Lower Passaic River Restoration Project

Field Sampling Plan
Volume 1

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FIELD SAMPLING PLAN, VOLUME 1

LOWER PASSAIC RIVER RESTORATION PROJECT

Prepared by:

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1.0 INTRODUCTION

The Field Sampling Plan (FSP) presents the technical approach for conducting site characterization activities for the Lower Passaic River Study Area. Volume 1 (this document) addresses the following sampling programs:

- Geotechnical Sediment Coring.
- Sediment Transport Studies.
- High Resolution Sediment Coring.
- Low Resolution Sediment Coring.
- Tidal Water Column Monitoring.
- Tributary Water Column Monitoring
- Porewater and Groundwater Sampling.
- Mudflat Sediment Sampling.

FSP Volume 1 was developed to collect environmental sediment and water column data to support the Data Quality Objectives (DQOs) provided in Attachment 1 to the Quality Assurance Project Plan [QAPP (Malcolm Pirnie, Inc., 2005a)], which include Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Water Resources Development Act (WRDA), and Natural Resource Damage Assessment (NRDA) objectives. The collected data will include:

- Information about contaminant sources, contaminated media, and geochemical data to characterize the nature and extent of contamination.
- Information about hydrodynamic, sediment transport and stability, and biotic processes to assess the fate and transport of contaminants in sediments, water, and biota.
- Description of exposure pathways and receptors to evaluate human health/ecological risks.

To date, numerous investigations, including environmental sampling, have been conducted in parts of the Lower Passaic River by various entities having differing objectives. Therefore, available information is being compiled and evaluated in preparation for the FSP Volume 1 activities, as summarized in Section 3.0 of this document. The content of each volume of the FSP is described below:

Volume 1: FSP Volume 1 (this document) includes investigations to characterize sediment and surface water quality in the Passaic River and in major tributaries. These investigations are being done to gain chemical and physical data necessary to evaluate the spatial extent of contamination, to prepare human and ecological health risk assessments, and to understand the fate and transport of contamination within the system (including measurements of hydrodynamic and sediment transport characteristics of the Lower Passaic River and major tributaries). To this end, Hydrodynamic, Sediment Transport, Fate and Transport, and Bioaccumulation Models will be developed and calibrated based on the collected data.

Volume 2: FSP Volume 2 (Malcolm Pirnie, Inc., in 2006) will include investigations that relate to the biota and ecological aspects of the Lower Passaic River and the surrounding watershed. Investigations are to include taking inventory and cataloging the species found within and around the Lower Passaic River and obtaining tissue samples to determine potential contaminant concentrations.

Volume 3: FSP Volume 3 (Malcolm Pirnie, Inc., 2005b) includes additional investigations on candidate restoration sites, upland areas, and wetland areas in the Study Area. FSP Volume 3 also includes the 17-mile bathymetric survey of the Lower Passaic River conducted in 2004 (USACE, 2004) and the geophysical surveys conducted in the spring of 2005.

The tasks implemented under FSP Volume 1 span multiple years. Some activities have been completed and are being used to guide current and future studies; some activities are developed and scheduled for implementation; and some are under development and planned for the future. Section 3.0 below describes the status of each FSP Volume 1 task.

1.1. SITE BACKGROUND

The U.S. Environmental Protection Agency (USEPA), New Jersey Department of Environmental Protection (NJDEP), the U.S. Army Corps of Engineers (USACE), the New Jersey Department of Transportation – Office of Maritime Resources (NJDOT-OMR), and the Trustees for Natural Resources have partnered to conduct a comprehensive study of the Lower Passaic River. The Study Area encompasses the 17-mile tidal reach of the Passaic River below the Dundee Dam, its tributaries (*e.g.*, Saddle River, Second River, and Third River), and the surrounding watershed that hydrologically drains below the Dundee Dam [refer to the Work Plan for a site location map (Malcolm Pirnie, Inc., 2005c)]. The Lower Passaic River Restoration Project (the project) is an integrated, joint effort among state and federal agencies that will take a comprehensive look at the problems within the Study Area and identify remediation and restoration options to address those problems. This multi-year study will provide opportunities for input from the public at all phases of development. The project's goals are to provide a plan to:

- Remediate contamination found in the river to reduce human health and ecological risks.
- Improve the water quality of the river.
- Improve and/or create aquatic habitat.
- Reduce the contaminant loading in the Passaic and the New York/New Jersey Harbor Estuary.

USEPA initiated work on the project using funds from the federal Superfund program. USEPA has also signed an agreement with over 30 companies (Cooperating Parties) for them to fund the Superfund portion of the joint Study. Congress provided the USACE-New York District with funds for the WRDA study elements in the annual

Energy and Water Development Appropriations Act. NJDOT-OMR is utilizing the funds from the New York/New Jersey Joint Dredging Plan and the Transportation Trust Fund to fulfill its contribution as local sponsor. As part of the study, the partnership will examine the best authorities to implement and fund the recommendations.

1.2. CONCEPTUAL SITE MODEL

An initial conceptual site model (CSM) and methods to update the CSM were developed to examine the assumed sources of contaminants, routes of environmental transport, contaminated media, routes of exposure, and receptors. The CSM is presented in Attachment A of the Work Plan (Malcolm Pirnie, Inc., 2005c). Data gathered during the activities programmed in this FSP will be used to update the CSM, ultimately providing the basis to adapt and adjust field data collection. Additional geochemical and sediment stability analyses are currently being conducted to update the CSM and to provide guidance in determining future sampling locations for the sediment field programs described in this FSP. These geochemical and sediment analyses are listed below:

- Evaluation of historic changes in bathymetry.
- Evaluation of depositional record via radionuclide dating.
- Evaluation of historic sediment contaminant and physical properties data.

1.3. CANDIDATE RESTORATION SITES

The field sampling activities discussed in FSP Volume 2 and Volume 3 are designed to characterize the main stem of the Passaic River, its tributaries, and candidate restoration sites as well as upland and wetland areas. Some of the programs in FSP Volume 1 may be extended to support this characterization and co-located to provide information specific to candidate restoration sites. The process for selecting candidate restoration sites is outlined in the *Restoration Opportunities Report* (TAMS/Earth Tech, Inc. and Malcolm Pirnie, Inc., 2005). The candidate restoration sites include:

- Subtidal, intertidal, and riparian sites in the Lower Passaic River and along the river. These sites represent marine, brackish, and freshwater habitats.
- Large contiguous sites adjacent to the Lower Passaic River, including Oak Island Yards in Newark, New Jersey, and Kearny Point in Kearny, New Jersey.
- Main tributaries, including Second River, Third River, and Saddle River.
- Other areas in the watershed.

2.0 GENERAL FIELD REQUIREMENTS

2.1. MOBILIZATION/DEMOBILIZATION

Mobilization and demobilization procedures for field work are currently in progress at the field office site at the Kelway Industrial Park in East Rutherford, New Jersey. The following major activities have been conducted or are currently underway:

- Permitting, construction, and installation of a floating dock facility.
- Completion of a pre-occupancy surface sweep and wipe sample survey.
- Acquisition and launch of a field support vessel.
- Installation of an investigation-derived waste (IDW) storage facility.
- Installation of the lab benches, work stations, and equipment to be used to process sediment cores and manage sediment and aqueous samples.
- Installation of office, computer, and telephone equipment.

2.2. SITE FACILITIES

The field office/sample processing facility, staging areas and sampling/survey vessel floating dock are located at the Kelway Industrial Park in East Rutherford. This space is an 8,700 square-foot facility that contains a 7,200 square-foot open warehouse with 20-foot ceilings, two roll-up loading dock doors, and an office area that is approximately 1,500 square feet. The space is located about 200 yards from the east bank of the Passaic River at approximately river mile (RM) 13.5.

The company that owns the industrial park has riparian rights and is responsible for maintaining the bulkhead along the Passaic River. The owner (the Lessor) of the industrial park has included, in writing, a provision in the lease giving Malcolm Pirnie, Inc. (the Lessee) permission to install a floating dock against the bulkhead.

The USEPA, USACE-New York District, and NJDOT-OMR have agreed that leasing this facility is acceptable to their respective agencies. Finalization of permitting issues for the installation of a floating dock on the Passaic River, through the NJDEP, is complete.

2.3. HEALTH AND SAFETY

All FSP field tasks will be conducted in accordance with the site-specific Health and Safety Plan (HASP; Malcolm Pirnie, Inc., 2005d) and addenda, prepared in accordance with the Occupational Safety and Health Administration (OSHA) requirements contained in 29 Code of Federal Regulations (CFR) 1910 including the final rule contained in 29 CFR 1910.120. The procedures are also consistent with the guidance contained in the following documents:

- OSHA Guidance Manual for Hazardous Waste Site Activities [prepared jointly by the USEPA, National Institute for Occupational Safety and Health (NIOSH), OSHA, and the U.S. Coast Guard (USCG)];
- USACE's Safety and Health Requirements Manual, Engineering Manual (EM) 385-1-1 (USACE, 2003).

2.4. EQUIPMENT DECONTAMINATION

A description of equipment decontamination facilities and sequential decontamination procedures for non-dedicated equipment is provided as Standard Operating Procedures (SOPs) 6 and 7 in Attachment 1 to this volume of the FSP.

2.5. SAMPLE MANAGEMENT AND PRESERVATION

Since USEPA Contract Laboratory Program (CLP) laboratories are to be used for certain sample analysis, sample management will comply with Contract Laboratory Program Guidance for Field Samplers (USEPA 2004). As such, sample management will follow the SOP 1 Procedure to Conduct Sample Management for CLP and non-CLP Samples attached to the QAPP (Malcolm Pirnie, Inc., 2005a). Samples collected will be preserved following SOP 2 Procedures to Conduct Sample Preservation, also attached to the QAPP (Malcolm Pirnie, Inc., 2005a), to assure sample integrity when the samples are analyzed in the laboratory.

2.6. STANDARD OPERATING PROCEDURES

SOPs are provided in Attachment 1. The following SOPs are included [note SOP's 1-3 can be found in the QAPP (Malcolm Pirnie, Inc., 2005a)]:

- SOP 4: Locating Sample Points Using a Global Positioning System (GPS)
- SOP 5: Documenting Field Activities
- SOP 6: Decontamination of Soil Sampling Equipment
- SOP 7: Decontamination of Water Sampling Equipment
- SOP 8: Sediment Probing
- SOP 9: Vibracoring – Collecting High and Low Resolution Cores
- SOP 10: Split Spoon Sample Collection
- SOP 11: Core Processing – High Resolution
- SOP 12: Core Processing – Low Resolution
- SOP 13: Sediment Collection Using Hand Coring Devices
- SOP 14: X-radiograph Procedures – (to be added)
- SOP 15: Density Profiler Procedures – (to be added)
- SOP 16: Infiltrex 300 Trace Organic Sampling
- SOP 17: Deployment and Retrieval of Semipermeable Membrane Devices
- SOP 18: Small Volume Grab Water Samples and Cross-sectional Composite Sample Procedure
- SOP 19: 5-liter Niskin Bottle Use
- SOP 20: Ultra-clean Water Sampling Procedures for Mercury
- SOP 21: Horiba Use for Measuring Water Parameters
- SOP 22: Management and Disposal of Investigation Derived Waste
- SOP 23: Secchi Disk Depth (Transparency) Measurement
- SOP 24: Eckman Dredge

3.0 FIELD TASK STATUS

This section summarizes the field investigation tasks to support the data needs of the CERCLA and WRDA programs. It also presents a summary of non-direct field measurements associated with the data collection needs.

3.1. FIELD INVESTIGATION TASKS COMPLETED

Several field investigation tasks have been completed to date. These tasks have provided vital information for the planning of future tasks and in updating the CSM. These tasks include:

- Bathymetric Survey – The bathymetric survey was conducted for the project in 2004 by the USACE. This survey covered much of the 17-mile stretch of the river, extending to RM 15.8. The results of this survey have been combined with historical bathymetric survey results to update the CSM.
- Geophysical Surveys – Geophysical surveys, including side scan sonar (SSS), sub-bottom profiling, and a magnetometer survey, were conducted in 2005 to support characterization of the nature of the river bottom sediment type, selection of coring locations, and the function and structure of potential restoration sites. A complete description of the field activities associated with these surveys is presented in Section 4.3 of FSP Volume 3 (Malcolm Pirnie, Inc., 2005b).
- Geotechnical Sediment Coring – Geotechnical sediment coring was conducted in 2005 to obtain confirmatory "ground truth" samples to calibrate and verify the SSS and sub-bottom profiling geophysical surveys. A complete description of the field activities associated with these surveys is presented in Section 4.3 of FSP Volume 3 (Malcolm Pirnie, Inc., 2005b).
- Sediment Transport Studies – Sediment erosion measurements were conducted in May 2005 using two devices: 1) Gust Microcosm to understand erosion at the surface and at very low shear stresses and 2) Sedflume to understand erosion at depth and at greater shear stresses. Gust Microcosm is used to measure surface sediment erosion since it can resolve fine differences in shear stress which Sedflume cannot. Sedflume is used to measure erosion with depth, since it can simulate the higher shear stresses that might be encountered during flood conditions. Gust Microcosm was conducted at 6 sites while the Sedflume was performed at 15 locations. In addition, about 8 surface sediment samples [0 to 0.2 inches (0 to 0.5 cm)] were collected during the collection of the sediment cores for the erosion field experiments, for Be-7 and Th-

234 analysis. These radionuclides are tracers of the short term particle dynamics in the river. Details of the sediment erosion experiments, sediment coring for the analysis of short-lived radionuclides, including the data needs, and the rationale for selecting the site locations, are presented in the Hydrodynamic and Sediment Transport Sampling Plan for 2004-2005 and Site Selection Rationale Memorandum in Attachment 2 of this document.

3.1.1. Field Investigation Tasks Planned for 2005

The field tasks planned for 2005 include:

- High Resolution Sediment Coring;
- Low Resolution Sediment Coring – Initial Program;
- Tidal Water Column Monitoring – Initial Sampling;

These tasks are described in the Sections 4 “High Resolution Sediment Coring”, 5 “Low Resolution Sediment Coring”, and 6 “Tidal Water Column Sampling” of this document.

3.1.2. Future Investigation Planned for 2006

The field tasks planned for 2006 include:

- Low Resolution Sediment Coring – Continued Program;
- Porewater and Groundwater Sampling;
- Mudflat Sediment Sampling;
- Long-term Tidal Water Column Monitoring;
- Tributary and Head of Tide Water Column Monitoring.

The details of the field activities associated with these tasks will be presented as insertions to future versions of the FSP. Placeholder sections are part of this document to indicate where these programs will be described in the future.

3.2. NON-DIRECT MEASUREMENTS

There are several non-direct measurements that will be used during the investigation. These non-direct measurements, which include: historical data for various media, atmospheric deposition measurements, hydrodynamic studies, and fresh water inflows, are discussed below.

3.2.1. Historical Data

Previously, electronic historical data were obtained from various sources and were uploaded to the PREmis database. Historical data and information on the Passaic River are also available on the public website http://www.ourPassaic.org. A summary of the types of data available, the quality of the data, the results of preliminary evaluation, and the use of the data in developing the initial CSM is described in the Work Plan (Malcolm Pirnie, Inc. 2005c).

3.2.2. Atmospheric Deposition

Atmospheric deposition is the contribution of atmospheric pollutants or chemical constituents to land or water ecosystems. It consists of wet deposition via rain and snow, dry deposition of fine and coarse particles and gaseous air-water exchange. Atmospheric deposition loadings will be calculated based on data provided by the New Jersey Atmospheric Deposition Network (NJADN). The NJADN data were collected by researchers from Rutgers and Princeton Universities, with support from the Hudson River Foundation, New Jersey Sea Grant, and NJDEP. Up to four (4) NJADN stations were identified for application to model input:

- Liberty State Park – Applied to Harbor (*i.e.*, Hudson River below Haverstraw Bay, Upper Bay, Newark Bay, Arthur Kill and Kill van Kull, East River, Harlem River, Jamaica Bay);
- Sandy Hook – Applied to open water areas (*i.e.*, Lower Bay and New York Bight, Raritan Bay, Long Island Sound);
- New Brunswick – Applied to urban tributary areas (*i.e.*, Hackensack, Passaic, and Raritan Rivers);

- Chester – Applied to northern less urbanized areas (*i.e.*, Hudson River above Haverstraw Bay).

Some or all of these stations may be used to develop deposition over the open water areas. Atmospheric deposition loadings to the model used for the Study Area will use the available NJADN data for the following chemicals: total polychlorinated biphenyls (PCBs), PCB homologues, dioxin/furan congeners, polycyclic aromatic hydrocarbons (PAHs), pesticides, and metals including mercury. Representative chemicals from these chemical classes will be chosen for inclusion in the model based on physicochemical properties, modeling efficiencies and the decision needs of the Study.

Currently, historical deposition fluxes for PCB homologues, gases, particles, and precipitation at each of the four stations are available from NJADN and may be applied directly to the model. For mercury and cadmium, historical gas, particle, and precipitation flux data are available from NJADN on a harbor-wide basis and these will be applied to the entire model domain. For dioxin/furan congeners, NJADN did not calculate fluxes, but provided historical gas and particle concentration measurements for the Liberty State Park, Sandy Hook, and New Brunswick stations. NJADN protocols will be used to develop the concentration measurements into fluxes. The New Brunswick data will be applied to both urban and northern, less urbanized tributary areas since Chester data are not available for dioxin/furan congeners.

Details of the framework for deposition calculation are described by researchers associated with the NJADN (Totten *et al.*, 2004, Gioia *et al.*, 2005; Gigliotti *et al.*, 2005). In particular, the calculation of the dry deposition flux depends on assumed values of the particle deposition velocity, and a value of 0.5 cm^{-1} is used by NJADN (metric units used for precision). Typical values reported for dry deposition velocities range from 0.2 to 0.9 cm^{-1}, resulting in uncertainties of over 100% in the estimated dry deposition flux (Gigliotti *et al.*, 2005). It is anticipated that the dry deposition flux of chemicals of potential concern (COPCs) and chemicals of potential ecological concern (COPECs) is important to the overall mass balance, and such uncertainties in dry deposition will be evaluated through a sensitivity analysis.

3.2.3. Water Inflows

The U.S. Geological Survey (USGS) maintains long term data of hydrologic discharges in the Passaic River at Little Falls and three tributaries: the Saddle River at Lodi, the Third River at Passaic, and the Second River in Belleville. Time series data of water inflow from these stations will be used to specify the discharge at boundary conditions. Because the upstream boundary of the study area is at the Dundee Dam, the data from Little Falls will be used to determine a relationship between river discharge at Little Falls and discharge data that will be collected at Dundee Dam during the monitoring program. This relationship will allow for the reconstruction of historical discharges at Dundee Dam.

3.2.4. Hydrodynamic Measurements

Rutgers University, USGS, and Malcolm Pirnie are currently conducting a hydrodynamic study of the Lower Passaic River, with Rutgers and USGS focusing on the lower six miles to aid in the implementation of a pilot dredging study and Malcolm Pirnie focusing on the upper 11 miles to collect data to evaluate remedial options in the entire 17-mile stretch. During these studies, hydrodynamic parameters, including temperature, current, salinity, and depth, are monitored at fixed moored stations and during shipboard surveys under various river discharge and precipitation conditions. These measurements of the physical variables of interest within the modeling domain will be used in calibrating and validating the hydrodynamic model. More information on this effort is provided in the Hydrodynamic and Sediment Transport Sampling Plan (Attachment 2 to FSP Volume 1).

3.2.5. Vertical Mixing/Bioturbation

Vertical mixing of the sediments can be achieved by tidal flows, storms, wave action, boat traffic, scouring by ice or debris, dredging, and other physical processes, as well as by biological processes (bioturbation). The effects of physical processes cannot often be easily discerned from those due to biota. However, the net effect of the various processes is essentially the same – to mix the uppermost layers of the sediment.

Within stable sediment deposits, the most important natural process that brings contaminants to the sediment surface is bioturbation. In general, bioturbation is the active mixing of sediments by aquatic organisms. Bioturbation occurs in the uppermost layers of sediment in which the animals reside, with the most intensive activity in surficial sediments (generally on the order of centimeters), and a decrease in activity with increasing depth (Clarke, *et al*., 2001). In addition, the depth of mixing is also greater for marine/estuarine environments compared to freshwater environments. The extent and magnitude of the alteration caused by bioturbation depends on site location, sediment type, and the types of organisms and contaminants present.

The effects of vertical mixing can include:

- Alteration of sedimentary structures, thereby affecting analysis of the depositional history of sediments.
- Alteration of chemical forms of contaminants.
- Bioaccumulation in the tissues of benthic organisms resulting from exposure to deeper, more contaminated sediment.
- Transport of contaminants from the sediment to interstitial/pore water or the water column.
- A decrease in cohesion and bulk density due to burrowing (Boudreau, 1998).
- An increase or decrease in the ability of the sediment bed to resist erosion.
- Binding sediment particles and increased cohesion, due to secretions associated with tube building activities.

Because the effects of bioturbation are site-specific and can exhibit substantial spatial and seasonal variation, site-specific data will be required to scale the depths of the mixing zones in the freshwater, transitional, and brackish sections of the Passaic River. The scale of mixing and the sediment properties of surficial Passaic River sediments will be determined through the following:

- Measurements of short-lived (Be-7 and Th-234) radioisotopes in the top segments of sediment cores (including high resolution, and low resolution cores).
- High resolution X-radiograph and/or bulk density profiling of sediment cores (low resolution cores and mudflat cores).
- Sediment Profile Imagery (SPI) using a camera inserted into the sediments to photograph cross-section of sediment and biotic activity. The SPI will be used in conjunction with sediment cores collected during geophysical surveys to evaluate benthic populations residing in the Lower Passaic River. This device provides a snapshot of organisms residing in the shallow sediments, thus aiding in delineating the biologically active zone (BAZ) and identifying benthos present. Procedures for conducting SPI can be found in FSP Volume 3 (Malcolm Pirnie, Inc., 2005b).
- Oxidation-Reduction profile measurements to provide in-situ determination of reducing-oxidizing discontinuity, during high resolution, low resolution and mudflat sediment coring.

4.0 HIGH RESOLUTION SEDIMENT CORING

4.1. DATA NEEDS AND OBJECTIVES FOR THE HIGH RESOLUTION CORING PROGRAM

The objective of the High Resolution Coring Program is to investigate the depositional chronology and associated contaminant distribution in the Study Area. The data from these cores will assist in the development of the CSM by describing the nature and extent of current and historical inputs of contaminants. The High Resolution Coring Program supports the following data needs and satisfies the DQO questions 7, 8, 9, and 11 found in the QAPP (Malcolm Pirnie, 2005a):

- Determine the nature and extent of contamination by analyzing sediment samples for PAHs, PCB, polychlorinated dibenzodioxins/furans (PCDD/F), pesticides, and metals (refer to DQO tasks 7A and 8A).
- Estimate current inventory for each contaminant, including an estimate of total mass of contamination in the Study Area (refer to DQO tasks 7A and 9D).
- Determine the geochronology of contaminants, evaluate depositional rates and types of depositional environments, and identify major hydrologic/depositional events that can be discerned in the sediment core (refer to DQO tasks 7D and 8F).
- Estimate how external and internal sources have varied over time and evaluate diagnostic fingerprints of source(s) over time (refer to DQO task 11A).
- Evaluate extent of diagenesis and mixing/ bioturbation that will affect the availability and transport of contaminant inventory over time (refer to DQO task 7D).

4.2. HIGH RESOLUTION CORING SCOPE AND METHOD

4.2.1. Scope of High Resolution Coring Program

To satisfy these data needs, the scope of the field coring program is to collect high resolution cores that penetrate to a depth that corresponds to sediments deposited at the turn of the twentieth century (approximately 1900). Note that a subset of these cores will only extend to the 1950s. The program will include 15 coring locations plus 5 or more alternative locations. Alternative cores will be collected if coring locations are rejected in the field. Coring locations may be rejected based on material type, sediment layer thickness, or other field conditions. As discussed in Section 4.2.3, 13 target areas have been identified using the below described process. The 15 cores locations and 5 alternative coring locations will be collected from these 13 target areas.

It is anticipated that from the total 20 coring locations, at most 8 high resolution cores will be fully analyzed for contaminants. (Refer below to Section 4.2.4 "Sample Handling and Analysis of High Resolution Cores" for information on selecting cores for analyses.) However, during the sampling program implementation, some decision points may require collecting additional high resolution cores beyond the 5 alternative coring locations so that 8 complete cores may be produced. These decision points are presented graphically on Figure 4-1, which provides a decision strategy for the High Resolution Coring Program, including:

- Do the recovered cores meet percent recovery and sample quality goals (*e.g.*, a minimal number and size of voids[1])? If the quality or recovery of the core is inadequate, or if the core is not intact, then the core will be rejected and additional cores are required.
- Do the results of the radionuclide dating of the core segments meet data quality goals and will they withstand a rigorous geochemical evaluation without indication of inconsistencies? If the radionuclide data suggest inconsistencies or discontinuities in the core, then the core will be rejected and additional cores are required.

The 15 coring locations will be distributed throughout the Lower Passaic River and above the Dundee Dam. Cores collected within the Lower Passaic River will gather sediment data specific to the Brackish River Section (RM 0 to RM 6), Transitional River Section (RM 6-12), and Freshwater River Section (RM 12 to Dundee Dam). Cores situated upriver of the Dundee Dam will define the contaminant load at the upper boundary of the Study Area. Refer to the CSM [Attachment A of the Work Plan (Malcolm Pirnie, Inc., 2005c)] for a further description of these river sections. Table 4-1 provides detail regarding the distribution of the 15 coring locations among these river sections; as noted above, cores from 8 of the 15 locations will be analyzed for chemical contaminants. (Refer to Section 4.2.2 below "Selection Process of Coring Locations" for rationale on selecting specific sites for coring.)

[1]: SOP 11 attached describes the percent recovery and voids sizes acceptable for cores. For high resolution cores 85% recovery with no voids is the criteria as judged in the field by the processing staff.

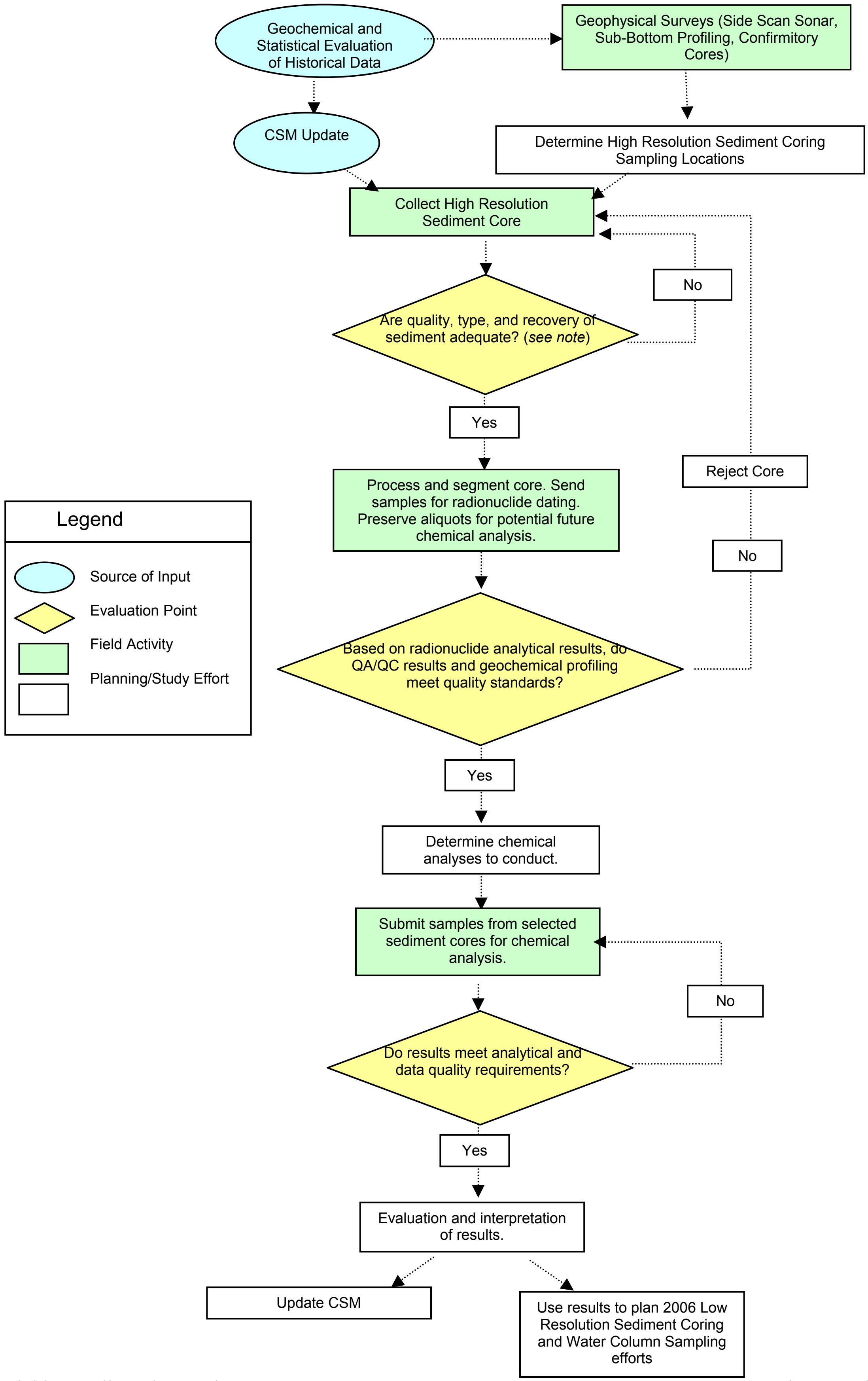
Table 4-1: High Resolution Target-Coring Locations

River Section	*Number of Locations*	*Target Core Length (feet)* [1]
Brackish Section (RM 0 to RM 6)	5	20
Transitional Section (RM 6 to RM 12)	4	15
Freshwater Section (RM 12 to RM 17.4)	3	10
Upriver of Dundee Dam	3	10
TOTAL	*15*	*NA* [2]

(1) The actual core length may be less than the proposed length if the core encounters refusal at a shallower depth. Based on the depth of penetration from the geotechnical borings, the anticipated core lengths reported in this table are likely greater than will be achieved in the field.
(2) NA = Not Applicable.

At each of the 15 coring location, a minimum of 2 cores will be collected with a possible third core (total of up to 45 cores for the program), including a sample core, an archival core, and a potential duplicate sample core (SOP 9 Vibracoring – Collecting High and Low Resolution Cores in Attachment 1). This potential duplicate core will be collected in target areas where sediment is less than 12 feet thick. Both cores will be analyzed for radiological dating and the other geochemical analyses will be distributed between the two cores (*e.g.*, the sediment for metals analyses come from one core while sediment for PCB analyses may come from the other) to assure that there is sufficient sample for all planned analyses (SOP 11 Core Processing – High Resolution in Attachment 1). The decision process for the high resolution core strategy is presented in Figure 4-1.

Figure 4-1: Decision Strategy for High Resolution Sediment Coring Efforts



4.2.2. Selection Process of Coring Locations

The coring sites must be located in depositional environments containing fine-grained sediments to assure successful collection of high resolution cores, containing complete radiological datasets and extending to the appropriate time horizon. To locate suitable depositional environments for coring, several sets of existing data will be considered in the site selection process. The best candidate coring locations can be chosen by combining or overlaying information on river sediment conditions, including data on sedimentation rates, historical depth of contamination, geotechnical borings, sediment texture, surficial grain size, historical radiological data, and Sedflume[2] results. Table 4-2 provides an overview of the available information, which will be used as data layers in a Geographic Information System (GIS) framework.

Table 4-2: Geographical Information Layers Used in Site Selection

Geographic Information Layer	*Contribution to Site Selection Process*	*Extent of Data Set*	*Data Source*
Sedimentation Rate	Identify areas of deposition and non-deposition	RM 0 to RM 15	1989 and 2004 bathymetric surveys
		RM 0 to RM 7	1995 and 2001 bathymetric surveys
Depth of Contamination	Estimate sediment depth where concentration of total DDT goes to zero (~1925)	RM 0 to RM 7	Passaic 1995 RI Sampling by Terra Solutions, Inc.
Geotechnical Borings	Provide profiles of sediment type for cores penetrating to refusal	RM 0 to RM 16	2005 MPI/Aqua Survey Geophysical Survey
Sediment Texture	Identify distribution of sediment texture based on SSS survey	RM 0 to RM 16	2005 MPI/Aqua Survey Geophysical Survey
Surficial Grain Size	Identify grain size distribution in sediment (0 to 6 inch)	RM 0 to RM 16.5	2005 MPI/Aqua Survey Geophysical Survey
Historical Radiological Data	Identify areas impacted by a major hydrological or depositional event	RM 0 to RM 7	Passaic 1995 RI Sampling by Terra Solutions, Inc.
Sedflume Results	Provide sediment characteristics at Sedflume locations	RM 0 to RM 14.5	2005 USACE-ERDC

[2]: Sedflume is a technique for measuring location specific erodibility of sediments within the Study Area.

The following discussion describes the application of each of these data sources to the process of coring site selection.

<u>Sedimentation Rates</u>

Maps of local sedimentation rates can be used to focus high resolution core site selection in areas of high sediment accumulation rates. Similarly, it can be used to eliminate areas where deposition is low or lacking since these areas are unlikely to have ideal depositional environments.

The "sedimentation rate" is derived from a comparison of two bathymetric surveys conducted at two points in time. The sedimentation rate at each river location is determined by calculating the change in bathymetry from 1989 to 2004 divided by the 15-year period between the two surveys to create a map of sediment deposition in inches per year. The 1989 bathymetric survey was conducted by Tallamy, Van Kuren, Gertis and Associates, and the 2004 bathymetric survey was conducted by Rogers Surveying, Incorporated. [Refer to *Technical Memorandum: Preliminary Geochemical Evaluation* found in Attachment B of the Work Plan (Malcolm Pirnie, Inc., 2005c).] This informational layer is presented in a series of three maps in Attachment 3 where sedimentation rates are differentiated through a series of colors. Gray on the maps represents areas of non-deposition or scouring. Areas of deposition are colored with the lowest sedimentation rate represented by blue grading through yellow to red, which represents areas where sedimentation rates exceed 5 inches per year. Note these sedimentation rates represent the average annual deposition from 1989 to 2004; however, short term sedimentation rates are likely to have varied substantively over this period.

The sedimentation rates vary throughout the Lower Passaic River. The Brackish River Section is characterized by extensive deposition at the river mouth, from RM 0 to RM 1.5, with sedimentation rates exceeding 5 inches/year. Other depositional areas occur near RM 2 and RM 4, with sedimentation rates greater than 3 inches/year. In general, non-depositional zones tend to be located on the banks and depositional zones tend to be located in the channel. While sedimentation rates remain heterogeneous in the Transitional and Freshwater River Sections, large areas in these river sections are non-depositional with a few sporadic high depositional areas. For example, in the Transitional Section, areas near RM 6.5 and RM 10 have sedimentation rates greater than

2 inches/year. In the Freshwater Section, small areas near RM 12.5 and RM 14 are depositional with sedimentation rates greater than 5 inches per year.

Depth of Contamination

The local depth of contamination, as established by historical core collection, can be used to identify those locations where a thick sequence of contaminated sediments exists. At some of these locations, it should be possible to obtain a relatively long high resolution sediment core, thereby providing ample sample volume for each core segment.

Bopp *et al.* (1991) established that 4-4'-Dichlorodiphenyltrichloroethane (DDT) contamination extends fairly deep within the sediments, first appearing in the sediments prior to 1945. As such, the depth of DDT appearance in the sediments can be used as a marker to identify locations with high deposition rates, or thick sediment beds. Combining the observations of Bopp *et al.* with the coring results obtained by Tierra Solutions, Inc. (low-resolution sediment cores were collected in 1995 from RM 1-7 and analyzed for total DDT), a map of the depth of sediment contamination was constructed to identify the potential depth of total DDT contamination. This information layer was then overlaid on the sedimentation map in Attachment 3; symbols (circles, triangles, and squares) classify the type of core collected and call-out boxes mark the depth of contamination in feet. (Note that total DDT is defined as the sum of 4,4-DDT, 4,4-DDD, and 4,4-DDE; where laboratory results flagged with a not detected [U] denotation were set equal to zero.)

- Complete Core (circle): the concentration of total DDT at the bottom of the core equals a non-detectable value (treated as zero). The "depth of contamination" is defined as the depth of the core-segment top where total DDT=0.
- Incomplete Rising Core (triangle): the concentration of total DDT at the bottom of the core is increasing or "rising." The "depth of contamination" is defined as deeper than the depth of the sediment core.
- Incomplete Declining Core (square): the concentration of total DDT at the bottom of the core is declining, but does nor equal zero. Note that to avoid laboratory and sampling error, "declining" is defined as a decrease in concentration by a factor of 3. The "depth of contamination" is defined as deeper than the depth of the sediment core.

Geotechnical Borings

As part of the June 2005 geophysical survey (Aqua Surveys, Inc., 2005), "ground truthing" effort, geotechnical borings were collected in the Lower Passaic River. The borings were organized along transects, one boring drilled adjacent to both bank and one boring drilled on the river centerline. Transects were positioned at each river mile from RM 0 to RM 16, totaling 17 transects. Borings were advanced until refusal, or 30 feet (whichever was first encountered), and sediments were visually classified by a geologist following the unified soil classification system (USCS). Fence diagrams of the borings in each transect are included in Attachment 3. One sample from a distinct stratigraphic zone collected from each boring was submitted for geotechnical analyses to confirm the field notes and USCS classification. The results from these cores provide information on the physical nature of sediments in the Passaic River. In particular, the cores document the thickness of silt and sand layers as well as a color transition from overlying black, possibly organic rich sediments to red brown sediments, which may be indicative of pre- and post-industrial development conditions. These results provide information on both the depth of sediment that may be cored in an area as well as the nature of sediment to be obtained.

Boring logs were converted into cross-sectional profile (Fence Diagrams) to identify the different geological strata in the sediment beds. In these profiles, the boring logs are oriented on the same depth and geographic coordinate system, and similar sediment types are connected into strata based on the USCS classification to create transect cross-section. The cross-sections were used to identify sub-surface sediment types, transitional zones between different sediment types, and depositional environments. This information, in conjunction with the Sediment Texture informational layer, will aid in choosing core locations where fine-grained sediments are expected at depth.

A review of the boring logs shows distinct differences among the sediments of the Lower Passaic River. For example, borings drilled in the Freshwater River Section (RM 12 to RM 17.4) generally encountered refusal before penetrating 4 feet. Sediments at RM 16 were characterized by poorly sorted gravel, which slowly transitioned to silty sand with gravel in RM 12. Note that sediments adjacent to the shoreline tend to contain more silts than the sediments at the centerline. In the Transitional River Section (RM 6 to RM 12), borings could be advanced to approximately 7 feet with sediments continuing to become finer down-estuary with beds dominated by silt, fine sand, and organic matter. Following this trend of sediment thickening and fining down-estuary, borings drilled in the Brackish River Section (RM 0 to RM 6) advanced more than 10 feet with the deepest boring advanced to 33 feet below the sediment/water interface. Sediments from the Brackish Section were dominated by silt and clay of varying plasticity.

Sediment Texture

High resolution cores are typically most "successful" when obtained from areas of fine-grained sediments; hence, a map identifying areas of fine-grained surficial sediments (identified through the SSS survey) will serve to focus the core collection efforts.

As part of the June 2005 geophysical survey, Aqua Surveys Inc. conducted SSS and sub-bottom profiling of the Lower Passaic River Study Area. The survey provides surficial sediment texture mapping, which was compared to the geotechnical boring survey to aid in determining surface and near-surface sediment types. A sub-bottom profiling survey was also conducted and is expected to provide information on sediment stratigraphy.

SSS mosaics were combined with the results of the shallow (0 to 6 inch) confirmation cores (refer to "Surficial Grain Size Distribution" below) to generate a simplified-surficial sediment texture map (Attachment 3). This map also contains contour lines relative the vertical datum NGVD29. Note that the sediment texture map only displays surficial sediment texture and does not identify sub-bottom sediment texture. In general, the Brackish River Section is dominated by silts, which mainly occur in the channel. Larger grain sizes are become more predominant on the shoreline. The Transitional River Section is characterized by a transition of sediment texture from mainly silts in RM 7 to coarse-grain sediments at RM 12. This coarse-grained sediment texture persists in the Freshwater River Section with granular material dominating RM 16. The data in this geographical information layer is consistent with the data obtained with the geotechnical borings.

Surficial Grain Size Distribution

As part of the June 2005 geophysical survey, shallow confirmatory cores were collected to support the interpretation of the SSS imagery. Five shallow cores (advanced up to 1 foot) were collected along each transect. Transects were positioned approximately every ½ mile from RM 0 to RM 16.5. Additional cores were placed in areas selected by the field geophysicist as areas of interest, yielding 275 shallow cores.

Of these cores, 100 cores were selected for geotechnical analyses including grain size, hydrometer of silt and clay, and total organic carbon. (Note that geotechnical analyses were conducted on a composite sample from the top 0.5-foot interval of the shallow confirmation core.) Criteria for selecting the 100 cores for geotechnical analyses included at least one sample per transect and selecting samples of unique sediment types to confirm the SSS results.

A map showing the locations of the shallow confirmatory cores is presented in Attachment 3 along with histograms of the grain size results. These histograms confirm the geotechnical borings findings, with coarse-grained surficial sediment typically located upriver of RM 6 while fine-grained silt and clay are located between RM 0 and RM 6. This attribute is displayed by plotting the 50% percentile grain size against river mile (Attachment 3). The Brackish River Section tends to have surficial sediment with median grain sizes ranging from 0.01 mm to 0.1 mm whereas the Transitional and Freshwater River Sections tend to have surficial sediments with grain sizes that are larger than 0.1 mm.

It is anticipated that fine-grained surficial sediments correlate with depositional areas and coarse-grained surficial sediment correlate with non-depositional areas. To examine this correlation, the grain size sampling locations were projected onto the sedimentation map, which is shown in Attachment 3, to connect grain size to a point-specific, sedimentation rate. [Note that only 71 of the 103 grain size samples overlapped with the sedimentation map (*i.e.*, samples located in RM 0 to RM 15).] The average sedimentation rate for the various grain sizes were computed and presented in tabular form in Attachment 3. As expected, the grain size decreases as the average sedimentation rate increases. However, this correlation does not hold true for sediments containing coarse-grained sediments and gravel. A geographic informational layer of 50 percentile grain size will be considered when selecting core locations.

<u>Historical Radiological Data</u>

Existing data on sediment radionuclide profiles can be used in a manner similar to that of the depth of DDT contamination described previously, that is, to identify areas of thick sediment deposits, potentially with steady rates of deposition. Locations with ideal radionuclide profiles will be identified as possible coring sites. Down-core profiles of radiological data (cesium-137 and lead-210) were constructed as part of the *Technical*

Memorandum: Preliminary Geochemical Evaluation [found in Attachment B of the Work Plan (Malcolm Pirnie, Inc., 2005c)]. These profiles will be referenced to identify possible coring sites based on good profiles as well as to identify areas where depositional discontinuities may already exist within the sediment beds. The radionuclide data are limited to the lower 7 miles of the Passaic River.

Sedflume Results Data

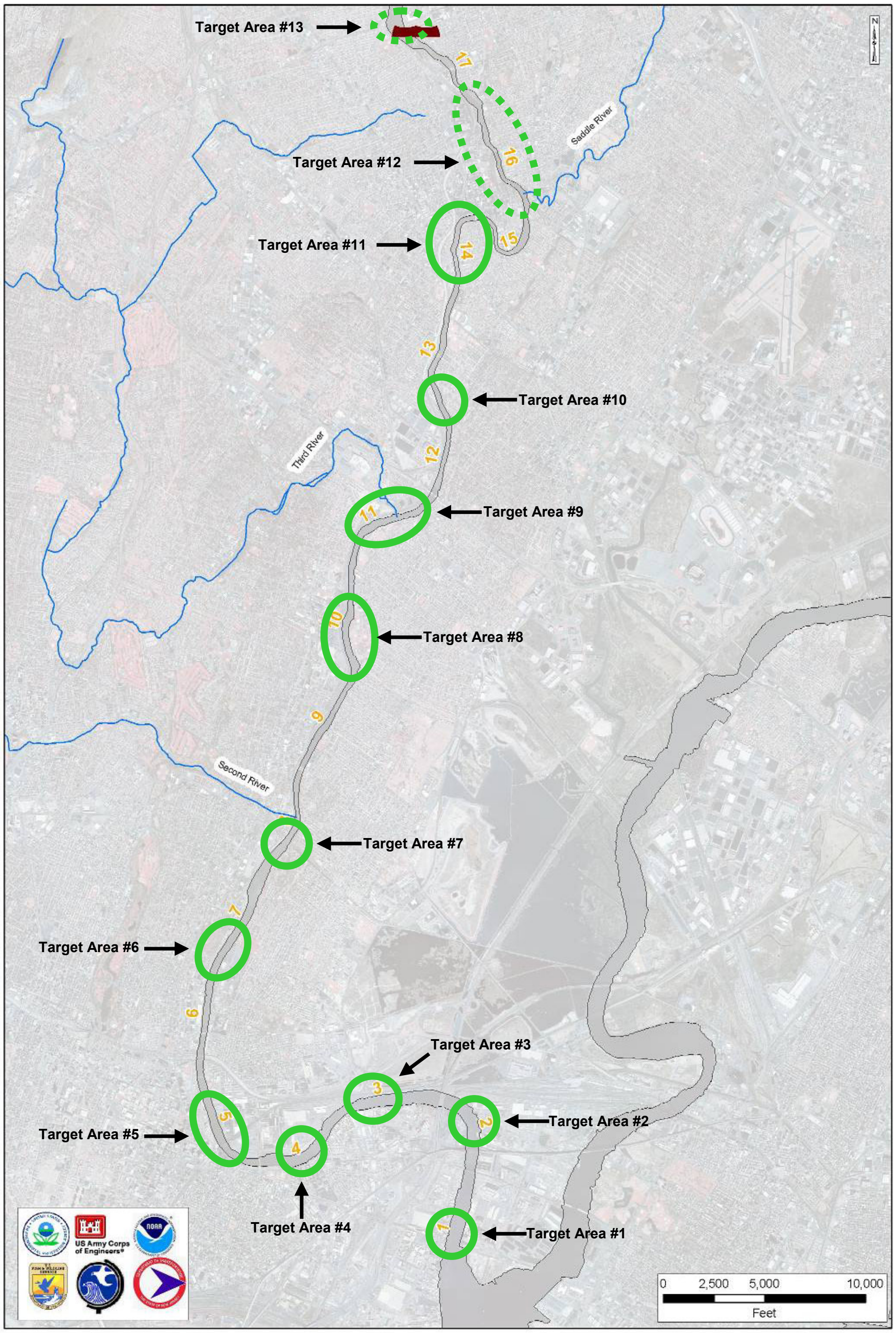
As part of the Sedflume experiments, sediments (approximately 0 to 1.3 feet) were characterized for bulk density, total organic carbon, and grain size. This information provides a general characterization of Passaic River sediments that will be considered in the design of the coring program.

4.2.3. Proposed Sites for High Resolution Coring

Using the information discussed above, 13 target coring areas were chosen. Within these 13 areas, 15 coring locations and 5 alternative coring locations will be identified in the field. Figure 4-2 shows the areas where high resolution core locations will be chosen in the field. Table 4-3 provides more information on each target area.

Table 4-3: Preliminary High Resolution Target Coring Locations

Target Area	Approximate River Mile	Description	Qualifier
1	1.0	Thick sediment beds of silt, black/brown color transition, and high sedimentation rates.	Good Location
2	2.0	Thick sediment beds of silt, black/brown color transition, and medium sedimentation rates.	Good Location
3	3.0	Thick sediment beds of silt, black/brown color transition, and medium sedimentation rates.	Good Location
4	4.0	Thin sediment beds of silt, black/brown color transition, and medium sedimentation rates.	Good Location
5	4.5 to 5.0	Potential depositional environment; location dependent on field investigation.	Anticipate Good Location
6	6.5 to 7.0	Potential depositional environment; location dependent on field investigation.	Anticipate Good Location
7	8.0	Potential depositional environment, thin sediment beds of silt, and black/brown color transition; location dependent on field investigation.	Anticipate Good Location
8	10.0	Potential depositional environment, thin sediment beds of sandy-silt, and bluish-gray/brown color transition; location dependent on field investigation.	Fair Location
9	11.0 to 11.5	Potential depositional environment, thin sediment beds of sandy-silt, and bluish-gray/brown color transition; location dependent on field investigation.	Fair Location
10	12.5	Potential depositional environment, thin sediment beds of silt, and grayish-olive/brown color transition; location dependent on field investigation.	Fair Location
11	14.0 to 14.5	Potential depositional environment, thin sediment beds of silt, and grayish-olive/brown color transition; location dependent on field investigation.	Fair Location
12	15.5 to 16.5	Location dependent on field investigation.	Unknown
13	Above Dam	Anticipate thick sediment beds of silt and high sedimentation rates.	Good Location



MALCOLM PIRNIE

Preliminary High Resolution Coring Target Areas

Lower Passaic River Restoration Study

Figure 4-2

August 2005

The choice of core locations within target areas will be based on field reconnaissance and sediment screening. This field reconnaissance will inspect small scale feature within the target areas, such as former bridge abutments, historic docks and piers or small tributary confluences, where long-term sediment deposition is expected to occur. Hand core samples will be collected at promising core location and sediment thickness will be probed (see SOP 8 Sediment Probing and SOP 13 Sediment Collection Using Hand Coring Devices in Attachment 1). The sediment thickness will be assessed in the field to determine if sufficient sample is available at the core location for the planned high resolution analyses (greater than 12 feet of black or blue-gray sediment) and the core top (0 to 0.5 inches) will be collected and sent to the laboratory for Be-7 analysis. It is anticipated that up to 30 locations will be screened following this process. The information gathered from the core observation and from the Be-7 analyses will be used to determine the 15 most promising and 5 alternative target coring locations (discussion of the Be-7 study conducted to locate promising high resolution core sites is presented in Attachment 3).

The goal of selecting 15 coring locations is to yield 12 to 15 cores that will be further screened by radionuclide analysis to produce 8 complete cores that are suitable for chemical contaminants analyses. These cores will be distributed throughout the river and above the Dundee Dam. Note that it may require more than 15 locations to yield 8 complete cores; therefore, up to five alternative locations may be needed. Table 4-4 shows the number of complete cores that will be retrieved per river section relative to the number of target coring locations. The expected number of complete cores (shown in Table 4-4) will not increase and may, in fact, decrease if the situation arises that all the cores collected from a given river section are deemed unsuitable for subsequent chemical analysis.

Table 4-4: Complete High Resolution Cores

River Section	**Number of Locations**	**Expected Number of Complete Cores**
Brackish Section (RM 0 to RM 6)	5	3-4
Transitional Section (RM 6 to RM 12)	4	2-4
Freshwater Section (RM 12 to RM 17.4)	3	1-2
Upriver of Dundee Dam	3	1
TOTAL	**15**	**8**

Above the Dundee Dam, one complete high resolution core is expected from the 3 coring locations selected. This core is intended to capture sediment geochronology and geochemistry at the upper boundary of the Study Area. Likewise, of the 3 target coring locations in the Freshwater River Section, one (possibly two) complete core is expected to characterize the Freshwater River Section; to evaluate differences and similarities between the Freshwater River Section and above Dundee Dam; and to assess the contributions from Saddle River. Three complete cores (possibly four) are expected in the Transitional River Section from the 4 target coring locations to characterize this river section. These cores will be distributed upriver and downriver of the confluences with Second River and Third River to assess the contributions from these tributaries. Finally, 3 (possibly 4) complete cores are expected in the Brackish River Section from the 5 target coring locations. One core will be positioned at the mouth of the Passaic River while the other two cores will be situated to: confirm historical coring data; estimate current potential sources; and characterize the Brackish River Section. Note that 5 target coring locations are proposed for the Brackish River Section since this area is prone to disturbances (*e.g.*, historical dredging and boat traffic) that may affect the geochronology of a sediment core. One additional core may be added to the total for any one river section in the event that the other river sections do not yield their expected number of cores. Nonetheless, the overall number of cores to be chemically analyzed will not exceed 8. Depending on the success of the core site selection, radionuclide analysis will be done on as many as 15 cores.

4.2.4. Sample Handling and Analysis of High Resolution Cores

In general, cores will be advanced using a vibracoring method that contains a Lexan or polycarbonate core tube with a 3.75-inch to 4.0-inch diameter (refer to SOP 9 Vibracoring – Collecting High and Low Resolution Cores in Attachment 1). Alternate methods (SOP 10 Split Spoon Sample Collection; and SOP 13 Sediment Collection Using Hand Coring Devices in Attachment 1) may be employed by the selected contractor if it can be demonstrated that an “undisturbed” core can been collected and that the core sample can be processed into representative “undisturbed” segments. Once collected, cores will remain in a vertical orientation and will be transported to the field office for processing (refer to SOP 11 Core Processing – High Resolution in Attachment 1). The archival core will be frozen for future analyses, as appropriate, without further processing.

Sample cores and any duplicate sample cores will be segmented into approximately 40 to 44 samples. An aliquot from each of the 40-44 samples will then be frozen for future chemical analysis of mercury (other metals), pesticides, PAHs, PCB congeners, and PCDD/F. The frozen aliquots will be analyzed after the radiological data is reviewed [and within the required holding time of frozen aliquots (refer to SOP 11 Core Processing – High Resolution in Attachment 1)].

To process cores and review radiological data efficiently, the following approach will be instituted:

- Analyze every other of approximately the upper 30 segments from each core for cesium-137 (Cs-137) and lead-210 (Pb-210). The Cs-137 analysis will identify two time horizons (1954 and 1963) in the cores, which can then be used to calculate a point-specific sedimentation rate. The Pb-210 analysis will provide a second, point-specific sedimentation rate and will identify any major hydrological/depositional event that may have caused a discontinuity in the geochronology of the sediment core. If necessary conduct Cs-137 and Pb-210 analyses of specific un-analyzed segments to bring higher resolution to the profile.
- The analyses for total organic carbon, bulk density, and grain size must be conducted immediately after the cores are collected to satisfy the holding time requirements for these analytes. Samples will be collected once the cores have been properly segmented.
- Assuming that no discontinuities are present in the Pb-210 geochronology and that the point-specific sedimentation rates calculated for Cs-137 and Pb-210 are consistent, combine the 40-44 frozen aliquots to form 20-22 samples for further chemical analysis or if the profile warrants use the top 20 to 22 aliquots. These 20-22 samples should contain sediments deposited during the different time periods represented by each core. Samples will be analyzed for mercury (other metals), pesticides, PAHs, PCB congeners, and PCDD/F.

With this approach, cores from up to 8 of the original 15 coring locations will be analyzed for geochemical parameters. However, if discontinuities are present in the Pb-210 dataset or other radionuclide disturbances are evident, the remaining cores may need to be analyzed for radionuclides and/or re-evaluated to achieve 8 complete, high resolution core datasets (refer to SOP 11 Core Processing-High Resolution in Attachment 1).

High Resolution Coring sediment sample analytical parameters are listed in the Data Needs/Data Uses Table in Attachment 1 of the QAPP (Malcolm Pirnie, Inc., 2005a).

4.3. HIGH RESOLUTION CORE REPORTING

The deliverable will be a technical memorandum describing the procedures used (along with field notes), description of complicating factors that occurred during the field work, results of the analyses, recommendations on how to update the CSM, and recommendations for future high resolution coring studies.

5.0 LOW RESOLUTION SEDIMENT CORING

5.1. DATA NEEDS AND SAMPLING OBJECTIVES

The objective of the Low Resolution Sediment Coring Program is to generate data on the nature and spatial extent of the contaminated sediments, characterize physical properties of the sediment for remedial alternative evaluations, and support both risk assessment and modeling data needs [refer to DQO Subtopics 7, 8, 11, 15, 20, and 22 found in the QAPP (Malcolm Pirnie, 2005a)].

5.2. LOW RESOLUTION SEDIMENT CORING SCOPE

In the lower 7 miles of the Study Area up to 10 cores will be collected in winter, 2006 to augment and evaluate the 1995 TSI data set. The winter 2006 co-located cores will be positioned to:

- Target locations where analyses of the TSI data suggest that significant concentrations of contaminants exist below the terminal depth of the core (*i.e.,* there is an incomplete sequence of contaminants represented in the TSI core).
- Establish a complete sediment inventory for a broad range of contaminants at the ten locations.
- Investigate the additional sediment accumulation or loss at these sites in the 10 years of erosional and depositional events since the TSI data were collected.

The upper 10 miles of the study area will be investigated with additional low resolution cores during subsequent sampling events. Initially in the upper 10 miles, low resolution cores may be collected on transects, with approximately 3 cores on each transect. The initial transect spacing in the upper 10 miles will provide an initial characterization of this portion of the Study Area, given the reduced amount of historic subsurface sediment data available for this area. Once the initial transects have been completed, additional cores will target specific locations identified from the results. The selection of low resolution coring locations in the upper 10 miles may also be influenced by the evaluation of data from high resolution cores collected in the upper reaches of the study area.

During both the winter 2006 program and subsequent low resolution coring program phases, cores will be advanced until refusal. For planning purposes, cores are estimated to be 20 to 30 feet in length in the lower 7 miles. Low resolution cores in the upper 11 miles are expected to reach refusal at more shallow depths, as encountered during geotechnical coring efforts conducted in early 2005. Sediment Probing (SOP 8 found in Attachment 1) will be used to confirm that the anticipated sediment type at the surface (based on the 2005 side-scan sonar survey) and, if possible, obtain a better estimate of core length at each location before collection is initiated. In some instances the sediment may be too thick to be completely probed by this method.

The 10 low resolution cores planned for winter 2006 will be co-located with TSI 1995 cores in the lower 7 miles of the Study Area based on evaluation of historical data. Cores will be located to confirm the data represented by the historical sampling and to examine the additional impacts of the last 10 years of river activities (*e.g.*, erosional and depositional events). The locations will be relatively evenly distributed across the lower 7 miles and chosen to coincide with historical cores that showed incomplete sequences of dioxin, DDT, and PCBs (*i.e.*, the bottom segments of the historic cores were still contaminated, see Table 5-1). The core locations will also be selected in depositional areas based on historical cores and bathymetric data review, and where silt is the surface material, based on side scan sonar results. Figure 5-1 shows the locations chosen for the winter 2006 low resolution core program.

TSI Core ID	Maximum Concentration of 2,3,7,8-TCDD (ppb)	Bottom Concentration of 2,3,7,8-TCDD (ppb)	Ratio of Bottom Concentration to Max Concentration (2,3,7,8-TCDD (ppb))	Maximum Concentration of DDT* (ppb)	Bottom Concentration of DDT* (ppb)	Ratio of Bottom Concentration to Max Concentration (DDT*) (ppb)	Maximum Concentration of PCBs* (ppb)	Bottom Concentration of PCBs* (ppb)	Ratio of Bottom Concentration to Max Concentration (PCBs*) (ppb)	Sediment Texture	Recommended? Co-located Core Identifier	Depth of Silt (cm)
285	5300	5300	100%	160000	160000	100%	4400	4400	100%	Silt	Y – **LR-9**	480
292	20	20	100%	850	850	100%	34000	34000	100%	Silt	Y – **LR-10**	120
230	15	15	100%	2900	2900	100%	6000	620	10%	Silt	Y – **LR-2**	200
234	29	29	100%	460	280	61%	11000	11000	100%	Silt	Y – **LR-3**	250
227	16	16	100%	3400	870	26%	10000	4500	45%	Silt	Y – **LR-1**	220
243	36	29	81%	1100	590	54%	9200	1000	11%	Silt and Sand	N	
252	24	15	63%	840	840	100%	11000	30	0%	Silt	Y – **LR-6**	230
278	27	12	44%	1800	1800	100%	10000	6000	60%	Silt	Y – **LR-8**	80
260	58	19	33%	930	930	100%	14000	14000	100%	Silt	Y – **LR-7**	100
240	46	13	28%	2500	1500	60%	14000	530	4%	Silt and Sand	N	
245	14	1.9	14%	1400	1400	100%	7200	92	1%	Silt	Y – **LR-5**	500
225	54	1.7	3%	8100	7400	91%	3600	31	1%	Silt	N	
239	23	0.26	1%	1700	1700	100%	1700	32	2%	Silt	Y – **LR-4**	500
244	4.1	0.0057	0%	3400	2.9	0%	1400	29	2%	Silt	N	
241	26	0.033	0%	3000	1300	43%	3300	30	1%	Silt	N	
93A	240	0.3	0%	220000	9900	5%	48000	28	0%	Silt	N	
214	12	0.012	0%	450	450	100%	1100	43	4%	Silt	N	
211	9.8	0.0091	0%	650	13	2%	4600	26	1%	Silt	N	
17A	81	0.051	0%	17000	82	0%	1800	19	1%	Silt	N	
242	34	0.021	0%	2500	1000	40%	3100	31	1%	Silt	N	
228	16	0.0083	0%	2000	450	23%	3900	30	1%	Silt	N	
274	27	0.0069	0%	2400	600	25%	3800	29	1%	Silt	N	
21A	16	0.0024	0%	69	2	3%	1400	20	1%	Silt	N	
248	5.1	0.00061	0%	1900	2.1	0%	7200	21	0%	Silt	N	
231	30	0.0027	0%	3900	200	5%	7400	29	0%	Silt	N	

Table 5-1: Low Resolution Core Location Selection

MALCOLM PIRNIE	Lower Passaic Restoration Project Proposed Low Resolution Sediment Core Locations	Figure 5-1

Each core segment obtained during the winter 2006 program will be analyzed both using immunoassay screening techniques and standard analytical procedures. The comparison of these analytical methods will be used to determine the utility of such screening methods for subsequent low resolution coring program phases.

During the winter 2006 program, the field investigators will evaluate two main decision points regarding data quality that will be included for each core:

- Do the recovered cores meet percent recovery and quality goals (*e.g.*, a minimal number and size of voids)? A core with less than 75% recovery will be rejected in most instances, subject to the discretion of the field geologist.
- Does the core clearly reach to below the post-industrial revolution sediments?

Additional low resolution cores will be collected, processed and analyzed in Summer-Fall 2006 to complete the evaluation of the spatial extent of sediment contamination. It is possible that 50 to 500 additional low resolution cores may be needed, depending on analyses of the data from the 2005-2006 sediment sampling program. For planning purposes, the high end number is based on coring transects spaced at 300 feet in the upper 10 miles of the Lower Passaic River, with 3 cores on each transect. However, actual selection of core locations will have the objective of reducing the uncertainty in the estimates of the spatial extent of contaminated sediments, and will be made in consultation with the Sampling Work Group.

5.3. LOW RESOLUTION CORE SAMPLE COLLECTION AND PROCESSING

Low resolution core sample collection and processing will be conducted in following SOP 9 Vibracoring Collecting High and Low Resolution Cores and SOP 12 Core Processing – Low Resolution found in Attachment 1. For the winter 2006 program, each of the 10 cores will be sectioned into 6 segments based on the strata found in the cores. The upper portion of each core, expected to represent post-industrial revolution sediments, will be divided into 5 segments and one segment will be collected below these sediments.

Currently it is planned that subsequent phases of the program will also follow this segmentation methodology, except for every third core. In these cases, the top 2 feet or so will be divided into 5 layers to provide the resolution required to define the sediment bed in the sediment transport model and to describe the extent of bioturbation for the risk assessment. Some finer segmentation may be required at depth for radionuclide dating to address geochemical evaluation data needs (according to data gaps identified during evaluation of the high resolution coring data).

For the winter 2006 program, sediment samples will be submitted from each of the 10 low resolution cores for PCB immunoassay and dioxin immunoassay screening analyses immediately after core processing. The winter 2006 cores will also be analyzed continuously to generate vertical contaminant profiles for comparison to the associated historical data for the selected location. All six segments from each of the winter 2006 cores will be sent for analyses. The results of the full analytical and screening techniques will be compared to determine the utility of the screening methods for use in the larger low resolution coring program.

If the screening methods are found to be useful in determining PCB and dioxin concentrations in the sediments, full laboratory analysis in the subsequent program phases may be limited to selected segments, with screening for each collected core and continuous, full laboratory analysis of one representative low resolution cores from each reach. Aliquots of each core segment will be archived in an on-site freezer to allow for further chemical analysis after screening analyses are completed. Following review of the screening sample results, about 10% of the samples that underwent screening will be submitted for the full suite of chemical analyses, by selecting and submitting appropriate archived samples for analyses. Archived samples will be selected to represent a full range of contaminant concentrations, to assess the correlation between screening analyses and more rigorous laboratory analytical results.

Low Resolution Coring sediment sample analytical parameters are listed in the Data Needs/Data Uses Table in Attachment 1 of the QAPP (Malcolm Pirnie, Inc. 2005a).

6.0 TIDAL WATER COLUMN SAMPLING – INITIAL SAMPLING

6.1. DATA NEEDS AND SAMPLING OBJECTIVES

The water column program is needed to support the following data needs and satisfy DQO questions 7, 9, 12, 13 and 18:

1. What are the COPCs and COPECs in the Study Area? (Refer to DQO task 7B.)
2. What are the major sources and processes controlling COPC and COPEC distribution in the Lower Passaic? What is the COPC and COPEC mass balance? (Refer to DQO tasks 9A and 12A.)
3. What is the current and future human health risk associated with exposure to sediment, surface water, and/or consumption of edible portions of fish or selfish? (Refer to DQO task 13A.)
4. What is the current ecological risk associated with exposure to sediment, surface water, porewater, and/or consumption of edible portions of fish or selfish or other edible species? (Refer to DQO task 18A.)

To appropriately address the above questions, field investigations are needed to provide:

- Baseline water column data on COPCs and COPECs for human health and ecological risk assessment.
- Baseline water column data on COPCs and COPECs to understand the fate and transport of dissolved and particle-associated contamination in the Study Area (and to that end, to support the development, calibration, and evaluation of fate and transport models).
- Baseline water quality data to support a remedial investigation designed to determine the nature and extent, and source areas of COPCs and COPECs.

The COPCs and COPECs in the Passaic River system can be categorized into three general groups: (1) hydrophobic organic compounds (HOCs) (*e.g.*, dioxins, PCBs, and PAHs), (2) trace metals and (3) methylmercury. In addition to these COPCs and COPECs, several conventional and hydrodynamic parameters are needed to support fate and transport analysis, eutrophication modeling, and risk assessment. These conventional and hydrodynamic parameters include: Total Suspended Solids (TSS), particulate organic carbon (POC), dissolved organic carbon (DOC), particle size distribution, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total Kjeldahl nitrogen, chlorophyll A, total and orthophosphate, ammonia, secchi disk depth, turbidity, current, temperature, water depth, and conductivity/salinity.

The behavior of COPCs and COPECs in the Passaic River system is influenced by many environmental variables including, but not limited to: pH, temperature, reduction-oxidation conditions, nutrient availability, sediment transport, biological activity, and the presence of inorganic and organic ligands. These factors can impact speciation, distribution between sediment and water phases, and cycling between inorganic and organic forms. Additionally, both HOCs' and organometals' biogeochemical behavior can result in strong sorption to solid surfaces, formation of stable complexes with organic matter, and bioaccumulation in the food chain.

Understanding fate and transport and the geochemical behavior of the site requires an evaluation of the partitioning of contaminants between the dissolved and particulate phases. Hence, the long-term water column sampling program should emphasize the collection of both dissolved phase and particulate phase COPCs and COPECs, under different hydrodynamic and hydraulic conditions. These data will support fate and transport model development and evaluations required to update the geochemical components of the conceptual site model.

Several sampling methodologies for HOCs are needed because the concentrations of select HOCs (*i.e.*, dioxin), particularly in the dissolved phase, are very low (parts per billion and in some cases parts per trillion). Each of these methodologies has associated uncertainties and the quality of the data obtained may be affected by shifts in HOC partitioning, the adsorption of HOCs to walls of the sampling containers, and the degree of HOC recovery in resin traps.

In order to address the complexities associated with low-level HOC sampling and analysis, and provide initial baseline water quality data to assess current-day levels of other target constituents (*e.g*, metals, conventional parameters) under varying hydrodynamic conditions, an initial sampling program is proposed. The objectives of this initial program are to:

1. Obtain a synoptic set of water column data on trace metals, methylmercury, TCL volatile and semivolatile organics, chlorinated herbicides and conventional parameters to update the CSM and calibrate the fate and transport model being developed for the restoration efforts. The sampling for trace metals, other than mercury, will use ultra-clean techniques in conformance with USEPA Method 1669. Sampling for mercury and methylmercury will use the ultra-clean aqueous sampling techniques.
2. Conduct a HOC sampling methodology validation study for the project. Section 6.1.1 “Sampling Methodologies Under Consideration for Water Column HOC”presents the different methodologies considered for this program. This validation study will answer the following questions:
    - What are the uncertainties associated with each HOC sampling methodology and which methodology best serves the project goals?
    - What are the effects of HOC phase shifts due to holding times and adsorption to the walls of the sampling containers?
3. Analyze the initial results of the above two sampling objectives and design a comprehensive long-term sampling program that will satisfy the data needs of the project. It is envisioned that the long term sampling program would be less broad and more focused than the short-term sampling program, once initial concentration patterns of COPCs and COPECs, as well as HOC sampling methodologies, are determined and validated.

6.1.1. Sampling Methodologies Under Consideration for Water Column HOC

A thorough “best practices” analysis for HOC water column sampling indicates three sampling methodologies offer scientific defensibility at reasonable costs: (1) intake pump/filtering system equipped with XAD^{tm} resin trap or similar sampling devices [*e.g.*, Infiltrex 300, Trace Organics Pollution Sampling (TOPS)] for the collection of discrete filtered samples (organics); (2) Niskin Bottles/20L Stainless Steel “Pop” Containers for collection of large volume samples for low to trace HOCs; (3) Semi-Permeable Membrane Devices (SPMDs) for collecting time-weighted average dissolved HOC concentrations. These methods are briefly described below.

The Infiltrex 300 is a commercialized version of the TOPS and available from Axys Technologies. It can operate from any water sampling platform and removes solids and HOCs/organometals from water samples (in the field) through the use of filters and XAD^{tm} traps. Although XAD^{tm} trap solids breakthroughs can occur when collecting samples over 20-30L, XAD^{tm} traps can be installed in series and analyzed separately to accommodate such samples. Most likely, a dedicated Infiltrex 300 would need to be maintained in a field sample processing facility or other controlled environment where power and other services are available (*i.e.*, anecdotal information indicates the Infiltrex is not robust enough to perform optimally on small boats). The Infiltrex 300 has been used for many years in multiple river systems (*e.g.*, Ohio River) similar in complexity to the Passaic River with great success. Procedures for the use of the Infiltrex 300 can be found in SOP 16 Infiltrex 300 Trace Organic Sampling in Attachment 1. It is the preferred system for water column sampling when field filtering is necessary.

Niskin bottles (10L) are weighted, water sample collection devices with triggered caps that can be remotely closed at a predetermined water column depth. They can be easily used to collect water samples across a river channel transect provided no field sample preparation is required. Generally, a composite of multiple samples are transferred into a 20L stainless steel pop container, which is transported in a cooler with ice to the analytical laboratory. Procedures to use Niskin bottles can be found in SOP 19 5-liter Niskin Bottle Use in Attachment 1. Niskin bottles, in conjunction with stainless steel pop containers, have been used with great success (*e.g.*, Delaware River Basin Commission program) when field filtering and sample preparation are not required.

SPMDs are passive water column sampling units that are deployed for days to months. They estimate dissolved phase contamination based on lab-determined partitioning coefficients and sampling rates. SPMDs consist of a tubular, lay-flat, low-density polyethylene (LDPE) membrane containing a thin film of a high-molecular weight lipid (triolein). When placed in an aquatic environment, SPMDs accumulate HOCs and organochlorine pesticides. The LDPE tubing mimics a biological membrane by allowing selective diffusion of organic compounds into the sampling device. The passive HOC sampling is driven by membrane- and lipid-water partitioning. SPMD is a useful technique for establishing temporally averaged spatial trends in dissolved organic contaminants. Because it is a semi-quantitative technique, it does not provide direct measurements of concentration, but it can be used to compare the relative concentration among the stations (assuming turbulence, temperature, etc., are uniform). Bio-fouling is likely an issue, as are variable sampling rates in differing salinities and under differing flow conditions. The procedure for using SPMDs is described in SOP 17 Procedure for Deployment and Retrieval of Semipermeable Membrane Devices in Attachment 1. SPMDs have been used successfully in the Columbia River for monitoring low-level HOCs.

6.2. TIDAL WATER COLUMN SAMPLING SCOPE

To satisfy the objectives of the short-term water column program, an initial monitoring program over a two month period is planned. The program will involve conducting sampling at the following locations:

- RM 0, the entrance to Newark Bay. This is the down-estuary end of the salt wedge, and in the brackish section of the CSM.
- RM 2.5, a salt-wedge station, above known contaminated sediment areas in Harrison Reach, in the brackish section of the CSM.
- RM 4.5, a salt-wedge station, down-estuary of combined sewer overflows near Newark, in the brackish section of the CSM.
- RM 10.5, down-estuary of Third River, in the transitional zone of the CSM.
- RM 17 at the Ackerman Bridge, close to the head of tide and the Dundee Dam boundary, in the freshwater zone of the CSM.
- The head of tide of the major tributaries to the Lower Passaic River including the Saddle River, Second River, and Third River.

These sampling locations are shown on Figure 6-1. Note that some of the proposed sampling will only be conducted at selected stations. Each sampling methodology will be implemented with quality control including field blanks, replicates, and spikes. The analysis related to the HOC sampling methodology validation study will be performed by the same laboratory. A separate program to determine COPC and COPEC loads at the head of tide of the major tributaries is planned for 2006 (see Section 7). The following sections provide an overview of the initial sampling program.

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Lower Passaic River Superfund Site
Water Column Sampling Locations

Figure 6-1

Map Document: (P:\0285924\Mapping\Small Volume Water Column\sampling locations areal photo.mxd) 1/9/2006

6.2.1. Time-Weighted Average Samples

Time-weighted average (TWA) samples will be collected from all sampling locations identified above using SPMDs (see SOP 17 in Attachment 1). At each location, SPMDs will be placed approximately 2 feet below the water surface. Additional SPMDs will be placed approximately 2 feet above the river bottom at RM 0, 2.5 and 4.5 to capture the stratification effects of the salt or brackish water. After 28 days, SPMDs will be collected and replaced with fresh SPMDs. The retrieved SPMDs will be packaged and shipped to the specialty subcontractor for sample preparation and extraction; all chemical analysis on the extract will be conducted by the same subcontractor laboratory. SPMDs will be used to estimate time-weight-averaged concentrations and bioconcentrations of trace HOCs such as PCBs, PAHs, dioxins, and pesticides. The SPMD data will be used to screen for the presence of certain HOCs in the tributaries and to compare the relative fingerprints of the HOCs in the different locations. Note that the SPMDs will not be used in the HOC sampling methodology validation study because this sampling methodology provides estimates of the dissolved phase HOC concentrations only.

6.2.2. Small-Volume Composite Grab Samples

Small volume (1-5 liters; see SOP 18 Small Volume Grab Water Samples and Cross-sectional Composite Sample Procedure in Attachment 1) water column composite grab (SVCG) samples will be collected from all SPMD locations. These small-volume samples will be analyzed for TAL metals, mercury and methylmercury, TCL volatile and semivolatile organics, chlorinated herbicides, and conventional and eutrophication model parameters [TSS, POC, DOC, particle size distribution, BOD, COD, Total Kjeldahl Nitrogen, Chlorophyll A, and total and orthophosphate ammonia] at each SPMD station. Field parameters, including temperature, pH, dissolved oxygen (DO), conductivity, and secchi disk, will also be monitored (see SOP 21 Horiba Use for Measuring Water Parameters and SOP 23 Secchi Disk Depth (Transparency) Measurement in Attachment 1). Samples will be collected at the same times at each of the tidally influenced stations, and the tidal stage and hydrodynamic conditions of the river will be noted. At each location, multiple small volume grabs will be collected across a river transect consisting of three to five sites per transect. With the exception of the samples collected for TSS analysis, all other transect grabs samples will be composited to represent the cross-section, managed/preserved as required, and shipped to the lab on the day of collection. A staff gage will be installed at each transect so that tide-height can be recorded when samples are collected.

6.2.3. HOC Sampling Methodology Validation Study

The HOC Sampling Methodology Validation Study (HSMVS) will be conducted at stations located at RM 2.5 and RM 10.5 after the SVCG sample collection. The HSMVS will:

- Use an Infiltrex 300 or similar large volume sampler to obtain particulate phase and XAD^{tm} trap dissolved phase samples (See SOP 16 Infiltrex 300 Trace Organic Sampling in Attachment 1).
- Collect representative large volume samples (~20L) and filter them immediately in the field (See SOP 16 Infiltrex 300 Trace Organic Sampling in Attachment 1). This may be conducted by using the Infiltrex to obtain the particulates. Pre-cleaned stainless steel pop bottles will be used to contain the filtrate. The XAD traps will not be used.
- Collect representative large volume whole water (~20L) using 10L Niskin bottles or similar clean sampling devices. The samples will be transferred on site to pre-cleaned stainless steel pop bottles, as previously used in the Delaware River Basin Program, and which will be immediately shipped to the lab for filtering and analysis (See SOP 19 5-liter Niskin Bottle Use in Attachment 1).

The sampling for this study will be conducted during ebb tide during the first month and flood tide during the second month, under high and low particulate or river flow conditions to reflect different flow/particulate concentrations. Samples for all three validation study programs will be done at the same time over a two-day period. Sampling on the first day of the HSMVS program will be done at river mile 2.5, and on the second day sampling will be done at RM 10.5. During each day of sampling a separate 5-liter whole water column sample will also be collected for analysis for TSS, POC and DOC, and PAHs. Conventional and hydrodynamic parameters including DO, conductivity, temperature, and pH will be monitored during the sampling period.

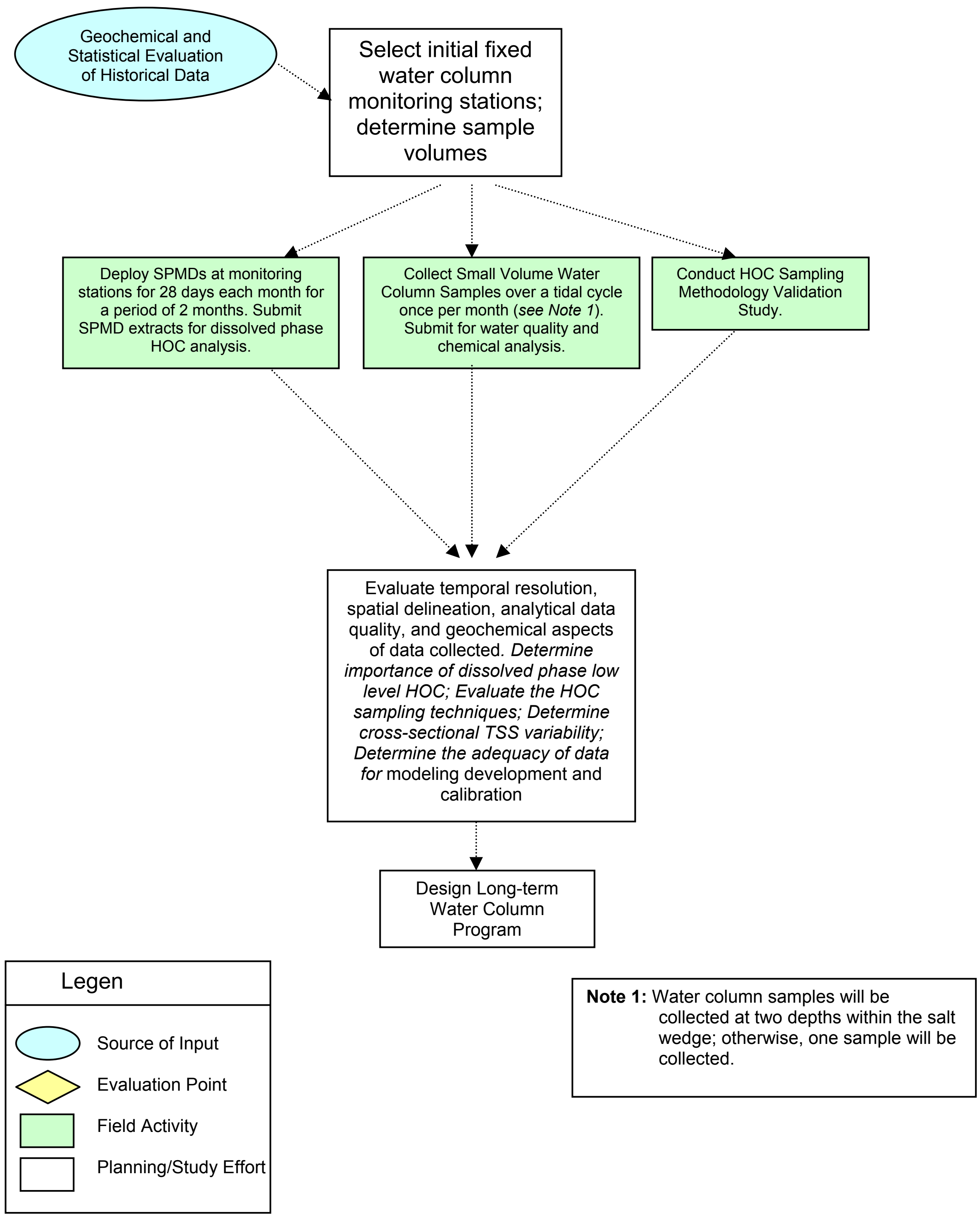
6.3. WATER COLUMN SAMPLE COLLECTION AND PROCESSING

A summary of the water column field activities, listed in the order in which they will be performed each month, is presented in Table 6-1. These methods will be evaluated in the field to assure that they are practical and are achieving the necessary results. A decision strategy is presented in Figure 6-2. If more efficient methods are identified, any modifications made after the first month of sampling will be submitted as an addendum to the water column program.

Table 6-1: Initial Water Column Sampling Activities

Task	Location	Sampling Time	No. of Samples/Month
Deploy 4 SPMDs	In the vicinity of (RM) 0, 2.5, 4.5, 10.5. At RM 0, 2.5 and 4.5 near water surface and near river bottom.	SPMDs will be deployed for a period of 28 days.	7 plus Quality Assurance/Quality Control (QA/QC).
Deploy 4 SPMDs	Head of tide at Dundee Dam and each major tributary (*i.e.*, 2nd River, 3rd River, and Saddle River).	SPMDs will be deployed for a period of 28 days.	4 plus QA/QC.
Collect SVCG samples	RM 0, 2.5, 4.5 10.5. At RM 0, 2.5 and 4.5 near water surface and near river bottom. Cross-sectional composite at transect of 3 to 5 stations.	- 1st month every 2 hours during ebb tide. - 2nd month every 2 hours during flood tide.	21 whole water plus QA/QC. 21 filtered water samples for metals. 29 samples plus QA/QC for TSS.
	Head of tide at Dundee Dam and each major tributary (*i.e.*, 2nd River, 3rd River, and Saddle River). Cross-sectional composite at transect of 3 to 5 stations.	Collect samples just before the 2 hour SVCG ebb tide sampling at Tidal Locations.	4 plus QA/QC. 4 filtered water for metals. 20 samples plus QA/QC for TSS.
Collect HSMVS: - Infiltrex - Large Volume Processed - Large Volume Whole Water	RM 2.5 and RM 10.5. At RM 2.5 near water surface and near river bottom.	- 1st month during Ebb tide. - 2nd month during flood tide.	6 plus QA/QC.

Figure 6-2: Decision Strategy for 2005 Initial Tidal Water Column Sampling Efforts



7.0 TRIBUTARY AND HEAD-OF-TIDE WATER COLUMN SAMPLING (TO BE ADDED IN 2006)

7.1. DATA NEEDS AND SAMPLING OBJECTIVES

7.2. TRIBUTARY WATER COLUMN SAMPLING PROGRAM SCOPE

7.3. TRIBUTARY WATER COLUMN SAMPLE COLLECTION AND PROCESSING

8.0 POREWATER AND GROUNDWATER SAMPLING (TO BE ADDED IN 2006)

8.1. DATA NEEDS AND SAMPLING OBJECTIVES

8.2. POREWATER SAMPLING SCOPE

8.3. POREWATER SAMPLE COLLECTION AND PROCESSING

9.0 MUDFLAT SEDIMENT SAMPLING (TO BE ADDED IN 2006)

9.1. DATA NEEDS AND SAMPLING OBJECTIVES

9.2. MUDFLAT SEDIMENT SAMPLING SCOPE

9.3. MUDFLAT SEDIMENT SAMPLE COLLECTION AND PROCESSING

10.0 LONG-TERM TIDAL WATER COLUMN SAMPLING (TO BE ADDED IN 2006)

10.1. DATA NEEDS AND SAMPLING OBJECTIVES

10.2. LONG TERM TIDAL WATER COLUMN SAMPLING SCOPE

10.3. TIDAL WATER COLUMN SAMPLE COLLECTION AND PROCESSING

11.0 ACRONYMS

ADCP	Acoustic Doppler Current Profiler
BAZ	Biologically Active Zone
Be-7	Beryllium-7
BOD	Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cm	Centimeter
COD	Chemical Oxygen Demand
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
Cs-137	Cesium-137
CSM	Conceptual Site Model
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	4-4'-Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQO	Data Quality Objective
EM	Engineering Manual
ERDC	Engineer Research Development Center
FS	Feasibility Study
FSP	Field Sampling Plan
Ft.	Feet
GIS	Geographical Information system
GPS	Global Positioning System
HASP	Health and Safety Plan
HOC	Hydrophobic Organic Compound
HSMVS	HOC Sampling Methodology Validation Study
IDW	Investigation-Derived Waste
L	Liter
LDPE	Low-density Polystyrene
LISST	Laser In-Site Scattering and Transmissometry
MPI	Malcolm Pirnie, Inc.
NA	Not Applicable
NGVD29	National Geodetic Vertical Datum, 1929
NIOSH	National Institute for Occupational Safety and Health
NJADN	New Jersey Atmospheric Deposition Network
NJDEP	New Jersey Department of Environmental Protection
NJDOT-OMR	New Jersey Department of Transportation – Office of Maritime Resources

NRDA	Natural Resource Damage Assessment
OBS	Optical Backscatter Sensor
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbon
Pb-210	Lead-210
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzodioxins
PCDD/F	Polychlorinated Dibenzodioxins/Furans
POC	Particulate Organic Carbon
PREmis	Passaic River Estuary Management Information System
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
RM	River Mile
SOP	Standard Operating Procedure
SPI	Sediment Profile Imagery
SPMD	Semi-Permeable Membrane Devices
SSS	Side Scan Sonar
SVCG	Small Volume Composite Grab
TAL	Target Analyte List
TCDD	Tetrachlorodibenzodioxin
TCL	Target Compound List
Th-234	Thorium 234
TOPS	Trace Organic Platform Sampler
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
TWA	Time Weighted Average
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
WRDA	Water Resources Development Act
XRF	X-Ray Fluorescence

12.0 REFERENCES

Aqua Surveys, Inc. 2005. Technical Report, Geophysical Survey, Lower Passaic River Restoration Project. Draft, August 2005

Bopp, R.F., M.L. Gross, H. Yong, H.J. Simpson, S.J. Monson, B.L. Deck, F.C. Moser, 1991. A Major Incident of Dioxin Contamination: Sediments of New Jersey Estuaries. Environmental Science and Technology, Volume 25, No. 5, pp. 951-956, 1991.

Boudreau, B.P. 1998. "Mean Mixed Depth of Sediments: The Wherefore and the Why." *Limnol.Oceanogr., 43*(3): 524-526.

Clarke, D., M. Palermo, and T. Sturgis. 2001. "Subaqueous Cap Design: Selection of Bioturbation Profiles, Depths, and Rates." DOER Technical Notes Collection (ERDC TN-DOER-C21), U.S. Army Engineering Research and Development Center, Vicksburg, MS.

Dyer A.R., *et al.* 1996. A comparison of in situ techniques for estuarine floc settling velocity measurements. Journal of Sea Research 36 (1/2): 15-29.

Eisma D. *et al.* 1996. Intercomparison of in situ suspended matter (floc) size measurements. Journal of Sea Research 36 (1/2): 3-14.

Fugate, D.C, C.T. Friedrichs. 2002. Determining concentration and fall velocity of estuarine particle populations using ADV, OBS and LISST. Continental Shelf Research 22: 1867-1886.

Gigliotti, Cari L., *et al.* 2005. Atmospheric concentrations and deposition of polycyclic aromatic hydrocarbons to the Mid-Atlantic east coast region. Environmental Science Technology 2005, 39, 5550-5559.

Gioia, Rosalinda, *et al.* 2004. Atmospheric concentrations and deposition of organochlorine pesticides in the US Mid-Atlantic region. Atmospheric Environment 39 (2005) 2309-2322.

Gotthard, D., 1998. Three-Dimensional, Non-Destructive Measurements of Sediment Bulk Density Using Gamma Attenuation. Report, Department of Mechanical and Environmental Engineering, University of California, Santa Barbara, CA 93106.

Jepsen, R., J. Roberts, W. Lick. 1997. Effects of bulk density on sediment erosion rates. Water, Air, and Soil Poll., Vol. 99, pp. 21-31.

Malcolm Pirnie, Inc. 2005a. Quality Assurance Project Plan, Lower Passaic River Restoration Project. Prepared in conjunction with Battelle and Hydroqual, Inc. August 2005.

Malcolm Pirnie, Inc. 2005b. Field Sampling Plan: Volume 3, Lower Passaic River Restoration Project. Revised Preliminary Draft. Prepared in conjunction with TAMS, *an Earth Tech company* and Greeley Polhemus Group, Inc. August 2004; geophysical program as amended July 2005.

Malcolm Pirnie, Inc. 2005c. Work Plan, Lower Passaic River Restoration Project. Prepared in conjunction with Battelle and Hydroqual, Inc. August 2005.

Malcolm Pirnie, Inc. 2005d. Health and Safety Plan, Lower Passaic River Restoration Project. Prepared in conjunction with Battelle and HydroQual, Inc. January 2005.

McNeil, J., C. Taylor, W. Lick. 1996. Measurements of the erosion of undisturbed bottom sediments with depth. J. Hydraul. Eng. – ASCE, 122(6), 316-324.

Roberts, J., R. Jepsen, D. Gottard, W. Lick. 1998. Effects of particle size and bulk density on erosion of quartz particles. J. Hydraul. Eng. – ASCE, 124(12), 1261-1267.

Sanford, L.P., J.P.-Y Maa,., 2001. A unified erosion formulation for fine sediments. Marine Geology, 179(1-2): 9-23.

Sanford, L.P., S.E. Suttles, J.P. Halka. 2001. Reconsidering the physics of the Chesapeake Bay Estuarine Turbidity Maximum. Estuaries, 24(5): 655-669.

TAMS/Earth Tech, Inc. and Malcolm Pirnie, Inc. 2005. Restoration Opportunities Report.

Totten, Lisa A., *et al.* 2004. Atmospheric concentrations and deposition of polychlorinated biphenyls to the Hudson River estuary. Environmental Science Technology. 2004, 38, 2568-2573.

USACE, 2004. Bathymetric Survey. Prepared by Rogers Surveying, P.L.L.C for the USACE in September-November 2004.

USEPA, 2004. Contract Laboratory Program Guidance for Field Samplers. 2004.