, but some PFP tests went to 120 to 150 minutes).

The pooled data in Exhibit G-3.6 were evaluated by multiple regression, with results presented and discussed in Exhibit G-3.10. Cake solids were best predicted by the fines content in the matrix, next by filter press feed % solids, and then by scale of the test (bench vs. pilot). Curiously, polymer dose was not statistically significant – see discussion in Exhibit G-3.10.

For several of the PFP runs, filtrate samples were analyzed. These analyses are summarized in Exhibit G-3.11. Suspended solids ranged 2 to 42 milligrams per liter (mg/L), with an average of 13.4 mg/L. TOC and dissolved organic carbon (DOC) ranged 3 to 14 mg/L, with an average of 7.8 mg/L. Total PCB ranged 430 nanograms per liter (ng/L) to 46 micrograms per liter (μg/L), with an average of 17.6 μg/L.

Alternatives to dewatering by plate and frame filter press include belt presses and centrifuges. Some screening tests were performed to estimate polymer consumption and cake solids achievable by these processes. Test results are shown in Exhibit G-3.12. The belt press screening tests achieved average 52% solids, only slightly lower than the 55 to 65% solids produced by PFP tests. Centrifugation achieved average 49% cake solids. It is notable that the centrate suspended solids and PCB concentrations were approximately 100 times that of PFP filtrate.

Filter press sizing calculations are presented in Exhibit G-3.1. Phase 1 processing will require 12 plate and frame filter presses, each with a capacity of 600 cubic feet. Press cake (55 to 65% solids) will discharge to roll-off boxes located below each press.

Press filtrate will discharge to the recycle water equalization tank, where it will mix with overflow from the thickeners. Sizing of the recycle water equalization tank is included in Exhibit G-3.1. Water from this tank is used to supply the size separation process water storage tank located at the waterfront.

4. Solidification and Stabilization

Stabilization/solidification treatability testing was performed to evaluate the effectiveness of various dosages of solidification agents on raw slurries and filter cake. The test data and observations are summarized on pages 759 to 760 in the Treatability Studies Appendix. Generally, it is noted that quicklime performed better at lower doses than other reagents tested. Dosages of 15 to 25+% were required, with very high dosages for S4 sediments. Typically, stabilization/solidification is performed at dosages of 7 to 10%. Filter press cakes all passed the paint filter test and did not require stabilization/solidification. Based on treatability testing, quicklime would be the material of choice for stabilizing off-spec batches of filter press cake.

Storage/transport stability tests were performed to ascertain the potential for water to be released from processed material during transport. A shaker test was used to simulate motion during transport that might result in water release from dewatered or solidified sediments. Results are presented in the appended *Treatability Studies Report*. All mixes were stable, and only three samples had a detectable amount of free water released.

5. Process Water Treatment

Process water treatment was tested during treatability studies. The treatment train included settling, filtration, and carbon adsorption. The processes were tested at a range of commonly applied hydraulic loading rates using filtrates produced during pilot tests by dewatering each of the sediment types (S1, S2, S3, and S4B) with PFPs. Results of the testing are included in Tables 23 and 24 of the appended *Treatability Studies Report*. These results are also summarized in Exhibits G-4.2 (Settled Filtrate) and G-4.3 (Process Water Filtration and Granular-Activated Carbon Adsorption). The tests were not designed to follow the processes through full cycles of headloss development or carbon exhaustion. Rather, the tests were intended to represent a snapshot of the process removal capabilities when treating waters from various sediments over a range of hydraulic loadings. The column tests were equilibrated for at least 10 bed volumes of flow before sampling.

After settling for 2 hours, the supernatants were used to feed the process filter and two GAC columns in series. Settled dewatering process effluents from the four sediment types were applied to the process filter (4-inch diameter x 4-foot bed height) at hydraulic loadings of 2, 6, and 10 gallons per minute per square foot (gpm/ft^2).

The process filter was connected in series to a train of two GAC columns (4-inch diameter x 5-foot bed height each), also in series. Sampling between the GAC columns and after the lag column allowed evaluation of two hydraulic loadings during each run. The three applied flow rates achieved carbon loading rates of 19 and 38 minutes, 6 and 13 minutes, and 4 and 8 minutes empty-bed contact times (EBCTs).

Exhibit G-3.11 shows PFP filtrate suspended solids ranging from 2 to 42 mg/L (13.4 mg/L average) and PCBs ranging from 0.43 to 46 µg/L (17.6 µg/L average). Exhibit G-4.2 shows settled PFP filtrates with suspended solids undetectable (at a detection limit of about 2 mg/L) in four of the five tests, and 13 mg/L for settled H1S4B filtrate. The settled filtrates had PCBs ranging from 40 to 1,100 ng/L. Heavy metals in the settled PFP filtrates were all well below the WQC Substantive Requirements.

Exhibit G-4.3 shows removals across the process filter and GAC columns. The feed PCBs were low for all sediment types, ranging from 22 to 56 ng/L. The process filter showed consistent further removals of PCBs, with filter effluents ranging from 12 to 46 ng/L (discounting a 76 ng/L outlier). The lead and lag GAC effluents were undetectable for PCBs at a detection limit of 9.3 to 9.8 ng/L (except for H1S4B with 17 ng/L from the lead column and undetectable from the lag column).

Even though feed heavy metals were all below WQC Substantive Requirements, there were consistent reductions of chromium, copper, and lead across the GAC, and to a lesser extent across the process filter. Cadmium and mercury were below detection levels in feeds and effluents. In other tests, effluent from RSSCT carbon columns was tested for mercury using EPA Method 1631. Mercury was not present at detection levels of 0.00051 µg/L. When present in feed streams, there were also expected reductions in COD, 5-day BOD5, TOC, DOC, TKN, and nitrate, typically to non-detectable levels from the lag GAC.

There were no outstanding differences in removals owing to the three hydraulic loadings tested.

The DRET tests provide some additional perspective on the potential solubilization of heavy metals from Hudson River sediments within the processing facilities, although that is not the intent of the DRET test. See Exhibit G-4.4. Settled (unfiltered) DRET water was observed to contain cadmium, chromium, lead, and mercury concentrations exceeding WQC Substantive Requirements; however, none of the filtered waters contained heavy metals above the WQC Substantive Requirements. Note that the DRET test uses a 1% sediment slurry, mixed, then settled. The sediment concentrations in the processing facility will be on the order of 25%. The metals in the PFP filtrates (Exhibit G-4.2) and the filter/GAC tests (Exhibit G-4.3) were not significantly different from the DRET test filtrates, indicating that dissolved metal concentrations are not sensitive to original slurry concentrations.

Process Water Equalization Tanks

The METSIM material balances (presented in Table 3-35) indicate that processing of inventory dredging barges during the 1-month Phase 2 demonstration period (conducted during Phase 1) will produce 300 to 409 gpm (0.43 to 0.59 [mgd]) of water to be treated, depending on the sediment type being processed. The material balances further indicate that processing of residuals dredging barges will generate 780 to 860 gpm (1.1 to 1.2 mgd) of water. Based on these expected flow rates, two water treatment trains of 500 gpm each will be constructed for Phase 1.

Excess water will be directed from the recycle water equalization tank (T-21001) to the process water equalization tank (T-30101). The 60,000-gallon process water equalization tank will provide a 60-minute retention/equalization time at the design flow rate of 1,000 gpm (Exhibit G-4.1). Either one or both process water treatment trains will draw from this tank.

Rapid/Mix and Flocculation Tanks

During the pilot studies, solids present in the PFP filtrate settled readily without further chemical treatment. However, to provide flexibility, chemical feed, rapid mix, and flocculation tanks will be provided with each 500 gpm train. These will be available for polymer addition and/or metal coagulant.

As presented in Exhibit G-4.1, a 1,500-gallon rapid mix basin (3 minutes) and a 2,500-gallon flocculation basin (5 minutes) will be provided along with appropriate mixers, to be specified during Phase 1 Final Design.

Clarifiers

The flocculation basins will each lead to a high-rate clarifier. A number of clarifiers are available that operate at hydraulic loading rates of 0.23 to 0.25 gpm/sf. Clarifiers are often supplied with integral rapid mix and flocculation facilities. Other clarifier systems (e.g., Krofta) may be integrated with filter media.

Process Filter Systems

Process filter systems are discussed in Exhibit G-4.1. A design hydraulic loading of 3.9 gpm/ft^2 is suggested. This rate is consistent with the screening tests done during treatability studies. Two filter units per process train are suggested.

Backwash water will be provided for an upflow rate of 15 gpm/ft^2 (1,000 gpm) and a backwash time of 15 minutes per filter once per day, for a total backwash requirement of 60,000 gallons per day. This is 4% of the forward flow at design loading.

Granular Activated Carbon Systems

As described in Exhibit G-4.1, four GAC vessels are recommended for each 500 gpm process water treatment train. Each GAC vessel will be designed for a recommended EBCT of 20 minutes, with two trains of two GAC vessels in series. Each vessel will contain 20,000 pounds of GAC, with a bed volume of 700 cubic feet. Piping will allow reversal of lead and lag columns in each train.

RSSCTs have been conducted to allow prediction of GAC bed life and breakthrough profiles. The results are currently being compiled and will be reported during Phase 1 Final Design. Available test results indicate that at typical loadings, the bed life is likely to last well beyond a single dredging season. Bag filters or cartridge filters will be provided at the end of each GAC train. Bag filter media will likely be 5 or 10 microns.

Backwash Holding Tank

A single 200,000-gallon backwash holding tank (T-30901) will serve the backwash needs of all filter columns and GAC columns. In addition, this tank will provide holding for decontamination and plant wash waters at all process areas, including rail yard decontamination needs. A listing of plant water needs is included in Exhibit G-4.1.

6. Stormwater Treatment

Design Storms

Three types of stormwater runoff are described in Section 3.6 of the Phase 1 IDR. These include Type I stormwater, which has the potential to contact PCB-containing materials; Type II stormwater, which has the potential to collect non-PCB sediments as a result of peripheral site activities; and Type III stormwater, which runs across areas of the site which are undisturbed and/or not involved in site activities.

Exhibit G-8.1 presents a tally of the Type I runoff areas and presents runoff volume calculations associated with 10-, 25-, and 100-year return interval storms. Type I stormwaters will be collected, stored, and treated as described below. Type II stormwaters will be gravity-drained to four stormwater sediment basins. These grass-surfaced basins will allow sedimentation and recharge, but will overflow to surface waters during higher-flow periods. Type III stormwaters will follow current recharge or discharge patterns.

Stormwater Treatment Systems

Type I stormwaters will be collected and routed as described in Section 3.6 of the Phase 1 IDR. Three types of storage systems will be used. Above-ground tanks will contain runoff (3.5 MG) from a 10-year 24-hour storm. Curbing and piping will contain additional storm volume (0.6 MG) generated from a 25-year 24-hour storm (4.1 MG), while curbing will contain additional storm volume (1.0 MG) generated from a 100-year 24-hour storm (5.1 MG).

A third water treatment train (in addition to the two described in Section G.5 [Process Water Equalization Tanks]) will be used to treat Type I stormwaters. This will be an additional 500 gpm train identical to the two 500 gpm process water treatment trains. Stormwater treatment will use available capacity, as needed, from the two process trains. If dredging is discontinued for any period, the process water treatment trains can be fully utilized for stormwater treatment. Similarly, when not needed to treat stormwater, the stormwater train can be available to address non-routine process treatment needs.

7. Processed Material Staging and Load-out Facilities

Waterfront Staging

Four types of materials will be staged and managed at the waterfront facility. These include:

- Large debris removed separately by grapple or sling. This may include logs and rocks, as well as large cultural debris, such as tires, appliances, or shopping carts;
- Debris greater than 6 inches in diameter rejected from the pipe grizzly;
- Debris greater than 3/8 inch in diameter rejected from the trommel screen; and
- Coarse solids from hydrocyclone underflow and dewatering screen.

Estimated quantities and temporary staging areas are presented in Exhibit G-5.1. Calculations of transport vehicles and trip cycles are also included. In the calculations a 16-hour work day is intended to represent a 67% utilization rate over a 24-hour day. Downtime is anticipated for truck maintenance, fueling, shift changes, and potential waiting time if loading or unloading operations experience delays.

Filter Cake Staging

At peak Phase 1 production, 12 filter presses will each produce a drop of 22 cy of 55% solids filter cake every 3 hours, for a total of 105 drops per day. These solids will drop into 30 cy roll-off containers. Two roll-off trucks will each need to transport two containers per hour from the filter press building to the fine sediment staging area.

Railside Staging

Exhibit G-5.1 presents five Phase 1 train scenarios. These scenarios list the weekly barged and processed sediment amounts, and calculate load-out volumes in accordance with assumed numbers of unit trains shipped each week. The net difference between each week's input and output becomes the additional cumulative storage volume. Each scenario reaches a maximum peak storage volume that declines as dredging production is reduced or as rail service is increased. The two principal scenarios were:

- Three trains per week (Scenarios 4 and 5) require 22,000 to 34,000 cy storage.
- Two trains per week (Scenario 1) require 83,000 cy storage.

The scenario utilizing two trains per week was selected as the basis for storage sizing because it minimizes the potential effects of rail service unreliability on processing facility operations. The 83,000-cy storage scenario can be accommodated in the four to five storage cells/structures shown on the Contract Drawings. This scenario will require the use of stackers to attain 20-foot high storage cells. The storage cells would include two for fine sediment cake, two for coarse sediments, and one for debris.

Exhibit G-5.1 also includes calculations for loading staged materials into rail cars. Four 8.7 cy wheel loaders (two loading coarse materials from the north staging cells and two loading fine sediments from the south staging cells) can load one 81-car unit train in 8 hours, not including train movement times.

8. Site Work, Roads, Utilities, and Administrative Areas

Stormwater

Stormwater handling was discussed in Section G.6 in connection with treatment requirements. The sizing of the Type II Stormwater Sediment Basins is being finalized in conjunction with the site grading plan. These basins will be modified during Phase 1 Final Design. Similarly, the curbed Type I stormwater impounded areas and piping systems are being finalized along with the site grading plan, and will be presented in the Phase 1 FDR.

Site Grading

The site grading plan will continue during Phase 1 Final Design. Approximate earthwork and fill quantities developed to date are presented in Exhibit G-8.1. These preliminary calculations indicate a need for an estimated 100,000 cy of net differential to be supplied by imported fill during the beginning of the Phase 1 construction period.

Exhibit G.1

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

General Electric Company
Hudson River PCBs Superfund Site
Phase 1 Intermediate Design Report

Attachment G.1.1 - SSAP Sediment Characteristics - Years 1 + 2

		Cum. % passing size (mm) - Quartile Average						D50	% Fines	Solids Sp. Grav.	Solids	PCB	TOC
		0.005	0.074	0.425	2.0	4.75	76.2	(mm)	<74um	(g/mL)	% (w/w)	mg/kg	mg/kg
Yr 1	S-1 Coarsest quartile	1.0	4.6	42.5	72.7	84.4	100.0	0.81	4.6	2.68	77.6	33.9	5,200
Yr 1	S-2 Coarse-fine	2.5	11.9	52.8	76.9	86.2	100.0	0.40	11.9	2.60	71.9	49.3	12,800
Yr 1	S-3 Fine-coarse	9.7	32.8	80.4	92.4	95.6	100.0	0.20	32.8	2.48	59.7	159	26,700
Yr 1	S-4 Finest quartile	34.5	76.4	96.1	98.8	99.3	100.0	0.03	76.4	2.39	50.1	196	39,000
Yr 1	**Overall Average**	**11.8**	**31.1**	**67.7**	**85.1**	**91.3**	**100.0**	**0.26**	**31.1**	**2.54**	**64.9**	**106.9**	**20,800**
													0
Yr 2	S-1 Coarsest quartile	2.1	5.2	43.4	79.3	86.9	99.3	0.71	5.2	2.70	79.0	9.4	5,500
Yr 2	S-2 Coarse-fine	8.4	28.3	82.7	93.5	95.9	100.0	0.21	28.3	2.56	63.2	58.9	24,400
Yr 2	S-3 Fine-coarse	16.0	55.0	94.1	98.5	99.1	100.0	0.07	55.0	2.47	54.6	117	34,400
Yr 2	S-4 Finest quartile	26.4	81.0	98.1	99.9	99.9	100.0	0.03	81.0	2.42	48.2	124	38,900
Yr 2	**Overall Average**	**13.2**	**42.3**	**79.5**	**92.8**	**95.5**	**99.8**	**0.15**	**42.3**	**2.54**	**61.3**	**84.9**	**25,800**
													0
Yr 1+2	S-1 Coarsest quartile	1.6	4.8	41.7	76.7	85.7	99.5	0.80	4.8	2.70	79.1	15.1	4,900
Yr 1+2	S-2 Coarse-fine	7.0	23.3	75.6	90.2	94.0	100.0	0.25	23.3	2.56	64.9	77.2	21,400
Yr 1+2	S-3 Fine-coarse	15.1	51.2	93.2	98.1	98.8	100.0	0.07	51.2	2.48	55.6	110	33,500
Yr 1+2	S-4 Finest quartile	28.1	80.7	97.9	99.8	99.9	100.0	0.03	80.7	2.42	48.5	138	39,200
Yr 1+2	**Overall Average**	**12.9**	**40.0**	**77.0**	**91.1**	**94.6**	**99.9**	**0.17**	**40.0**	**2.54**	**62.0**	**90.0**	**24,700**

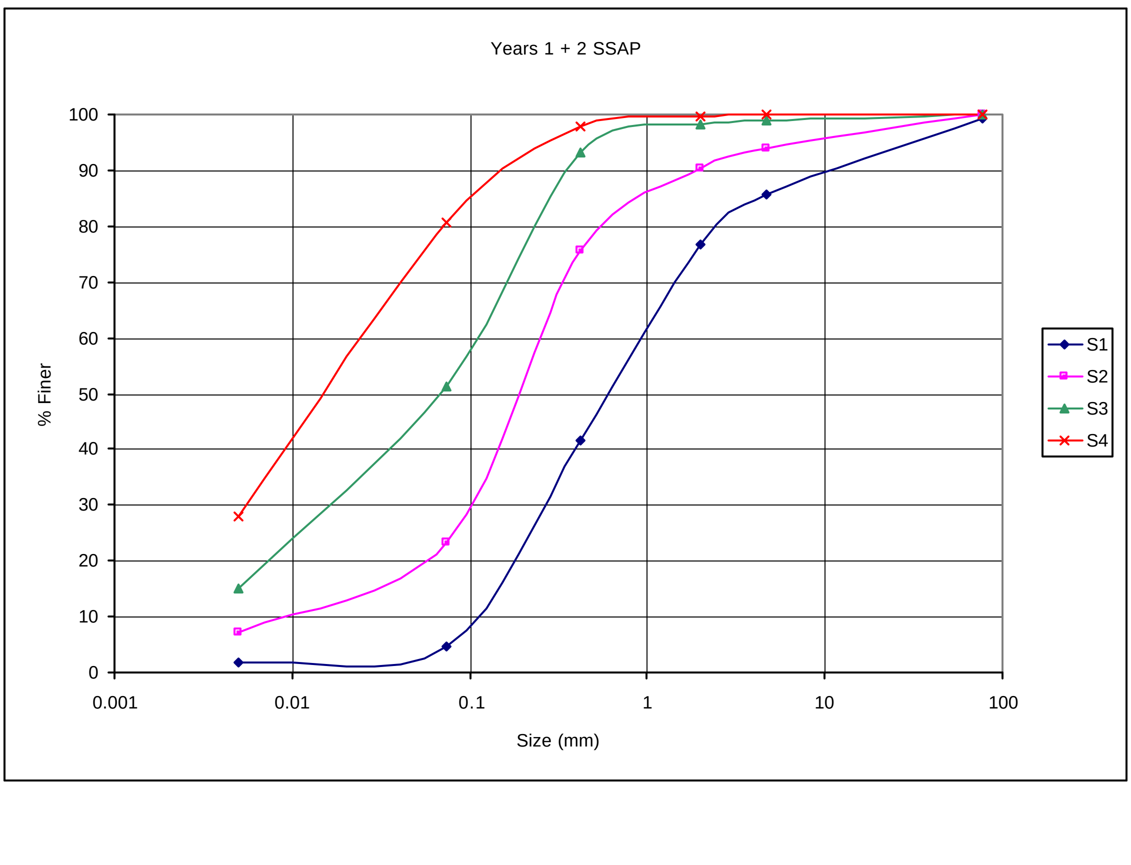

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Exhibit G.1.1 - SSAP Sediment Characteristics - Years 1 + 2

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		0.005	0.074	0.425	2.0	4.75	76.2	(mm)	<74um	(g/mL)	% (w/w)	mg/kg	mg/kg
Yr 1	S-1 Coarsest quartile	1.0	4.6	42.5	72.7	84.4	100.0	0.81	4.6	2.68	77.6	33.9	5,200
Yr 1	S-2 Coarse-fine	2.5	11.9	52.8	76.9	86.2	100.0	0.40	11.9	2.60	71.9	49.3	12,800
Yr 1	S-3 Fine-coarse	9.7	32.8	80.4	92.4	95.6	100.0	0.20	32.8	2.48	59.7	159	26,700
Yr 1	S-4 Finest quartile	34.5	76.4	96.1	98.8	99.3	100.0	0.03	76.4	2.39	50.1	196	39,000
Yr 1	**Overall Average**	**11.8**	**31.1**	**67.7**	**85.1**	**91.3**	**100.0**	**0.26**	**31.1**	**2.54**	**64.9**	**106.9**	**20,800**
													0
Yr 2	S-1 Coarsest quartile	2.1	5.2	43.4	79.3	86.9	99.3	0.71	5.2	2.70	79.0	9.4	5,500
Yr 2	S-2 Coarse-fine	8.4	28.3	82.7	93.5	95.9	100.0	0.21	28.3	2.56	63.2	58.9	24,400
Yr 2	S-3 Fine-coarse	16.0	55.0	94.1	98.5	99.1	100.0	0.07	55.0	2.47	54.6	117	34,400
Yr 2	S-4 Finest quartile	26.4	81.0	98.1	99.9	99.9	100.0	0.03	81.0	2.42	48.2	124	38,900
Yr 2	**Overall Average**	**13.2**	**42.3**	**79.5**	**92.8**	**95.5**	**99.8**	**0.15**	**42.3**	**2.54**	**61.3**	**84.9**	**25,800**
													0
Yr 1+2	S-1 Coarsest quartile	1.6	4.8	41.7	76.7	85.7	99.5	0.80	4.8	2.70	79.1	15.1	4,900
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Yr 1+2	S-3 Fine-coarse	15.1	51.2	93.2	98.1	98.8	100.0	0.07	51.2	2.48	55.6	110	33,500
Yr 1+2	S-4 Finest quartile	28.1	80.7	97.9	99.8	99.9	100.0	0.03	80.7	2.42	48.5	138	39,200
Yr 1+2	**Overall Average**	**12.9**	**40.0**	**77.0**	**91.1**	**94.6**	**99.9**	**0.17**	**40.0**	**2.54**	**62.0**	**90.0**	**24,700**

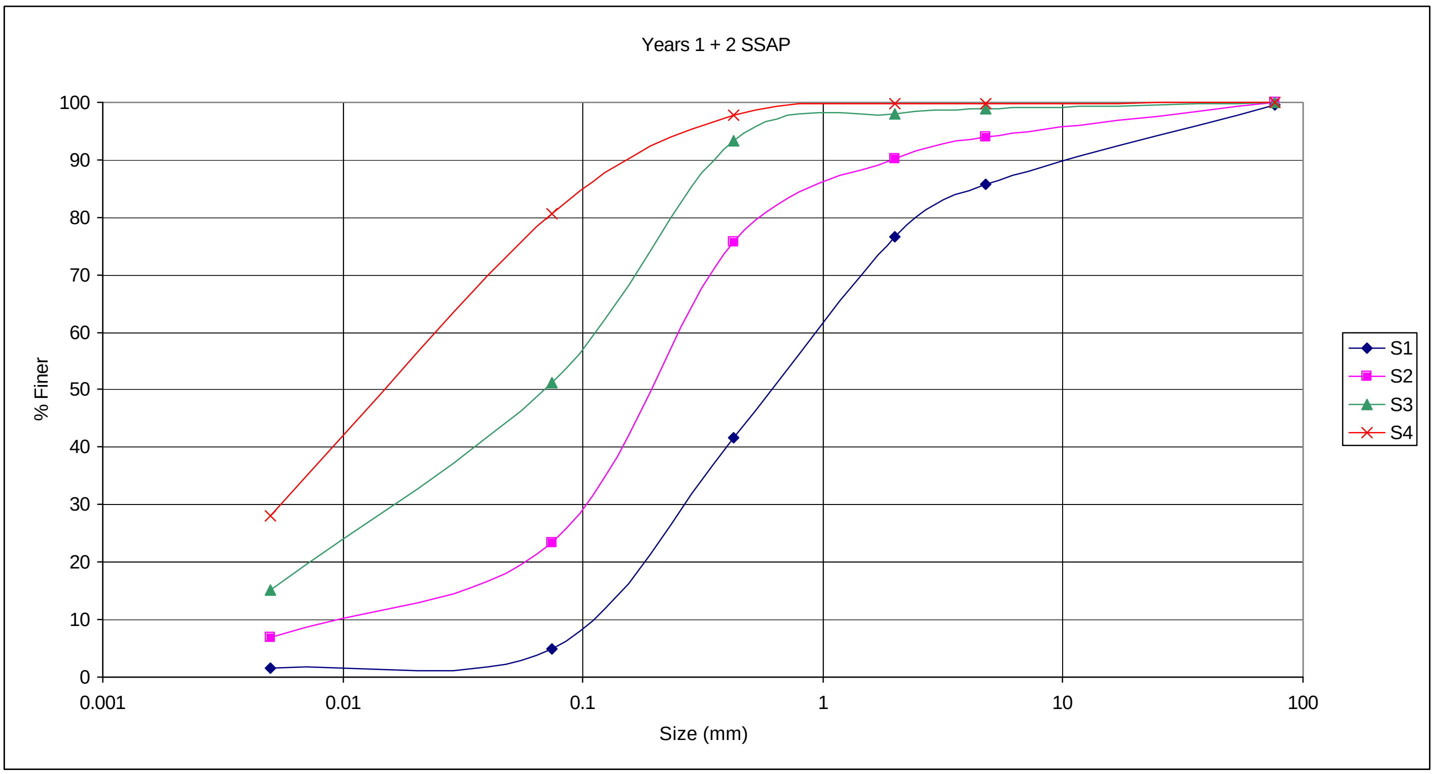

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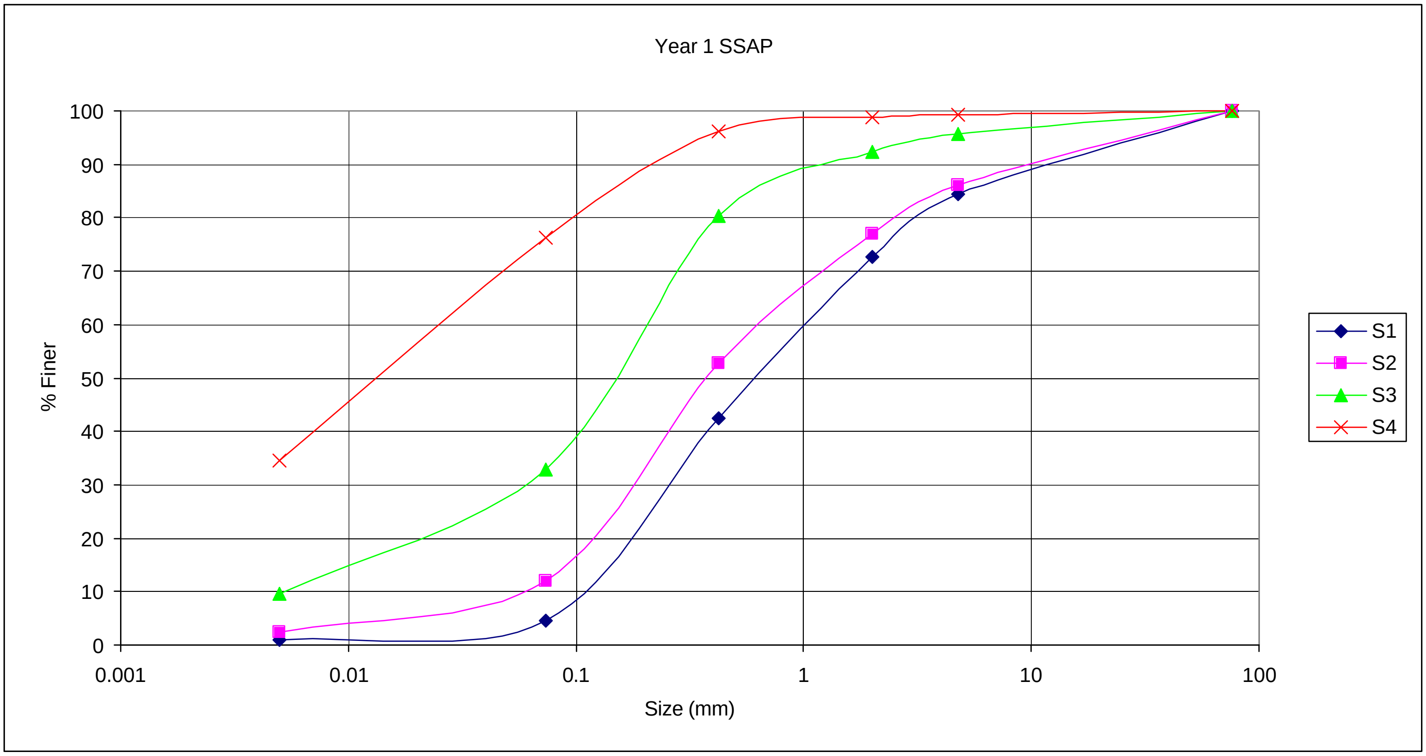
Exhibit G.1.2 - SSAP Sediment Characteristics - Year 1 & Year 2



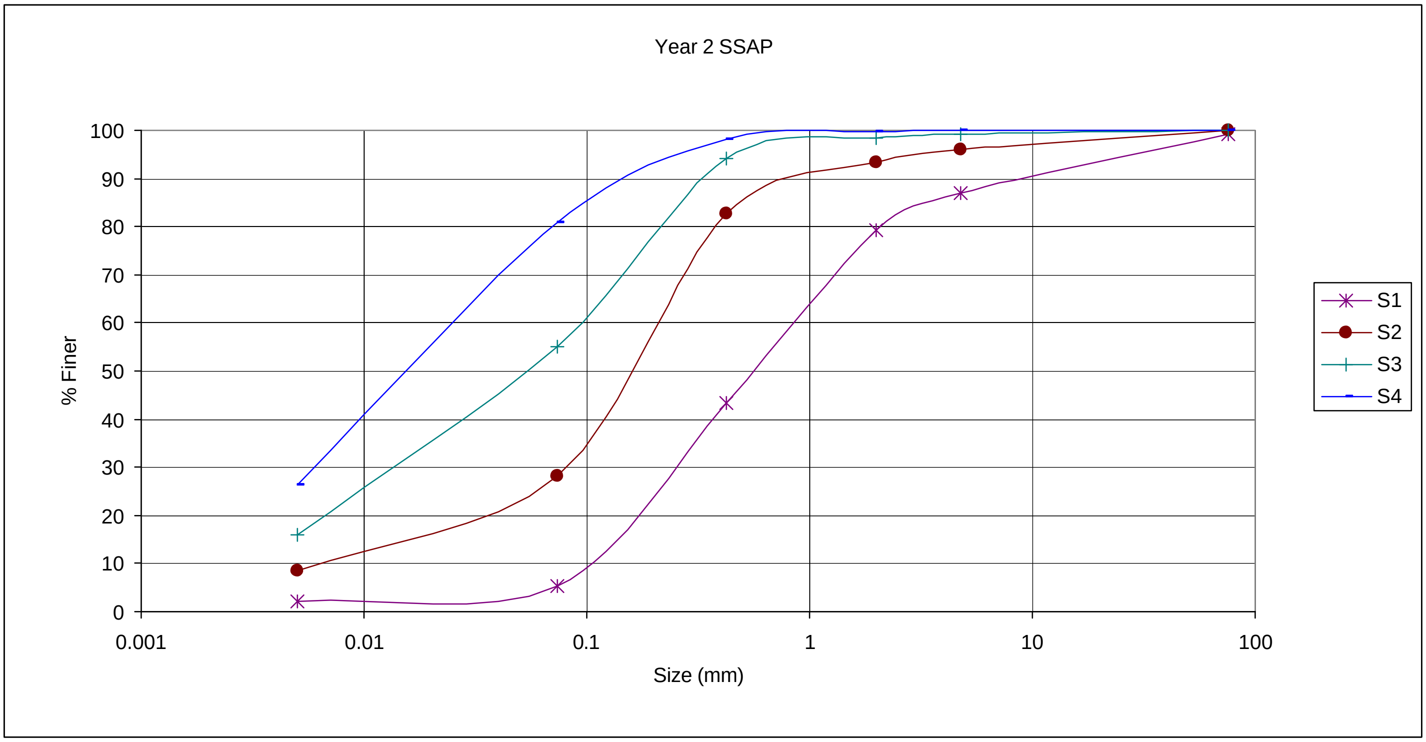


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Exhibit G.1.3 - Baseline Sediment Sample Data

Sample ID: / Date Collected:		S1 6/10/2004	S1-DUP 6/10/2004	S2 5/19/2004	S3 5/19/2004	S4B 6/24/2004	S4B-DUP 6/24/2004
Total PCBs	mg/kg	8	11.3	138	101	490	466
Total PAHs	mg/kg	0.316 J	0.581 J	0.245 J	1.97 J	0.656 J	0.496 J
Ammonia Nitrogen	mg/kg	27.4	13.1	96.7	213	390	384
Bulk Density	g/cc	1.3	1.5	0.75	0.79	0.41	0.37
Total Kjeldahl Nitrogen	mg/kg	891 X	822 X	1,480 X	1,680 X	4,320	4,140
TOC	mg/kg	7,800	8,600	30,000	33,000	85,000	73,000
Total Phosphorous (PO4)	mg/kg	532	78	690	828	1,170	1,270
Total Phosphorous (as P)	mg/kg	174	26	225	270	382	414
Percent Solids	%	79.1	79.1	53.1	56.8	33	33
Finer than #200	%	10.1	8.8	30.2	40.8	59.2	78.6
Total TEQs (WHO TEFs)	mg/kg	2.8E-06	NA	4.73E-06	0.00000377	0.00013	0.00012
Aluminum	mg/kg	5,330	5,270	8,380	9,360	14,000	14,100
Antimony	mg/kg	0.1 XN	0.11 XN	2.4 NE	1.4 NE	5.5 NE	6.5 NE
Arsenic	mg/kg	1.9 NE	1.5 NE	2.1	2	3.9	4
Barium	mg/kg	58.5 N	62.7 N	81	74.9	129	134
Beryllium	mg/kg	0.31	0.29	0.42	0.38	0.65	0.64
Cadmium	mg/kg	0.44 E	0.46 E	12.3	7	39.2 NE	36.8 NE
Calcium	mg/kg	1600	1590	2220	4340	5530	5540
Chromium	mg/kg	24.8 N	27.4 N	235	121	518	518
Cobalt	mg/kg	4.9	4.5	5.8	6.2	8.6	8.4
Copper	mg/kg	12.2	15.4	37.8	26.5	78.3	88.3
Iron	mg/kg	10200	9900	11900	13400	18600	18500
Lead	mg/kg	19.1	22.3	219 E	144 E	637	639
Magnesium	mg/kg	1980	1870	2230	3610	3410	3470
Manganese	mg/kg	121 N	123 N	107	159	184	183
Mercury	mg/kg	0.066	0.072	1.6	0.79	3.9	4.1
Nickel	mg/kg	8.4	7.9	12.8	12.4	21.5	20.9
Potassium	mg/kg	898	957	835	762	1280	1360
Selenium	mg/kg	0.47 X	0.44 X	0.74 XN	0.72 XN	1.5 N	1.5 XN
Silver	mg/kg	0.048 X	0.053 X	0.26	0.21	0.91	0.87
Sodium	mg/kg	116 E	99.5 E	148 E	140 E	279 E	269 E
Thallium	mg/kg	0.22 *	0.077 X*	0.097 X	0.075 X	0.32	0.56
Vanadium	mg/kg	14.9 E	15.6 E	33.9 E	26.6 E	73.5 E	71.5 E
Zinc	mg/kg	52.9 E	51.3 E	194 E	147 E	521 NE	510 NE

Notes:

1. Samples were collected by Blasland, Bouck & Lee, Inc., and submitted to Severn Trent Laboratories, Inc. (Pittsburgh and Burlington), Paradigm Analytical Laboratories, and Northeast Analytical Services, Inc. for analysis.
2. Results have not yet been validated. Additional qualifiers will be added, as needed, following validation.
3. Total 2,3,7,8-TCDD toxicity equivalents (TEQs) were calculated using Toxicity Equivalency Factors (TEFs) derived by the World Health Organization (WHO) and published by Van den Berg et al. in Environmental Health Perspectives 106(2), December 1998.
4. Results are presented in dry weight.
5. mg/kg = milligrams per kilogram.
6. g/cc = grams per cubic centimeter.
7. NA - Not analyzed.

8. Laboratory Data Qualifiers:
   Organics (PAHs, PCDD/PCDFs)
      E - Analyte exceeded calibration range.
      J - Indicates an estimated value less than the practical quantitation limit (PQL).
      Q - Indicates the presence of quantitative interferences.
      DPE - Polychlorinated Diphenyl Ether (PCDPE) Interference.
   Inorganics (TAL Metals, Total Kjeldahl Nitrogen)
      B - Indicates an estimated value between the lower calibration limit and the target detection limit.
      E - Matrix interference.
      N - Indicates sample matrix spike analysis was outside control limits.
      X - Method blank contamination.
      * - Serial dilution results not within 10%. Applicable only if analyte concentration is at least 50X the IDL in original sample.

General Electric Company
Hudson River PCBs Superfund Site
Phase 1 Intermediate Design Report

Exhibit G.1.4 - Baseline Sediment Sample Data

Sample ID: Date Collected:		S4 5/19/2004	S4A 6/10/2004	S2-2	S3-2	S3-3	S3-4	S4B-2
Total PCBs	mg/kg	162	100	73	13	156	89	351
Total PAHs	mg/kg	1.45 J	1.09 J	0.567 U	0.537 U	4.15	1.77 J	0.874 U
Ammonia Nitrogen	mg/kg	75.2	37.5	37.7	56.5	116	45.4	121
Bulk Density	g/cc	0.78	0.82	0.74	0.87	0.78	0.88	0.42
Total Kjeldahl Nitrogen	mg/kg	1.83	1,730 X	1,110	1,170	1,270 X	1,390	2,580
TOC	mg/kg	34,000	33,000	56,000	17,000	19,000	27,000	53,000
Total Phosphorous (PO4)	mg/kg	671	147	648	887	622	964	26 U
Total Phosphorous (as P)	mg/kg	219	48	211	289	203	315	9
Percent Solids	%	56.9	58.5	58.1	61.6	55	59.6	37.4
Finer than #200	%	28.1	29.6	16.8	30.3	20.4	36.4	69.1
Total TEQs (WHO TEFs)	mg/kg	8.4E-06	2.6E-05	3.5E-05	8.3E-06	4.9E-05	3E-05	9.1E-05
Aluminum	mg/kg	7,760	7,240	4,760	6,240	8,150	6,860	11,000
Antimony	mg/kg	1.4 J	0.97 N	0.67 E	0.27 B	2.6	0.87	2.6
Arsenic	mg/kg	1.8 J	1.3 NE	1.3	0.98	2.2	1.5	4.3
Barium	mg/kg	64.6	67.7 N	63.8	44.7	66.6	60.5	120
Beryllium	mg/kg	0.36	0.38	0.26	0.35	0.38	0.29	0.66
Cadmium	mg/kg	6.3	16.3 E	5.2	1.5	15.4	6.1	18.9
Calcium	mg/kg	2,560	2,750	1,700	2,950	2,220	3,230	5,550
Chromium	mg/kg	195	130 N	157	38.4	287 X	97.4 X	303
Cobalt	mg/kg	5.9	6.6	4.4	4.1	5.8	4.2	8.1
Copper	mg/kg	38	28.3	26	10.1	38.2	21	58.9
Iron	mg/kg	10,500	10,500	7,580	8,670	9,760	9,770	17,800
Lead	mg/kg	192 J	151	146 X	36.6 X	280	105	355 X
Magnesium	mg/kg	2,100	2,090	1,340 X	1,800 X	2,450	1,950	3,450 X
Manganese	mg/kg	105	206 N	53.9	62.5	86.4	82.4	189
Mercury	mg/kg	0.9	1.3	0.94	0.21	1.5	0.7	2.2
Nickel	mg/kg	12.4	11.2	9.5	6.4	11.5	8.6	18.7
Potassium	mg/kg	788	828	437	507	687	714	1300
Selenium	mg/kg	0.66 J	0.79 X	0.760 B	0.86	0.91 B	0.65 B	1.7
Silver	mg/kg	0.25	0.54	0.180	0.051 B	0.46 X	0.2	0.54
Sodium	mg/kg	167 J	169 E	130	162	177 X X	164	234
Thallium	mg/kg	0.074	0.14 X	0.440 XE	0.0980 XB	0.530	0.420	0.200 XB
Vanadium	mg/kg	30.7 J	22.4 E	16.8	16.2	40.2 X	26.3	40.2
Zinc	mg/kg	173 J	130 E	148 E	66	259 X	113	313

Notes:

1. Samples were collected by Blasland, Bouck & Lee, Inc., and were submitted to Severn Trent Laboratories, Inc. (Pittsburgh and Burlington), Paradigm Analytical Laboratories, and Northeast Analytical Services, Inc. for analysis.
2. U = Indicates the constituent was not detected. The value preceding the U indicates the laboratory quantitation limit.
3. Results have not yet been validated. Additional qualifiers will be added, as needed, following validation.
4. Total 2,3,7,8-TCDD toxicity equivalents (TEQs) were calculated using Toxicity Equivalency Factors (TEFs) derived by the World Health Organization (WHO) and published by Van den Berg et al. in Environmental Health Perspectives 106(2), December 1998.
5. Results are presented in dry weight.
6. mg/kg = milligrams per kilogram.
7. g/cc = grams per cubic centimeter.

8. Laboratory Data Qualifiers:
   Organics (PAHs, PCDD/PCDFs)
   - E - Analyte exceeded calibration range.
   - J - Indicates an estimated value less than the practical quantitation limit (PQL).
   - Q - Indicates the presence of quantitative interferences.
   - DPE - Polychlorinated Diphenyl Ether (PCDPE) Interference.

   Inorganics (TAL Metals, Total Kjeldahl Nitrogen)
   - B - Indicates an estimated value between the lower calibration limit and the target detection limit.
   - E - Matrix interference.
   - N - Indicates sample matrix spike analysis was outside control limits.
   - X - Method blank contamination.
   - * - Serial dilution results not within 10%. Applicable only if analyte concentration is at least 50X the IDL in original sample

Exhibit G.2

Size Separation Design Calculations

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Exhibit G.2.1

Size Separation Design Calculations

Hopper with Pipe Grizzly

SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Hopper w/ Pipe Grizzly	20437	TEM	8/4/05	1/2

CALCS. BY TEM ; DATE 8/4/05 CHECKED BY [signature] ; DATE 8/8/05

① Feed Rate to Hopper - calculated two ways:

ⓐ $\frac{1000 \text{ CY Barge of S1 sediment}}{3 \text{ hr maximum off-load time}} = \frac{333 \text{ CY}}{\text{hr}} \times \frac{1.52 \text{ wtons}}{\text{CY of S1 sediment}} =$

$= \boxed{\frac{506 \text{ wet tons}}{\text{hr}} \text{ fed to hopper}} \approx \boxed{510 \text{ wtons/hr}}$

ⓑ 5 CY clamshell @ 90% full w/ 50 second swing time

$= \frac{5 \text{ CY (S1 sediment)}}{50 \text{ seconds}} \times (0.90) \times \frac{3600 \text{ sec}}{\text{hr}} \times \frac{1.52 \text{ wtons}}{\text{CY of S1 sediment}}$

$= \boxed{492 \frac{\text{wtons}}{\text{hr}} \approx 500 \frac{\text{wtons}}{\text{hr}}}$

② Hopper Sizing

- Hopper will be fed by single 5 CY clamshell
- Hopper needs to be sized to accommodate maximum width of clamshell when fully open
- Clamshell assumed to be < 15' wide when open, therefore hopper currently specified is 20' x 20'.

③ Hopper Screening Requirements

- Hopper to be fitted with a pipe grizzly with 6-inch spacing (6-inch spacing dictated by Trommel Screen Vendor

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson River - Hopper w/ Pipe Grizzly	20437	TEM	8/4/05	2/2

CALCS. BY ____ ; DATE ____ CHECKED BY SEO ; DATE 8/8/05

③ Cont'd

- Pipe grizzly shall be constructed with tapered pipes (5" at top, 6 to 6.5" at bottom) to distribute load

- Pipe grizzly shall be installed at angle equal to angle of repose (where oversize material (+6") will fall off). Angle of pipe grizzly shall be field adjustable necessary to obtain angle of repose

④ Belt Feeder (accepts U/F from hopper)

- Belt Feeder shall be sized to accommodate maximum hopper feed rate of 510 wtons/hr

- Belt Feeder shall be designed wide enough necessary to distribute load equally (may consider vibratory feeder)

- Belt Feeder shall be equipped with variable speed necessary to equalize flow to rotary trommel screen

⑤ Inclined Conveyor (conveys sediment from belt feeder to rotary trommel screen)

- Inclined Conveyor sized to accommodate maximum hopper feed rate of 510 wtons/hr

- Inclined conveyor shall be installed at angle that will permit transfer of material containing 40%

Rotary Trommel Screen

① Feed Rate to Trommel

- Feed rate assummed to be equal to maximum Feed rate to hopper ≈ **510 wtons/hr**

- Rotary trommel screen shall be sized for 510 wtons/hr of S1 sediment (72% solids)

- Rotary trommel screen shall be constructed with distribution feeder necessary to evenly distribute incoming Feed

- Rotary trommel screen shall be constructed with spray pipe assembly tolerant of incoming water Feed with 1% or higher suspended solids

② Rotary Trommel Screen Oversize Material Inclined Conveyor

Per METSIM material balance - Table 3-26, the maximum oversize solids discharge rate from trommel screen =

$$= \frac{998 \text{ wet tons S1}}{\text{day}} \times \frac{1}{15 \text{ hr continuous offloading}}$$

$$= 66.5 \text{ wtons/hr} \approx \boxed{70 \text{ wtons/hr}}$$

- Conveyor shall be sized to transport a maximum 70 wtons/hr to clay pile

- Oversize solids anticipated to consist of 90% solids

Sediment Slurry Tank

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE- Hudson River - Sediment Slurry Tank	20437	TEM	8/4/05	1

CALCS. BY TEM ; DATE 8/4 CHECKED BY SRG ; DATE 8/8/05

① Sediment Slurry tank sizing:

ⓐ estimate max feed rate to Hydrocyclone:
Per METSIM MATERIAL BALANCE - Table 3-26

Stream # 103

$\frac{7860 \text{ wtons}}{24 \text{ hr day}} = \frac{327.5 \text{ wtons}}{\text{hr}}$ = 24 hr average off-loading rate

MAXIMUM design offloading rate ≃ 510 $\frac{\text{wtons}}{\text{hr}}$

* Conversion Factor = $\frac{510}{327.5}$ = 1.56

Apply this conversion factor to METSIM Stream # 107 to get maximum hydrocyclone feed rate

= 3,185 gpm x 1.56 = 4968 gpm ≈ **5,000 gpm**

ⓑ Minimum required retention time @ sediment slurry tank = 5 minutes (JOE KEANE)

SEDIMENT SLURRY TANK VOLUME = 5,000 gpm x 5 minutes

= **25,000 GALLONS**

ⓒ SEDIMENT SLURRY tank shall be constructed with sloping sidewalls necessary to direct all slurry/solids to Hydrocyclone Feed pump suction line.

Hydrocyclone System

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Hydrocyclone System	20437	TEM	8/4/05	1/2

CALCS. BY TEM ; DATE 8/5 CHECKED BY SRG ; DATE 8/8/05

① Per sediment slurry tank sizing calculations,
maximum Hydrocyclone Feed Rate = 5,000 gpm

② 6-inch Hydrocyclone Calculations

Per attached 7/19/05 calculations from Krebs Engineers,

33 operating 6-inch-diameter Krebs cyclones required when processing an influent feed = 4779 GPM

∴ $\frac{4779 \text{ GPM}}{33 \text{ 6-inch cyclones}} \approx$ **145 gpm/6-inch Krebs Cyclone**

@ 5,000 gpm × $\frac{\text{6-inch Krebs Cyclone}}{145 \text{ gpm}}$ = **34 operating 6-inch Hydrocyclones**

③ 10-inch Hydrocyclone Calculations

Per attached 7/19/05 calculations from Krebs Engineers,

14 operating 10-inch-diameter Krebs Cyclones required when processing an influent feed = 4,779 Gpm

∴ $\frac{4779 \text{ GPM}}{14 \text{ 10-inch cyclones}}$ = $\frac{341 \text{ Gpm}}{\text{10-inch cyclone}}$

@ 5,000 GPM × $\frac{\text{CYCLONE}}{341 \text{ GPM}}$ ≅ **15 operating 10-inch Hydrocyclones**

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River – Hydrocyclone System	20437	TEM	8/4/05	2/2

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY [illegible] ; DATE 8/8/05

④ MAXIMUM Hydrocyclone Overflow discharge rate

Per METSIM MATERIAL BALANCE, TABLE 3-26,

Stream # 111, = 2540 GPM x 1.56 (Conversion Factor = to 3 hr barge offloading) = 3,962 GPM

≈ 4,000 GPM

⑤ MAXIMUM Hydrocyclone UnderFlow discharge rate

Per METSIM MATERIAL BALANCE, TABLE 3-26

Stream # 112 = 645 GPM x 1.56 = 1,006 GPM ≈ **1,000 GPM**

$= \frac{4{,}627 \text{ s tons}}{\text{dy}} \times \frac{\text{dy}}{24\text{hr}} \times 1.56 =$ **300 solid tons / hr**

MATTHEW RYAN - RE: Pump Calcs and 10" Hydrocyclones

From: "Mike Wilkins" <mwilkins@KREBS.COM>
To: "MATTHEW RYAN" <MRYAN@bbl-inc.com>
Date: 8/4/2005 10:49 AM
Subject: [illegible]

Matthew,

For discussion I am looking at the 8/4/05 GMAX6 run (corrected from the 7/19/05 run) and the 7/27/05 run that were both done on the S1 (107 HC Feed) data.

Each GMAX6 (6 inch) cyclone is able to handle 145 gpm with a 2 inch vortex at a 15 psi pressure drop. The total estimated recovery based on the PSD was 93.3% of the material in the feed. This was based on this cyclone having a d50 of 19.5 microns. The d50 defines the point were a particle has a 50/50 chance of going out the top or the bottom of the cyclone. After reviewing the recovery sheets, this cyclone had 100% recovery of all particles 200 mesh (75 microns) and courser that had a density of 2.7 or heaver. The cyclone also had a 97.7% recovery at 400 mesh (37 microns) of all 2.7 SG and heavier particles.

Each DS10LB-GMAX (10 inch) cyclone is able to handle 341 gpm with a 4 inch vortex at a 14.4 psi pressure drop. The total estimated recovery based on the PSD was 93.0% of the material in the feed. This was based on this cyclone having a d50 of 27.6 microns. The d50 defines the point were a particle has a 50/50 chance of going out the top or the bottom of the cyclone. After reviewing the recovery sheets, this cyclone had 100% recovery of all particles 100 mesh (150 microns) and courser that had a density of 2.7 or heaver. The cyclone also had a 82.1% recovery at 400 mesh (37 microns) of all 2.7 SG and heavier particles.

U.S.D.A. Classification
Gravel = 2.0-100 mm (2000+ microns)
Very Coarse Sand = 1.0=2.0 mm (1000-2000 microns)
Coarse Sand = 0.5-1.0 mm (500-1000 microns)
Medium Sand = 0.25-0.5 mm (250-500 microns)
Fine Sand = 0.1-0.25 mm (100-250 microns)
Very Fine Sand = 0.05-0.1 mm (50-100 microns)
Silt = 0.002-0.05 mm (2-50 microns)
Clay = <0.002 mm (<2 microns)

As you can see from above, both cyclones are more than capable of having a strong recover of all three classifications of sand. If you have any further questions, please let me know.

Sincerely,

Mike Wilkins

Regional Sales Manager
Krebs Engineers
(520) 829-5303 phone
(520) 909-7831 cell
(520) 844-1962 fax

[illegible]
[illegible] inc.com]
Sent: Friday, July 29, 2005 7:36 AM

KREBS ENGINEERS

SHEET: 1

DATE: 19- July-05

BY: MWW

Client: Blasland, Bouck & Lee, Inc.

Problem: Cyclone recovery of S1 (107 HC Feed) Data at the 16HR hour rate based on Table 2 - Loadings METSIM Material Balances Phase 2 Basis of Design.

Number, Model Krebs Cyclones: 33 operating GMAX6-3193-SRC Krebs Cyclones

	Inlet Area	Vortex Finder	Apex	Pressure Drop
Orifices:	2.20 sq. in.	2.00 in.	1.25	26.5 PSI

Specific Gravity: Solids: 2.700 Liquid: 1.000 Temperature: Amb.°F Viscosity: 1 Cps

	FEED	OVERFLOW	UNDERFLOW	CYCLOWASH
STPH Solids	307.22	19.47	287.75	0.00
STPH Liquids	1082.68	1075.02	123.32	115.67
STPH Slurry	1389.89	1094.49	411.07	115.67
Wt Solids	22.10	1.78	70.00	0.00
S.G. Slurry	1.162	1.011	1.788	1.000
Vol% Solids	9.51	0.67	46.36	0.00
GPM Slurry	4779.00	4322.74	918.26	462.00
M3/Hr. Slurry	1085.42	981.79	208.56	104.93

Ref: 15.4 4.0 53.0

Mesh	Micron	FEED Cum. % +	FEED Ind. % +	FEED STPH	OVERFLOW Cum. % +	OVERFLOW Ind. % +	OVERFLOW STPH	UNDERFLOW Cum. % +	UNDERFLOW Ind. % +	UNDERFLOW STPH	ACT. REC.	
40	425.0	50.50	50.50	155.1	0.00	0.00	0.0	53.92	53.92	155.1	100.0	
60	250.0	62.80	12.30	37.8	0.00	0.00	0.0	67.05	13.13	37.8	100.0	
100	150.0	75.10	12.30	37.8	0.00	0.00	0.0	80.18	13.13	37.8	100.0	
200	75.0	91.80	16.70	51.3	0.00	0.00	0.0	98.01	17.83	51.3	100.0	
400	37.0	92.70	0.90	2.8	0.04	0.04	0.0	98.97	0.96	2.8	99.7	
-400	-37.0	100.00	7.30	22.4	100.00	99.96	19.5	100.00	1.03	3.0	13.2	
TOTAL				307.22			19.47			287.75	93.7	

KREBS ENGINEERS
5505 WEST GILLETTE ROAD TUCSON, AZ 85743
TEL: (520) 744-8200 FAX: (520) 744-8300
www.krebs.com

KREBS ENGINEERS

SHEET: 1

DATE: 27-July-05

BY: MWW

Client: Blasland, Bouck & Lee, Inc.

Problem: Cyclone recovery of S1 (107 HC Feed) Data at the 16HR hour rate based on Table 2 - Loadings METSIM Material Balances Phase 2 Basis of Design.

Number, Model Krebs Cyclones: 14 operating DS10LB-GMAX-SRC

	Inlet Area	Vortex Finder	Apex	Pressure Drop
Orifices:	7.80 sq. in.	4.00 in.	2.0	14.4 PSI

Specific Gravity: Solids: 2.700 Liquid: 1.000 Temperature: Amb.°F Viscosity: 1 Cps

	FEED	OVERFLOW	UNDERFLOW	CYCLOWASH
STPH Solids	307.22	21.65	285.56	0.00
STPH Liquids	1082.68	1075.96	122.38	115.67
STPH Slurry	1389.89	1097.61	407.95	115.67
Wt Solids	22.10	1.97	70.00	0.00
S.G. Slurry	1.162	1.013	1.788	1.000
Vol% Solids	9.51	0.74	46.36	0.00
GPM Slurry	4779.00	4329.71	911.29	462.00
M3/Hr. Slurry	1085.42	983.38	206.97	104.93

Ref: 27.6 4.0 53.0

Mesh	Micron	FEED			OVERFLOW			UNDERFLOW			ACT.
		Cum. % +	Ind. % +	STPH	Cum. % +	Ind. % +	STPH	Cum. % +	Ind. % +	STPH	REC.
40	425.0	50.50	50.50	155.1	0.00	0.00	0.0	54.33	54.33	155.1	100.0
60	250.0	62.80	12.30	37.8	0.00	0.00	0.0	67.56	13.23	37.8	100.0
100	150.0	75.10	12.30	37.8	0.00	0.00	0.0	80.79	13.23	37.8	100.0
200	75.0	91.80	16.70	51.3	0.22	0.22	0.0	98.74	17.95	51.3	99.9
400	37.0	92.70	0.90	2.8	2.51	2.29	0.5	99.54	0.79	2.3	82.1
-400	-37.0	100.00	7.30	22.4	100.00	97.49	21.1	100.00	0.46	1.3	5.9
TOTAL				307.22			21.65			285.56	93.0

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Vibratory Dewatering Screens

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engineers & scientists

SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE- Hudson River Vibratory Dewatering Screens	20437	TEM	8/4/05	1/1

CALCS. BY TEM ; DATE

CHECKED BY SRO ; DATE 8/8/05

Per Hydrocyclone calculations, maximum anticipated Hydrocyclone underflow discharge rate = $\frac{300 \text{ solid tons}}{\text{hr}}$

Per Derrick Corporation, each 5' X 12' vibratory dewatering screen can process 150 to 200 $\frac{\text{stons}}{\text{hr}}$

$\therefore$ @ $300 \frac{\text{solid tons}}{\text{hr}} \times \frac{\text{hr} \div \text{capacity}}{150 \text{ solid tons}} =$ **2 UNITS required**

Each 5'x 12' screen will be designed to recover −40 x +400 MESH MATERIAL

Process Water Storage Tanks

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Process Water Storage Tanks	20437	TBM	8/5/05	1/

CALCS. BY TBM ; DATE 8/4/05 CHECKED BY JRG ; DATE 8/8/05

① SIZE Separation Process Water Storage Tank

Tank designed to store recycle water required for rotary trommel screen, sediment slurry tank, and hydrocyclone wet well discharge line flushing

Per Metsim Material Balance, Table 3-26,

maximum required recycle water occurs when processing 4,300 in situ CY/dy of S1 sediment

$= 2{,}534 \text{ gpm} \times \frac{24 \text{ hr}}{\text{dy}} \times \frac{60 \text{ min}}{\text{hr}} = 3{,}648{,}960 \text{ gallons}$

Tank sized to provide one hour retention

$= 3{,}648{,}960 \text{ gallons} \times \frac{1}{24 \text{ hr}} \times 1.56$ (conversion factor - base off flows in Ar 510 wtons/hr)

$= \boxed{237{,}182 \text{ gallons}}$

② Treated Water Storage Tank

Tank designed to hold treated water needed for decon/wash water

Assumed usage for decon wash water =

$= 25 \text{ gpm} \times 16 \text{ hrs (operating hrs)} \times \frac{60 \text{ min}}{\text{hr}} = \boxed{24{,}000 \text{ GALLONS}}$

General Electric Company
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Exhibit G.2.2 - Size Separation Summary

		H1S1					
Sieve Number	**Particle Size (µm)**	**Solids % Retain**	**PCBs (ppm)**	**% Solids**	**TOC (mg/kg)**	**Specific Gravity**	**pH**
--	--	(S1)	8.0	79.1%	7,800	--	--
10	2,000	26.2%	9.6	92.6%		2.52	8.01
20	850	6.2%	6.3	76.8%		2.64	7.47
40	425	9.3%	4.6	77.8%		2.82	7.19
60	250	14.4%	5.1	74.9%	5,300	2.82	7.18
80	180	12.5%	3.3	76.0%		2.94	6.94
100	150	6.2%	3.7	76.2%		3.02	6.91
200	75	11.2%	7.2	74.9%		2.97	7.08
<200	<75	14.0%	24	47.7%	--	2.54	6.22
Weighted Avg.		--	8.9	76.3%	--	--	--

		H1S2					
Sieve Number	**Particle Size (µm)**	**Solids % Retain**	**PCBs (ppm)**	**% Solids**	**TOC (mg/kg)**	**Specific Gravity**	**pH**
--	--	(S2)	138	54.3%	30,000	--	--
10	2,000	3.8%	36	73.0%		1.99	6.29
20	850	3.9%	60	55.8%		2.38	6.48
40	425	7.4%	82	58.2%		2.63	6.66
60	250	11.1%	37	66.4%	20,000	2.60	6.74
80	180	15.3%	17	69.3%		2.66	6.84
100	150	7.5%	24	68.5%		2.75	6.62
200	75	15.6%	24	65.9%		2.85	6.65
<200	<75	35.4%	320	35.0%	--	2.41	5.81
Weighted Avg.		--	135	55.0%	--	--	--

		S3					
Sieve Number	**Particle Size (µm)**	**Solids % Retain**	**PCBs (ppm)**	**% Solids**	**TOC (mg/kg)**	**Specific Gravity**	**pH**
--	--	--	101	57.4%	33,000	--	--
10	2,000	3.1%	62	51.9%		2.35	6.73
20	850	1.4%	128	61.2%			6.00
40	425	2.5%	55	42.8%		2.47	6.18
60	250	3.3%	18.1	32.0%	20,000	2.66	6.12
80	180	7.6%	21.9	31.9%		2.65	6.44
100	150	5.8%	7.9	28.9%		2.70	6.57
200	75	26.3%	9.5	28.2%		2.69	6.67
<200	<75	50.0%	166	58.9%	--		5.80
Weighted Avg.		--	93	45.6%	--	--	--

		S4B					
Sieve Number	**Particle Size (µm)**	**Solids % Retain**	**PCBs (ppm)**	**% Solids**	**TOC (mg/kg)**	**Specific Gravity**	**pH**
--	--	--	490	33.0%	85,000	--	--
10	2,000	0.1%	1,460	86.3%		--	5.26
20	850	0.4%	1,720	86.8%		--	5.17
40	425	1.3%	1,600	81.9%		1.78	5.20
60	250	2.1%	1,399	81.4%	160,000		5.31
80	180	2.0%	843	73.3%		2.16	5.30
100	150	1.4%	505	65.7%			5.41
200	75	9.9%	306	52.8%		2.52	5.60
<200	<75	82.8%	465	59.5%	--	2.39	5.73
Weighted Avg.		--	498	60.1%	--	--	--

General Electric Company
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Exhibit G.2.3 - Hydrocyclone Test Matrix

Date: 8/19/04, 8/20/04, 10/08/04, 10/28/04

Sed. Type	Target % Solids (w/w)	Cyclone	Vortex Finder	Cylinder	Trunc'd Cone	Feed Pressure (psi)		Feed							Overflow							Underflow - Total														
						Target	Measured	gpm	% solids	SpG (gm/mL)	Solids (gm/L)	PCB (mg/kg)	Solids Flux (gm/min)	PCB Flux (gm/min)	gpm	% solids	SpG (gm/mL)	Solids (gm/L)	PCB (mg/kg)	Solids Flux (gm/min)	PCB Flux (gm/min)	gpm	% solids	SpG (gm/mL)	Solids (gm/L)	PCB (mg/kg)	Solids Flux (gm/min)	PCB Flux (gm/min)	Solids Flux IN (gm/min)	Solids Flux OUT (gm/min)	Solids O/F % of OUT	Solids U/F % of OUT	PCB Flux IN (gm/min)	PCB Flux OUT (gm/min)	PCB O/F % of OUT	PCB U/F % of OUT
S4	10	D4B	1	Y	N/A	5	5 +/- 0.5	25.8	4.60	2.59	47.3	244.3	4,628	1.13	24.8	1.65	2.59	16.67	790	1565	1.24	1.0	14.1	2.59	154.8339	1,019	604	0.62	4,628	2,169	72.2%	27.8%	1.13	1.85	66.8%	33.2%
S4	10	D4B	1	Y	N/A	10	10 +/- 0.5	33.4	4.60	2.59	47.3	244.3	5,976	1.46	32.4	0.37	2.59	3.71	4105	455	1.87	1.0	13.0	2.59	141.8402	1,128	511	0.58	5,976	965	47.1%	52.9%	1.46	2.44	76.4%	23.6%
S4	10	D6B	3	Y	1.25	5	5 +/- 0.5	55.5	4.60	2.59	47.3	244.3	9,944	2.43	45.5	2.19	2.59	22.20	720	3823	2.75	10.0	16.4	2.59	182.1671	393	6,895	2.71	9,944	10,718	35.7%	64.3%	2.43	5.46	50.4%	49.6%
S4	10	D6B	3	Y	1.25	10	10 +/- 0.5	72.0	4.60	2.59	47.3	244.3	12,900	3.15	61.0	1.98	2.59	20.04	730	4628	3.38	11.0	13.1	2.59	142.3209	685	5,926	4.06	12,900	10,553	43.9%	56.1%	3.15	7.44	45.4%	54.6%
S4	10	D6B	3	Y	0.75	5	5 +/- 0.5	50.1	4.60	2.59	47.3	244.3	8,976	2.19	46.0	2.38	2.59	24.15	660	4205	2.78	4.1	19.2	2.59	217.8309	200	3,380	0.68	8,976	7,586	55.4%	44.6%	2.19	3.45	80.4%	19.6%
S4	10	D6B	3	Y	0.75	10	10 +/- 0.5	73.3	4.60	2.59	47.3	244.3	13,133	3.21	67.0	1.85	2.59	18.71	710	4745	3.37	6.3	16.0	2.59	177.671	207	4,237	0.88	13,133	8,982	52.8%	47.2%	3.21	4.25	79.4%	20.6%
S4	10	D6B	2.25	Y	0.75	5	5 +/- 0.5	41.7	4.60	2.59	47.3	244.3	7,474	1.83	41.0	1.7	2.59	17.18	750	2666	2.00	0.7	34.0	2.59	429.1057	331	1,159	0.38	7,474	3,825	69.7%	30.3%	1.83	2.38	83.9%	16.1%
S4	10	D6B	2.25	Y	0.75	10	10 +/- 0.5	61.5	4.60	2.59	47.3	244.3	11,024	2.69	60.5	2.74	2.59	27.87	700	6382	4.47	1.0	30.8	2.59	379.1047	316	1,479	0.47	11,024	7,860	81.2%	18.8%	2.69	4.93	90.5%	9.5%
S4	10	D6B	2.25	N	0.75	5	5 +/- 0.5	41.6	4.60	2.59	47.3	244.3	7,460	1.82	41.0	3.03	2.59	30.87	428	4791	2.05	0.6	49.7	2.59	714.4929	42	1,715	0.07	7,460	6,506	73.6%	26.4%	1.82	2.12	96.6%	3.4%
S4	10	D6B	2.25	N	0.75	10	10 +/- 0.5	41.6	4.60	2.59	47.3	244.3	7,460	1.82	41.0	3.14	2.59	32.02	474	4969	2.36	0.6	29.7	2.59	362.564	192	870	0.17	7,460	5,839	85.1%	14.9%	1.82	2.52	93.4%	6.6%
S4	10	D6B	3	N	0.75	5	5 +/- 0.5	41.6	4.60	2.59	47.3	244.3	7,460	1.82	41.0	2.97	2.59	30.25	483	4695	2.27	0.6	33.2	2.59	416.7769	90	1,000	0.09	7,460	5,695	82.4%	17.6%	1.82	2.36	96.2%	3.8%
S4	10	D6B	3	N	0.75	10	10 +/- 0.5	66.1	4.60	2.59	47.3	244.3	11,843	2.89	60.0	3.61	2.59	36.92	443	8384	3.71	6.1	7.3	2.59	76.46036	399	1,765	0.70	11,843	10,149	82.6%	17.4%	2.89	4.42	84.1%	15.9%
S4	10	D6B	3	N	0.75	10	10 +/- 0.5	66.1	4.60	2.59	47.3	244.3	11,843	2.89	60.0	2.89	2.59	29.42	327	6682	2.18	6.1	12.7	2.59	137.5148	109	3,175	0.35	11,843	9,857	67.8%	32.2%	2.89	2.53	86.3%	13.7%
																															65.3%					
S4	15	D4B	1	Y	N/A	5	5 +/- 0.5	22.1	10.17	2.59	108.4	244.3	9,061	2.21	20.0	4.31	2.59	44.3	600	3347	2.01	2.1	21.1	2.59	242.5419	852	1,946	1.66	9,061	5,293	63.2%	36.8%	2.21	3.67	54.8%	45.2%
S4	15	D4B	1	Y	N/A	10	10 +/- 0.5	34.9	10.17	2.59	108.4	244.3	14,309	3.50	32.7	3.67	2.59	37.5	610	4636	2.83	2.2	21.6	2.59	249.6283	971	2,088	2.03	14,309	6,724	68.9%	31.1%	3.50	4.85	58.2%	41.8%
S4	15	D6B	3	N	0.75	5	5 +/- 0.5	44.4	10.17	2.59	108.4	244.3	18,211	4.45	39.1	7.11	2.59	74.3	536	10996	5.89	5.3	29.3	2.59	357.6883	136	7,148	0.97	18,211	18,144	60.6%	39.4%	4.45	6.86	85.9%	14.1%
S4	15	D6B	3	N	0.75	10	10 +/- 0.5	68.7	10.17	2.59	108.4	244.3	28,179	6.88	60.8	7.89	2.59	82.9	650	19062	12.39	7.9	24.3	2.59	285.8519	149	8,569	1.28	28,179	27,631	69.0%	31.0%	6.88	13.67	90.6%	9.4%
S4	15	D6B	3	Y	0.75	5	5 +/- 0.5	44.5	10.17	2.59	108.4	244.3	18,261	4.46	36.2	7.28	2.59	76.2	545	10426	5.68	8.4	21.9	2.59	253.5302	112	8,013	0.90	18,261	18,439	56.5%	43.5%	4.46	6.58	86.3%	13.7%
S4	15	D6B	3	Y	0.75	10	10 +/- 0.5	71.7	10.17	2.59	108.4	244.3	29,402	7.18	58.0	6.55	2.59	68.2	546	14982	8.18	13.6	32.4	2.59	403.9425	268	20,809	5.58	29,402	35,791	41.9%	58.1%	7.18	13.76	59.4%	40.6%
S4	15	D6B	2.25	Y	0.75	5	5 +/- 0.5	39.7	10.17	2.59	108.4	244.3	16,275	3.98	35.9	5.19	2.59	53.6	389	7277	2.83	3.8	31.2	2.59	386.6547	186	5,547	1.03	16,275	12,824	56.7%	43.3%	3.98	3.87	73.2%	26.8%
S4	15	D6B	2.25	Y	0.75	10	10 +/- 0.5	59.5	10.17	2.59	108.4	244.3	24,404	5.96	54.4	7.10	2.59	74.2	447	15275	6.83	5.1	42.4	2.59	573.3789	104	11,025	1.15	24,404	26,300	58.1%	41.9%	5.96	7.98	85.6%	14.4%
S4	15	D6B	2.25	Y	1.25	5	5 +/- 0.5	43.8	10.17	2.59	108.4	244.3	17,953	4.39	36.9	4.64	2.59	47.8	491	6672	3.28	6.9	36.0	2.59	462.9497	176	12,038	2.12	17,953	18,710	35.7%	64.3%	4.39	5.40	60.7%	39.3%
S4	15	D6B	2.25	Y	1.25	10	10 +/- 0.5	52.6	10.17	2.59	108.4	244.3	21,585	5.27	43.9	5.68	2.59	58.9	458	9794	4.49	8.7	20.8	2.59	238.1664	478	7,816	3.73	21,585	17,609	55.6%	44.4%	5.27	8.22	54.6%	45.4%
S4	15	D6B	2.25	N	0.75	5	5 +/- 0.5	34.5	10.17	2.59	108.4	244.3	14,145	3.46	33.1	4.64	2.59	47.8	470	5987	2.81	1.4	38.0	2.59	495.9375	49	2,590	0.13	14,145	8,577	69.8%	30.2%	3.46	2.94	95.7%	4.3%
S4	15	D6B	2.25	N	0.75	5	5 +/- 0.5	34.5	10.17	2.59	108.4	244.3	14,145	3.46	33.1	5.06	2.59	52.2	600	6538	3.92	1.4	52.4	2.59	771.4948	29	4,030	0.12	14,145	10,568	61.9%	38.1%	3.46	4.04	97.1%	2.9%
S4	15	D6B	2.25	N	0.75	10	10 +/- 0.5	49.2	10.17	2.59	108.4	244.3	20,198	4.93	47.3	3.77	2.59	38.6	495	6906	3.42	2.0	49.9	2.59	720.3216	44	5,317	0.23	20,198	12,223	56.5%	43.5%	4.93	3.65	93.6%	6.4%
S4	15	D6B	2.25	N	0.75	10	10 +/- 0.5	49.2	10.17	2.59	108.4	244.3	20,198	4.93	47.3	4.63	2.59	47.7	558	8534	4.76	2.0	49.5	2.59	710.5304	207	5,244	1.09	20,198	13,779	61.9%	38.1%	4.93	5.85	81.4%	18.6%
S4	15	D6B	1	Y	N/A	2	2 +/- 0.5	52.8	10.17	2.59	108.4	244.3	21,650	5.29	50.3	3.29	2.59	33.6	497	6393	3.18	2.5	29.3	2.59	357.205	620	3,367	2.09	21,650	9,760	65.5%	34.5%	5.29	5.26	60.4%	39.6%
S4	15	D6B	3	N	N/A	15	15 +/- 0.5	92.6	10.17	2.59	108.4	244.3	37,978	9.28	74.7	3.88	2.59	39.7	557	11222	6.25	17.9	32.2	2.59	401.501	284	27,157	7.72	37,978	38,378	29.2%	70.8%	9.28	13.97	44.8%	55.2%
																															56.9%					

Date: 12/15/2004; 12/16/2004

Sed. Type	Target % Solids (w/w)	Cyclone	Vortex Finder	Cylinder	Apex Diameter	Feed Pressure (psi)	Overflow Vacuum (" Hg)	Feed							Overflow							Underflow														
								gpm	% solids	SpG (gm/mL)	Solids (gm/L)	PCB (mg/kg)	Solids Flux (gm/min)	PCB Flux (gm/min)	gpm	% solids	SpG (gm/mL)	Solids (gm/L)	PCB (mg/kg)	Solids Flux (gm/min)	PCB Flux (gm/min)	gpm	% solids	SpG (gm/mL)	Solids (gm/L)	PCB (mg/kg)	Solids Flux (gm/min)	PCB Flux (gm/min)	Solids Flux IN (gm/min)	Solids Flux OUT (gm/min)	Solids O/F % of OUT	Solids U/F % of OUT	PCB Flux IN (gm/min)	PCB Flux OUT (gm/min)	PCB O/F % of OUT	PCB U/F % of OUT
S2-2	25	D6B w/	2.25 "	no	1.25 "	10	-2	140.0	22.4	2.59	259.7	33.9	137,623	4.67	120	5.07	2.59	52.30	47.7	23,755	1.13	20.0	66.0	2.59	1,110	18.7	83,994	1.57	137,623	107,749	22.0%	78.0%	4.67	2.70	41.9%	58.1%
S2-2	25	D6B w/	2.25"	no	1.25 "	10	-2	132.5	26.8	2.59	320.8	54.2	160,873	8.72	115	5.25	2.59	54.20	78.0	23,592	1.84	17.5	73.4	2.59	1,336	30.2	88,494	2.67	160,873	112,086	21.0%	79.0%	8.72	4.51	40.8%	59.2%
S2-2	25	D6B w/o	2.25"	no	3/4 "	10	0	116.5	21.6	2.59	249.0	56.0	109,806	6.15	110	6.30	2.59	65.50	77.0	27,271	2.10	6.5	65.4	2.59	1,093	85.0	26,884	2.29	109,806	54,154	50.4%	49.6%	6.15	4.38	47.9%	52.1%
S2-2	15	D6B w/	2.25"	no	1.25 "	10	-2	137.0	16.0	2.59	177.4	31.4	92,004	2.89	122	3.02	2.59	30.80	100	14,223	1.42	15.0	64.0	2.59	1,054	21.0	59,851	1.26	92,004	74,074	19.2%	80.8%	2.89	2.68	53.1%	46.9%
S2-2	15	D6B w/	2.25"	no	1.25 "	10	-2	135.0	18.6	2.59	210.0	29.0	107,293	3.11	119	3.20	2.59	32.60	254	14,684	3.73	16.0	73.9	2.59	1,353	27.9	81,918	2.29	107,293	96,601	15.2%	84.8%	3.11	6.02	62.0%	38.0%
S3-4	25	D6B w/	2.25"	no	1.25 "	10	-2	112.5	26.7	2.59	319.3	25.0	135,981	3.40	93	11.09	2.59	119.00	155	41,889	6.49	19.5	70.3	2.59	1,237	17.2	91,281	1.57	135,981	133,169	31.5%	68.5%	3.40	8.06	80.5%	19.5%
S3-4	25	D6B w/	2.25"	no	1.25 "	10	-2	125.0	26.5	2.59	316.5	35.9	149,738	5.38	104	10.39	2.59	111.00	166	43,694	7.25	21.0	70.0	2.59	1,227	14.9	97,567	1.45	149,738	141,261	30.9%	69.1%	5.38	8.71	83.3%	16.7%
S3-4	25	D6B w/o	2.25"	no	3/4 "	10	0	103.5	26.4	2.59	315.1	67.1	123,425	8.28	99	18.21	2.59	205.00	37.8	76,817	2.90	4.5	65.7	2.59	1,101	12.4	18,755	0.23	123,425	95,571	80.4%	19.6%	8.28	3.14	92.6%	7.4%
S3-4	15	D6B w/	2.25"	no	1.25 "	10	-2	127.5	22.0	2.59	254.4	26.9	122,747	3.30	111	4.18	2.59	42.90	133	18,024	2.40	16.5	68.6	2.59	1,185	14.2	74,011	1.05	122,747	92,035	19.6%	80.4%	3.30	3.45	69.5%	30.5%
S3-4	15	D6B w/	2.25"	no	1.25 "	10	-2	138.5	18.9	2.59	213.8	24.1	112,083	2.70	125	4.72	2.59	48.60	252	22,994	5.79	13.5	68.7	2.59	1,188	20.4	60,707	1.24	112,083	83,701	27.5%	72.5%	2.70	7.03	82.4%	17.6%

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Exhibit G.2.4 - PCB and Solids Balance

	INPUTS			OUTPUTS						
Stream Number	103	402	501	106	305	391	490	590		
Description	Dredge Slurry	Decon Water	Storm Water	Oversize	Cake Load-out	Coarse Load-out	Process Effl	Storm Effl	Mass In (dry T/d)	Mass Out (dry T/d)
Tot. mass (wet T/d)	6,620	150	6,685	321	2,139	2,617	2,088	6,290		
Solids mass (dry T/d)	3,656	0.752	33.4	289	1,176	2,224	0.0063	0.0189	3,690	3,689
Solids (%)	55.2	0.50	0.50	90.0	55.0	85.0	0.0003	0.0003		
Uptime (%)	100	100	100	67	100	100	100	100		
Operating flow (gpm)	724	25	1,111	35	234	205	348	1,049		
PCB mass (dry T/d)	0.329	0.00007	0.0030	0.010	0.285	0.037	0.0000001	0.0000004	0.332	0.332
PCB conc (mg/kg S)	90	90	90	35	242	17	222	213		
PCB conc (mg/L)	76	0.45	0.45	48	203	30	0.00007	0.00006		
Solids (mg/L)		5,011	5,012				3.0	3.0		

Note:
Dredging at 4,300 cy/d; S2/S3 sediment type.

Exhibit G.2.5 - Coarse Fraction Drainage Data Sheet

Slurry ID	Sample Weight	Date/ Time/ Initials	% Solids Concentration (w/w)				Collected Water Volume (mL)		
			Initial	24 hr	48 hr	72 hr	24 hr	48 hr	72 hr
H1S1-01 Coarse	1.0 kg	7/13/04 0930 JL	78.70	85.82	86.22	86.79	0	0	0
H1S2-01 Coarse	1.0 kg	7/13/04 0935 JL	70.60	73.62	72.91	73.63	6.3	0	0
S4-HC-15-UF	1.0 kg	8/30/04 1400 SC	41.83	77.36	77.06	73.5	345	9	4

Exhibit G.3

Includes:
Slurry Pumps from Hydrocyclones
Dredge Slurry Holding Tanks
Gravity Thickeners
Dredge Slurry Holding Tank Transfer Pump
Dewatering Conditioning Tanks
Thickener Sludge Pumps
Polymer Addition to Thickeners
Polymer Addition to Filter Presses
Filter Press Feed Pumps
Filter Presses
Recycle Water Equalization Tank

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Exhibit G.3.1

Thickening and Dewatering Design Calculations

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Slurry Pumps from Hydrocyclones

Slurry Pumps from Hydrocyclones to the Dredge Slurry Holding Tanks/Gravity Thickeners

- Distance from Hydrocyclones to Dredge Slurry Holding Tanks is approximately 1200 linear feet.
- Slurry properties based on manufacturer's field experience (Metso Minerals).
- Percent solids of slurry conveyed will be 2% to 18%.
  - Based on METSIM values.
- Specific gravity of slurry conveyed will be 1.17.
  - Calculated SG based on percent solids.
- Static head will be 20 feet.
  - Assume above grade storage tanks with working tank depth of approximately 20 feet.
- Pump will operate by means of flooded suction.
- Pumps will be sized based on maximum capacity.
- Basis of design flow is 2,768 gallons per minute.
  - Based on METSIM values.
- Pumps will be arranged in 2 trains of 2 pumps each.
- Supplemental pump for barge unloading free water will be added to one process train
  - Supplemental pump allows for barge unloading free water conveyance during peak instantaneous conveyance of hydrocyclone overflow.
- System is designed to cover failure of 1 pump per train (hydrocyclone overflow only).
- Each pump will have a capacity range of 692 to 2800 gallons per minute (hydrocyclone overflow only).
- Supplemental pump will have maximum capacity of 1,150 gallons per minute.
  - Based on estimated barge unloading rate and upstream pump capacities.
- Each pump will be 125 horsepower (hydrocyclone overflow only).
  - Manufacturer's estimate based on design conditions.

SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson	20437	BSC	8/5/05	1/1

CALCS. BY ________ ; DATE ________ CHECKED BY JCP ; DATE 8/5/05

Dredge Slurry Holding Tank pumps

☆ Use Metsim Flow Data
Q = 2768

☆ Assume 2 trains of 2 pumps each

☆ Each pump must be capable of pumping all flow for that train

$$\left(\frac{2768 \text{ gal}}{\text{min}}\right)\left(\frac{1}{2 \text{ trains}}\right) = \frac{1384 \text{ gpm}}{\text{Train}}$$

$$1384 \text{ gpm} \Big/ 2 \text{ pumps a train} = 692 \text{ gpm per pump}$$

∴ Each pump must have a range of 692 gpm to 1384 gpm

∴ Each pump should have a max of 1400 and a min of 650

Thickener to Dewatering Conditioning Tanks, Slurry pumps

☆ assume 4 Trains of 1 pump each

☆ assume 902 gpm Flow from Metsim

$$\left(\frac{902 \text{ gal}}{\text{min}}\right)\left(\frac{1}{4 \text{ Trains}}\right) = 225.5 \text{ gpm per pump}$$

∴ Each pump must be able to pump 226 gpm

Dredge Slurry Holding Tanks

Dredge Slurry Holding Tanks

- Total storage volume of 1,400,000 gallons.
    - Based on 8 hours of storage at design flow.
    - Storage volume also allows for equalization of different sediment types.
- Dredge slurry holding tanks will be constructed of above grade bolted steel tanks.
    - This construction method will provide a cost effective and efficient thickener installation. It will also simplify tank removal.
- Mixers will be required to maintain suspension of solids in dredge slurry holding tanks.
- Each of 2 dredge slurry holding tanks will be designed to contain 700,000 gallons of dredge slurry.
- Dredge slurry holding tanks will each have a diameter of 70 feet.
- Dredge slurry holding tanks will each have a height of 26 feet.
- Actual depth of dredge slurry in dredge slurry holding tanks will vary.
- Percent solids for dredge slurry will average 10 percent by weight, with a range of 2.1 to 17.9 percent.
    - Based on METSIM values.
- Mixer design based on a range of G-values between 200 per second and 800 per second.
    - Based on the treatability study results.

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SUBJECT GE HUDSON DREDGE SLURRY HOLDING TANKS	PROJ. NO.	BY JGP	DATE 8/5/05	SHEET 1/1

CALCS. BY ________ ; DATE ________ CHECKED BY BSC ; DATE 8/5/05

- PROVIDE TOTAL 1,400,000 GALLONS OF STORAGE VOLUME
- PROVIDE TWO, 700,000 GALLON HOLDING TANKS
- EACH TANK 70-FT DIAMETER WITH 28-FT SIDE WALL HT.
- PROVIDE MIN. 3-FT OF FREEBOARD IN EACH HOLDING TANK
- VOLUME CHECK:
  - 70 FT Ø, AREA = $\pi\left(\frac{D}{2}\right)^2$ = 3,848 SF
  - 25 FT WATER DEPTH
  - VOL. EQUAL TO 25 FT × 3,848 SF = 96,200 CF = 720,000 GAL ✓
- TYPE OF TANK: BOLTED STEEL, ABOVEGRADE STORAGE TANK

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE HUDSON DREDGE SLURRY HOLDING TANK - MIXING		JRP	8/5/05	

CALCS. BY ______ ; DATE ______ CHECKED BY JRG ; DATE 8/8/05

TOTAL VOLUME = 1,400,000 GAL.
VOL. EACH TANK = 700,000 GAL.

TANK DIAMETER = 70 FT
WATER DEPTH = 24 FT

VELOCITY GRADIENT = 200 MIN TO 800 MAX (PER TREAT. TESTING)
SPECIFIC GRAVITY = 1.17
PERCENT SOLIDS = 2.1% MIN. TO 17.9% MAX. (PER METSIM)

PER MANUFACTURES RECOMMENDATIONS, EACH TANK TO BE EQUIPPED WITH:

- 5 MIXERS
- EACH 75 HP
- TOP ENTRY INTERFERENCE MIXERS

Gravity Thickeners

Gravity Thickeners

- Gravity Thickener feed will be approximately 2 percent solids.
  - Based on METSIM values.

- Gravity Thickener underflow will be approximately 15 percent solids.
  - Based on optimal feed concentration to filter presses per filter press manufacturers.

- Two tanks provided to allow for operational flexibility and the ability to take a unit off-line if necessary. Each unit will be sized to treat the highest solids loading scenario, S4 (1,616 dry tons per day).

- Gravity Thickener solids loading will be designed for 0.3 tons dry solids per square foot of thickener per day (dry T/sf-da).
  - This solids loading rate is consistent with manufacturer's recommendations for sediment thickening.

  - Current treatability tests support this loading rate. Using the modified Talmage and Fitch method for various thickener feed concentrations, the theoretical design loading ranges from 0.21 to 0.35 dry T/sf-da for various slurry feed concentrations.

- Gravity Thickeners will consist of two, 60 feet diameter units with a 12 feet water depth
  - Sizing based on assumed loading rate and manufacturer's recommendations.

- Gravity Thickeners will be constructed of above grade steel tanks.
  - This thickener construction method will provide a cost effective and efficient thickener installation. Will also simplify tank removal at end of processing period.

- Provisions for an anionic flocculant and cationic coagulant will be provided to enhance particulate settlement and thickening.
  - Current treatability testing has demonstrated optimum settling and thickening using a combination of a cationic polymer coagulant (approximately 60 to 250 ppm GE Betz Developmental E) and an anionic polymer flocculant (approximately 30 to 125 ppm PolyFloc AE1115).

- Gravity Thickeners will be fed from slurry pumps from either the hydrocyclones or dredge slurry holding tanks.
  - During normal operations, hydrocyclone overflows will be conveyed to the thickeners for thickening prior to being fed to the filter presses for dewatering. Under conditions where surplus dredge slurry has been stored, the thickeners will be fed from the dredge slurry holding tanks.

MEMORANDUM

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To: John Perriello

From: Brenna Mannion

Date: 08/05/05

cc: Scott Schiller

Re: Thickener Sizing from Laboratory Settling Tests.

There are three applicable methods to determine gravity thickener surface area per ton of sludge from laboratory settling tests, they are as followed:

- Modified Talmage and Fitch Method;
- Oltmann Method; and
- Coe and Clevenger Method.

The Coe and Clevenger method underestimates the thickener area needed because it uses the initial (rapid) settling rate, making finding the "compression point" unnecessary. Both the Modified Talmage and Fitch and Oltmann methods require that the compression point of the solids is first determined in order to find the underflow time (t_u). The Modified Talmage and Fitch method tends to provide the most conservative estimate of thickener area.

Since the desired concentration for the finished sludge product is known to be 150 kg/m^3 (15% solids), we can determine the final mud line height using a proportionality equation and the known initial concentration and initial mud line height. At the determined final height, a line is drawn on the graph, and for each method the underflow time (t_u) is determined. For the Modified Talmage-Fitch method the intersection of the line tangent to the compression point, and the final mud line height, provides the underflow time (t_u). For the Oltmann method, the intersection of the line connecting the initial height point to the compression point, and the final height line, provide the underflow time (t_u'). For the Coe and Clevenger method, all that is necessary is the initial instantaneous settling rate in m/day. This represents the highest rate of settling achieved by the solids, which decreases with time. (Example calculations for each method are attached).

The data used to execute these models were 2 Liter column settling tests of type S3 sediments as provided by GE on July 5, 2005. Four different solids loading percentages were tested with six different combinations of coagulant (Developmental E), and flocculent (AE1115). The settling tests with coagulant and flocculent which provided the most efficient settling for each of the four given solids loadings, were dosages selected for gravity thickener area determination. The four optimal settling tests are as follows:

- 2.51% solids, 61ppm Dev E, 30.4ppm AE1115
- 4.01% solids, 123ppm Dev E, 61.5ppm AE1115
- 6.20% solids, 187ppm Dev E, 93.4ppm AE1115
- 8.56% solids, 252ppm Dev E, 126ppm AE1115

Transmitted Via Interoffice

In order to determine the underflow times, the results were graphed, spanning the full settling test duration of 1440 minutes. To obtain more accurate underflow times, the information was re-plotted to only include the settling data for the initial 30 to 40 minutes. The graphs are attached.

To determine the most accurate compression point for each sample, Barnea graphs were also developed using the dimensionless height, H' and settling rate U calculated from the mud-line heights and times. The formulas are as follows:

$$U_n = (h_{n-1} - h_{n+1}) / (t_{n+1} - t_{n-1})$$

$$H'_n = (h_n - h_\infty) / (h_o - h_\infty)$$

Settling rate U (cm/s) is plotted against the dimensionless height H' on a log-log scale. The Barnea plots are attached.

The compression points determined using the Barnea plots correspond to the mud-line plots by data point number. By counting the number of points on the Barnea plots, the corresponding compression point could be determined on the height vs. time plots. Using these plots, the tangent and secant lines were plotted over the graphs according to the Modified Talmage and Fitch and Oltmann methods.

The tables and equations from the analysis are attached.

BAM

GE Thickener Analysis Table

Data from BBL Graphs based on GE Lab Data (Metric)

Test Sample	Co (kg/m^3)	Ho (m)	Cu (kg/m^3)	Hu (m)	U (initial settling rate m/day)	tu (per 1440 min.)	tu' (per 1440 min.)	Co (ton/m^3)	Talmage-Fitch Area m^2/(ton-24Hrs)	Oltmann Area m^2/(ton-24Hrs)	Oltmann Area xSF 1.2 m^2/(ton-24Hrs)	Oltmann Area xSF 2.0 m^2/(ton-24Hrs)	Coe-Clevenger Area m^2/(ton-24Hrs)
									Formula = tu/HoCo	Formula = tu'/CoHo	Formula = tu'/CoHo	Formula = tu'/CoHo	Formula = (1/Co - 1/Cu)/U
2.51% solids, 61ppm Dev E, 30.4 AE1115	25.1	0.422	150	0.071	838.1	0.005	0.002	0.028	0.440	0.184	0.221	0.369	0.036
4.01% solids, 123ppm Dev E, 61.5 AE1115	40.1	0.427	150	0.114	66.1	0.007	0.002	0.044	0.368	0.129	0.155	0.258	0.251
6.20% solids, 187ppm Dev E, 93.4 AE1115	62	0.433	150	0.179	30.0	0.008	0.006	0.068	0.263	0.195	0.234	0.390	0.286
8.56% solids, 252ppm Dev E, 126 AE1115	85.6	0.438	150	0.250	18.0	0.011	0.009	0.094	0.269	0.218	0.262	0.437	0.253

Data from BBL Graphs based on GE Lab Data (English)

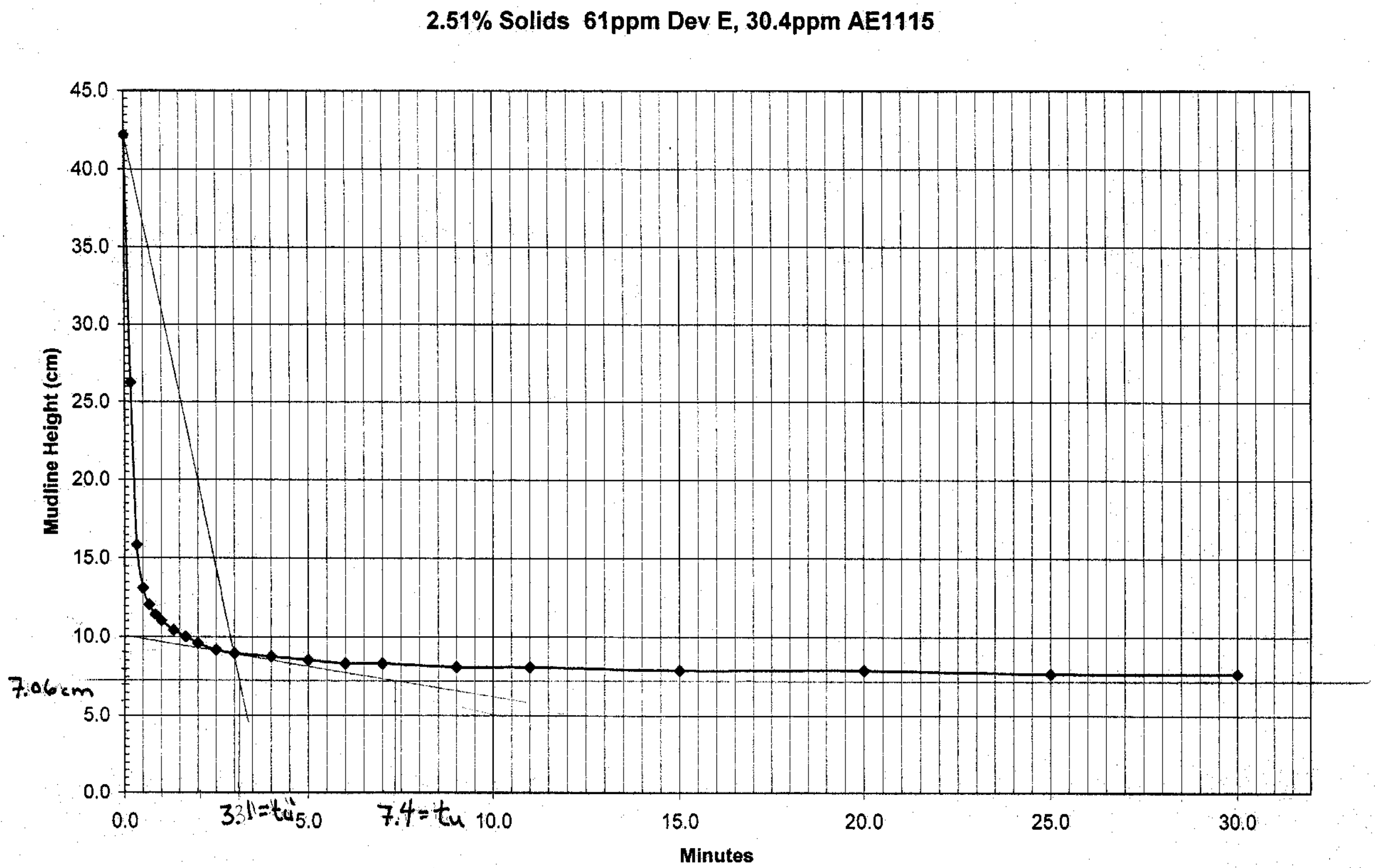
USE THIS METHOD → Talmage-Fitch

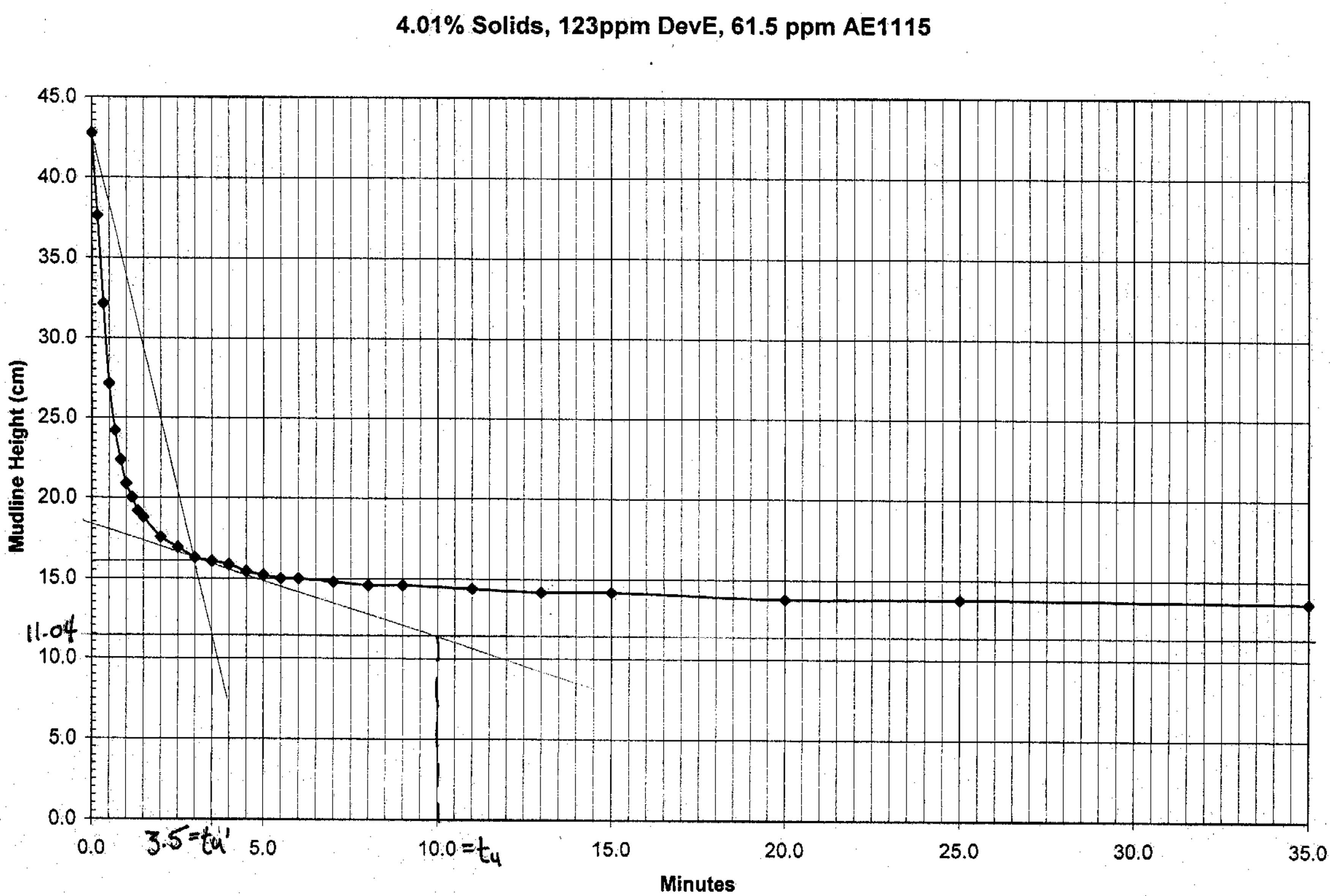
Test Sample		Talmage-Fitch Area ft^2/(ton-24Hrs)	Oltmann Area ft^2/(ton-24Hrs)	Oltmann Area xSF 1.2 ft^2/(ton-24Hrs)	Oltmann Area xSF 2.0 ft^2/(ton-24Hrs)	Coe-Clevenger Area ft^2/(ton-24Hrs)
		Formula = tu/HoCo	Formula = tu'/CoHo	Formula = tu'/CoHo	Formula = tu'/CoHo	Formula = (1/Co - 1/Cu)/U
2.51% solids, 61ppm Dev E, 30.4 AE1115		4.74	1.98	2.38	3.97	0.39
4.01% solids, 123ppm Dev E, 61.5 AE1115		3.96	1.39	1.66	2.77	2.70
6.20% solids, 187ppm Dev E, 93.4 AE1115		2.83	2.10	2.52	4.19	3.08
8.56% solids, 252ppm Dev E, 126 AE1115		2.89	2.35	2.82	4.70	2.72
AVG. :		3.605	1.955	2.345	3.908	2.22
LOADING RATE ; T/SF-DA :		0.28	0.51	0.43	0.26	0.45

RANGE ; T/SF-DA 0.21 – 0.35

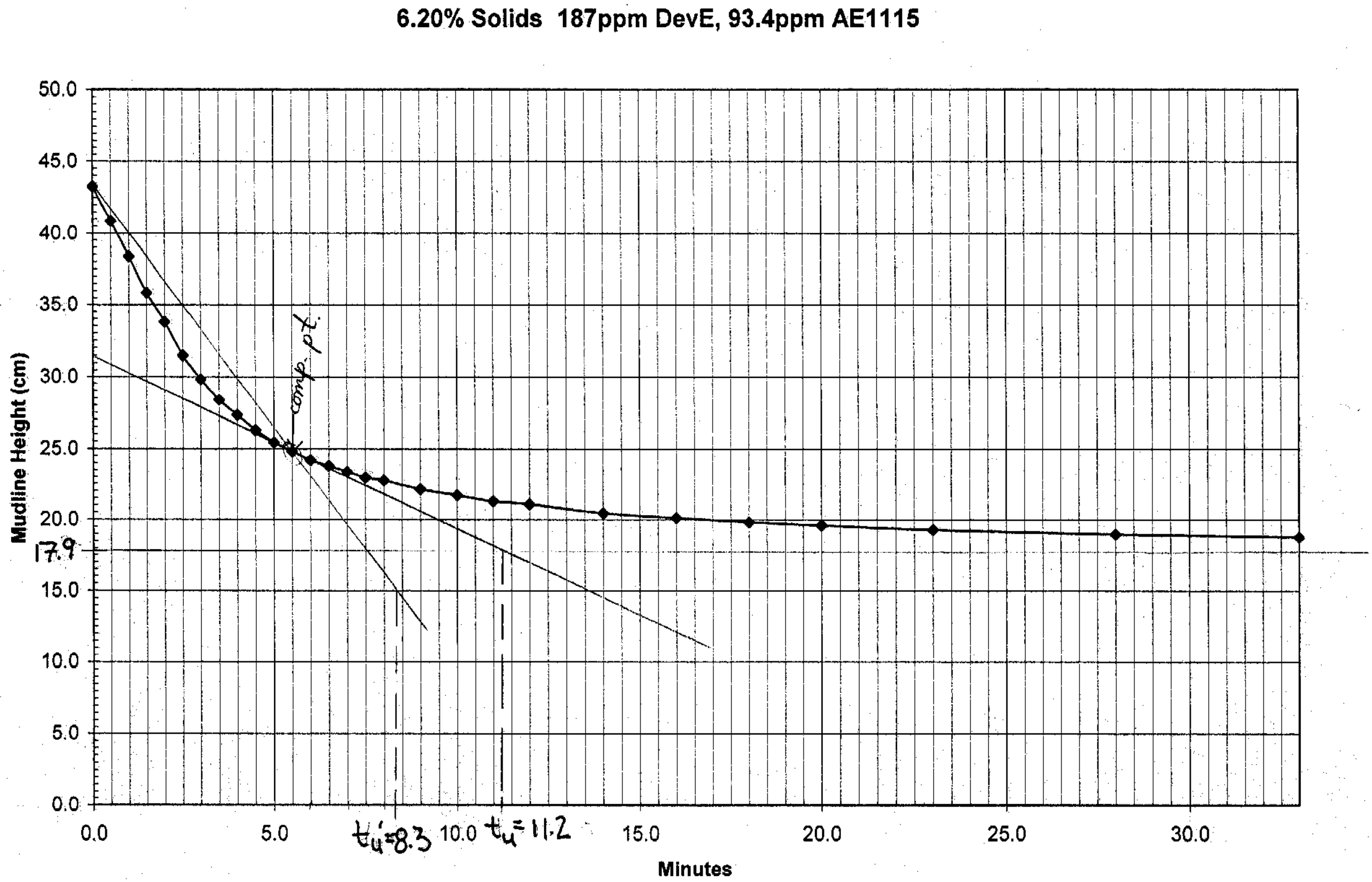
GRAVITY THICKENER SURFACE AREA ; USE 0.3 T/SF-DA

- THICKENER FEED SOLIDS LOADING (DRY T/DAY) = 1,616
- AREA REQUIRED = 1,616 / 0.3 = 5,387 SF
- TWO THICKENERS, EA ; 5,387/2 = 2,694 SF ; 60 FT DIA.


2.51% Solids 61ppm Dev E, 30.4ppm AE1115
Mudline Height (cm)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
7.06cm
0.0
5.0
10.0
15.0
20.0
25.0
30.0
3.1=tü
7.4=tu
Minutes

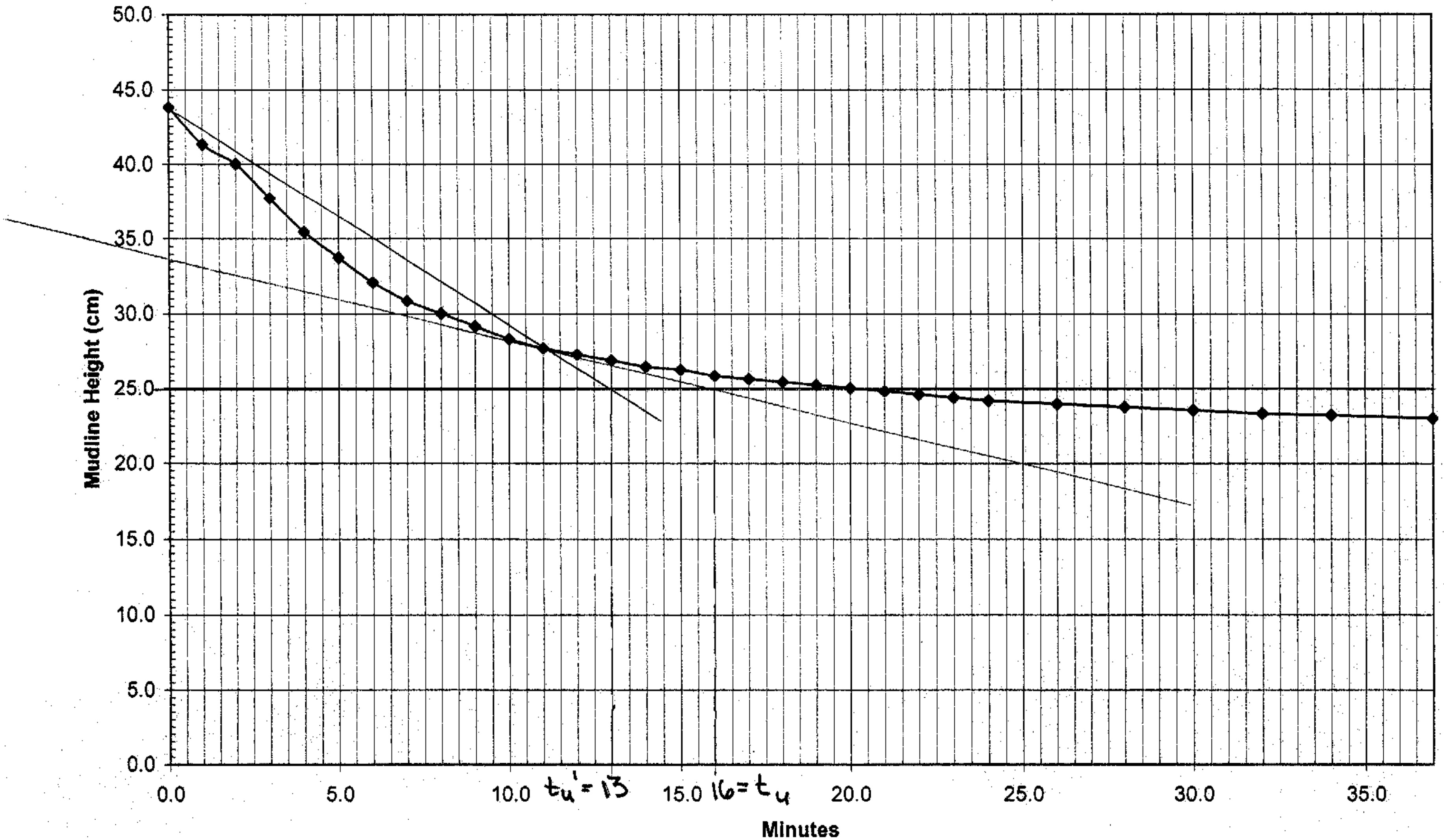


4.01% Solids, 123ppm DevE, 61.5 ppm AE1115
Mudline Height (cm)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
11.04
10.0
5.0
0.0
0.0
3.5=tu'
5.0
10.0=tu
15.0
20.0
25.0
30.0
35.0
Minutes



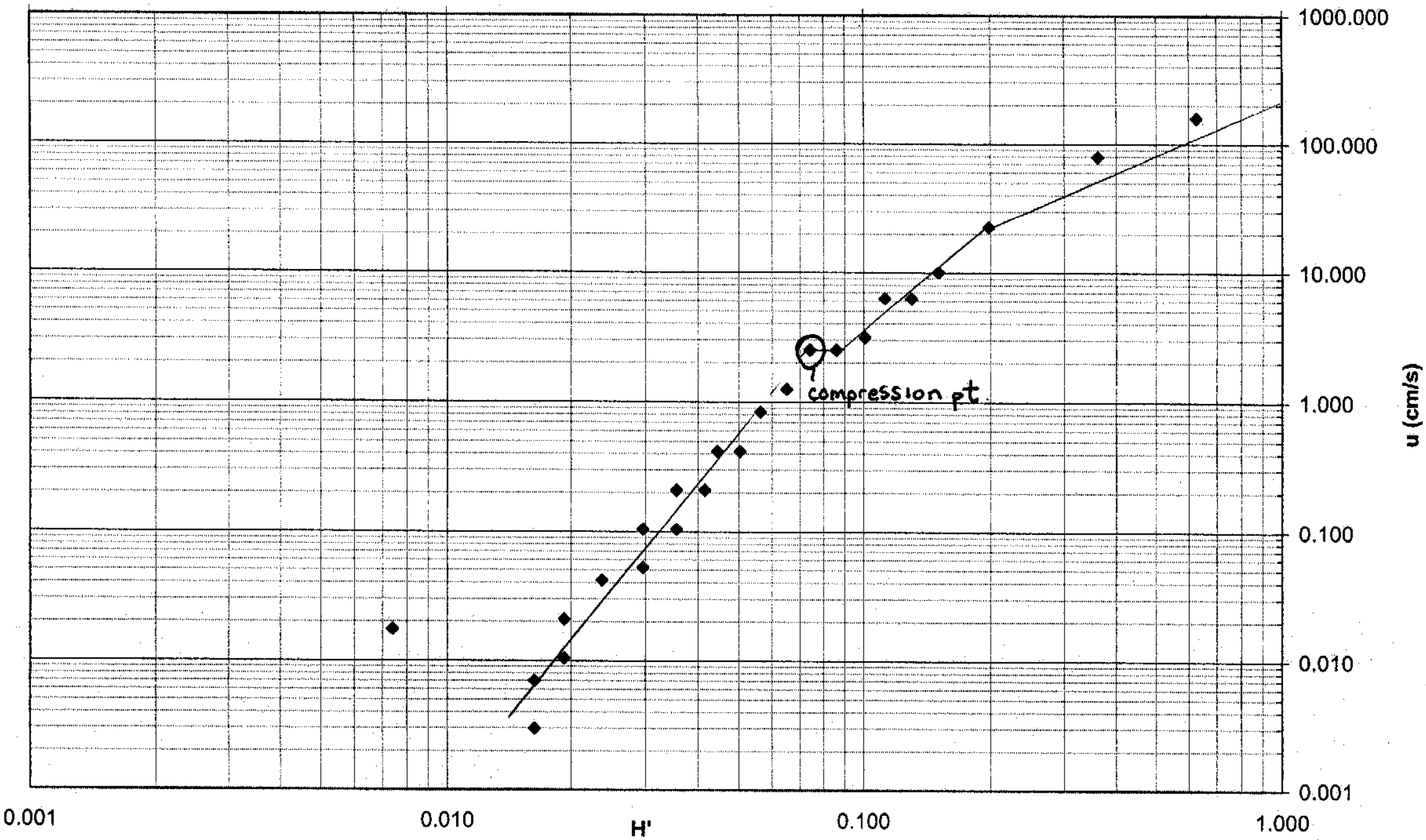
6.20% Solids 187ppm DevE, 93.4ppm AE1115
Mudline Height (cm)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
17.9
15.0
10.0
5.0
0.0
comp. pt.
0.0
5.0
$t_u' = 8.3$
10.0
$t_u = 11.2$
15.0
20.0
25.0
30.0
Minutes

8.56% Solids 252ppm DevE, 126ppm AE1115



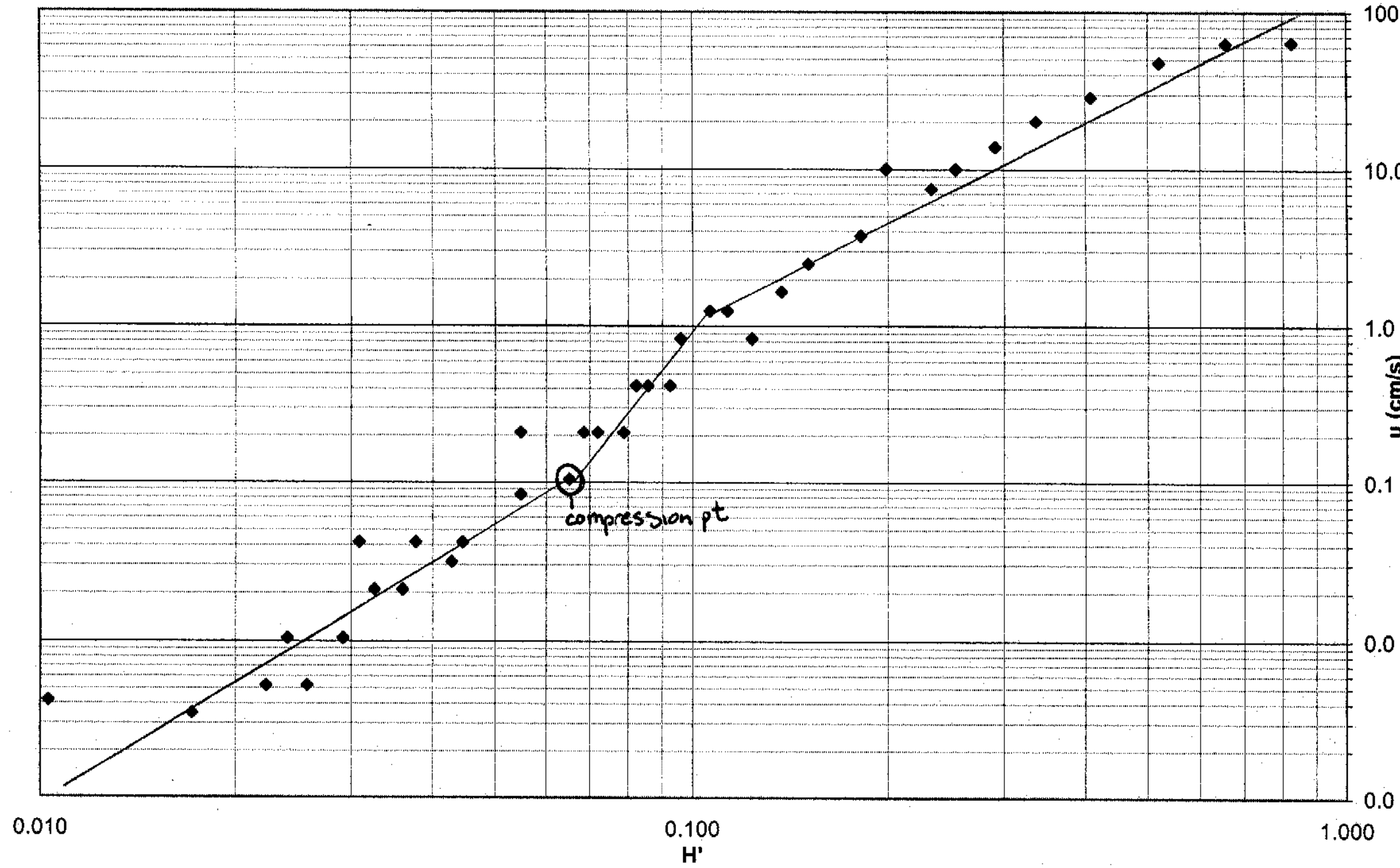
Barnea Plot

2.51% Solids, 61ppm DevE, 30.4ppm AE1115



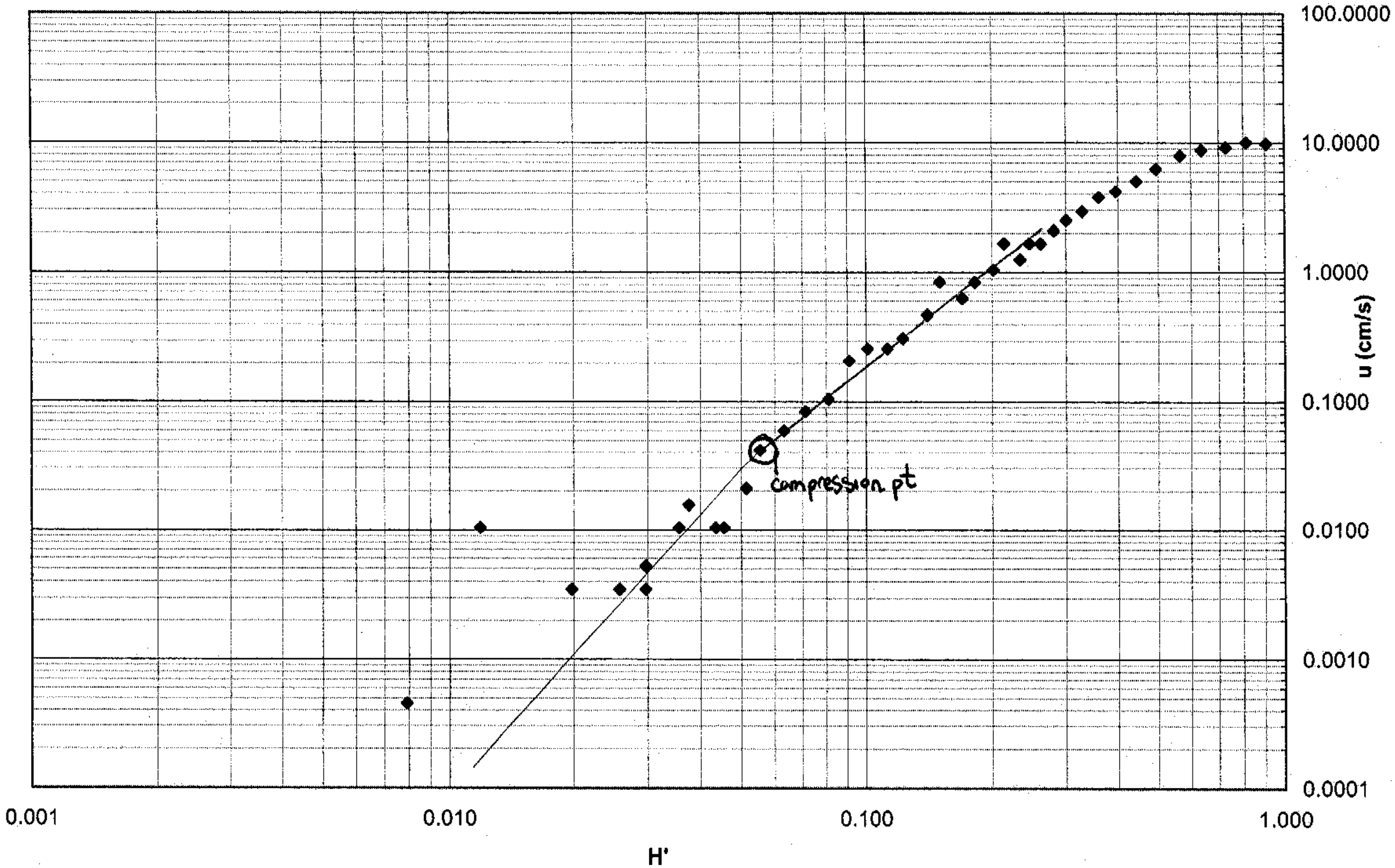
Barnea Plot

4.01% Solids, 123ppm DevE, 61.5ppm AE1115



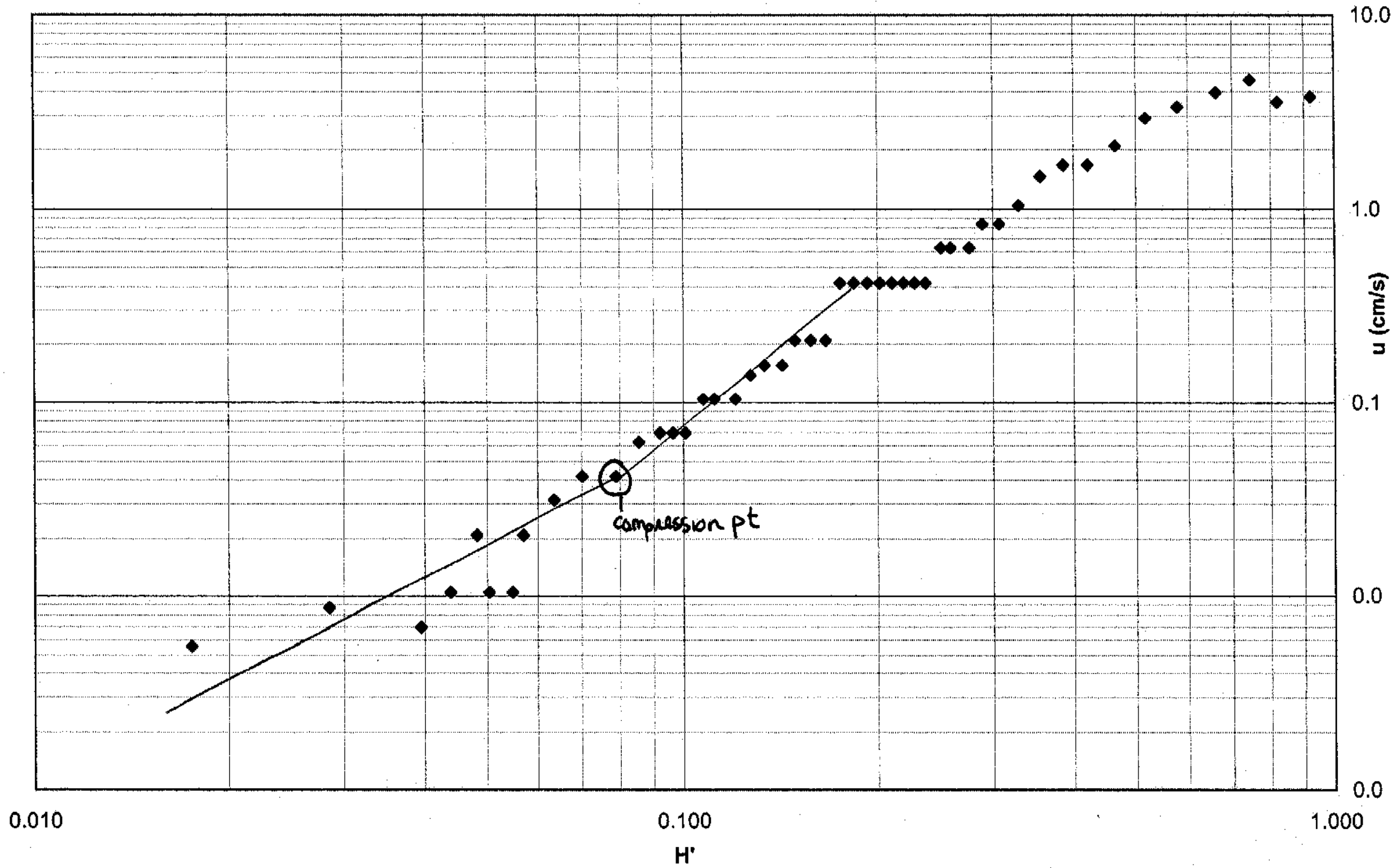
Barnea Plot

6.20% Solids, 187ppm DevE, 93.4ppm AE1115



Barnea Plot

8.56% Solids, 252ppm DevE, 126ppm AE1115



Dredge Slurry Holding Tank Transfer Pumps

Dredge Slurry Holding Tank Transfer Pumps

- Distance from Dredge Slurry Holding Tanks to the Gravity Thickeners is approximately 100 linear feet.

- Capacity of system will be 2,768 gallons per minute.
  - Based on METSIM values.

- Pumps will be arranged in 2 trains of 2 pumps each.

- Each train will have a capacity of 1,384 gallons per minute.

- Each pump will have a capacity of 1,400 gallons per minute.

Dewatering Conditioning Tanks

Dewatering Conditioning Tanks

- One dewatering conditioning tank per filter press train for a total of four dewatering conditioning tanks.

- Basis of design flow is 902 gallons per minute.
    - Based on METSIM values.

- Each dewatering conditioning tank will have 15 minutes of retention time.
    - Provides adequate contact time with polymer.

- Each dewatering condition tank will have a storage volume of 3,500 gallons.
    - Based on design flow and retention time.

- Each dewatering conditioning tank will have a diameter of 8 feet.

- Each dewatering conditioning tank will have a height of 10 feet.

- Percent feed solids to the dewatering conditioning tanks will range from 10% to 25%.
    - Based on METSIM values.

Thickener Sludge Pumps

Thickener Sludge Pumps from Gravity Thickeners to Dewatering Conditioning Tanks

- Distance from Gravity Thickeners to Dewatering Conditioning Tanks is approximately 400 linear feet.

- Basis of design flow is 902 gallons per minute.
  - Based on METSIM values.

- Percent solids of fluid conveyed will be 10% to 25%.
  - Based on METSIM values.

- 4 pumps will be arranged in 4 trains of 1 pump each.

- Each pump will normally operate at 226 gallons per minute.
  - Design flow will be conveyed by all 4 pumps together.

- Each pump will be 30 horsepower.
  - Manufacturer's estimate based on design conditions.

Dredge Slurry Holding Tank pumps

☆ Use MetSim Flow Data
Q = 2768

☆ Assume 2 trains of 2 pumps each

☆ Each pump must be capable of pumping all flow for that train

$$\left(\frac{2768\ gal}{min}\right)\left(\frac{1}{2\ trains}\right) = \frac{1384\ gpm}{train}$$

$$1384\ gpm \Big/ 2\ pumps\ a\ train = 692\ gpm\ per\ pump$$

∴ Each pump must have a range of 692 gpm to 1384 gpm

∴ Each pump should have a max of 1400 and a min of 650

Thickener to Dewatering Conditioning Tanks, Slurry pumps

☆ assume 4 trains of 1 pump each

☆ assume 902 gpm Flow from MetSim

$$\left(\frac{902\ gal}{min}\right)\left(\frac{1}{4\ trains}\right) = 225.5\ gpm\ per\ pump$$

∴ Each pump must be able to pump 220 gpm

Polymer Addition to Thickeners

Polymer Addition to Gravity Thickeners

- Polymer addition will include a cationic coagulant and an anionic flocculant.
  - Current treatability testing has demonstrated optimum settling and thickening using a combination of approximately 60 to 250 ppm of a cationic polymer coagulant (GE Betts Developmental E) and approximately 30 to 125 ppm of an anionic polymer flocculant (AE1115).

- Solids mass will be 1,616 dry tons per day
  - Based on METSIM values, treatability results and the attached calculations.

- 2 trains will be used for this operation
  - One train will be provided per gravity thickener.

- Chemical feed pumps will be arranged in 2 trains of 1 pump each.
  - Each pump will be sized for required design flow.

- Coagulant assumptions:

  - Coagulant usage at 10 pounds per dry ton will be 16,610 pounds
    - Based on METSIM values, treatability results and the attached calculations.

  - Density of coagulant will be 9.16 pounds per gallon
    - Based on METSIM values, treatability results and the attached calculations.

  - Maximum coagulant usage will be 1,764 gallons per day
    - Based on METSIM values, treatability results and the attached calculations.

  - Onsite storage capacity will be 2 weeks
    - Provides adequate on-site capacity at maximum feed rates while limiting frequency of coagulant deliveries.

  - Storage will be provided by means of 1 bulk storage tank at 22,000 gallons.
    - Based on the attached calculations.

  - Coagulant to be diluted to 5%.
    - Based on treatability study results.

  - Water usage will be 26 gallons per minute.
    - Based on previously stated water ratio and attached calculations.

- Flocculant assumptions:

  - Flocculant usage at 30 mg/l will be 1,000 pounds/day.
    - Based on METSIM values, treatability results and the attached calculations.

  - Density of flocculant will be 9.16 pounds per gallon

- Based on METSIM values, treatability results and the attached calculations.

- Maximum flocculant usage will be 109 gallons per day
  - Based on METSIM values, treatability results and the attached calculations.

- Onsite storage capacity will be 2 weeks
  - Provides adequate on-site capacity at maximum feed rates while limiting frequency of flocculant deliveries.

- Storage will be provided by means of 1 bulk storage tank at 2,000 gallons.
  - Based on the attached calculations.

- Flocculant to be diluted to 1%.
  - Based on treatability study results.

- Water usage will be 7.6 gallons per minute.
  - Based on previously stated water ratio and attached calculations.

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE HUDSON - COAGULANT @ THK.	20437	DB		

CALCS. BY ______ ; DATE ______ CHECKED BY JG ; DATE 8/5/05

COAGULANT FOR ADDITION TO GRAVITY THICKENERS -

2768 GPM FEED RATE

1616 DRY TON/DAY

9.16 LB/GAL FOR COAGULANT

10 LB/TON DS POLYMER DOSAGE

↳ (10)(1616) = 16160/9.16 = 1764 GAL/DAY ✓

DILUTE COAGULANT TO 5%

1764/.05 = 35280 GAL WATER NEEDED ✓

TOTAL FEED RATE = POLYMER + WATER

1764 + 35280 = 37044 GAL/DAY → 26 GPM ✓

STORAGE FOR 2 WEEKS -

(2)(6)(1764 GAL/DAY) = 21,168 GALS ✓

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE - POLYMER FLOCCULANT @ THC	20437	DG		

CALCS. BY ______ ; DATE ______ CHECKED BY ______ ; DATE 8/5/05

POLYFLOC AE1115 - ANIONIC FLOCCULANT

FLOC. DOSE OF 20 mg TO 30 mg/L → ASSUME 30 m/L

2768 GPM FEED RATE → 10,478 l/m

(30 mg/l)(10,478 l/min) = .31 Kg/min

TOTAL FLOC PER DAY (.31)(24 HR/DAY)(60 min/HR) = 453 Kg/DAY
= 1,000 LB/DAY

DILUTION OF FLOC 0.1 TO 1%
↳ .001%

ASSUME FLOC 9.16 LB/GAL → 1000 LB/DAY / 9.16 LB/GAL = 109 GAL/DAY FLOC.

ASSUME 1% → 109/.01 = 10900 GAL/DAY WATER

2 WEEKS STORAGE → (2)(6)(109 GAL/DAY) = 1308 GAL
↳ 2,000 GAL TANK

→ 10900/24/60 = 7.6 GPM WATER

Polymer Addition to Filter Presses

Polymer Addition to Filter Presses

- Polymer addition will include a cationic coagulant.
  - Based on treatability study results.
- Solids mass will be 1,601 dry tons per day.
  - Based on METSIM values, treatability results and the attached calculations.
- 4 trains will be used for this operation.
  - Based on number of filter press trains.
- Chemical feed pumps be arranged in 4 trains of 1 pump each.
- Polymer usage at 7 pounds per dry ton will be 11,207 pounds.
  - Based on METSIM values, treatability results and the attached calculations.
- Polymer usage at 19 pounds per dry ton will be 30,419 pounds.
  - Based on METSIM values, treatability results and the attached calculations.
- Specific gravity of polymer will be 9.16 pounds per gallon
  - Based on METSIM values, treatability results and the attached calculations.
- Minimum polymer usage will be 306 gallons per train per day
  - Based on METSIM values, treatability results and the attached calculations.
- Maximum polymer usage will be 830 gallons per train per day
  - Based on METSIM values, treatability results and the attached calculations.
- Minimum polymer dosage will be 0.32 gallons per minute per train
  - Based on METSIM values, treatability results and the attached calculations.
- Maximum polymer dosage will be 0.86 gallons per minute per train
  - Based on METSIM values, treatability results and the attached calculations.
- Operating range of each pump will be 0.16 to 0.86 gallons per minute
  - Based on the attached calculations.
- Maximum polymer usage will be 3,321 gallons per day
  - Based on METSIM values, treatability results and the attached calculations.
- Onsite storage capacity will be 2 weeks
  - Provides adequate onsite capacity at maximum feed rates while limiting frequency of polymer deliveries.
- Coagulant storage for filter press addition will be combined with coagulant storage for gravity thickener addition. Additional storage necessary is 25,000 gallons.
  - Based on the attached calculations.

- Polymer to water ratio will be 1:10.
  - Assumption used to preliminarily size chemical feed pumps.
  - Based on treatability study results.

- Water usage will be 8.6 gallons per minute.
  - Based on previously stated water ratio and attached calculations.

- Water pump capacity will be 9.46 gallons per minute.
  - Based on previously stated water ratio and attached calculations.

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE HUDSON POLYMER DOSING	20137	DG	7/1/05	1 OF 2

FILTER PRESS SYSTEM

CALCS. BY ______ ; DATE ______ CHECKED BY JB ; DATE 8/5/05

ASSUME 4 TRAINS

SOLID MASS 1601 DTPD

POLYMER USAGE AT 7 LB/DT → (7)(1601) = 11207 LB ✓

POLYMER USAGE AT 19 LB/DT → (19)(1601) = 30419 LB ✓

SPECIFIC GRAVITY OF POLYMER 1.1 ∴ (8.33)(1.1) = 9.16 LB/GAL ✓

MIN USAGE 11207/9.16 = 1223 GAL → 306 GAL/TRAIN/DAY ✓

MAX USAGE 30419/9.16 = 3321 GAL → 830 GAL/TRAIN/DAY ✓

MIN DOSE 1223/16/60 = 1.27 GPM → .32 GPM/TRAIN ✓

MAX DOSE 3321/16/60 = 3.46 GPM → .86 GPM/TRAIN ✓

GPM PER PUMP (~~DOUBLE~~ ~~2~~ 1 PUMP PER TRAIN ∴ ~~8~~ 4 PUMPS)

GPM PER PUMP (MIN) → ~~.16 GPM~~ 0.32 GPM
" (MAX) → ~~.43 GPM~~ 0.86 GPM

CHEM FEED PUMP FOR EACH TRAIN MUST BE CAPABLE OF MIN GPM OR 2X'S THE MAX (ASSUME ONE PUMP DOWN)

∴ ~~.16 – .86~~ 0.32 – 1.72 GPM PER PUMP

BULK STORAGE – ASSUME MAX USAGE 3321 GAL/DAY + 2 WK SUPPLY (6 DAYS/WK)

(3321 GAL/DAY)(12 DAY) = 39852 GAL

2 TANKS → 39852/2 = 19926 GAL ≈ 20,000 GAL EA

✓

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE - POLYMER	20137	[initials]	7/6/05	1 OF 1

CALCS. BY ______ ; DATE ______ CHECKED BY [signature] ; DATE 8/5/05

ASSUME 1:10 RATIO OF WATER TO POLYMER

(~~.86~~ 1.72)(10) = ~~8.6~~ 17.2 GPM WATER

MAX ∴ ~~8.6~~ 17.2 + ~~.86~~ 1.72 = ~~9.46~~ 18.9 GPM PER PUMP

DILUTE CATIONIC COAGULANT 5-10% → SAY 10%

MIN (~~.16~~ 0.32)(10) = ~~1.6~~ 3.2 GPM WATER

∴ ~~1.6~~ 3.2 + ~~.16~~ .32 = ~~1.76~~ 3.52 GPM PER PUMP

Filter Press Feed Pumps

Filter Press Feed Pumps

- Distance from Dewatering Conditioning Tanks to Filter Presses is approximately 200 linear feet.

- Pumps will be the centrifugal type.
  - Based on manufacturer's recommendations.

- Each feed pump will be capable of 900 gallons per minute.
  - Based on METSIM values.

- Feed pumps will convey fluids with approximately 15 percent solids.
  - Based on METSIM values.

- Each pump will have a 60 horsepower motor.
  - Based on manufacturer's specifications.

Filter Presses

Filter Presses

- Filter press feed will have a specific gravity of approximately 1.17.
  - Based on METSIM values and the attached calculations.

- Filter press cake will have a specific gravity of approximately 1.52.
  - Based on METSIM values and the attached calculations.

- Filter press feed will be approximately 15 percent solids.
  - Based on METSIM values and manufacturer's recommendation.

- Filter press cake will be approximately 55 percent solids.
  - Based on METSIM values and manufacturer's recommendation.

- Filter press cake will be approximately 1.5 inches thick in each plate.
  - Based on manufacturer's specifications.

- Filter presses will be operated 24 hours a day.
  - Based on optimization of operating time.

- Filter presses will be placed on platforms and elevated approximately 10 feet off of the floor of the filter press building to allow for the use of roll off containers transported by trucks.

- Each treatment train will have one installed spare.
  - Based on manufacturer's recommendations.

- Each filter press will have a cycle time of approximately 3 hours.
  - Based on manufacturer's field experience.

- Each filter press will be fed by an individual feed pump.
  - Based on manufacturer's recommendations.

- Each filter press will be fed by a centrifugal feed pump to a pressure of 100 pounds per square inch.
  - Based on manufacturer's recommendations.

- Each filter press feed pump will be capable of conveying 900 gallons per minute of 15 percent sediment slurry.
  - Based on manufacturer's recommendations.

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson Specific Gravity	20437	BSC	6/16/05	1/2

CALCS. BY ______ ; DATE ______ CHECKED BY [signature] ; DATE 8/5/05

Filter Press Feed

Q = 987 gpm

$$\left(\frac{987\ gal}{min}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{24\ hr}{1\ day}\right) = \frac{1421280\ gal}{day}$$

$$\left(\frac{1421280\ gal}{day}\right)\left(\frac{1\ cy}{202\ gal}\right) = \frac{7036.04\ cy}{day}$$

☆ From Metsim ⇒ 6945 ton/day

$$\left(\frac{6945\ ton}{day}\right)\left(\frac{2000\ lbs}{1\ ton}\right) = \frac{13890000\ lbs}{day}$$

$$\frac{\left(\frac{13890000\ lbs}{day}\right)}{\left(\frac{7036.04\ cy}{day}\right)} = 1974.12\ lbs/cy$$

$$\left(1974.12\ lbs/cy\right)\left(\frac{.0005933\ lbs/cy}{1\ gm/mL}\right) = 1.17\ gm/mL \Rightarrow \underline{\underline{1.17\ S.G.}}$$

Filter Press Cake

Q = 327

$$\left(\frac{327\ gal}{min}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{24\ hr}{1\ day}\right) = \frac{470880\ gal}{day}$$

$$\left(\frac{470880\ gal}{day}\right)\left(\frac{1\ cy}{202\ gal}\right) = \frac{2331.09\ cy}{day}$$

☆ From Metsim ⇒ 2985 ton/day

(Cont'd on page 2)

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson Specific Gravity	20437	BSC	6/16/05	2/2

CALCS. BY ______ ; DATE ______ CHECKED BY [signature] ; DATE 8/5/05

Filter press Cake cont'd

$$\left(\frac{2985 \text{ ton}}{\text{day}}\right)\left(\frac{2000 \text{ lbs}}{\text{ton}}\right) = \frac{5970000 \text{ lbs}}{\text{day}}$$

$$\frac{\left(\frac{5970000 \text{ lbs}}{\text{day}}\right)}{\left(\frac{2331.09 \text{ cy}}{\text{day}}\right)} = 2561.03 \text{ lbs/cy}$$

$$\left(\frac{2561.03 \text{ lbs}}{\text{cy}}\right)\left(\frac{.0005933 \text{ lbs/cy}}{1 \text{ gm/mL}}\right) = 1.52 \text{ gm/mL} \Rightarrow \underline{\underline{1.52 \text{ s.g.}}}$$

FILTER PRESS SIZING CALCULATIONS

FEED SLURRY

	TRIAL #1	TRIAL #2	TRIAL #3
Solids (% by wt) :	[illegible]	15.00	15.00
Specific Gravity :	[illegible]	1.17	1.17
Gallons/Day :	[illegible]	1421280	1,421,280
# Dry Solids/Day :	2,080,285	2080285	2080285
Cycle Time (hrs) :	[illegible]	[illegible]	4.0
Operating Time/Day :	[illegible]	24	24

FILTER CAKE

	TRIAL #1	TRIAL #2	TRIAL #3
Solids (% by wt) :	[illegible]	[illegible]	[illegible]
Specific Gravity :	[illegible]	[illegible]	[illegible]
Cubic Feet/Day :	39877.9	39877.9	39877.9
Density (lbs/cf) :	94.8	94.8	94.8

FILTER PRESS SIZE

	TRIAL #1	TRIAL #2	TRIAL #3
Cycles/Day :	12	8	6
Cubic ft/cycle:	**3323.16**	**4984.73**	**6646.31**
Volume/Cycle (gal) :	118440	177660	236880

Number of 600 cu ft presses	
#1	**6**
#2	**9**
#3	**12**

Recycle Water Equalization Tank

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Recycle Water EQ. TANK	20437	TEM	8/4/05	1/3

CALCS. BY TEM ; DATE 8/4/05 CHECKED BY [illegible] ; DATE 8/8/05

Recycle Water EQ. Tank Needs to store Waters Discharged from the thickeners and Filter presses. Water collected in this tank is either recycled to the waterfront for slurry make-up water or discharged to water treatment

EQ. tank needs to be large enough to provide maximum gallons of water to waterfront over shortest period of time (~15 hrs waterfront operation) plus necessary equalization volume for water treatment operations

(1) MAXIMUM Storage Volume of sediment slurry water required when waterfront process 4,300 in situ/cy dy of S1 sediment over 15 hrs while Thickening and Dewatering Systems process the same volume over 24 hrs.

Per METSIM WATER BALANCE, Table 3-26

MAXIMUM REQUIRED RECYCLED WATER = 2534 gpm x 24 hr x 60 (Stream 1D4)

= 3,650,000 GALLONS (REQUIRED OVER 15 hrs)

MAXIMUM RECYCLE WATER PRODUCED AT THICKENER AND DEWATERING FACILITY (Stream # 4D4)

= 2809 gpm x 60 min x 15 hr = 2,528,100 GALLONS produced over 15 hrs

REQUIRED Storage NEEDED TO BE AVAILABLE AT START OF DAY = 3,650,000 - 2,528,100

= 1,122,000 GALLONS

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Recycle Water EQ. TANK	20437	TEM	8/4/05	2/3

CALCS. BY TEM ; DATE 8/4/05 CHECKED BY SRG ; DATE 8/8/05

(2.) MAXIMUM storage volume of water for treatment at water treatment plant occurs when process 4,300 INSITU cubic yards of S4 inventory one day (15 hr/dy) after treating 4,300 cubic yards of S1 sediment

When treating S4 inventory, 694 x 24 x 60 (Stream 104 - METSIM, TABLE 3-26)

= **999,360 gallons (over 15 hrs)**

RECYCLE WATER PRODUCED AT THICKENER AND DEWATERING FACILITY over same 15 hrs = 1078 gpm x 60 x 15 = 970,200 GALLONS

Amt of water needed to be treated over same 15 hrs = 970,200 gallons - 999,360 gallons = **-29,160 GALLONS**

Amt of water needed to be generated for water treatment 9 hrs waterfront is not in operation

$= 1{,}078 \text{ gpm} \times \frac{60 \text{ min}}{\text{hr}} \times 9 \text{ hr} = 582{,}120$ gallons

Amt of Water EQUALIZATION REQUIRED when operating (2) 500 GPM TRAINS =

(1078 gpm - 1000 gpm) X 9 hrs X 60 min = **42,120 GALLONS**

Amount of WATER EQUALIZATION REQUIRED when operating (1) 500 GPM TRAIN

= (1,078 - 500 GPM) X 9 X 60 = **312,120 GALLONS**

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River – Recycle WATER EQ. TANK	20437	TEM	8/5/05	3/3

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY JRG ; DATE 8/8/05

Summary

Required water volume needed to process 4,300 in situ cy of S1 sediment in approximately 15 hrs when dewatering facility is operating on a 24 hr day

= 1,122,000 GALLONS

Required additional water volume needed for water treatment plant equalization when processing 4,300 in situ CY of S4 sediment in approximately 15 hrs when dewatering facility is operating on a 24 hr day (assuming 1,000 GPM WTP capacity)

= 42,120 GALLONS

∴ Recycle Water Equalization tank size =

= 1,122,000 GAL + 42,120 GALLONS

= 1,164,120 gallons × 1.30 ≈ 1,500,000 GALLONS

(30% safety factor will cover unplanned WTP downtime, and events that require use of river water for make-up supply)

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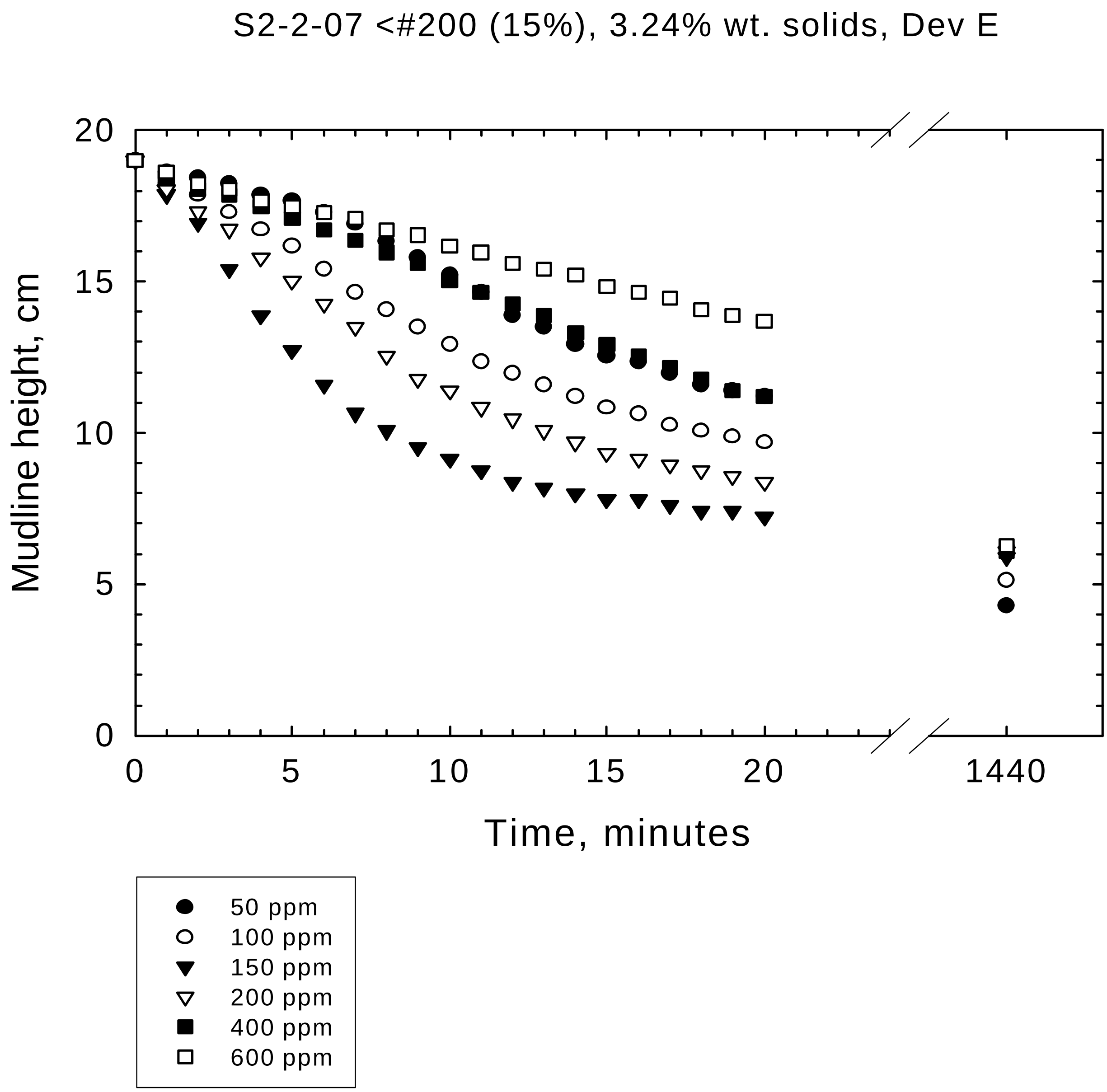
Exhibit G.3.2a - Thickening with Polymer Coagulant



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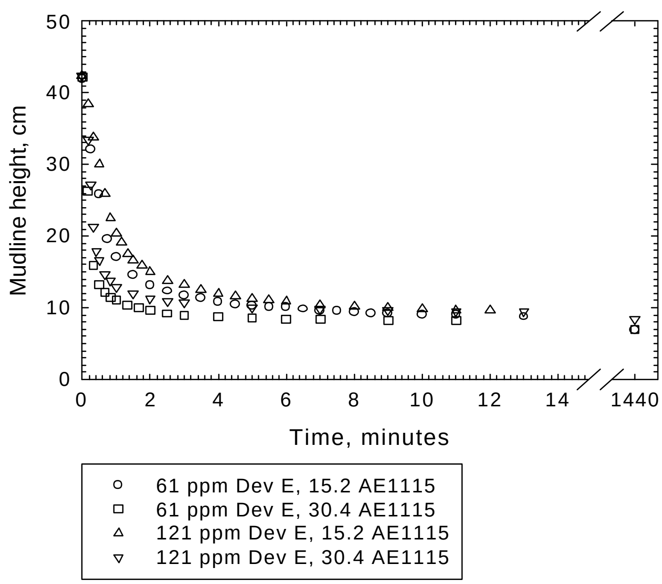
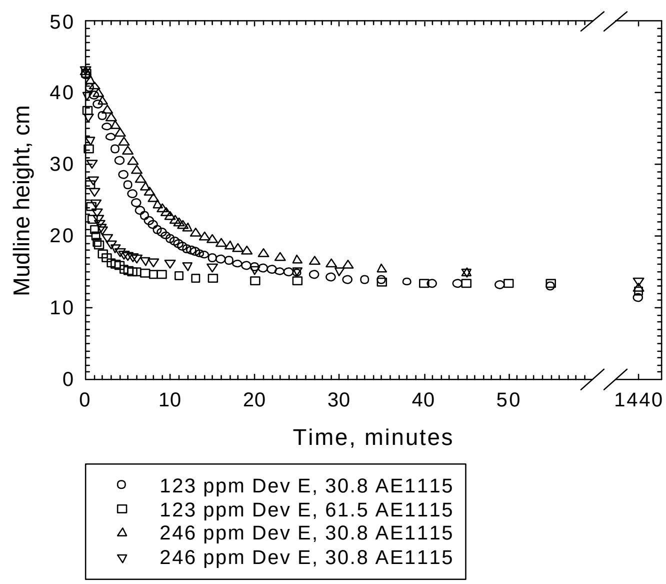
<u>Exhibit G.3.2b - Thickening with Polymer Treatment</u>

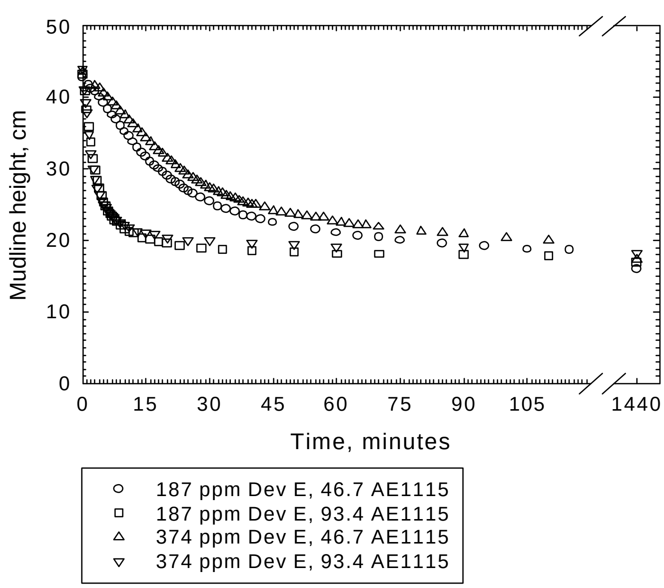
2.51% wt. solids initial



4.01% wt. solids initial



6.20% wt. solids initial



8.56% wt. solids initial

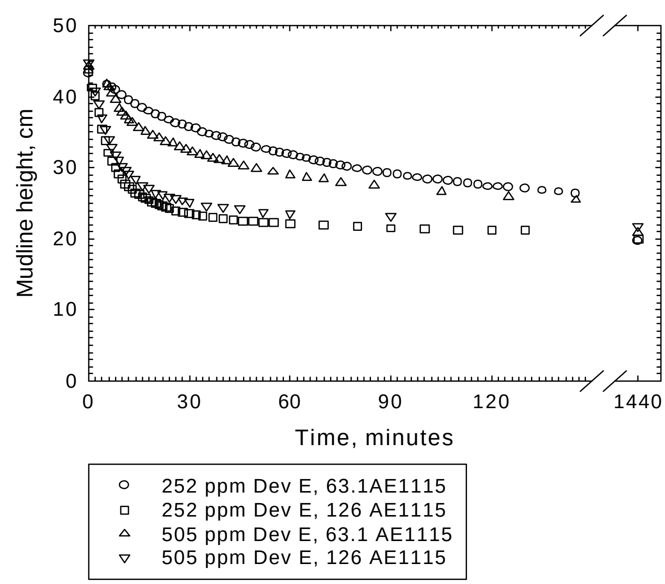


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Exhibit G.3.3 - Primary Settling Column Results

Sample	initial % wt. solids	initial density s.g.	Time h	Interface height in.	Settled volume in.3	Settled density s.g.	% wt. solids
H2S4B	4.33	1.03	0.0	77.3	8737	1.03	4.3
	4.33	1.03	0.5	64.0	7238	1.03	5.2
	4.33	1.03	1.0	55.0	6220	1.04	6.0
	4.33	1.03	2.0	40.5	4580	1.05	8.1
	4.33	1.03	8.0	22.3	2516	1.10	14.1
	4.33	1.03	24.0	17.3	1951	1.12	17.7
H2S3	1.8	1.01	No interface observed				
H2S2	1.16	1.01	No interface observed				
H1S3	10.41	1.07	0.0	79.0	8935	1.07	10.4
	10.41	1.07	1.0	79.0	8935	1.07	10.4
	10.41	1.07	2.0	79.0	8935	1.07	10.4
	10.41	1.07	5.2	45.8	5174	1.12	17.2
	10.41	1.07	8.0	41.8	4722	1.13	18.6
	10.41	1.07	24.0	36.0	4072	1.15	21.2
H1S2	9.66	1.06	0.0	79.0	8935	1.06	9.7
	9.66	1.06	0.8	75.3	8511	1.07	10.1
	9.66	1.06	1.0	74.0	8369	1.07	10.3
	9.66	1.06	1.7	69.5	7860	1.07	10.9
	9.66	1.06	2.0	67.3	7606	1.08	11.2
	9.66	1.06	2.7	64.5	7295	1.08	11.7
	9.66	1.06	4.1	58.3	6588	1.09	12.8
	9.66	1.06	8.0	46.5	5259	1.11	15.7
	9.66	1.06	24.0	36.8	4156	1.14	19.4
H1S1	3.24	1.02	0.0	78.8	8906	1.02	3.2
	3.24	1.02	0.5	15.0	1696	1.11	15.7
	3.24	1.02	1.0	10.0	1131	1.16	22.4
	3.24	1.02	2.0	8.0	905	1.20	27.1
	3.24	1.02	8.0	6.5	735	1.25	32.1
	3.24	1.02	24.0	5.5	622	1.29	36.6
		2.65	solids s.g.		12 in. dia		113 in.2

Note: No polymers were used in these tests.

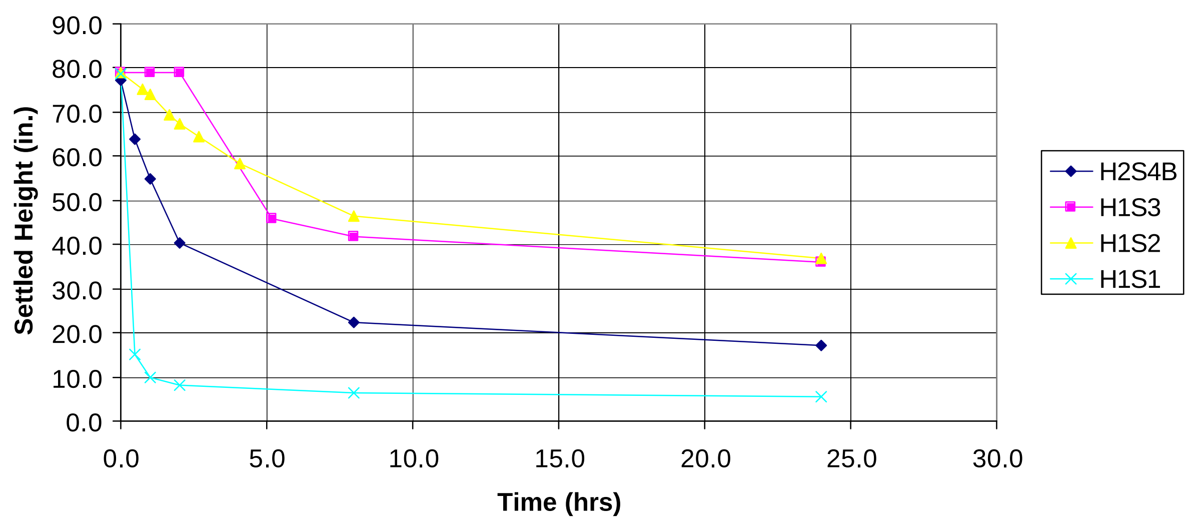
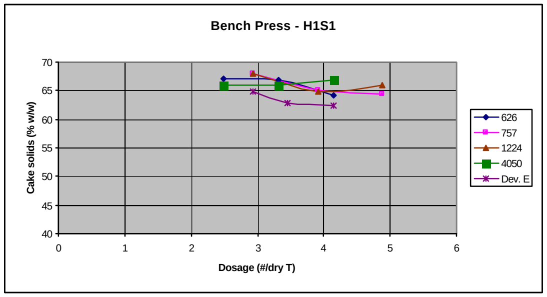
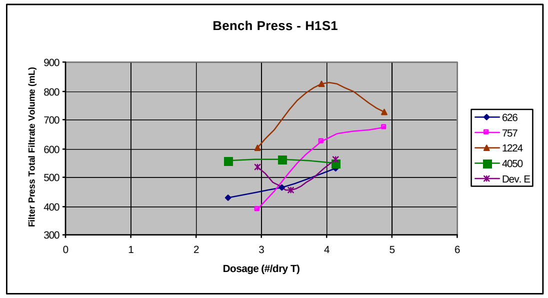
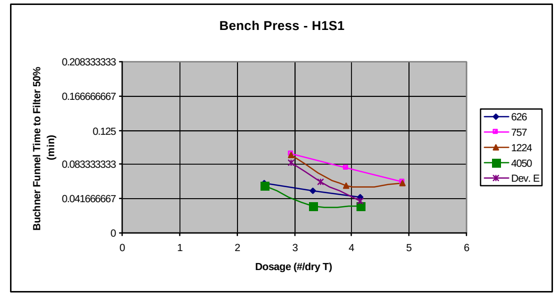
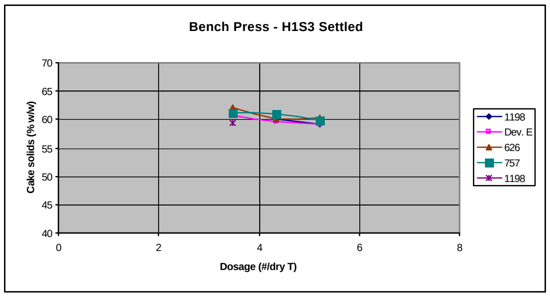


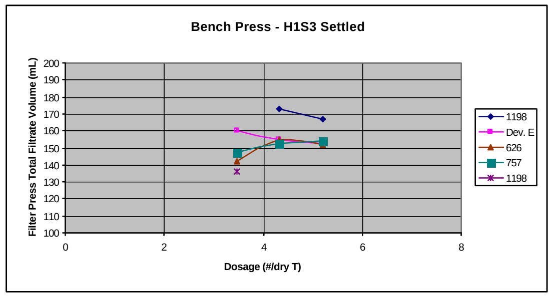
Exhibit G.3.4 - Filter Press Polymer Screening Results

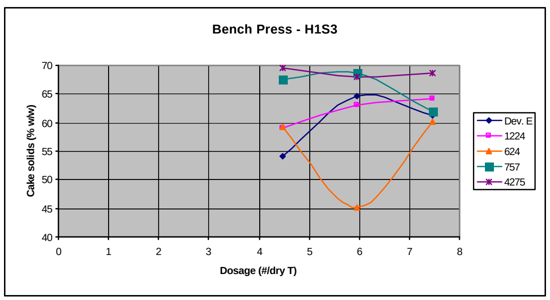


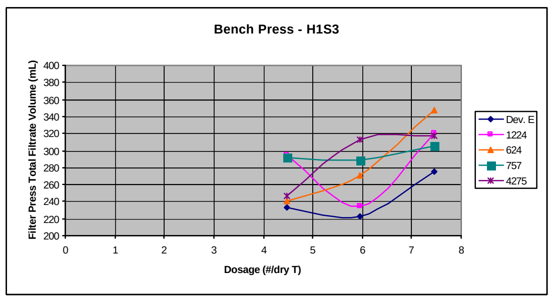


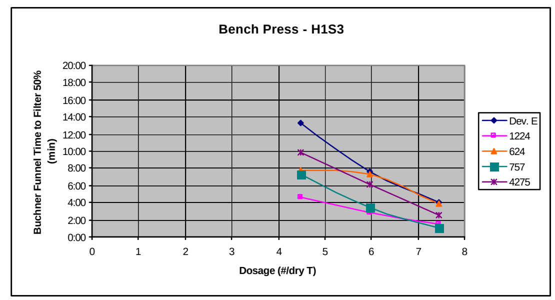


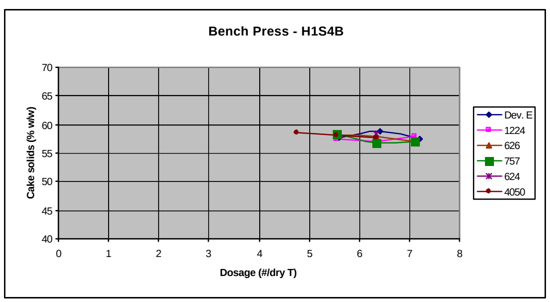


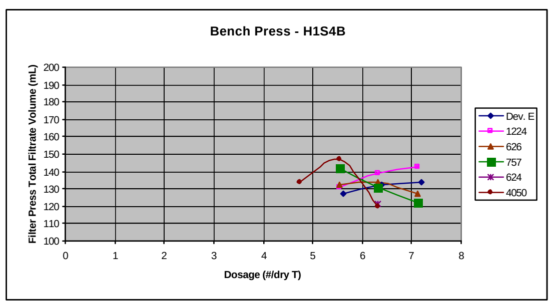












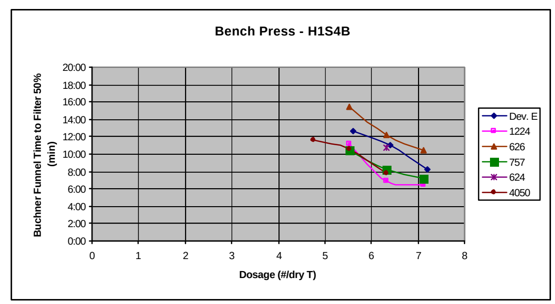


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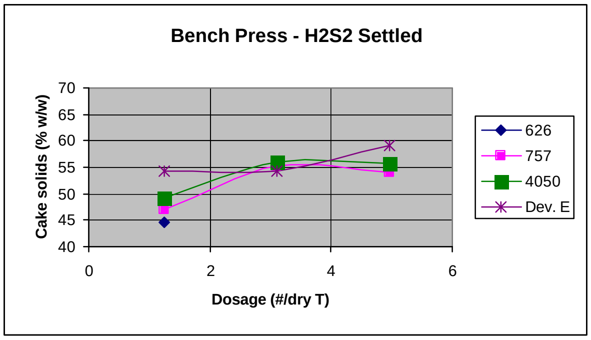
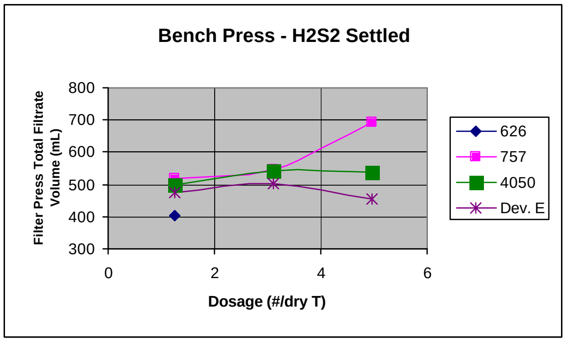
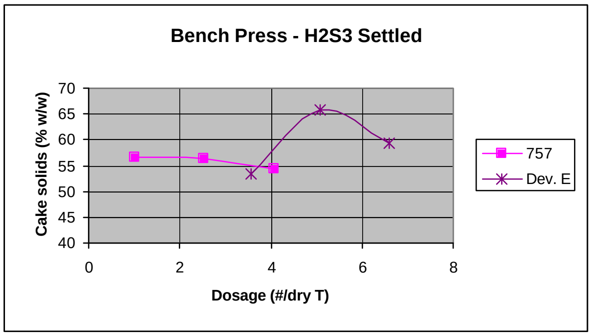
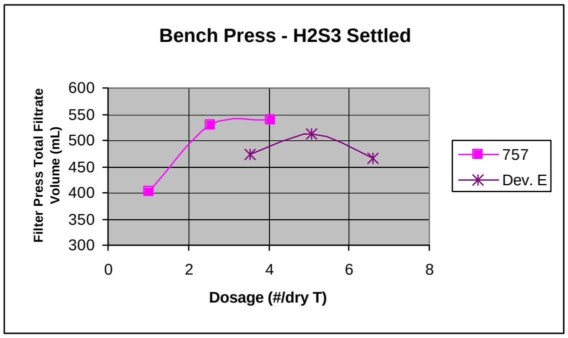
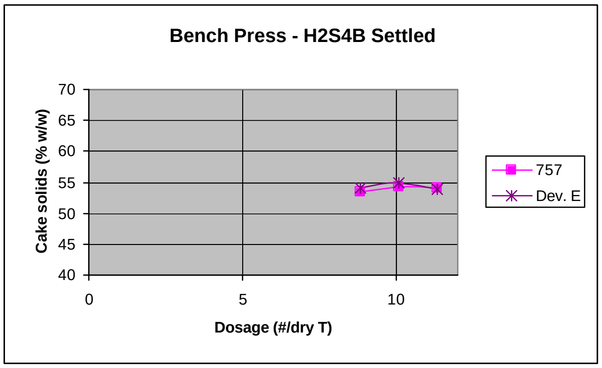
Exhibit G.3.5 - Filter Press Polymer Screening Results

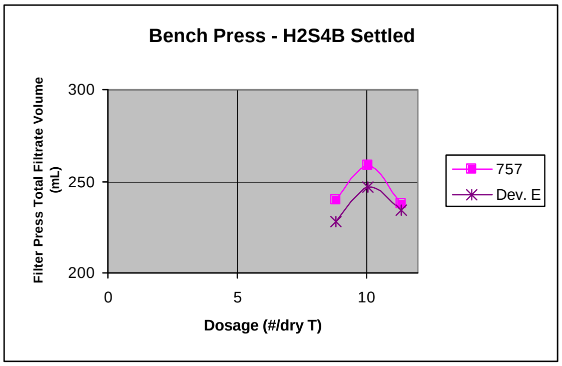


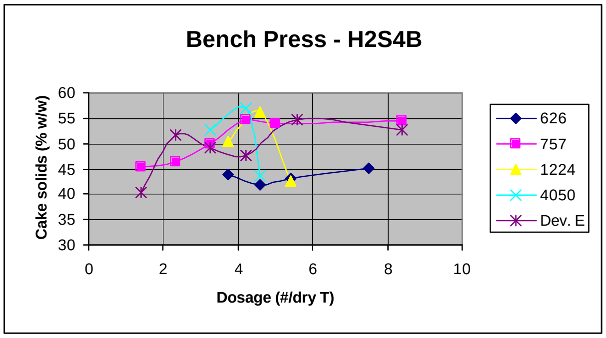












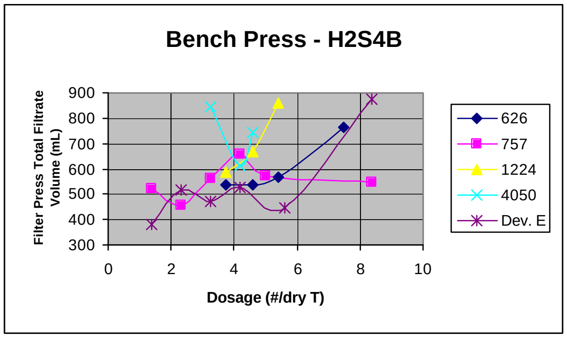


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Exhibit G.3.6 - Bench and Pilot Filter Press Results

Scale	Test ID	Slurry ID	Matrix	Feed %Solids	Polymer ID	Polymer Dose (ppm)	Polymer (lb/dryT)	Cake %Solids	Total Press Time (min)	Pressure (psi)	Cake Quality
1	BFP-9	H1S3 Set. Solids	S3	23.07	1198	400	2.98	59.38	45	100	Fair
1	BFP-10	H1S3 Set. Solids	S3	23.07	1198	500	3.73	60.03	60	100	Good
1	BFP-11	H1S3 Set. Solids	S3	23.07	1198	600	4.47	59.12	60	100	Good
1	BFP-12	H1S3 Set. Solids	S3	23.07	Dev. E	400	2.98	60.73	60	100	Good
1	BFP-13	H1S3 Set. Solids	S3	23.07	Dev. E	500	3.73	59.72	60	100	Very good, no blinding
1	BFP-14	H1S3 Set. Solids	S3	23.07	Dev. E	600	4.47	59.16	60	100	good, no blinding
1	BFP-15	H1S3 Set. Solids	S3	23.07	626	400	2.98	62.08	60	100	Very good
1	BFP-16	H1S3 Set. Solids	S3	23.07	626	500	3.73	60.11	60	100	Good, no blinding
1	BFP-17	H1S3 Set. Solids	S3	23.07	626	600	4.47	60.21	60	100	fair
1	BFP-18	H1S3 Set. Solids	S3	23.07	757	400	2.98	61.24	60	100	very good, no blinding
1	BFP-19	H1S3 Set. Solids	S3	23.07	757	500	3.73	60.87	60	100	very good, no blinding
1	BFP-20	H1S3 Set. Solids	S3	23.07	757	600	4.47	59.79	60	100	good, no blinding
1	BFP-21	H1S4B-01	S4	24.97	Dev. E	700	4.76	57.59	60	100	good, no blinding
1	BFP-22	H1S4B-02	S4	24.97	Dev. E	800	5.44	58.84	60	100	very good, very slight blinding
1	BFP-23	H1S4B-03	S4	24.97	Dev. E	900	6.12	57.4	60	100	very good, very slight blinding
1	BFP-24	H1S4B-02	S4	25.29	1224	700	4.69	57.57	60	100	good, no blinding
1	BFP-25	H1S4B-02	S4	25.29	1224	800	5.36	56.94	60	100	good, slight blinding
1	BFP-26	H1S4B-02	S4	25.29	1224	900	6.03	57.94	60	100	very good, no blinding
1	BFP-27	H1S4B-02	S4	25.29	626	700	4.69	58.23	60	100	very good, very slight blinding
1	BFP-28	H1S4B-02	S4	25.29	626	800	5.36	57.95	60	100	very good, slight blinding
1	BFP-29	H1S4B-02	S4	25.29	626	900	6.03	56.91	60	100	good, no blinding
1	BFP-30	H1S4B-02	S4	25.29	757	700	4.69	58.27	60	100	very good, very slight blinding
1	BFP-31	H1S4B-02	S4	25.29	757	800	5.36	56.74	60	100	very good, very slight blinding
1	BFP-32	H1S4B-02	S4	25.29	757	900	6.03	57.05	60	100	very good, very slight blinding
1	BFP-33	H1S4B-02	S4	25.29	624	800	5.36	58.26	60	100	OK, stained, no blinding
1	BFP-34	H1S4B-02	S4	25.29	4050	600	4.02	58.67	60	100	very good, no blinding
1	BFP-35	H1S4B-02	S4	25.29	4050	700	4.69	58.08	60	100	very good, no blinding
1	BFP-36	H1S4B-02	S4	25.29	4050	800	5.36	57.59	60	100	very good, slight blinding
1	BFP-37	H1S3-04	S3	13.42	Dev. E	300	4.11	54.06	60	100	fair, OK - slight blinding
1	BFP-38	H1S3-04	S3	13.42	Dev. E	400	5.48	64.56	60	100	very good, very slight blinding
1	BFP-39	H1S3-04	S3	13.42	Dev. E	500	6.85	61.25	60	100	very good, very slight blinding
1	BFP-40	H1S3-04	S3	13.42	1224	300	4.11	59.13	60	100	good, slight blinding in lower half
1	BFP-41	H1S3-04	S3	13.42	1224	400	5.48	63.11	60	100	good, very slight blinding
1	BFP-42	H1S3-04	S3	13.42	1224	500	6.85	64.23	60	100	very good, no blinding
1	BFP-43	H1S3-04	S3	13.42	624	300	4.11	59.27	60	100	very good, slight blinding
1	BFP-44	H1S3-04	S3	13.42	624	400	5.48	45.05	60	100	OK, slight blinding on bottom half
1	BFP-45	H1S3-04	S3	13.42	624	500	6.85	60.18	60	100	excellent, no blinding
1	BFP-46	H1S3-04	S3	13.42	757	300	4.11	67.45	60	100	very good, slight blinding
1	BFP-47	H1S3-04	S3	13.42	757	400	5.48	68.69	60	100	good, slight sticking, slight blinding
1	BFP-48	H1S3-04	S3	13.42	757	500	6.85	61.96	60	100	very good, slight blinding
1	BFP-49	H1S3-04	S3	13.42	4275	300	4.11	69.64	60	100	good, some sticking, slight blinding
1	BFP-50	H1S3-04	S3	13.42	4275	400	5.48	68	60	100	very good, no blinding
1	BFP-51	H1S3-04	S3	13.42	4275	500	6.85	68.73	60	100	good, just slight blinding on bottom
1	BFP-52	H1S1-08	S1	4.09	1224	60	2.86	67.89	60	100	very good, 30% blinded
1	BFP-53	H1S1-08	S1	4.09	1224	80	3.81	64.8	60	100	good release, 50% blinded
1	BFP-54	H1S1-08	S1	4.09	1224	100	4.77	65.97	60	100	good, 30% blinded
1	BFP-55	H1S1-08	S1	4.09	757	60	2.86	67.92	60	100	good, moderate blinding
1	BFP-56	H1S1-08	S1	4.09	757	80	3.81	65.06	60	100	good, 40% blinding
1	BFP-57	H1S1-08	S1	4.09	757	100	4.77	64.5	60	100	very good, 40% blinding
1	BFP-58	H1S1-08	S1	4.09	Dev. E	60	2.86	64.92	60	100	good, 30% blinding
1	BFP-59	H1S1-09	S1	4.64	Dev. E	80	3.35	62.9	60	100	good, blinding
1	BFP-60	H1S1-10	S1	4.83	Dev. E	100	4.02	62.31	60	100	good, some blinding
1	BFP-61	H1S1-10	S1	4.83	626	60	2.41	66.98	60	100	very good, very slight blinding
1	BFP-62	H1S1-10	S1	4.83	626	80	3.22	66.83	60	100	good, some blinding
1	BFP-63	H1S1-10	S1	4.83	626	100	4.02	64.09	60	100	good, slight blinding
1	BFP-64	H1S1-10	S1	4.83	4050	60	2.41	65.96	60	100	good, slight blinding
1	BFP-65	H1S1-10	S1	4.83	4050	80	3.22	65.96	60	100	good, very slight blinding
1	BFP-66	H1S1-10	S1	4.83	4050	100	4.02	66.77	60	100	good, very slight blinding
1	BFP-67	H1S2-05	S2	8.46	624	300	6.73	37.92	60	100	good, some blinding
1	BFP-68	H1S2-05	S2	8.46	627	300	6.73	47.57	60	100	good, slight blinding
1	BFP-69	H1S2-05	S2	8.46	Dev. E	300	6.73	46.74	60	100	good, some blinding
1	BFP-70	H1S2-05	S2	8.46	1224	300	6.73	55.33	60	100	very good
1	BFP-71	H1S2-05	S2	8.46	757	300	6.73	57.64	60	100	very good, no blinding
1	BFP-72	H1S2-05	S2	8.46	4050	300	6.73	58.45	60	100	very good, no blinding
1	BFP-73	H1S2-05	S2	8.46	1198	300	6.73	57.2	60	100	very good, no blinding
1	BFP-74	H1S2-06	S2	8.38	627 EX	300	6.80	60.4	60	100	very good, very slight blinding
1	BFP-75	H1S2-06	S2	8.38	626	300	6.80	52.88	60	100	very good, no blinding
1	BFP-76	H1S2-06	S2	8.38	758	300	6.80	50.91	60	100	good, slight blinding
1	BFP-77	H1S3-06	S3	12.97	644	6000	85.25	64.29	60	100	firm
1	BFP-78	H1S3-06	S3	12.97	644+4884	,000 of each		62.98	50	100	Fair, somewhat soft

General Electric Company
Hudson River PCBs Superfund Site
Phase 1 Intermediate Design Report

Exhibit G.3.6 - Bench and Pilot Filter Press Results

Scale	Test ID	Slurry ID	Matrix	Feed %Solids	Polymer ID	Polymer Dose (ppm)	Polymer (lb/dryT)	Cake %Solids	Total Press Time (min)	Pressure (psi)	Cake Quality
1	BFP-79	H1S3-06	S3	12.97	Dev. E	400	5.68	70.44	60	100	good, soft top
1	BFP-79 Dup	H1S3-06	S3	12.97	Dev. E	400	5.68	72.82, 71.68	60	100	v. good, v. sl. soft top, sandy
1	BFP-80	H1S3-06	S3	12.97	Dev. E	400	5.68	72.75	60	100	v. good/excellent
1	BFP-81	H1S3-06	S3	12.97	Dev. E	400	5.68	72.73	60	100	good, very sandy, not esp. solid in all spots
1	BFP-82	H1S3-06	S3	12.97	Dev. E	400	5.68	69.16	60	100	v. good,
1	BFP-83	H1S3-06	S3	12.97	Dev. E	400	5.68	67.06	60	100	excellent
1	BFP-84	H1S3-06	S3	12.97	Dev. E	400	5.68	71.46	60	125	excellent
1	BFP-85	H1S2-07	S2	8.53	757	300	6.67	55.6	60	100	good, small soft spot on top
1	BFP-86	H1S2-07	S2	8.53	757	300	6.67	57.26	60	100	v. good, sl. soft top
1	BFP-87	H1S2-07	S2	8.53	757	300	6.67	54.7	60	100	good, small soft spot on top
1	BFP-88	H1S2-07	S2	8.53	757	300	6.67	59.24	60	100	very good, v.sl. Soft top
1	BFP-89	H1S2-07	S2	8.53	Dev. E	300	6.67	NA - incomplete cake	60	125	Poor, incomplete
1	BFP-90	H1S2-07	S2	8.53	757	300	6.67	58.94	60	125	good, sl. soft top
1	BFP-91	H1S2-08	S2	7.98	757	300	7.16	54.63	60	225	good, soft at top otherwise v. solid
1	BFP-92	H1S2-08	S2	7.98	Dev. E	300	7.16	48.29	60	225	fair, soft top
1	BFP-93	H1S2-08	S2	7.98	Dev. E	500	11.93	57.69	60	100	v. good, some blinding
1	BFP-94	H1S2-08	S2	7.98	757	300	7.16	49.19	60	100	good, no blinding
1	BFP-95	H1S2-08	S2	7.98	757	300	7.16	42.35	60	100	good, some blinding (~40%)
1	BFP-96	H1S2-08	S2	7.98	757	300	7.16	43	60	100	good, some blinding (~40%)
1	BFP-97	H1S2-08	S2	7.98	Dev. E	500	11.93	55.67	60	100	very good, some blinding
1	BFP-98	H1S2-08	S2	7.98	Dev. E	500	11.93	52.25	60	100	good, some blinding (same as BFP-9
1	BFP-99	H1S2-08	S2	7.98	Dev. E	500	11.93	51.8	60	100	good, some blinding (same as BFP-97,98)
1	BFP-100	H2S2 Settled Solids	S2	3.22	4050	20	1.22	49.16	60	100	good, no blinding
1	BFP-101	H2S2 Settled Solids	S2	3.22	4050	50	3.04	55.95	60	100	good, no blinding
1	BFP-102	H2S2 Settled Solids	S2	3.22	4050	80	4.87	55.75	60	100	good, no blinding, slight sticking
1	BFP-103	H2S2 Settled Solids	S2	3.22	757	20	1.22	46.9	60	100	good, no blinding
1	BFP-104	H2S2 Settled Solids	S2	3.22	757	50	3.04	55.35	60	100	good, no blinding
1	BFP-105	H2S2 Settled Solids	S2	3.22	757	80	4.87	54.13	60	100	good, very slight sticking, no blinding
1	BFP-106	H2S2 Settled Solids	S2	3.22	626	20	1.22	44.61	60	100	good, very slight blinding
1	BFP-107	H2S2 Settled Solids	S2	3.22	Dev. E	20	1.22	54.25	60	100	good, no blinding
1	BFP-108	H2S2 Settled Solids	S2	3.22	Dev. E	50	3.04	54.36	60	100	good, no blinding
1	BFP-109	H2S2 Settled Solids	S2	3.22	Dev. E	80	4.87	59.11	60	100	slight sticking, no blinding
1	BFP-111	H2S3 Settled Solids	S3	3.94	Dev. E	70	3.47	53.38	60	100	good, no blinding
1	BFP-110	H2S3 Settled Solids	S3	3.94	Dev. E	100	4.95	65.77	60	100	very good, no blinding
1	BFP-112	H2S3 Settled Solids	S3	3.94	Dev. E	130	6.44	59.35	60	100	very good, no blinding
1	BFP-113	H2S3 Settled Solids	S3	3.94	757	20	0.99	56.52	60	100	good, no blinding
1	BFP-114	H2S3 Settled Solids	S3	3.94	757	50	2.48	56.3	60	100	good, no blinding
1	BFP-115	H2S3 Settled Solids	S3	3.94	757	80	3.96	54.42	60	100	good, no blinding
1	BFP-116	H2S4B Settled Solids	S4	15.87	Dev. E	700	7.97	54.16	60	100	slight sticking, no blinding
1	BFP-117	H2S4B Settled Solids	S4	15.87	Dev. E	800	9.11	54.96	60	100	very good, no blinding
1	BFP-118	H2S4B Settled Solids	S4	15.87	Dev. E	900	10.25	53.82	60	100	good, very slight sticking, no blinding
1	BFP-119	H2S4B Settled Solids	S4	15.87	757	700	7.97	53.4	60	100	very good, no blinding
1	BFP-120	H2S4B Settled Solids	S4	15.87	757	800	9.11	54.22	60	100	very good, no blinding
1	BFP-121	H2S4B Settled Solids	S4	15.87	757	900	10.25	54.02	60	100	good release, no blinding
1	BFP-122	H2S4B-05	S4	4.29	Dev. E	30	1.36	40.41	60	100	very good release, no blinding
1	BFP-123	H2S4B-05	S4	4.29	Dev. E	50	2.27	51.63	60	100	very good, slight blinding
1	BFP-124	H2S4B-05	S4	4.29	Dev. E	70	3.18	49.12	60	100	very good release, no blinding
1	BFP-125	H2S4B-05	S4	4.29	Dev. E	90	4.09	47.58	60	100	very good release, no blinding
1	BFP-133	H2S4B-05	S4	4.29	Dev. E	120	5.45	54.59	60	100	very good, no blinding
1	BFP-130	H2S4B-05	S4	4.29	Dev. E	180	8.17	52.75	60	100	good release, no blinding
1	BFP-126	H2S4B-05	S4	4.29	757	30	1.36	45.4	60	100	good release, no blinding
1	BFP-127	H2S4B-05	S4	4.29	757	50	2.27	46.29	60	100	very good release, very slight blinding
1	BFP-128	H2S4B-05	S4	4.29	757	70	3.18	49.99	60	100	very good release, very slight blinding
1	BFP-129	H2S4B-05	S4	4.29	757	90	4.09	54.59	60	100	good release, no blinding
1	BFP-135	H2S4B-07	S4	4.81	757	120	4.84	54.01	60	100	very good, no blinding
1	BFP-131	H2S4B-05	S4	4.29	757	180	8.17	54.43	60	100	very good, no blinding
1	BFP-134	H2S4B-05	S4	4.29	4050	70	3.18	52.72	60	100	very good, very slight sticking
1	BFP-132	H2S4B-05	S4	4.29	4050	90	4.09	56.93	60	100	good release, no blinding
1	BFP-136	H2S4B-07	S4	4.81	4050	110	4.44	43.51	60	100	poor, stuck, no blinding
1	BFP-137	H2S4B-07	S4	4.81	1224	90	3.63	50.34	60	100	very good, very slight blinding
1	BFP-138	H2S4B-07	S4	4.81	1224	110	4.44	56.11	60	100	very good, very slight blinding
1	BFP-142	H2S4B-07	S4	4.81	1224	130	5.25	42.57	60	100	fair, sticking
1	BFP-139	H2S4B-07	S4	4.81	626	90	3.63	43.87	60	100	very good, no blinding
1	BFP-140	H2S4B-07	S4	4.81	626	110	4.44	41.95	60	100	good release, very slightly blinded
1	BFP-141	H2S4B-07	S4	4.81	626	130	5.25	42.99	60	100	very good, no blind
1	BFP-143	H2S4B-07	S4	4.81	626	180	7.27	45.02	60	100	very good, no blind

Exhibit G.3.6 - Bench and Pilot Filter Press Results

Scale	Test ID	Slurry ID	Matrix	Feed %Solids	Polymer ID	Polymer Dose (ppm)	Polymer (lb/dryT)	Cake %Solids	Total Press Time (min)	Pressure (psi)	Cake Quality
1	BFP-144	H2S4B-07	S4	4.81	Dev. E	120	4.84	45.27	45	100	very good, no blinding
1	BFP-145	H2S4B-07	S4	4.81	Dev. E	120	4.84	55.95	90	100	good, very slight sticking, no blind
1	BFP-146	H2S4B-07	S4	4.81	Dev. E	120	4.84	45.59	60	100	fair, soft top and center
1	BFP-147	H2S4B-07	S4	4.81	Dev. E	120	4.84	58.07	60	100	very good, no blind
1	BFP-148	S4-HC-10-OF	S4	4.011	Dev. E	100	4.87	n/a	60	100	good, no blinding
1	BFP-149	S4-HC-10-OF	S4	4.011	Dev. E	130	6.32	n/a	60	100	good, no blinding
1	BFP-150	S4-HC-10-OF	S4	4.011	Dev. E	220	10.70	36.61	60	100	v. good, no blinding
1	BFP-151	S4-HC-10-OF	S4	4.011	Dev. E	280	13.62	37.41	60	100	v. good, no blinding
1	BFP-152	S4-HC-10-OF	S4	4.011	Dev. E	380	18.49	48.69	60	100	v. good, no blind
1	BFP-153	S4-HC-10-OF	S4	4.011	Dev. E	450	21.89	50.26	60	100	v. good, no blinding
1	BFP-154	S4-HC-10-OF	S4	4.011	Dev. E	480	23.35	54.39	60	100	v. good, no blinding
1	BFP-155	S4-HC-10-OF	S4	4.011	Dev. E	550	26.76	54.38	60	100	v. good, no blinding
1	BFP-156	S4-HC-15-OF	S4	6.31	Dev. E	400	12.19	35	60	100	v. good, no blinding
1	BFP-157	S4-HC-15-OF	S4	6.31	Dev. E	500	15.24	40.5	60	100	v. good, no blinding
1	BFP-158	S4-HC-15-OF	S4	6.31	Dev. E	600	18.29	46.36	60	100	v. good, no blinding
1	BFP-159	S4-HC-15-OF	S4	6.31	Dev. E	700	21.34	46.02	60	100	v. good, no blinding
1	BFP-160	S4-HC-15-OF	S4	6.31	Dev. E	800	24.39	47.65	60	100	v. good, no blinding
1	BFP-161	S4-HC-15-OF	S4	6.31	Dev. E	900	27.43	50.19	60	100	v. good, no blinding
1	BFP-162	S4-HC-10-OF	S4	4.01	757	480	23.36	52.92	60	100	v. good, no blind
1	BFP-163	S4-HC-15-OF	S4	6.31	757	800	24.39	50.91	60	100	v. good, no blinding
1	BFP-164	H1S4A-01	S4	9.03	Dev. E	500	10.47	57.94	60	100	v. good, no blinding
1	BFP-165	H1S4A-01	S4	9.03	Dev. E	600	12.56	57.19	60	100	v. good, no blinding
1	BFP-166	H1S4A-01	S4	9.03	Dev. E	400	8.37	58.95	60	100	v. good, no sticking or blinding
1	BFP-167	H1S4A-01	S4	9.03	Dev. E	300	6.28	55.79	60	100	v. good, no sticking or blinding
1	BFP OF SS 01	S2-2-HC-15-2 OF SS	S2	10.94	Dev. E	100	1.71	NA	60	125	Incomplete
1	BFP OF SS 02	S2-2-HC-15-2 OF SS	S2	10.94	Dev. E	300	5.12	35.42	60	125	Poor
1	BFP OF SS 03	S2-2-HC-15-2 OF SS	S2	10.94	Dev. E	500	8.53	38.42	60	125	Poor
1	BFP OF SS 08	S2-2-HC-15-2 OF SS	S2	10.94	Dev. E	900	15.36	38.33	60	125	Poor
1	BFP OF SS 11	S2-2-HC-15-2 OF SS	S2	10.94	Dev. E	1500	25.60	47.47	60	125	Good
1	BFP OF SS 12	S2-2-HC-15-2 OF SS	S2	10.94	Dev. E	900	15.36	48.14	120	125	Good
1	BFP OF SS 04	S3-4-HC-15-1 OF SS	S3	14.45	Dev. E	1000	12.63	46.89	60	125	OK
1	BFP OF SS 05	S3-4-HC-15-1 OF SS	S3	14.45	Dev. E	1400	17.68	52.8	60	125	Very good
1	BFP OF SS 09	S3-4-HC-15-1 OF SS	S3	14.45	Dev. E	2000	25.26	52.65	60	125	Excellent
1	BFP OF SS 13	S3-4-HC-15-1 OF SS	S3	14.45	Dev. E	1000	12.63	54.59	120	125	Very Good
1	BFP OF SS 06	S3-4-HC-25-2 OF SS	S3	21.15	Dev. E	1400	11.54	46.33	60	125	Poor
1	BFP OF SS 07	S3-4-HC-25-2 OF SS	S3	21.15	Dev. E	1800	14.84	47.66	60	125	Poor
1	BFP OF SS 10	S3-4-HC-25-2 OF SS	S3	21.15	Dev. E	2500	20.61	51.97	60	125	Good
1	BFP OF SS 14	S3-4-HC-25-2 OF SS	S3	21.15	Dev. E	1800	14.84	54.39	120	125	Fair
2	PFP-1	H1S3-07	S3	14.62	Dev. E	600	7.48	65.75	60	100	Excellent, hard, solid cake.
2	PFP-2	H1S3-07	S3	14.62	Dev. E	600	7.48	61.23	30	100	Very good, less solid towards center
2	PFP-3	H1S3-07	S3	14.62	Dev. E	600	7.48	64.23	45	100	Excellent, hard, solids cake.
2	PFP-4	H1S2-09	S2	10.11	Dev. E	500	9.28	58.59	90	100	Excellent cake
2	PFP-5	H1S3-07	S3	14.62	Dev. E	600	7.48	62.18	45	100	solid
2	PFP-6	H1S2-09	S2	10.11	Dev. E	500	9.28		Terminated at 26:30 (insufficient feed)	100	N/A
2	PFP-7	H1S3-08	S3	12.33	Dev. E	600	9.00	62.76	45	100	solid
2	PFP-8	H1S2-10	S2	8.31	Dev. E	500	11.43	58.11	60	100	very good, slightly soft center
2	PFP-9	H1S3-08	S3	12.33	Dev. E	600	9.00	59.91	45	100	excellent, firm throughout
2	PFP-10	H1S2-10	S2	8.31	Dev. E	500	11.43		Terminated at 45 min (insufficient	100	N/A incomplete cake
2	PFP-11	H1S3-09	S3	9.88	Dev. E	600	11.42	67.16	45	100	excellent
2	PFP-12	H1S2-11	S2	8.94	Dev. E	500	10.58	61.22	90	100	excellent cake, firm
2	PFP-13	H1S2-11	S2	8.94	Dev. E	500	10.58	63.95	75	100	excellent
2	PFP-14	H1S3-09	S3	9.88	Dev. E	600	11.42	63.73	45	100	excellent
2	PFP-15	H1S3-09	S3	9.88	Dev. E	600	11.42	67.37	45	100	excellent
2	PFP-16	H1S2-12	S2	12.07	Dev. E	500	7.68	62.06	75	100	excellent
2	PFP-17	H1S3-11	S3	14.25	Dev. E	600	7.69	65.29	45	100	very good, slightly soft on top
2	PFP-18	H1S3-11	S3	14.25	Dev. E	600	7.69	63.61	45	100	excellent
2	PFP-19	H1S3-13	S3	14.5	Dev. E	600	7.55	67.8	45	100	excellent
2	PFP-20	H1S3-13	S3	14.5	Dev. E	600	7.55	65.09	45	100	excellent
2	PFP-21	H1S3-13	S3	14.5	Dev. E	600	7.55	63.07	45	100	excellent
2	PFP-22	H1S1-10	S1	3.15	Dev. E	60	3.74		120	100	incomplete
2	PFP-23	H1S1-11	S1	3.08	Dev. E	60	3.82		120	100	poor
2	PFP-24	H2S4B-03	S4	5.2	Dev. E	75	2.79		75	100	incomplete
2	PFP-25	H1S1-12	S1	2.56	Dev. E	60	4.61		150	100	incomplete
2	PFP-26	H2S4B-03	S4	3.62	Dev. E	75	4.05		60	100	incomplete
2	PFP-27	H2S4B-03	S4		Dev. E	75		39.1	180	100	fair, soft, incomplete top
2	PFP-28	H1S1-12	S1	2.56	Dev. E	60	4.61	68.6	300	100	fair, soft, incomplete top
2	PFP-29	H1S4B-05	S4	24.88	Dev. E	800	5.46	53.3	30	100	fair/good

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Exhibit G.3.6 - Bench and Pilot Filter Press Results

Scale	Test ID	Slurry ID	Matrix	Feed %Solids	Polymer ID	Polymer Dose (ppm)	Polymer (lb/dryT)	Cake %Solids	Total Press Time (min)	Pressure (psi)	Cake Quality
2	PFP-30	H1S1-14	S1	3.46	Dev. E	60	3.40	60.7	126	100	incomplete, soft/wet tops
2	PFP-31	H1S4B-05	S4	24.88	Dev. E	800	5.46	52.72	30	100	fair/good
2	PFP-32	H1S4B-06	S4	24.1	Dev. E	800	5.67	58.56	60	100	very good, excellent
2	PFP-33	H1S1-15	S1	5.23	Dev. E	60	2.22	65.38	105	100	incomplete, soft/wet top
2	PFP-34	H1S4B-06	S4	24.1	Dev. E	800	5.67	58.33	45	100	excellent
2	PFP-35	H1S4B-06	S4	24.1	Dev. E	800	5.67	59.74	60	100	excellent
2	PFP-36	H1S4B-06	S4	24.1	Dev. E	800	5.67	59.62	60	100	excellent
2	PFP-37	H1S1-16	S1	2.86	Dev. E	60	4.12		120	100	incomplete
2	PFP-38	H1S4B-06	S4	24.1	Dev. E	800	5.67	59.35	60	100	excellent
2	PFP-39	H2S4B-06	S4	4.35	Dev. E	75	3.36	42.42	240	100	Fair
2	PFP-40	H2S4B-06	S4	4.35	Dev. E	75	3.36	51.45	180	100	good, soft, slightly wet top
2	PFP-41	H2S4B-08	S4	4.92	Dev. E	120	4.73	45.02	150	100	good, soft top
2	PFP-42	H2S4B-08	S4	4.92	Dev. E	120	4.73	48.28	180	100	good/fair, soft top
2	PFP-43	H2S4B-08	S4	4.92	Dev. E	120	4.73		130	100	poor, N/A, incomplete
2	PFP-44	H1S3-15	S3	13.48	Dev. E	600	8.17	62	60	100	excellent, dry
2	PFP-45	H1S2-13	S2	11.87	Dev. E	500	7.82	57.02	75	100	excellent
2	PFP-46	H1S3-15	S3	13.48	Dev. E	600	8.17	58.9	60	100	excellent, dry
2	PFP-47	H1S2-13	S2	11.87	Dev. E	500	7.82	59.24	75	100	excellent
2	PFP-48	H1S3-16	S3	15.89	Dev. E	600	6.82	68.14	55 min - terminated / equipment	100	excellent, dry, solid
2	PFP-49	H1S3-16	S3	15.89	Dev. E	600	6.82	66.55	45	100	excellent, solid
2	PFP-50	H1S3-16	S3	15.89	Dev. E	600	6.82	68.35	45	100	excellent
2	PFP-51	H1S2-14	S2	7.23	Dev. E	500	13.22	55.08	60	100	very good / excellent
2	PFP-52	H1S4B-07	S4	23.83	Dev. E	800	5.74	59.32	45	100	excellent
2	PFP-53	H1S4B-07	S4	23.83	Dev. E	800	5.74	59.08	45	100	excellent
2	PFP-54	H1S4B-07	S4	23.83	Dev. E	800	5.74	58.02	45	100	excellent
2	PFP-55	H1S4B-07	S4	23.83	Dev. E	800	5.74	57.35	45	100	excellent
2	PFP-56	H1S3-17	S3	18.04	Dev. E	600	5.92	69.14	60	100	excellent, crumbly
2	PFP-57	H1S4-03	S4	16.57	Dev. E	500	5.43	63.6	60	100	excellent, dry, sandy
2	PFP-58	H2S4B-08	S4	4.22	Dev. E	120	5.54	53.18	120	100	good, soft top and center
2	PFP-59	H1S4-03	S4	11.81	Dev. E	500	7.86	62.88	60	100	excellent
2	PFP-60	H1S4B-09	S4	23.94	Dev. E	800	5.71	60.56	45	100	excellent
2	PFP-61	H2S4B-08	S4	4.22	Dev. E	120	5.54		19	100	N/A
2	PFP-62	H1S4B-09	S4	23.94	Dev. E	800	5.71	57.69	45	100	excellent

Notes:
Scale "1" = Bench (Hockey pucks)
Scale "2" = Plate & Frame pilot
2.54 = Solids SpG.

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Exhibit G.3.7a - Plate and Frame Filter Press Summary

Slurry ID	Test Number	Feed Solids (%)	Polymer Type	Polymer Dosage (ppm)	Press Time (Minutes)	Polymer Dosage (lb/dry T)	Cake Solids (%)
Plate and Filter Press Summary							
H1S1-12	PFP-28	2.56	Dev E	60	300	4.94	***68.60***
H1S1-14	PFP-30	3.46	Dev E	60	126	3.63	60.70
H1S1-15	PFP-33	5.23	Dev E	60	105	2.38	65.38
					H1S1 Avg.	**3.65**	**64.89**
H1S2-09	PFP-4	10.11	Dev E	500	90	9.93	58.59
H1S2-10	PFP-8	8.31	Dev E	500	60	12.23	58.11
H1S2-11	PFP-12	8.94	Dev E	500	90	11.32	61.22
H1S2-11	PFP-13	8.94	Dev E	500	75	11.32	***63.95***
H1S2-12	PFP-16	12.07	Dev E	500	75	8.22	62.06
H1S2-13	PFP-45	11.87	Dev E	500	75	8.37	57.02
H1S2-13	PFP-47	11.87	Dev E	500	75	8.37	59.24
H1S2-14	PFP-51	7.23	Dev E	500	60	14.15	55.08
					H1S2 Avg.	**10.49**	**59.41**
H1S3-07	PFP-1	14.62	Dev E	600	60	8.00	65.75
H1S3-07	PPF-2	14.62	Dev E	600	30	8.00	61.23
H1S3-07	PFP-3	14.62	Dev E	600	45	8.00	64.23
H1S3-07	PFP-5	14.62	Dev E	600	45	8.00	62.18
H1S3-08	PFP-7	12.33	Dev E	600	45	9.64	62.76
H1S3-08	PFP-9	12.33	Dev E	600	45	9.64	59.91
H1S3-09	PFP-11	9.88	Dev E	600	45	12.22	67.16
H1S3-09	PFP-14	9.88	Dev E	600	45	12.22	63.73
H1S3-09	PFP-15	9.88	Dev E	600	45	12.22	67.37
H1S3-11	PFP-17	14.25	Dev E	600	45	8.23	65.29
H1S3-11	PFP-18	14.25	Dev E	600	45	8.23	63.61
H1S3-13	PFP-19	14.50	Dev E	600	45	8.08	67.80
H1S3-13	PFP-21	14.50	Dev E	600	45	8.08	63.07
H1S3-13	PFP-20	14.50	Dev E	600	45	8.08	65.09
H1S3-15	PFP-44	13.48	Dev E	600	60	8.75	62.00
H1S3-15	PFP-46	13.48	Dev E	600	60	8.75	58.90
H1S3-16	PFP-48	15.89	Dev E	600	55	7.30	68.14
H1S3-16	PFP-49	15.89	Dev E	600	45	7.30	66.55
H1S3-16	PFP-50	15.89	Dev E	600	45	7.30	68.35
H1S3-17	PFP-56	18.04	Dev E	600	60	6.34	***69.14***
					H1S3 Avg.	**8.72**	**64.61**
H1S4-03	PFP-57	16.57	Dev E	500	60	5.81	***63.60***
H1S4-03	PFP-59	11.81	Dev E	500	60	8.41	62.88
					H1S4 Avg.	**7.11**	**63.24**

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Exhibit G.3.7a - Plate and Frame Filter Press Summary

Slurry ID	Test Number	Feed Solids (%)	Polymer Type	Polymer Dosage (ppm)	Press Time (Minutes)	Polymer Dosage (lb/dry T)	Cake Solids (%)
Plate and Filter Press Summary (Cont'd)							
H1S4B-05	PFP-29	24.88	Dev E	800	30	5.84	53.30
H1S4B-05	PFP-31	24.88	Dev E	800	30	5.84	52.72
H1S4B-06	PFP-32	24.10	Dev E	800	60	6.07	58.56
H1S4B-06	PFP-34	24.10	Dev E	800	45	6.07	58.33
H1S4B-06	PFP-35	24.10	Dev E	800	60	6.07	59.74
H1S4B-06	PFP-36	24.10	Dev E	800	60	6.07	59.62
H1S4B-06	PFP-38	24.10	Dev E	800	60	6.07	59.35
H1S4B-07	PFP-52	23.83	Dev E	800	45	6.15	59.32
H1S4B-07	PFP-53	23.83	Dev E	800	45	6.15	59.08
H1S4B-07	PFP-54	23.83	Dev E	800	45	6.15	58.02
H1S4B-07	PFP-55	23.83	Dev E	800	45	6.15	57.35
H1S4B-09	PFP-60	23.94	Dev E	800	45	6.11	***60.56***
H1S4B-09	PFP-62	23.94	Dev E	800	45	6.11	57.69
					H1S4B Avg.	**6.06**	**57.97**
H2S4B-03	PFP-27	3.62	Dev E	75	180	4.34	39.10
H2S4B-06	PFP-39	4.35	Dev E	75	240	3.59	42.42
H2S4B-06	PFP-40	4.35	Dev E	75	180	3.59	51.45
H2S4B-08	PFP-41	4.92	Dev E	120	150	5.06	45.02
H2S4B-08	PFP-42	4.92	Dev E	120	180	5.06	48.28
H2S4B-08	PFP-58	4.22	Dev E	120	120	5.93	***53.18***
					H2S4B Avg.	**4.60**	**46.58**
H1S4A-09	PFP-63	14.12	Dev E	600	60	8.31	69.33
H1S4A-03	PFP-64	12.15	Dev E	600	45	9.79	64.32
H1S4A-03	PFP-65	12.15	Dev E	600	60	9.79	66.52
H1S4A-05	PFP-67	16.30	Dev E	600	45	7.10	77.15
H1S4A-04	PFP-68	15.48	Dev E	600	60	7.52	69.71
H1S4A-05	PFP-69	16.30	Dev E	600	60	7.10	76.84
H1S4A-04	PFP-70	15.48	Dev E	600	60	7.52	70.90
H1S4A-05	PFP-71	16.30	Dev E	600	60	7.10	***78.69***
H1S4A-04	PFP-72	15.48	Dev E	600	60	7.52	76.15
H1S4A-05	PFP-73	16.30	Dev E	600	60	7.10	73.47
H1S4A-04	PFP-74	15.48	Dev E	600	60	7.52	76.96
H1S4A-05	PFP-75	16.30	Dev E	600	60	7.10	74.57
H1S4A-04	PFP-76	15.48	Dev E	600	30	7.52	77.56
H1S4A-06	PFP-77	18.31	Dev E	600	60	6.23	77.34
H1S4A-06	PFP-78	18.31	Dev E	600	60	6.23	74.47
H1S4A-06	PFP-79	18.31	Dev E	600	60	6.23	75.37
H1S4A-06	PFP-80	18.31	Dev E	600	60	6.23	69.88
					H1S4A Avg.	**7.41**	**73.48**
					OVERALL AVG.	**7.47**	**63.35**

Notes:

2.54 =SpG (gm/mL) solids

1.07 =SpG (gm/mL) polymer

1. Dev E is Developmental E polymer from GE Water.

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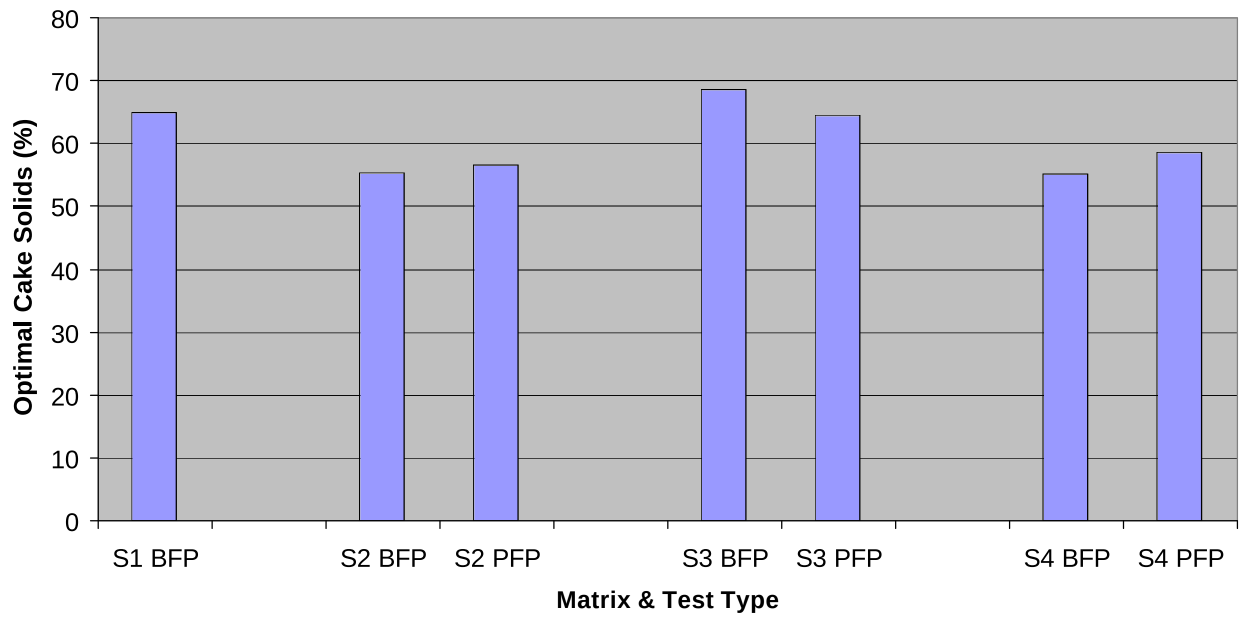
Exhibit G.3.7b - Comparison of Bench-Scale and Pilot-Scale Filter Press Optimal Results

Scale	Test ID	Matrix	Feed %Solids	Polymer ID	Polymer (lb/dryT)	Cake %Solids	Cake PFP/BFP
1	BFP	S1 BFP	4.1	Dev. E	2.9	64.9	--
1	BFP	S2 BFP	7.0	Dev. E	11.0	55.3	
2	PFP	S2 PFP	7.8	Dev. E	12.9	56.6	**1.02**
1	BFP	S3 BFP	13.2	Dev. E	5.7	68.5	
2	PFP	S3 PFP	13.8	Dev. E	8.9	64.6	**0.94**
1	BFP	S4 BFP	10.6	Dev. E	6.8	55.1	
2	PFP	S4 PFP	22.6	Dev. E	6.7	58.7	**1.07**



Notes:
Scale "1" = Bench (Hockey pucks)
Scale "2" = Plate & Frame pilot
Data collection includes Dev E polymer, 100 psi, and 30-60 min runs.

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Exhibit G.3.8 - Bench-Scale Filter Press of Hydrocyclone Overflows

Test ID	Slurry ID	Feed % Solids	Polymer	Dose (ppm)	Time / Pressure	w/w Dose (#/dryT)	Cake % Solids	Cake Quality
Filter Press of Hydrocyclone Overflows								
BFP OF SS 01	S2-2-HC-15-2 OF SS	10.94	Dev "E"	100	60 min / 125 psi	1.83	N/A	Incomplete
BFP OF SS 02	S2-2-HC-15-2 OF SS	10.94	Dev "E"	300	60 min / 125 psi	5.48	35.42	Poor
BFP OF SS 03	S2-2-HC-15-2 OF SS	10.94	Dev "E"	500	60 min / 125 psi	9.13	38.42	Poor
BFP OF SS 08	S2-2-HC-15-2 OF SS	10.94	Dev "E"	900	60 min / 125 psi	16.44	38.33	Poor
BFP OF SS 11	S2-2-HC-15-2 OF SS	10.94	Dev "E"	1500	60 min / 125 psi	27.40	47.47	Good
BFP OF SS 12	S2-2-HC-15-2 OF SS	10.94	Dev "E"	900	120 min / 125 psi	16.44	48.14	Good
BFP OF SS 04	S3-4-HC-15-1 OF SS	14.45	Dev "E"	1000	60 min / 125 psi	13.51	46.89	OK
BFP OF SS 05	S3-4-HC-15-1 OF SS	14.45	Dev "E"	1400	60 min / 125 psi	18.92	52.80	Very good
BFP OF SS 09	S3-4-HC-15-1 OF SS	14.45	Dev "E"	2000	60 min / 125 psi	27.02	52.65	Excellent
BFP OF SS 13	S3-4-HC-15-1 OF SS	14.45	Dev "E"	1000	120 min / 125 psi	13.51	54.59	Very Good
BFP OF SS 06	S3-4-HC-25-2 OF SS	21.15	Dev "E"	1400	60 min / 125 psi	12.35	46.33	Poor
BFP OF SS 07	S3-4-HC-25-2 OF SS	21.15	Dev "E"	1800	60 min / 125 psi	15.88	47.66	Poor
BFP OF SS 10	S3-4-HC-25-2 OF SS	21.15	Dev "E"	2500	60 min / 125 psi	22.05	51.97	Good
BFP OF SS 14	S3-4-HC-25-2 OF SS	21.15	Dev "E"	1800	120 min / 125 psi	15.88	54.39	Fair
BFP-148	S4-HC-10-OF	4.011	Dev "E"	100	60	5.21	N/A	N/A
BFP-149	S4-HC-10-OF	4.011	Dev "E"	130	60	6.77	N/A	N/A
BFP-150	S4-HC-10-OF	4.011	Dev "E"	220	60	11.45	36.61	N/A
BFP-151	S4-HC-10-OF	4.011	Dev "E"	280	60	14.58	37.41	N/A
BFP-152	S4-HC-10-OF	4.011	Dev "E"	380	60	19.78	48.69	N/A
BFP-153	S4-HC-10-OF	4.011	Dev "E"	450	60	23.43	50.26	N/A
BFP-154	S4-HC-10-OF	4.011	Dev "E"	480	60	24.99	54.39	N/A
BFP-155	S4-HC-10-OF	4.011	Dev "E"	550	60	28.63	54.38	N/A
BFP-156	S4-HC-15-OF	6.31	Dev "E"	400	60	13.05	35	N/A
BFP-157	S4-HC-15-OF	6.31	Dev "E"	500	60	16.31	40.5	N/A
BFP-158	S4-HC-15-OF	6.31	Dev "E"	600	60	19.57	46.36	N/A
BFP-159	S4-HC-15-OF	6.31	Dev "E"	700	60	22.83	46.02	N/A

Notes:
2.54 =SpG (gm/mL) solids
1.07 =SpG (gm/mL) polymer
1. Dev E is Developmental E polymer from GE Water.

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Exhibit G.3.9 - Cake Release Screening Data

BFP Test #	Slurry ID	Polymer ID	Dosage (ppm)	Filter Cloth	Filter Cloth Porosity	Filter Press			
						Time (min)	Total Filtrate Volume (mL)	% Solids (w/w)	Observations
BFP-80	H1S3-06	Dev E	400	85X	0.5-1 CFM	60	253	72.75	v. good/exc. cake, v. good release, no blinding; no sediment in filtrate, but sl. Cloudy at first, then clear. Sl. lt. brown in color.
BFP-79	H1S3-06	Dev E	400	85X/5	4-6 CFM	60	273	70.44	good cake w/ sl.soft top, good release, no blinding, initial filtrate discharge was dirty with sediment, then clear and sl. yellow.
BFP-81	H1S3-06	Dev E	400	855X/10	8-12 CFM	60	163	72.73	good cake, good release, no blinding; initial filtrate was dirty with sediment, very cloudy, then clear.
BFP-82	H1S3-06	Dev E	400	85X/15	15 CFM	60	299	69.16	v. good cake, good release, no blinding; initial filtrate dirty with sediment, remained somewhat cloudy with a lt. brown tinge.
BFP-85	H1S2-07	757	300	85X	0.5-1 CFM	60	362	55.60	good cake, sl. soft top, v. good release, no blinding; Filtrate sl. yellow and clear.
BFP-87	H1S2-07	757	300	85X/5	4-6 CFM	60	330	54.70	good cake, sl. soft top, v. good release, no blinding; Initial filtrate had sediment, then sl. cloudy and lt. brown, then sl. yellow and clear.
BFP-86	H1S2-07	757	300	855X/10	8-12 CFM	60	361	57.26	v. good cake, sl. soft top, excellent release, no blinding; Initial filtrate was dirty and brown with sediment, then sl. yellow and cloudy with sl. sediment.
BFP-88	H1S2-07	757	300	85X/15	15 CFM	60	317	59.24	v.good cake, v.sl.soft top, good release, no blinding; Initial filtrate had sediment, then sl. cloudy and yellow, then got clearer and less yellow.

Exhibit G.3.10 - Multiple Regression of Pooled Filter Press Test Data

203 data sets
Cake = Percent solids
Feed = Initial slurry Percent solids
Dose = Polymer dose in Pounds per dry ton of solids
Fines = 1, 2, 3, or 4 representing S1, S2, S3, or S4 sediment types
Scale = 1 (bench scale hockey pucks) or 2 (Plate & frame tests)

Regression Analysis: Cake versus Fines, Feed, Dose, Scale

```
The regression equation is
Cake = 60.7 - 4.34 Fines + 0.488 Feed + 0.0408 Dose + 2.86 Scale

Predictor     Coef  SE Coef      T      P
Constant    60.705    1.850  32.82  0.000
Fines      -4.3446   0.4810  -9.03  0.000
Feed       0.48789  0.06365   7.67  0.000
Dose       0.04085  0.05843   0.70  0.485
Scale        2.864    1.024   2.80  0.006

S = 6.22183   R-Sq = 38.0%   R-Sq(adj) = 36.7%

Analysis of Variance

Source           DF       SS      MS      F      P
Regression        4   4694.2  1173.6  30.32  0.000
Residual Error  198   7664.8    38.7
Total           202  12359.1
```

Comments:
Overall R-sq of 38% is not a strong relationship. However, analysis of individual predictors is of interest.

The “Fines” factor was the strongest predictor (highest T). The regression equation suggests that S2 sediments produce about 4.3%-points lower cake solids than corresponding S1 sediments, with similar drops for S3 from S2 and S4 from S3.

The Feed solids was the next strongest predictor. The regression equation suggests that a 1% increase in feed solids should produce a 0.5%-point increase in cake solids.

The Dose factor was not statistically significant. The data set includes a variety of different polymers, although most were Poly-DADMACs. Most dosages attempted to seek the optimum, with dosages slightly below and above optimum. The dose/performance relationship increases to the optimum, with falling performance at dosages above the optimum. Therefore, the dose factor would not be expected to follow a linear regression relationship.

It was interesting that the “Scale” factor was statistically significant. The regression equation would suggest that Plate & Frame tests produce cake solids 2.9%-points higher than corresponding hockey puck tests.

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Exhibit G.3.11 - Plate and Frame Filter Press Filtrate Sample Data

Sample ID	Date Collected	Total PCBs (mg/L)	PCB Qualifier	Total Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Total Suspended Solids (mg/L)	pH (pH Units)
PFP-01-5 TO 30	7/27/2004	0.01	J	NA	NA	37.6	NA
PFP-01-5 TO 30-DUP	7/27/2004	NA		NA	NA	40.8	NA
PFP-01-30	7/27/2004	0.014		NA	NA	7.8	NA
PFP-01-30 TO 60	7/27/2004	0.0038		NA	NA	4.6	NA
PFP-04-5 TO 30	7/28/2004	0.038		NA	NA	4.8	NA
PFP-04-30	7/28/2004	0.031		NA	NA	2	NA
PFP-04-30 TO 60	7/28/2004	0.036		NA	NA	2	NA
PFP-04-60	7/28/2004	0.046		NA	NA	2	NA
PFP-04-60 TO 90	7/28/2004	0.037		NA	NA	2	NA
PFP-17-FILTRATE	8/3/2004	0.0048		5.51	NA	5.31	7.01
PFP-17-FILTRATE-DUP	8/3/2004	0.0051		7.14	NA	7.07	7.02
PFP-28-FILTRATE	8/9/2004	0.00052		3.7	3.63	2	NA
PFP-28-FILTRATE-DUP	8/9/2004	0.00043		3.59	3.65	2	NA
PFP-35-FILTRATE	8/10/2004	0.011		12.9	11.6	38.6	NA
PFP-35-FILTRATE-DUP	8/10/2004	0.0087		13.8	12.2	42.4	NA

Min:	0.00043		3.59	3.63	2
Average:	0.0176		7.77	7.77	13.40
Max:	0.0460		13.80	12.20	42.40

Notes:
1. Samples were collected by Blasland, Bouck & Lee, Inc. (BBL), and were submitted to Northeast Analytical Services, Inc. for analysis.
2. U = Indicates the constituent was not detected. The value preceding the U indicates the laboratory quantitation limit.
3. As specified in the Treatability Studies Work Plan (BBL, 2004), data validation was performed on approximately 10% of the analytical data set.
4. NA - Not analyzed.
5. mg/L = milligrams per liter.
6. Laboratory Data Qualifiers
   Organics (PCBs)
   J - Indicates an estimated value.

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Exhibit G.3.12 - Belt Filter Press and Centrifuge Summary

Slurry ID	Test Number	Feed Solids (%)	Polymer Type	Polymer Dosage (ppm)	Test Conditions (Cycles at 25 psi for 15 Seconds)	Polymer Dosage (lb/dry T)	Cake Solids (%)
Belt Filter Press Summary							
H1S3-12	BP-4	14.61	2651	800	4	10.68	53.47
H1S3-12	BP-5	14.61	2651	850	4	11.35	56.78
H1S3-12	BP-6	14.61	2651	900	4	12.02	59.53
H1S3-14	BP-13	14.36	4440	1,300	4	17.69	53.21
H1S3-14	BP-14	14.36	4440	1,350	4	18.37	53.61
H1S3-14	BP-15	14.36	4440	1,400	4	19.05	54.28
H1S3-14	BP-16	14.36	4808	1,200	4	16.33	60.61
H1S3-14	BP-17	14.36	4808	1,250	4	17.01	60.72
H1S3-14	BP-18	14.36	4808	1,300	4	17.69	***61.17***
H1S3-14	BP-20	14.36	4808	1,250	8	17.01	59.68
					H1S3 Avg.	**15.7**	**57.3**
H1S4B-03	BP-1	24.84	4808	2,350	4	17.20	50.27
H1S4B-03	BP-2	24.84	4808	2,400	4	17.56	48.59
H1S4B-03	BP-3	24.84	4808	2,450	4	17.93	49.42
H1S4B-04	BP-7	24.90	4440	1,950	4	14.23	43.72
H1S4B-04	BP-8	24.90	4440	2,000	4	14.59	45.91
H1S4B-04	BP-9	24.90	4440	2,050	4	14.96	45.66
H1S4B-04	BP-10	24.90	2651	1,950	4	14.23	***51.19***
H1S4B-04	BP-11	24.90	2651	2,000	4	14.59	49.61
H1S4B-04	BP-12	24.90	2651	2,050	4	14.96	50.02
H1S4B-04	BP-19	24.90	2651	1,950	8	14.23	49.20
H1S4B-04	BP-21	24.90	4440	2,700	4	19.70	48.46
H1S4B-04	BP-22	24.90	4440	2,800	4	20.43	47.77
H1S4B-04	BP-23	24.90	4440	2,900	4	21.16	48.10
					H1S4B Avg.	**16.6**	**48.3**
					OVERALL AVG.	**16.2**	**52.2**

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Exhibit G.3.12 - Belt Filter Press and Centrifuge Summary

Slurry ID	Test Number	Feed Solids (%)	Polymer Type	Polymer Dosage (ppm)	Spin RPM/Time (Minutes)	Polymer Dosage (lb/dry T)	Cake Solids (%)
Centrifuge Summary							
H1S3-08	CF-13	12.33	none	0	3,500/3	0.00	41.33
H1S3-08	CF-16	12.33	none	0	3,500/5	0.00	48.61
H1S3-12	CF-19	14.61	4440	650	3,500/5	8.68	53.05
H1S3-12	CF-20	14.61	4440	700	3,500/5	9.35	50.29
H1S3-12	CF-21	14.61	4440	750	3,500/5	10.01	52.35
H1S3-12	CF-22	14.61	2651	750	3,500/5	10.01	59.30
H1S3-12	CF-23	14.61	2651	800	3,500/5	10.68	***61.20***
H1S3-12	CF-24	14.61	2651	850	3,500/5	11.35	59.04
H1S3-12	CF-25	14.61	4808	1,200	3,500/5	16.02	53.20
H1S3-12	CF-26	14.61	4808	1,250	3,500/5	16.69	55.94
H1S3-12	CF-27	14.61	4808	1,300	3,500/5	17.36	59.05
					H1S3 Avg.	**10.0**	**53.9**
H1S4B-03	CF-01	24.84	4808	2,350	3,500/5	17.20	47.78
H1S4B-03	CF-02	24.84	4808	2,400	3,500/5	17.56	47.95
H1S4B-03	CF-03	24.84	4808	2,450	3,500/5	17.93	47.42
H1S4B-03	CF-04	24.84	4440	1,950	3,500/5	14.27	46.13
H1S4B-03	CF-05	24.84	4440	2,000	3,500/5	14.64	46.54
H1S4B-03	CF-06	24.84	4440	2,050	3,500/5	15.00	46.75
H1S4B-03	CF-07	24.84	2651	1,950	3,500/5	14.27	49.31
H1S4B-03	CF-08	24.84	2651	2,000	3,500/5	14.64	51.97
H1S4B-03	CF-09	24.84	2651	2,050	3,500/5	15.00	***53.24***
H1S4B-03	CF-10	24.84	4808	2,400	3,500/3	17.56	46.97
H1S4B-03	CF-11	24.84	4440	2,000	3,500/3	14.64	45.83
H1S4B-03	CF-12	24.84	2651	2,000	3,500/3	14.64	47.70
H1S4B-03	CF-14	24.84	none	0	3,500/3	0.00	36.48
H1S4B-03	CF-17	24.84	none	0	3,500/5	0.00	38.65
					H1S4B Avg.	**13.4**	**46.6**
H2S4B-01	CF-15	3.37	none	0	3,500/3	0.00	34.43
H2S4B-01	CF-18	3.37	none	0	3,500/5	0.00	***37.89***
					H2S4B Avg.	**0.0**	**36.2**
					OVERALL AVG.	**11.0**	**48.8**

Notes:
2.54 =SpG (gm/mL) solids
1.07 =SpG (gm/mL) polymer
1. Dev E is Developmental E polymer from GE Water.
2. 2651 is Novus CE2651 polymer from GE Water.
3. 4440 and 4808 are polymers from Kemira (formerly Vulcan Chemicals).

Exhibit G.4

Water Treatment System Calculations
Includes:
Equalization Tank
Rapid Mix and Flocculation Tank Clarifier
Multi-Media Filter System
Granular Activated Carbon System

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Exhibit G.4.1

Process and Storm Water Treatment, Design Calculations

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Equalization Tank

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson River – Process Water Equalization Tank	20437	MMR	8/4/05	1

CALCS. BY MMR; DATE 8/4/05 CHECKED BY [illegible]; DATE 8/8/05

1.) Water Treatment plant design flow will be 1000 gpm and Equalization Tank retention time will be 1 hour.

$$= 1000 \frac{gal}{min} \times 60 min \text{ retention time} = \boxed{60,000 \text{ gal}}$$

Therefore, a 60,000 gallon tank would be required for a 1000 gpm flow rate with a 1 hour retention time.

Rapid Mix and Flocculation Tank

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson River – Rapid/Mix & Flocculation Tanks	20437	MMR	8/4/05	1

CALCS. BY MMR ; DATE 8/4/05 CHECKED BY SRG ; DATE 8/8/05

1.) Water treatment plant design flow will be 1000gpm. Flow will be divided into two separate trains at 500gpm a piece entering a Rapid/Mix & Flocculation Tank. Each tank consists of two chambers, the first being the Rapid/Mix chamber and the second being a Flocculation Chamber. The retention time in chamber 1 will be 3min and the retention time in chamber 2 will be 5min.

Chamber 1 $= 500 \frac{gal}{min} \times 3 min = 1500 gal$

Chamber 2 $= 500 \frac{gal}{min} \times 5 min = 2500 gal$

Therefore, chamber 1 of the Rapid/Mix section of the tank will be 1500 gal and chamber 2 of the tank, the flocculation section, will be 2500 gal. Giving a combined total of 4,000 gal for the entire tank.

Clarifier

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson River – Inclined Plate Clarifier	20437	MMR	8/4/05	

CALCS. BY MMR ; DATE 8/4/05 CHECKED BY [initials] ; DATE 8/8/05

1.) Water treatment plant design flow will be 1000 gpm. Flow will be divided into two seperate trains at 500 gpm apiece going into the Inclined Plate clarifiers. Each clarifier is designed for 500 gpm of flow and the maximum required hydraulic loading rate is 0.23 gpm/SF Ellis corporation) to 0.25 gpm/SF (Parkson).

Hydraulic Loading Rate

$0.23 \frac{gpm}{SF}$ $\frac{500 \text{ gpm}}{0.23 \frac{gpm}{SF}} =$ **2000 SF** required settling area

$0.25 \frac{gpm}{SF}$ $\frac{500 \text{ gpm}}{0.25 \frac{gpm}{SF}} =$ **2200 SF** required settling area

Multimedia Filter System

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson River - Multi Media Filter System	20437	MMR	8/4/05	1/2

CALCS. BY MMR ; DATE 8/4/05 CHECKED BY [illegible] ; DATE 8/8/05

1.) Flow rate entering the Multi Media filters will be divided into two separate trains of 250 gpm apiece. Each vessel will be 108" diameter, which is appoximately 64 square ft (SF).

Per US Filter, the recommended design loading rate is 5 gpm/SF, the recommended maximum loading rate is 9 gpm/SF and the minimum loading rate is 2 gpm/SF

Design Flow

$$\frac{250\ gpm}{64\ SF} = \boxed{3.9\ gpm/SF}$$ when operating in parallel.

Maximum Flow

$$\frac{500\ gpm}{64\ SF} = \boxed{7.8\ gpm/SF}$$ when total flow is going to only one filter (during backwash event)

Minimum Flow

$$64\ SF \times 2\ \frac{gpm}{SF} = \boxed{128\ gpm}$$ [illegible] drop [illegible] on-line

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River – MULTI-MEDIA FILTER System	20437	TEM	8/5/05	2/2

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY SRG ; DATE 8/8/05

② Estimated Backwash Water Volume Generated

EACH MULTI-MEDIA FILTER WILL BE BACKWASHED AS DICTATED BY DIFFERENTIAL PRESSURE DROP However, it is assummed that each vessel will be backwashed once per day during normal OPERATIONS.

Hydraulic Loading rate required during backwashing

$$= \frac{15\text{ gpm}}{\text{SF}} \times \frac{64\text{ SF}}{\text{Vessel}} \cong \frac{1{,}000\text{ gpm}}{\text{vessel}}$$

Recommended Backwash Time ≈ 15 minutes

Required Backwash Water Volume / Vessel = 1,000 x 15

= 15,000 GALLONS

Required backwash water available if backwashing all eight (process water + stormwater) multi-media vessels =

= 8 x 15,000 gallons = **120,000 GALLONS**

Granular Activated Carbon System

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE Hudson River – Granular Activated Carbon	20437	MMR	8/4/05	

CALCS. BY MMR ; DATE 8/4/05 CHECKED BY [illegible] ; DATE 8/8/05

1.) The recommended empty bed contact time for PCB treatment is 20 minutes per vessel (us filter Westates Carbon)

Each carbon vessel contains 20,000 lbs of granular activated carbon and a carbon bed volume of 702 ft^3.

Therefore:

$$702\ ft^3 \times \frac{7.4805\ gal}{ft^3} = 5251\ gal$$

The maximum allowable flowrate to one 20,000 lbs vessel is:

$$\frac{5251\ gal}{vessel} \times \frac{1}{20\ min} = 262\ gpm/vessel$$

Each 500 gpm water treatment train will consist of (2) primary 20,000 lbs granular activated carbon vessel operating in parallel. Each primary vessel will be paired with one 20,000 lbs granular activated carbon vessel operating in series for 100% redundancy.

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
PLANT WATER NEEDS	20437	JRO	8/11/05	

CALCS. BY ______ ; DATE ______ CHECKED BY ______ ; DATE ______

I, Waterfront
- Haul Truck decontamination
  - 5 trucks × 3 trips/hr × 24 hrs = 360 loads × 25 gal = 9,000 gpd.
- NYSCC vehicle washes
  - 3 per shift × 2 × 25 gal = 150 gpd.
- NYSCC vehicle crossing area
  - 3 per shift × 2 × 50 gal = 300 gpd.
- Trommel screen & slurry tank (use process recycle water)

II Thickening & Dewatering
- Polymer makeup ~~& feed~~ - 1,000 gpd × 2 = 2,000 gpd
- Polymer feed dilution - 4 gpm × 2 = 12,000 gpd
- Flocculant makeup - 1,000 gpd × 2 = 2,000 gpd
- Flocculant feed - 4 gpm × 2 = 12,000 gpd
- Dewatering polymer - 2,000 gpd × 4 = 8,000 gpd
- Filter wash water - 5 gpm × 4 = 29,000 gpd
- Misc washdown - 3 gpm = 4,300 gpd

III Water Treatment
- Polymer makeup - 4,000 × 2 = 8,000 gpd
- Misc. washdown - 3 gpm × 3 = 13,000 gal.

IV Railyard Staging
- Haul truck decontamination
  - 5 trucks × 3 trips/hr × 24 hrs = 360 × 25 = 9,000 gpd
  - 2 rolloff trucks × 100 loads × 25 gal = 5,000 gpd
- Misc. washwater - 5 gpm × 5 = 36,000 gpd
- Rail car decontam.
  - 81 + 81 = 162/wk × 50 gal ÷ 6 d/wk = 1,500 gpd

V Admin.
- Misc. decontamination - 5 gpm × 3 = 22,000 gpd

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Exhibit G.4.2 - Settled Filtrate from Pilot Plate & Frame Filter Press

Sample ID:	H1S1 SETTLED FILTRATE TOP	H1S2 SETTLED FILTRATE TOP	H1S3 SETTLED FILTRATE TOP	H1S4B SETTLED FILTRATE TOP	H2S4B SETTLED FILTRATE TOP
Date Collected:	**9/2/2004**	**9/2/2004**	**9/2/2004**	**9/2/2004**	**9/2/2004**
Total PCBs	0.000080 J	0.00098	0.000040 J	0.0011	0.00033
Total Suspended Solids	1.96 U	2.25 U	1.96 U	13.1	1.96 U
Total TEQs (WHO TEFs)	0.0000000625	0.0000000615	0.0000000266	0.0000000616	0.0000000497
Cadmium	0.00100 U	0.000230 B	0.00100 U	0.000300 B	0.00100 U
Chromium	0.00180 B	0.00240	0.00240	0.00560	0.00200
Copper	0.00190 B	0.00250	0.00240	0.00220	0.00110 B
Lead	0.000180 B	0.000320 B	0.000260 B	0.00250	0.000370 B
Mercury	0.000200 U	0.000200 U	0.000200 U	0.000200 U	0.000200 U

Notes:
1. All results as milligrams per liter (mg/L).
2. This table is condensed from Table 23 of IDR Attachment 4 (Treatability Studies Report).
3. Samples were collected by Blasland, Bouck & Lee, Inc. (BBL), and were submitted to Severn Trent Laboratories, Inc., Pittsburgh; Paradigm Analytical Laboratories; and Northeast Analytical Services, Inc. for analysis.
4. U = Indicates the constituent was not detected. The value preceding the U indicates the laboratory quantitation limit.
5. As specified in the Treatability Studies Work Plan (BBL, 2004), data validation was performed on approximately 10% of the analytical data set.
6. NA - Not analyzed.
7. Laboratory Data Qualifiers:
   Organics (PCBs, PCDD/PCDFs)
      J - Indicates an estimated value.
   Inorganics (TAL Metals)
      B - Indicates an estimated value between the lower calibration limit and the target detection limit.

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Exhibit G.4.3 - Process Water Filtration & Carbon Adsorption

Sample ID:	WQC	H1S1 MMFIN	H1S1 MMFOUT2	H1S1 BETGAC2	H1S1 GAC2OUT2
Date Collected:		**9/7/2004**	**9/7/2004**	**9/7/2004**	**9/7/2004**
Total PCB	0.0003	0.0000220 J	0.0000125 J	NA	NA
Total PAHs		0.00943 U	0.00926 U	0.00980 U	0.00962 U
Ammonia Nitrogen		0.510	0.410	0.370	0.300
BOD (five day)		2 U	2 U	2 U	2 U
COD		8	8	5U	5U
Nitrate		1.1	0.80	0.20	0.20 U
Nitrite		0.020	0.010	0.010	0.010
Total Organic Carbon		0.966 U	0.966 U	0.966 U	0.966 U
Dissolved Organic Carbon		0.97 U	2.6	0.97 U	0.97 U
Total Kjeldahl Nitrogen		0.680	0.650	0.370	0.330
Total Phosphorous (PO4)		0.0500 U	0.0500 U	0.0500 U	0.0500 U
Total Suspended Solids	50	2.20	0.952 U	1.24	0.952 U
Total TEQs (WHO TEFs)		0.0000000448	0.0000000611	0.0000000625	0.0000000625
Cadmium	0.04	0.00100 U	0.00100 U	0.00100 U	0.00100 U
Chromium	0.21	0.00210	0.00220	0.00140 B	0.00150 B
Copper	0.136	0.0141	0.00590	0.000760 B	0.00190 B
Lead	0.038	0.0181	0.00230	0.000920 B	0.000490 B
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC		H1S1 MMFOUT6	H1S1 BETGAC6	H1S1 GAC2OUT6
Date Collected:			**9/7/2004**	**9/7/2004**	**9/7/2004**
Total PCB	0.0003		0.0000156 J	0.00000934 U	0.00000934 U
Total PAHs			0.0100 U	0.00926 U	0.00926 U
Ammonia Nitrogen			0.430	0.390	0.410
BOD (five day)			2 U	2 U	2 U
COD			11	5U	5U
Nitrate			0.90	0.20 U	0.20 U
Nitrite			0.010	0.010	0.010 U
Total Organic Carbon			2.62	0.966 U	0.966 U
Dissolved Organic Carbon			2.6	0.97 U	0.97 U
Total Kjeldahl Nitrogen			0.690	0.440	0.330
Total Phosphorous (PO4)			0.0500 U	0.110	0.0500
Total Suspended Solids	50		0.952 U	0.952 U	0.952 U
Total TEQs (WHO TEFs)			0.0000000620	0.0000000509	0.0000000615
Cadmium	0.04		0.00100 U	0.00100 U	0.00100 U
Chromium	0.21		0.00180 B	0.00100 B	0.000950 B
Copper	0.136		0.00650	0.000500 B	0.000680 B
Lead	0.038		0.00180	0.000800 B	0.000550 B
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC		H1S1 MMFOUT10	H1S1 BETGAC10	H1S1 GAC2OUT10
Date Collected:			**9/7/2004**	**9/7/2004**	**9/7/2004**
Total PCB	0.0003		0.0000766	NA	NA
Total PAHs			0.00926 U	0.00980 U	0.00926 U
Ammonia Nitrogen			0.400	0.430	0.380
BOD (five day)			2 U	2 U	2 U
COD			7	5U	5U
Nitrate			0.90	0.20 U	0.20 U
Nitrite			0.010	0.010	0.010
Total Organic Carbon			2.60	0.966 U	0.966 U
Dissolved Organic Carbon			2.6	0.97 U	0.97 U
Total Kjeldahl Nitrogen			0.610	0.360	0.340
Total Phosphorous (PO4)			0.0500 U	0.100	0.0900
Total Suspended Solids	50		0.952 U	0.952 U	0.952 U
Total TEQs (WHO TEFs)			0.0000000624	0.0000000625	0.0000000502
Cadmium	0.04		0.00100 U	0.00100 U	0.00100 U
Chromium	0.21		0.00130 B	0.00110 B	0.00100 B
Copper	0.136		0.00780	0.000630 B	0.000480 B
Lead	0.038		0.00190	0.000900 B	0.000670 B
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

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Exhibit G.4.3 - Process Water Filtration & Carbon Adsorption

Sample ID:	WQC	H1S2 MMFIN	H1S2 MMFOUT2	H1S2 BETGAC2	H1S2 GAC2OUT2
Date Collected:		**9/14/2004**	**9/14/2004**	**9/14/2004**	**9/14/2004**
Total PCB	0.0003	0.0000562	NA	NA	NA
Total PAHs		0.00926 U	0.00926 U	0.00926 U	0.00943 U
Ammonia Nitrogen		5.75	5.62	5.52	5.03
BOD (five day)		2	2 U	2 U	2 U
COD		14	17	5U	5U
Nitrate		0.20 U	0.20 U	0.20 U	0.20 U
Nitrite		0.020	0.010	0.010 U	0.010 U
Total Organic Carbon		4.13	3.85	0.966 U	0.966 U
Dissolved Organic Carbon		3.8	4.2	0.97 U	0.97 U
Total Kjeldahl Nitrogen		6.23	5.83	5.54	5.07
Total Phosphorous (PO4)		0.0500 U	0.0500 U	0.120	0.0800
Total Suspended Solids	50	5.97	1.00	1.00 U	1.00 U
Total TEQs (WHO TEFs)		0.0000000248	NA	NA	NA
Cadmium	0.04	0.0000900 B	0.00100 U	0.00100 U	0.00100 U
Chromium	0.21	0.00170 B	0.00110 B	0.00160 B	0.00160 B
Copper	0.136	0.0475	0.0152	0.00210	0.00230
Lead	0.038	0.0136	0.00280	0.00140	0.000750 B
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC		H1S2 MMFOUT6	H1S2 BETGAC6	H1S2 GAC2OUT6
Date Collected:			**9/14/2004**	**9/14/2004**	**9/14/2004**
Total PCB	0.0003		0.0000461	0.00000934 U	0.00000934 U
Total PAHs			0.00926 U	0.00926 U	0.00926 U
Ammonia Nitrogen			5.75	5.55	5.25
BOD (five day)			2 U	2 U	2 U
COD			5U	5U	5U
Nitrate			0.20 U	0.20 U	0.20 U
Nitrite			0.010	0.010 U	0.010 U
Total Organic Carbon			3.89	0.966 U	0.966 U
Dissolved Organic Carbon			3.6	0.97 U	0.97 U
Total Kjeldahl Nitrogen			6.12	5.67	5.38
Total Phosphorous (PO4)			0.0500 U	0.0500	0.110
Total Suspended Solids	50		1.10	1.00 U	1.00 U
Total TEQs (WHO TEFs)			0.0000000466	0.0000000616	0.0000000567
Cadmium	0.04		0.00100 U	0.00100 U	0.00100 U
Chromium	0.21		0.00180 B	0.00150 B	0.00160 B
Copper	0.136		0.0156	0.00260	0.00190 B
Lead	0.038		0.00360	0.00230	0.00170
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC		H1S2 MMFOUT10	H1S2 BETGAC10	H1S2 GAC2OUT10
Date Collected:			**9/14/2004**	**9/14/2004**	**9/14/2004**
Total PCB	0.0003		NA	NA	NA
Total PAHs			0.00926 U	0.00926 U	0.00926 U
Ammonia Nitrogen			5.66	5.51	5.36
BOD (five day)			2 U	2 U	2 U
COD			17	5U	5U
Nitrate			0.20 U	0.20 U	0.20 U
Nitrite			0.010	0.010 U	0.010 U
Total Organic Carbon			4.03	0.966 U	0.966 U
Dissolved Organic Carbon			3.5	0.97 U	0.97 U
Total Kjeldahl Nitrogen			6.07	5.78	5.58
Total Phosphorous (PO4)			0.0500 U	0.0700	0.130
Total Suspended Solids	50		1.20	1.20	1.00 U
Total TEQs (WHO TEFs)			NA	NA	NA
Cadmium	0.04		0.00100 U	0.00100 U	0.00100 U
Chromium	0.21		0.00260	0.00110 B	0.00140 B
Copper	0.136		0.0191	0.00380	0.00250
Lead	0.038		0.00560	0.00280	0.00200
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

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Exhibit G.4.3 - Process Water Filtration & Carbon Adsorption

Sample ID:	**WQC**	**H1S3 MMFIN**	**H1S3 MMFOUT2**	**H1S3 BETGAC2**	**H1S3 GAC2OUT2**
Date Collected:		**9/9/2004**	**9/9/2004**	**9/9/2004**	**9/9/2004**
Total PCB	0.0003	0.0000443	0.0000254 J	NA	NA
Total PAHs		0.00926 U	0.00926 U	0.00926 U	0.00943 U
Ammonia Nitrogen		12.7	12.9	12.6	11.8
BOD (five day)		16	5	2 U	3
COD		19	16	5U	5 U
Nitrate		3.3	3.3	0.30	0.20
Nitrite		2.0	2.1	0.10	0.020
Total Organic Carbon		5.30	5.32	0.966 U	0.966 U
Dissolved Organic Carbon		5.8	5.2	0.97 U	0.97 U
Total Kjeldahl Nitrogen		12.8	12.7	12.0	10.9
Total Phosphorous (PO4)		0.0500 U	0.0500 U	0.130	0.130
Total Suspended Solids	50	3.69	1.37	1.19	1.00 U
Total TEQs (WHO TEFs)		0.0000000625	0.0000000619	0.0000000618	0.0000000620
Cadmium	0.04	0.000110 B	0.00100 U	0.00100 U	0.00100 U
Chromium	0.21	0.00150 B	0.00150 B	0.00110 B	0.00130 B
Copper	0.136	0.0118	0.0347	0.00190 B	0.00110 B
Lead	0.038	0.00630	0.00560	0.00170	0.000510 B
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U

Sample ID:	**WQC**		**H1S3 MMFOUT6**	**H1S3 BETGAC6**	**H1S3 GAC2OUT6**
Date Collected:			**9/9/2004**	**9/9/2004**	**9/9/2004**
Total PCB	0.0003		0.0000199 J	0.00000934 U	0.00000934 U
Total PAHs			0.00926 U	0.00926 U	0.00926 U
Ammonia Nitrogen			13.2	12.8	12.8
BOD (five day)			3	7	3
COD			20	5U	5 U
Nitrate			3.1	0.50	0.20 U
Nitrite			2.0	0.38	0.030
Total Organic Carbon			5.13	0.966 U	0.966 U
Dissolved Organic Carbon			4.7	0.97 U	0.97 U
Total Kjeldahl Nitrogen			12.6	11.9	11.7
Total Phosphorous (PO4)			0.0500 U	0.0800	0.130
Total Suspended Solids	50		1.05 U	1.05 U	1.03 U
Total TEQs (WHO TEFs)			0.0000000621	0.0000000616	0.0000000619
Cadmium	0.04		0.0000770 B	0.00100 U	0.00100 U
Chromium	0.21		0.00160 B	0.00140 B	0.00140 B
Copper	0.136		0.0208	0.00390	0.00130 B
Lead	0.038		0.00460	0.00290	0.00170
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

Sample ID:	**WQC**		**H1S3 MMFOUT10**	**H1S3 BETGAC10**	**H1S3 GAC2OUT10**
Date Collected:	0.0003		**9/9/2004**	**9/9/2004**	**9/9/2004**
Total PCB			0.0000191 J	NA	NA
Total PAHs			0.00926 U	0.00926 U	0.00926 U
Ammonia Nitrogen			13.1	13.5	12.4
BOD (five day)			6	2 U	6
COD			17	5U	5 U
Nitrate			3.2	0.80	0.20 U
Nitrite			2.1	0.67	0.050
Total Organic Carbon			5.21	0.966 U	0.966 U
Dissolved Organic Carbon			5.1	0.97 U	0.97 U
Total Kjeldahl Nitrogen			12.8	11.9	11.6
Total Phosphorous (PO4)	50		0.0500 U	0.0600	0.100
Total Suspended Solids			1.11	1.60	1.03 U
Total TEQs (WHO TEFs)	0.04		0.0000000625	0.0000000506	0.0000000621
Cadmium	0.21		0.000140 B	0.00100 U	0.00100 U
Chromium	0.136		0.00180 B	0.00160 B	0.00130 B
Copper	0.038		0.0266	0.00190 B	0.00140 B
Lead	0.038		0.00500	0.00530	0.00230
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

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Exhibit G.4.3 - Process Water Filtration & Carbon Adsorption

Sample ID:	WQC	H1S4B MMFIN	H1S4B MMFOUT6	H1S4B BETGAC6	H1S4B GAC2OUT6
Date Collected:		**9/15/2004**	**9/15/2004**	**9/15/2004**	**9/15/2004**
Total PCB	0.0003	0.0000419	0.0000326	0.0000174 J	0.00000934 U
Total PAHs		0.00926 U	0.00926 U	0.00926 U	0.00943 U
Ammonia Nitrogen		19.9	19.1	16.6	19.2
BOD (five day)		2	2 U	2 U	2 U
COD		31	29	7	6
Nitrate		0.20 U	0.20 U	0.20 U	0.20 U
Nitrite		0.010	0.010	0.010 U	0.010 U
Total Organic Carbon		9.35	9.13	1.11	0.966 U
Dissolved Organic Carbon		8.2	7.4	0.97 U	0.97 U
Total Kjeldahl Nitrogen		20.8	20.0	18.8	18.3
Total Phosphorous (PO4)		0.0500 U	0.0700	0.110	0.190
Total Suspended Solids	50	13.5	8.30	5.10	2.50
Total TEQs (WHO TEFs)		0.0000000623	0.0000000509	0.0000000512	0.0000000499
Cadmium	0.04	0.000290 B	0.000260 B	0.000120 B	0.0000760 B
Chromium	0.21	0.00440	0.00400	0.00260	0.00230
Copper	0.136	0.0377	0.0605	0.0126	0.00730
Lead	0.038	0.00920	0.0177	0.00860	0.00510
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC				GAC2OUT6-DUP
Date Collected:					**9/15/2004**
Total PCB	0.0003				0.0000122 J
Total PAHs					0.00943 U
Ammonia Nitrogen					NA
BOD (five day)					NA
COD					NA
Nitrate					NA
Nitrite					NA
Total Organic Carbon					0.966 U
Dissolved Organic Carbon					0.97 U
Total Kjeldahl Nitrogen					NA
Total Phosphorous (PO4)					NA
Total Suspended Solids	50				2.40
Total TEQs (WHO TEFs)					0.0000000615
Cadmium	0.04				0.00100 U
Chromium	0.21				0.00220
Copper	0.136				0.00890
Lead	0.038				0.00520
Mercury	0.0002				0.0002 U

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Exhibit G.4.3 - Process Water Filtration & Carbon Adsorption

Sample ID:	WQC	H2S4B MMFIN	H2S4B MMFOUT2	H2S4B BETGAC2	H2S4B GAC2OUT2
Date Collected:		**9/13/2004**	**9/13/2004**	**9/13/2004**	**9/13/2004**
Total PCB	0.0003	0.0000322 J	NA	NA	NA
Total PAHs		0.00926 U	0.00926 U	0.00926 U	0.00943 U
Ammonia Nitrogen		3.83	3.71	3.49	3.49
BOD (five day)		15	11	6	10
COD		7	8	5 U	5 U
Nitrate		2.0	1.9	0.20 U	0.20 U
Nitrite		0.29	0.37	0.070	0.040
Total Organic Carbon		2.83	2.96	0.966 U	0.966 U
Dissolved Organic Carbon		2.8	2.6	0.97 U	0.97 U
Total Kjeldahl Nitrogen		4.47	4.25	4.03	3.56
Total Phosphorous (PO4)		0.0500 U	0.0500 U	0.0120	0.0500 U
Total Suspended Solids	50	3.00	1.20	1.00 U	1.00 U
Total TEQs (WHO TEFs)		0.0000000288	NA	NA	NA
Cadmium	0.04	0.0000730 B	0.00100 U	0.00100 U	0.00100 U
Chromium	0.21	0.00210	0.00220	0.00120 B	0.00110 B
Copper	0.136	0.0616	0.0157	0.00170 B	0.000980 B
Lead	0.038	0.0197	0.00640	0.00280	0.000880 B
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC		H2S4B MMFOUT6	H2S4B BETGAC6	H2S4B GAC2OUT6
Date Collected:			**9/13/2004**	**9/13/2004**	**9/13/2004**
Total PCB	0.0003		0.0000252 J	0.00000934 U	0.00000934 U
Total PAHs			0.00926 U	0.00926 U	0.00926 U
Ammonia Nitrogen			3.70	3.57	3.53
BOD (five day)			16	15	12
COD			8	5 U	6 U
Nitrate			2.2	0.30	0.20 U
Nitrite			0.38	0.22	0.060
Total Organic Carbon			3.20	0.966 U	0.966 U
Dissolved Organic Carbon			2.8	0.97 U	0.97 U
Total Kjeldahl Nitrogen			4.19	3.67	3.54
Total Phosphorous (PO4)			0.0500 U	0.0500	0.140
Total Suspended Solids	50		1.00 U	1.10	1.00 U
Total TEQs (WHO TEFs)			0.0000000624	0.0000000625	0.0000000482
Cadmium	0.04		0.00100 U	0.00100 U	0.00100 U
Chromium	0.21		0.00180 B	0.00240	0.00150 B
Copper	0.136		0.0192	0.00320	0.00210
Lead	0.038		0.00820	0.00440	0.00340
Mercury	0.0002		0.0002 U	0.0002 U	0.0002 U

Sample ID:	WQC			H2S4B BETGAC6-DUP	
Date Collected:				**9/13/2004**	
Total PCB	0.0003			0.00000934 U	
Total PAHs				0.00926 U	
Ammonia Nitrogen				NA	
BOD (five day)				NA	
COD				NA	
Nitrate				NA	
Nitrite				NA	
Total Organic Carbon				0.966 U	
Dissolved Organic Carbon				0.97 U	
Total Kjeldahl Nitrogen				NA	
Total Phosphorous (PO4)				NA	
Total Suspended Solids	50			1.20	
Total TEQs (WHO TEFs)				NA	
Cadmium	0.04			0.00100 U	
Chromium	0.21			0.00140 B	
Copper	0.136			0.00350	
Lead	0.038			0.00470	
Mercury	0.0002			0.0002 U	

Notes:
All results as mg/L
This table is condensed from Table 24 of IDR Attachment 4 (Treatability Studies Report).

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Exhibit G.4.4 - Comparison of DRET Test Results and WQC Substantive Requirements

	Cd	Cr	Cu	Pb	Hg
Max Conc:	0.04	0.21	0.136	0.038	
#/Day Limit:	0.62	18.9	0.75	0.31	
(MGD)	Concentration Limit at Max. Mass Flow Rate				
0.1	0.040	0.210	0.136	0.038	0.0002
0.2	0.040	0.210	0.136	0.038	0.0002
0.5	0.040	0.210	0.136	0.038	0.0002
0.661	0.040	0.210	0.136	0.038	0.0002
0.978	0.040	0.210	0.092	0.038	0.0002
1.0	0.040	0.210	0.090	0.037	0.0002
1.86	0.040	0.210	0.048	0.020	0.0002
2.0	0.037	0.210	0.045	0.019	0.0002

DRET Test Results

Sediment Type	Cadmium Unfiltered	Cadmium Filtered	Chromium Unfiltered	Chromium Filtered	Copper Unfiltered	Copper Filtered	Lead Unfiltered	Lead Filtered	Mercury Unfiltered	Mercury Filtered
DRET 1										
S1	0.0021	0.001 U	0.0737	0.00227	0.0422	0.00243	0.0731	0.00063 B	0.000343	0.0002 U
S2	0.0413	0.000343 XB	0.633	0.0054	0.103	0.0035	0.766	0.0165	0.00517	0.0002 U
S3	0.025	0.000297 B	0.347 X	0.00533	0.0726 X	0.00287	0.45	0.0077	0.00263	0.0002 U
S4B	0.0669	0.00025 B	0.719 X	0.00563	0.107 X	0.00237 B	0.997	0.0104	0.00757	0.0002 U
DRET 2										
S1	0.0014	0.001 U	0.0556	0.0038 X	0.0329	0.0033 X	0.0551	0.0030	0.00024	0.0002 U
S2	0.0238	0.0002 B	0.3563	0.0075 X	0.0549	0.0025 X	0.4103	0.0165	0.00303	0.0002 U
S3	0.0256 X	0.0013 B	0.361 X	0.0250 X	0.0701	0.0086	0.4653	0.0315	0.00293	0.000206 UB
S4B	0.0557	0.0009 B	0.633 X	0.0155 X	0.0880	0.0039	0.8473	0.0247	0.00670	0.00022 U

Notes:
1. Concentrations are as mg/L.
2. DRET1 test results are estimated due to temperature as received. Tests were redone as DRET2.
3. DRET test results are average of three replicates.
4. Shading:
   - [blue] Indicates DRET concentrations were below Water Quality Certification Substantive Requirements (at maximum concentration, which decreases as flow rate increases).
   - [yellow] Indicates flow rate at which concentration limit applies (not mass limit).
5. Laboratory qualifiers: U=not detected at Laboratory Quantitation Limit, B=estimated value and X=method blank contamination.

Exhibit G.5

Processed Material Staging and Load-Out Facilities
Includes:
Waterfront Staging and Load-Out Calculations
Load-out Facility Storage Volume Requirements
Staging/Storage Area Capacities
Rail Car Loading Calculations

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Exhibit G.5.1

Processed Material Staging and Load-Out Facilities Design Calculations

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Waterfront Staging and Load-Out Calculations

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Waterfront Staging and Loadout	20437	TEM	8/5/05	1/2

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY [illegible] ; DATE 8/8/05

1) Estimated daily Volume and Load-out Calculations

Per METSIM MATERIAL BALANCE, (TABLE 3-26), MAXIMUM AMOUNT OF Oversize SOLIDS (+3/8") and coarse material (+200 MESH) from Hydrocyclone overflow occurs when processing 4,300 in situ cubic yards of S1 sediment.

Volumes are as follows:

Oversize mater (METSIM stream # 106) ≈ **520 CY/day**

Coarse screen solids (METSIM stream # 114) ≈ **3,000 CY/day**

Debris (+6" material) has been estimated to be approximately **100 CY/dy**

∴ A total maximum volume of ≈ 3600 CY/dy of material must be transported to the staging and load out facility near the rail yard.

Per attached spread sheet, based on a 16 hr work day, two to six trucks per hour (dependant on size) will be required to transport the maximum anticipated waterfront storage volume to the staging and load-out facility (Assumes up to 7 trips per hour per truck)

Work Day Length (hrs)	16
Phase I Material to be Transported Per Day (yd3/day)	3600

	Truck Type		
Data	**Truck A**	**Truck B**	**Truck C**
Capacity (yd3)	5	10	15
Distance (ft)	1600.0	1600.0	1600.0
Speed (ft/s)	14.7	14.7	14.7
Time to Travel Dist. (sec)	109.1	109.1	109.1
Body Hoist (sec)	10	15	20
Accelerate (ft/s)	3	3	3
Decelerate (ft/s)	3	3	3
Time to Accel/Decel (sec)	10	10	10
Turning Around (sec)	60	60	60
Loading and Unloading (sec)	300	300	300
Total Time (sec)	489.1	494.1	499.1
Total Time (min)	8.2	8.2	8.3
Trips in Hour	7.4	7.3	7.2
Amount Transported in an Hour	36.8	72.9	108.2
Oversized Material Separated Per Hour (yd3)			
Phase I (Assuming 3600 Yd3/Day)	225	225	225
Trucks Needed	6	3	2

Note:

This is assuming a 16 hr work day.

The distance is from the waterfront staging area to the Debris and Course Material Staging / Storage area.

The speed is assuming a plant speed of 10 mph.

Equipment times are estimations taken from the Caterpillar Performance Handbook.

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River – Waterfront Staging + Loadout	20437	TEM	8/5/05	2/2

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY GRO ; DATE 8/8/05

② Estimated WATERFRONT MATERIAL Staging Area Calculations

Assuming one-day staging volume required, maximum area at waterfront will be as follows:

Debris – 100 CY MAXIMUM
- assuming a 15' high cone pile, maximum area required ≈ **615 SF ≈ 28'-diameter**

Oversize solids (+3/8") – 500 CY MAXIMUM

- assuming a 15' high cone pile, maximum area required ≈ **3,000 SF ≈ 60'-diameter**

Coarse solids (+200 mesh) – 3,000 CY MAXIMUM

- assuming a 15' high cone piles maximum area required = **18,000 SF** or **(6) 60'-diameter piles**

Load-Out Facility Storage Volume Requirements

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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - LOAD-OUT FACILITY STORAGE VOLUME REQUIREMENTS	20437	TEM	8/5/05	1/1

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY [initials] ; DATE 8/8/05

Based on Phase I dredge schedule, the attached spreadsheets calculates peak storage required during the dredging season assuming a specific rail schedule.

Summary of attached Train Scenarios:

Train Scenario	Ramp up wks.	Production wks.	# Trains	Ramp down wks.
1	3-5	6-27	2	-
2	3-6	7-11	2	
		12-17	3	
		18-23	2	24-26
3	3-4	5-19	1,2,3 (alternating)	
		20-26	2	27
4	3-6	7-17	3	
		18-19	2	20-21
5	3-4	5-8	2	
		9-18	3	
		19-20	2	21-24

Phase 1 Train Scenario 1

	Week	Tons Processed	Cum Tons Processed	Unit Trains Shipped	Tons Shipped	Cum Tons Shipped	Storage (tons)	Storage (cy)	Delta Storage (cy)
May	1	5174	5174	0	0	0	5174	3449	3449
	2	2807	7980	0	0	0	7980	5320	1871
	3	11718	19698	1	8505	8505	11193	7462	2142
	4	12611	32309	1	8505	17010	15299	10199	2737
June	5	20646	52954	1	8505	25515	27439	18293	8094
	6	22217	75172	2	17010	42525	32647	21764	3471
	7	18406	93578	2	17010	59535	34043	22695	931
	8	23336	116914	2	17010	76545	40369	26912	4217
	9	26403	143316	2	17010	93555	49761	33174	6262
July	10	30852	174168	2	17010	110565	63603	42402	9228
	11	31929	206097	2	17010	127575	78522	52348	9946
	12	33934	240031	2	17010	144585	95446	63630	11283
	13	31504	271535	2	17010	161595	109940	73293	9663
August	14	21320	292855	2	17010	178605	114250	76166	2873
	15	19033	311888	2	17010	195615	116273	77515	1349
	16	16843	328731	2	17010	212625	116106	77404	-111
	17	20905	349636	2	17010	229635	120001	80001	2597
	18	21535	371171	2	17010	246645	124526	83017	3017
September	19	10610	381781	2	17010	263655	118126	78751	-4267
	20	4320	386101	2	17010	280665	105436	70291	-8460
	21	4754	390855	2	17010	297675	93180	62120	-8171
	22	4307	395162	2	17010	314685	80477	53651	-8469
October	23	3038	398200	2	17010	331695	66505	44337	-9315
	24	0	398200	2	17010	348705	49495	32997	-11340
	25	0	398200	2	17010	365715	32485	21657	-11340
	26	0	398200	2	17010	382725	15475	10317	-11340
	27	0	398200	2	17010	399735	-1535	-1023	-11340
November	28	0	398200		0	399735			1023
	29	0	398200		0	399735			0
	30	0	398200		0	399735			0
	31	0	398200		0	399735			0
December	32	0	398200		0	399735			0
	33	0	398200		0	399735			0
	34	0	398200		0	399735			0
	35	0	398200		0	399735			0

Note - assumes 81-car trains, 105 tons per car (8,505 tons per train).

Phase 1 **Train Scenario 2**

	Week	Tons Processed	Cum Tons Processed	Unit Trains Shipped	Tons Shipped	Cum Tons Shipped	Storage (tons)	Storage (cy)	Delta Storage (cy)
May	1	5174	5174	0	0	0	5174	3449	3449
	2	2807	7980	0	0	0	7980	5320	1871
	3	11718	19698	1	8505	8505	11193	7462	2142
	4	12611	32309	1	8505	17010	15299	10199	2737
June	5	20646	52954	1	8505	25515	27439	18293	8094
	6	22217	75172	1	8505	34020	41152	27434	9141
	7	18406	93578	2	17010	51030	42548	28365	931
	8	23336	116914	2	17010	68040	48874	32582	4217
	9	26403	143316	2	17010	85050	58266	38844	6262
July	10	30852	174168	2	17010	102060	72108	48072	9228
	11	31929	206097	2	17010	119070	87027	58018	9946
	12	33934	240031	3	25515	144585	95446	63630	5613
	13	31504	271535	3	25515	170100	101435	67623	3993
August	14	21320	292855	3	25515	195615	97240	64826	-2797
	15	19033	311888	3	25515	221130	90758	60505	-4321
	16	16843	328731	3	25515	246645	82086	54724	-5781
	17	20905	349636	3	25515	272160	77476	51651	-3073
	18	21535	371171	2	17010	289170	82001	54667	3017
September	19	10610	381781	2	17010	306180	75601	50401	-4267
	20	4320	386101	2	17010	323190	62911	41941	-8460
	21	4754	390855	2	17010	340200	50655	33770	-8171
	22	4307	395162	2	17010	357210	37952	25301	-8469
October	23	3038	398200	2	17010	374220	23980	15987	-9315
	24	0	398200	1	8505	382725	15475	10317	-5670
	25	0	398200	1	8505	391230	6970	4647	-5670
	26	0	398200	1	8505	399735	-1535	-1023	-5670
	27	0	398200		0	399735			1023
November	28	0	398200		0	399735			0
	29	0	398200		0	399735			0
	30	0	398200		0	399735			0
	31	0	398200		0	399735			0
December	32	0	398200		0	399735			0
	33	0	398200		0	399735			0
	34	0	398200		0	399735			0
	35	0	398200		0	399735			0

Note - assumes 81-car trains, 105 tons per car (8,505 tons per train).

Phase 1 Train Scenario 3

	Week	Tons Processed	Cum Tons Processed	Unit Trains Shipped	Tons Shipped	Cum Tons Shipped	Storage (tons)	Storage (cy)	Delta Storage (cy)
May	1	5174	5174	0	0	0	5174	3449	3449
	2	2807	7980	0	0	0	7980	5320	1871
	3	11718	19698	1	8505	8505	11193	7462	2142
	4	12611	32309	1	8505	17010	15299	10199	2737
June	5	20646	52954	1	8505	25515	27439	18293	8094
	6	22217	75172	2	17010	42525	32647	21764	3471
	7	18406	93578	3	25515	68040	25538	17025	-4739
	8	23336	116914	1	8505	76545	40369	26912	9887
	9	26403	143316	2	17010	93555	49761	33174	6262
July	10	30852	174168	3	25515	119070	55098	36732	3558
	11	31929	206097	1	8505	127575	78522	52348	15616
	12	33934	240031	2	17010	144585	95446	63630	11283
	13	31504	271535	3	25515	170100	101435	67623	3993
August	14	21320	292855	1	8505	178605	114250	76166	8543
	15	19033	311888	2	17010	195615	116273	77515	1349
	16	16843	328731	3	25515	221130	107601	71734	-5781
	17	20905	349636	1	8505	229635	120001	80001	8267
	18	21535	371171	2	17010	246645	124526	83017	3017
September	19	10610	381781	3	25515	272160	109621	73081	-9937
	20	4320	386101	2	17010	289170	96931	64621	-8460
	21	4754	390855	2	17010	306180	84675	56450	-8171
	22	4307	395162	2	17010	323190	71972	47981	-8469
October	23	3038	398200	2	17010	340200	58000	38667	-9315
	24	0	398200	2	17010	357210	40990	27327	-11340
	25	0	398200	2	17010	374220	23980	15987	-11340
	26	0	398200	2	17010	391230	6970	4647	-11340
	27	0	398200	1	8505	399735	-1535	-1023	-5670
November	28	0	398200		0	399735			1023
	29	0	398200		0	399735			0
	30	0	398200		0	399735			0
	31	0	398200		0	399735			0
December	32	0	398200		0	399735			0
	33	0	398200		0	399735			0
	34	0	398200		0	399735			0
	35	0	398200		0	399735			0

Note - assumes 81-car trains, 105 tons per car (8,505 tons per train).

Phase 1 Train Scenario 4

	Week	Tons Processed	Cum Tons Processed	Unit Trains Shipped	Tons Shipped	Cum Tons Shipped	Storage (tons)	Storage (cy)	Delta Storage (cy)
May	1	5174	5174	0	0	0	5174	3449	3449
	2	2807	7980	0	0	0	7980	5320	1871
	3	11718	19698	1	8505	8505	11193	7462	2142
	4	12611	32309	2	17010	25515	6794	4529	-2933
June	5	20646	52954	2	17010	42525	10429	6953	2424
	6	22217	75172	2	17010	59535	15637	10424	3471
	7	18406	93578	3	25515	85050	8528	5685	-4739
	8	23336	116914	3	25515	110565	6349	4232	-1453
	9	26403	143316	3	25515	136080	7236	4824	592
July	10	30852	174168	3	25515	161595	12573	8382	3558
	11	31929	206097	3	25515	187110	18987	12658	4276
	12	33934	240031	3	25515	212625	27406	18270	5613
	13	31504	271535	3	25515	238140	33395	22263	3993
August	14	21320	292855	3	25515	263655	29200	19466	-2797
	15	19033	311888	3	25515	289170	22718	15145	-4321
	16	16843	328731	3	25515	314685	14046	9364	-5781
	17	20905	349636	3	25515	340200	9436	6291	-3073
	18	21535	371171	2	17010	357210	13961	9307	3017
September	19	10610	381781	2	17010	374220	7561	5041	-4267
	20	4320	386101	1	8505	382725	3376	2251	-2790
	21	4754	390855	1	8505	391230	-375	-250	-2501
	22	4307	395162		0	391230	3932	2621	2871
October	23	3038	398200		0	391230	6970	4647	2025
	24	0	398200		0	391230			-4647
	25	0	398200		0	391230			0
	26	0	398200		0	391230			0
	27	0	398200		0	391230			0
November	28	0	398200		0	391230			0
	29	0	398200		0	391230			0
	30	0	398200		0	391230			0
	31	0	398200		0	391230			0
December	32	0	398200		0	391230			0
	33	0	398200		0	391230			0
	34	0	398200		0	391230			0
	35	0	398200		0	391230			0

Note - assumes 81-car trains, 105 tons per car (8,505 tons per train).

Phase 1 Train Scenario 5

	Week	Tons Processed	Cum Tons Processed	Unit Trains Shipped	Tons Shipped	Cum Tons Shipped	Storage (tons)	Storage (cy)	Delta Storage (cy)
May	1	5174	5174	0	0	0	5174	3449	3449
	2	2807	7980	0	0	0	7980	5320	1871
	3	11718	19698	1	8505	8505	11193	7462	2142
	4	12611	32309	1	8505	17010	15299	10199	2737
June	5	20646	52954	2	17010	34020	18934	12623	2424
	6	22217	75172	2	17010	51030	24142	16094	3471
	7	18406	93578	2	17010	68040	25538	17025	931
	8	23336	116914	3	25515	93555	23359	15572	-1453
	9	26403	143316	3	25515	119070	24246	16164	592
July	10	30852	174168	3	25515	144585	29583	19722	3558
	11	31929	206097	3	25515	170100	35997	23998	4276
	12	33934	240031	3	25515	195615	44416	29610	5613
	13	31504	271535	3	25515	221130	50405	33603	3993
August	14	21320	292855	3	25515	246645	46210	30806	-2797
	15	19033	311888	3	25515	272160	39728	26485	-4321
	16	16843	328731	3	25515	297675	31056	20704	-5781
	17	20905	349636	3	25515	323190	26446	17631	-3073
	18	21535	371171	3	25515	348705	22466	14977	-2653
September	19	10610	381781	2	17010	365715	16066	10711	-4267
	20	4320	386101	1	8505	374220	11881	7921	-2790
	21	4754	390855	1	4771	378991	11864	7909	-11
	22	4307	395162	1	8505	387496	7665	5110	-2799
October	23	3038	398200	1	8505	396001	2199	1466	-3645
	24	0	398200	1	8505	404506	-6306	-4204	-5670
	25	0	398200		0	404506			4204
	26	0	398200		0	404506			0
	27	0	398200		0	404506			0
November	28	0	398200		0	404506			0
	29	0	398200		0	404506			0
	30	0	398200		0	404506			0
	31	0	398200		0	404506			0
December	32	0	398200		0	404506			0
	33	0	398200		0	404506			0
	34	0	398200		0	404506			0
	35	0	398200		0	404506			0

Note - assumes 81-car trains, 105 tons per car (8,505 tons per train).

Rail Car Loading Calculations

BBL
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SUBJECT	PROJ. NO.	BY	DATE	SHEET
GE-Hudson River - Rail Car Loading Calculations	20437	TEM	8/5/05	1/1

CALCS. BY TEM ; DATE 8/5/05 CHECKED BY [signature] ; DATE 8/8/05

The attached spreadsheets were adapted from calculations initially prepared by HDR for loading rail cars (42 at a time) from North and South storage structures simultaneously

Per attached calculations, utilizing two 8.7 cy wheel loaders per storage structure, it is estimated to take < 4 hrs to load 42 trains total

∴ to load one 81-car train it is estimated to take 8 working hrs (not accounting for train movements or time necessary to remove/replace covers.

Loader and Material

Type of loader	988 H Caterpillar			
Bucket Size (volume)	8.7	*yd3*		
Rail Car Capacity	80.76923077	*yd3*	*Assuming the material density to be 1.3 tons/yd3*	

Cycle Time

Pad Location (1st or 2nd)	**1st**			
Average Round Trip Distance North Structures	508.5571429	*ft*		
Average Round Trip Distance South Structures	551.09	*ft*		
Wheel Loader Velocity	10	*mph*	14.66666667	*ft/s*
Time for Distance North Structure	34.67435065	*sec*		
Time for Distance South Structure	37.57431818	*sec*		
Cycle Time to Load and Unload	31.2	*sec*		
Cycle Time for Accel, Decel, and misc	39.77777778	*sec*		
Structure Location (North or South)	**North**			
Total Time Traveled to Load Car	140.3264791	*sec*	2.338774651	*min*
Trips Per Hour	25.65445968	*# of trips / hour*		
Amount Transferred in an Hour	223.1937992	*yd3/hr*		
How Long to Load One Railcar	0.362913308	*hrs*	21.77479848	*min*
How Long to Load 21 Railcars Operating With One Wheel Loader	7.621179467	*hrs*	457.270768	*min*
Operating With 2 Wheel Loaders	3.810589734	*hrs*		

Note:

Density of the material is an estimation based on the data provided in the METSIM reports.

Loader and Material

Type of loader	988 H Caterpillar			
Bucket Size (volume)	8.7	*yd3*		
Rail Car Capacity	80.76923077	*yd3*	*Assuming the material density to be 1.3 tons/yd3*	

Cycle Time

Pad Location (1st or 2nd)	**1st**			
Average Round Trip Distance North Structures	508.5571429	*ft*		
Average Round Trip Distance South Structures	551.09	*ft*		
Wheel Loader Velocity	10	*mph*	14.66666667	*ft/s*
Time for Distance North Structure	34.67435065	*sec*		
Time for Distance South Structure	37.57431818	*sec*		
Cycle Time to Load and Unload	31.2	*sec*		
Cycle Time for Accel, Decel, and misc	39.77777778	*sec*		
Structure Location (North or South)	**South**			
Total Time Traveled to Load Car	146.1264141	*sec*	2.435440236	*min*
Trips Per Hour	24.63620298	*# of trips / hour*		
Amount Transferred in an Hour	214.334966	*yd3/hr*		
How Long to Load One Railcar	0.37791314	*hrs*	22.6747884	*min*
How Long to Load 21 Railcars Operating With One Wheel Loader	7.93617594	*hrs*	476.1705564	*min*
Operating With 2 Wheel Loaders	3.96808797	*hrs*		

Note:

Density of the material is an estimation based on the data provided in the METSIM reports.

Distance Calculations for Loading Pad #1

Rail Car Position	Distance Inside Structure	Distance to Loading Pad #1	Distance to Railcar	Total Distance
1	75	125	741.7	941.7
2	75	125	683.4	883.4
3	75	125	625.1	825.1
4	75	125	566.8	766.8
5	75	125	508.5	708.5
6	75	125	450.2	650.2
7	75	125	391.9	591.9
8	75	125	333.6	533.6
9	75	125	275.3	475.3
10	75	125	217	417
11	75	125	158.7	358.7
12	75	125	100.4	300.4
13	75	125	42.1	242.1
14	75	125	100.4	300.4
15	75	125	158.7	358.7
16	75	125	217	417
17	75	125	275.3	475.3
18	75	125	333.6	533.6
19	75	125	391.9	591.9
20	75	125	450.2	650.2
			Average	**551.09**
21	75	125	641.7	841.7
22	75	125	583.4	783.4
23	75	125	525.1	725.1
24	75	125	466.8	666.8
25	75	125	408.5	608.5
26	75	125	350.2	550.2
27	75	125	291.9	491.9
28	75	125	233.6	433.6
29	75	125	175.3	375.3
30	75	125	117	317
31	75	125	58.7	258.7
32	75	125	0.4	200.4
33	75	125	58.7	258.7
34	75	125	117	317
35	75	125	175.3	375.3
36	75	125	233.6	433.6
37	75	125	291.9	491.9
38	75	125	350.2	550.2
39	75	125	408.5	608.5
40	75	125	466.8	666.8
41	75	125	525.1	725.1
			Average	**508.5571429**

Notes:

Each pad holds 41 rail cars and two wheel loaders load the 20/21 railcars that are closest to their respective structure.

Each railcar is 58.3 feet long.

Cycle calculations provided by HDR did not include the distances traveled within the structures and therefore are less than the calculations provided in these worksheets.

Exhibit G.8

Site Work, Roads, Utilities, and Administrative Areas

Includes:

TR-55 Curve Number and Run-Off Depth Calculations

Processing Facility Estimated Stormwater Storage Volumes

Processing Facility Earthwork and Select Fill Summary Table

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Exhibit G.8.1

Site Work, Roads, Utilities, and Administrative Areas Design Calculations

BLASLAND, BOUCK & LEE, INC.
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PROCESSING FACILITY SITE

TR-55 Curve Number and Runoff Depth Calculation

TYPE I Stormwater Management Areas

CURVE NUMBER

Hydrologic Soil Type	Cover Description	CN	Area (Acres)[1]
Claverack C & Wallington C	Impervious Areas - Filter Press Building Area	98	3.01
Claverack C & Wallington C	Impervious Areas - Waterfront Area	98	7.01
Claverack C & Wallington C	Impervious Areas - Roadways and Storage Bldgs.	98	26.97
		Total Area	36.99

Total CN X Area 981.96

Weighted Curve No. 98

RUNOFF DEPTH - Q

Return Interval	Rainfall - P (inches)[3]	Runoff Depth - Q (inches)
10	3.9	3.67
25	4.6	4.36
100	5.6	5.36

(1) Areas have been determined from proposed site plan dated 7-05-05
(2) Estimated runoff depth and storage volumes computed using TR-55 analysis for Type I Stormwater Management (contact) areas only.
(3) 24 hour Rainfall amounts from NRCS TR-55 Reference TP-40 Rainfall Maps

Processing Facility Site
Estimated Stormwater Storage Volumes

Return Interval (Year)	Runoff Depth - Q (Inches)	Area[1] (Sq. Ft.)	Estimated Storage Vol. [2,3] Q X Area (Ft^3)	Estimated Storage Vol. [2,3] (Acre-Feet)	Estimated Storage Vol. [2,3] (Gallons)
10	3.67	1,611,284	492,200	11.3	3,681,700
25	4.36	1,611,284	586,000	13.5	4,383,300
100	5.36	1,611,284	720,100	16.5	5,386,400

(1) Areas have been determined from proposed site plan dated 7-05-05
(2) Estimated runoff depth and storage volumes computed using TR-55 analysis for Type I Stormwater Management (contact) areas only.
(3) Values have been rounded up to the nearest hundred.

PROCESSING FACILITY
EARTHWORK AND SELECT FILL SUMMARY TABLE

LOCATION/DESCRIPTION	EARTHWORK		SELECT FILL MATERIALS					
	Excavation Volume - CY	Fill Volume - CY	Type A (CY)	Type B (CY)	Type C (CY)	Type D (CY)	Type E (CY)	Type F (CY)
Site Grading [1]	17,964	143,952						
Roadways	746	19,004					12,570	
Drainage	2,460							
Sedimentation Basins								
A	7,773							
B	19,260							
C	2,208							
D	1,681							
TOTALS	**52100**	**163000**					**12,570**	
Topsoil Stripping 6"	29900							

Topsoil Stripping Vol = Area of Site Developed x 6 inches = 36.99 Acres X 43560 X .5 / 27 = 29839 CY

NOTES:
1. Topsoil Stripping is not included in Site Grading Cut/Fill Volumes
2. Volume calculations are preliminary and based on the Site Grading and Drainage Plan dated 8-04-05
3. Cut/fill volumes do not include swell/shrinkage factors

Phase 1 Intermediate Design Report
Hudson River PCBs Superfund Site

Attachment H – Design Analysis: Backfilling/Capping

General Electric Company
Albany, New York

August 22, 2005

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

Attachment H – Design Analysis: Backfilling/Capping

This attachment presents the design analysis supporting the development of backfill/cap prototypes and provides an analysis of potential backfill/cap placement equipment and techniques for the Hudson River project.

1. Development of Backfill/Cap Prototypes

Backfill prototypes consider habitat replacement/reconstruction objectives and bed stability as the basis for material selection. Cap prototypes consider many factors, including their ability to isolate PCBs, hydrodynamic influences such as water velocities and vessel forces (i.e., wakes and propeller wash), and the general influence of ice. The effect of these factors on the design analysis for backfill and cap prototypes is discussed below.

1.1 Backfill

As specified in the ROD (EPA, 2002a), backfill will consist of a nominal 12-inch layer of granular material placed on top of the residual sediment layer in dredged areas. An exception may be made if less than 12 inches of sediment are removed in a particular dredge cut, in which case, the backfill will be added to bring the final grade back to the original (pre-dredging) river bed elevation. The primary purposes of the backfill are to reduce surficial PCB concentrations and to provide substrate for habitat restoration. Thus, backfill material is primarily designed using a stable bed approach (i.e., defined for design purposes as being in geomorphic equilibrium during the 2-year flood event), with the goal of providing backfill with stability characteristics similar to the native sediments. In some cases, the backfill will provide the desired habitat characteristics, while in others, the backfill will be designed as stable material upon which natural deposition and revegetation will occur over time (see Section 3.10 of the Phase 1 IDR, Habitat Replacement and Reconstruction). Backfill will not be placed in the navigation channel or in sections of the river where the resultant deeper water (following remediation) is desired for habitat purposes. Backfill will not be placed in areas where post-dredged surficial Tri+ PCB concentrations are less than 0.25 mg/kg, unless necessary to meet specific habitat goals, as these areas would already meet the substantive requirements of the ROD (EPA, 2002a) and Hudson EPS (EPA, 2004).

This section presents a general discussion of how each type of backfill will be used to meet habitat replacement and reconstruction goals, bed stability objectives and other considerations to confirm that the selected backfill is appropriate for the river environment in which it is to be placed.

1.1.1 Habitat Considerations

In 2003 and 2004, the following habitat types were delineated and assessed in candidate Phase 1 areas:

- Unconsolidated river bottom;
- Aquatic vegetation beds;
- Fringing wetlands; and
- Shorelines.

Note that additional habitat assessment activities are being performed in 2005, with results to be incorporated in the Phase 1 FDR. The primary goal of the habitat replacement and reconstruction program is to replace the functions of the habitats of the Upper Hudson River to within the range of functions found in similar physical settings in the Upper Hudson River in light of the changes in river hydrology, bathymetry, and geomorphology that may result from dredging. In support of these goals, and where deemed necessary, backfill material types will be selected to provide an appropriate substrate, as follows:

- **Type 1 Backfill – Medium-Grained Material:** This material will consist of medium to coarse sand of approximately 0.5 to 2.0 mm D_{50} with total organic content ranging from trace up to 2.5%. The acceptable TOC range of Type 1 material may be refined during the Phase 1 Final Design. Type 1 material will be used alone or in combination with other materials (cobbles, woody debris, etc.) as a substrate for aquatic vegetation bed and riverine fringing wetland habitats. This material may also be used in unconsolidated river bottom areas to provide a substrate for benthic macroinvertebrate colonization. Type 1 material can be placed at any water depth where flow velocities are below 1.5 ft/s during a 2-year flow event.

- **Type 2 Backfill – Coarse-Grained Material (Fine Gravel):** This material will consist of fine gravel of approximately 6.0 to 12.0 mm (0.25- to 0.5-inch) D_{50}. Total organic matter content is expected to be minimal. The actual TOC of Type 2 material may be refined during the Phase 1 Final Design. This material will be used to replace or reconstruct unconsolidated river bottom or aquatic vegetation bed habitat to allow benthic invertebrate recolonization and provide fish habitat. Type 2 material can be placed at any water depth where flow velocities are above 1.5 ft/s.

1.1.2 Bed Stability Considerations

The engineering consideration for the selection of backfill is the stability of the material in the river environment. The design objective is to approximate the long-term stability of the existing sediment bed (or as termed herein, a "stable bed" approach) determined by modeling an appropriate high flow condition. The ability of non-cohesive, granular backfill to resist erosion forces is mainly dependent on its grain size. Backfill stability will increase once vegetation is established and/or heavier material is placed on top of the fill. The cohesive interactions that provide stability to very fine bed materials above that expected from size alone would increase stability, but are not considered in this analysis.

Backfill will be selected to resist scour due to river flow such that the newly established bed will remain stable under typical river conditions, a "stable bed" concept. As some degree of bed mobility is natural in river systems, the backfill will not be designed to "armor" the sediment bed with an immovable layer (i.e., it will not be designed to resist extreme erosional forces when the natural bed would be expected to likewise move).

The 2-year flow event was chosen for the backfill stability design as it is generally considered to represent geomorphically balanced, stable bed conditions (Rosgen, 1996; Federal Interagency Stream Restoration Work Group, 1998). River velocities and bed shear stress during the 2-year flow were predicted using the hydrodynamic and hydraulic models developed by the GE (QEA, 1999; Connolly et al., 2000; Ziegler et al., 2000) as presented in Attachment E of the Phase 1 IDR. Due to uncertainties in the final bathymetry, existing river conditions were used in the hydraulic model (i.e., the effect of changes in river bathymetry due to dredging and backfilling were not considered). Additional modeling is planned in support of the Phase 1 Final Design using more current and accurate bathymetric data. However, the magnitude of the changes in modeling results is not expected to be sufficient to alter the underlying basis of design related to hydrodynamic forces present in the Upper Hudson River. Modeling results predict that 2-year flow velocities have a maximum value of 4.6 ft/s over Phase 1 areas, with 85% of the area having velocities less than 3 ft/s. The median (50% value) velocity and shear stress predicted by the model for the Phase 1 dredge areas are 2.5 ft/s and 40 dynes per square centimeter (dynes/cm^2), respectively.

A variety of empirical relations have been developed to determine the size of stable bed material based upon either water velocity or shear stress (i.e., tractive force). While these methods have different underlying conditions or assumptions, they do provide a range of empirically derived values upon which to evaluate appropriate sized backfill material for geomorphic stability. The relations used in assessing potential stability for backfill material under 2-year flow conditions include:

- Julien (1995) – a linear relationship between shear stress and grain size for non-cohesive sediments;
- Lane (1955) – a graphic method based on compilation of many studies relating shear stress to transportable particle size, originally developed for sizing of canal cross-sections;
- Hjulstrom (1935, as presented in Morris and Fan, 1997) – a graphic method for relating critical velocities for erosion, transport and deposition to sediment grain size;
- USACE (1994) – a graphic method suggesting maximum permissible velocity for a range of sediment gradations, based on observed bed material for channels subject to estimated maximum velocities;
- Shields Diagram (Morris and Fan, 1997)– a relationship between shear stress and grain size for incipient sediment motion, the Shields coefficient is subject to some variations depending on the specific study, bed material variability and movement determination (Buffington and Montgomery, 1997); and
- Neill (1973) – a graphic relationship for limiting velocity in terms of grain size and water depth, which assumes bed erosion until the limiting velocity for a given non-cohesive sediment bed gradation is reached.

The stable particle sizes were computed for each of these methods using a range of velocities and shear during 2-year flow conditions. Results are presented in Table H1, below.

Table H1 – Stable Backfill Grain Size at 2-Year Flow Conditions

Relative Frequency (% less than)	Velocity (ft/s)	Shear Stress (dynes/cm^2)	Stable Sediment Size (mm)					
			Julien	Lane	Hjulstrom	USACE	Shields	Neill
16	1.5	11	0.85	0.6	1.4	<0.2	2.2	<0.3
25	1.85	22	2.8	1.8	2.8	0.3	3.8	<0.3
50	2.50	40	5.0	3.5	3.5	0.8	5.4	1
75	2.85	53	6.7	6.0	4.0	1.2	8.0	2
90	3.16	64	8.1	8.5	5.0	1.6	10	3.4
100	4.62	134	17	13	7	4.2	20	12

Based on the potential range of stable sediment size values obtained from the bed stability analysis presented in Table H1, the two backfill material types (i.e., the Type 2 backfill [fine gravel, 6 to 12 mm D_{50} (0.25- to 0.5-inch)] for high-velocity areas, and the Type 1 backfill [medium to coarse sand, 0.5 to 2 mm D_{50}] for the low-velocity areas would provide a stable bed over the range of predicted velocities during a 2-year event, as long they were used in the appropriate areas. As discussed above, it is envisioned that Type 1 backfill will be placed in areas with velocities up to 1.5 ft/s, while Type 2 backfill will be used in the rest of the areas (note that Type 2 backfill could also be used in areas with velocities less than 1.5 ft/s, if habitat considerations require so). As such, the specific type of backfill material to be placed in the dredged areas will be based on desired habitat replacement/reconstruction objectives, as described in Section 3.10 of the Phase 1 IDR. Further details regarding the observed habitat conditions in the river reaches, and the resulting rationale to use the various backfill types therein, will be presented in the Phase 1 FDR.

1.1.3 Other Considerations

Consolidation of both in-situ sediments and the backfill material is an important factor affecting overall stability. Since the residual sediment layer will have been subsurface material prior to dredging, some degree of consolidation would already have occurred. In rare instances, certain riverbed areas may contain sediments with low-bearing capacity such that the sediments will not support the backfill material. In these circumstances, alternate construction techniques such as multiple lifts, time-phased lifts, and/or geotextile base layering will be evaluated. This is not expected to occur based on data collected thus far from the SEDC Program; however, this will be reassessed in the Phase 1 Final Design using all available data. Backfill material is not expected to undergo any appreciable consolidation since no material being used for backfill construction is fine-grained material (defined as material with greater than 50% by weight passing a # 200 sieve) (Palermo et al., 1999).

1.1.4 Summary of Backfill Types

The two potential backfill types are summarized in Table H2, below.

Table H2 – Backfill Conceptual Types

Backfill Type	Habitat Objective
Type 1 - Medium-Grained Material (12-inch layer of medium to coarse sand; 0.5 to 2 mm D_{50})*	Used to promote benthic macroinvertebrate recolonization and as a substrate for aquatic vegetation beds and riverine fringing wetland habitats.
Type 2 - Coarse-Grained Material (12-inch layer of fine gravel; 6 to 12 mm D_{50})*	Used to promote benthic invertebrate recolonization and fish habitat.
No Backfill	Deep-water habitats, navigation channels.

* Refer to Section 3.10 of the Phase 1 IDR for further details on specific habitat objectives and use criteria for these materials types.

1.2 Capping

Capping, in the context of the Hudson River project, plays the role of an engineering contingency to be used in dredge areas where the Residuals Performance Standard is not met. Capping of the residual sediments will then be implemented as a means of reducing the accessibility and availability of PCBs within the system by providing a physical barrier between the residual sediment and the overlying water column. The locations where caps would be applied are described in Section 3.9 of the Phase 1 IDR.

1.2.1 Design Objectives

The design objectives for the sub-aqueous engineered caps as specified in the Hudson EPS (EPA, 2004) include:

- *"Physically isolate the residual sediments from indigenous benthos and minimize bioturbation of the residual sediments;*
- *Resist erosion due to currents, vessel wakes and waves, propeller wash, and ice rafting, etc. and stabilize the contaminated sediments (i.e., prevent resuspension and migration of the contaminated sediments);*
- *Minimize or eliminate the flux of contaminants into the water column;*
- *Maintain integrity among the individual cap layers/components (e.g., address consolidation of compressible materials);*
- *Include consideration of additional protective measures and institutional controls that are needed (e.g., additional controls for caps constructed in any area where future navigation dredging may be necessary, notifications to boaters not to drop anchor in capped areas, etc)."*

The cap design also must address the following elements:

- Selection and characterization of materials for cap construction;
- Equipment and placement techniques to be used for cap construction;
- Appropriate monitoring and management program, including construction monitoring during cap placement, followed by a long-term monitoring and maintenance program (which will include periodic inspections and actions that may be required based on the inspection results); and
- Ability to isolate the contaminated sediments chemically such that the concentration of Tri+ PCBs in the upper 6 inches of the cap is 0.25 mg/kg or less upon placement.

For purposes of design and construction of caps, the above objectives will be satisfied so long as the cap meets the basis of design set forth for the two cap types below.

Prototype designs were developed to account for a range of possible conditions in the river, including, but not limited to, residual sediment PCB concentration, water depth, and anticipated water velocities. Additional considerations may include location in the river (e.g., navigation channel, river banks), and habitat replacement and reconstruction objectives. Cap prototypes have been developed for two basic cap types:

- **Isolation Cap Type A,** to be placed in a CU where the average Tri+ PCB concentration after dredging is less than or equal to 6 mg/kg and capping is necessary; and

- **Isolation Cap Type B,** to be placed in a CU where the average Tri+ PCB concentration after dredging is greater than 6 mg/kg and GE and the EPA have determined that additional dredging is not required.

In the case of both cap types, the caps will be placed over sufficient portions of the CU such that the arithmetic average Tri+ PCB concentration of the uncapped nodes is 1 mg/kg or less and no individual uncapped node has a Tri+ PCB concentration at or above 15 mg/kg.

These prototypes will be "pre-designed" for the range of conditions expected to be encountered after dredging. The objective of developing these prototypes now is to allow construction planning and material procurement to proceed and allow placement after dredging without delay. The prototype designs will need to consider practical limitations and efficiency of the dredging and capping operations and account for factors such as bottom conditions, hydraulic conditions, residuals PCB concentrations, habitat replacement and reconstruction needs, and cap placement success (in completed CUs). The decision regarding appropriate cap type to be installed will be made in the field by GE's field representative (in consultation with the design engineer and subject to approval by EPA's field representative), since the actual performance of the dredge equipment and subsequent residuals concentrations will not be known until project implementation.

<u>Basis of Design for Isolation Cap Type A</u>

The basis of design for Isolation Cap Type A will be as follows:

- The design objectives will be achieved by installation of an armoring layer designed to withstand a minimum 10-year recurrence interval flow event.
- A filter layer (i.e., layer of material with smaller particle size to separate residuals from the armor) will be installed below (or mixed in with) the armor layer, if necessary, to prevent transport of residual sediment up through the armor material. An Isolation Cap Type A will have a total thickness of at least 12 inches when installed, which will satisfy the objective of isolating the residual sediments from indigenous benthos and limiting bioturbation of residual sediment.

Basis of Design for Isolation Cap Type B

The basis of design for Isolation Cap Type B will be as follows:

- The design objectives will be achieved by installation of an engineered isolation layer and an armor layer.
- The isolation layer will consist of material to physically and chemically isolate PCBs in contaminated sediment from the overlying water column. This layer may include a filter layer if deemed necessary for armoring purposes. An Isolation Cap Type B that includes an isolation layer that is at least 6 inches thick and have a minimum TOC content of 0.5% when installed shall satisfy the objective of reducing the flux of Tri+ PCBs from contaminated sediment into the water column. In addition, an Isolation Cap Type B will have a total thickness of at least 12 inches when installed, which will satisfy the objective of isolating the contaminated sediments from indigenous benthos and limiting bioturbation of residual sediment.
- An armoring layer will be designed to withstand a 100-year recurrence interval flow event. The armoring layer will also be designed to withstand ice events, vessel wake, and propeller wash in areas likely to be subject to such events.

1.2.2 Other Design Considerations

Similar to backfill, consolidation of cap material and underlying sediments is an important consideration affecting stability. However, considering the fact that the new sediment layer would most likely have been subsurface material prior to dredging, some degree of consolidation would have already occurred. In rare instances, certain riverbed areas may contain sediments with low-bearing capacity such that the sediments will not support the backfill material. In these circumstances, alternate construction techniques such as multiple lifts, time-phased lifts, and/or geotextile base layering will be evaluated. This is not expected to occur based on data collected thus far from the SEDC Program; however, this will be reassessed in the Phase 1 Final Design using all available data. No consolidation of cap material itself has been assumed since material being used for cap construction is not fine-grained material (defined as material with greater than 50% by weight pass a #200 sieve) (Palermo et al., 1999).

The effects of benthic organisms on the cap have been considered in the cap design. “In the biologically active sediment layer, which can extend down to depths of approximately 5 to 10 cm, rates of diffusion and particle mixing are greatly enhanced by bioturbation” (NRC, 2001). Bioturbation is a broadly defined term for the movement or alteration of sediment particles or porewater as a result of the activities of benthic organisms. It can include specific processes such as bioadvection, biodiffusion, and bioirrigation (Clarke et al., 2001). The depth to which burrowing can occur is dependent on characteristics of both the species and the substrate. More than 90% of the 240 observations for bioturbation depths in both marine and freshwater settings reported by Thoms et al. (1995) were 15 cm or less, with 80% being 10 cm or less. Even in marine settings where the organisms tend to be larger and burrow deeper, the region of sediment heavily affected by benthic organisms tends to be 5 to 15 cm, and "occasionally deeper excisions by organisms generally do not significantly affect the overall mass of contaminants or the exposure of animals living in overlying water" (NRC, 2001). It has also been observed that a sandy substrate inhibits the depth of bioturbation compared to a silty bed (Morton, 1989).

In preparation of the *Guidance for In-situ Subaqueous Capping of Contaminated Sediments* (Palermo, 1998), a survey was made of noted aquatic biologists from several research facilities around the Great Lakes. Most of the researchers found that bioturbation in a sand cap would be limited to the top 5 to 10 cm. In addition, the presence of armor stone should inhibit colonization by deeper burrowing benthic organisms (Palermo et al., 1998). Benthos at such a capped site is likely to be limited to the fine-grained, organic-rich sediments that may deposit on top of the cap or settle in the interstices of armor stone (Palermo et al., 1998).

For the prototype Hudson River caps, a bioturbation allowance of up to 6 inches (15 cm) is within acceptable limits. This is more than the expected depth for bioturbation activity in the upper Hudson River. As long as benthos cannot burrow to the depth of the residual sediment, the cap will perform as designed. For the low-velocity Type A caps, there is a net target cap thickness of 12 inches. For the medium- to high-velocity Type A caps, there is 6 inches of armor with an additional 6-inch fine gravel layer below. For the Type B caps, bioturbation will be limited to the area above the isolation material. There is 6 inches of armor layer for the low-velocity cap; and, for the medium- and high-velocity caps, a 6-inch armor layer and a 3-inch filter layer is provided for, between the residual sediment and the upper cap surface.

1.2.3 Design Evaluations

The following sections provide the basis for the selection of the three main components of the prototype caps – armor layer, filter layer, and isolation or base layer.

1.2.3.1 Armor Layer

Proper armoring is important because many of the sediment-water processes that are responsible for PCBs entering the water column or interacting with biota are only present at or near the sediment bed surface and are directly eliminated by the physical barrier of an intact cap. A properly armored cap also prevents the most obvious transport mechanism for particle bound hydrophobic contaminants such as PCBs - resuspension of particles by scour during high flow conditions. In addition to resuspension, PCBs are subjected to other sediment-water processes within the sediment bed that can contribute to vertical migration. These include molecular diffusion, ground-water induced advection, sediment mixing by river flow-induced turbulence, bioturbation, biodiffusion/bioirrigation, direct desorption, bed structure pressure-induced flows, ebullition of diagenic gases, and emergence and uprooting of aquatic plants or other processes (DePinto, 2003). With an intact cap providing physical separation between the residual sediment and overlying water, for current Hudson River conditions as much as 90% of the non-capped flux can be eliminated even without the consideration of a sorptive isolation layer (Thibodeaux, 2003).

High-river flows can cause hydraulic scour in river areas. The 10-year flow (for Isolation Cap Type A) and 100-year flow (for Isolation Cap Type B) were used as the design criteria. Unlike the stable bed used for sizing potential backfill material, for the Isolation caps, the cap armor layer is determined by a more rigorous standard of specifying material in dis-equilibrium with existing river conditions, sized for essentially no movement or loss. In addition, if Isolation Cap Type B is to be placed in locations where ice scour or vessel wake/propeller wash is likely to be dominant, the cap has been designed with consideration of such forces.

Hydraulic Modeling of River Flows

River velocities and bed shear stress for the 10- and 100-year flow conditions were predicted using the hydrodynamic and hydraulic models developed by GE (QEA, 1999; Connolly et al., 2000; Ziegler et al., 2000) as presented in Attachment E in the Phase 1 IDR. Existing river hydraulic conditions were used in the armor layer design without consideration of the effect of changes in river bathymetry due to dredging. Figures H1 through H8 show the velocity distributions over the Phase 1 dredge areas. These figures will be used as a basis in the determination of armor types that will be used within the dredge area following dredging (if a cap is required).

Isolation Cap Type A Armor Design

For the Isolation Cap Type A, the design objectives will be achieved by installation of an upper surface layer that is designed to withstand a 10-year recurrence interval flow event (e.g., 34,500 cubic feet per second [cfs] at

Fort Edward). The selection of cap armor material types also considered commonly available material types in the project area.

Because of the higher residual sediment concentrations being capped by the Isolation Caps, a more conservative armoring relation, rather than the previously discussed stable bed relation (for backfills), will be used in designing the surface material for these caps. The Isbash equation (Maynord, 1995) was used to determine the median grain size (D_{50}) for the Isolation Cap Type A armor stone as follows:

$$D_{50} = \frac{C * V^2}{\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)}$$

where:

D_{50} = median stone diameter (ft)

C = Isbash constant for embedded stone (0.69)

g = acceleration due to gravity (32.2 ft/sec^2)

γ_s = specific weight of stone (165 lb/ft^3)

γ_w = specific weight of water (62.4 lb/ft^3)

V = velocity (fps)

The Isbash equation yields an armor that is essentially "non-moving" under the action of the design forces considered. For the designated velocity ranges, the resulting stone sizes based on the Isbash equation are given below in Table H3.

Table H3 - Isolation Cap Type A Armor Sizing

Velocity (ft/s)	D50 (inches)
1.5	0.18
3.5	0.96
5	1.96

Based on the range in stable stone size presented above, the Isolation Cap Type A for the low-velocity areas (<1.5 ft/s during a 10-year event) will consist of a 12-inch layer of fine gravel (6 to 12 mm, or 0.25- to 0.5-inch

D_{50}). Approximately 10% of the Phase I area has 10-year velocity less that 1.5 ft/s. The fine gravel will provide both physical isolation and armoring for the low-velocity Type A cap.

For medium- to high-velocity Isolation Cap Type A placed in areas with flow greater than 1.5 ft/s at a 10-year flow event, a 6-inch thick armor layer consisting of coarse gravel material (2-inch D_{50}) will be provided to resist the higher velocities. Note that the upper surface layer of coarse gravel should be stable to a velocity slightly exceeding 5 ft/s (which is the higher end of the maximum predicted 10-year velocity range), based on Table H3. This layer will be placed above a 6-inch base layer consisting of fine gravel, resulting in a total layer thickness of 12 inches for this cap.

Isolation Cap Type B Armor Design

For the Isolation Cap Type B, the armor layer is designed to withstand a 100-year recurrence interval flow event (e.g., 47,300 cfs at Fort Edward). The low-velocity armor for the Isolation Cap Type B is designed to withstand a maximum water velocity of 1.5 ft/s. Approximately 60% of the Phase 1 area has predicted 100-year velocities above 3.5 ft/s, falling into the high-velocity designation. The high-velocity armor for the Isolation Cap Type B is designed to withstand a water velocity of 6 ft/s. Less than 2% of the Phase 1 area has predicted velocities exceeding 6 ft/s.

Like Isolation Cap Type A, the Isbash equation (Maynord, 1995) was used to determine the median grain size (D_{50}) for the Isolation Cap armor stone. In addition, due to the higher residual concentrations that this cap is intended to protect against, an additional safety factor of 1.33 was used to account for potentially variable localized velocities within the modeled hydrodynamic grid and to account for other data uncertainties. For the designated velocity ranges, the resulting stone sizes based on the Isbash equation with and without the factor of safety are given below in Table H4, below

Table H4 - Isolation Cap Type B Armor Sizing

Armor Stone Sizing from Isbash Equation		
Velocity Range (ft/s)	D50 (inches)	D50 * FS[1] (inches)
1.5	0.18	0.23
3.5	0.96	1.27
6	2.83	3.77

Note: FS = Factor of safety = 1.33

In the low-velocity areas (<1.5 ft/s during a 100-year event), the Isolation Cap Type B armor will consist of a 6-inch layer of fine gravel (6 to 12 mm, or 0.25- to 0.5-inch D_{50}).

For the Isolation Cap Type B in medium-velocity areas (>1.5 ft/s but <3.5 ft/s), the armor layer consists of a 6-inch layer of coarse gravel (2 inches D_{50}).

For the Isolation Cap Type B in high-velocity areas (>3.5 ft/s), the armor layer consists of a 6-inch layer of cobble-sized material (4-inch D_{50}). Note that the layer thickness above accounts for guidance specifying the need for thickness to be greater or equal to 1.5 times the D_{50}, and the need to consider constructability aspects when specifying layer thickness (Maynord, 1995; Palermo et al., 1998).

<u>Vessel Effects</u>

Vessel effects that could potentially act on the cap include prop wash and vessel wake. Data from the NYSCC regarding vessels using the river were used to estimate vessel effects. Only those vessels with dimensions that would allow them to use the Champlain Canal (depth = 12 feet) were considered. Vessel specifications for the three classifications of watercraft used in this evaluation are presented in Table H5, below.

Table H5 - Vessel Specifications Summary Table

Watercraft	Velocity (mph)	Draft (ft)	Width (ft)	Length (ft)	Applied HP	Propeller Diameter (ft)	Depth of Propeller Axle (ft)
Tugboat	6	6	13	60	800	3	3
High-Speed Pleasure Boat	12	1.5	8	25	50	1.4	2
Cabin Cruiser	10.5	4	14	50	100	2	2

<u>Note</u>:

1. mph = miles per hour

Propeller Wash

Propeller wash was estimated using the equation given by Blaauw and Van de Kaa (1978), as follows:

$$V_{bp} = C_1 * U_o * \frac{D_p}{H_p}$$

where:

V_{bp} = maximum bottom velocity, expressed in ft/s

C_1 = 0.22 for non-ducted propellers

D_p = propeller diameter, expressed in feet

H_p = the distance from the propeller shaft to the channel bottom, expressed in feet

U_o = jet velocity exiting the propeller, expressed in ft/s

U_o is estimated as follows:

$$U_o = C_2 * \left(\frac{P_d}{D_p^{\,2}} \right)^{1/3}$$

where:

C_2 = 9.72 for non-ducted propellers

P_d = applied engine power, expressed in horsepower (hp)

In an analysis of prop wash effects at aquatic disposal sites, Clausner and Truitt (1987) noted that for practical purposes, the stable particle size computed by the above methods is probably too large. Following were some of the reasons cited by Clausner and Truitt (1987):

- It is unlikely that the craft will be operating at a high throttle within a confined channel;
- The bottom velocities are reduced if the craft is underway; and
- The length of time a craft is over a given location is probably small.

Propeller wash-induced bottom velocities were nevertheless evaluated for each vessel type at a range of water depths using the above methods. This analysis assumed that the tugboat activity would be restricted to in or near the navigation channel, and that the high-speed pleasure craft and cabin cruisers would navigate both deep and shallow waters (i.e., as shallow as 5 feet). Propeller wash from the tugboat was evaluated for water depths ranging from 10 to 30 feet. Propeller wash from the high-speed pleasure craft and cabin cruiser was evaluated for water depths ranging from 5 to 30 feet. The resulting bottom velocities are shown in Table H6, below.

Table H6 - Propeller Wash Bottom Velocities

Watercraft	Jet Velocity (ft/s)	Water Depth (ft)						
		30	25	20	15	10	7.5	5
		Bottom Velocity (ft/s)						
Tugboat	43.3	1.1	1.3	1.7	2.3	4.1	NA	NA
High-Speed Pleasure Craft	28.6	0.3	0.4	0.5	0.7	1.1	1.6	2.9
Cabin Cruiser	28.4	0.5	0.5	0.7	1.0	1.6	2.2	4.2

These velocities are within the low-high flow velocity range already anticipated for the 10- and 100-year storms being used as criteria for the Type A and Type B Isolation Caps, respectively. In general, watercraft prop wash impacts are likely to produce velocities less disruptive than flood events in high-velocity areas. In rare occurrences where a craft passes through very shallow water, some disruption to the cap surface may take place; however, there would likely be no substantial loss of cap material (due to the short impact time, the relatively small area affected by the propeller wash and the relatively high settling velocity of these materials). For example, the fine gravel used in the low-velocity Type B cap has settling velocities on the order of 1 ft/s.

Vessel Wakes

Vessel wakes can erode shorelines and shallow water areas. Vessel wakes are generated due to the pressure gradient that develops along the vessel hull as it moves through the water. The height of the wake wave depends on the vessel speed, bow and stern geometry, and the clearance between the vessel hull and channel bottom and sides. The period and direction of the wake waves is dependent on vessel speed and water depth. Vessel-generated waves decrease with increasing distance from the vessel (*Coastal Engineering Manual)* (USACE, 2002).

The USACE's *Coastal Engineering Manual* recommends reviewing published vessel wave measurement data to compare with the vessel, vessel speed, and channel conditions that most closely approach the design conditions and select a conservative wave height from these data. Two sources were reviewed for this evaluation: Maynord (2001) published vessel wake wave measurement data for vessels 16 to 20 feet in length and motors ranging from 35 to 50 hp. Wake waves were measured on Johnson Lake and on the Kenai River, Alaska. The maximum wake wave produced for all conditions was 1.07 feet.

The USACE's *Interim Report for the Upper Mississippi River – Illinois Waterway System Navigation Study, Prediction of Vessel-Generated Waves with Reference to Vessels Common to the Upper Mississippi River System* (Sorenson, 1997) summarizes vessel wake data collected from cruiser-type vessels at velocities ranging from 2 to 14 mph in water depths ranging from 10 to 33 feet. Wave height data were collected at distances ranging from 40 to 800 feet from the vessel. The maximum reported wave wake is approximately 2.1 feet.

Since only two published data sets were found that could be applied to the project environment, vessel-generated wave wake was also modeled. Several methods for modeling vessel wake are available in the literature; however, most are only applicable for deepwater conditions and non-breaking waves. Deepwater conditions are defined as Froude number (F_r) less than 0.7. Froude number is calculated by:

$$F_r = \frac{V}{\sqrt{gd}}$$

where:
V = vessel velocity, expressed in ft/s
g = gravitational constant, 32.2 ft/s^2
d = water depth at the vessel, expressed in ft

Non-breaking wave conditions exist when H_{max}/d is less than 0.6 and where H_{max} is the maximum height of the vessel-generated wave. The Froude number under the site conditions generally did not meet the criteria for deepwater conditions. Therefore, the equation given by Hochstein in USACE, 1980 was used to estimate the maximum wave height (H_{max}) generated by watercraft. The equation is given by:

$$H_{\max} = 0.0448V^2\left(\frac{D}{L}\right)^{0.5}\left(1-\frac{bD}{Ac}\right)^{-2.5}$$

where:
L = length of vessel, expressed in feet
V = vessel velocity, expressed in ft/s
Ac = cross sectional area of the channel, expressed in ft^2
D = draft of vessel, expressed in feet
b = width of vessel, expressed in feet

The wake was estimated for cross-sectional areas ranging from 2,000 to 120,000 ft^2 based on estimated channel bathymetry. The high-speed pleasure craft was found to generate the largest vessel wake, with a maximum wave height of 2.98 feet at a 2,000 ft^2 channel cross-section.

The effect of a 3-foot wave on the river bed is generation of a bottom velocity of 3.3 ft/s (calculated as the maximum horizontal velocity at edge of the bottom boundary layer, U_m). This is developed from the relationship given by Sheng and Lick, (1979):

$$U_m = \frac{\pi H}{T * \sinh\left(2\pi h / L\right)}$$

where:

H = wave height in ft

T = wave period in seconds

L = wave length in ft, and

h = water depth in ft

The resulting velocity from this equation was also confirmed using USACE's computer program, ACES (Automated Coastal Engineering System). This velocity is within the medium to high flow-velocity range already anticipated for the 10- and 100-year storms being used as criteria for the Type A and Type B isolation caps respectively. Thus, vessel wake effects are likely to produce velocities less disruptive than flood events in high-velocity areas. In rare occurrences where a craft passes through very shallow water, some disruption to the cap surface may take place; however, there would likely be no substantial loss of the cap material (due to the short impact time, the relatively small area affected by the event and the relatively high settling velocity of these materials).

Ice Effects

Ice can damage armor layers through the plucking of stones by rising and falling water levels and by ice shoving, as well as indirectly damaging armor layers through turbulent, high-flow produced beneath ice jamming. An analysis of potential ice impacts in the Phase I area was performed in June 2005 by Dr. George Ashton (see Attachment I to the Phase 1 IDR).

Findings by Dr. Ashton include:

- Dams at and upstream of Hudson Falls retain ice in those upstream reaches. This fact, combined with no observed tree scarring other than at the water line caused by floating debris, leads to a conclusion that there is no historical evidence of ice jamming from the upstream end of Rogers Island to the Thompson Island Dam;

- Frazil ice (ice in very small crystals formed in supercooled flow, slightly below 0ºC) formation upstream of Rogers Island is possible, and if transported downstream and accumulated on the underside of the ice cover could increase local velocities to a limiting critical velocity of approximately 2.0 to 2.3 fps. Above this velocity, the frazil ice would stay in the water column and be transported further downstream;

- Anchor ice (frazil ice which is distributed through the depth of the flow and attaches itself to the bottom sediments) formation is limited to areas above Rogers Island with little potential for anchor ice formation in designated dredge areas; and

- There is some potential for freezing of shallow waters (less than 2-foot depth) that could entrain sediments. However, areas of the river conductive to the thickest ice formation are also protected areas outside of the main flow where the ice may melt in place.

This limiting critical velocity for frazil ice is within the medium to high flow-velocity range already anticipated for the 10- and 100-year storms being used as criteria for the Type A and Type B Isolation Caps, respectively. Thus, normal ice effects are likely to produce velocities less disruptive than flood events in high-velocity areas. In situations where ice impacts very shallow water, some disruption to the cap surface may take place, however, it is expected that there would likely be minimal loss of sediment from the cap due to the relatively small areas affected by the event.

Further details of the ice analysis, as presented in Dr. Ashton's report, are included in Attachment I to the Phase 1 IDR.

1.2.3.2 Filter Layer

The objective of a filter layer is to protect the residual sediments or base layer from hydraulic "winnowing" (i.e., loss of smaller particles, such as the isolation material, through the void spaces in much larger material, such as the armor) and/or scour, and help to distribute the load induced by the armor layer so that the geotechnical instability of the residual sediments and/or engineered isolation layer is minimized. The filter layer is needed only for the armoring specified in the medium-velocity and high-velocity Isolation Cap Type B. The filter layer criteria, however, is used in evaluating the base layer of the medium to high-velocity Isolation Cap Type A. The Terzaghi-Vicksburg criteria (1943) are often used as guidelines in the design of a filter layer. Three criteria must be met to provide hydraulic stability. These criteria must be met when comparing the armor and filter layers, as well as the filter layer and the underlying material. These criteria are:

Armor layer $_{(A)}$ and filter layer $_{(F)}$:

$D_{15(A)} < 5D_{85(F)}$;
$20D_{15(F)} > D_{15(A)} > 5D_{15(F)}$; and
$D_{50(A)} < 25D_{50(F)}$.

Filter layer $_{(F)}$ and isolation or base layer $_{(IC)}$:

$D_{15(F)} < 5D_{85(IC)}$;
$20D_{15(IC)} > D_{15(F)} > 5D_{15(IC)}$; and
$D_{50(F)} < 25D_{50(IC)}$.

For application to Hudson River capping, among the various criteria, the relation $D_{15(A)} < 5^* D_{85(F)}$, which deals with winnowing of material through the armor, is the most important, since this controls the long-term physical stability of the cap's isolation layer.

Based on estimates of the relative size of the potential armor and underlying material, gradation for the suggested filter layer is 0.25- to 0.5-inch (6 to 12 mm) fine gravel.

According to the USACE's *Hydraulic Design of Flood Control Channels* (USACE, 1991/1994), at minimum, the filter layer thickness should be 25% of the armor stone layer thickness. In this case, assuming the 6-inch stone armor material, the resulting thickness is 1.5 inches. However, because it may not be practical to place such a thin layer underwater, a filter layer with a 3-inch thickness is used in the cap design.

1.2.3.3 Base/Isolation Layer

The type of isolation cap (i.e., Isolation Cap Type A or Type B) will be used to determine the type of base isolation layer required to control PCB migration into the water column. Since the physical presence of the cap will isolate the residual sediments from direct interaction with the water column, the possibility of scour is reduced and potential PCB mobility is primarily associated with the dissolved phase.

The Isolation Cap Type A will not include a base isolation layer specifically designed to provide a chemical barrier. Instead, this cap will provide isolation by reducing the potential for erosion of residual sediment and provide a physical barrier to direct intrusion by benthic biota. To provide a barrier to benthic intrusion, a 6-inch layer of fine gravel type material should provide adequate protection. For the low-velocity Type A caps, the base layer will be 12 inches thick; while for the medium to high-velocity Type A caps, the base layer will be a 6-inch thick fine gravel material, with another 6 inches of coarse gravel armor placed over it.

An adsorptive isolation layer is included in Isolation Cap Type B. The adsorptive layer will contain a minimum of 6 inches of fine sand with a TOC content of 0.5%. The adsorptive isolation layer is intended to control diffusive and advective flux of dissolved PCBs through the cap. Diffusive flux is a relatively slow process in which a solute moves from areas of higher concentration to areas of lower concentration due to random molecular motion, whereas for advective flux, solute mass transport is driven by fluid movement (e.g., groundwater flow). As described above in Sections 1.3.1 and 1.3.2 of this attachment, bioturbation should be limited to the armoring and filter layers above the isolation material.

Mathematical models were used to estimate flux through the isolation layer due to diffusive and advective processes, and are presented in subsequent sections.

The two major design parameters for the isolation layer of the Isolation Cap Type B are the organic carbon content (or other measure of sorptive capacity) and the layer thickness. As noted above, the minimum thickness for the isolation layer is 6 inches with a TOC content of 0.5%. The organic carbon content of the isolation layer material increases the ability of the layer to sorb PCBs, providing greater retardation of PCB migration through the layer. The thickness of the isolation layer controls the time for migration through the layer – migration time increases proportionately with thickness.

Chemical Migration by Diffusion

Diffusive flux is mathematically modeled by Fick's law taking the general form:

$$\frac{\partial C}{\partial t} = D\left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2} + \frac{\partial^2 C}{\partial z^2}\right)$$

where:

C = solute concentration

t = time

x, y, and z = the three directions of the Cartesian coordinate system

D = the diffusion coefficient

The solution for one-directional chemical flux via diffusion through the chemical isolation layer of a cap is estimated by Wang et al. (1991), Thoma et al. (1993), and Murray et al. (1994), as:

$$\frac{F_t}{F_{ss}} = 1 + 2\sum_{N=1}^{\infty} -1^N \exp\left(\frac{-D_t N^2 \rho^2 t_b}{L^2}\right)$$

where:

F_t = Flux at time 't', expressed in kg/yr/m^2

F_{ss} = Steady-state flux expressed in kg/yr/m^2

t_b = breakthrough time expressed in seconds

L = cap thickness expressed in cm

D_t = transient transport effective diffusion coefficient expressed in cm/s, where $D_t = \frac{D_e}{R}$

R = retardation factor (unitless), where $R = \varepsilon + \rho_b K_p$

D_e = effective diffusivity expressed in cm^2/s, where $D_e = D_w e^{4/3}$

D_w = chemical diffusivity expressed in cm^2/s

ε = sediment porosity (unitless)

K_P = partitioning coefficient (L/kg), where $K_p = K_{oc} f_{oc}$

K_{oc} = chemical distribution coefficient (L/kg)

f_{oc} = fraction of organic carbon (unitless)

ρ_b = bulk density expressed in g/cm^3

Using the conservative assumption of an infinite supply of PCB in the residual sediment to calculate breakthrough (5% of maximum flux) time (t_b in seconds),and steady state (95% of maximum flux) time (t_{ss}), the above equation reduces to:

$$t_b = \frac{0.54L^2}{D_t \pi^2}$$

and

$$t_{ss} = \frac{3.69L^2}{D_t \pi^2}$$

Chemical Migration by Advection

When groundwater movement through the sediment and isolation layer occurs, solute transport occurs via both advective and diffusive processes. The following one-dimensional advective/dispersive equation incorporating a retardation factor for adsorption of PCBs was used to estimate the breakthrough and steady-state times associated with advective transport of PCBs through the isolation layer:

$$\frac{\partial C}{\partial t} = \frac{D_H}{R}\frac{\partial^2 C}{\partial x^2} - \frac{V}{R}\frac{\partial C}{\partial x}$$

The solution to this equation is given by (Bedient et al., 1985; Fetter, 1993):

$$C(x,t) = \frac{C_0}{2}\left[erfc\left(\frac{Rx - Vt}{2\sqrt{RD_H t}}\right) + \exp\left(\frac{V_x}{D_H}\right) erfc\left(\frac{Rx + Vt}{2\sqrt{RD_H t}}\right)\right]$$

where:

C = porewater concentration at location x at time t

C_o = porewater concentration in the residual layer

erfc is the complementary error function

The second term of the equation can be neglected where advective processes are the predominant mechanism of transport without introduction of measurable error (Ogata and Banks, 1961). When x is set to the isolation layer thickness (L), the equation then reduces to:

$$\frac{C}{C_o} = \frac{1}{2} erfc\left(\frac{RL - Vt}{2\sqrt{RD_H t}}\right)$$

In the presence of dissolved organic carbon, which may facilitate the transport of PCBs, a lower limit of the retardation coefficient associated with DOC-facilitated transport can be estimated as (Magee et al., 1991):

$$R = 1 + \frac{\left(K_p \rho_b / \varepsilon\right)}{\left(1 + K_{DOC} M_{DOC}\right)}$$

where:

K_{DOC} = chemical – DOC distribution coefficient (L/kg)

M_{DOC} = concentration of porewater DOC (kg/L)

Cap Design Assumptions

For the purposes of modeling mass transport through the cap during the design, the base isolation layer of the cap was assumed to have the following characteristics (see Table H7, below):

Table H7 - Isolation Cap Type B Parameter Summary Table

Parameter	Value
Thickness of isolation layer	6 inches
TOC of isolation material	0.5%
Cap Bulk Density	1.5 g/cm^3
Cap Porosity	0.4 (unitless)

Where measurable upward seepage of groundwater is present, mass transport will be dominated by advection through a cap. This assumption was tested using the dimensionless Peclet number, which indicates the relative magnitude of diffusion to advection in the cap (Palermo et al., 1998). The Peclet number for conditions in the Upper Hudson River is much greater than 1 indicating advection dominates; therefore, only the results from the advective transport analytical modeling are presented. To evaluate the performance of the cap with the above characteristics, representative conditions for the river were selected as inputs to the advective mass transport equation (see Table H8, below):

Table H8 - Sediment Parameter Summary Table for Cap Modeling

Parameter	Basis	Source
Seepage Velocity	0.18 $L/m^2/hr$	TIP Report (QEA, 1998)
Dissolved Organic Carbon	33.7 mg/L	TIP Report (QEA, 1998) Butcher and Garvey, 2004
Hydrodynamic Dispersion Coefficient	1E-10 m^2/s	Tchobanoglous and Schroeder, 1985
K_{OC}	$10^{5.4}$ L/kg	TIP Report (QEA, 1998)
K_{doc}	$10^{4.4}$ L/kg	(Koc *0.1) (OBG, 1991) (Koc *0.033) (Butcher and Garvey, 2004)
Sediment TOC	2.5%	Range 1-4% (SSAP) 1.8% (Butcher and Garvey, 2004)
TOC of Isolation Material	0.5%	To provide sufficient retardation properties; expected to be available from local sources.

These values are reasonably conservative for the Upper Hudson River. The seepage velocity used represents the highest measured rates from six locations along the Thompson Island Pool during late spring. The average for all measurements was 0.04 $L/m^2/hr$. Connolly et al. (2000) indicated a log K_{oc} of 6.26 near Fort Edward, decreasing to 5.6 at Thompson Island Pool for Tri+ PCBs. Erickson et al. (2005) estimated a Tri+ PCB log K_{oc} of 5.55. Butcher and Garvey (2004) found log K_{oc} of 5.7 or greater for all studied tri+ congeners, and the corresponding K_{doc} values ranging from 0.09 to 0.01 times K_{oc} (averaging 0.033 K_{oc}). The low K_{doc} values are consistent with the observation that paired measurements of water and sediment indicated DOC-facilitated transport was not a significant factor in determining PCB phase distribution in Hudson River water and sediments (Connolly et al., 2000).

Based upon the parameters listed above, the breakthrough time for the 6-inch isolation layer would be approximately 80 years with steady state flux achieved in 120 years. These values are specific to the conditions listed above, but do provide an estimate of the anticipated performance. Other conservative assumptions included no depletion of the residual sediment PCB source by losses either from degradation or migration, no desorption of PCB fraction within the sediment matrix and no additional retardation provided by the filter and/or armor layer material or deposition of new sediment. The continuation of sediment deposition for at least the next several decades is predicted by the sediment transport model, even if the river experiences extreme events such as the 100-year flood (Connolly et al., 2000). Based on Cesium-137 (Cs-137) profiles, ongoing sediment deposition is averaging approximately 0.5 to 1 cm/year, which, given the higher natural TOC in native sediments compared to cap material, is the equivalent of approximately 10 to 30 years of sorption capacity.

Even if breakthrough eventually occurs, the cap can provide significant reduction in flux compared to the uncapped condition. Connolly et al. (2000) had previously noted that vertical advection is not significant in the Upper Hudson River sediment bed. Thibodeaux (2003) graphically illustrated the theoretical behavior of PCB flux from sediments related to differences in mass transfer coefficients associated with various bed processes. In terms of chemodynamics, the role of capping is to decrease the mass transfer coefficient present at a site. While the decrease is certainly greater prior to breakthrough, the cap at steady state still can significantly reduce the flux of PCBs. In a comparison of generic order of magnitude flux rates, Thibodeaux (2003) found that the various processes at the surface sediment can be 2 to 3 orders of magnitude greater than the advective processes.

To compare the relative advective flux at steady state with the flux under the "without cap condition", the advective flux can be compared to a corresponding surface flux based on observed sediment-water exchange coefficients. Due to the complexities in understanding the contributions of individual processes associated with sediment water exchange of chemicals, Thibodeaux et al. (2001) proposed use of a mechanistic model of sediment-water exchange using "field-observed" exchange coefficients. Several attempts have been made to define a PCB sediment water exchange coefficient (K_f) for the Upper Hudson River for non-scour flow conditions. Connolly et al. (2000) found the winter value of K_f for Tri+ PCBs to be approximately 3 cm/day, increasing to 10 to 14 cm/day in the spring. Erickson et al. (2005) computed average K_f for 12 congeners, ranging from 2.6 to 18.8 cm/day, with an estimated Tri+ PCB exchange coefficient of 12.8 cm/day (individual determinations ranging from 1.04 to 64.6). This was in good agreement with earlier EPA (2000) estimates that averaged 12.15 cm/day (ranging from 1.96 to 44.7). Butcher and Garvey (2004) present a value of 14.8 cm/day for Tri+ PCBs in the Thompson Island Pool sediments. Note that the observed K_f value is more than 2 orders of magnitude larger than the effective transfer based solely on the molecular diffusion coefficient for PCBs in porous sediments, indicating that, even at the surface, molecular diffusion by itself is not a significant mechanism of PCB migration (Erickson et al., 2005).

The sediment-water exchange coefficient values are multiplied by the concentration difference between PCBs in the sediment pore water and the overlying water column, or if the overlying water concentration is assumed to be zero thereby maximizing the gradient, the relation simplifies to K_f times the pore water PCB concentration to derive a flux. Similarly, at steady state, the flux due to advective transport is the seepage velocity (specific discharge) times pore water PCB concentration. The 0.18 L/m^2/hr (representing the value during the maximum recorded period) corresponds to a velocity 0.43 cm/day. Using a conservative K_f of 5 cm/day and an assumed residual Tri+ PCB concentration of 10 mg/kg, if uncapped, the flux is estimated at 53 mg/m^2/yr. If capped, the steady state flux (estimated to occur after more than 100 years) for a seepage velocity of 0.43 cm/day is less than 5 mg/m^2/yr.

Even using a relatively high value for advective transport, the physical segregation provided by the cap accounts for more than 90% of the flux reduction during non-scour periods (as well as elimination of resuspension) compared to rates if the residual were in contact with the water column, with additional flux suppression being provided for nearly a century by the isolation layer. These results are in general agreement with the order of magnitude assessment of bed transport processes developed by Thibodeaux (2003).

The values presented above are for illustrative purposes only to provide a representative example of anticipated cap performance in the Upper Hudson River for the prototype Isolation Cap Type B. The values given are neither being presented, nor should they be interpreted, as numeric goals for cap performance.

1.2.3.4 Cap Selection - Other Considerations

The above-described cap types will need to be modified to include additional engineering considerations under three conditions: a) when the cap is placed along a shoreline; b) when a cap is placed within the navigational channel; and c) when a cap interfaces laterally with either the native sediment or backfill material. These conditions are discussed below.

Shoreline areas: As discussed in the steps for developing dredge prisms (Section 3.3.3.1 of the Phase 1 IDR), a 2-foot vertical cut will be made at the shoreline for dredge areas that come in contact with the shoreline. Then, the slope from the bottom of this cut to the DoC line will be 3 horizontal to 1 vertical (3:1). Following completion of dredging activities, one of the backfill or other appropriate material types will be used up to the shoreline areas and any structures placed in the river (such as sheet piling) will be removed. In shoreline areas that require capping, the cap will be constructed so that the elevation and slope of the final cap surface results in stable shoreline conditions (3:1 side-slopes). Additional protection will likely be needed for maintained shorelines disturbed by site activities (e.g., shoreline areas with existing riprap). In these areas, the shoreline will be restored to at least its pre-remediation level of protection. For natural shorelines, there are habitat treatments that may be employed, as described in Section 3.10 of the Phase 1 IDR. The shoreline stabilization design details will be completed during Phase 1 Final Design. A conceptual detail for shoreline stabilization is presented on Contract Drawing H-0052.

Navigation channel: In conformance with the Residuals Performance Standard, should a cap be placed in the navigation channel, the cap must be placed so the final surface is no higher than the prescribed channel depth and includes an indicator layer of coarse material to signal the proximity of the cap during future navigation dredging. In certain cases, additional dredging, beyond inventory and residual dredging, may be needed to deepen the area to the required depth. In these cases, the residuals will be tested to determine whether capping is still required following completion of the deepening dredging passes. These special cases will be evaluated during Phase I Final Design.

Interface with native sediment or backfill: At the lateral extent of each cap, the cap will either interface with shoreline (discussed above), native sediment in the river or areas to be backfilled. To the extent practicable, efforts will be made so that the cap smoothly transitions to the native bed or post-backfill elevation. The cap material will either taper upward or downward (depending on the relative position in comparison to other material) at a slope to be determined during the Phase 1 Final Design. To provide protection against undercutting of the cap, the upper layer of cap material (and the filter material, if used) will be placed along the slope with native material. For the interface with the backfill material, the cap will be placed first and tapered (at a slope to be determined during the Phase 1 Final Design). The backfill will then be placed covering part or all of the tapered portion of the cap. Further details of these concepts will be presented in the Phase 1 FDR.

1.2.3.5 Summary of Prototype Caps

Based on the information presented above, six prototype cap designs have been developed to address the range of conditions expected to be encountered in dredged areas. These six caps represent a combination of two PCB concentration ranges as described in Section 3.9 of the Phase 1 IDR (i.e., Isolation Cap Type A in CUs with average Tri+ PCBs ≤ 6 mg/kg and Isolation Cap Type B in CUs with average Tri+ PCBs > 6 mg/kg) with three flow-velocity ranges (0 to 1.5 ft/s; 1.5 to 3.5 ft/s; and greater than 3.5 ft/s), as summarized in Table H9, below.

Table H9 - Summary of Design for Prototype Caps

Cap Type	Velocity Area	Cap Materials	Thickness
Isolation Cap Type A	Low-velocity	• Fine gravel, 0.25- to 0.5-inch D_{50}.	12 inches
	Medium- to High-velocity	• Isolation layer of fine gravel, 0.25- to 0.5-inch D_{50} ; and	6 inches
		• Armor layer of coarse gravel, 2-inch D_{50}.	6 inches
Isolation Cap Type B	Low-velocity	• Isolation layer of fine sand with a TOC of approximately 0.5%; and	6 inches
		• Armor layer of fine gravel, 0.25- to 0.5-inch D_{50}.	6 inches
	Medium-velocity	• Isolation layer of fine sand with a TOC of approximately 0.5%;	6 inches
		• Filter layer of fine gravel, 0.25- to 0.5-inch D_{50}; and	3 inches
		• Armor layer of coarse gravel, 2-inch D_{50}.	6 inches
	High-velocity	• Isolation layer of fine sand with a TOC of approximately 0.5%;	6 inches
		• Filter layer of fine gravel, 0.25- to 0.5-inch D_{50}; and	3 inches
		• Armor layer of cobbles, 4-inch D_{50}.	6 inches

Note that these specifications may be refined during Final Design, based on additional data.

2. Review of Potential Placement Techniques and Equipment

The accuracy and efficiency of material placement during backfilling/capping operations are critical to promoting the effectiveness of remedial activities. During Phase 1 Intermediate Design, several backfilling/capping techniques were evaluated based on their applicability to sediment types found in the river, anticipated environmental conditions that would occur in the Upper Hudson River, and estimated accuracy in the field. To compare potentially applicable methods, a literature review and review of completed projects were conducted to supplement prior experience. Due to the different types of backfilling/capping materials and the various river regimes, several techniques are potentially applicable at the Hudson River.

This attachment provides an overview of the backfilling/capping techniques evaluated, including the following:

- Conventional equipment;
- Spreading via barge movement;
- Pipeline with baffle plate or sand box;
- Clamshell bucket;
- Submerged diffuser;
- Sand spreader barge; and
- Trémie pipes.

While surficial (i.e., at the water surface) placement techniques such as surface discharge and barge spreading are commonly used in deep water applications, and techniques such as clamshell are applicable to almost any situations, concerns over water column effects have driven some projects to use submerged discharge. Herbich (2000) notes that "If the placement of contaminated sediment by surface discharge would result in unacceptable water column effects, or if the anticipated degree of spreading and water column dispersion for either the contaminated or capping material would be unacceptable, submerged discharge is a potential control measure." Submerged discharge provides additional control and accuracy during placement and, as a result, will reduce the amount of capping material required (USAEWES, 1991). Several equipment alternatives are available for submerged discharge including subsurface placement using clamshell, submerged diffuser, sand spreader barge, and Trémie pipe.

When comparing various backfilling/capping techniques, factors to consider include navigational and positioning equipment control and the compatibility of the equipment and capping material (USAEWES, 1991). Additional equipment, such as mooring barges, electronic positioning devices, and real-time helmsman's aids, can enhance the effectiveness of the backfilling/capping activities. An example of such a system is the WINOPS system – a software program designed to aid in positioning dredges and barges during marine operation.

The various placement techniques are described below.

2.1 Surface Discharge with Conventional Equipment

Cap placement by surface discharge involves the release of capping or backfill material at the water surface allowing material to settle through the water column. The successful placement of capping material using this method depends on a number of factors, including the physical characteristics of the material being placed and site characteristics. Materials released in this manner tend to "…descend rapidly to the bottom as a dense jet with minimal short-term losses to the overlying water column" (USAEWES, 1991).

Although there are several types of surficial discharge methods, barge and pipeline placement were evaluated for the Hudson River project. Barge placement typically results in a tighter mound and less water column dispersion than pipeline placement. However, the surface discharge method does allow some of the material to become entrained in the water column during descent, which will ultimately reduce the amount of material placed in the desired area (EPA, 2002b).

Surface discharge with conventional equipment would not be appropriate for the Hudson River project due to the lack of accuracy of placement, control of equipment, and unfavorable site conditions (e.g., shallow water depths).

2.2 Spreading via Barge Movement

This method is similar to surface discharge, but controls placement of the material by slowly moving the barge during discharge and distributing the material over a specified area. Most commonly, this method involves controlling the opening of a conventional split hull barge, which results in a sprinkling action of the material. Tugs are used to move the barge slowly during release and the sediment is spread as a thin layer over a large area.

Barge movement techniques have been successfully used for the placement of predominantly coarse grained, sandy capping materials at sites in Puget Sound (Sumeri, 1989). Another location where spreading by barge was used for *in situ* capping operations was the Eagle Harbor East in Washington (Sumeri, 1995). This cap was placed to 1 to 3 feet in thickness with 275,000 cy of sand material (Palermo, 2002).

This method is not suitable for fine- to medium-grained material since such material can exit the barge relatively quickly while the barge is only partially opened. Using barges for spreading cap materials may not be suitable in shallow water depths because of the water depths needed for barge draft and door openings (EPA, 2002b). Thus, spreading via barge movement would not be appropriate to the Hudson River project

2.3 Pipeline with Baffle Plate or Sand Box

This method involves the discharge of material through a surface pipeline with the aid of a spreading device (such as baffle plate) attached to the end of the pipeline. The baffle plate or momentum plate serves two functions for discharging material during cap placement. First, the baffle plate allows for radial discharge as the material strikes the plate while exiting the pipe. Second, the angle of the plate can be adjusted to be able to maneuver the end of the pipeline in an arcing motion further controlling the placement of material (USAEWES, 1991). This method is best suited for spreading thin layers over a large area. This technique is similar to the sand box, where the device acts as a diffuser using the baffles and side boards to dissipate energy (Palermo et al., 2000). A site where this method was successfully used was the Simpson-Tacoma Kraft site in Puget Sound (Sumeri, 1989).

Hydraulic placement is well-suited to placement of thin layers over large surface areas (Palermo et al., 2000). For the Hudson River, the acreage of each cap is dependent upon residual concentration (which may or may not be a large surface area). Further, this method does not allow for the placement of the armor layers (2- to 4-inch stones) and therefore is not applicable to the entire range of Hudson River capping operations.

2.4 Clamshell Bucket

A clamshell bucket operated from a barge is a time-tested placement technology for marine operations, including cap placement. This method can be either surface or subsurface discharge as shown in the Grasse River demonstration study. The Grasse River study showed that the placement of dry, bulky capping material via clamshell was more effective and cost-efficient in achieving environmental objectives than the Trémie method of placing slurried capping material. The combination of a sophisticated clamshell positioning system (GPS/WINOPS) and experienced crane operator was found to be important to the success of cap placement (Alcoa, 2002).

Clamshell placement of cap material is also being used for the capping at the Thea Foss Wheeler Osgood Waterway project, Commencement Bay Superfund site, Tacoma, Washington. In this project, the clamshell is lowered 3 to 5 feet below water surface and slowly swung while being opened. This double action facilitates relatively even distribution of the cap material.

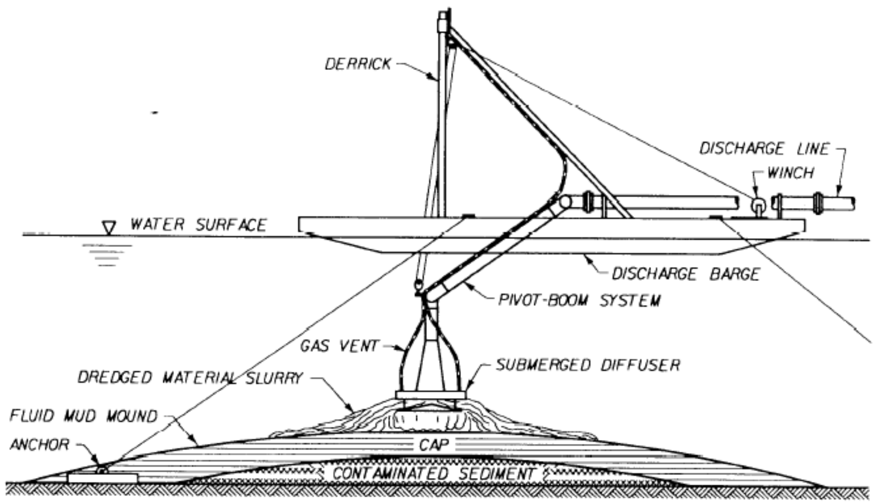
A modified clamshell bucket was also used to place cap material at the Pacific Sound Resources Superfund Site Marine Sediments Operable Unit in Seattle, Washington. Capping was completed in water depths ranging from about 0 to -35 feet MLLW, with total cap thickness varying from 4 to 7 feet. Caps were placed on relatively flat areas as well as on sloped areas of about 2:1. Capping was performed by lowering the clamshell to within 3 feet of the sediment surface, opening the clamshell, and releasing cap material. Five types of cap material were placed with the clamshell, including gravel mix, habitat mix, sand, gravel, and riprap.

This method is applicable to the Hudson River capping operations due to both the accuracy of the placement of materials and the range of materials and conditions under which the system can operate. Clamshell placement is also expected to meet the Noise Performance Standard with little to no modification to the equipment.

2.5 Submerged Diffuser

This technology was developed under the direction of the USACE Dredged Material Research Program. A submerged diffuser can be used to provide additional control for submerged pipeline discharge (Herbich, 2000). The diffuser is mounted to the end of a pipeline discharge and isolates the discharge from the majority of the water column. This method is best suited to material that is in slurry form and is illustrated on Figure H9, below. A variation of this diffuser design was used in a demonstration study at Calumet Harbor, Illinois, where it was noted that it "…significantly reduced pipeline exit velocity, confined the discharged material to the lower portion of the water column and reduced suspended solids in the upper portion of the water column" (Palermo et al., 2000). Submerged diffusers produce less turbidity than other methods that involve placement at the water surface. Submerged diffusers can place material more quickly than clamshell placement.

Figure H9 -- Submerged Diffuser System (Herbich, 2000)



This technology was also used in the Simpson Capping Project in Tacoma, Washington, which was aimed at isolating the chemical contamination present in the marine sediments and restoring the intertidal and shallow water habitat (RETEC, 2002). The capping material was placed using a diffuser and the final thickness ranged from 8.2 to 21.3 feet. Riprap was used to prevent erosion from wave action in the intertidal areas (RETEC, 2002). Results of monitoring indicate that the cap is functioning as intended.

For the Hudson River, submerged diffusers could only be used to place the finer grained backfill or cap material. Another placement method would be needed for the coarser-grained material. Submerged diffusers could accurately place cap material and document placement locations. Submerged diffusers may be less effective at placing cap material on slopes when compared to a clamshell. Finally, backfill and cap materials are likely to arrive at the site dry (i.e., with low moisture content). The addition of water would be required to use submerged diffusers. Therefore, this method is unlikely to be used solely for site operations due to the inability to place armor material.

2.6 Sand Spreader Barge

A sand spreader barge is a specialized barge used for the hydraulic spreading of sand that employs a combination of a hydraulic dredge with a submerged discharge. This process involves transporting the material by barge to the spreader; water is added to the sand, which is then pumped as slurry through a submerged pipeline. The spreader can be moved by using a winch system to cap a large area. However, this method is for sand only and may not be used for the armor material.

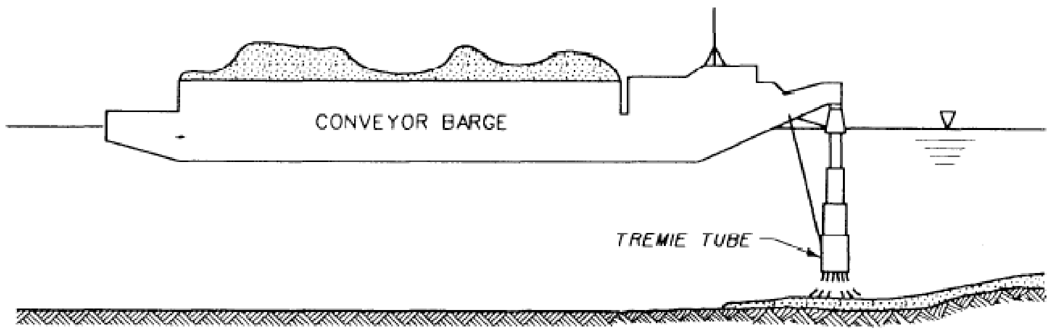
Through studies performed for the Fox River, the spreader mechanism can readily place a sand or silt-sand mixture of backfill at rates approaching 250 cy/hour and thereby cover more than an acre per day of backfill material at a thickness of 12 inches (EPA, 2004). Barge spreading has successfully been used for capping operations at Eagle Harbor, Washington (EPA, 2002b).

For the Hudson River, sand spreaders could only be used to place the finer grained backfill or cap material. Another placement method would be needed for the coarser grained material. Sand spreaders could more accurately place cap material. Sand spreaders may be less effective at placing cap material on slopes when compared to a clamshell. Sand spreaders can place material more quickly than clamshell placement, and produce equivalent or less turbidity. This method is unlikely to be used solely for site operations due to the inability to place armor material.

2.7 Trémie Pipe

The Trémie consists of a large-diameter conduit extending from the surface to just above the bottom (see Figure H10, below). This equipment improves placement accuracy and isolates the material from the water column. However, the velocity at which the material encounters the bottom is not reduced within the conduit due to the equipment typically having a large-diameter straight vertical section. The equipment, due to its size and construction, will be subject to currents and vessel wakes. Past studies have indicated that this technique results in a more controlled placement (Georgia Tech Research Corporation, 2005).

Figure H10 -- Conveyor Unloading Barge with Trémie (USAEWES, 1991)



A variation of this system was used at a capping demonstration project in Hamilton Harbor in Burlington Ontario. The Hamilton Harbor capping project consisted of a 1.64-foot thick sand cap placed over 2.47 acres using an array of Trémie tubes for sand spreading. Sand was applied in three lifts to achieve a final thickness of approximately 1.14 feet (Azcue et al., 1998). To maintain accuracy of placement of material, a system of anchors and cables was used. Sand, piled on a flat-deck barge, was placed into a hopper barge using a small front-end loader. Inside the hopper, the sand was slurried and routed into 6-inch diameter, PVC plastic tubes. The tubes extended 30 feet down, where the sand exited about 5 to 10 feet above the sediment. An anchor and winch system was used to position the barge (EPA, 2002b).

Trémie pipe placement could likely be used for the range of grain sizes planned for backfill and cap material. This method would most likely be appropriate for all components of the backfill/capping operations. Trémie pipes could accurately place cap material and document placement locations. Trémie pipes may be less effective at placing cap material on slopes as a result of the velocity at which the material will impact the sediment surface. Trémie pipes likely produce more turbidity than other subsurface placement methods because of the velocity at which cap material will impact the sediment surface. Additional information is needed on effectiveness of the technique over a range of material sizes.

2.8 Summary of Potentially Applicable Placement Techniques

The backfilling/capping technique selected for the Hudson River should be appropriate over the range of materials being installed and the conditions in which capping operations will be performed. To conduct efficient operations for both backfilling and capping, the same placement method should also be appropriate for the backfill placement operations as well. Based on a review of the various options, the clamshell method (surface or subsurface placement) is the most likely backfill/cap placement method to be used for the Hudson River. This is due to the fact that while both clamshell and Tremie pipes seem attractive based on their unique features, a clamshell is more proven in placing varying material types in conditions similar to the Hudson River. The type of clamshell, operation of the clamshell, and construction tolerances, will be evaluated further during Final Design.

2.9 Backfill and Cap Placement Plan

A backfilling/capping placement plan was developed in order to determine barge traffic requirements and volumetric production quantities during backfilling/capping operations (see Tables 3-46 and 3-47). This plan is similar to the Phase 1 Inventory and Residual Dredging Plans, which are detailed in Section 3.3 of the Phase 1 IDR. The backfill placement plan creates a schedule detailing daily placement volumes according to each dredging subarea. Placement rates are taken into consideration according to the location of each gridcell, varying cycle times and uptime according to differences in shoreline, obstructions and accessibility. These placement volumes were then used to determine the required number of barges for delivery of backfill and capping materials for each day of placement.

The placement volume for the intermediate design backfilling/capping placement plan is based on the following assumptions:

- Phase 1 total dredge area is 80 acres.
- Since backfill will not be placed in the navigational channel, the effective maximum area for backfill is 63 acres.
- For the purpose of backfill placement and barging plans, a total mass (or volume) of 217,000 tons (167,000 cy) was assumed based on the following:
  - Backfill will be placed over 40 acres
    - Assumed thickness of backfill is 12 inches.
    - A 15% contingency over the 40 acres has been assumed for engineering purposes.
    - This results in a total backfill volume of 96,000 tons (74,000 cy).
  - Capping materials will be placed over 40 acres
    - Assumed cap thickness is 15 inches.
    - A 15% contingency over the 40 acres has been assumed for engineering purposes.
    - This results in a total cap volume of 121,000 tons (93,000 cy).

- An additional 15% backfill allowance (26,000 tons or 20,000 cy) over the entire 80 acres of dredge areas will be allocated for creation of SAV beds; however, for the purposes of the backfill/cap placement plan, this additional volume (26,000 tons or 20,000 cy) is already accounted for through the overall assumption that all 80 acres in Phase 1 will receive backfill or cap and the 15% engineering purpose contingency (29,000 tons or 22,000 cy).

To determine the rates of placement, several assumptions were made concerning the abilities of the placement equipment. A 4-cy clamshell bucket with a cycle time of approximately 120 seconds was used to establish the maximum daily rate of placement. For loading, the bucket was assumed to be 90% full (on average), and during placement, a 20% bucket placement overlap (with nearby grid) was assumed. Rates of production included an uptime of 70% (which includes allowance for time lost due to barge movement, weather delays, and minor repairs). Major repairs or other operations requiring longer spans of time are assumed to be constrained to off production days - assumed to be Sundays for these schedules. Using these assumptions, a placement rate of 75 cy/hr is computed which equates to about 2,340 tons/day (1,800 cy/day).

Conditions within specific grid cells which will slow placement operations, include work within 30 feet of the shoreline which is assumed to reduce the placement rate to 60% of full operational ability (to 45 cy/hr), and obstructions which are assumed to reduce the placement rate to 50% of maximum (to 37.5 cy/hr). Regions of difficult access have a further reduction due to barge movement constraints. In order to account for the fact that the backfilling/capping operation has to always follow the completion of the dredging program at each CU, an additional reduction factor of 25% to 50% was applied on top of the previously stated efficiency factors. Backfill operations are assumed to begin approximately 3 weeks following the start of residuals dredging. This allows time for post-residuals dredging hydrographic survey, lab testing of samples and the completion of CU certification checklist.

As with the dredging plans, barge access issues within the upper regions of NTIP requires the usage of two different barge sizes. A 900-ton deck barge (i.e., a barge that can hold 900 tons of material) is assumed for the subareas EGIA, NTIP02B, NTIPO2G, and most of NTIP02F. A smaller, 500-ton barge is assumed for NTIP01, NTIP02A, NTIP02C, NTIP02D, NTIP02E, and a portion of NTIP02F.

The results from the analysis (see Tables 3-46 and 3-47) indicate that two or more barge loads are needed for over 99% of the placement operations, with four or more barge loads being needed for approximately 50% of the time, and six or more barge loads being needed for approximately 7% of the time. To decrease the number of lockages required for backfilling/capping barges, two smaller barge loads could be placed in the lock at the same time and be pushed by one tug just as long as the total length of the barges and tugs does not exceed the maximum canal length.

Note that this plan results in an upper end conservative analysis and should be considered as a planning tool only for Phase 1 IDR purposes. This plan may be revised during the Phase 1 Final Design and through contractor submittals during project implementation.

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Figures

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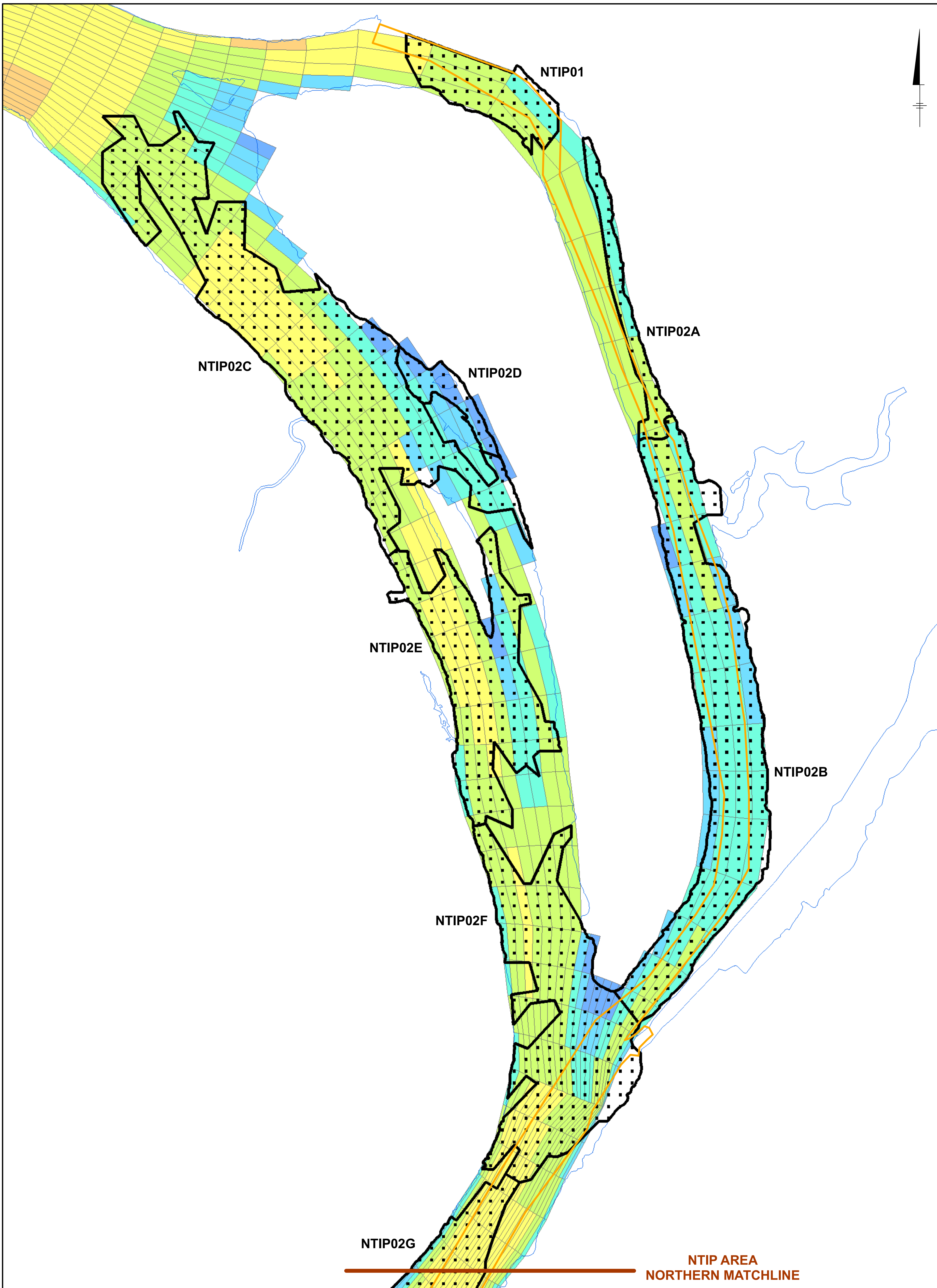

LEGEND:

- NAVIGATION CHANNEL
- DREDGE AREAS - REVISED BY BBL, INC.
- SHORELINE

VELOCITY - 10 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

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GENERAL ELECTRIC COMPANY
HUDSON RIVER PCBs SUPERFUND SITE
ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 10 YEAR VELOCITY DATA - NTIP NORTH

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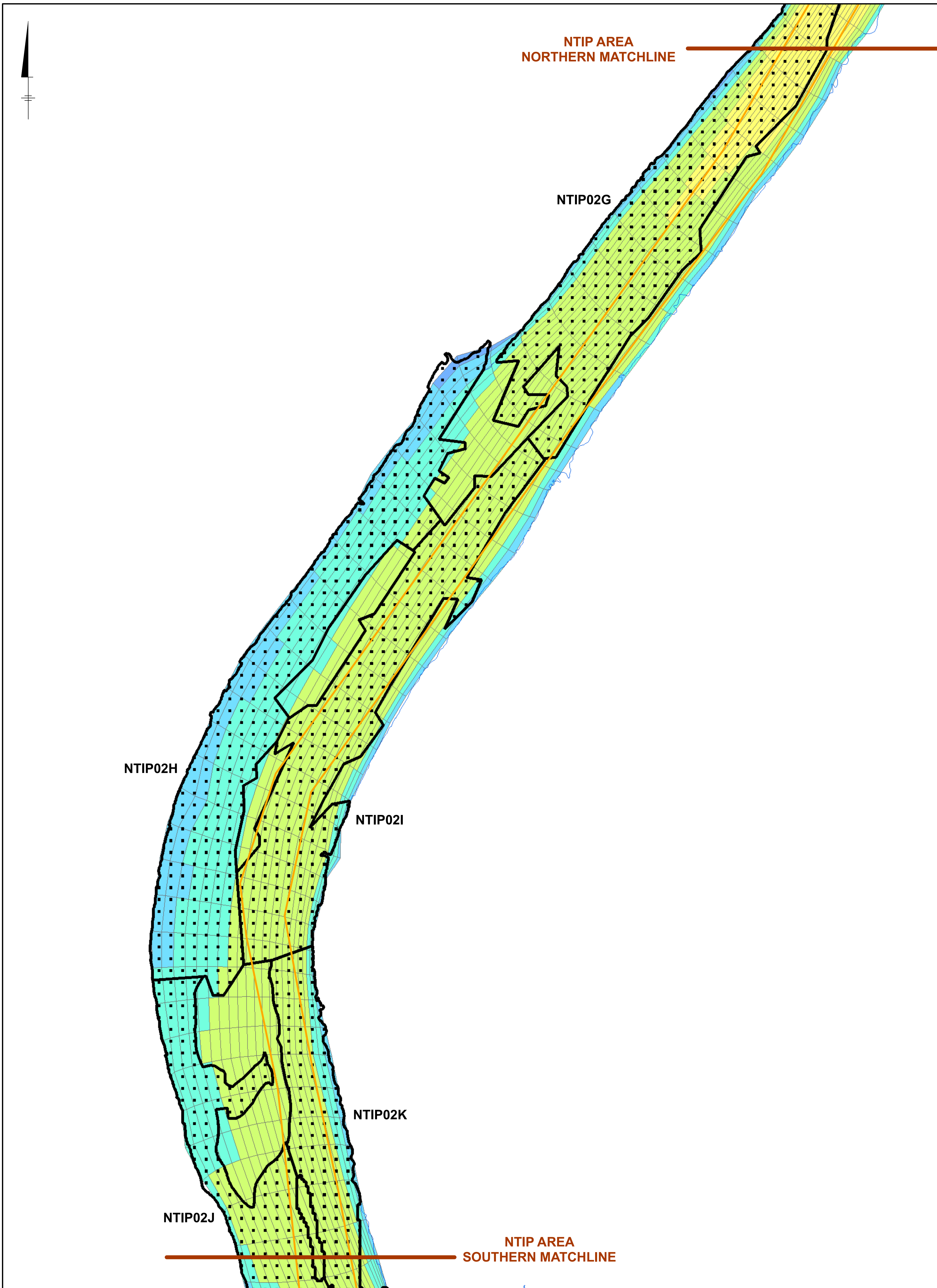
FIGURE **H1**



LEGEND:

- NAVIGATION CHANNEL
- DREDGE AREAS - REVISED BY BBL, INC.
- SHORELINE

VELOCITY - 10 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

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ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 10 YEAR VELOCITY DATA - NTIP CENTRAL

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FIGURE **H2**

8/20/05 SYR-85 MTK
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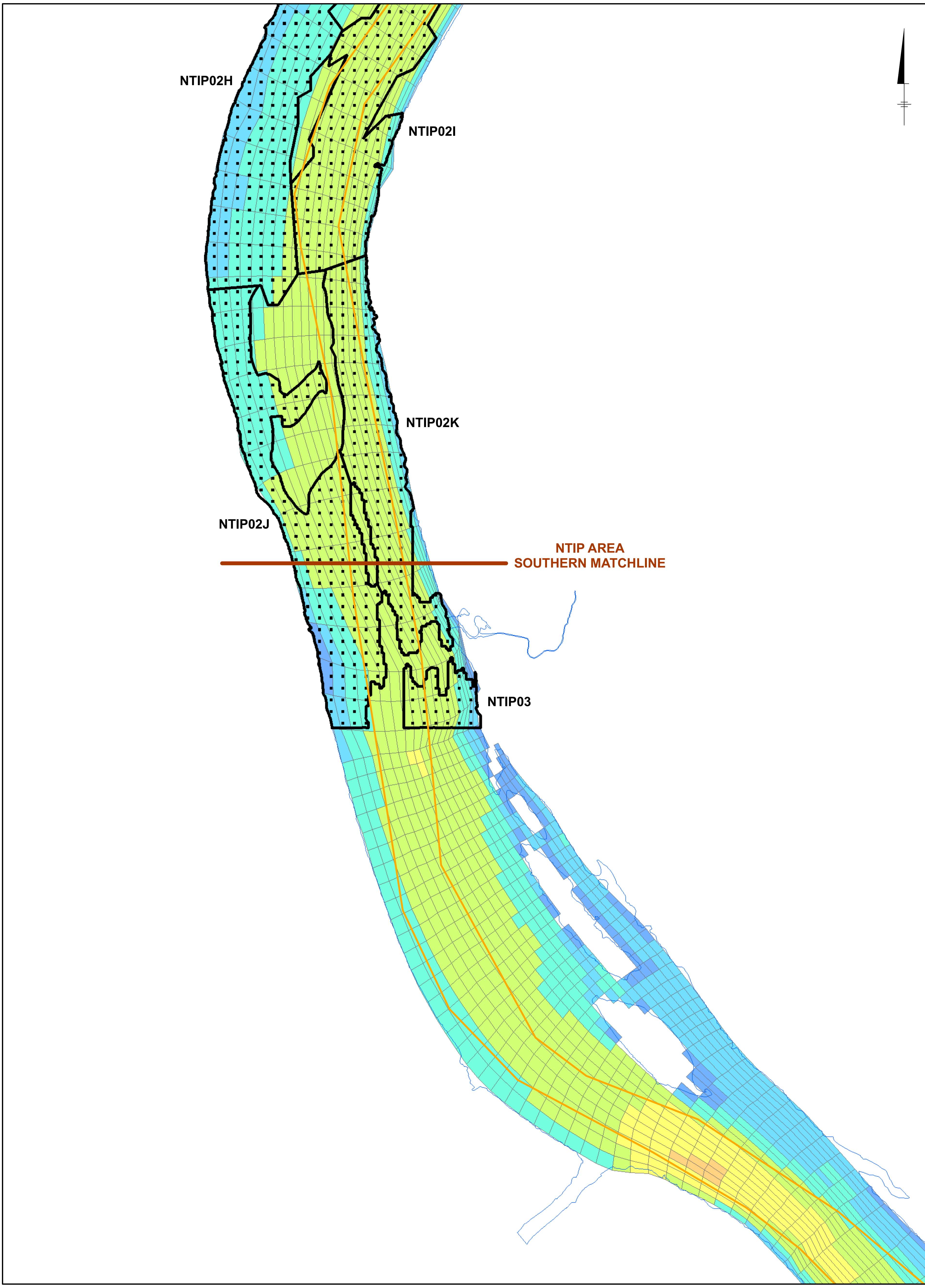

LEGEND:

- NAVIGATION CHANNEL
- DREDGE AREAS - REVISED BY BBL, INC.
- SHORELINE

VELOCITY - 10 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

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ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 10 YEAR VELOCITY DATA - NTIP SOUTH

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FIGURE **H3**

8/20/05 SYR-85 MTK
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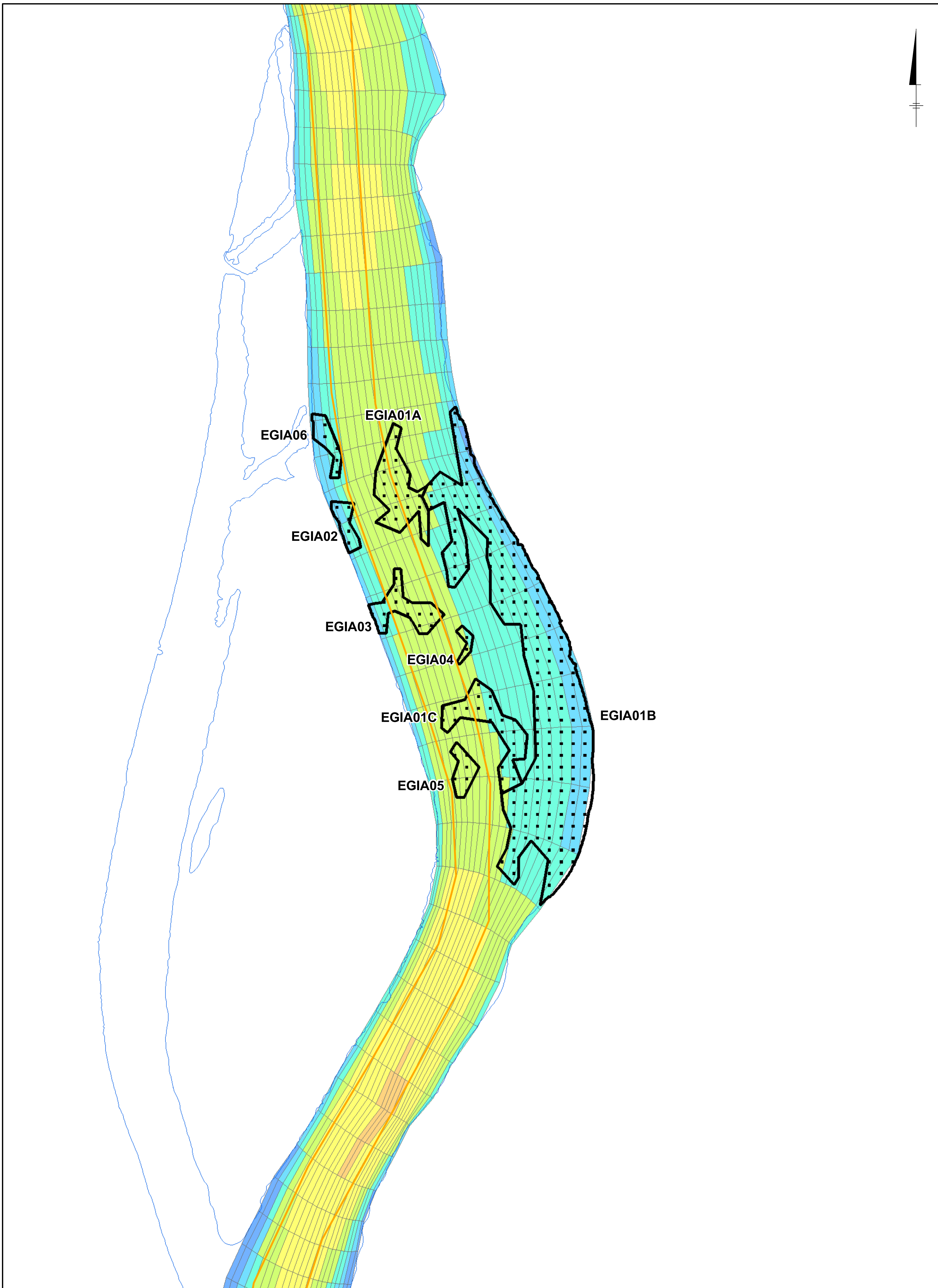

LEGEND:

NAVIGATION CHANNEL

DREDGE AREAS - REVISED BY BBL, INC.

SHORELINE

VELOCITY - 10 YR (ft/s)

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2 - 3

3 - 4

4 - 5

5 - 6

6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
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8/20/05 SYR-85 MTK
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GENERAL ELECTRIC COMPANY
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ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 10 YEAR VELOCITY DATA - EGIA

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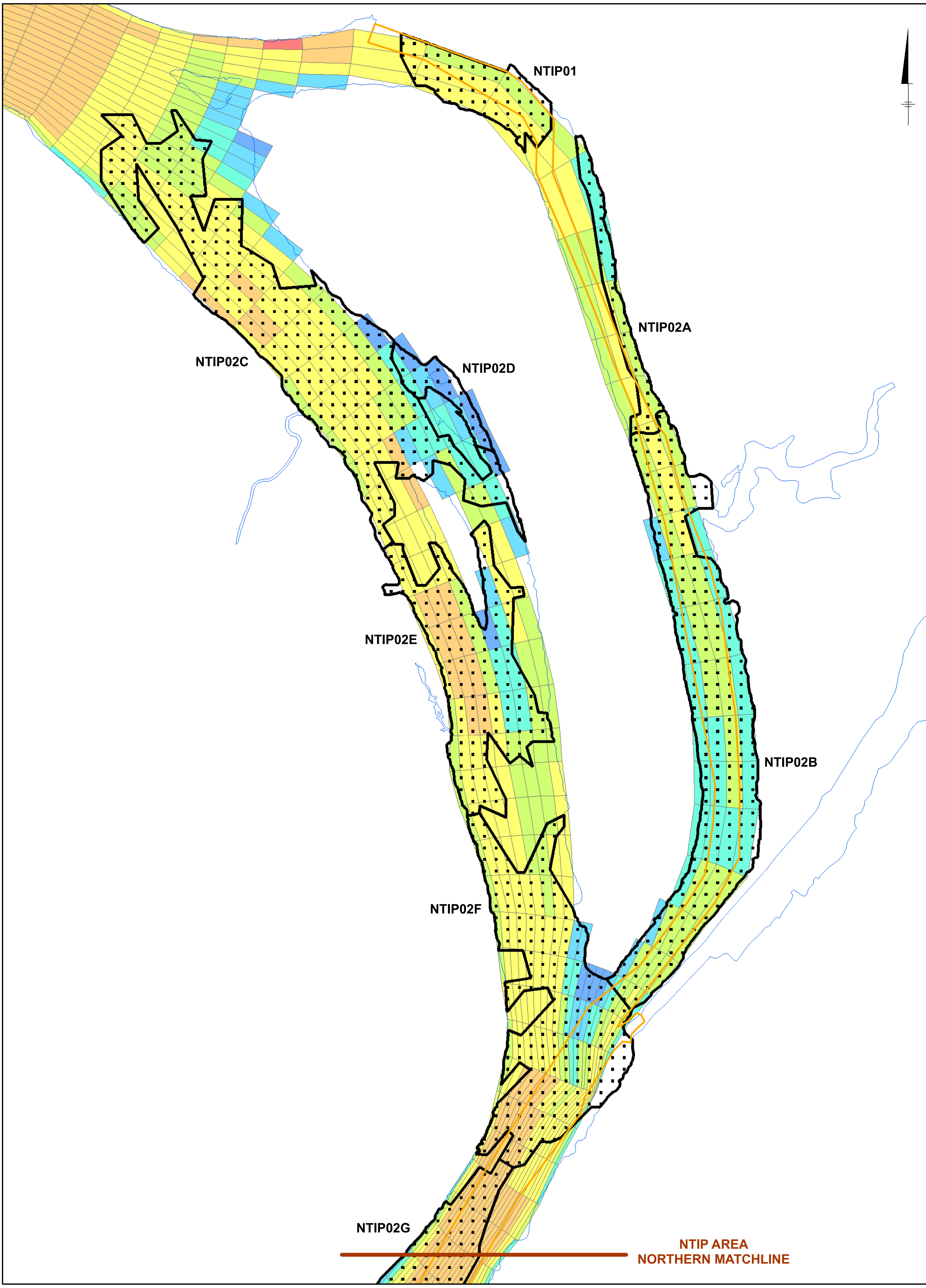
FIGURE
H4



LEGEND:

- NAVIGATION CHANNEL
- DREDGE AREAS - REVISED BY BBL, INC.
- SHORELINE

VELOCITY - 100 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

GENERAL ELECTRIC COMPANY
HUDSON RIVER PCBs SUPERFUND SITE
ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 100 YEAR VELOCITY DATA - NTIP NORTH

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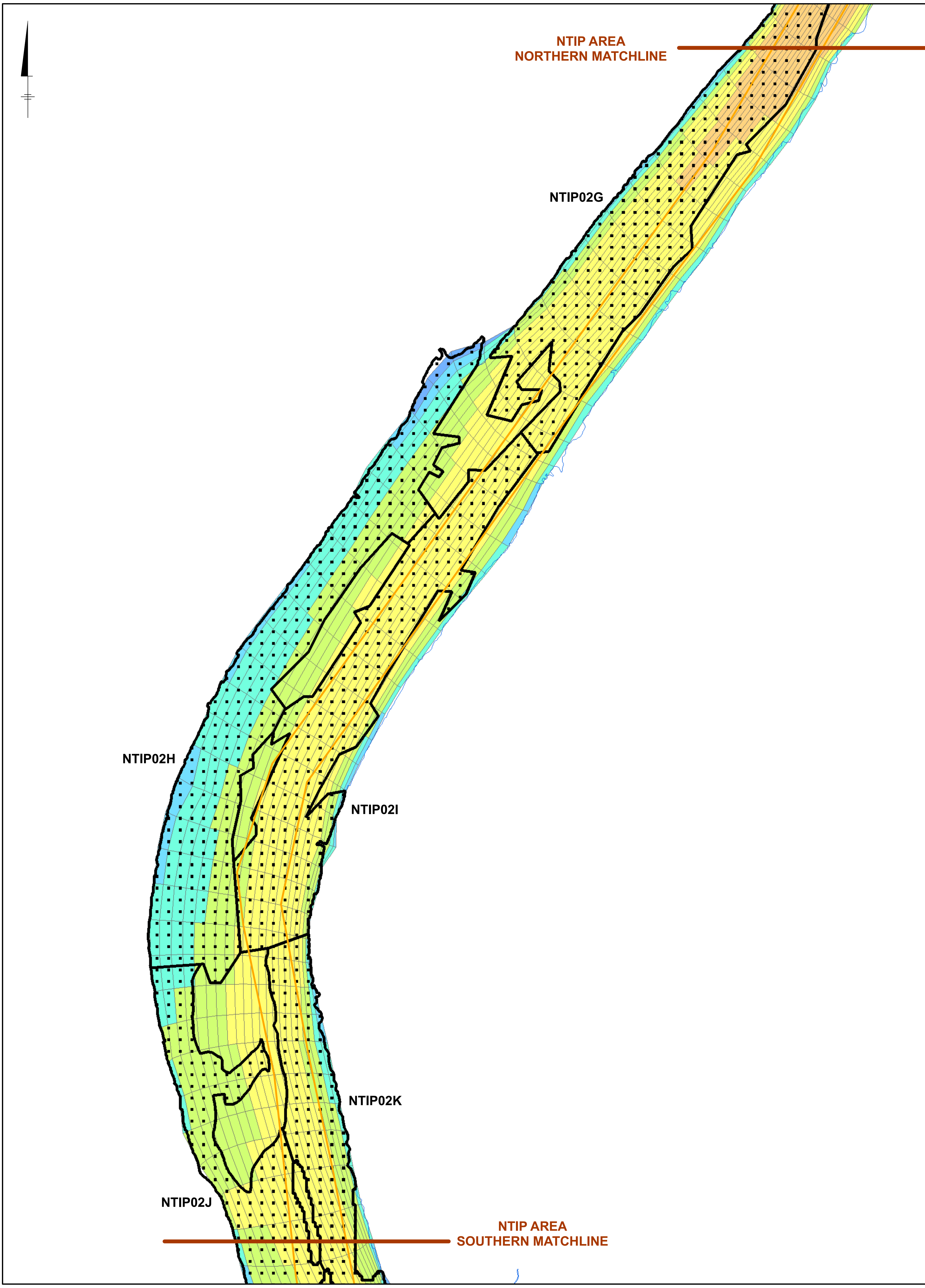
engineers, scientists, economists

FIGURE
H5

8/20/05 SYR-85 MTK
GE Hudson (20437.800)
G:\GE_GIS\GE-HudsonRiver\VelocityShearStress_Phase1Areas\mxd\100 Year Velocity and SS - NTIP North 11x17.mxd



LEGEND:

- NAVIGATION CHANNEL
- DREDGE AREAS - REVISED BY BBL, INC.
- SHORELINE

VELOCITY - 100 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

GENERAL ELECTRIC COMPANY
HUDSON RIVER PCBs SUPERFUND SITE
ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 100 YEAR VELOCITY DATA - NTIP CENTRAL

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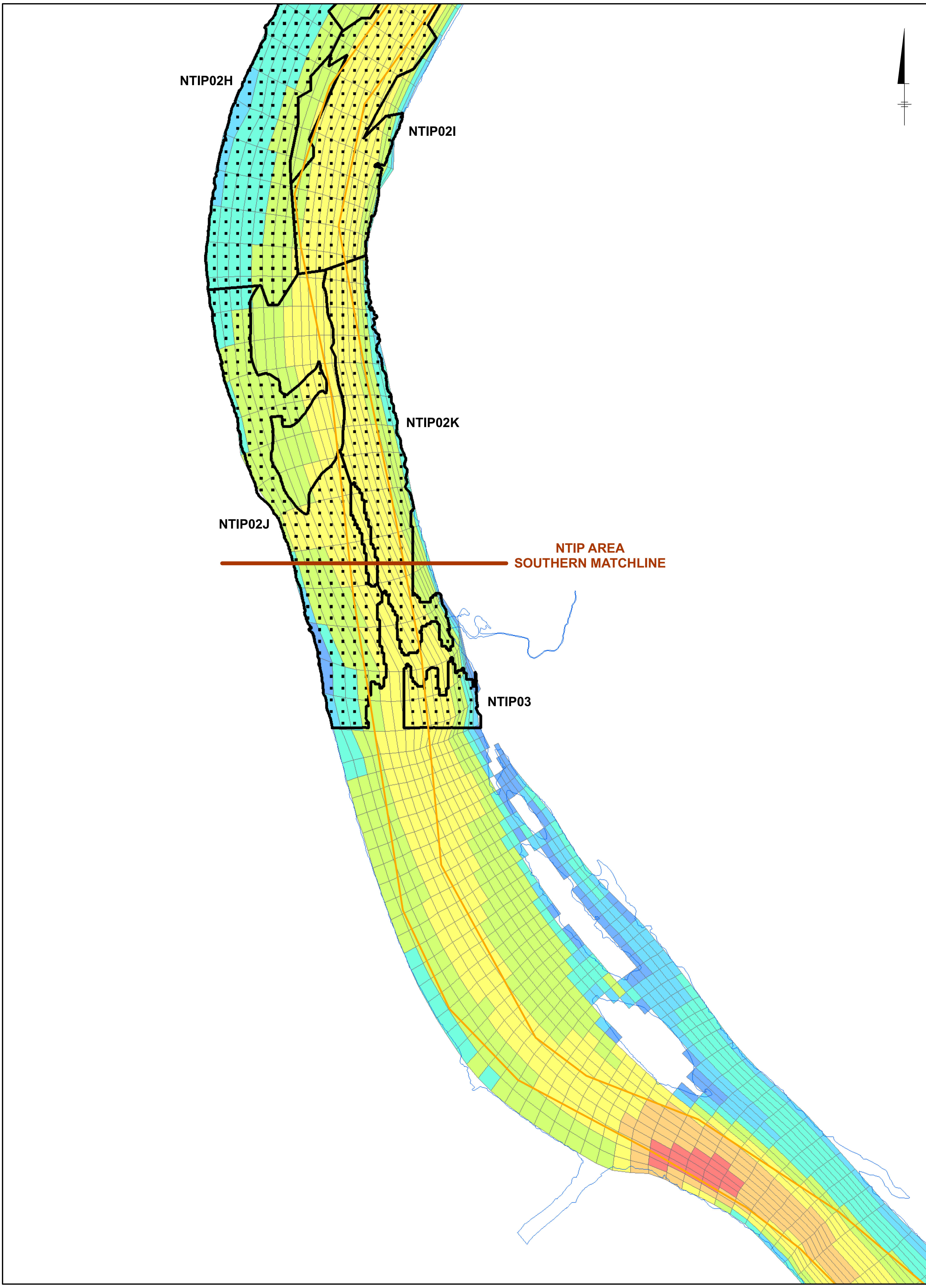
FIGURE **H6**

8/20/05 SYR-85 MTK
GE Hudson (20437.800)
G:\GE_GIS\GE-HudsonRiver\VelocityShearStress_Phase1Areas\mxd\100 Year Velocity and SS - NTIP Central 11x17.mxd



LEGEND:

NAVIGATION CHANNEL

DREDGE AREAS - REVISED BY BBL, INC.

SHORELINE

0 420 840 Feet

GRAPHIC SCALE

VELOCITY - 100 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

8/20/05 SYR-85 MTK
GE Hudson (20437.800)
G:\GE_GIS\GE-HudsonRiver\VelocityShearStress_Phase1Areas\mxd\100 Year Velocity and SS - NTIP South 11x17.mxd

GENERAL ELECTRIC COMPANY
HUDSON RIVER PCBs SUPERFUND SITE
ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 100 YEAR VELOCITY DATA - NTIP SOUTH

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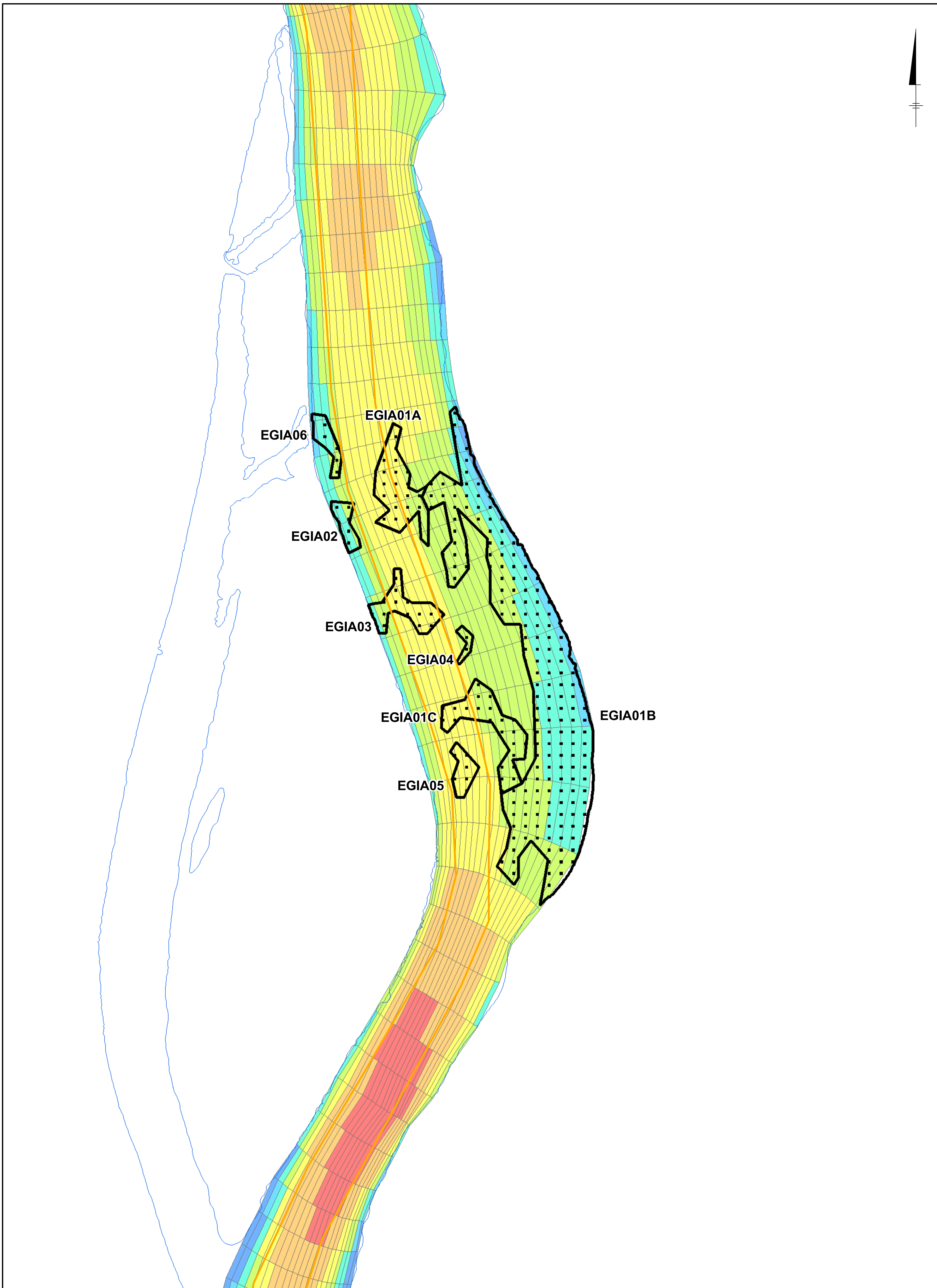
FIGURE
H7



LEGEND:

- NAVIGATION CHANNEL
- DREDGE AREAS - REVISED BY BBL, INC.
- SHORELINE

VELOCITY - 100 YR (ft/s)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 6.5

0 420 840 Feet

GRAPHIC SCALE

NOTE:

1. BASEMAPPING AND DATA PROVIDED BY QEA.
2. ESTIMATED LOCATION OF NAVIGATION CHANNEL AS DEVELOPED BY QEA AND BBL BASED ON HISTORICAL MAPS, DREDGING, AND BATHYMETRIC DATA.
3. SHORELINE AND SHORELINE STRUCTURES BASED ON AERIAL MAPPING PERFORMED BY CHAS H. SELLS, INC IN THE SPRING OF 2002.

GENERAL ELECTRIC COMPANY
HUDSON RIVER PCBs SUPERFUND SITE
ATTACHMENT H - DESIGN ANALYSIS: BACKFILLING/CAPPING

DREDGE PRISMS SHOWING 100 YEAR VELOCITY DATA - EGIA

BBL® BLASLAND, BOUCK & LEE, INC. *engineers, scientists, economists*

FIGURE **H8**

8/20/05 SYR-85 MTK
GE Hudson (20437.800)
G:\GE_GIS\GE-HudsonRiver\VelocityShearStress_Phase1Areas\mxd\100 Year Velocity and SS - EGIA 11x17.mxd

Phase 1 Intermediate Design Report Hudson River PCBs Superfund Site

Attachment I – Evaluation of Potential Ice Effects on Hudson River Remediation – Hudson River – Phase 1 Areas, Near Fort Edward, NY (River Section 1)

General Electric Company
Albany, New York

August 22, 2005

BLASLAND, BOUCK & LEE, INC.
engineers, scientists, economists

MEMORANDUM

ATTACHMENT I
EVALUATION OF POTENTIAL ICE EFFECTS ON HUDSON RIVER REMEDIATION – HUDSON RIVER – PHASE 1 AREAS, NEAR FORT EDWARD, NY (RIVER SECTION 1)

By
George D. Ashton, Ph.D.
86 Bank Street
Lebanon, NH 03766

BACKGROUND

As part of the effort to remediate sediments in the Hudson River in the reach just downstream of the dam at Hudson Falls, NY (approximately river mile 197) to Thompson Island Dam (approximately river mile 188.6), (Hudson River Phase 1 Remediation Areas), the potential effects of ice on caps that may be employed as part of the planned remediation measures needed to be evaluated. This report discusses the nature of the ice in the Hudson River along Phase 1 areas and associated processes that could conceivably interact with the capping of those sediments. The conclusions below are based on review of data available for the site, on a site visit, on published literature dealing with ice and sediments, and on some 35 years of personal experience examining river and lake ice behavior.

HUDSON RIVER NEAR FORT EDWARD, NY

The Hudson River site of concern is bounded by a large hydroelectric dam at the upstream end of the reach at Hudson Falls, NY (approximately river mile 197) and extending 8 miles downstream to another dam just downstream of Griffin Island (approximately at river mile 188.6). Upstream of the dam at Hudson Falls are other dams. The site of the old Fort Edward Dam (removed about 1973) is at about river mile 194.7. Prior to about the winter of 1982-83 and again in the winter of 1988-89 the flow was partially controlled in the sense that during lower mean flows (below about 6,000 cubic feet per second [cfs]) there were characteristic "weekend drops" in flows (See USGS record for gage 01327750 Hudson River at Fort Edward, NY). Since that time there is no evidence in the hydrograph that there are such intermittent storages and release associated with meeting the demands of hydropower and the hydroelectric dam operates as a "run-of-river" facility and even passes a portion of very high flows (over about 9,000 cfs) over the spillway (Conley, 2005). There is a short, shallow rapids reach downstream of the site of the old Fort Edward Dam, and then the river deepens while simultaneously splitting into two channels around Rogers Island but with most of the flow in the west channel. The west channel at Rogers Island is about 480 feet wide, with maximum depths of the order of 8 to 10 feet, while the east channel is about 200 feet wide, with about the same depth (although shallower at its upstream end). At the downstream end of Rogers Island (located at river mile 193.75), the river becomes a single channel and deepens significantly to a maximum depth of about 13 to 20 feet. Directly east of the downstream end of Rogers Island is Lock 7 of the Champlain Canal. It contributes insignificant flow to the Hudson River and is not operated during the winter. Downstream of Rogers Island and extending to river mile 192, the river varies in width gradually widening from about 400 feet to about 650 feet.

SITE VISIT

A site visit was made on 22 June 2005 and consisted of observations by boat nearly to the upstream end of the west channel at Rogers Island, up to the Fort Edward Yacht Basin on the east channel and downstream to the next dam (Thompson Island Dam) just downstream of Griffin Island at about river mile 188.6. Observations were made from the boat of the vegetation and structures along the shores with the objective of detecting any damage due to ice effects. Operating personnel at the Hudson Falls Dam were also contacted and queried about winter operations. At the time of the site visit, the discharge was about 9,000 cfs. Observations of the reach upstream of Rogers Island to the dam at Hudson Falls were made by occasional access to the top bank of the river by automobile.

CLIMATE AND HYDRAULICS

In terms of winter ice formation, the Hudson River at Fort Edward is in a climatic area where often the ice cover does not always form and persist until break up. Rather, it is cold enough to produce ice possibly as thick as about 20 inches in extremely cold years; but often the ice cover is interrupted by mid-winter thaws, and with those, occasional higher discharges. The average maximum degree-days of freezing, S_F, at Glens Falls (just west of Fort Edward) is 488 °C-days with a standard deviation of 148. The average date of the maximum accumulation of degree days of freezing is 15 March. (See Schmidlin and Dethier, 1985). While historically there have been days during which the minimum air temperature has been as low as -30 °F, these are rare. An examination of the 1961-1990 record at Glens Falls showed few cases during which the January minimum temperature was much colder than -10° F.

The hydraulics of the Hudson River at Fort Edward is also variable. The mean monthly flows during the period of record of the USGS Station 01327750 Hudson River at Fort Edward NY are shown in Table I1 (Period of record 1899-1908 and 1977-2002).

Table I1 – Average and Maximum Monthly Mean Streamflow (cfs) Hudson River at Fort Edward, NY

Month	Average Monthly Mean Streamflow (cfs)	Maximum Monthly Mean Streamflow (cfs)
November	5,092	9,326
December	5,138	10,270
January	4,918	9,766
February	4,696	7,836
March	6,307	10,950

The daily flow record for December through March was also examined for the winters from 1976-77 to 2002-03. While the daily flows were typically in the range of flows shown in Table I1, there were often short duration higher flows during the winter. The seasonal annual daily peak flow observed during the period 15 December to 15 March for each of the 27 years of recent record (winter 1976-77 to winter 2002-03) was extracted from the record and ranked. The ten highest ranked peak daily flows for this period for different years resulted in the following ranking presented in Table I2:

Table I2 – Ranking of Annual Peak Winter Flows During the Period 15 Dec to 15 March

Rank	Highest Daily Peak Flow Period 15 Dec – 15 March (cfs)	Date	Air Temperatures During, Before and After Peak Discharge		
			Average Temperature on Date (˚F)	Before	After
1	33,000	10 Jan 98	35	Warm	Gradually falling
2	26,000	15 March 77	44	Warm	Gradually falling
3	22,000	23 Feb 81	47	Very warm	Gradually falling
4	17,800	1 Jan 85	29	Very warm	Cold to -10 low 9 Jan
5	17,400	10 Jan 78	7	Very warm	17 ˚F average for 5 days
6	16,000	20 Feb 84	40	Warm	Warm
7	15,900	21 Jan 96	18.5	Warm	Gradually falling
8	15,000	25 Dec 90	22.5	Warm	Cool then warm
9	13,000	8 Mar 79	35.5	Warm	Warm
10	13,000	19 Dec 00	Unavailable at time of writing		

While a more detailed statistical analysis was not performed, it is clear that in about 1 year in 10 a daily flow of the order of 20,000 to 30,000 cfs might be expected during the winter period from 15 December to 15 March. These may be compared to an estimated return period of 2 years for a maximum peak daily flow of 23,000 cfs for the entire year and a return period of 10 years for a maximum peak daily flow of 34,500 cfs at the Fort Edward gaging station. The daily air temperatures on the date of the peak and before and after the peak occurrence were examined for the 9 highest ranked discharges and showed very clearly that these winter peaks are almost always associated with warm temperatures (daily averages above 32°F) except for the 17,400 cfs event of 10 January 1978, and the high discharges rarely persist for more than a few days.

ICE JAMMING

Since the dam at Hudson Falls and the dams upstream effectively retain ice upstream, it was not expected that there would be enough ice supply to form an ice jam composed of blocks of ice. In fact, operating personnel at the Hudson Falls dam take no special precautions when ice is arriving from upstream and simply pass the ice through the turbines (telephone conversation with Dan McCarty of the Hudson Falls power plant, 22 June 2005). They also were of the opinion that ice was not associated with short duration high flows during the winter period.

Since ice jams act to scar the trees and vegetation along the shorelines, a large number of trees were examined from the boat during the site visit along the entire reach of interest, with particular attention to those that would be prone to ice damage (exposed and near the banks). No evidence was seen of any tree scarring except possible abrasions near the waterline and these could just as well have been due to abrasion by floating debris. It was concluded that there was no evidence of ice jamming in the reach from at least the upstream end of Rogers Island on downstream to the Thompson Island Dam.

FRAZIL AND ANCHOR ICE FORMATION

In very large lakes, and most rivers subject to very cold temperatures, frazil ice can form and be carried to great depths. Frazil is ice in very small crystals formed in supercooled flow (slightly below 0ºC). In fast flowing rivers, frazil can be distributed through the depth of the flow and attach itself to the bottom sediments. In this form, it is termed "anchor" ice. Upon warming slightly or when the buoyancy exceeds the adhesion at the bed, it can rise and sometimes bring a quantity of sediment to which it had adhered. There is considerable experience in assessing the nature and intensity of frazil formation based on mean water velocity and this is well represented by Figure I1 (originated by Matousek, 1984; and presented with some addition and simplification by Ashton, 1988).

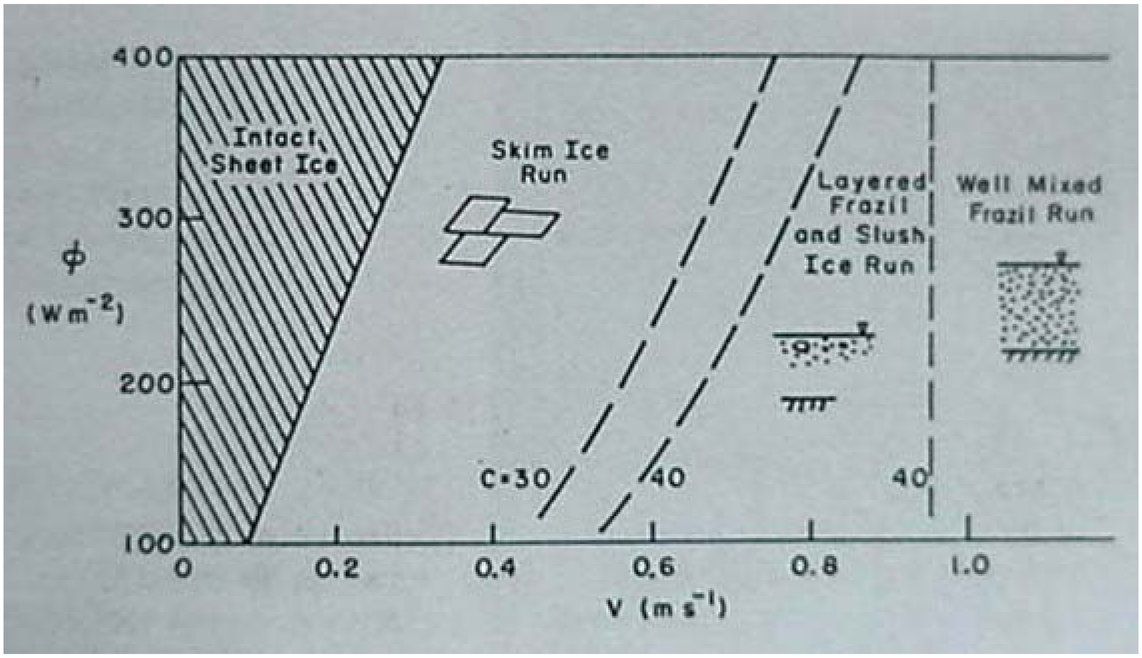


Figure I1. Ice Flow Thresholds (from Matousek, 1984)

In Figure I1 above, the ordinate Φ is the heat loss rate from the open water surface. The boundary between the regime of rapid formation of a sheet ice cover and a frazil run varies from a velocity of 0.1 meter/second (m/s) to 0.3 m/s as the heat loss rate increases from 100 W/m^2 (roughly equivalent to an air temperature of – 5 °C) to 400 W/m^2 (roughly equivalent to an air temperature of – 20 °C). The boundary between the regime of a surface skim ice run and a layered frazil and slush run at the upper surface depends on the Chezy coefficient and the mean velocity. Note that Matousek's field observations were for relatively shallow rivers (~ 0.5 meter and 1 meter depths), and there is no effect of depth explicit in Matousek's diagram. However, larger depth is not expected to be a controlling factor in these calculations. If anything, deeper rivers will exhibit a shift toward the left of the diagram (less depth of frazil entrainment). It is also emphasized that the character of the frazil behavior is that at the onset of frazil formation in an open reach of river.

From 0 to about 0.2 m/s (0.6 feet/second [ft/s]) the initial ice formation is in the form of thin sheets on the surface and little frazil formation. From about 0.2 m/s (0.6 ft/s) to about 0.7 m/s (2.3 ft/s) a "skim ice run" occurs, again, with little frazil formation. From about 0.7 m/s (2.3 ft/s) to about 0.95 m/s (3.1 ft/s) the frazil forms a "layered frazil and slush run" with the ice confined to the near surface of the water. Finally, as the velocity increases to about 0.95 m/s (or 3.1 ft/s at a Chezy coefficient of about 40), the frazil becomes well mixed over the depth. Above about 0.95 m/s (3.1 ft/s) a "well mixed frazil run" occurs with frazil transported to some or the entire depth of flow. It is this last type of formation that can lead to anchor ice formation on the bed. There is some effect on these boundaries between types of ice formation due to the intensity of cooling with higher cooling rates tending to shift the types of ice formation somewhat towards the more severe types. At about 2 ft/s and below, the frazil formation is able to accumulate into an initial ice cover and, once stationary, will continue to thicken by thermal growth. Thus, frazil produced in high velocity reaches is carried downstream until a lower velocity reach is present at which it forms a solid cover. If the velocity is below about 2 ft/s, the ice coverage will progress upstream by accumulation of the arriving ice. If the velocity is above about 2 ft/s, it will be difficult for the ice to progress upstream and the arriving ice will be transported beneath the ice cover or deposit out (upwards) beneath the ice cover. In some cases, such accumulations may form very thick "hanging dams." As the deposit thickens, the diminished cross section causes velocities to increase beneath the accumulation. The critical velocity beneath which frazil deposits out from the flow is about 2.0 ft/s based on observations of frazil deposits in rivers and is consistent with numerical models that use that value as the critical velocity, and with laboratory experiments. Once deposited, the frazil develops some cohesion between the ice particles and, as a consequence, the critical value for erosion is generally taken to be slightly higher and about 2.3 ft/s (0.7 m/s). While these threshold numbers are not exact, they enable characterization of the expected formation of the ice cover.

When the entire flow is supercooled, and the velocities are high enough, frazil particles may come in contact with the bed and adhere to the bed material. In this form the frazil is termed "anchor ice." Further thickening of the anchor ice may occur over time, and typically large masses rise to the surface with only slight warming of the flow, usually on a daily basis.

To summarize, it is expected that there will be frazil formation when the water surface does not have an intact ice cover. This corresponds to regions where the surface velocity is 2 ft/s or greater. There will be a possibility of anchor ice formation in regions where the flow velocity is greater than about 3 ft/s.

OCCURRENCE OF FRAZIL, ANCHOR ICE, AND SURFACE ICE COVER AT SITE

With the above guidance, it is possible to describe the nature of ice formation at the site using charts of the velocity associated with different discharges. Charts were available that mapped the mean velocities associated with a discharge of 23,000 cfs (corresponding to the 2-year return period of annual peak flows) into surface areas with velocities 0 to 1 ft/s, 1 to 2 ft/s, 2 to 3 ft/s, 3 to 4 ft/s, and 4 to 5 ft/s. While not exactly precise, these same areas correspond to, respectively 0 to 0.5 ft/s, 0.5 to 1 ft/s, 1 to 1.5 ft/s, 1.5 to 2 ft/s, and 2 to 2.5 ft/s for a flow of 11,500 cfs, and half of those, in turn, for a flow of 5,750 ft/s. We will refer to these values as the "high winter flow" case, the "medium winter flow" case and the "typical winter flow" case.

Using the guidance developed above we can now describe the probable nature of the formation of ice cover for each of the three cases by examining the charts of the 2-year return period mapping of velocities. The analysis below assumes that air temperatures are quite cold during the cases. Particularly for the "high flow case" this was only true for the flow ranked 5 of 17,400 cfs on 10 January 1978.

“High Flow” Case

In the “high flow case” (23,000 cfs), there will likely be extensive open water extending downstream from the Hudson Falls dam to just upstream of Rogers Island. Along the east channel by Rogers Island flow velocities are typically 2-3 ft/s in mid-channel and we would expect border ice to form and some open water in the mid-channel. We would not expect anchor ice to form here. In the west channel, velocities higher than 3 ft/s extend along most of the reach although the region of occurrence tapers from nearly full width at the upstream end to a narrow band at the lower end of the west channel. Here we expect a persistent open mid-channel area and the possibility of limited anchor ice formation dominantly along the upper half of the reach. Just downstream of Rogers Island the velocities again rise to the 3 to 4 ft/s range and we would expect an open area in the ice cover but extending only a short distance (0.4 mile or so) to where the velocities decrease to 2 to 3 ft/s. Here there will be some border ice formation but it is expected the central portions will remain open over most of the reach. However, the velocities are less than 3 ft/s so we don’t expect any anchor ice formation. It is also noted that these high discharge cases are generally associated with mid-winter thaws and the water temperature (and air temperatures) may be such as to preclude significant ice formation. It is also noted that, in general, these high discharge cases are of short duration, of the order of a few days and generally less.

“Medium Flow” Case

This case (11,500 cfs) corresponds to periods during the winter when the flow is unusually high relative to the long-term average but somewhat less than the extreme peak flows. In this case, there will again be some open water extending downstream from the Hudson Falls dam to just upstream of Rogers Island. Along the east channel by Rogers Island flow velocities are typically 1 to 1.5 ft/s in mid-channel and we would expect border ice to form and rapid formation of a more-or-less complete ice cover with the possibility of some open water in the mid-channel during initial formation. There will be no frazil formation once the ice cover is established since the ice cover blocks heat loss from the flow. In the west channel, velocities higher than 1.5 ft/s extend along most of the reach although tapering from nearly full width at the upstream end to a narrow band at the lower end of the west channel. Here we again expect rapid formation of a complete ice cover perhaps with a persistent narrow open mid-channel area. Just downstream of Rogers Island the velocities again rise to the 1.5 to 2 ft/s range and we would expect slower formation of a complete ice cover but only extending a short distance (0.4 mile or so) to where the velocities decrease to 1 to 1.5 ft/s. We thus expect frazil formation to only occur upstream of Rogers Island, except for a very short initial period of cold temperatures while the surface frazil accumulates to form the first cover.

“Typical Flow” Case

This case (5,750 cfs) corresponds to periods during the winter when the flow is near the long term average. In this case, there will again be some open water extending downstream from the Hudson Falls dam to just upstream of Rogers Island. Along the east channel by Rogers Island flow velocities are typically 0.5 to 0.75 ft/s in mid-channel and we would expect rapid formation of a more-or-less complete ice cover initially composed of skim ice. There will be no frazil formation once the ice cover is established since the ice cover blocks heat loss from the flow. In the west channel maximum velocities are in the 1 ft/s range. Here we again expect rapid formation of a complete ice cover. Just downstream of Rogers Island the velocities again rise to the 0.75 to 1 ft/s range and we would expect slower formation of a complete ice cover but only extending a short distance (0.4 mile or so) to where the velocities decrease to 0.5 to 0.75 ft/s. We thus again expect frazil formation to only occur upstream of Rogers Island, except for a very short initial period of cold temperatures while the surface frazil accumulates to form the first cover.

Summary of cases

In all cases, it is expected that the river surface will remain partially open from the Hudson Falls dam to just upstream of Rogers Island. This is the region of significant frazil formation and almost assuredly some anchor ice formation, although the region of possible anchor ice production is not currently targeted for remediation. Downstream there will be very little, if any, anchor ice formation and only very limited frazil formation at the beginning of the period of ice formation while the ice cover is being established. An ice cover effectively prevents frazil formation by blocking the heat transfer from the water to the air above the ice cover. Thus the dominant production of frazil that is carried downstream as far as Rogers Island occurs in the rapids region extending from the site of the old Fort Edward dam to just upstream of Rogers Island.

Production of frazil ice in the rapids reach

The production of frazil in the rapids reach through a winter period may be estimated from the cumulative degree-days of freezing. A simple heat balance between the production of frazil and the heat loss to the atmosphere results in

$$\rho \lambda h_f = H_{wa} (T_m - T_a) t$$

where ρ is the density of solid ice, λ is the heat of fusion of ice, h_f is the thickness of ice produced over time t when exposed to an air temperature T_a relative to the freezing point T_m). The value of ρ is accurately known at 916 kilograms per cubic meter, and λ is accurately known at 334,000 Joules per kilogram. H_{wa} is a heat transfer coefficient between the water surface and the air above. It varies with wind speed with higher wind speeds yielding higher heat transfer rates. H_{wa} typically varies from 10 Watts per square meter per °C under still air conditions and is about 30 Watts per square meter per °C for moderately windy conditions. Here we will use a more typical average value of 20 Watts per square meter per °C. The product $(T_m - T_a)$ t is the degree-days of freezing. At Glens Falls the average cumulative degree-days of freezing is 488 °C – days with a standard deviation of 148. However, the manner in which these degree-days of freezing are accumulated include the period at the beginning of the season before the water temperature has cooled to the freezing point. For this reason, it is considered appropriate to use the average value to provide an estimate of frazil production. Inserting these values into the above equation results in a potential thickness of solid ice production per unit area of 2.74 meters (about 9 feet) per unit area of open water surface exposed throughout the winter. The rapids reach is about 1000 feet long and 600 feet wide. Thus the resulting potential frazil production is a volume of 200,000 cubic yards of solid ice. When deposited the frazil has porosity of the order of 0.5 so the total bulk volume of frazil produced is estimated to be about 400,000 cubic yards.

Deposition of frazil downstream of the rapids reach

The frazil produced in the rapids reach will be carried downstream and, just as sediment deposits out in slower velocity reaches, so does the frazil deposit (upwards) beneath the downstream ice cover. It does this rather quickly and accumulates in thickness until the resulting diminished flow area beneath the deposit has increased the velocity to about 2 ft/s, at which point it is carried further downstream until the velocity again decreases. The process may be visualized as an extending (upside down) delta. The upstream sections will accumulate first and the deposit will gradually extend itself downstream. It is possible to do a time – stepping simulation of this deposition process, but for present purposes we simply calculated the flow volume beginning at river mile 194.4 and extending to river mile 193.5. The cumulative flow volume over this reach was found to be approximately 1,100,000 cubic yards. Thus the frazil production of 400,000 cubic yards (bulk volume) can be contained in a deposit occupying only 36 % of the flow volume. We thus expect the majority of the thick frazil deposits to be upstream of river mile 193.5 (just downstream of Rogers Island).

The same limiting velocity beneath which frazil deposits out from the flow also means that bottom sediments whose critical erosion velocity is above that, will not be scoured by the flow. It is prudent to use the critical velocity for those considerations as the somewhat higher value associated with erosion of frazil (2.3 ft/s) since there clearly could be cases where increasing flows will take some time to erode the frazil deposit.

ANCHOR ICE FORMATION

Anchor ice is frazil ice that has been carried to the bottom of a stream or river and attaches to the bottom material (and, after initial covering, to itself). Once attached, the crystals may subsequently grow quite a bit larger than those seen in the bulk flow. It is most readily observed in shallow mountain streams and may build up to considerable thicknesses, but it also occurs in deep rivers and in lakes where the mixing arises from wind and wave action.

As pointed out above, the only location where anchor ice is expected to form is in the high velocity reach in the rapids upstream of Rogers Island. This area is not currently targeted for remediation.

Occasionally anchor ice has been known to entrain the sediment to which it is attached into the flow when the ice releases from the bottom. The author has seen small-fist-sized rocks in floating ice covers that undoubtedly were the result of such a process but when seen, these have been widely dispersed and represent only insignificant transport. The magnitude of such sediment transport may be appreciated by a simple hydrostatic force balance. The buoyant upward force of the ice mass is $(\rho_w - \rho_i)(1 - p) h_i$ where ρ_w is the density of water, ρ_i is the density of solid ice, p is the porosity and h_i is the thickness of the anchor ice accumulation. The resisting downward force is $(\rho_w - \rho_s)(1 - p) h_s$ where ρ_s is the density of the sediments and h_s is the thickness of sediment which is in equilibrium with the attached ice mass. Assuming similar porosities and a specific gravity of the sediment particles of 2.67 (silica) the ratio of h_i to h_s is (2.67-1.0)/(1.0 – 0.916) = 19.9. In short, the thickness of sediment possibly entrained by an anchor ice deposit is 1/20 the thickness of the deposit. This assumes, of course, that the sediment has enough cohesion to support the sediment beneath the ice-sediment interface. This author doubts that anchor ice deposits ever exceed about a foot or so in thickness at the site, and in any case, are confined to the rapids area, which is not subject to remediation.

FREEZING TO BOTTOM IN SHALLOW WATER

In shallow water regions of the site, we are concerned with those regions where the water is shallower than the maximum thickness of ice that can form over the winter. In such areas, the freezing process may continue into the bed beneath, and upon rise of the water level with increasing discharge, the material (i.e., sediment or capping material) frozen to the bottom of the ice cover may be lifted and transported with the ice cover. This would apply, of course, to regions where the ice cover is sufficiently buoyant to overcome the weight of the sediment frozen to the bottom. After breakup of rivers, ice pieces with a thin layer of sediment on the bottom are often seen. It is believed that this is a very minor sediment transport mechanism and probably offset by sedimentation in such shallow areas during the remainder of the year.

The maximum thickness of ice that might be expected at the site is given by a modified Stefan equation of the form $h_i = C\, S_f^{1/2}$ where, if h_i is given in inches and S_f is the degree days of freezing in °F – days, then C is typically about 0.5 to 0.7 for slow flowing rivers and protected still waters. For the average S_f of 488 °C days (= 878 °F – days), this results in a thickness of 14.8 to 20.7 inches. If the average plus one standard deviation of degree days of freezing is used, this results in maximum ice thicknesses of 16.9 to 23.7 inches. Thus, the mechanism described above is applicable to regions where the water depth is 2 feet or less under average or typical discharges during the winter. Following the same buoyancy calculation as used in estimating the sediment that could be lifted by anchor ice (see above) only now the ice has a zero porosity results in the maximum thickness that could be lifted of about 1/10 the ice thickness. While such a thickness seems theoretically possible and would result in a capping material of about 2-inch size, the author doubts that it need be that large to protect the bed. Additionally, most of the regions of the river where the ice can attain such maximum thicknesses are in protected areas and the ice is more likely to melt in place. This seems to be the case in this reach of the Hudson River. Examination of the topography of the bottom from river mile 194.5 to river mile 189.5 showed only one significant area of such shallow water, namely the slough west of Griffin Island. There the velocity is nearly zero and the ice will melt in place.

SUMMARY OF FINDINGS

No evidence was found of jamming in the reach extending from river mile 194.5 (just upstream of Rogers Island) to river mile 188.6 (Thompson Island Dam). The general character of the ice formation in this reach of river is one of rapid formation of a more-or-less complete ice cover with the onset of cold temperatures. There very likely will be some open water areas upstream of Rogers Island, particularly in a rapids reach just downstream of the dam at Hudson Falls and near the site of the old Fort Edward dam. Here it is possible for anchor ice to form during very cold periods but is not in areas planned for remediation. There will also be some sustained frazil production possible in these open areas during cold periods of the winter. An estimate of the frazil production through a winter season was made and the volume produced can be accommodated by a deposit beneath the ice cover that would likely not extend downstream further than the lower end of Rogers Island at river mile 193.75. These frazil deposits are easily eroded and should not result in scour of sediments that are resistant to velocities of about 2.3 ft/s. There is a theoretical possibility of the ice cover freezing to the bed in shallow protected areas less than about 20 to 24 inches deep, and with rising flows moving the sediment frozen to the bottom. However, this is considered a minor sediment transport mechanism.

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