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PHASE 2A SAMPLING PLAN - REVIEW COPY

HUDSON RIVER PCB REASSESSMENT RI/FS

EPA WORK ASSIGNMENT NO. 013-2N84

SEPTEMBER 1991

Region II

ALTERNATIVE REMEDIAL CONTRACTING STRATEGY (ARCS)

FOR

HAZARDOUS WASTE REMEDIAL SERVICES

EPA Contract No. 68-S9-2001

TAMS CONSULTANTS, Inc.

and

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1. INTRODUCTION

In accordance with the USEPA Scope of Work for the Reassessment (December 1990), Phase 2 will be performed to further characterize and analyze site conditions. The Phase 2 work will be based on the review and synthesis of information collected and reported in the Phase 1 Report - Interim Characterization and Evaluation (August 1991).

In order for the Hudson River PCB Oversight Committee (HROC) and the participants in the Community Interaction Program (CIP) to provide input into the Phase 2 work, these groups will be allowed sufficient time to evaluate the Phase 1 Report. Therefore, a full Phase 2 Work Plan will not be developed until after comments are received on the Phase 1 Report. There are some data, however, that USEPA believes should be collected in Fall 1991, because the data will be needed to guide subsequent sampling activities and allow the project schedule to be maintained. These priority sampling activities, which will be conducted this Fall, are described in this sampling plan.

It should be noted that the Health and Safety Plan, the QA/QC plan and several analytical techniques are not included in this sampling plan proposal. In addition, several of the analytical techniques are only generally described in Appendix C. The additional documentation for the various plans and analytical procedures will be supplied to EPA in the next few weeks.

2. OBJECTIVE

The objective of the proposed Phase 2 Sampling Program is to obtain additional data on current riverine conditions so as to enhance existing data and facilitate the evaluation of current and potential future human health and environmental risks posed by PCBs in the Hudson River. In addition, the program will provide additional information so that both implementability and remediation costs can be evaluated for the Feasibility Study. The objective of the Phase 2A Sampling Program is to begin the study of certain specific riverine conditions which provide a basis for subsequent investigation as part of Phase 2B or whose analysis will require substantial amounts of time. In both instances, it is important for these tasks to begin now so that the entire investigation can be completed in a timely manner.

In Phase 1, available Hudson River PCB site-related data have been collected, digitally compiled, and analyzed. Based on CIP participant review of the Phase 1 Report, any other relevant data that may be identified will be incorporated in the project's electronic database and evaluated for their importance to site characterization. However, the Phase 1 program has identified several critical data gaps that must be addressed in order to characterize the site and the risks it poses to human health and the environment, and to establish viable remedial cleanup alternatives for the Hudson River PCB site.

The data gaps related to the site characterization and risks depend upon assumptions about future conditions. Two principal assumptions about the future can be made: (1) assume that current river conditions and water quality trends will continue indefinitely into the future (quasi-steady state scenario); and (2) assume a major flood or other catastrophic event occurs that is capable of re-mobilizing a substantial portion of the highly contaminated sediments in the Upper Hudson (flood scenario). Potentially, the re-mobilization event could return riverine water column contamination levels to those of the mid-1970's.

For the quasi-steady state scenario, the following data gaps have been identified:

1. Current sediment total PCB concentrations and PCB congener mixtures;

2. Current water column total PCB concentrations and PCB congener mixtures;

3. PCB concentration and PCB congener mixture variability with time;

4. Extent and rate of in situ degradation;

5. Effect of remnant capping on current PCB water column transport;

6. Current mass of PCBs in the Upper Hudson for the purpose of evaluating the possible duration of their effects on river water quality;

7. Current shoreline soil and sediment PCB levels;

8. Current air-borne PCB levels attributable to the Hudson; and

9. Current hot spot distribution.

For the flood scenario, additional data required are:

1. Estimates of the current mass of PCBs in the Upper Hudson and the portion which could be mobilized under the flood scenario;

2. Estimates of the area of contamination subject to scour under the flood scenario; and

3. Bed scour characteristics.

These data will provide the needed information to complete the site characterization and the Feasibility Study. Obtaining congener-specific information, which is currently minimal, has particular importance. Such data have the potential to provide extensive information on possible PCB sources and biodegradation by providing a congener pattern fingerprint, which may be directly linked to a source or a degradation process.

3. PHASE 2A SAMPLE PROGRAM TASKS

As part of this initial investigation of the Hudson River, five separate data collection tasks have been designed. These tasks include geophysical, sedimentological and geochemical studies and each of the tasks is listed below.

1. Establishment of Shoreline Control Points for Precision Navigation in the Upper and Lower Hudson.

2. Geophysical Surveys of the Upper Hudson from the Bakers Falls Pool to the Lock 4 Dam.

3. Confirmatory Sampling for Calibration of the Upper Hudson Geophysical/Surveys.

4. High Resolution Coring at Locations Throughout the Lower and Upper Hudson River.

5. Water Column Monitoring of the Upper Hudson River from Glens Falls to Waterford.

These tasks are discussed individually in more detail below. In addition, further detailed descriptions of the sampling techniques and a report on a demonstration of the geophysical survey techniques are provided as appendices.

3.1 Establishment of Shoreline Control Points for Precision Navigation in the Upper and Lower Hudson River

The success of this program is very dependent upon precise navigation in the Hudson River. The ability to compare results among the various sampling tasks is contingent upon knowing very precisely all sampling locations in the Hudson. For this reason, a system of shoreline points will be established which will enable precision navigation, nominally accurate to one meter. To the extent that shoreline control points still exist from previous investigations, these will be utilized. It is anticipated that for the geophysical survey of Upper Hudson, between the Bakers Falls Pool and the Lock 4 Dam about 20 shoreline points will need to be established, either from existing points from prior investigation or from appropriate surveying techniques, about one control point every one and one-half miles. For the high resolution coring locations which do not fall within the geophysical survey area, additional shoreline control points will need to be established. Because of the distance between the individual coring locations, one control point will need to be established for each coring location. For the Lower Hudson, 12 control points will be required. For the Upper Hudson, four to five additional control points will be required.

All shoreline points will be referenced to the N.Y.S. Plane Coordinate System, North American Datum (NAD83). Vertical data will be referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929). It is anticipated that this task will require about 18 days of field work spread over a three to four week period.

3.2 Geophysical Surveys of the Upper Hudson from the Bakers Falls Pool to the Lock 4 Dam

This task will involve the study of river bottom sediment textures, bathymetry, topography and sediment thickness in the most PCB-laden region of the Hudson using geophysical measurement techniques. These data will be used to construct a map of the river bottom conditions, effectively providing an "aerial photograph" perspective of the river bottom conditions. The information will be calibrated and confirmed by sample collection as described in Section 3.3 of this sampling plan. The information has many important potential uses, as a basis for the selection of additional coring locations in Phase 2B, identifying areas of river sediment susceptible to scour, and estimating volumes of mobile sediments, among others. Finally, the results of the task will create a baseline survey of river bottom conditions for long term monitoring purposes.

The geophysical surveys proposed here include side-scan sonar, bathymetry and single frequency sub-bottom profiling. Figure 1 is a map of the Upper

Hudson, showing the areas to be surveyed as a part of this effort. About two-thirds of the survey will cover areas previously demonstrated to contain PCB hot spots. The remaining third will be more exploratory in nature, examining areas which would appear to represent depositional conditions similar to those found at the hot spots, but not delineated as hot spot areas. This effort will commence roughly two to three weeks following completion of the shoreline control points survey in the Upper Hudson. The following is a brief description of the individual sub-tasks to be completed as a part of the geophysical survey effort:

3.2.1 Bakers Falls Pool to River Mile 182

1. A side scan sonar survey of all accessible areas in this region of the river will be conducted using 100 and 500 kHz sonar. Data on the river bottom will be collected at relatively high resolution, covering a swath roughly 75 m across. The swath width may be adjusted in the field to allow for variations in the width of the river at the discretion of the field scientists. The survey lines will generally run parallel to the direction of river flow. Each survey line will be roughly one to two miles long, depending on navigational constraints. Each of these lines will be separated by about 40 m, yielding bottom coverage for the river of about 150%. This method will ensure that the edges of each swath overlap and that the bottom of the river will be completely surveyed. Figure 2 is a schematic showing the approximate layout of the survey grid. The survey of the Thompson Island Pool will cover the entire navigable area between the former dam site at Ft. Edward and the Thompson Island Dam. This survey will cover 20 of the 40 previously defined hot spots. The survey of the Bakers Falls Pool will cover the area behind the Bakers Falls Dam to roughly one half-mile upstream. The survey between the Thompson Island Dam and River mile 182 will cover all accessible areas in this region and an additional 15 of the 40 previously defined hot spots. The survey coverage of the river bottom in the last region may be somewhat limited due to the unknown and potentially shallow water depths in some areas of this region.

    -- Navigation will be nominally accurate to 1 m and referenced to the N.Y.S. Plane Coordinate System, North American Datum (NAD83).

    -- Vertical data will be referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929).

-- Data from the bathymetry and sub-bottom profiling equipment will be collected concurrently with the side-scan sonar data.

2. A bathymetric survey will be conducted for the areas defined for the side-scan sonar survey. The survey will consist of survey lines about 150 m apart perpendicular to the direction of flow. These data will be used in conjunction with the bathymetry data obtained during the side scan sonar survey, effectively generating a wire net of coverage of the river bottom.

    -- Navigational and vertical data will be of the same quality as that for the side-scan sonar survey.

3. A single frequency sub-bottom profile survey will be conducted for all surveyed areas.

    -- Navigational and vertical data will be of the same quality as that for the side-scan sonar survey.

    -- Data will be collected concurrently with the bathymetric and side-scan sonar surveys.

3.2.2 Upper Hudson River from River Mile 182 to the Lock 4 Dam

1. For the region between river mile 182 and the Lock 4 Dam, several areas viewed as potential depositional environments will be surveyed in the same manner as described above. These areas will include the one hot spot located in this reach of the Hudson. This brings the total hot spot coverage to 36 of the 40 hot spots as defined by NYSDEC. To the extent that schedule and budget permit, additional areas in this region of the river will be surveyed to better complete the coverage. It is anticipated that the survey will cover at least seven of the 14 river miles in this region. Additional coverage of the Upper Hudson will be left to the geophysical support work to be performed as part of the high resolution sediment coring effort and to Phase 2b.

    -- Navigational and vertical data will be of the same quality as that for the upriver survey.

3.3 Confirmatory Sampling for the Calibration of the Upper Hudson Geophysical Survey

To ensure proper interpretation of the geophysical data to be collected, confirmatory samples will be collected immediately following the completion of the geophysical surveys. It is estimated that about 10 field days will be required to collect sediments from an anticipated 100 locations for this effort. Samples will be collected by hand coring or by grab sampling. The confirmatory sampling locations would be selected based on the geophysical results and placed using the same navigational controls and precision as that for the geophysical surveys so that the two sets of data could be directly correlated and mapped. All successfully collected samples will be stored for later examination and analysis. In addition to the sediment sampling, a remotely operated underwater video camera will be used to visually examine bottom structures. The following is a list of additional details for the confirmatory sampling effort:

- Sediment samples will be visually examined for sediment texture and stratification for calibration of both the side-scan sonar and the sub-bottom profiling survey data.

- Cores will be photographed to record visible sedimentological structures.

- Cores will be X-rayed to detect in situ density variations before extrusion of the core.

- Core samples will be sectioned in the field in two inch intervals and stored wet in cans. Redox measurements will be made on extruded sections during the extrusion process.

- All samples will be analyzed to determine their grain size distribution using a coulter counter and by a standard technique available under CLP.

- About 250 samples will be analyzed for total carbon and total nitrogen. 50 of these samples will also be analyzed for total organic carbon for comparison with the total carbon analysis.

- Samples will be stored wet and kept cool for a period of one year. After this time the samples will be air dried for long term storage or discarded.

-- Sample handling procedures will follow the required sample handling procedures for Superfund sites, including chain-of-custody forms, etc.

3.4 High Resolution Coring at Locations Throughout the Lower and Upper Hudson

This task will involve the collection of sediment cores from locations throughout the Upper and Lower Hudson. These cores will be analyzed for radionuclides on a two to four cm layer basis in order to establish the year of deposition of a given sediment layer. These same layers will be analyzed for total PCB concentration and PCB congener concentration as well as other parameters. In this manner, the historic trends of PCB loads in the river at the studied locations can be established. (See the Phase 1 Report, Interim Characterization and Evaluation, Volume 1, 1 of 2, Part A, Section A.3.1.) In addition, by analyzing the sediment layer for PCB congeners, the trend in congener mix with time can be established. On the basis of the congener mixture, it should be possible to "fingerprint" the PCBs and determine the relative contribution of various sources to the total PCB load at any given location in the river. The results of the cores collected for this effort will be used in conjunction with the historic studies in the literature to compile a complete PCB history for the river and to evaluate the extent of in situ PCB degradation. Finally, the sediment PCB record may also be useful for comparison with the existing biological data.

The Phase 2A effort will begin with core collection from the Lower Hudson. After the coring effort from the Lower Hudson is complete and, if weather conditions in the Upper Hudson permit, the cores will be collected from the Upper Hudson this fall. Otherwise the coring effort for the Upper Hudson will be completed in Phase 2B. Listed below are the individual efforts for the Lower and Upper Hudson River and a description of the sample handling procedures.

1. Cores from twelve locations in the Lower Hudson will be collected. Their locations are shown in Figure 3.

   -- Cores will be collected from the following previously sampled approximate River Mile locations: -1.7, -1.65, 3, 44, 53.8, 60, 88.6, 91.8, 143.4 and Newtown Creek.

   -- Cores will be collected from these additional approximate River Mile locations to expand the core data base: 115 and 130.

2. Cores from eleven locations in the Upper Hudson will be collected. Their locations are shown in Figure 4.

   -- Cores will be collected from the following previously sampled approximate River Mile locations: 168, 189, 190, 191, and 203.

   -- Cores will be collected from the following new River Mile locations to expand the core data base: 166, 195, and 197.

   -- Cores will be collected from the Hoosic and Mohawk Rivers near their confluence with the Upper Hudson to evaluate the relative contribution of PCBs from each river.

3. All cores will be collected using a hand coring technique whenever possible.

   -- Cores will be transported in a vertical position as collected to a field laboratory location or to the Lamont-Doherty Geological Observatory for subsequent sample preparation.

   -- Cores will be sectioned into approximately two cm layers for the uppermost eight cm. The remainder of the core will be sectioned into four cm layers. These sections will be individually homogenized while wet and subsectioned, with portions reserved for PCB, total carbon, total nitrogen, total organic carbon, and grain-size distribution analyses. The remaining portion of each layer will be dried under a PCB-free atmosphere, and analyzed for radionuclides (^{137}Cs, ^{7}Be and ^{60}Co among others). Subsequently, this portion of the sample (typically about half of a given layer) will be archived in a sealed aluminum can.

   -- To the extent that a core does not yield an interpretable radionuclide chronology, one additional core will be collected from the original location to replace the first core. If the second attempt does not yield an interpretable core chronology, the location will be abandoned. Further coring in the area will be left for Phase 2B.

3.5 Water Column Monitoring of the Upper Hudson River from Glens Fails to Waterford

This data collection task is designed to determine current water-born PCB levels and congener mixtures in both dissolved and suspended matter fractions.

These data will be used to determine the approximate location of the current PCB base load and the effect, if any, of recent remedial efforts on the water column levels. The effort is also designed to examine the correlation of PCB loading with water flow. Finally, the results will also be used to examine the partitioning of PCB congeners between the dissolved and suspended matter phases. This task is expected to extend over several months, with sampling events separated by several weeks to one month. Listed below is a basic description of the task efforts:

1. Water monitoring stations will be sampled on at least seven separate occasions at 10 locations from Glens Falls to Waterford. The locations are shown in Figure 5.

   -- Nine locations (constituting one transect) will be sampled along the main river axis in order to delimit the area of the Upper Hudson where the current base load originates, as follows: Glens Falls, Bakers Falls, upper remnant deposit pool, lower remnant deposit pool, Rogers Island at Ft. Edward, Thompson Island Dam, Schuylerville, Stillwater, Waterford. One additional station will be occupied on the Hoosic River just upstream of its confluence with the Upper Hudson.

   -- A background sample will be collected during each transect from one location well away from Hudson River PCB contamination. This sample will serve as an additional blank check.

   -- At each station, data will be collected on water column conductivity, temperature, dissolved oxygen, and pH, using appropriate probes.

   -- Water will be collected at each station for PCB analysis (on a 20 liter aliquot and on a 1 liter aliquot), dissolved organic carbon analysis, total suspended matter analysis and chlorophyll-a.

   -- Each sample collected for PCB analysis at each station will be separated by filtration into a dissolved fraction and a particulate fraction. The samples will be filtered in the field as soon as possible after collection but no more than four hours after collection. Each fraction will be analyzed on a congener specific basis.

- Four separate sampling events along the transect will coincide with low flow (less than 8,000 cfs at Ft. Edward) to typify current low flow PCB transport conditions.

- Three separate sampling events along the transect will coincide with high flow events (much greater than 8,000 cfs at Ft. Edward) to examine current high flow PCB transport conditions. These events will coincide with sustained high flow for at least one to two days prior to sampling.

- Samples will be collected from north to south while monitoring the flow at the USGS hydrographic stations in the Upper Hudson so as to generally follow the same parcel of water through the Upper Hudson River.

- During the first low flow and high flow events, two 20-liter samples will be collected at each station along the transect, one to be field filtered, and one to be laboratory filtered. The laboratory sample will be held a minimum of four days before filtering to ensure that equilibrium between dissolved and particulate phases is reached.

- At each station, samples will be collected at several points across the river and mixed together to account for cross-section heterogeneity in the PCB levels.

3.6 Summary of Phase 2A Sampling Program

The sampling program as described above is summarized in Table 3-1 in terms of the number of samples to be collected and the types of analyses. In total, 123 sediment cores or grab samples and 77 water samples will be collected. Each of the high resolution cores (23) will be split into roughly 10 to 12 sections. Each high resolution core section will be sent for PCB congener analysis for a total of 230 to 276 samples. It is anticipated that about one half of the confirmatory sampling locations will yield sediment cores and one half will yield grab samples. Each of the confirmatory sample cores (50) will be split into about six sections. All confirmatory sediment samples will be analyzed for grain-size distribution. About 250 to 300 of these samples will be analyzed for total carbon and total nitrogen. For the water column, 198 samples will be sent for PCB congener analysis. The program also involves several other analytical procedures including total carbon analysis, total nitrogen analysis, total organic carbon analysis, grain size distribution analysis, radionuclide analysis via gamma spectrometry, dissolved organic carbon analysis, and total suspended matter analysis.

4. SITE OPERATIONS PLAN

4.1 Objective

The objective of this Site Operations Plan is to establish a structure for conducting field operations along the Hudson River. At the present time it is envisioned that TAMS/Gradient personnel will be involved with all phases of the field investigations, with assistance from the New York State Department of Environmental Conservation (NYSDEC), Lamont-Doherty Geological Observatory (LDGO), the Marine Sciences Research Center of SUNY-Stony Brook and Ocean Surveys, Inc. during specific portions of the data collection tasks.

This entire field investigation effort will be performed under the direction of TAMS/Gradient staff. The logistical coordination for this project will emphasize an in-depth understanding of the requirements for each aspect of the work elements.

Daily field sampling crew goals will be based on the established schedules of laboratories, the ability of the field support crews to process samples and the impact of adverse weather.

4.2 Site Operation Zones

The proposed field operations will be conducted on and along the Hudson River from River Mile -1.7, south of the Battery, to approximately River Mile 203, near the city of Glens Falls. For purposes of simplifying the field coordination, the river has been divided into three work zones. The Upper Hudson will be divided into two zones, Zone I and Zone II while the Lower Hudson will be considered as Zone III.

Zone I

Zone I is that portion of the Upper Hudson extending from Fort Edward to Glens Falls. This section of the river is mostly unnavigable for a boat equipped with an outboard motor due to rapids, protruding boulders, falls and shallow water.

Access to the sampling locations in the river will be made by motor boat where possible or by wading or by portaging a small boat to the riverbank and then motoring or paddling to the area. Other access means, such as sampling from bridges, will be used where possible.

Zone II

Zone II extends along the Upper Hudson from Fort Edward to the Troy dam and includes a portion of the Hoosic River and the Mohawk River. This area consists of a series of locks and dams and is navigable by any size boat required by the field sampling teams. Boat traffic on this portion of the river consists primarily of pleasure craft which cruise the Hudson and its tributaries.

Access to the river will be made from public boat launches which are usually situated near key towns or cities. Sampling from bridges, as allowed by the Health and Safety Plan, may also be performed in this zone.

Zone III

Zone III extends from the Troy dam to just below the Battery, in Upper New York Bay. This area is tidal and is open to commercial river traffic. Large tugboats pulling or pushing multiple gang barges, oil tankers, and pleasure boats travel the length of this section. Commuter ferryboats, hovercraft, cruise ships, and sightseeing boats also share the waters in and near New York harbor.

Access to the river will be made from public boat launches located along the river. Sampling will be performed from boats in this zone.

4.3 Proposed Field Operations

The proposed field sampling operations will consist of the following items: (specific methodologies are described in the appendices)

4.3.1 Sediment Sampling

High resolution core sampling is currently proposed at 23 locations. One to two cores will be obtained at each of the locations. Two locations are planned in Zone I, nine in Zone II, and twelve in Zone III.

Confirmatory sediment sampling is planned for the Upper Hudson at approximately 100 locations. Three to five locations are planned for Zone I, with the remainder in Zone II. There is currently no proposed confirmatory sediment sampling for Zone III.

4.3.2 Water Column Sampling

High volume water column sampling is currently proposed at eleven locations over seven separate sampling events. Four sampling events will be conducted at approximate three to four week intervals, assuming relatively constant riverine flow. The remaining three events will be conducted during high flow conditions, resulting from major storms or the spring thaw. Approximately 20 liters of river water will be collected at each sampling location. Collection of the samples will be scheduled so that the same approximate water slug will be sampled as it travels down stream. Four samples will be collected within Zone I and six will be collected within Zone II. One sample will be collected outside the investigation area as a background sample.

4.4 Support Facilities

4.4.1 Mobile Command Post

In order to adequately support the field operations, a command post will be established to act as a control facility for ongoing field activities. Due to the vast territory which this project site covers, over 230 river miles, the command post established for this field investigation must be a mobile unit. The team is anticipating the use of a 14 foot cube van for this purpose. This vehicle is large enough to be used to store expendable supplies in limited quantities, to serve as a mobile office, and to provide facilities for proper sample preparation and packaging. TAMS currently has such a unit purchased under the ARCS program. This vehicle will be equipped with a mobile telephone and hand held two-way radio communication. Project plans, safety documents, and schedules will be maintained in the mobile command post. If project needs require, a facsimile machine may also be made available.

Depending on the level of effort at any given time it is anticipated that zero to two persons will be required at the command post.

4.4.2 Temporary Support Facility

During special sampling events and particularly during the hot spot core sampling, additional work space may be required. Large numbers of sample bottles, coolers, vermiculite packaging material and other support materials will need to be stored in a temporary support facility. Most likely the field investigation team will require a public storage rental unit, in one or more convenient locations, to temporarily house these items.

The temporary support facility will only be used to store equipment and supplies and will not require any personnel.

4.4.3 Support Vehicles

Boats

Boats required for the remote sensing geophysical surveys will be supplied by subcontractors. The area of study (i.e., Zone I or Zone II) will determine the size of the boat required.

Land Vehicles

In addition to the mobile command post vehicle, up to two additional support vehicles will be required. These vehicles will be used to transfer the sediment samples to the air freight office for shipment and to tow the two larger boats. Land vehicles will require one driver each.

During the water column sampling program land vehicles will have to be used to follow the water parcel. This is necessary due to the river conditions found in Zone I and due to the locks and dams encountered in Zone II. These conditions would necessitate the launching and removal of the boats from the river, which would add time restraints to the sampling effort. By using land vehicles to reach the next sampling area, a sample will be collected from bridge or other easy access location.

4.5 Plan of Operations

4.5.1 Field Reconnaissance

Soon after approval of the 1991 sampling program is received and the final sampling quantities and locations have been decided, a thorough field reconnaissance will be performed. This reconnaissance will assist in determining the ultimate boat launch sites to be used to access various reaches of the river, evaluate boat requirements in Zone I, and aid in establishing land support vehicle access areas. This will include the proper support locations when taking into account various health and safety needs such as easy access to hospitals, and other requirements of the plan. Temporary support facilities will also be scouted out.

4.5.2 Mobilization

Field mobilization will be initiated from the TAMS/EPA warehouse in Garfield, New Jersey. A majority of the expendables and all of the capital property anticipated for the project will be acquired prior to field mobilization and stored at the warehouse. If the need arises to obtain more equipment to accommodate the project, then additional supplies will be purchased as needed and shipped directly to the site. This approach will minimize the possibility of over-purchasing supplies and having a significant surplus at the completion of the project.

Mobilization of supplies such as EPA approved sample bottles, coolers and packaging materials to the temporary support facility (if established) will be managed by the field crew as they see fit.

4.5.3 Communication

Each vehicle (boat, car or truck) will be equipped with two-way radio communication. Persons expecting to travel great distances from the command post will be equipped with portable telephone communication, at the discretion of the site manager. However, portable telephone communication will be maintained at the command post for emergency uses and for coordinating project support.

4.5.4 Sample Numbering System Establishment

A sampling numbering system will be established before sample collection begins. It is the responsibility of the site manager to see to it that all subcontractors adhere to the established system. Elements of the sample numbering system may include DATE-LOCATION-MATRIX and other sequencing information.

Where appropriate, SMO sample identification will be adhered to. Because the proposed subcontractors have significant sampling experience but minimal experience dealing with EPA/CLP protocols for sample management and custody, the TAMS/Gradient field team will assist in sample management.

4.5.5 Coordination with Field Crews - Logistics

The scheduling of all personnel will be coordinated by the site manager so that the project schedule may be achieved. Each person involved with the field operation will be assigned to a task or set of tasks. It is the responsibility of the site personnel to evaluate the scheduling and notify the site manager of any

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difficulties which may impede the work effort, baring normal equipment failures and adverse weather conditions.

Prior to mobilization, all sampling and testing apparatus will be specified. Quantities will be established by the site manager in coordination with people assigned the tasks of sampling. This information will be presented to the TAMS Property Administrator who will arrange to have the apparatus available.

Requirements for sampling apparatus decontamination will be specified. During the field work decontamination aboard boats will be minimized. So as to limit the generation of decon fluids in the field, laboratory decon will be performed on equipment which is able to be dedicated to the collection of a single sample. These items may include sediment core tubes, mixing spoons and bowls.

The preparation of decontaminated sampling equipment in the field needs to be coordinated so that field blanks will be minimized and sampling crews will be able to do their work, as scheduled, each day.

4.5.6 Transfer of Samples to on Shore Personnel

The coordination of the transfer of samples is important because it is not possible for boat crews to deliver samples directly to an overnight courier. Schedules will be established and radio communication will be maintained so that boat crews may be located and the sample transfers may take place. Boat crews will need to establish a meeting place for the land-based personnel, such as at a bridge or other easily located structure, so that the sample transfer may take place.

Specific attention will be paid to sample integrity as the samples are being moved. This is especially critical for the high resolution sediment samples which need to be transferred in an upright position, while minimizing any agitation of the sample.

4.5.7 Sample Preparation/Preservation

Detailed discussions of the individual sample handling procedures are given in the Appendix.

Sediment Core Samples - After collection, the ends of the sediment sampling tubes will be sealed with tape and that tube stored in and upright position. Tube sealing will be performed on the boat. Subsequent handling will be performed at the mobile command post or at a laboratory facility.

Grab samples will be subsectioned as appropriate and placed in containers while on the boat.

Water column samples will be filtered in the field and must be filtered within four hours of collection. These samples will be collected using clean, prepared sample bottles. The filtrate from each station will be collected in clean, prepared 4 liter bottles for shipment. The filter with suspended matter will also be placed in a jar for shipment. Additional containers for each station will be filled as needed for other analyses.

4.5.8 Transportation to Lab or Holding Facility

Once the samples are preserved, prepared, and packaged, they will be shipped to the proper location. In Zones I and II, most samples will be shipped via overnight courier. It will therefore be necessary to deliver these samples to the shipping office prior to their closing time, which will need to be determined beforehand. High resolution core samples will probably be transported by courier or subcontractor personnel to the Lamont-Doherty Geological Observatory.

4.6 Demobilization

The demobilization of the field equipment back to the warehouse will occur on an as-needed basis. Demobilization of the temporary storage facility will also be performed as soon as is practical so as to minimize the rental costs. If possible, items may be transferred to the mobile command post.

The process of demobilization includes cleaning and checking of all equipment and an inventorying of each returned item. All property which is defective will be reported to the TAMS Property Administrator. Finally, to conclude the project, the property will be logged into the warehouse facility.

Table 3-1

Summary of the Phase 2A Sampling Plan Analytical Program

Sediment Program [1]

Task	Number of Locations	Number of Samples per Core	PCB Congener Analysis	Total Carbon & Nitrogen Analysis
Confirmatory Sampling Sediment Cores & Grab Samples	100	1 - 8 [4]	-	250 - 300
High Resolution Sediment Coring	23 [3]	10 - 12	230 - 276	230 - 276
SEDIMENT TOTAL	123	-	230 - 276	480 - 576

Task	Total Organic Carbon Analysis [6]	Grain Size Distribution [10]	Radionuclide Analysis
Confirmatory Sampling Sediment Cores & Grab Samples	50	300 - 400	-
High Resolution Sediment Coring	230 - 276	230 - 276	230 - 276 [5]
SEDIMENT TOTAL	280 - 326	530 - 676	230 - 276

Water Column Program [2]

Task	Number of Transects	Number of Samples per Transect	Dissolved Phase PCB Congener Analysis	Suspended Matter PCB Congener Analysis
Water Column Monitoring				
- Field Filtered Samples	7	11 [8]	77	77
- Laboratory Filtered Samples	2 [7]	11 [8]	22	22
WATER COLUMN TOTAL	7	-	99 [11]	99 [11]

Task	Dissolved Organic Carbon Analysis [9]	Total Suspended Matter Analysis	Total Water Column PCB Analysis	Chlorophyll- A Analysis
Water Column Monitoring				
- Field Filtered Samples	77	77	77	77
- Laboratory Filtered Samples	22	22		
WATER COLUMN TOTAL	99	99	77 [12]	77

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Table 3-1 (cont.)

Summary of the Phase 2A Sampling Plan Analytical Program

Notes

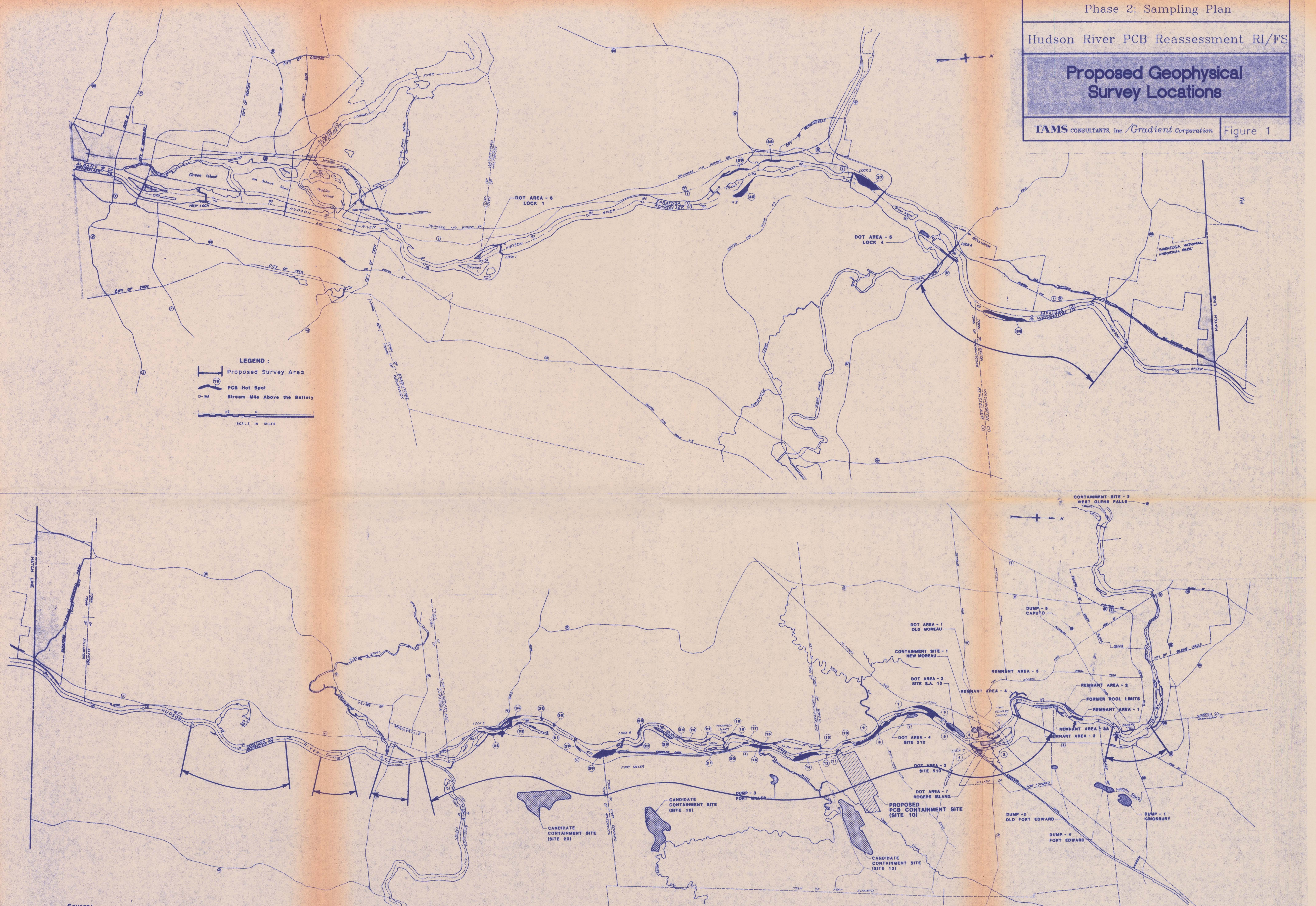
1. All sediment samples to be analyzed for redox potential in the field.
2. All water column stations to include field measurements of conductivity, temperature and pH.
3. Twelve locations to be placed in the Lower Hudson, eleven in the Upper Hudson.
4. Grab samples will generate 1 sample per location. Core samples wil generate 5 to 10 samples per core, one core per location. It is anticipated that 50% of the locations will yield sediment cores and 50% will yield grab samples.
5. Samples to be analyzed by Lamont-Doherty Geological Observatory for radionuclides, including cesium-137 (^{137}Cs), beryllium-7 (^{7}Be), and cobalt-60 (^{60}Co). See Appendix C.
6. Total organic carbon data to be obtained by a difference method, subtracting a total inorganic carbon measurement from a total carbon method. See Appendix C.
7. These represent duplicates of the the samples collected for the first low flow transect and the first high flow transect.
8. This total includes nine samples from the Upper Hudson, one from the Hoosic River and one background sample per transect.
9. These data will be obtained from two separate measurements of dissolved organic carbon, one based on a persulfate digestion and one based on a complete combustion of the sample. See Appendix C.
10. Grain size distribution will be measured twice for each sample using a sieve and a coulter counter or laser-based technique.
11. Samples derived from 20 liter aliquots.
12. Samples derived from one liter aliquots.

Phase 2: Sampling Plan

Hudson River PCB Reassessment RI/FS

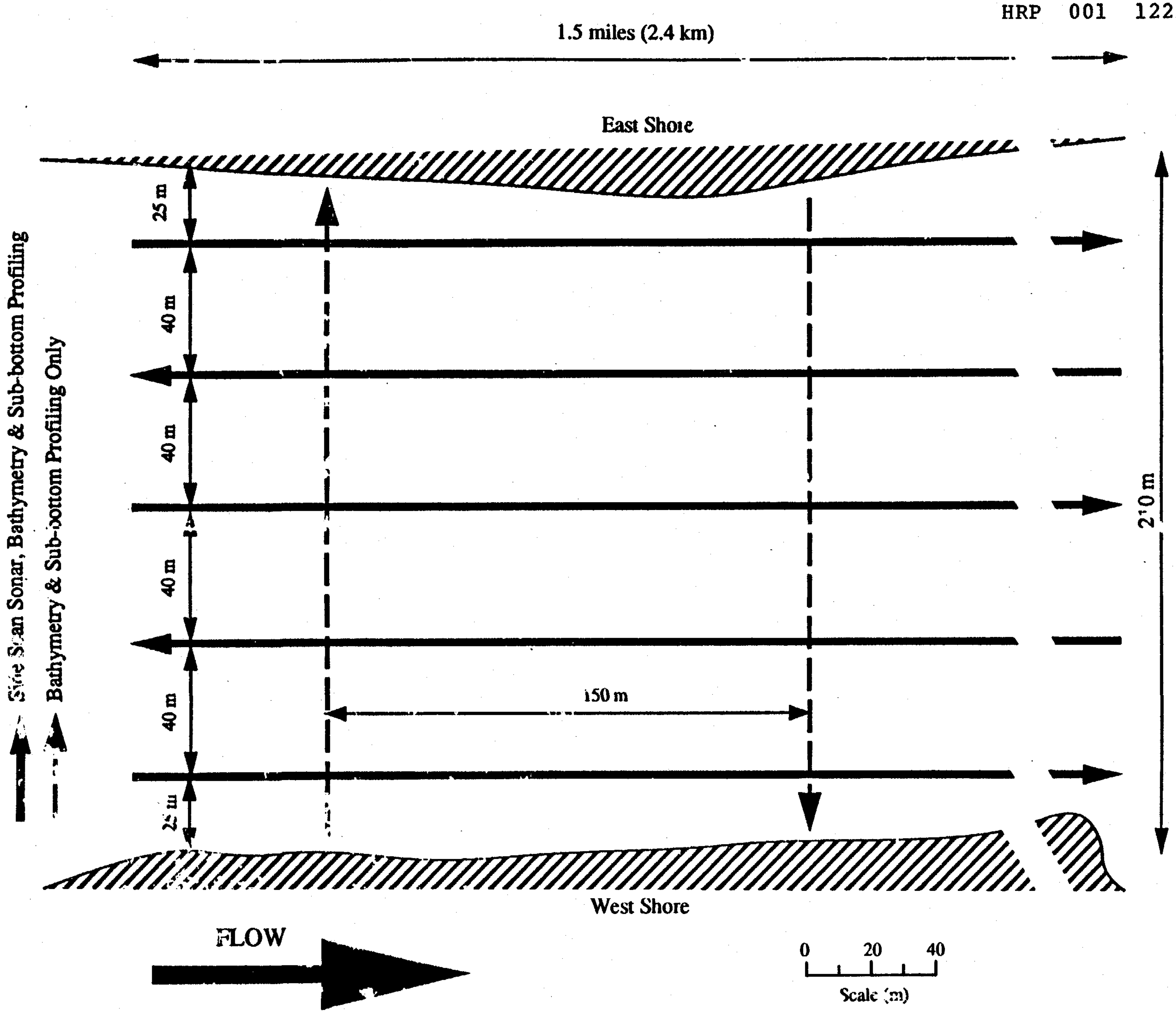
Proposed Geophysical Survey Locations

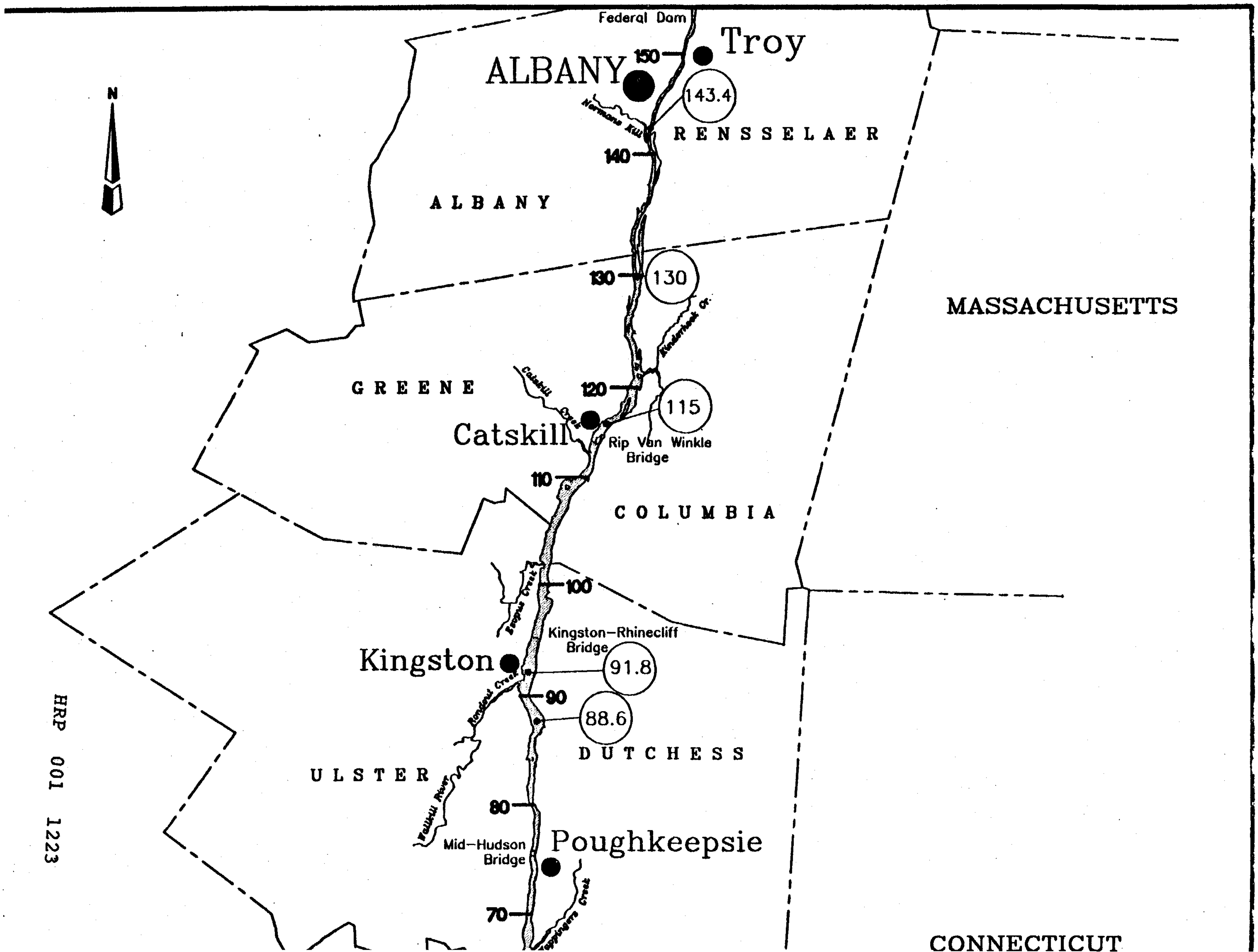
TAMS Consultants, Inc./Gradient Corporation | Figure 1

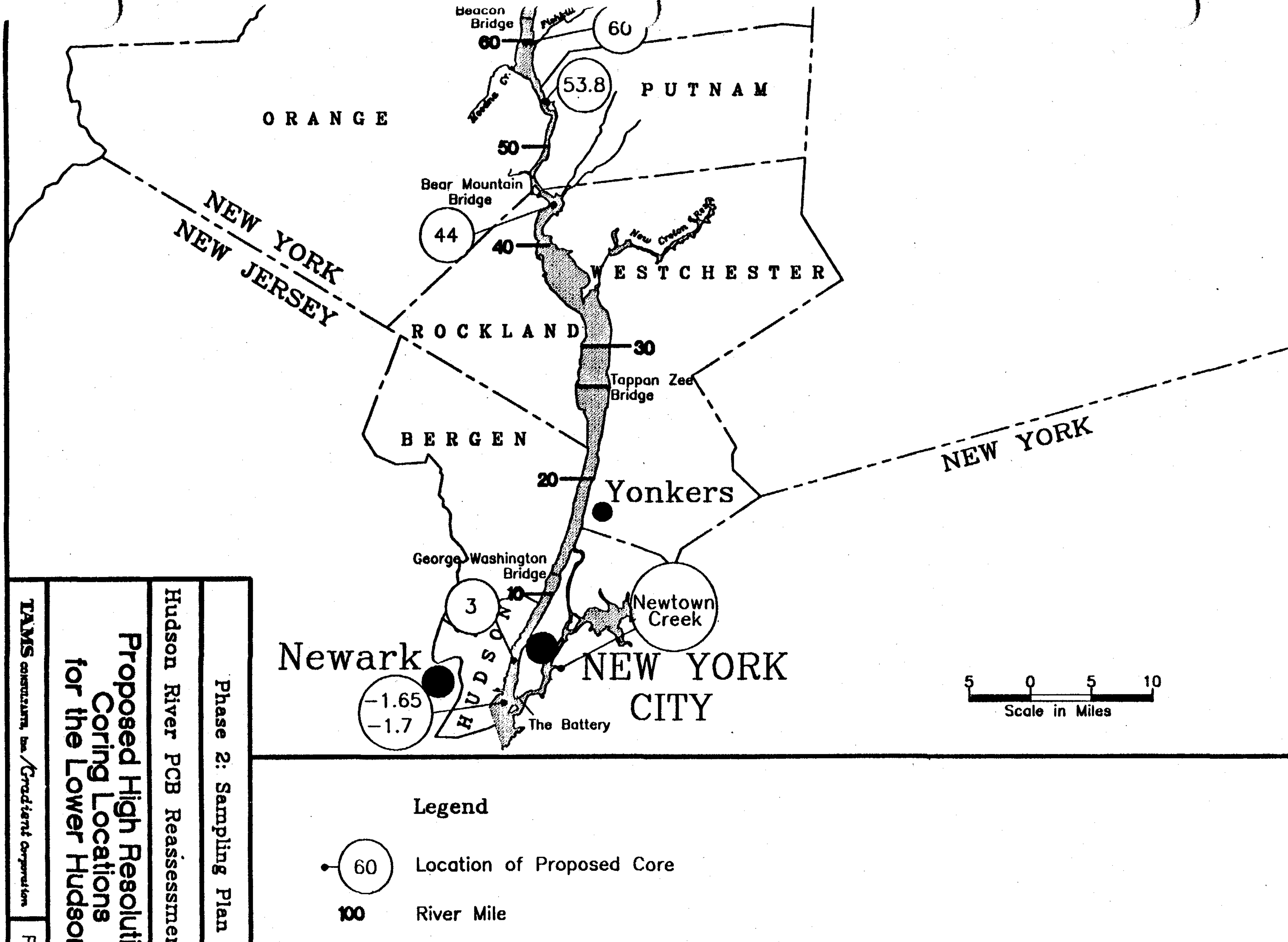


Source:
MALCOLM PIRNIE, INC.

Figure 2
Schematic of Proposed Geophysical Survey Grid




Federal Dam
Troy
ALBANY
150
143.4
Normans Kill
RENSSELAER
140
ALBANY
130
130
MASSACHUSETTS
Kinderhook Cr.
Catskill Creek
GREENE
120
115
Catskill
Rip Van Winkle
Bridge
110
COLUMBIA
100
Esopus Creek
Kingston-Rhinecliff
Bridge
Kingston
91.8
Rondout Creek
90
88.6
DUTCHESS
ULSTER
Wallkill River
80
Mid-Hudson
Bridge
Poughkeepsie
70
Wappingers Creek
CONNECTICUT



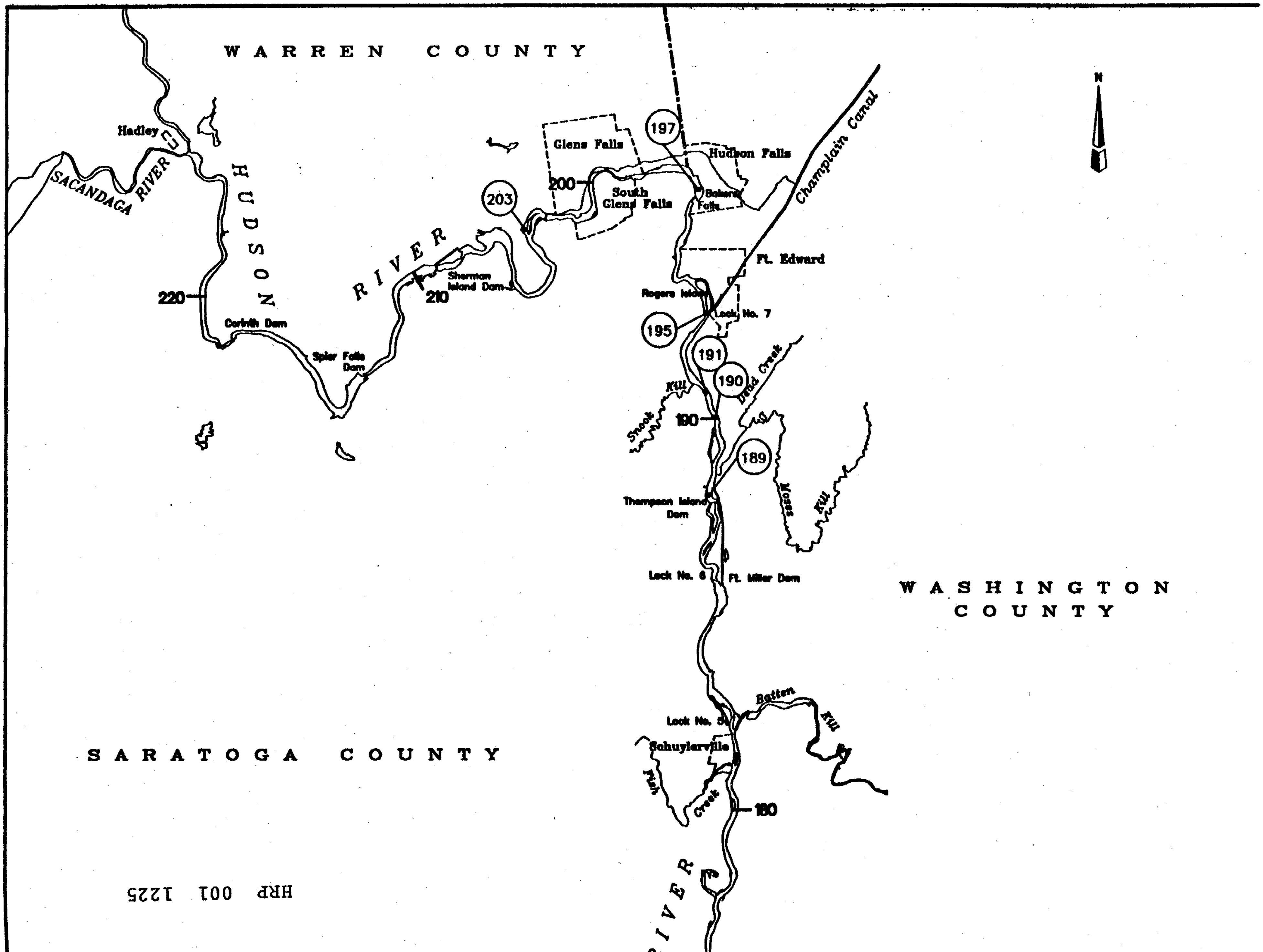
Phase 2: Sampling Plan

Hudson River PCB Reassessment RI/FS

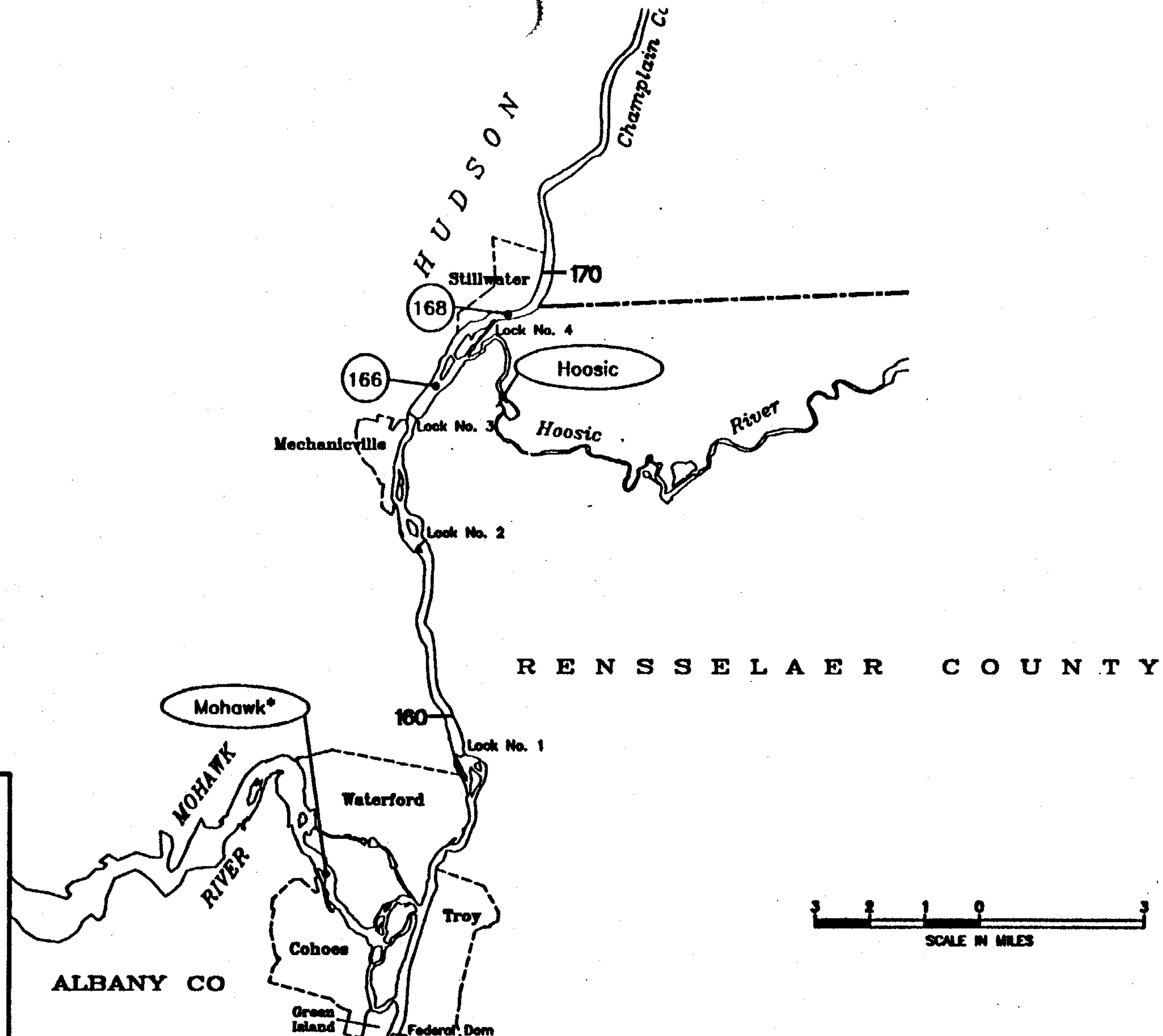
Proposed High Resolution Coring Locations for the Lower Hudson

TAMS Consultants, Inc./Gradient Corporation

Figure 3



WARREN COUNTY
N
Hadley
SACANDAGA RIVER
HUDSON
RIVER
220
Corinth Dam
Spier Falls Dam
210
Sherman Island Dam
203
Glens Falls
200
South Glens Falls
197
Hudson Falls
Bakers Falls
Champlain Canal
Ft. Edward
Rogers Island
Lock No. 7
195
191
190
Dead Creek
Snook Kill
190
189
Moses Kill
Thompson Island Dam
Lock No. 6
Ft. Miller Dam
WASHINGTON COUNTY
Batten Kill
Lock No. 5
Schuylerville
Fish Creek
180
RIVER
SARATOGA COUNTY



Legend

(188) Location of Proposed Core

180 River Mile

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* Note: Mohawk has two proposed core locations near this point.

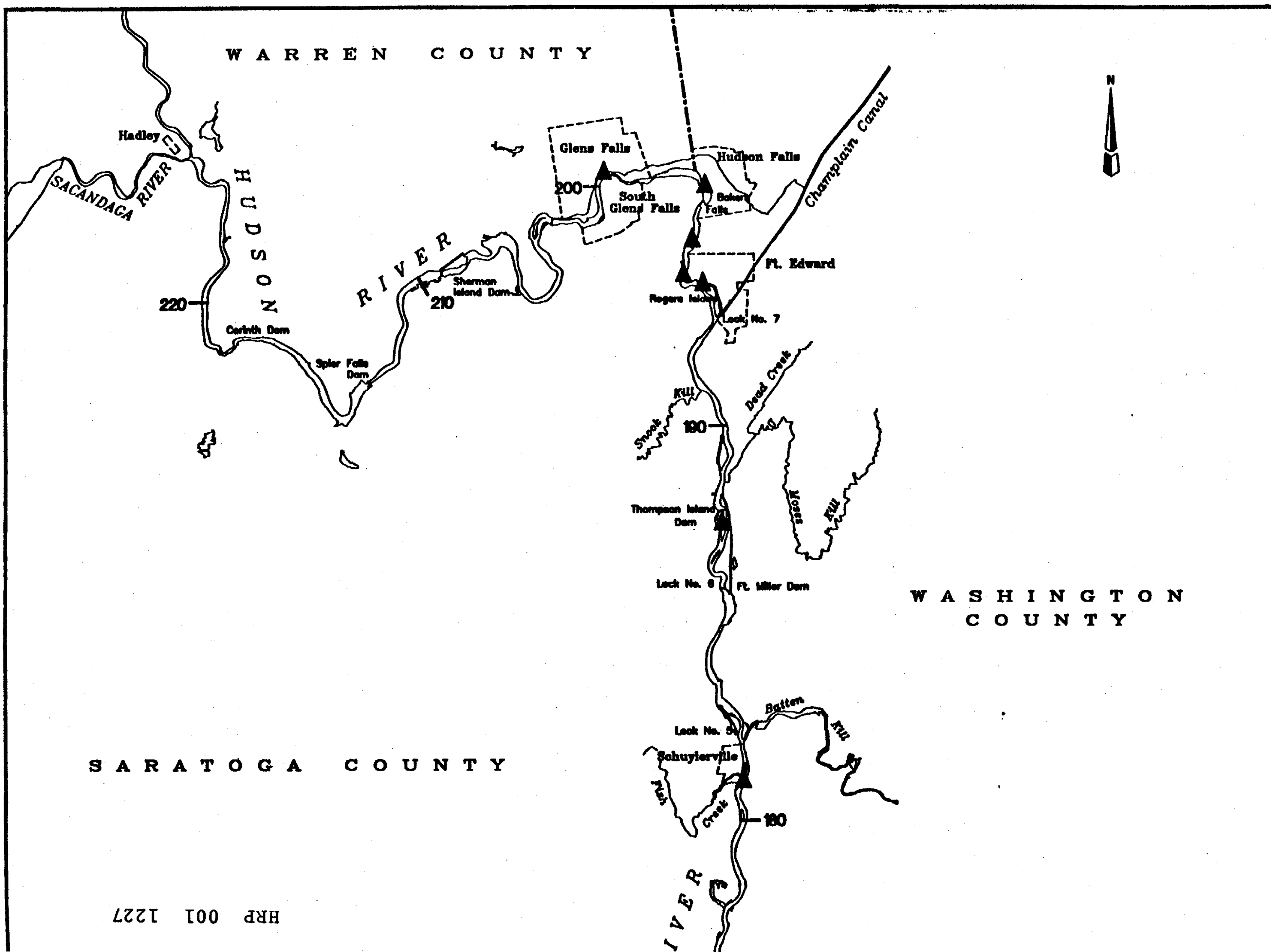
Phase 2: Sampling Plan

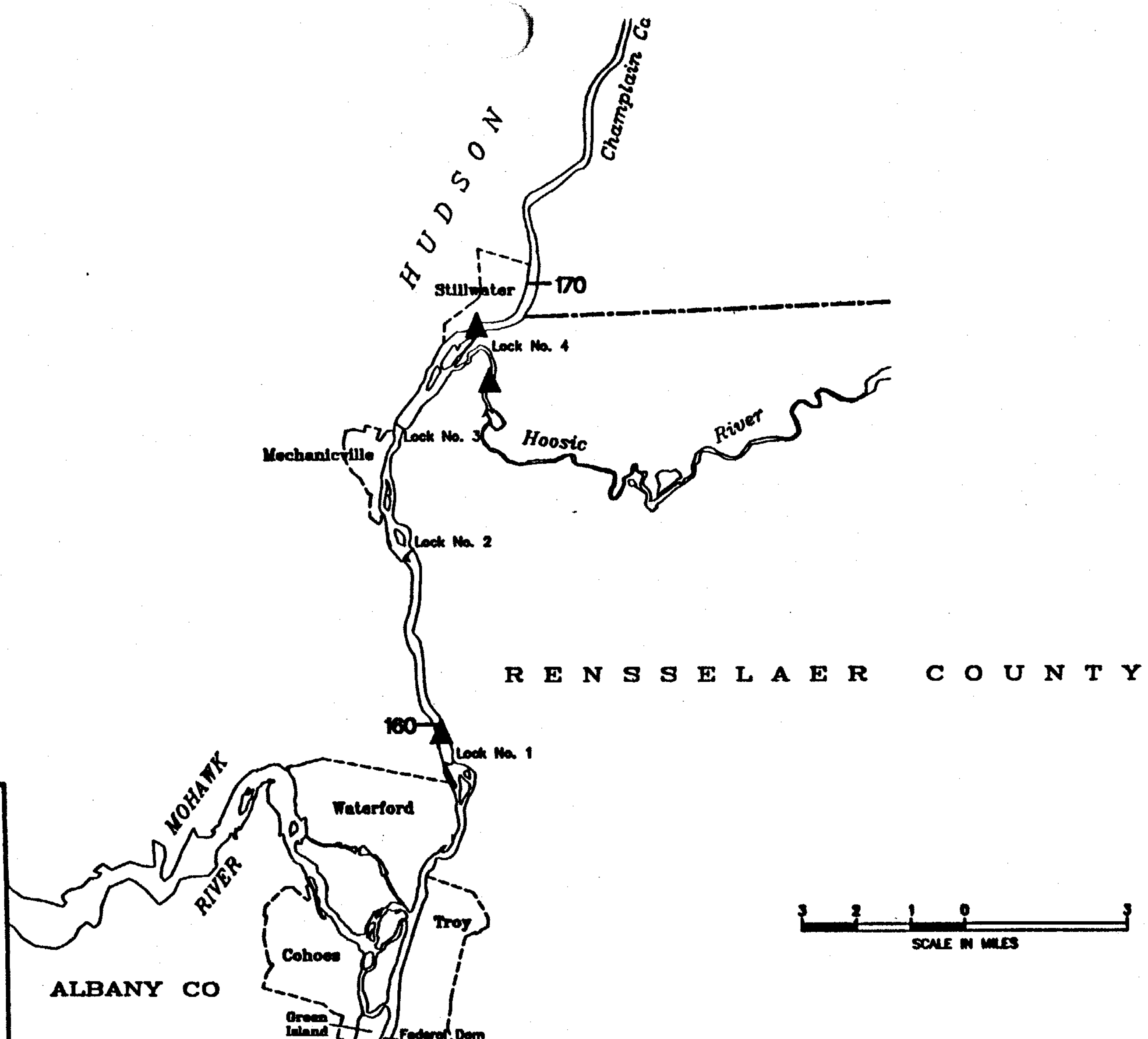
Hudson River PCB Reassessment RI/FS

Proposed High Resolution Coring Locations for the Upper Hudson

TAMS Consultants, Inc./Gradient Corporation

Figure 4


WARREN COUNTY
N
Hadley
SACANDAGA RIVER
HUDSON
RIVER
Glens Falls
Hudson Falls
Champlain Canal
200
South Glens Falls
Baker Falls
Ft. Edward
Sherman Island Dam
210
220
Rogers Island
Lock No. 7
Corinth Dam
Spier Falls Dam
Dead Creek
Snook Kill
190
Moses Kill
Thompson Island Dam
Lock No. 6
Ft. Miller Dam
WASHINGTON COUNTY
Batten Kill
Lock No. 5
Schuylerville
SARATOGA COUNTY
Fish Creek
180
RIVER



Legend

▲ Proposed Water Monitoring Station

180 River Mile

Phase 2: Sampling Plan

Hudson River PCB Reassessment RI/FS

Proposed Water Quality Monitoring Stations

TAMS CONSULTANTS, Inc./Gradient Corporation

Figure 5

HRP 001 1228

APPENDIX A

GEOPHYSICAL SURVEY METHODOLOGY

AND DEMONSTRATION

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A-1 GEOPHYSICAL MEASUREMENT METHODOLOGY

1.0 SIDE SCAN SONAR BATHYMETRY, AND SUB-BOTTOM PROFILING

The side scan sonar, bathymetry and sub-bottom profile surveys will require the use of the following equipment in the field.

1. Dual frequency side scan sonar unit (100 and 500 khz).

2. Digital or analog signal tape recorder.

3. Short pulse, single frequency echosounder.

4. Short pulse, single frequency sub-bottom profiler.

5. Miniranger or equivalent navigational system.

6. Shallow draft boat (< 2 ft.).

The equipment shall be used under the following guidelines to ensure correct measurements and to minimize processing time after the data has been collected.

1. All sonar signals shall be recorded on a digital or analog signal tape recorder capable of being replayed in the field so as to ensure proper data storage and to confirm initial hard copy output. The signal shall be replayable with slant-range and ship speed corrections applied.

2. A real time hard copy output will be generated continuously during the operation of the sonar units. Both the hard copy and tape recording will have the time-of-day recorded electronically.

3. The surveys will cover the river bottom at a high resolution scale, roughly a 75 m path at approximately three to four mph over the river bottom to ensure equality of the along-track and cross-track scales.

4. The side scan sonar and the single frequency equipment will be operated synchronously to avoid interferences in sonar signals.

5. Navigation must be precise to one meter nominal, based on surveyed landmarks and must be recorded via electronic media in sync with the sonar recordings at a frequency of at least one per minute.

6. Combined side scan sonar, echo sounder and sub-bottom profiler operations will be performed on measurement tracks separated by roughly 40 m, run parallel to the direction of flow. This approach will generate 150% of the river

bottom and ensure complete coverage of the river bottom by the side scan sonar technique. The near shore tracks will lie within 25 m of the shoreline where possible to ensure complete coverage to shore.

7. Additional echo sounder and sub-bottom profiler tracks will be completed perpendicular to the direction of river flow about 150 m apart. The combined parallel and perpendicular tracks will generate a wire-net of coverage of the river bottom.

Upon completion of these surveys, the data will be manipulated via computer to generate one or more maps of river bottom topography, sediment textures, and related features.

A-2 SIDE-SCAN SONAR AND

200 kHz SUB-BOTTOM PROFILER DEMONSTRATION

Side-Scan Sonar and 200 kHz Subbottom Profiler Demonstration
Thompson Island Pool -- May 4 and 10, 1991

Survey Report and Initial Data Interpretation

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State University of New York
Stony Brook, New York 11794-5000
(516) 632-6971/8700

May 28, 1991

Introduction

An exploratory side-scan sonar survey was conducted in the Thompson Island Pool of the Hudson River (Figure 1) on May 4, 1991, at the request of TAMS Consultants, Inc., to determine the nature of features present on the bottom of the Thompson Island Pool. In addition, the survey allowed us to evaluate the potential for side-scan sonar to classify sediment and to aid in the determination of PCB distribution patterns in bottom sediments. One of the prime interests was to understand some of the underlying reasons for the apparent extreme variability in sediment type and PCB distribution patterns within the Thompson Island Pool and to use our understanding of sediment process to provide an independent estimate of the resuspension potential and dredgability of bottom sediments.

A test of a 200 kHz short-pulse echosounding system was carried out on May 10, 1991, to determine the possible utility of such a system in determining the presence and thickness of fine-grained sediments in the region of the Thompson Island Pool.

The objective of this report is to briefly summarize the kinds of sonar targets observed in this portion of the river, the overall distribution of those targets, and to provide an initial interpretation of sedimentation processes as they may affect PCB distribution patterns and sediment erodibility. We stress that these data have been in hand for only about three weeks, and that our statements here are thus only preliminary, subject to revision, and designed to provoke discussion into the underlying causes of sediment and PCB variability in the study area. Our final interpretation of the sonar data and a more complete discussion of these topics will need to await the availability of high resolution data from all sections of the study area.

Personnel: Roger Flood, MSRC, party chief
Bret Zielenski, MSRC, boat captain
Patricia Manley, Middlebury College
Ed Garvey, TAMS
Richard Bopp, NY DEC
Jang-Geun Park, MSRC
Rob Pedersen, Middlebury College

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Methods

The Middlebury College Klein 595 dual-frequency (100 kHz and 500 kHz) side-scan sonar was towed twice along the length of the Thompson Island Pool from Ft. Edward to the Thompson Island Dam providing almost complete coverage of the bottom at a swath width of 75 m/side (about 1"=60'). In addition, one section of the river was surveyed at a swath width of 50 m/side and 35 m/side (Figure 1). The higher resolution, narrower swath data gave a much clearer picture of the nature of the river-bottom morphology, while the wider swath, lower resolution data allowed us to estimate distribution of different kinds of river-bottom morphologies along the length of the study area. The primary survey navigation was by reference to the navigation buoys placed along the channel. Loran C navigation data were also recorded along the survey track; however, these fixes are not precise to better than about 100' or more and are only useful for general navigation.

The sonar survey was done on May 4, 1991, from a 24' open boat brought to the area from MSRC. The sonar fish was towed at a depth of about 6 feet during the first pass along the river, but the fish hit the bottom several times and the tail fins were lost. Temporary fins were rigged for the second run when the fish was towed at a depth of about 2 feet. We recommend the shallower tow depth for future surveying. The side-scan sonar returns were recorded in two ways. First, the 17" wide paper records (with the two frequencies displayed side-by-side) are the primary data that has been used for all interpretations to date. In addition, the analog signals (100 kHz and 500 kHz, port and starboard, along with synchronization signals) were recorded on an Hewlett-Packard 8-track instrumentation tape recorder to permit later replay and a more quantitative analysis of the dual-frequency sonar data.

The 200 kHz short-pulse echosounder was provided by R. Flood at MSRC. It is a commercial system whose pulse has been shortened to about 5 cm. Such a system will show layering in fine-grained sediments, but cannot penetrate coarse sediments. The system was tested primarily in the region of the river where the higher resolution sonar data was collected.

Eight sediment samples were taken with a grab sampler within the sonar area in order to develop an initial understanding of the relationship between sediment texture and reflectivity on the sonar record. The sampled sediments were returned to the river following on-board description. In addition, Richard Bopp, NY DEC, collected four push-core samples of river bed sediments for analysis.

Analysis of Sonar Targets

The side-scan sonar data have been interpreted in a multi-step process to provide preliminary insights into the nature of sediment processes and variability within the study area and to make preliminary interpretations with respect to possible PCB distribution patterns and the potential for resuspension. The steps involved in sonar interpretation include the following: (1) Sketching the survey track on the five bathymetric/PCB survey maps presented in Brown et al. (1988) on the basis of studies undertaken in 1984. (2) Characterizing the reflection patterns in the region of the detailed, higher resolution study area near buoys 214, 215 and 216. (3) Characterizing the lower resolution data collected along the length of the Thompson Island Pool and undertaking a first-order mapping of sonar targets on the bathymetric/PCB inventory maps of Brown et al. (1988) paying particular attention to the distribution of sonar targets with respect to sediment types and bathymetric features. (4) Interpreting the sonar distribution patterns with respect to PCB distribution patterns mapped in 1984 and providing some preliminary discussions as to possible factors to be considered in assessing sediment dredgability and the potential for resuspension. In characterizing sonar targets we paid particular attention to sediment reflectivity at both 100 kHz and 500 kHz because by using data at two different frequencies we can begin to remotely classify sediment types. Only the 100 kHz records are shown here because those images often provide the clearest indication of sediment morphology.

Targets near River Mile 192.5 -- Higher Resolution Survey

As noted above, high resolution side-scan sonar records in the vicinity of buoys 214, 215 and 216 (near river mile 192.5; 1977 hot-spot number 6) allowed us to determine the kinds of sediment morphology within this region of the river. These data show that the river bottom here can be divided into at least 5 regions based on the sonar data (Figure 2).

On the western bank, within about 20 m of the shore line, the sonar shows a relatively uniformly reflective province that is usually moderately reflective on 100 kHz but poorly reflective on 500 kHz sonar records (pattern 1; Figure 3), but can sometimes be less reflective on 100 kHz as well. Echo sounding records in these areas show that the bottom is smoothly varying while our grab samples here and in a similar province off the eastern shore suggest that surficial samples are fine-grained in this region. Also characteristic of this region are submerged tree branches and logs as well as occasional larger targets without sediment tails, especially in the deeper-water portions of this sonar field.

At a distance of 20 to 50 m from the west bank, a portion of the river bottom is characterized by rock layers that crop out on the river bottom apparently with sediment ponds within the rock outcrops (pattern 2; Figure 3). In this and other rocky areas, rock units extend several feet above the surrounding river bottom giving rise to pronounced sonar shadows. The rock outcrops are in general characterized by numerous, short, parallel reflections that are highly reflective at 100 kHz but only moderately reflective at 500 kHz. Because the Hudson River below Ft. Edward has been dredged as part of the Champlain Canal, and rock outcrops are not unexpected. The rocks underlying the river can be observed in outcrop along the river banks and along Route 4 adjacent to the river. These exposed rocks are shales that appear to have been extensively fractured such that individual fragments are about 1 to 10 cm long and up to 1 to 2 cm thick. Occasional thicker sand units are present within the shale beds. Where observed throughout this stretch of the river, rock outcrops are often associated with shallower ridges on the bathymetric map that trend roughly northeast-southwest. Many samples recovered from the rivers show gravel-sized material. Based on our limited sampling, we suggest that much of the gravel-sized sediment are fragments of these shales which have come from the submerged outcrops. Based on existing sediment samples as summarized on maps supplied by TAMS, the sediment ponds amongst the rock outcrops appear to be filled with gravel, fine sand and clay.

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At a distance of 50 to 100 m from the west bank, but still west of the channel and overlapping to some extent with the rock outcrops and sediment ponds described in pattern 2, is a field characterized by isolated, higher-reflectivity targets ranging from about 1 to 4 m in diameter that are either rock outcrops or large, isolated rocks (pattern 3; Figure 4). Sediment tails appear to be located directly downstream from these targets. Such sediment tails created when mobile sediments are trapped in the low-flow region in the wake of an obstacle. Sediment types reported from this region show a mixture of gravel, coarse sand, coarse sand with wood chips, and fine sand; however, the precise distribution of sediments in the tails is not known. A similar pattern is recorded in many other regions of the river, but the intensity of sediment tails seems to vary from area to area.

In the deepest portion of the channel, a 50 m wide portion of the river bottom is characterized by a series of well-defined linear grooves trending along the river that echosounding records suggest range from about 0.25 to 1 ft. deep (pattern 4; Figure 5). Sediments associated with these grooves are moderately reflective at both 100 and 500 kHz. A sediment sample from the western portion of this province recovered gravel while a sample from the eastern portion recovered coarse sand with wood chips; however, lateral sediment variability across individual grooves has not been studied. Towards the western side of the province, the grooves become less common where the cross-stream bottom slope becomes steeper, but the bottom has the same overall reflectivity pattern suggesting similar sediment types.

The sonar record collected along the eastern shore here (Figure 6) is quite similar to that from the western shore (Figure 3) with a relatively smooth sediment present within 10 to 20 m of the shore. A sediment sample from near the pipe (an old dock support) shows that this region contains fine-grained sediments.

The high resolution 200 kHz profile collected within this detailed study area did not resolve many subbottom targets. This is thought to result from the general coarse nature of the sediments within the region and the fact that coarse sediments and gassy sediments rapidly attenuate signals at 200 kHz. However, in one region along the eastern bank, a reflection pattern was observed that appears to indicate the presence of fine-grained sediments up to about 1 ft. thick filling in a depression in the more reflective underlying sediments (Figure 7). The lack of similar reflection patterns in areas of the detailed transect is not understood; however, gain settings may have been different during that segment of the profiling or sediment attenuation may have been higher due to gas.

Targets observed during Lower Resolution Survey

By comparing the higher and lower resolution sonar records, we observe that some of the targets clearly identified on the higher resolution records are only poorly characterized on the lower resolution records. In particular, the sediment tail province shows up on the lower resolution records as a somewhat indistinct region of strong reflectors (the obstacles) with the tails only occasionally visible. Also, there appears to be some variability in the size and nature of the obstacles, and in the sediments between the obstacles, from area to area. Other provinces, including the large grooves and the rock outcrops appear to fairly well resolved although detailed correlations between the different records have not been made. However, we can use the insights gained during the higher resolution survey to infer sediment morphology throughout other portions of the river where only lower resolution records are available.

In determining sediment morphology in the remainder of the river, we can identify at least 2 additional major reflection patterns and numerous minor patterns. Downstream of the detailed study area described above, much of the channel floor is characterized by a lineation pattern (pattern 5) that is less well developed than the channel-floor lineations described in pattern 4 above (Figure 8). These sediments appear to be less reflective at both 100 and 500 kHz than the sediments associated with pattern 4. Pattern 6 is only found near where Moses Kill enters the Hudson River immediately above the Thompson Island Dam (hot spot 16). This fan-shaped sediment deposit is characterized by moderate reflectivity at 100 kHz, very weak reflectivity at 500 kHz as well as by an abundance of trees, logs and/or other large targets (Figure 8). This pattern may be related to pattern 3 (obstacles and sediment tails); however, sediment tails are not clearly observed in this region and the 500 kHz profile shows much lower reflectivity than is typical of pattern 3. Based on our observations, Moses Kill appears to add fine-grained sediments to the Hudson River that may quickly associate with PCBs present in the water column.

Several sonar patterns were only occasionally observed. These patterns include sediments that are poorly reflective at both 100 kHz and 500 kHz that appear to be most commonly found in some of the deeper depressions present in the river. Such sediments may be related to those associated with the more lineated pattern 5. Based on a preliminary correlation with available sediment texture data, these less reflective sediments appear to be finer-grained sands without gravel. Tree trunks and logs are imaged in many reaches of the lake including both near the shallow edges of the river and in the deeper portions where the wood must be water-logged.

Generalized Relationships between Sonar Targets and PCB Contaminant Loadings

The generalized distribution patterns of the major sonar echo types have been mapped out in order to provide some insights into possible relationships between imaged river-bottom morphology and PCB distribution patterns and variability, and sediment type and variability. These studies show that the deepest portion of the river bed is often characterized by a lineated topography; however, the largest lineations are only found north of river mile 192.4. The field of large lineations appears to be terminated by a rock outcrop that effectively blocks the transport of coarser sediments downstream in the river bed at this point. Rock outcrops cross the channel in other regions, and the topography associated with those outcrops may play a role in interrupting transport of some materials down river. It is interesting to note that the only place where a hot spot identified in 1977 crossed the river bed was upstream of river mile 192.4 where the rock outcrop may have restricted bedload transport. In several areas, occasionally high PCB contaminant loadings are reported from regions characterized by rock outcrops. These sediment samples most likely come from the pockets of sediment that occur within the outcrop areas. Samplers often report that some probing is needed in order to recover sediments from many areas of the river. We suggest that the presence of these outcrops and sediment pockets is one of the reasons for this variability.

Sonar pattern 3 (obstacles with common tails) dominates much of the channel margins offshore from the finer-grained surficial sediments that characterize the river edges. Thus most of the 1977 hot spots, which are typically found near the river banks, appear to be developed within this kind of setting. For example, the large hot spot along the eastern margin of the river at river mile 190 is developed in this kind of province (Figure 9). This is 1977 hot spot 14 which was thought to contain 33% of the total hot-spot PCB mass. Brown et al. (1988) confirm the existence of elevated levels, and suggest that this is one of the areas with the greatest potential for PCB resuspension during a 100-year flood. As noted above, a distinctive sediment deposit somewhat similar to sonar pattern 3 occurs off Moses Kill (Figure 8) that appears to contain significant quantities of PCBs. Clearly sediment character and processes within this kind of region need to be better understood in order to determine the reasons for this large PCB accumulation and the likelihood of resuspension during an unusual flow event.

Variability of Sediment Types and PCB Loadings, Potential for Sediment Resuspension, and Potential Dredgability

Many of the targets identified suggest that sedimentation processes may be a major cause of variability in sediment type and perhaps in PCB contamination. Table 1 represents a preliminary attempt to provide estimates of PCB loadings (based on the general correlation between sediment morphology and PCB analyses reported by Brown et al., 1988) and qualitative estimates of the probable potential for sediment resuspension based only on sediment morphology. These predictions will be revised as additional data become available. While variability in sediment texture seems reasonable to predict, variability in PCB concentrations and inventories are a bit more difficult to predict particularly since there does not appear to be a consistent relationship between sediment type and PCB inventories. However, one can hypothesize that different sediment fractions, with different PCB loadings (perhaps due to the initial position of those sediments, including wood chips, behind the Ft. Edward dam), may be present in different portions of the river bed and in association with the sediment features.

The processes that deposit sediments between obstacles, often creating sediment tails behind those obstacles, and that fill in depressions in rock outcrops are all likely to create variability in sediment texture with potentially high PCB loadings. This may be true because of possible rapid sediment accumulation in such areas following the removal of the Ft. Edward dam in 1973 by sediments that may have high PCB concentrations. Once deposited, the contaminated sediments within the rock outcrop regions may be somewhat difficult to resuspend because of their possible protected depositional sites. Contaminated sediments associated with obstacles and possible sediment tails on the channel margins might be somewhat easier to resuspend, especially if the obstacles could be moved by strong current flows.

Sediments associated with grooved sediments in the channel floor generally appear to have relatively low PCB loadings. However, we expect that these sediments have been and will continue to be relatively easily reworked by bottom flows. Thus the potential for sediment resuspension is high.

Fine-grained, reflective sediments along the margin are thought to have relatively high PCB loadings; however these sediments appear to have been poorly sampled during 1984. We expect that these fine-grained sediments can be resuspended relatively easily, especially if the numerous tree trunks present in this area are dragged along the bottom by strong currents.

The dredgability of contaminated sediments depends in part on their thickness as well as on sediment properties. Unfortunately, little can be said here about sediment thickness except to note that in many areas, moderately contaminated sediments appear to be located within sediment pools in rock outcrops and be associated with larger obstacles that may be isolated rock outcrops or tree trunks. In addition to attempting to measure sediment thickness using acoustic and/or sediment sampling techniques, the dredging history of the Hudson River, including dredging done when the present canal was created and enlarged as well as more recent dredging to remove contaminated sediments or to remove navigation hazards, should be compiled. This information may provide information

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on the maximum river depth, and thus the maximum potential sediment thickness that exists in these areas.

Summary and Conclusions

This dual-frequency side-scan sonar study of sediment morphology in the Thompson Island Pool of the Hudson River clearly demonstrates that there is extreme sediment variability associated with the distribution of bedrock, along and across-river variations in sedimentation processes and variations in sedimentation patterns associated with each sediment tail, groove, or pocket. The study also demonstrates that the side-scan sonar technique, especially when two frequencies are used, can provide information essential to the understanding of sediment and contaminant distributions. We expect that detailed sediment sampling in conjunction with detailed sonar surveying would reveal relationships between sediment type and morphology that are more understandable and predictable than the sediment distribution patterns based only on scattered sampling.

Using data presently available, one can begin to understand potential processes that have resulted in the observed variability and to develop a rational for predicting the distribution of sediment types, potential PCB contaminant loadings, and potential for resuspension. The actual predictions presented in this brief report are only preliminary, and have been made in part to demonstrate some of the reasoning processes to be considered when attempting to use data on sediment morphology to address some of the problems in this important area. Clearly, additional data will be needed before any final conclusions can be drawn as to the nature or significance of any particular sonar target, the processes responsible for the formation of that target, the likely PCB loadings, the potential for sediment resuspension, or factors to be considered in order to dredge the sediments.

Reference

Brown, M.P., Werner, M.B., Carusone, C.R. and Klein, M., 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River. Final report of the Hudson River Reclamation Demonstration Project Sediment Survey. New York State Department of Environmental Conservation, Albany, New York. 92pp.

TABLE 1

Sonar Patterns, Probable PCB Loadings, and Potential for Resuspension

May 28, 1991

Classification	**PCB loading**	**Probable Potential for Resuspension**
rock outcrops	low	low
sediment pockets in outcrops	high	low - moderate
obstacles, often with tails, on channel margin	high	moderate - high, esp. if obstacle is moved
elongate grooves in channel axis	low - moderate	high
smooth sediment with variations in reflectivity sediments on channel margin	low - high	moderate - high
tree trunks, branches on channel margin and in channel	low?	high? (moving tree trunk can stir up sediment)

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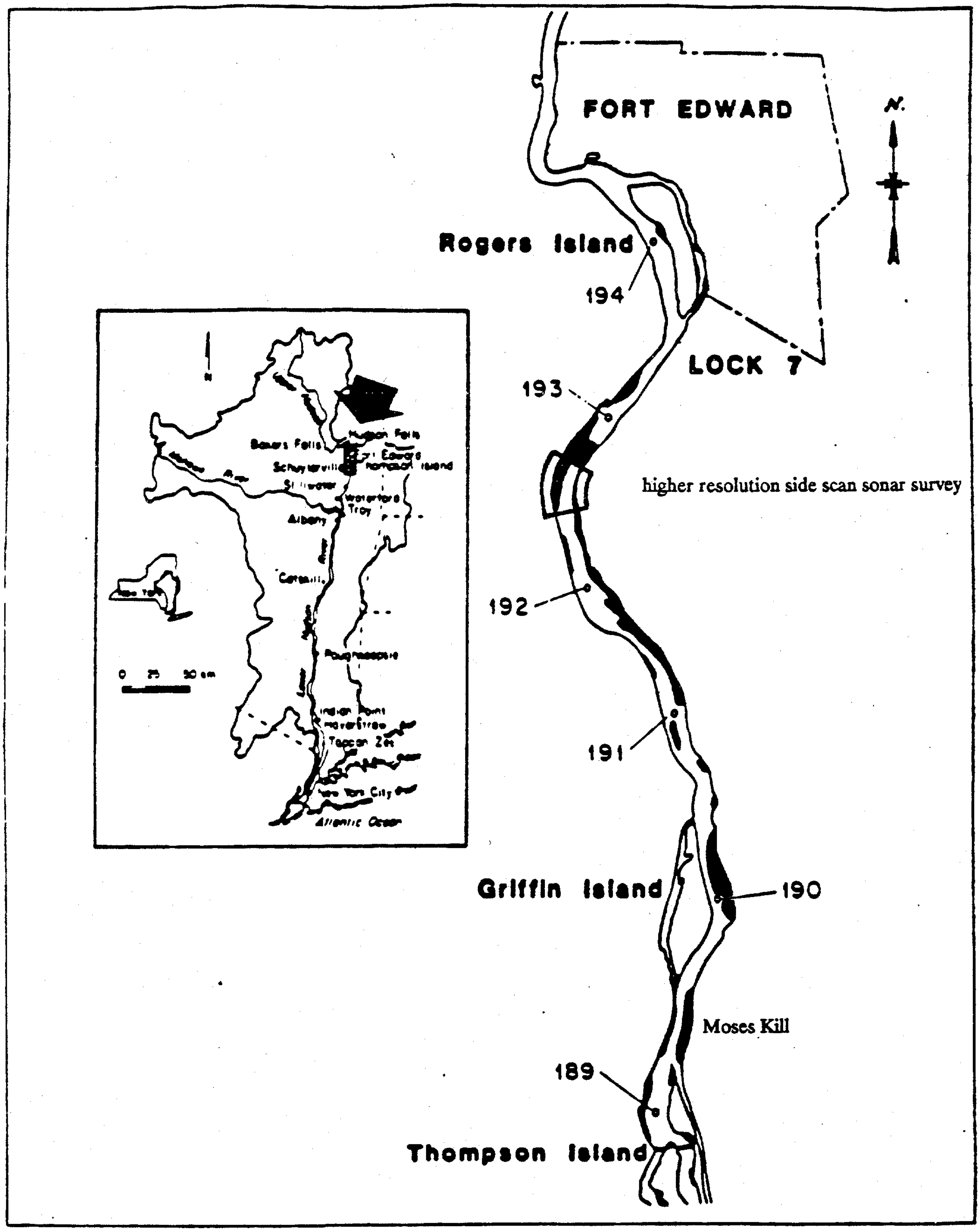

Figure 1. Thompson Island Pool and PCB hot spots as delineated by the 1976-1977 sediment survey (From Brown et al., 1988). Also shown are river miles (measured from the Battery) and the location of the higher resolution side scan sonar survey.

HRP 001 1242

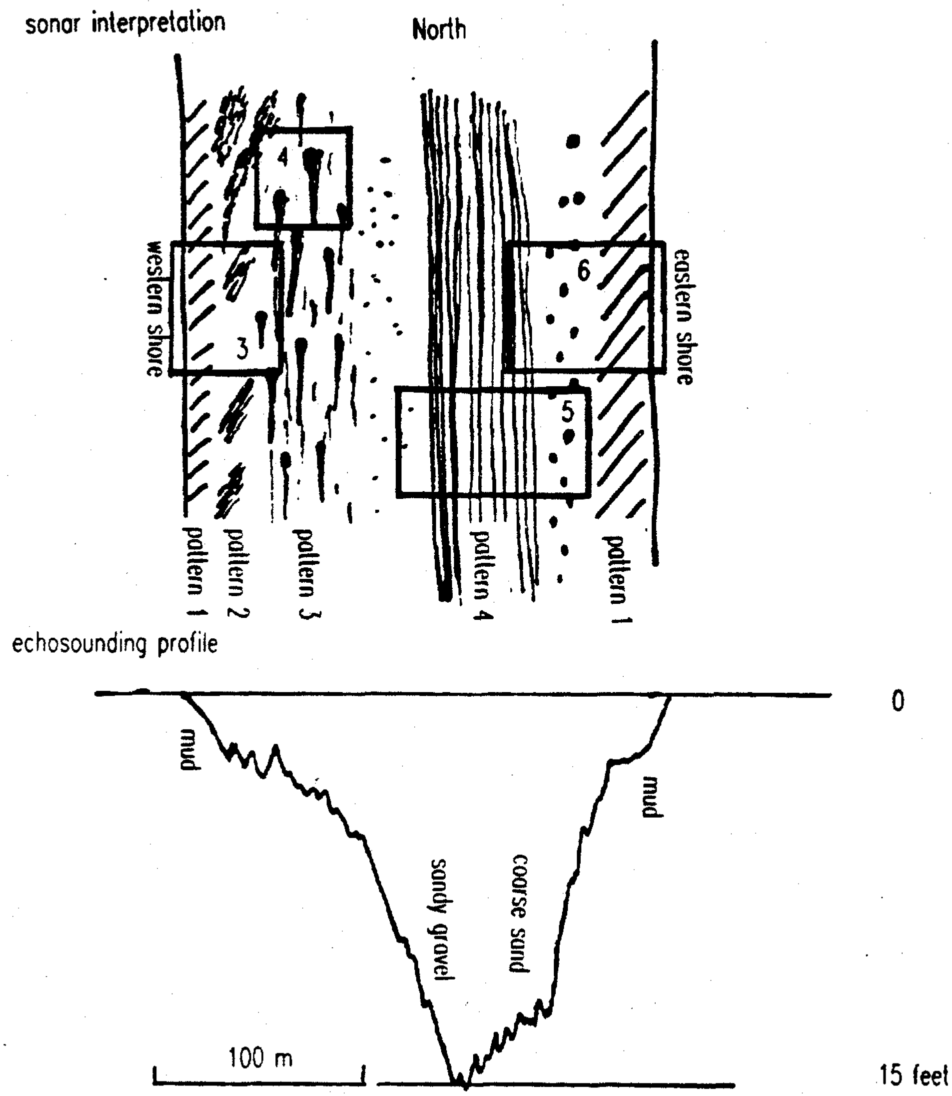

Figure 2. upper: Sketch map showing the locations of side-scan sonar targets within the higher resolution side-scan sonar study at river mile 192.5. Approximate locations of Figures 3, 4, 5 and 6 are also shown. lower: sketch of bathymetric profile showing sediment types recovered by a grab sampler.

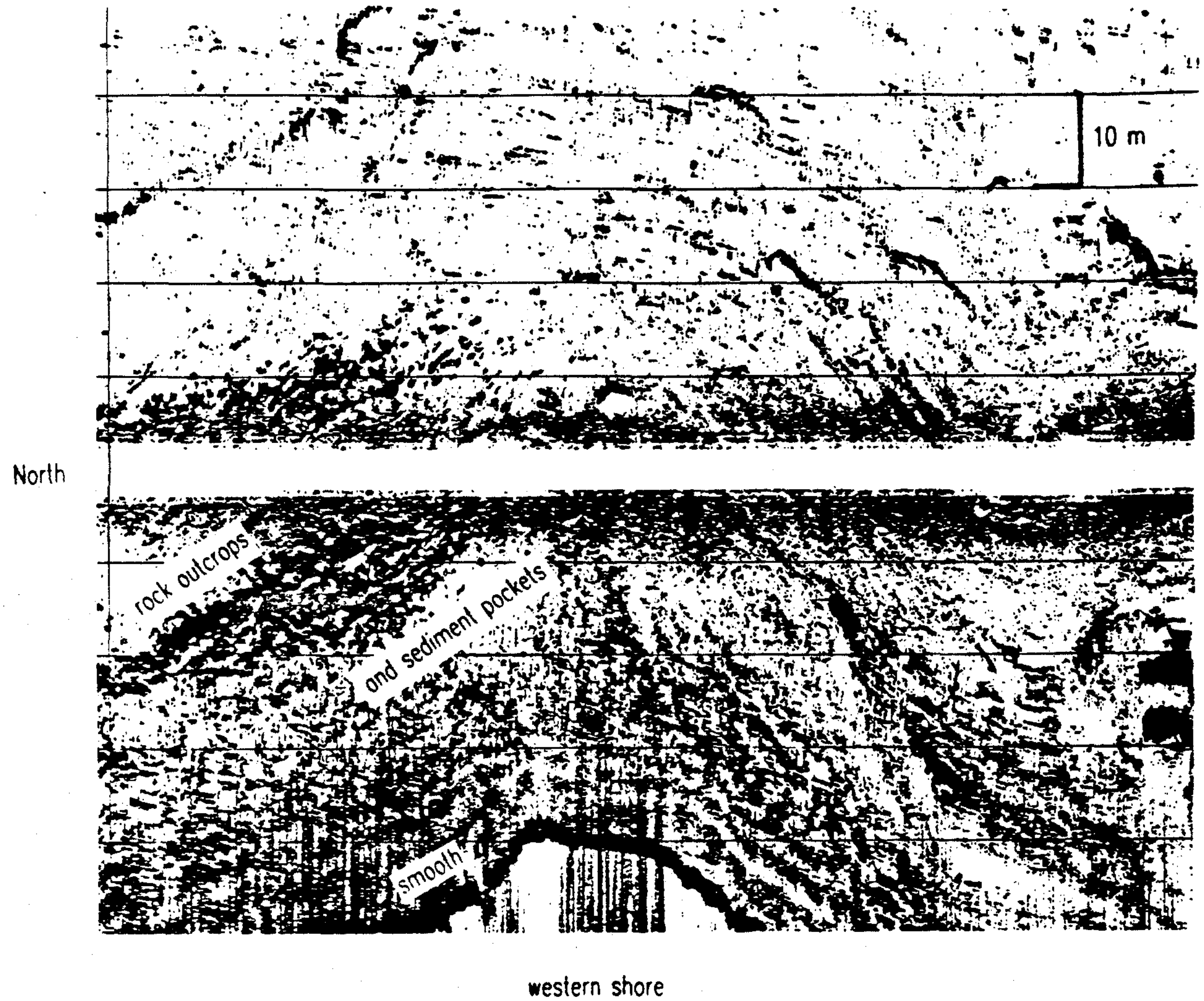

Figure 3. Side-scan sonar record at 100 kHz recorded along the western bank at river mile 192.5 showing sonar patterns 1 (generally smooth and moderately reflective at 100 kHz; characterized by fine-grained sediments) and 2 (distinctive rock outcrops highly reflective at 100 kHz and less-reflective sediment pockets). Lineations near shore line are most likely an artifact.

IRP 001 1244

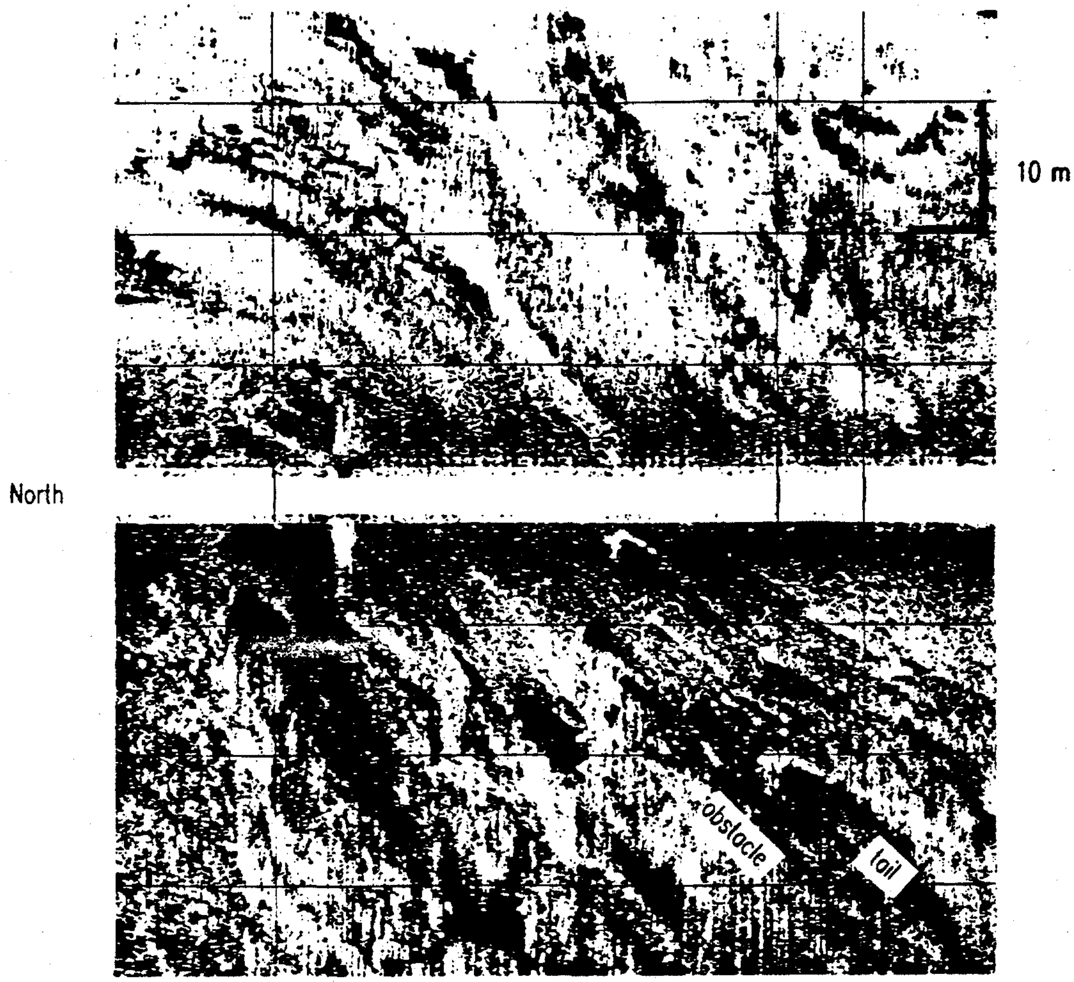

Figure 4. Side-scan sonar record at 100 kHz showing sediment tails forming behind obstacles in sonar pattern 3. These tails are located downriver from the obstacles suggesting that material has been swept into these areas by river flow. Other lineated patterns are also observed in this region.

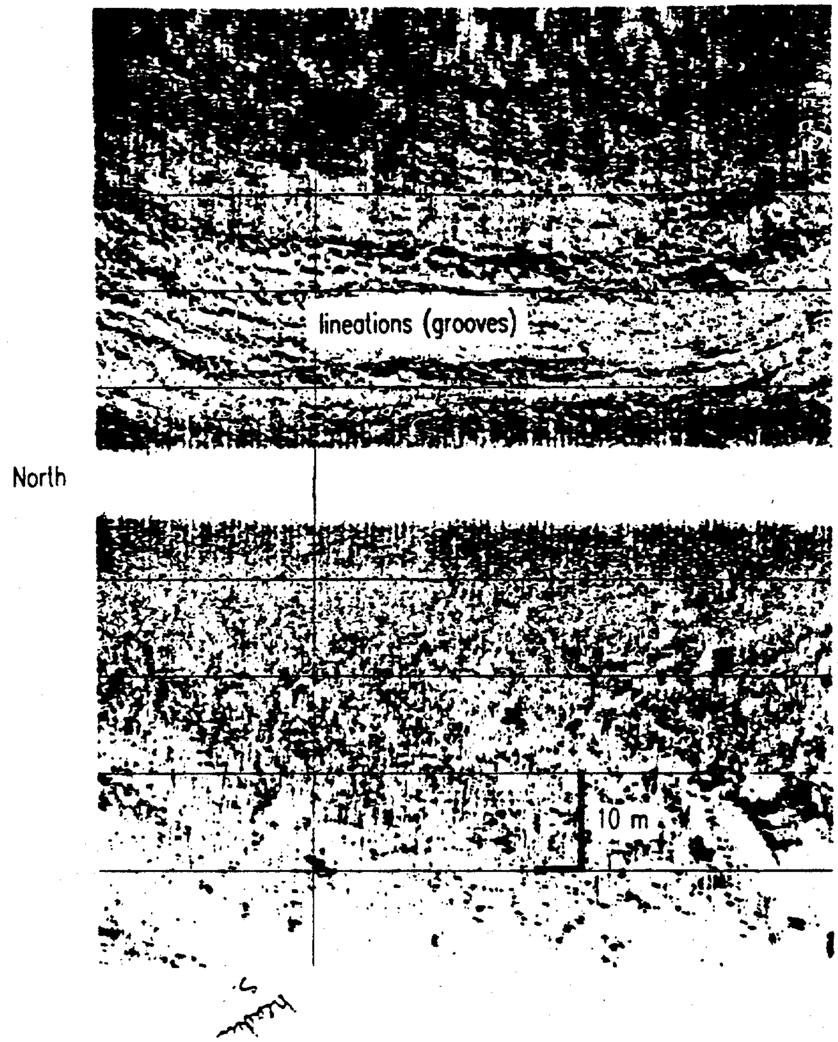

Figure 5. Side-scan sonar record at 100 kHz showing the distinctive lineation (groove) pattern in the deepest portion of the channel (sonar pattern 4). These grooves appear to be aligned parallel to the river bed.

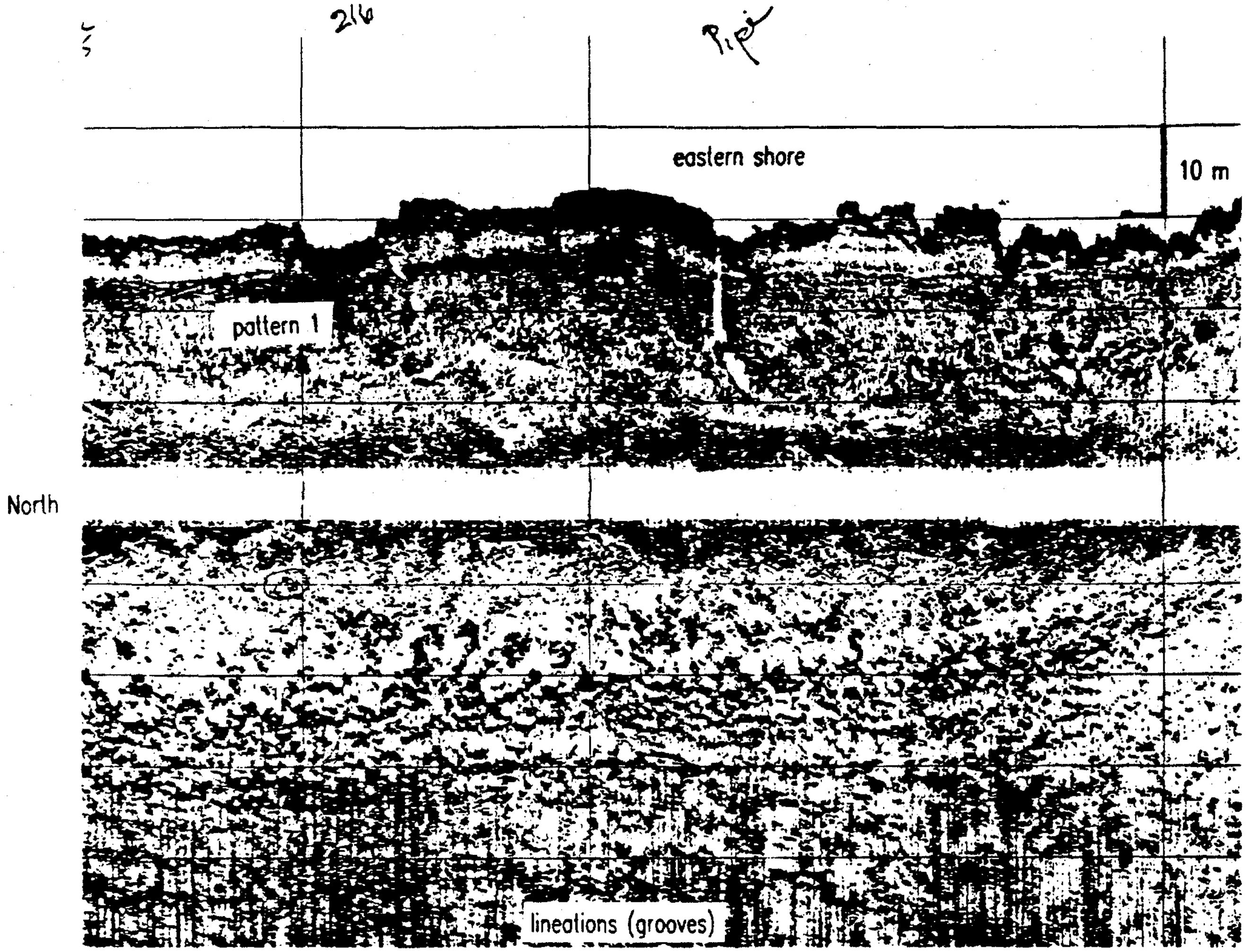

Figure 6. Side-scan sonar record at 100 kHz showing eastern shoreline and fine-grained, moderately reflective sediments near shoreline (pattern 1). The lineated channel-floor pattern can be seen at the bottom edge of the image.

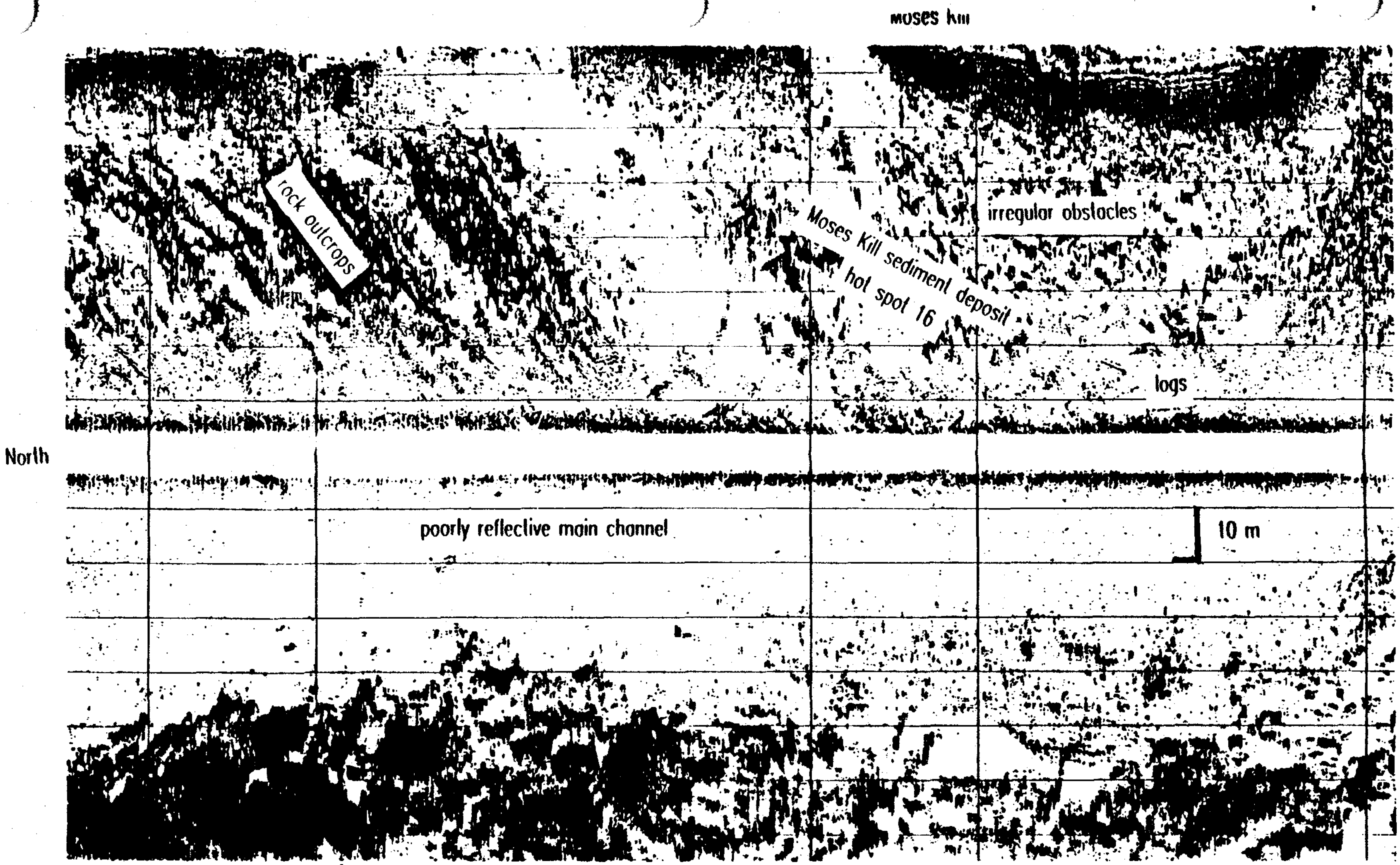

Figure 8. Side-scan sonar record at 100 kHz showing the distinctive reflection patterns in the vicinity of Moses Kill near river mile 189.5 (1977 hot spot 16). Note the rock outcrops on the northeastern corner of the image and the irregularly speckled sediment deposit at the mouth of Moses Kill. Note also the presence of logs in the central portion of the image. This sediment deposit is poorly reflective at 500 kHz.

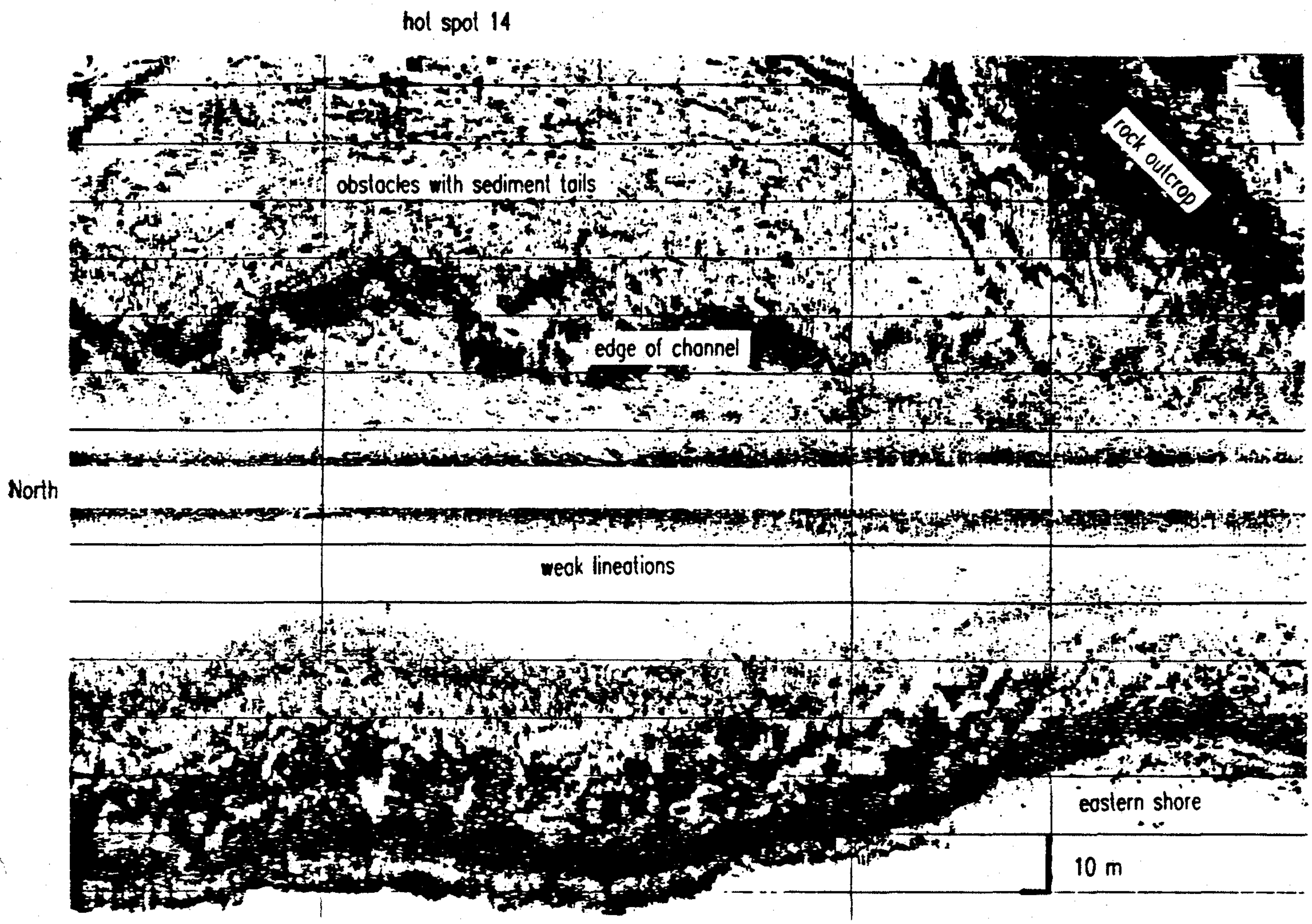

Figure 9. Side-scan sonar record at 100 kHz showing the obstacle-and-tail sonar pattern 3 in the vicinity of 1977 hot spot 14 (river mile 190). Note also poorly reflective, weakly lineated sediments in the channel and the rock outcrop near the southeastern corner. Brown et al. (1988) suggest that sediments in this area contain significant quantities of PCB that are likely to be resuspended in a 100-year flood.

APPENDIX B

SAMPLING PROCEDURES

APPENDIX B

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SAMPLING PROCEDURES

1.0 GENERAL CORING TECHNIQUES

The collection of sediment from the river bottom during the Phase 2A investigation will be accomplished by the use of hand coring or grab sample techniques at each location. The procedure for each technique is described below. Hand coring is considered the best technique since it usually involves minimal disturbance of the sediment, preserving the sediment stratigraphy. In case when hand coring is unsuccessful, grab sampling will be performed. In dense, gravel-rich sediments, it is often the only technique which will work. Other coring techniques are also available, specifically gravity coring or vibra-coring, when a grab sample is not an acceptable alternative to hand coring. The other coring procedures will be used on an as-needed basis. The coring and grab sampling techniques are described in Sections 1.1 to 1.4. The additional steps involved in the core collection procedure are described in Sections 1.5 and 1.6 for high resolution coring and confirmatory sampling, respectively. In all cases, the navigational control will be comparable to that for the geophysical investigation, i.e., nominally accurate to one meter. Alternative the high resolution coring locations may be located using survey maps and compass bearings, yielding an accuracy of about 25 m.

1.1 Hand Coring

1. A clean, decontaminated, 2.5 inch (i.d.) by 36 inch clear plastic coring tube liner is mounted on the end of a hand coring apparatus. (Note that no external coring tube support is used in this technique.)

2. The boat or sampling platform should be positioned and stabilized over the sampling location to the extent possible. The exact location should be recorded.

3. The apparatus with the tube attached is lowered thorough the water column vertically, tube end first until the river bottom is reached.

4. The apparatus is gently pushed into the river bottom while maintaining the apparatus vertically. The apparatus can be twisted on the vertical axis in order to obtain the maximum penetration.

5. The apparatus is then pulled upward out of the river bottom and raised to the surface, while maintaining the apparatus vertically.

6. Before or as the bottom of the tube breaks the surface, a cap is placed over the bottom to prevent the loss of material from the corer. The core is then inspected to ensure that sufficient material was collected in an undisturbed manner.

7. The apparatus is removed from the top of the clear coring tube and a second cap is placed on the top of the tube.

8. The tube is then rinsed with a small amount of river water and the end caps taped in place with Scotch Brand No. 33 electrical tape.

9. The core is stored vertically until it is sectioned on shore or in a laboratory.

10. In the event that the corer does not obtain the length of sediment core desired the tube is brought to the surface and rinsed with river water by submerging it and lifting it out of the water several times until the tube appears free of sediment. The sampling location is then adjusted slightly and the coring is attempted again, beginning with step 3.

11. In the event that the hand coring technique still does not obtain acceptable results or is preclude by too great a water column depth, grab sampling or one of the other coring techniques listed below may be implemented.

1.2 Gravity Coring

1. A clean, decontaminated, 2.5 inch (i.d.) by 36 inch clear plastic coring tube liner is mounted within a gravity coring apparatus. The apparatus is then attached to the end of a rope or cable to enable it to be lowered to the river bottom.

2. The boat or sampling platform should be positioned and stabilized over the sampling location to the extent possible. The exact location should be recorded.

3. The apparatus is lowered below the water surface and then allowed to free fall to the river bottom.

4. If needed, the corer is driven further into the sediments with lead weights by dropping the weights down the cable to the corer.

5. The apparatus is then pulled upward out of the river bottom and raised to the surface, while maintaining the apparatus vertically.

6. Before or as the bottom of the tube breaks the water surface, a cap is placed over the bottom to prevent the loss of material from the corer. The core liner is then removed from the coring apparatus and a cap is placed over the top. The tube is inspected to ensure that sufficient material was collected in an undisturbed manner.

7. The tube is then rinsed with a small amount of river water and the end caps taped in place using Scotch Brand No. 33 electrical tape.

8. The core is stored vertically until it is sectioned on shore or in a laboratory.

9. In the event that the corer does not obtain the length of sediment core desired the tube is brought to the surface and rinsed with river water by submerging it and lifting it out of the water several times until the tube appears free of sediment. The sampling location is then adjusted slightly and the coring is attempted again, beginning with step 3.

1.3 "Vibra-coring"

1. A clean, decontaminated coring tube liner is mounted within the "vibra-coring" apparatus. The apparatus is then attached to the end of a rope or cable to enable it to be lowered to the river bottom.

2. The boat or sampling platform should be positioned and stabilized over the sampling location to the extent possible. The exact location should be recorded.

3. The apparatus is lowered to the river bottom.

4. The apparatus is then used to obtain a core according to the manufacturers instructions.

5. The apparatus is then pulled upward out of the river bottom and raised to the surface, while maintaining the apparatus vertically.

6. Before or as the bottom of the tube breaks the waster surface, a cap is placed over the bottom to prevent the loss of material from the corer. The core liner is then removed from the coring apparatus and a cap placed over the top. The tube is inspected to ensure that sufficient material was collected in an undisturbed manner.

7. The tube is then rinsed with a small amount of river water and the end caps taped in place using Scotch Brand No. 33 electrical tape.

8. The core is stored vertically until it is sectioned on shore or in a laboratory.

1.4 Grab Sampling

1. A clean, decontaminated sampling apparatus is attached to a rope or cable.

2. The boat or sampling platform should be positioned and stabilized over the sampling location to the extent possible. The exact location should be recorded.

3. The trip mechanism is set and the apparatus is lowered to the water surface.

4. The sampling apparatus is then allowed to free fall to the river bottom.

5. The apparatus is pulled back up to the boat and all water is drained.

6. The sampling apparatus is then gently opened so as to minimize the disturbance of the sediments obtained.

7. The contents of the sampling apparatus are described and photographed if appropriate.

8. A portio of sediments is removed and placed into a clear, labeled sample container, being sure to include surface materials if they can be discerned. A temporary cap is placed over the container.

9. In the event that the apparatus does not obtain a sufficient quantity of material for subsequent analysis, the apparatus will be thoroughly rinsed with river water and another attempt at sampling will be made. A small adjustment in the sampling location can be made if needed but the final location and all unsuccessful locations must be noted.

1.5 High Resolution Coring

High resolution coring involves the use of one of the first three coring techniques listed in Section 1.0 of this appendix. The minimum thickness of material to be obtained for these cores is 12 inches (31 cm). In general, this procedure will use the hand coring, gravity coring, and "vibra-coring" techniques, in order of decreasing preference. It is unlikely that the "vibra-coring" technique will be used at all for these samples. Instead, the coring location will be adjusted as necessary in order to obtain the type and quantity of sediments required. The following procedures will apply once a sediment core has been obtained:

1. The core is obtained from the boat or sampling platform and brought to the sample handling facility (typically the Lamont-Doherty Geological Observatory) while always maintaining it vertically.

2. The core is photograph and the sedimentological features noted. Additional features are noted during the extrusion process.

3. When ready to begin separating the core, the top cap on the core tube is removed and the water overlying the sediments is gently syphoned off, taking care not to disturb the sediment water interface or to remove any sediment.

4. The bottom cap is then removed and replaced with a piston to be used to displace the sediments from the tube.

5. The piston is pushed upward into the tube until the sediments approach the other end.

6. A redox probe is inserted into the sediment about half of the next extrusion thickness and a stable potential reading is obtained. A redox reading is taken for each section prior to extrusion.

7. The first 2 cm of sediment are extruded beyond the end of the tube and sliced off using a clean metal plate. A small amount of sediment on the outside perimeter of the slice is removed and discarded . The remaining sediments are then placed in a clean container and labelled for later handling. In the even that the sediment surface is uneven, the core should be sliced such that about the same material as a full 2 cm slice is obtained. In no case should the core be sliced less than 1 cm below the lowest point on the sediment surface.

8. The sample section is homogenized and portions of the sample separated for PCB analysis, radionuclide analysis and other analysis as appropriate.

9. Steps 6, 7 and 8 are repeated until 4 sections are obtained, each time removing the peripheral material and using a clean metal plate and a clean container to collect the sediment section. In circumstances where these nominal sectioning intervals do not correspond to clear differences in the sediment layering based on grain size or other sediment physical properties, the core section interval would be altered to correspond to the observed boundary. This approach would be applied throughout the entire core.

10. For the remainder of the core, the sediments are extruded in 4 cm sections instead of 2 cm sections. These sections are treated in the same fashion as the 2 cm sections.

11. Continue slicing, mixing and labelling individual sediment layers leaving the last 1-2 cm of material in the core tube. The integrity of these sediments is sometimes compromised by the extrusion process and should not be used.

1.6 Confirmatory Sampling

Confirmatory sampling involves the use of the hand core or grab sample techniques described in the previous portions of this appendix followed by the additional procedures described in Section 1.6.1 and 1.6.2, respectively.

1.6.1 Hand Coring Sample Handling

Hand coring is the preferred sampling technique for all confirmatory sampling locations. This technique will be considered successful if at least 8 inches (20 cm) of undisturbed sediment are obtained. The following steps described sample handling after a core has been obtained.

1. The core is obtained from the boat or sampling platform and brought to the sample handling facility (typically a mobile laboratory while always maintaining it vertically.

2. Before the core is disturbed, it is photographed, x-rayed (to determine density variations) and its visual features are described. Addition features observed during the extrusion process will also be noted.

3. When ready to begin separating the core, the top cap on the core tube is removed and the water overlying the sediments is gently syphoned off, taking care not to disturb the sediment water interface or to remove any sediment.

4. The bottom cap is then removed and replaced with a piston to be used to displace the sediments from the tube.

5. The piston is pushed upward into the tube until the sediments near the other end.

6. A redox probe is inserted into the sediment about 1 inch (half of the planned section thickness) and a stable redox potential reading is obtained.

7. The first 2 in. (5 cm) of sediment are extruded beyond the end of the tube and sliced off using a clean metal plate. A small amount of sediment on the outside perimeter of the slice is removed and discarded. The remaining sediments are then placed in a labeled sample container. Portions of the sample are removed for total carbon analysis, grain size analysis, etc. in a

representative fashion (e.g., a pie slice portion). If a sample cannot be subsectioned in a representative fashion, it is first homogenized in the sample container and then portions are removed for the appropriate analyses. In the event that the sediment surface is uneven, the core should be sliced such that about the same volume of material is obtained as in a full 5 in. slice.

8. Continue slicing, mixing and labelling individual sediment layers leaving the last 1-2 cm of material in the core tube. The integrity of these sediments is sometimes compromised by the extrusion process and should not be used.

1.6.2 Grab Sample Handling Procedure

Grab coring is the least preferable sampling option because of the loss of the integrity of the sample stratigraphy. The following steps describe the handling procedure once a sample has been brought to the sample handling facility.

1. Remove the temporary cover from the sample container and discard.

2. Using a clean spatula, homogenize the sample inside the sample container.

3. Remove appropriate portions for total carbon/total nitrogen analysis and grain-size distribution analysis and place these portions into clean, labeled containers.

4. Seal all containers and ship chilled to the appropriate facilities.

2.0 WATER COLUMN SAMPLING

This section describes the water column sampling procedures for both dissolved and suspended matter fractions.

2.1 Sampling Collection

1. The sampling locations should be defined prior to the sampling transects via a reconnaissance visit to the prospective location.

2. Each sample for PCB analysis will be collected directly into clean, prepared 4 liter glass bottles. The cleaning procedure is described liter in this appendix.

3. Each PCB sample will consists of 5 - four liter bottles. The bottles will be filled at five points located across the river at each sampling location so as to approximately represent the cross-sectional variation.

4. At each point a clean, prepared bottle is lowered to the correct sampling depth (half way between the surface and river bottom but at least 0.5 m below the surface) tripped with a weighted messenger to open the bottle and once filled, quickly returned to the surface.

5. Conductivity and temperature will be measured at each collection point in the cross-section either during or just prior to the sample collection.

6. The five points at each station will be sampled as quickly as possible to generate a near-instantaneous sample of the water column parameters.

7. Additional water needed for other analyses will be obtained from a sixth clean, prepared bottle from the center point in the cross-section. Each station will include a measurement of pH, dissolved organic carbon, total suspended solids and chlorophyll-a. In addition, a one liter sample for PCB analysis via the NYSDEC method will also be collected from the sixth four liter bottle.

8. For those stations where 2 twenty liter samples are required, each point will be sampled twice in succession (i.e., two 4 liter bottles will be filled at point one, two at point 2, etc.) so as to minimize the difference between the paired samples. The second set of samples in this case would be held for four days at the Lamont-Doherty Geological Observatory at room temperature. The bottles will be inverted once per day during this period to stir the sediment from the bottom of the bottle and speed equilibration. After four days, the sample will be filtered as described in the next section and treated in exactly the same manner as the standard water sample.

2.2 Field Processing

Within 4 hours of collection, each standard 20 liter sample must be separated into dissolved and suspended matter fractions (excluding those being held for a 4 day period).

1. A clean, pre-fired 6 in. Watman glass fiber filter grade GF/F (0.7 um) is placed in a 6 in. stainless steel filter housing. The filter is pre-fired in clean, PCB free air at 450 °C overnight.

2. The sample is passed through the filter by gravity, under pressure using a pump or by pressurizing the holding container with air. If air is used to displace the liquid then a magnetic stirring rod will be used to keep the suspended matter suspended.

3. It may be necessary to use a second filter if the first filter becomes clogged. Both filters will then be treated as one suspended matter sample.

4. After the fluid has been filtered once, a small amount is used to rinse the holding container(s) and recover any additional suspended matter still residing in the container(s). This rinsate is also passed through the filter. This step is repeated as necessary until no suspended material is visible on the surface of the holding container(s).

5. A fifth 4 liter bottle or a calibrated 20 liter bottle is used to collect the filtered liquid, depending upon whether the sample volume is to be determined by the laboratory or in the field. In all cases, all bottles used to hold the 20 liter sample will be sent to the laboratory to be extracted along the sample itself. If a fifth 4 liter bottle is used then after the first bottle has been emptied and rinsed it is used to collect the filtered liquid from the second bottle. This is repeated until all 5 bottles have been filtered.

6. The filters containing the suspended matter are placed in a labelled, clean glass jar for shipment to the laboratory.

2.3 Sample Bottle Preparation

The sequence of steps to be followed for clean-up of the all glass containers used for PCB sampling and transport would include:

1. Wash with tap water and laboratory soap, followed by extensive tap water rinse.

2. Rinse with distilled water (three times).

3. Rinse twice with acetone (pesticide grade).

4. Rinse twice with hexane (pesticide grade).

5. Rinse twice with acetone (pesticide grade).

6. Stand inverted for 20 minutes to permit acetone to drain.

7. Heat in large, low temperature (60 °C) oven at least six hours to remove last traces of organic solvents.

8. Cool glass container and cover with aluminum foil previously rinsed with hexane.

9. Secure aluminum foil cover with rubber band.

10. Collect all organic solvents in metal storage containers for eventual disposal by an approved service company.

11. After each large glass bottle has been returned to the laboratory, fill with tap water and soap to stand for at least six hours before beginning a new clean-up procedure.

APPENDIX C

ANALYTICAL PROCEDURES

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This section outlines several of the special analytical procedures to be used in the Phase 2A investigation. The procedures have not been finalized but represent the current status. The final description of the analytical procedures will be submitted separately. These descriptions are provided to give the reader a better understanding of the type of procedures required for the program.

1.0 ANALYSIS OF DISSOLVED ORGANIC CARBON IN HUDSON RIVER WATER

Two aliquots of water will be obtained for dissolved organic carbon analysis from each water sampling station. Each sample will be filtered with a small diameter (47mm) stainless steel positive pressure system, using glass fiber filters which had been precombusted in the laboratory. One sample will be prepared and sent for analysis via EPA method 415.1 for total organic carbon. One sample will be sent to the Lamont-Doherty Geological Observatory for analysis. This sample is acidified in the field, after filtration into clean glass BOD bottles with 0.5 ml of 2N sulfuric acid. This samples is then returned to the laboratory for measurement of DOC by a persulfate oxidation method. The acidified sample is purged of CO_2 by bubbling with a stream of N_2 , and then an aliquot is sealed with persulfate, heated in an oven and the resultant sample analyzed for CO_2 by gas chromatography, using a thermal conductivity detector.

2.0 TOTAL CARBON AND TOTAL NITROGEN ANALYSIS IN HUDSON RIVER WATER

The analytical technique we propose to use to measure total C and total N in Hudson sediments is an instrumental method based on high temperature (1050 °C) combustion, followed by reduction of the combustion gases at 650 °C, with each of these steps occurring in a separate catalytic reactor column. The stationary phase in the combustion column is composed of a porous layer of the oxidation catalyst chromium trioxide (Cr2O3) overlying silvered cobaltous cobaltic oxide (Co_3O_4 + Ag). The reduction reactor is packed with metallic copper, and is designed to convert nitrogen oxides to N_2 and to remove any oxygen from the gas stream leaving the oxidation reactor. The resultant gases are passed through a third reactor column containing magnesium perchlorate to strip water vapor and than analyzed by gas chromatography using thermal conductivity detection of CO_2 and N_2 (Verardo et. al., 1990). The instrument to be used is a modified Carlo Erba NA-1 500 Analyzer recently established at LDGO for measurement of C and N in deep sea sediments. Since marine sediments usually have much lower organic material proportions than fine-grained river and estuary sediments, the sensitivity of this instrument is more than adequate for our purposes. For sediment samples of 5 to 10 mg, the detection limit is usually about 0.01 % carbon (weight percent).

Standardization of the instrument is accomplished by generation of a response curve using Acetanilide: $CH_3CON(CH_3)C_6H_4OH$, which is a compound issued by NBS (no. 141C) as a standard for these measurements. The C/N weight ratio of this compound is 7.71 and the molar ratio of C/N is 9.

References

Verardo, D.J., P.N. Froelich and A. McIntyre, Determination of organic carbon and nitrogen in marine sediments using the Carlo Erba NA-1500 Analyzer, Deep-Sea Research 37, 157-165, (Instruments and Methods Section), 1990.

3.0 TOTAL ORGANIC CARBON ANALYSIS IN HUDSON RIVER WATER

Data on total organic carbon levels in a sediments will be obtained based on the difference between the procedure for total carbon described in Section 2 of this appendix and the following coulometric procedure for total inorganic carbon.

The general procedure is described here. A more specific procedure will be submitted in the near future. A portion of sediment is weighed out and placed in a reaction vessel along with an aliquot of CO_2 - free distilled water. CO_2 - free N_2 is bubbled through the water while it is stirred with a magnetic stirring bar. The mixture of water and sediment is then titrated with acid. The CO_2 eluted is determined with a CO_2 -specific coulometer, yielding the total inorganic carbon in the sample.

4.0 LOSS ON IGNITION ANALYSIS FOR HUDSON RIVER SEDIMENTS

The "Loss on Ignition" procedure is defined here as the weight loss experienced by a sediment sample as the result of combustion in air at 375 °C (14-16 hours), following drying at 110 °C. This measurement provides a determination of organic material in Hudson sediments capable of combustion at relatively low temperature and also provides direct comparison with a considerably body of previous measurements of PCBs and organic material (performed with this same analytical technique) in Hudson River sediments (Bopp, 1979). This measurement, combined with data on the organic carbon content of samples analyzed by the instrumental method described above, would permit the ratio of the weight of organic material to organic carbon to be established as a function of location in Hudson sediments. Sediment samples (0.4 to 1.0 grams) are first added to a small pre-weighed porcelain crucible. After weighing the combined sample + crucible (to ± 0.1 mg), the crucible is placed in an oven maintained at 110 °C overnight and then reweighed after cooling to room temperature in a drying cabinet. Finally the crucible containing the oven-dried sediment is placed in a muffle furnace and combusted 1 4-1 6 hours at 375 °C and then cooled to room temperature in a drying cabinet and reweighed. The difference between the last two weights is divided by the original weight of the sample after oven drying (loss on ignition). A temperature of 375 °C instead of 500 °C is used for loss on ignition determinations because studies at the Lamont-Doherty Geological Observatory have shown that a significant portion of the weight loss of Hudson sediment samples between 450 °C and 550 °C represents water from clay dehydroxylation reactions. This was established by analyzing samples in the 400-550 °C range on a Consolidated Electrodynamics Corporation moisture analyzer. Following Ball (1964), weight loss at 375 °C for 14-16 hours was chosen as an index of the organic matter content of samples capable of combustion at relatively low temperatures.

References

Ball, D.F., Loss-on-ignition as an estimate of organic matter and organic carbon in non-calcareous soils. J. Soil Sci, 1.5, 84-92, 1 964.

Bopp, R.F., The Geochemistry of Polychlorinated biphenyls in the Hudson River, Ph.D. dissertation, Columbia University, 191 pp., 1979.

5.0 TOTAL SUSPENDED SOLIDS IN HUDSON RIVER WATER

Total Suspended Solids will be determined using EPA method 160.2.

6.0 GAMMA SPECTROMETRY OF HUDSON RIVER SEDIMENT SAMPLES

This analysis involves the determination of several radionuclides, both natural and anthropogenic in Hudson River sediments. The measurements would be made by nondestructive gamma spectrometry using lithium-drifted germanium [Ge(Li)] detectors with high resolution for the decay energies of gamma ray emissions. This high resolution permits the activities of many different radionuclides to be measured simultaneously on sediment samples (dry weights from 10 to 300 grams) with counting times ranging between a few hours and a few days. The laboratory at the Lamont-Doherty Geological Observatory has been continuously measuring sediment radionuclide activities in Hudson River sediments since March, 1975, as part of a number of.research projects funded by USDOE, USEPA, NSF, NOAA, NYSDEP, NYCDEC, NJDEP and the Hudson River Foundation (e.g. Simpson et. al., 1976, Olsen, 1979, Olsen et. al., 1981, Bopp et. al., 1982).

The most important radionuclides to be measured for the purposes of establishing approximate times of accumulation of sediment layers in the Hudson are: cesium-137 (half-life - 30 yrs), cesium-134 (half-life = 2.1 yrs), cobalt 60 (half-life = 5.3 yrs) and beryllium-7 (half-life = 54 days).

In addition to the above radionuclides to be employed as "natural" tracers of the time of sediment accumulation, data would also be obtained for several other radionuclides useful in characterizing the mineral composition of the sediments: potassium-40, bismuth-214 and actinium-228, These latter two nuclides are in the natural decay series of uranium-238 and thorium-232 and thus indicative of the concentrations of U and Th. Measurement of these additional components does not require any more sample mass or counting time.

The sequence of steps to be followed for the measurements include the following:

1. Dry the sectioned sediment core samples at low temperature. Dry samples are necessary for the gamma counting method because all of the detector calibrations have been performed with dry materials. This also permits the highest and most uniform counting efficiencies to be achieved by eliminating absorption of gamma rays by variable quantities of water in the samples.

2. Grind the dry sediments to a fine powder with a large mortar and pestle. This step is essential to achieving a well-mixed uniform texture sample for gamma counting and for representative subsampling for other analyses.

3. Seal the dry sediment powder in air-tight aluminum cans to obtain a reproducible geometry for gamma spectrometry and to permit the daughter products of Rn-222 (half-life . 3.8 days) and Rn-220 (half-life - 54 seconds), both of which are gases, to achieve secular equilibrium with the critical gamma-emitting daughter products in the U and Th decay series retained in the sample container prior to and during the actual counting. Aluminum cans of two different sizes will be used for the gamma spectrometry measurements: small cans (100 cc) for high resolution core segments and large cans (300 cc) for low resolution core segments.

4. Set the sealed aluminum cans aside for a minimum of approximately 5 half-lives of Rn-222 to permit achievement of secular equilibrium of U-238 decay series nuclides.

5. Place a sealed, equilibrated aluminum can on the top surface of a Ge(Li) detector, after enclosing the can in a plastic bag to prevent introduction of dust into the shielded counting space around the detector.

6. Start accumulation of the spectrum of gamma emissions as a function of energy of each gamma ray detected.

7. Stop accumulation of the gamma spectrum after enough counts have been recorded for critical nuclides, such as Cs-1 37 and Be-7, to be measured with enough precision to accurately define the shape of the vertical profile of radionuclides in the sediments. For high resolution cores in Hudson sediments the minimum counting time for each core section interval will be about 24 hours. For low resolution core sections, the minimum counting time will be of the order of 3-4 hours, partly because of reduced requirements for accuracy in the final data for Cs-137, and partly because of substantially larger sample masses presented to the Ge(Li) detector.

8. Record the counts in each photo peak of interest from the gamma spectrum on a data sheet, along with other relevant data necessary for calculation of the radionuclide activities per unit weight of sample: sample weight (dry), sample collection date, sample counting date, proportion of can filled by the sample powder, total counting time (live time for the detector), code information for sample identification (e.g. core mile point, depth interval, laboratory control number).

9. Enter the data discussed above in the calculation program to obtain concentrations for each radionuclide of interest, expressed in terms of activity units, picoCuries (pCi), per kilogram of dry weight of sediment. One pCi is equivalent to 2.22 disintegrations per minute (dpm), or 0.037 Becquerels (1 Becquerel = 1 disintegration per second, dps). One Curie equals the number of decays per gram of pure radium-226, and one pCi equals 10e-12 Ci. Typical activities of Cs-137 in "recent" fine-grained Hudson River sediments (accumulated since the mid 1950s) usually fall in the range of a few hundred to a few thousand pCi per kg, when decay-corrected to the time of collection of the sediment core. Sandy sediments, in most cases, have much lower specific activities of Cs-137 (and of other contaminants with a strong tendency to bind to fine particles). Activities of fine-grained sediments in the upper Hudson, such as those behind the Thompson Island Dam, can sometimes have considerably higher activities of Cs-137, especially for fine-grained layers accumulated during the mid 1960s during the years of maximum global fallout from atmospheric testing of nuclear weapons.

10. Store sealed aluminum cans containing dry sediment powder after completion of gamma counting. In this mode the samples can be saved indefinitely without risk of contamination or need to retain at low temperature to prevent microbial alteration of any important labile constituents. The containers can be opened at a later time for further sampling and resealed in the same can.

References

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7.0 GRAIN SIZE DISTRIBUTION ANALYSIS OF HUDSON RIVER SEDIMENT

Sediment samples will be analyzed using two different techniques for grain size distribution. The first technique will be ASTM method 422-63 for a general analysis of all sediment components. A second technique based on a coulter counter or laser particle analyzer method will be applied to the fraction smaller than 120 μm. The details of the coulter counter method will be submitted for review in the near future.

8.0 CHLOROPHYLL-A ANALYSIS IN HUDSON RIVER WATER

Water samples will be analyzed for chlorophyll-a. The details of the method will be submitted for review in the near future.