Phase 1 Intermediate Design Report
Hudson River PCBs Superfund Site

Treatability Studies Report

General Electric Company
Albany, New York

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

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1. Introduction and Objectives

On behalf of the General Electric Company (GE), treatability studies were conducted during 2004 and 2005 to support the design of the remedy selected by the United States Environmental Protection Agency (EPA) to address polychlorinated biphenyls (PCBs) in sediments of the Upper Hudson River, located in New York State. Treatability studies were conducted to provide data to guide equipment selection and sizing during the remedial design, as specified in the *Treatability Studies Work Plan* (TS Work Plan) (Blasland, Bouck & Lee, Inc. [BBL], 2004) approved by the EPA on February 13, 2004. This *Treatability Studies Report* (TS Report) provides documentation of these studies and provides the resulting data except ongoing studies of settling and filter press simulation (see Section 2.2 for a description of Treatability Studies Corrective Action Memorandum [TS CAM] No. 008).

The activities described in the TS Work Plan are being conducted under 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) (EPA/GE, 2003). The treatability studies also validated, on a small scale, performance specifications of processes developed during the remedial design. As described in the TS Work Plan, the objectives of the treatability studies were to provide the data needed to:

- Determine the potential for water quality impacts caused by dredging;
- Develop the sediment dewatering design to meet anticipated landfill acceptance or Beneficial Use Determination (BUD) requirements;
- Develop the water processing design to provide data relative to achieving discharge requirements; and
- Develop the disposal design to meet anticipated landfill acceptance requirements.

These objectives represent broad design goals. However, because it is not possible to address these goals with absolute precision, the primary goal of the treatability testing was to reasonably reduce the uncertainty so that informed design decisions could be made. Additional treatability study testing is being performed and will continue concurrently with the development of the *Phase 1 Final Design Report* (Phase 1 FDR). These studies will not affect the schedule for submission of the Phase 1 FDR.

2. Treatability Studies Planning and Contractors

2.1 Treatability Studies Work Plan

Activities conducted during the treatability studies are described in the TS Work Plan and consisted of:

- Collecting samples (sediment and water) from the river and submitting them for pre-treatment characterization;
- Conducting treatability studies to simulate certain unit processes and/or to produce data on the behavior of dredged sediment or associated water subject to these operations; and
- Submitting samples from the treatability studies for analytical and geotechnical testing.

2.2 Corrective Action Memoranda

During performance of the treatability studies, a series of TS CAMs were submitted to the EPA for review and approval. These TS CAMs described significant changes to the treatability studies and are summarized below. A copy of the TS CAMs is provided in Attachment A.

- TS CAM No. 001, submitted on May 5, 2004, modified the standard operating procedure (SOP) for sample collection for treatability studies to reflect the actual procedures to be followed for the work being performed. The EPA verbally approved a draft of this TS CAM on May 3, 2004, but has not yet provided written approval.
- TS CAM No. 002, submitted June 29, 2004, documented a number of minor inconsistencies within and corrections to the TS Work Plan that were identified during preparation of the final SOPs by the selected treatability studies contractor. TS CAM No. 002 also included modifications to and clarifications concerning the laboratory methods for PCB analysis of water samples. The EPA approved TS CAM No. 002 on July 23, 2004
- TS CAM No. 003, submitted on August 6, 2004, addressed the collection of additional sediment sample volume in order to meet the target PCB concentration and grain-size distribution for each of the four

sediment types used in the treatability studies. TS CAM No. 003 also included an SOP for hydrocyclone performance testing. The EPA approved TS CAM No. 003 on August 9, 2004.

- TS CAM No. 004, submitted on August 9, 2004, described a series of modifications regarding sediment types used in several of the treatability tests. The EPA has not yet provided written approval of TS CAM No. 004.
- TS CAM No. 005, submitted on October 22, 2004, provided for further sediment and water collection for additional treatability studies. The EPA has not yet provided written approval of TS CAM No. 005.
- TS CAM No. 006, submitted on December 10, 2004, described additional size separation studies, including hydrocyclone performance testing. TS CAM No. 006 also included revised SOPs for size separation and hydrocyclone performance testing. The EPA has not yet provided written approval of TS CAM No. 006.
- TS CAM No. 007, submitted on April 20, 2005, covered additional bench-scale filter press test simulations. The EPA has not yet provided written approval of TS CAM No. 007.
- TS CAM No. 008, submitted on July 8, 2005, proposed additional settling tests and bench-scale filter press test simulation of fine material (hydrocyclone overflow). The EPA provided a few questions to GE on TS CAM No. 008 on July 20, 2005, which GE answered on July 22, 2005. The additional settling tests were completed in July 2005.

In addition to the TS CAMs, there has been additional correspondence between GE and EPA regarding extension of the treatability studies schedule, primarily to complete the rapid small-scale column tests (RSSCTs). A copy of this correspondence is also provided in Attachment A.

2.3 Duties of Contractors and Laboratories

BBL and Quantitative Environmental Analysis, LLC (QEA) collected sediment and water samples from the river for the treatability studies. Waste Stream Technology, Inc. (Waste Stream) of Buffalo, New York completed the studies, including a portion of the analytical testing, from July 2004 to May 2005. The baseline analytical testing and additional analyses throughout the treatability studies were conducted by the following laboratories:

- Northeast Analytical, Inc. (NEA) in Schenectady, New York;
- Paradigm Analytical Laboratories (Paradigm) in Wilmington, North Carolina;

- Severn Trent Laboratories (STL) in Burlington, Vermont and Pittsburgh, Pennsylvania;
- Geotechnics in Pittsburgh, Pennsylvania; and
- St. Peter's Bender Laboratory (St. Peter's) in Albany, New York, under subcontract to NEA.

The testing performed by each laboratory is summarized in Table 2-1, below.

Table 2-1 – Analyses Performed by Each Laboratory

Laboratory	Analyses Performed
NEA	• PCBs • Water content • Total organic carbon (TOC) • Polynuclear aromatic hydrocarbons (PAHs) • Bulk density • pH (solids) • Total suspended solids (TSS)
Paradigm	• Polychlorinated dibenzo-dioxin/polychlorinated dibenzo-furan (PCDD/PCDF)
STL	• Target Analyte List (TAL) metals • Grain-size distribution • Specific gravity • Atterberg limits • Total phosphorus/phosphate (P/PO_4) (solids) • Ammonia/total Kjeldahl nitrogen (NH_3/TKN) (solids) • Toxicity Characteristic Leaching Procedure (TCLP) – metals, volatiles, semivolatiles, pesticides, herbicides
Geotechnics	• Unconfined compressive strength • Consolidation
St. Peter's	• Biological oxygen demand – 5 day (BOD_5) • Chemical oxygen demand (COD) • P/PO_4 (liquids) • NH_3/TKN (liquids) • Nitrite/Nitrate (NO_2/NO_3)
Waste Stream	• Paint filter liquids test • Water content • Turbidity

3. Sample Collection and Slurry Preparation

3.1 Summary of Sediment Sample Collection

Representative sediment samples were collected from the river for use in the treatability studies in accordance with the TS Work Plan and subsequent TS CAMs. The sediment sample collection approach was designed to consider the specific treatability studies and the key variables that affect the results of those studies. While many of these variables ultimately influence the overall remedial design, the following two key variables were consistently important in achieving the treatability studies objectives:

- Grain-size distribution of the sediments; and
- PCB concentration of the sediments.

Recognizing the importance of these two variables and the general relationship that exists between PCB concentration and sediment type (i.e., historical data for the site indicate that higher PCB concentrations are associated with fine-grained sediments), four categories of PCB concentration/sediment types were identified to represent the anticipated range of sediments present in removal areas. Descriptions of these four sediment categories are presented in Table 3-1, below.

Table 3-1 – Sediment Categories for Treatability Testing

Sediment Category Designation	Physical Characteristics	Chemical Characteristics
S1	Coarse-grained sediment	Relatively low PCB concentrations
S2	Mixture of coarse- and fine-grained sediment	Moderate PCB concentrations
S3	Fine-grained sediment	Relatively high PCB concentrations
S4	Fine-grained sediment with oils and/or lower bulk density	Highest PCB concentrations

Following sediment collection, the sediment was homogenized, placed into 5-gallon plastic buckets, and stored in a refrigerated trailer at GE's Fort Edward, New York facility pending delivery to Waste Stream. Representative samples were submitted for testing of physical properties and analytical chemistry for the following parameters:

- PCBs (General Electric Hudson River [GEHR] Modified Method 8082);
- PAHs (EPA Solid Waste [SW]-846 Method 8270C/3545);
- TOC (Lloyd Kahn);
- TAL metals (EPA SW-846 Method 6010B/7471A);
- PCDD/PCDF (EPA 1613B);
- P/PO_4 (EPA 365.2);
- NH_3/TKN (EPA 350.1/351.3);
- Bulk density (American Society for Testing and Materials [ASTM] D4531, modified);
- Water content (Standard Method [SM] 2540G);
- Grain-size distribution (from Sieve Analysis, ASTM D422);
- Grain-size distribution for finer fraction (from Hydrometer Analysis, ASTM D1140); and
- Visual observations during sample collection.

Analytical data for the collected sediment are presented in Tables 1 through 5 in Attachment B. The results provided pre-processing data for the treatability studies and allowed for analysis of treatability studies results across the range of sediment types anticipated to be handled during remedial action implementation. The analytical results were also used to confirm that the collected sediment was representative of its designated category (i.e., grain-size distribution and relative PCB concentrations were as desired). As described in the TS Work Plan and TS CAM Nos. 001, 003, and 005, sediment was collected during five events to obtain sediment that was representative of the four categories described in Table 3-1, and to collect additional sediment for use during ongoing treatability studies. The location where each sediment type was collected is presented on Figure 1 and summarized in Table 3-2, below. Each sediment type was collected from the area bounded by the coordinates to the maximum depth shown in Table 3-2. Sediment to a maximum depth of 0.2 feet was collected using a ponar dredge. All other sediment was collected using vibra-core or push coring techniques.

Table 3-2 – Locations Where Sediment was Collected

Sediment Identification and River Section Collected From	Coordinates (New York State Plane East, North American Datum [NAD] 83)								Maximum Collection Depth (feet)
	Northwest Corner		Southwest Corner		Southeast Corner		Northeast Corner		
	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting	
S1 - River Section 1 (originally designated SX2)	1,595,947	737,592	1,595,848	737,592	1,595,848	737,712	1,595,947	737,712	1.2
S1 - River Section 1 (originally designated SX4)	1,615,064	735,096	1,614,977	735,087	1,614,977	735,202	1,615,068	735,212	0.2
S2 - River Section 1	1,608,911	732,730	1,608,805	732,724	1,608,805	732,835	1,608,899	732,829	5.3
S2 - River Section 2	1,571,444	735,583	1,571,337	735,583	1,571,337	735,688	1,571,444	735,688	1.9
S3 - River Section 1	1,607,785	732,221	1,607,690	732,221	1,607,690	732,312	1,607,785	732,312	3.8
S3 - River Section 3	1,503,237	725,467	1,503,122	725,467	1,503,122	725,565	1,503,237	725,566	5.1
S4B - River Section 1	1,610,060	733,457	1,610,060	733,457	1,610,060	733,457	1,610,060	733,457	3.0
S4B - River Section 1	1,609,990	733,416	1,609,990	733,416	1,609,990	733,416	1,609,990	733,416	3.0
SX1 - River Section 3	1,498,640	724,536	1,498,534	724,536	1,498,534	724,637	1,498,640	724,637	0.2
SX3 - River Section 3	1,498,640	724,536	1,498,534	724,536	1,498,534	724,637	1,498,640	724,637	2.0
S4 - River Section 1	1,593,043	736,251	1,592,927	736,251	1,592,927	736,359	1,593,043	736,359	3.1
S4 - River Section 2	1,576,492	737,715	1,576,398	737,715	1,576,398	737,841	1,576,492	737,841	3.0
S4A - River Section 1	1,595,855	737,819	1,595,855	737,819	1,595,855	737,819	1,595,855	737,819	0.2
S2-2 - River Section 1	1,608,911	732,730	1,608,805	732,724	1,608,805	732,835	1,608,899	732,829	5.3
S3-2 - River Section 1	1,607,785	732,221	1,607,690	732,221	1,607,690	732,312	1,607,785	732,312	3.8
S4B-2 - River Section 1	1,610,060	733,457	1,610,060	733,457	1,610,060	733,457	1,610,060	733,457	3.0
S3-3 - River Section 1	1,608,051	732,301	1,608,051	732,301	1,608,051	732,301	1,608,051	732,301	2.0

The sediment collection events are described in more detail below.

In May 2004, sediment with the following designations was collected: SX1, SX2, SX3, SX4, S2, S3, and S4. The SX1, SX2, SX3, and SX4 sediments were collected from four different areas (see Figure 1) to meet target PCB concentration and grain-size distribution for S1 sediment specified in the TS Work Plan. This approach was used because two grab samples, designated RS1-S1 and RS3-S1, indicated that sediment in the original two target areas for S1 may not meet the required criteria. However, based on the analytical results, it was determined that the SX2 and SX4 sediments could be combined and homogenized to make up S1 sediment used in the treatability testing.

The S4 sediment that was collected failed to meet the target PCB concentration and grain-size distribution specified in the TS Work Plan. This sediment designated as S4 had physical and chemical characteristics more similar to S2 than those targeted for S4 sediment. Additional S4 sediment was collected on June 9, 2004 and designated S4A (see Figure 1). Following receipt of the analytical results, this S4A sediment, like the original S4 sediment, did not meet the target PCB concentration and grain-size distribution specified in the TS Work Plan. Therefore, additional S4 sediment was collected on June 23, 2004. This material, designated S4B, met the requirements for S4 sediment identified in the TS Work Plan and was used in the treatability testing (see Figure 1).

As described in TS CAM No. 006, a series of hydrocyclone performance and size separation tests were added to the treatability studies. To complete these tests, additional sediment was required. This additional sediment was collected in October 2004 and designated S2-2, S3-2, and S4B-2 (see Figure 1). Because analytical results for the S2-2 and S4B-2 sediments were consistent with S2 and S4B samples collected for the initial treatability studies, these sediments were acceptable for use in the additional treatability studies. However, because analytical results for the S3-2 sediment were not consistent with the S3 sediment used for the initial treatability studies, the S3-2 sediment was not acceptable. Additional S3 sediment, designated S3-3, was collected in November 2004 (see Figure 1). The analytical results for the S3-3 sediment were also not consistent with the S3 sediment used for the initial treatability studies; therefore, the S3-3 sediment was also not acceptable. An additional S3 sediment, designated S3-4, was prepared by homogenizing a 60:40 composite of S3-2 and S4B-2 sediments. The resulting S3-4 sediment was acceptable for use in the additional treatability studies.

The identification and collected volume of sediment are summarized in Table 3-3, below. The table also includes information on whether the sediment was used for conducting treatability studies.

Table 3-3 – Summary of Sediment Collected for Treatability Testing

Sediment Identification	Collected Volume (gallons)	Comment
S1 (formed from SX2 and SX4)	140	Used in Treatability Studies
S2	82.5	Used in Treatability Studies
S3	112.5	Used in Treatability Studies
S4B	105	Used in Treatability Studies
S2-2	100	Used in Treatability Studies
S4B-2	30	Used in Treatability Studies
S3-3	80	Not Used in Treatability Studies

Sediment Identification	Collected Volume (gallons)	Comment
S3-4	--	Formed from S3-2 and S4B-2 and Used in Treatability Studies
S4	102.5	Used Primarily for Hydrocyclone and Mixing Energy Tests
SX1	60	Not Used in Treatability Studies
SX3	72.5	Not Used in Treatability Studies
S3-2	100	Not Used in Treatability Studies
S4A	95	Not Used in Treatability Studies

Sediment designated for use in the treatability studies was transported to Waste Stream in 5-gallon plastic buckets and stored in a cooler prior to use. Sediment not used in the treatability studies was retained at GE's Fort Edward, New York facility pending future disposal in accordance with applicable regulations. Excess sediment not used in the treatability studies and sediment samples generated by the treatability studies, but not submitted for analytical testing, will be returned to GE's Fort Edward, New York facility for disposal in accordance with applicable regulations.

While not required by the TS Work Plan or subsequent TS CAMs, Waste Stream analyzed each 5-gallon plastic bucket used in treatability studies for water content. Additionally, most of the individual 5-gallon buckets of sediment used for treatability studies were sampled by Waste Stream and analyzed for PCBs. Additionally, samples from three to four buckets of each sediment type were submitted for grain-size analysis, including a triplicate sample from one bucket of each sediment type. The analytical data for PCB and grain-size analysis for individual buckets is presented in Table 6 in Attachment B. Field log sheets, including the water content results, are included in Attachment C.

3.2 Summary of Water Sample Collection

Representative surface water was collected for use in the treatability studies from the Thompson Island sampling station located at river mile (RM) 187.5, approximately 1 foot below the water surface. A total of 2,400 gallons of water were collected during sampling events in May 2004 (900 gallons), August 2004 (600 gallons), and November 2004 (900 gallons).

Following collection of water during each sampling event, a representative water sample was submitted for analytical testing of chemical properties for the following parameters:

- PCBs (Modified Green Bay Mass Balance Method);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration);
- Turbidity (EPA 180.1);
- TOC filtered and unfiltered (Tekmar Dohrmann);
- Field pH (probe measurement);
- Field dissolved oxygen (DO) (probe measurement);
- TAL metals (EPA 200.8/245.1);
- PCDD/PCDF (EPA 1613B); and
- Visual observations during sample collection.

Analytical data for the collected river water are presented in Tables 7 and 8 in Attachment B. The analytical results were used to provide pre-processing data for the treatability tests. In addition, the results determined the representativeness of the sample.

Collected water was transported to Waste Stream for use in the treatability studies. Water generated during the treatability studies that was not submitted for analytical testing was treated through carbon and discharged by Waste Stream to the sanitary sewer in accordance with their local requirements.

3.3 Sediment Slurry Preparation

Sediment slurries were prepared to simulate both hydraulic and mechanical dredging methods. In addition, sediment slurries were also prepared to simulate mechanically dredged material that is hydraulically transported. Dredged material slurry simulations for these three dredging and transport/offloading scenarios were prepared by mixing sediment samples with varying quantities of river water. Slurries were mixed to simulate dredging conditions, as summarized in Table 3-4, below.

Table 3-4 – Dredged Material Slurry Simulations

Slurry Designation	Sediment/Solids to Water Ratio	Purpose
M1	80:20 (sediment: water, volumetric proportions)	To simulate mechanically dredged material with a typical amount of entrained water.
H1	25:75 (solids: water, weight proportions)	To simulate high-solids content material that was mechanically dredged, but hydraulically transported.
H2	5:95 (solids: water, weight proportions)	To simulate hydraulically dredged material with a typical solids content.

Samples from each of the four sediment categories were tested to determine the range of sediment properties that would need to be accommodated by the material handling and processing facilities. Dredged material slurry simulations were prepared for each of the sediment categories, producing the following dredged material slurries:

- M1S1, H1S1, and H2S1 were prepared from Sediment S1.
- M1S2, H1S2, and H2S2 were prepared from Sediment S2.
- M1S3, H1S3, and H2S3 were prepared from Sediment S3.
- M1S4B, H1S4B, and H2S4B were prepared from Sediment S4B.

In addition to those listed above, slurries were also prepared with the S4 sediment for specific tests as described in Section 4. The water content of each of these slurries was tested to verify that acceptable slurries had been prepared. Field log sheets, including the water content results, are included in Attachment C.

These slurries provided a "feedstock" of materials to be used in dewatering and water treatment tests. Feedstock was used within a 3-day period of preparation to reduce the potential for changes in the chemical composition of the slurry. Feedstock was mixed immediately prior to use to resuspend settled material. The solids that quickly resettled due to the force of gravity were typically not included with the feedstock used in treatability studies.

4. Treatability Studies Implementation

4.1 Treatability Studies Overview

The treatability studies were a series of unit process-specific tests that provided the data necessary to advance the project design. Many of the tests were closely interrelated, with the residuals from one test used as the feed materials for a subsequent test. Individual treatability studies are summarized below.

- Determine the potential for water quality impacts caused by dredging – The dredge elutriate test (DRET) procedure was used to simulate the release of PCBs and other analytes to the water column from a dredge head.

- Develop the sediment dewatering design to meet anticipated landfill acceptance or BUD requirements – For mechanically dredged/offloaded slurries (M1), solidification agents were mixed at varying doses with slurries of different sediment types to determine the quantity of agent necessary to stabilize free liquids. For mechanically dredged/hydraulically transported slurries (H1) and hydraulically dredged slurries (H2), size separation tests, drainage tests, primary sedimentation tests, dewatering polymer tests, mixing sub-studies tests, cake release screening tests, plate and frame filter press tests, cake solids vs. time sub-study tests, high-volume plate and frame filter press tests, centrifuge tests, laboratory belt filter press tests, mixing energy tests and hydrocyclone performance tests were completed.

- Develop the water processing design to provide data relative to achieving discharge requirements – This study involved the use of precipitation/flocculation filtrate settling tests, filtrate column settling tests, multimedia filtration (MMF) tests, carbon column tests, and RSSCTs.

- Develop the disposal design to meet anticipated landfill acceptance requirements – Shaker table studies, which simulated the motion of rail cars in transit, were completed on samples of filter cake and stabilized slurries to determine if water would release from the solids during shipment.

Analytical data tables for the treatability studies are presented electronically and in paper form in Attachment B. Field data, as well as observations and results from the treatability studies laboratory, are presented in Attachment C. A database of chemical analyses completed during the treatability studies is presented in Attachment D. The geotechnical analytical reports are presented in Attachment E. Data validation assessed

the technical usability of the analytical data for making decisions pertaining to project objectives. Full data validation was performed on 10% of the analytical results for the treatability studies. These data validation reports are presented in Attachment F.

4.2 Treatability Studies Summary

The treatability studies were conducted to develop data to support the remedial design. Table 4-1, below, summarizes the name of each treatability study, the design element that incorporates the data, the relevant section and associated data quality objectives (DQOs) from the TS Work Plan, and the table number in Attachment B where the analytical data are presented.

Table 4-1 – Treatability Studies Summary

Treatability Study	Element of Design Used For	TS Work Plan Section	DQOs	Analytical Data Table in Attachment B
Dredge Elutriate Tests	Dredging and Resuspension Control	2.3.1 & 2.3.2	3a. & 3b.	9, 10
Mixing Energy Tests	Sediment Slurry Tanks	2.4.10	4b. (5) & 4c. (5)	--
Size Separation Tests	Screening and Desanding	2.4.2	4b. (1a) & 4c. (1a)	11, 12, 13, 14
Hydrocyclone Performance Tests	Hydrocyclone (Desanding)	TS CAM Nos. 003 and 006	4b. (1a) & 4c. (1a)	13, 14, 15, 16
Primary Sedimentation Tests	Gravity Thickener Tanks	2.4.5	4b. (2b) & 4c. (2b)	17, 18
Dewatering Polymer Tests	Dewatering Conditioning Tanks	2.4.6	4b. (3a) & 4c. (3a)	--
Mixing Sub-Studies Tests	Dewatering Conditioning Tanks	2.4.6	4b. (3a) & 4c. (3a)	--
Cake Release Screening Tests	Filter Press (Dewatering)	2.4.6	4b. (3a) & 4c. (3a)	--
Plate and Frame Filter Press Tests	Filter Press (Dewatering)	2.4.7	4b. (3b) & 4c. (3b)	19, 20, 21, 22
Cake Solids vs. Time Sub-Study Tests	Filter Press (Dewatering)	2.4.7	4b. (3b) & 4c. (3b)	--
High-Volume Plate and Frame Filter Press Tests	Filter Press (Dewatering)	2.4.7	4b. (3b) & 4c. (3b)	--
Precipitation/Flocculation Filtrate Settling Tests	Flocculation and ClarificationTanks	2.5.1	5a. (1)	--
Filtrate Column Settling Tests	Clarification Tanks	2.5.1	5a. (1)	23
MMF Tests	Multimedia Filter Systems	2.5.2	5a. (2)	24
Carbon Column Tests	Granular Activated Carbon Systems	2.5.3	5a. (3)	24
RSSCTs	Granular Activated	2.5.3	5a. (3)	25, 26

Treatability Study	Element of Design Used For	TS Work Plan Section	DQOs	Analytical Data Table in Attachment B
	Carbon Systems			
Drainage Tests	Sediment Product Storage Area	2.4.3	4b. (1b) & 4c. (1b)	--
Stabilization/Solidification Tests	Filter Cake Rework Area	2.4.1 & 2.4.9	4a. (1), 4b. (4) & 4c. (4)	27
Storage/Transportation Stability Shaker Tests	Off-Site Sediment Disposal	2.6.1	6a.	27
Primary Sedimentation Polymer Tests	Not proposed to be included as part of the processing facility	2.4.4	4b. (2a) & 4c. (2a)	--
Centrifuge Tests	Not proposed to be included as part of the processing facility	2.4.8	4b. (3c) & 4c. (3c)	28
Laboratory Belt Filter Press Tests	Not proposed to be included as part of the processing facility	TS CAM No. 004	4b. (3c) & 4c. (3c)	--

4.2.1 Dredge Elutriate Tests

The DRET is a bench method used to determine the resuspension qualities of sediment into the water column. Sediments used for testing were S1, S2, S3, and S4B. Three replicates were conducted for each sample to account for variability. The DRETs were originally completed in July 2004. However, the delivery service did not transmit the samples for TAL metals to the laboratory in a timely manner, and the cooler temperature was higher than required by the analytical method. As a result, all of the sample results were flagged as estimated values during validation. Therefore, the DRETs were repeated in September 2004.

During both DRETs, water samples were analyzed for the following parameters:

- PCBs filtered and unfiltered (Modified Green Bay Mass Balance Method);
- TAL metals filtered and unfiltered (EPA 200.8/245.1);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration);
- Turbidity (EPA 180.1);
- TOC-filtered and unfiltered (Tekmar Dohrmann);
- pH (probe measurement);
- Dissolved oxygen (DO) (probe measurement); and
- Visual observations during sample collection.

Additionally, prior to conducting each DRET, one sediment sample in each of the four sediment categories (S1, S2, S3, and S4B) was analyzed for PCBs by the Modified Green Bay Mass Balance Method. The analytical results for the DRETs are presented in Tables 9 and 10 in Attachment B. Field log sheets, including visual observations, are included in Attachment C.

Other than completing the DRETs twice, the only modification from the TS Work Plan and subsequent TS CAMs was that filtering of water for dissolved TOC analyses was performed by Waste Stream in accordance with the analytical method rather than NEA, as originally planned. In addition to the DRETs, this practice was followed through the treatability studies described in this section.

4.2.2 Mixing Energy Tests

During processing of Hudson River dredged material, it may be necessary to store dredged slurries for various reasons. Because dredged materials in a slurry consist of settleable particulates, it will be necessary either to keep these settleable particulates in suspension or to provide solids-removal mechanisms in the storage facilities. Mixers may be used to keep slurried solids in suspension until they are removed for treatment. The mixing energy tests were conducted to provide calibration points for mixer design calculations.

Material used for testing was from slurries H1S1, H1S2, H1S4B, H2S1, and H2S3. Mixing energy testing was conducted in August 2004. Field log sheets, including visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the mixing energy tests were as follows:

- Slurry H1S4 was used in place of H1S2 because there was no remaining S2 sediment to use at the time of the test, and the physical characteristics of the S4 sediment were similar to those of the S2 sediment.

- Five-gallon buckets were used for testing instead of the jars required by the SOP because the larger volume would provide more representative data.

4.2.3 Size Separation Tests

Size separation tests were conducted to evaluate the potential to reduce the volume or mass of dredged material requiring more restrictive landfill disposal (e.g., Toxic Control Substances Act [TSCA]) and to maximize the potential beneficial use for each size cut. Size separation testing was conducted from July through September 2004 and in December 2004.

Slurries and sediment originally used for size separation testing were H1S1, H1S2, S3, S4B, and S4. In conjunction with the hydrocyclone performance testing conducted in August and December 2004, size separation tests were conducted on numerous feed and underflow materials.

A sample was collected from each solid fraction (i.e., fraction retained on each sieve) and submitted for the following analyses:

- PCBs (GEHR Modified Method 8082);
- pH (EPA 9045C);
- TAL metals (EPA SW-846 Method 6010B/7471A);
- Specific gravity (ASTM D854); and
- Atterberg limits (ASTM D4318).

In addition, the coarse fraction from the size-separation tests (i.e., the fraction retained on or above the #200 sieve) was analyzed for TOC (Lloyd Kahn). The analytical results for the size separation tests, including results associated with the hydrocyclone performance testing described in the next section, are presented in Tables 11, 12, 13, and 14 in Attachment B. Field log sheets, including visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the size separation tests were as follows:

- In the size separation tests prior to December 2004, a centrifuge with polymer was used to separate solids that passed through the #200 sieve from the rinse water.

- Due to the required sample volume, fractions were sometimes combined for specific gravity analyses.

- Due to the required sample volume, most samples tested for Atterberg limits were from combined fractions. Additionally, Atterberg limit testing was not conducted on material that passed through a #200 sieve or was retained by a #40 sieve.

- Wet screening with site water was used in place of the drying step included with the original SOP.

- Only PCB and TOC analyses were conducted on each solid fraction developed from the size separation conducted in conjunction with the hydrocyclone performance testing performed in December 2004.

4.2.4 Hydrocyclone Performance Tests

Although hydrocyclone performance tests were not originally specifically included in the TS Work Plan, they were included in TS CAM Nos. 003 and 006. Hydrocyclone performance tests were conducted to separate fractions of sediments based on density and particle size. Sediments used in hydrocyclone performance testing were S4, S2-2, and S3-4. Hydrocyclone performance testing was conducted in August and December 2004.

Samples of the hydrocyclone feed, underflow, and overflow streams were analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082);
- TOC (Lloyd Kahn);
- Total dissolved solids (TDS) (EPA 160.1);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration);
- Water content (SM 2540G);
- Grain-size distribution (from Sieve Analysis, ASTM D422); and
- Grain-size distribution for finer fraction (from Hydrometer Analysis, ASTM D1140);

One sample of hydrocyclone underflow streams was also submitted for analysis of TAL metals (EPA SW-846 Method 6010B/7471A), pH (EPA 9045C), specific gravity (ASTM D854), and Atterberg limits (ASTM D4318).

Depending on the stream that was being sampled and the specific hydrocyclone test that was being conducted, not every parameter was analyzed for every sample. The analytical results for the hydrocyclone performance testing, including size separation tests on samples collected from the hydrocyclone, are presented in Tables 13, 14, 15, and 16 in Attachment B. Field log sheets, including visual observations, are included in Attachment C.

4.2.5 Primary Sedimentation Tests

Sedimentation of fresh-water slurries with a concentration less than 100 grams per liter can generally be characterized as flocculent settling. As slurry concentrations are increased, the sedimentation process may be characterized as a zone settling process, in which a clearly defined interface is formed between the clarified supernatant water and the more concentrated settled material. The primary sedimentation tests examined the sedimentation of suspended solids under flocculent settling conditions.

Material used for testing was from slurries H1S1, H1S2, H1S3, H2S2, H2S3, and H2S4B. Primary sedimentation testing was conducted in July and August 2004.

Aliquots of supernatant were collected from various column heights throughout the test and analyzed for TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration).

Solids samples were collected from the bottom of the column after the 24-hour test and analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082);
- Water content (SM 2540G); and
- TOC (Lloyd Kahn).

Supernatant samples collected from the top of the column at the 24-hour duration were analyzed for PCBs (GEHR Modified Method 8082). In addition, filtered and unfiltered supernatant samples were analyzed for TOC (Tekmar Dohrmann).

The analytical results for the primary sedimentation tests are presented in Tables 17 and 18 in Attachment B. Field log sheets, including visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the primary sedimentation tests were as follows:

- Sample collection point at 8 feet was eliminated because it was above the usable height of the column.
- Sample collection at a settling duration of 1 hour was added to provide more data near the beginning of the test.
- All slurries tested were de-sanded (by gravity) prior to being added to the column. This coarse material was sampled and analyzed for PCBs (GEHR Modified Method 8082).
- Floatable material was not observed during any of the tests, so samples could not be collected.

4.2.6 Dewatering Polymer Tests

Sediments that are hydraulically dredged, transported, or offloaded typically must be mechanically dewatered using a combination of polymer conditioning and filter press treatment. Dewatering polymer tests were conducted to identify the preferred polymer conditioning for this treatment.

Material used for testing was from slurries H1S1, H1S2, H1S3, H1S4A, H1S4B, and H2S4B; settled solids were from slurries H1S3, H2S2, H2S3, and H2S4B; overflow material from hydrocyclone performance testing was from S4 sediment; and select fractions were from sediment S2-2. Dewatering polymer testing was conducted from July through September 2004 and in June 2005. This testing, including associated small column settling tests, will continue concurrent with development of the Phase 1 FDR.

Filter cake samples were tested by Waste Stream for water content (SM 2540G). Field log sheets, including the water content results and visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the dewatering polymer tests were as follows:

- The screening and confirmation test steps were completed in parallel rather than in series. This allowed for the testing of a wider range of conditions.

- Additional bench-scale filter press tests were run, and a reduced number of Buchner funnel tests were conducted. The net impact was that a greater number of tests were run than were specified in the TS Work Plan and subsequent TS CAMs.

4.2.7 Mixing Sub-Studies Tests

The floc produced by most polymers is sensitive to shear and over-mixing; however, some media and some polymers are more sensitive to floc shear than others. The mixing sub-studies tests were performed to compare the sensitivity of several polymers to shear due to over-mixing when treating the stimulated dredged material slurries.

Material used for testing was from slurries H1S3 and H2S4B. Mixing sub-studies testing was conducted in July and August 2004.

Filter cake samples were tested by Waste Stream for water content (SM 2540G). Field log sheets, including the water content results and visual observations, are included in Attachment C.

The modification from the TS Work Plan and subsequent TS CAMs to the mixing sub-studies tests was that settled solids from slurries H2S2 and H2S4B were deleted, but slurry H2S4B was added in their place.

4.2.8 Cake Release Screening Tests

Filter leaf tests were performed to evaluate cake releaseability from a variety of filter media fabrics and weave tightness. Material used for testing was from slurries H1S2 and H1S3. Cake release screening testing was conducted in July 2004.

Filter cake samples were tested by Waste Stream for water content (SM 2540G). Field log sheets, including the water content results and visual observations, are included in Attachment C.

The modification from the TS Work Plan and subsequent TS CAMs to the cake release screening tests was that settled solids from slurries H2S3 and H2S4B were deleted so that four different fabrics could be tested with the two slurries used.

4.2.9 Plate and Frame Filter Press Tests

Plate and frame filter tests were conducted to develop data to help size a full-scale filter press. Material used for testing was from slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B. Plate and frame filter testing was conducted from July through September 2004.

Filtrate was analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082); and
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration).

Filter cake samples were analyzed by Waste Stream for water content (SM 2540G) and paint filter liquids test (EPA SW-846 Method 9095A).

The analytical results for the plate and frame filter press tests are presented in Table 19 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the plate and frame filter press tests were as follows:

- Plate and frame filter press tests were not conducted on settled solids from slurries H2S2 and H2S4B, but were completed on slurries H1S1, H1S4B and H2S4B because these slurries were being used in high-volume plate and frame filter press tests.

- Filter press maximum pressure was increased to from 100 pounds per square inch (psi) to 125 psi.

- Filtrate volume was measured on a more frequent basis, with readings collected at 5 minutes into the test and then every 30 minutes until the test was completed.

4.2.10 Cake Solids vs. Time Sub-Study Tests

The cake solids vs. time sub-study tests were conducted to evaluate the changes in filter cake solid content during plate and frame filter press tests to optimize the length of the press run. Material used for testing was from slurry H1S3, and the testing was conducted in July 2004.

Filter cake samples collected at 30, 45, and 60 minutes were analyzed by Waste Stream for water content (SM 2540G) and paint filter liquids test (EPA SW-846 Method 9095A). Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

The modification from the TS Work Plan and subsequent TS CAMs to the cake solids vs. time sub-study tests was that settled solids from slurries H2S2 and H2S4B were not completed because those materials were not included in the high-volume plate and frame filter press tests.

4.2.11 High-Volume Plate and Frame Filter Press Tests

The high-volume plate and frame filter press tests were conducted to produce filtrate for further water treatment testing, which is described in subsequent sections. A secondary purpose was to produce filter cake for landfill acceptance testing (i.e., passing the paint filter liquids test).

Material used for testing was from slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B. High-volume plate and frame filter press testing was conducted from July through September 2004.

Filtrate samples were analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration);

- Turbidity (EPA 180.1);
- TOC filtered and unfiltered (Tekmar Dohrmann);
- pH (probe measurement); and
- Visual observations during sample collection.

Filter cake samples were submitted for the following analyses:

- PCBs (GEHR Modified Method 8082);
- TOC (Lloyd Kahn);
- TAL metals (EPA SW-846 Method 6010B/7471A);
- PCDD/PCDF (EPA 1613B);
- TCLP metals (EPA SW-846 Method 1311/3010A/6010B/7470A);
- TCLP volatiles (EPA SW-846 Method 1311/8260B);
- TCLP semivolatiles (EPA SW-846 Method 1311/3510C/3520C/8270C);
- TCLP pesticides (EPA SW-846 Method 1311/3510C/3520C/8081A);
- TCLP herbicides (EPA SW-846 Method 1311/8151A);
- Unconfined compressive strength (ASTM D2166-00);
- Consolidation (ASTM D2435);
- Specific gravity (ASTM D854);
- Atterberg limits (ASTM D4318);
- Grain-size distribution (from Sieve Analysis, ASTM D422);
- Grain-size distribution for finer fraction (from Hydrometer Analysis, ASTM D1140);
- Water content (SM 2540G); and
- Paint filter liquids test (EPA SW-846 Method 9095A).

The analytical results for the high-volume plate and frame filter press tests are presented in Tables 19, 20, 21, and 22 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C. The geotechnical lab reports for the high-volume plate and frame filter press tests are presented in Attachment E.

Modifications from the TS Work Plan and subsequent TS CAMs to the high-volume plate and frame filter press tests were as follows:

- Filter press maximum pressure was increased from 100 psi to 125 psi.

- Filtrate volume was measured on a more frequent basis, with readings collected at 5 minutes into the test and then every 30 minutes until the test was completed.

- To generate the required volume of filtrate for subsequent water tests, slurry H1S4 was used in place of H1S2 for two of the filter press runs because there was no remaining S2 sediment, and the physical and chemical characteristics of the S4 sediment were similar to those of the S2 sediment. Samples of the filtrate and filter cake generated during these two runs were not submitted for the analyses specified above, but the filtrate was blended with filtrate generated from the H1S2 slurry.

- In an attempt to generate feed water for the RSSCTs, slurry H1S4A was used for a number of filter press runs. The filtrate generated was ultimately not used for the RSSCTs. Samples of the filtrate and filter cake generated during these runs were not submitted for the analyses specified above.

4.2.12 Precipitation/Flocculation Filtrate Settling Tests

Precipitation/flocculation filtrate tests were conducted on filtrate from the high-volume plate and frame filter press runs to evaluate the performance of precipitating/flocculation polymers. Material used for testing was from slurries H1S1, H1S2, H1S3 H1S4B, and H2S4B. Precipitation/flocculation filtrate testing was conducted in August 2004.

Filtrate samples were analyzed by Waste Stream for turbidity (EPA 180.1). Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

4.2.13 Filtrate Column Settling Tests

Filtrate column settling tests were performed on the filtrate from the high-volume plate and frame filter press runs to evaluate the settling characteristics of particulate matter remaining in the filtrate. Material used for

testing was from slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B. Filtrate column settling testing was conducted in September 2004.

Because there was minimal particulate matter in the majority of the filtrate from the filter press and there was limited volume of each filtrate available, the settling tests were completed in 55-gallon drums rather than conducting the tests in columns. The filtrate in each drum was well mixed and then allowed to settle for 2 hours. Aliquots of supernatant were collected from near the top of the drum and analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082);
- Turbidity (EPA 180.1);
- PCDD/PCDF (EPA 1613B);
- TAL metals (EPA 200.8/245.1); and
- pH (probe measurement).

Additionally, samples were collected from near the top, near the bottom, and near the middle of the drum (if sufficient volume was present) and analyzed for TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration). At the conclusion of sampling, all of the filtrate, except for any settled solids in the bottom of the drum, was transferred to clean drums for use in subsequent water tests, as described later in this section.

The analytical results for the filtrate column settling tests are presented in Table 23 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

The modification from the TS Work Plan and subsequent TS CAMs to the filtrate column settling tests involved completing the tests in 55-gallon drums, as described above.

4.2.14 Multimedia Filtration Tests

MMF tests were conducted on effluent from the filtrate column settling tests to determine the amount of PCB and suspended solids that could be expected to be removed at typical design loading conditions. Material used for testing was from slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B. MMF testing was conducted in

September 2004 at hydraulic loading rates of 2, 6, and 10 gallons per minute per square foot of multimedia surface area (gpm/ft^2).

Aliquots of influent and effluent samples from the MMF were analyzed for the following parameters:

- PCBs (Modified Green Bay Mass Balance Method);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration);
- Turbidity (EPA 180.1);
- BOD_5 (EPA 405.1);
- COD (EPA 410.2)
- TOC filtered and unfiltered (Tekmar Dohrmann);
- pH (probe measurement);
- DO (probe measurement);
- TAL metals (EPA 200.8/245.1);
- PCDD/PCDF (EPA 1613B);
- Total P/PO_4 (EPA 365.2);
- PAHs (EPA SW-846 Method 8270C/3520C);
- $NH_3/TKN/NO_2/NO_3$ (EPA 350.2/351.3/353.3/354.1); and
- Visual observations during sample collection.

The analytical results for the MMF tests are presented in Table 24 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the MMF tests were as follows:

- Testing was performed in conjunction with the carbon column tests, so the MMF effluent sample was the same as the carbon column influent sample.

- Due to limited filtrate volume available to complete the tests, samples were collected after a minimum of three bed volumes were filtered at each hydraulic loading rate.

- Due to limited filtrate volume available to complete the tests, samples of the filtrate were collected from the H1S4B slurry at only the 6 gpm/ft^2 hydraulic loading rate.

- Due to limited filtrate volume available to complete the tests, samples of the filtrate were collected from the H2S4B slurry at only the 2 and 6 gpm/ft^2 hydraulic loading rate.

4.2.15 Carbon Column Tests

Carbon column tests were used to further evaluate carbon consumption rates and PCB removal efficiencies following liquid-phase granular-activated carbon (GAC) treatment. Material used for testing was from slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B. Carbon column testing was conducted in September 2004 at hydraulic loading rates of 2, 6, and 10 gpm/ft^2 through two carbon columns arranged in series.

Water samples were collected from the carbon influent, between carbon units and the carbon effluent, and analyzed for the following parameters:

- PCBs (Modified Green Bay Mass Balance Method);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration);
- Turbidity (EPA 180.1);
- BOD_5 (EPA 405.1);
- COD (EPA 410.2)
- TOC filtered and unfiltered (Tekmar Dohrmann);
- pH (probe measurement);
- DO (probe measurement);
- TAL metals (EPA 200.8/245.1);
- PCDD/PCDF (EPA 1613B);
- Total P/PO_4 (EPA 365.2);
- PAHs (EPA SW-846 Method 8270C/3520C);
- $NH_3/TKN/NO_2/NO_3$ (EPA 350.2/351.3/353.3/354.1); and
- Visual observations during sample collection.

The analytical results for the carbon column tests are presented in Table 24 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

Modifications from the TS Work Plan and subsequent TS CAMs to the carbon column tests were as follows:

- Testing was performed in conjunction with the MMF tests, so the carbon column influent sample was the same as the MMF effluent sample.

- Due to limited filtrate volume available to complete the tests, samples were collected after a minimum of three bed volumes had passed through the carbon columns at each hydraulic loading rate.

- Due to limited filtrate volume available to complete the tests, samples of the filtrate were collected from the H1S4B slurry at only the 6 gpm/ft^2 hydraulic loading rate.

- Due to limited filtrate volume available to complete the tests, samples of the filtrate were collected from the H2S4B slurry at only the 2 and 6 gpm/ft^2 hydraulic loading rates.

- Additional carbon was added to each column to provide empty bed contact times (EBCTs) ranging from approximately 4 minutes in a single column at the highest hydraulic loading rate to approximately 40 minutes in the double columns at the lowest hydraulic loading rate.

- Carbon was changed after the filtrate from each slurry type had been tested.

4.2.16 Rapid Small-Scale Column Tests

RSSCTs were conducted to estimate carbon consumption rates and removal efficiencies. In addition, RSSCTs compared the performance of carbon obtained from Calgon Carbon Corporation (Calgon) and NORIT Americas Inc. (Norit). During the RSSCTs, water was passed through the following six column set-ups:

- Single column with Calgon carbon;
- Two columns in series with Calgon carbon;
- Single column with Norit carbon;
- Two columns in series with Norit carbon;
- Single blank column; and

- Two blank columns in series.

Using this configuration, the RSSCT was able to simulate EBCTs of 10 (single column) and 20 (double columns) minutes. Additionally, the RSSCT simulated approximately 1 month of full-scale operation in only 4 days.

There were several attempts to create RSSCT feed water with PCB concentrations in the 5 to 15 micrograms per liter range to complete a meaningful test. Ultimately, the material used for the RSSCT was filtrate generated from sediment S4B-2. The RSSCT was conducted in May and June 2005, and will continue concurrent with development of the Phase 1 FDR.

Samples of effluent water from each for the six column set-ups were collected at six points during the course of the RSSCT and analyzed for the following parameters:

- PCBs (Modified Green Bay Mass Balance Method);
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration); and
- TOC (Tekmar Dohrmann).

Samples were also collected each day from the effluent of the six column set-ups and analyzed by Waste Stream for turbidity (EPA 180.1). Additionally, samples were periodically collected from all or some of the six column set-ups and analyzed for PCBs (EPA 608). A weekly composite sample of the RSSCT feed water was also submitted for analysis of PCBs (EPA 608). Lastly, one grab sample was collected from the RSSCT feed water and analyzed for total mercury (EPA 1631).

The analytical results for the RSSCTs are presented in Tables 25 and 26 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

There have been modifications to the RSSCT from the TS Work Plan, as described in subsequent TS CAMs and extensive correspondence with the EPA. The majority of these changes were related to the feed water and analytical testing, as described above.

4.2.17 Drainage Tests

During processing of Hudson River dredged material, larger-sized particulates may be separated from finer solids in de-sanding process equipment such as hydrocyclones or screens. The purpose of the drainage tests was to estimate the water content of separated coarse material after gravity draining.

Material used for testing was from slurries H1S1 and H1S2, and one of the underflow samples from hydrocyclone performance testing was from sediment S4. Drainage testing was conducted in July and August 2004.

Samples collected at 24, 48, and 72 hours were analyzed by Waste Stream for water content (SM 2540G). Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C.

The modification from the TS Work Plan and subsequent TS CAMs to drainage tests included the addition of one of the underflow samples from the hydrocyclone performance testing using sediment S4.

4.2.18 Stabilization/Solidification Tests

Stabilization/solidification tests were used to determine the effectiveness of solidification agents mixed at varying doses with mechanically dredged/offloaded slurries (M1) to allow for land filling of dredged material. In addition, stabilization/solidification tests were to be conducted on filter cakes from high-volume plate and filter press tests on slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B if cake dryness goals (i.e., passing the paint filter liquids test) were not obtained. However, because these filter cakes all passed the paint filter liquids test, stabilization/solidification was not performed.

Slurries used for testing were M1S1, M1S2, M1S3, and M1S4B. Stabilization/solidification testing was conducted from July through September 2004. For each slurry, Portland cement, lime, fly ash, and calciment were added at three different doses, and the mixture was allowed to cure for 3 days.

Each solidified sediment sample was analyzed for the paint filter liquids test (EPA SW-846 Method 9095A). In addition, two solidified sediment samples from each slurry simulation (selected based on the paint filter liquids test results and visual observations) were analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082);
- TAL metals (EPA SW-846 Method 6010B/7471A);
- TCLP metals (EPA SW-846 Method 1311/3010A/6010B/7470A);
- TCLP volatiles (EPA SW-846 Method 1311/8260B);
- TCLP semivolatiles (EPA SW-846 Method 1311/3510C/3520C/8270C);
- TCLP pesticides (EPA SW-846 Method 1311/3510C/3520C/8081A);
- TCLP herbicides (EPA SW-846 Method 1311/8151A);
- pH (EPA 9045C);
- PCDD/PCDF (EPA 1613B);
- TOC (Lloyd Kahn);
- Unconfined compressive strength (ASTM D2166-00);
- Consolidation (ASTM D2435);
- Specific gravity (ASTM D854);
- Atterberg limits (ASTM D4318);
- Grain-size distribution (from Sieve Analysis, ASTM D422);
- Grain-size distribution for finer fraction (from Hydrometer Analysis, ASTM D1140);
- Water content (SM 2540G); and
- Visual observations during sample collection.

The analytical results for the stabilization/solidification tests are presented in Table 27 in Attachment B. Field log sheets, including visual observations, are included in Attachment C. The geotechnical lab reports for the stabilization/solidification tests are presented in Attachment E.

4.2.19 Storage/Transportation Stability Shaker Tests

Handling, storing, and transporting processed (i.e., dewatered and/or stabilized) materials via rail may have the undesirable effect of liberating free liquids that would require additional treatment at the landfill prior to acceptance of the material for disposal. Storage/transportation stability shaker tests were conducted to discern whether free liquids could be liberated from materials as a result of handling and transportation.

Material used for testing was from slurries M1S1, M1S2, M1S3, and M1S4B following stabilization/solidification, plus filter cakes from high-volume plate and frame filter press tests on slurries H1S1, H1S2, H1S3, H1S4B, and H2S4B. Storage/transportation stability shaker testing was conducted from July through September 2004.

Following testing, the material in the shaker tube was subjected to the paint filter liquids test (EPA SW-846 Method 9095A). All samples passed the paint filter liquids test and were submitted for the following geotechnical analyses:

- Consolidation (ASTM D2435);
- Specific gravity (ASTM D854); and
- Atterberg limits (ASTM D4318).

The analytical results for the storage/transportation stability shaker tests are presented in Table 27 in Attachment B. Field log sheets, including visual observations, are included in Attachment C. The geotechnical lab reports for the storage/transportation stability shaker tests are presented in Attachment E.

Modifications from the TS Work Plan and subsequent TS CAMs to the storage/transportation stability shaker tests were as follows:

- Shaker speed was increased from about 60 revolutions per minute (rpm) to 200 rpm to achieve more vigorous shaking of the samples.
- Filter cakes from high-volume plate and frame filter press tests were not submitted for specific gravity or Atterberg limits analyses because those samples did not require stabilization/solidification, so those analyses were already completed on these samples.

4.2.20 Primary Sedimentation Polymer Tests

In the TS Work Plan, primary sedimentation polymer tests were to be performed as an initial step in evaluating their efficiency in improving particulate removal during primary sedimentation However, as the design proceeded in parallel with the treatability studies, BBL determined that polymers would not be utilized in the primary sedimentation. Therefore, as outlined in TS CAM No. 004, primary sedimentation polymer tests were not required.

4.2.21 Centrifuge Tests

Centrifuge tests were conducted to determine whether centrifuges would be an appropriate technique for dewatering the dredged sediment. Material used for testing was from slurries H1S3, H1S4B, and H2S4B, plus slurries H1S3 and H1S4B with polymers. Centrifuge testing was conducted in August 2004.

Centrate samples were submitted for analysis of the following parameters:

- PCBs (GEHR Modified Method 8082); and
- TSS (EPA 160.2, with modifications consistent with ASTM D3977-97, Test Method B – Filtration).

In addition, cake samples were analyzed for the following parameters:

- PCBs (GEHR Modified Method 8082); and
- Water content (SM 2540G).

The analytical results for the centrifuge tests are presented in Table 28 in Attachment B. Field log sheets, including results from Waste Stream and visual observations, are included in Attachment C. Based on these results, BBL determined that a centrifuge would not be included as part of the processing facility.

4.2.22 Laboratory Belt Filter Press Tests

While not originally included in the TS Work Plan, laboratory belt filter press tests were included in TS CAM No. 004. Laboratory belt filter press tests were conducted to determine whether they would be an appropriate technique for dewatering the dredged sediment.

Material used for testing was from slurries H1S3 and H1S4B with polymers. Laboratory belt filter press testing was conducted in August 2004.

Filter cake samples were tested by Waste Stream for water content (SM 2540G). Field log sheets, including the water content results and visual observations, are included in Attachment C. Based on these results, BBL determined that additional testing of the filter cake or filtrate from the laboratory belt filter press was not necessary. Additionally, BBL determined that a belt filter press would not be included as part of the processing facility.

5. References

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6. Acronyms and Units of Measurement

AOC	Administrative Order on Consent
ASTM	American Society for Testing and Materials
BBL	Blasland, Bouck & Lee, Inc.
BOD	biological oxygen demand
BUD	Beneficial Use Determination
COD	chemical oxygen demand
DO	dissolved oxygen
DQO	data quality objective
DRET	dredge elutriate test
EBCT	empty bed contact time
EPA	United States Environmental Protection Agency
GAC	granular-activated carbon
GE	General Electric Company
GEHR	General Electric Hudson River
MMF	multimedia filtration
NEA	Northeast Analytical, Inc.
NH_3/TKN/NO_2/NO_3	ammonia/total Kjeldahl nitrogen/nitrite/nitrate
PAH	polycyclic aromatic hydrocarbons
Paradigm	Paradigm Analytical Laboratories
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-dioxin
PCDF	polychlorinated dibenzo-furan
Phase 1 FDR	*Phase 1 Final Design Report*
QEA	Quantitative Environmental Analysis, LLC
RM	river mile
RSSCT	rapid small-scale column test
SOP	standard operating procedure
STL	Severn Trent Laboratories
SM	Standard Measurement
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure

TOC	total organic carbon
TS	treatability studies
TS CAM	Treatability Studies Corrective Action Memoranda
TS Report	*Treatability Studies Report*
TS Work Plan	*Treatability Studies Work Plan*
TSCA	Toxic Substances Control Act
TSS	total suspended solids

gpm/ft^2	gallons per minute per square foot of surface area
psi	pounds per square inch