HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX G

MONITORING PROGRAM DEVELOPMENT

Appendix G

Part A

Monitoring Programs For The Hudson River

G.1 Introduction

An important component of any remedial alternative for the Hudson is the monitoring of river conditions before, during and after the remedial effort. The purpose of the monitoring is primarily to document the improvement in river conditions as a result of the remedial effort as well as to ensure that the remedial effort succeeds in achieving its clean-up goals. Additionally, monitoring can provide assurance that remedial activities do not create unacceptable conditions during the clean-up process itself.

The goals of the monitoring programs described here conform to the purposes described above. Various aspects of the monitoring proposed address the long-term changes in the PCB levels of the sediment, water and fish. Additionally, sediment PCB levels immediately prior to and subsequent to any remedial activity are also to be monitored. Finally, impacts of the remedial activities on water column and fish conditions are addressed. Each of these aspects is covered to a differing degree, depending on the remedial activity selected.

The monitoring scenarios fall into four separate categories as follows:

- Monitored Natural Attenuation
- Design Support
- Construction Monitoring
- Post-Construction Monitoring

The titles of these scenarios are somewhat self-explanatory but are explained in detail below. Note that no monitoring is proposed for the No Action alternative, consistent with USEPA guidelines. In the subsections that follow the basic premise of each of the monitoring scenarios is presented along with a discussion of the monitoring tasks. In several instances, the monitoring scenarios have several tasks in common. In this case, the task is described only in the first scenario in which it appears and simply referenced in subsequent scenario discussions. Additionally, several of the monitoring programs (*e.g.*, design support) have features specific to the remedial scenario chosen. In these instances, the remedial scenario-specific details are discussed as well under the monitoring task.

The length and spatial coverage varies widely among the monitoring scenarios, covering a range from 1 to 25 years and from as little as 30 to as much as 200 river miles. Additionally, there are variations within several of the scenarios that depend upon the exact remedial alternative selected. In particular, the design support, construction and post-construction monitoring are all dependent on the type and extent of remediation selected. Additionally, if No Action or Monitored Natural Attenuation is selected, clearly the other scenarios become superfluous. Figure 5-6 in Chapter 5 of the FS presents a schedule of the various monitoring tasks.

It should be noted that with each of these scenarios there are significant tasks in addition to the sampling effort itself. These tasks include the tallying, reporting and interpretation of the data (*i.e.*, data analysis). These additional tasks involve greater effort for some of the monitoring programs relative to the others. For example, Monitored Natural Attenuation will require more extensive analysis than a removal action, as discussed below. For the purposes of the cost estimates, the reporting and interpretation has been estimate based on a per-sample basis. Monitored Natural Attenuation has the additional effort of incorporating the data collection results into further modeling analysis. This is needed to determine whether the actual data trajectory matches the model forecast. To the extent that there are differences, the model will require adjustment and possibly recalibration to reflect the actual data and make more accurate forecasts. A smaller but similar modeling program is planned for the post-construction monitoring period.

G.2 Monitored Natural Attenuation

Monitored Natural Attenuation involves several large monitoring programs, covering sediment, water and biota. River conditions prompting this alternative are not considered acceptable and thus this alternative involves extensive monitoring to document the occurrence of natural attenuation at a rate similar to or better than that predicted by the Phase 2 modeling analysis. Monitoring under this program replicates and extends the existing long-term sampling programs begun by NYSDEC, GE and others. Water, fish and sediment are to be monitored under this program. Samples in this program are designed to provide integrating information on loads and exposures to PCBs throughout the Hudson. In the event that natural attenuation is not occurring at an acceptable rate, other remedial alternatives for the river may be considered. Additionally, this alternative involves the use of acoustic techniques (*e.g.*, side-scan sonar) to monitor any physical changes in the sediment properties and river bathymetry over time. Changes such as these will have a direct bearing on the issues of sediment resuspension and burial. A final goal of this program is to develop data sets that can be used to validate and further refine the USEPA models. These models will require revision to enhance their accuracy over the long term and correct any differences between the model forecast and the actual measured trends. It is expected that model review and recalibration will occur on a three-to-five cycle to reflect the newest data in the model forecasts. This cycle time also corresponds to the frequency of the major sediment monitoring events. A five-year recalibration has been assumed for cost estimation purposes.

Monitored Natural Attenuation is planned for a thirty-year period. In the event that conditions substantially improve over time, it may be possible to reduce the frequency of monitoring and still achieve a useful record. However, since the timing of such a condition is difficult to estimate, particularly since the model does not predict attainment of the PRGs within the study period. Thus, no allowance has been made to the associated cost estimate.

It should be noted that if a sediment remediation program is selected, it will still be necessary to implement the Monitored Natural Attenuation programs prior to the on-set of remediation.

In this case, the monitoring program provides a baseline for comparison once the remediation is completed. As will be discussed later, the post-construction monitoring program is very similar to the Monitored Natural Attenuation; thus the data collected prior to remediation will be directly comparable to subsequent data collection efforts.

Monitored Natural Attenuation consists of four major programs that are described below.

G.2.1 Surface Water Monitoring

Surface water monitoring under Monitored Natural Attenuation consists of five tasks, two of which are similar in nature to the monitoring work performed by USEPA in 1993, specifically, Upper Hudson water column monitoring and monitoring in the freshwater Lower Hudson. The remaining three tasks under this program are designed to collect data to further enhance the understanding of PCB loads in the Upper Hudson. These tasks involve daily monitoring of suspended solids (program 3) and quarterly float surveys (programs 4 and 5). Table G-1a contains an outline of these programs.

Upper Hudson Monitoring

This program consists of regular time-of-travel surveys of water column conditions in the Upper Hudson. In each time-of-travel survey, sampling stations are occupied in sequence from upstream to downstream while allowing sufficient time for the parcel of water sampled at the previous station to arrive at the next station at the time of sampling. The timing for each event is a function of the flow in the river at that time. For example, during a typical flow condition of 5000 cfs, approximately 12 hours must be allowed between the collection of a sample at Rogers Island and the Thompson Island Dam sample collection. Similar time allowances must be made for the stations down stream of TI Dam.

The purpose of this program is to continue to document PCB loads and concentrations in the Upper Hudson. Under the consent decree for the Post-Construction Monitoring Program for the Remnant Deposits (Administrative Order on Consent II CERCLA 90224), General Electric is required to monitor water column concentrations in the Ft Edward area. This program extends and continues the GE program to build upon the existing data set and further the understanding of PCB transport in the Upper Hudson. Notably, the water column time-of-travel data obtained by USEPA and the weekly monitoring data obtained by GE have proved invaluable in understanding PCB transport in this system. This program will serve to extend these data sets into the future. Additionally, this program will provide data for correlation with the fish and sediment monitoring programs that parallel this effort. As such the water column program provides data for the estimation of fish exposure to PCBs.

The Upper Hudson water-column monitoring program consists of weekly monitoring at seven stations in the Upper Hudson as listed in Table G-1a. Because of the important differences in congener pattern among the various potential PCB sources in the region, congener-specific data are required. Ancillary measurements include suspended solids and the fraction of organic carbon on the suspended solids.

Monitoring in the Freshwater Lower Hudson

This program largely represents an extension of the Upper Hudson program to the lower river. Because the absolute levels, and thus the impacts from PCBs, are substantively lower in this region of the Hudson, sampling will be less frequent. Additionally, tidal fluctuations and mixing serve to reduce the variations in PCB levels found in this region, while tidal mixing in general makes the calculation of water column PCB fluxes problematic. As a result, samples will only be collected once per month in this program, from three Lower Hudson stations plus the Mohawk River. This program is also outlined on Table G-1a.

The timing of these samples will follow sequentially after the Upper Hudson samples so as to make the results directly comparable.

Suspended Solids Monitoring

Monitoring of suspended solids is needed to further refine and improve the existing modeling analysis of solids transport in the Upper Hudson. In particular, suspended solids loads from the tributaries in the Upper Hudson are relatively poorly constrained and can benefit from the additional data. The suspended solids program will involve the automated collection of suspended matter samples at each of 13 locations in the Upper Hudson. These stations will also require the installation of staff gauges and automated flow-monitoring equipment to record daily flow at these locations. The 13 locations include both mainstem and tributary stations in the Upper Hudson.

Float Surveys

The remaining two water-related programs are float survey programs, similar in design to the studies done by GE in 1996 and 1997. The first of the float survey programs covers the TI Pool while the second covers the region from TI Dam to Lock 5. These surveys are focused on the warmer months of the year and are intended to study the processes and the areas responsible for the PCB release from the sediments so clearly documented in the USEPA and GE data. As discussed in Chapter 3 of this report, the shallow regions of the river represent the most likely PCB source to the water column. Each survey consists of 25 to 30 cross-sections wherein samples are collected from the main channel of the river and from the shallow areas to either side. Each cross-section consists of four samples, with one sample in the river channel and three in the shallows. Cross-sections are separated by 0.25-mile intervals. These surveys will be conducted four times a year from mid-May to the end of September. Each survey is expected to represent about a day of sampling per river reach. By observing the evolution of PCB contamination from the sediments to the water, sediment-related PCB source areas can be identified and the magnitudes of their releases estimated.

G.2.2 Fish Monitoring under Monitored Natural Attenuation

NYSDEC has traditionally monitored fish body burdens in the Hudson on a regular basis. Their records for PCBs in fish extend back to at least 1977. In 1997, NYSDEC developed a proposed monitoring program for the Hudson. The proposed plan is included later in this appendix. The proposal describes the basic goals for the sampling program as defined by

NYSDEC. Three of the four goals listed by NYSDEC are also shared by the monitoring programs for the Reassessment RI/FS and are replicated below:

- To assess temporal tends in PCB concentrations in selected resident species;
- To evaluate spatial relationships in Hudson River PCB contamination as reflected by concentration in the fish; [and]
- To ascertain PCB concentrations in the striped bass recreational and commercial fisheries for purposes of providing health advice through the New York State Department of Health and for regulating commercial fisheries when PCB levels exceed the U.S. Food and Drug Administration tolerance level of 2 ppm.

Essentially, the program is intended to further the understanding of PCB uptake in fish while also monitoring to determine when fish levels reach acceptable concentrations for recreational and commercial use.

To accomplish this, fish monitoring will continue as it has for the last several years, with the collection of resident species from both the Upper and Lower Hudson in the spring of each year, followed by collection of young-of-the-year pumpkinseed in the fall. Striped bass collection will take place in both spring and fall with monthly collections at Albany from June to October. These programs were designed by NYSDEC to extend and enhance its fish monitoring program and also satisfy the needs of the Reassessment RI/FS. This program is summarized in Table G-1b. Additional information (*i.e.*, the NYSDEC proposed plan) is provided in part E of this appendix.

G.2.3 Sediment Monitoring under Monitored Natural Attenuation

Sediment monitoring under Monitored Natural Attenuation will involve two main programs that derive from the historical sediment investigations conducted by USEPA and GE in the 1990s. Specifically, the sediment programs will involve the collection of high resolution cores from selected Hudson sites and the collection of low resolution cores (sediment inventory cores) from several documented *hot spots.* The sediment program is outlined in Table G-1c.

<u>Collection of Sediment Cores for Dating and Analysis (High Resolution Coring)</u>

During the Phase 2 investigation, the USEPA made extensive use of the dated sediment cores collected from the Hudson. Dateable cores were successfully obtained from about 14 locations and were used to provide an integrative perspective of long-term PCB transport in the Hudson. The cores documented both the principal source of PCBs to the River (*i.e.*, the GE facilities) as well as the long-term fate of PCBs within the sediments in the absence of resuspension. It is important to the continued understanding of PCB contamination in the Hudson that this program be continued into the future.

These cores document major releases of PCBs to the river along the river’s length. Eleven locations on the main stem of the Hudson plus a location in the Mohawk near its confluence with the Hudson will be occupied for this program. The sampling frequency for this program is 5 years for most of the 30 year monitoring period, although cores are collected in years 1 and 4 (three years apart) to examine the initial conditions.

In this program, cores are sliced into thin layers (2 to 4 cm each) and analyzed for PCBs as well as radionuclides. The radionuclides provide the information required to establish the core depositional chronology. PCB analysis is done on a congener-specific basis for this program to provide information on the transformations of the PCB mixtures contained within the sediment over time (*e.g.*, dechlorination). Additionally, congener-specific data can also be used to identify new sources to the river when the source pattern is distinct from that contributed by GE. In this manner, these cores document the long-term response of PCB contamination in the Hudson as well as the introduction of new sources.

<u>Sediment Inventory Monitoring</u>

The sediments of several NYSDEC-identified *hot spots* will be examined approximately every five years to assess the in-place inventory and compare it with prior inventory estimates. Additionally, composite samples similar to those collected by GE and used in the modeling analysis will be generated every five years to track changes in the surface sediment conditions. These results can be directly incorporated into the HUDTOX model as a part of future model refinements anticipated under the Monitored Natural Attenuation alternative. By sampling on this frequency, the results should permit the documentation of changes in sediment PCB inventory and concentration over time. The actual planned sampling years for sediment inventory monitoring include years 1, 4, 9, 14, 19, 24, and 29, the same as those proposed for the high resolution coring program.

For the sediment inventory study, eight *hot spots* will be examined periodically to assess changes in their respective inventories. The *hot spots* selected represent a substantial portion of the sediment PCB mass and thus should represent the general condition of similar *hot spot* areas. Thirty-six cores will be collected per *hot spot* so as to provide a sufficient basis to assess the mean condition and the inherent variability. (The basis for the value of 36 per unit area is presented in subsection G.3.2.) Nominally, five core sections will be obtained per core, similar in design to the low resolution coring program, with the top- and bottom-most slices analyzed for radionuclides and the three main intermediate slices (about 12 inches in length each) analyzed for total PCBs. Unlike the high resolution coring program, PCB analyses from these samples need only represent total PCB mass and not congener-specific levels. Organic carbon will be collected as an ancillary measurement.

For the shallow sediment inventories, sample composites will be produced to represent sediment depths to 25 cm in five 5-cm intervals. Composites will roughly approximate those obtained by GE but a greater thickness of the sediment will be represented and composites will not extend over long distances (*i.e.*, more than 1 mile). These composites will be analyzed for total PCBs as well as radionuclides and organic carbon. The program will consist of the collection of one thousand cores to be sliced into five 5-cm segments. Groups of ten locations will be composited into 5 composite samples, one for each sediment layer, yielding a total of 500 samples per event.

G.2.4 Geophysical Monitoring under Monitored Natural Attenuation

The last monitoring program under this alternative involves the acoustic mapping of sediment properties and river bathymetry. This program is outlined on Table G-1d. The geophysical surveying via acoustic techniques is very similar in style to the Phase 2 efforts completed in 1992. In this instance, side-scan sonar and multibeam sensors will be used to simultaneously collect data on sediment type, sediment thickness (sub-bottom profiling) and bathymetry. Additional coverage of the river bottom for bathymetry, specifically for the purpose of assessing sediment burial or resuspension over time, will be conducted in addition to the regular acoustic survey. The timing for this task is intended to provide a large quantity of data on the sediments and their spatial variability at the beginning of the program followed by more-regular, less frequent monitoring later in the program. Specifically, the acoustic survey will be conducted quarterly in the first year, followed by annual surveys in years 2 to 5, with surveying on five-year intervals during years 6 through 30, matching the frequency of the sediment monitoring program.

Bathymetry

A review of the Fox River studies indicated that river sediment thicknesses vary significantly and seasonally throughout the year. As part of Monitored Natural Attenuation, bathymetric data will be collected to examine this possible occurrence in the Hudson. Bathymetric data for this task will require consistent and accurate vertical control in order that differences in river bottom elevation over time can be discerned. In each survey, bathymetric cross sections will be measured roughly every tenth of a mile from Rogers Island to Lock 5 and in the general vicinity of *hot spots* 36 to 40, downstream. In this fashion an extensive and precise coverage of river bathymetry will be accumulated so as to permit the evaluation of changes in riverbed elevation over time.

Side-Scan Sonar and Multibeam Survey

This task will monitor the properties of the river bottom sediments, updating the USEPA side-scan sonar survey of 1992 on a regular basis. Its purpose is to document the changes in the sediment textures, morphology and thicknesses over time as a basis to evaluate sediment resuspension and deposition. These results will be used in conjunction with the bathymetric data described above.

G.3 Design Support

Unlike the previous monitoring program, the design support program does not represent a remedial alternative by itself. Rather, this program would be implemented as part of a remedial program involving sediment removal or capping. The purpose of the design support program is to provide current data on river conditions prior to the initiation of sediment remediation. In particular, this program is intended to describe the current sediment contamination levels. These data will form the basis for the final selection of sediments to be remediated whether by dredging or by capping with dredging. Because the information to be gathered on the sediments is needed for both dredging and capping scenarios, the number of samples and the sampling density are the same for both options, given the same level of clean-up. For example, the 0/10/10 clean-up scenario requires the same number of samples for both the dredging option and the capping with dredging option. This is because both programs need to know both the horizontal and vertical extent of contamination since both involve sediment removal.

The design support program involves water, sediment, fish and geophysical sampling during a one-year period. As part of this program, the five water monitoring programs previously described in section G.2, Monitored Natural Attentuation, will be implemented to establish water column conditions prior to remediation (see Table G-2a). Similarly, the fish monitoring program described under Monitored Natural Attenuation will be initiated as part of the design support program. Additional monitoring requirements for fish, sediment and geophysical surveying are described below and are outlined in Tables G-2b, c and d.

G.3.1 Fish Monitoring

In addition to the fish monitoring program described under Monitored Natural Attenuation (see Table G-1b for an outline of the program), the USEPA will implement a caged fish study during the design support program (see Table G-2b). This will establish a baseline of conditions for comparison to caged fish studies planned for the post-construction period. The program itself will consist of caged fish deployed at six stations in the Upper Hudson. Three rounds of sampling will be conducted (spring, summer and fall) with three replicates collected per station. This yields 18 samples per sampling event or 54 samples in total per year. PCB analyses will include Aroclor-based total PCB measurements for all samples and congener-specific measurements for 25 percent of the samples since these analyses will form the baseline for subsequent caged fish studies. The deployments themselves will last 30 days.

G.3.2 Assessment of Sediment Inventory

As discussed elsewhere in this report, several remedial scenarios have been developed which involve varying degrees of sediment removal or capping. Within a given region these can vary from no remediation (monitored natural attenuation) to the removal of all sediment. In between these two extremes are the Expanded Hot Spot removal (sediment inventory greater than 3 g/m^2 or surface concentrations greater than 10 mg/kg) and the Hot Spot removal (sediment inventory greater than 10 g/m^2 or surface concentrations greater than 30 mg/kg). These scenarios have been based on the most current data available to describe the horizontal and vertical extent of contamination but it is unclear that the dredging/capping zones selected by each approach will exactly coincide with the ultimate project goals, that is, the removal of all or nearly all sediment at the respective PCB inventory level. Additionally, given the anticipated cost of sediment removal, it would appear wise to minimize, to the extent possible, the removal of clean sediments. On this basis then the design support program will reassess the sediment PCB inventory of the Upper Hudson. Table G-2c summarizes the sampling needs for the sediment under this program.

Estimation of the number of cores required to assess the sediments is not straightforward, in part because of the need to select a minimum area unit for remediation and, more importantly, because of the inherent variability in the data. To the first issue, a minimum area unit was selected on the basis of the dredge zones defined for the program. For both the Hot Spot remediation and the Expanded Hot Spot remediation scenarios, the nominal median area selected was 5 acres, based on the minimal remedial area selected as shown in Table G-3. This table provides a list of the acreage for each individual remedial zone by remediation scenario for Sections 1 and 2 of the Upper Hudson. Based on the acreage identified, the minimum area for examination in the coring program was set at 5 acres for these remedial scenarios. Note this value is less than half of the mean remediation zone area in both remediation scenarios and thus should provide sufficient resolution for the purposes of classifying areas. For Full-Section remediation, the minimum area unit was doubled to 10 acres simply to limit the number of samples while still providing a useful size for decision making. Thus, based on the sampling programs described below, decisions for the Hot Spot remediation and the Expanded Hot Spot remediation scenarios will be based on 5-acre sampling areas and decisions on Full-Section remediation will be based on 10-acre sampling areas.

Estimation of Sampling Requirements in Remediation Areas

The estimation of the number of cores required per unit area depended on several assumptions as described below. For the selected remediation zones already identified based on the 1984 and 1994 data sets, it was assumed that the major data requirement for these zones was the depth of contamination (*i.e.,* the depth of sediment requiring remediation). It was assumed that these zones did not require recertification as being contaminated. The estimation of the number of cores required for these areas was then based the following discussion and was derived from the existing core depth information.

For those areas selected for remediation, a depth of contamination criteria was set up so as to minimize the residual contamination left behind after dredging to a specific depth. The desired depth in this case is not the mean or median depth of contamination but rather a depth that incorporates about 90 percent of the range of measured depths of contamination. Essentially, the number of cores for each sampling area should provide a 95 percent certainty that less than 10 percent of the sampling area has sediment contamination that extends beyond the cleanup depth. For example, in a previously selected remedial zone, if 90 percent of the area has PCB contamination extending to a depth of 2 ft and ten percent has PCB contamination to a depth of three feet, the remediation program would optimally select a removal/treatment depth of three feet in 95 percent of such instances. In this example, for those instances where removal/treatment to 2 feet (instead of the optimal 3 feet) is selected, approximately 5 percent of the PCB inventory would be left behind, assuming a constant PCB concentration in the entire area. In all likelihood, the actual inventory left behind would probably be less since the maximum contamination tends to lie midway through the zone of contamination and thus within the first 2 feet of sediment.

The actual calculation of the number of cores required to assess the depth of contamination was based on USEPA (1989) and is provided in part B of this appendix. The depth data on the vertical extent of PCB contamination used in the calculation were obtained from the 1994 USEPA low resolution sediment coring results for the Upper Hudson. For these cores, the depth of contamination in each core was defined as the depth to sediment less than 1 mg/kg. These data were selected for this calculation since they were considered most representative of current conditions in fine-grained sediments and they were specifically tested for "completeness" by determining the presence of cesium-137 in the bottom-most core segment. This is discussed at length in USEPA (1998). Notably, the USEPA data yield similar median and mean depths of contamination in all three sections of the Upper Hudson.

These calculations yield a requirement of 40 cores per unit area, which was applied to all selected areas. For 5-acre units, this yields 8 cores per acre with a nodal distance of 80-ft (*i.e.*, 80 ft between sampling locations). For 10-acre units, this represents 4 cores per acre with a nodal distance of 112 ft.

Briefly summarizing the above, Full-Section remediation programs required sampling at 4 cores per acre to establish the depth of contamination on a ten-acre basis. For the Hot Spot and Expanded Hot Spot remediation scenarios, the selected areas require sampling at 8 cores per acre to establish the depth of contamination on a five-acre basis.

Sampling Requirements and Selection of Areas for Screening

The sampling requirements to assess PCB inventory in areas outside the selected remediation areas turned out very similar to that required to establish depth of contamination within the remediation areas, described above. In this instance, however, it was necessary to establish both the number of cores required per sampling area as well as the areas of the Upper Hudson requiring this assessment. The estimation of the number of cores required per unit area is presented first.

The data sets for sediment PCB inventory obtained by NYSDEC and the USEPA have both been shown to best approximate a log-normal distribution (as opposed to a normal distribution (USEPA, 1997; USEPA, 1998). Based on this observation, the sampling requirements were derived assuming a lognormal distribution of the PCB inventory at the proposed time of sampling. The derivation of the sampling requirements for inventory was based on Gilbert, 1987 and are given in part C of this appendix. The criteria were set such that the coring results would yield an estimate of the median PCB concentration with a 95 percent confidence limit of $\pm$50 percent. Based on this analysis, 36 cores were required per sampling area. For 5-acre units, this yields 7.2 cores per acre with a nodal distance of 84 ft.

Like the determination of the sampling requirement itself, the selection of areas of the river requiring screening under the Hot Spot and Expanded Hot Spot remediation scenarios is also based on the observation of a log-normal distribution in the PCB data. Each sediment core or grab sample collected from the Hudson can be thought of as representing the central tendency of the local conditions. Given that the data are log-normally distributed, each sample can be thought of as a best estimate of the local median. Thus, the screening criteria were created to identify those areas of the river bottom outside the selected remediation areas that had at least a 5 percent chance of having a mean inventory greater than 10 g/m^2 or 3 g/m^2, depending on the scenario. These criteria were created assuming that the data to be collected will represent a median condition for the sediments.

The NYSDEC 1984 data set was used to estimate the overall variability of the areas selected under the Hot Spot and Expanded Hot Spot remediation scenarios. The degree of variability was estimated separately for each scenario. This variability was applied to all areas of the Upper Hudson for the purposes of selecting areas to be screened.

Given the high variability of the data, 36 cores per unit area are required to provide a 95 percent confidence limit about the sample median at $\pm$50 percent of the value of the median. Using a minimum-variance-unbiased-estimator (MVUE) of the arithmetic mean assuming a log-normal distribution (Gilbert, 1987), the screening criterion for the Hot Spot remediation scenario (*i.e.,* 10 g/m^2 threshold) is 2 g/m^2. Similarly, the screening criterion for the Expanded Hot Spot remediation scenario (*i.e.,* 3 g/m^2 threshold) is 1.2 g/m^2. Thus all areas above 2 g/m^2 require screening under the Hot Spot remediation scenario and all areas above 1.2 g/m^2 require screening under the Expanded Hot Spot remediation scenario. These areas are summarized in Table G-4. Part D of this appendix contains the derivation of the screening criteria.

Notably under the Expanded Hot Spot remediation scenario in the TI Pool, the area to screened for possible inclusion in the remediation is essentially equal in size to the areas already identified for remediation. Together they cover nearly all areas of the TI Pool. For this reason, the Expanded Hot Spot remediation scenario is assumed to survey the entire TI Pool. By comparison, the Hot Spot remediation scenario covers a much smaller area of the TI Pool but again the selected areas and the screened areas are nearly equal.

Selection of similar areas below TI Dam is problematic due to the lack of appropriate data. The USEPA low resolution cores provide sufficient coverage within the *hot spot* areas but the regions outside these areas are not well represented. The observation that the selected and screened areas matched so closely in the TI Pool was utilized in this program design for the purposes of area estimation. Thus the estimates of the screening areas below TI Dam were assumed to be equal in size to the areas selected for remediation in this region of the river for both scenarios.

<u>Sampling in Other Areas</u>

Sampling in areas of low contamination and therefore low likelihood of remediation was set at 1 core-per-acre between Rogers Island and Lock 5 and 2 cores-per-5-acres below Lock 5. The purpose of this sampling is to provide additional information on the sediment PCB inventory as well as to search for any contaminated zones not already documented.

<u>Sampling Depth</u>

Sampling depth was nominally set at 41 inches, representing three 1-ft core sections for PCB analysis and one 5-inch section at the core bottom for radionuclide analysis. As shown in Figures G-1 and G-2, which present depth of contamination data for the 1984 and 1994 coring results, a wide range in the depth of contamination has been observed. Thus, coring depth must vary with sampling area. It should be noted that the depth of contamination for the 1984 data is based on slightly different criteria due to its lower sensitivity relative to the 1994 data. Specifically, the depth of contamination for the 1984 cores was defined as the depth to nondetect levels (layers assigned a concentration of zero, thought to represent a detection limit of approximately 1 mg/kg although a strict detection limit was not defined for these data) or as the depth to a second core segment whose screening result was assigned as “cold”. In the latter case, the first “cold” segment would be assigned a value of 3.3 mg/kg while the second and all subsequent “cold” segments would be assigned a value of zero, moving from shallow to deeper sediment segments. The handling of the 1984 data is described at length in USEPA (1997).

Summary

The design support sampling program required the incorporation of several data sets in order to properly estimate the sampling density. Sampling density varied with scenario as well as by river region, since most scenarios have different goals in each region. For the areas most likely to be removed under the Hot Spot and Expanded Hot Spot scenarios, 40 cores per 5 acre-units were required to accurately assess sediment depth. For areas with a high probability of sediment contamination at or near the 10 g/m^2 and 3 g/m^2 threshold values, sampling density was estimated at 36 cores per five-acre unit. Finally, low probability areas were sampled at a low density, one core per acre or less. Derivations of the various estimates included in this section are included in parts B, C and D of this appendix. Ultimately, the remedial programs selected for detailed analysis yielded between 4,800 and 7,600 coring sites for the design support sediment sampling program. Table G-5 provides a breakdown of the coring requirements by scenario and area (*e.g.* selected areas, screened areas and other areas). Because of the extensive removal component in any capping scenario, the sampling program was estimated to be the same for both capping and dredging. Cores were nominally estimated at three feet in length consisting of three separate core segments for PCBs plus additional radionuclide analyses.

G.3.3 Design Support Geophysical Surveying

The geophysical survey has two major goals: first, to establish river bathymetry and sediment type prior to the onset of remediation and, second, to re-examine the river bottom in conjunction with the sediment sampling program discussed above as an aid to the final delineation of remediation areas. Table G-2d contains an outline of the geophysical program.

Bathymetry

Under the design support program, the collection of accurate bathymetric data is paramount for the measurement of the actual volume of sediment removed, the depth of cap installed, and achievement of the desired dredging depths. The design support bathymetric survey provides the reference surface for the interpretation of subsequent surveys for the dredged volumes, dredged depths, and cap thicknesses. To this end, the bathymetric cross-sections are to be obtained in a fairly dense coverage in the areas slated for remediation.

Side-Scan Sonar and Multibeam Survey

This task will provide current data on the nature of the river bottom sediments, updating the USEPA side-scan sonar survey of 1992, which will be approximately 10 years old when the design effort begins. This survey will also document the occurrence of debris that may interfere with sediment remediation. Finally and most importantly, this survey will be used in conjunction with the design support coring program to map out dredging/capping boundaries and sediment thicknesses and finalize the remedial design.

G.4 Construction Monitoring

This program is intended to document PCB levels in the Hudson during the remediation of the river sediments. It contains several tasks that specifically address PCB and suspended solids levels in the vicinity of the dredging operations and the resulting downstream impacts. This program also represents the confirmational sampling effort wherein sediment samples will be collected after dredging, backfilling and capping to ascertain the degree of cleanliness achieved. Tables G-6a through G-6d provide an outline of the program. The program is six years long, with the first year consisting of monitoring only while the remedial design is prepared. The latter five years involve monitoring during the remediation period itself. Note that if the Full-Section remediation is selected this program will be 8 years in length, one year prior to implementation plus the anticipated 7 year construction effort. Note as well that this program continues for the entire construction period, whatever its length. A 5-plus-1-year plan has been estimated based on the preferred alternative.

G.4.1 Water Column Monitoring During Construction

This program will continue the weekly time-of-travel monitoring for the Upper Hudson as well as the monthly Lower Hudson water column monitoring begun during the Design Support program (see Table G-6a). These programs are the same as those originally defined under Monitored Natural Attenuation. It is important that these water-column monitoring efforts begin prior to the initiation of remedial operations so as to establish a baseline for subsequent comparisons during and after construction. The monthly monitoring in the Lower Hudson will also examine the impacts of remediation on the Lower Hudson, if any occur.

There are two important water column programs added during construction. The first is the monitoring of suspended solids in the vicinity of the dredging operations. Twice daily measurements of suspended solids via turbidity meter will be made upstream and downstream of each dredge. Approximately 10 percent of the turbidity measurements will be confirmed by a direct suspended solids measurement. These measurements serve to monitor the escape of suspended solids from the dredging operations and will serve to trigger the following program when turbidity exceeds a specific threshold.

When turbidity exceeds a specific level in the downstream measurement, this event will serve to trigger a water column time-of-travel sampling event. These events constitute the last water column program under Construction Monitoring and represent water column sampling in addition to the weekly monitoring. In these events, the water column monitoring will be conducted so as to track the plume of increased turbidity as it travels downstream.

G.4.2 Fish Monitoring During Construction

This program is identical to the fish monitoring program proposed under Monitored Natural Attenuation (compare Tables G-6b and G-1b). In this case, the fish monitoring results will serve to integrate the 6-month to several-year impact of the remedial operation if an impact occurs and is significant enough to be observed. Caged fish studies begun during the Design Support program will be suspended and will recommence during the post-construction monitoring

G.4.3 Confirmational Sediment Sampling

This program is designed to document the degree of cleanup achieved by the remediation activities. Specifically, it consists of sediment core collection in the remediation zones after dredging, backfilling and capping (see Table G-6c). In the case of dredging, core collection will serve to document the removal of the PCB inventory and the attainment of acceptable PCB concentrations. This will be accomplished via a field laboratory, presumably using an immunoassay technique for a threshold PCB concentration. Twenty-five percent of the samples will be sent to a conventional laboratory for PCB, organic carbon and radionuclide (cesium-137) analyses. Sampling to confirm the dredging operation will be fairly dense, until an anticipated success rate and the degree of post-dredging sediment variability can be determined. The task has been estimated assuming that the dredged areas will exhibit the same level of variability as seen in the historical data. Thus the requirement of 36 cores per 5-acre unit as derived in part C of this appendix was used in the estimate. It is estimated that 90 percent of the cores will be sampled to a depth of 4 inches. Ten percent will be analyzed to a depth of 24 inches. These percentages will likely require adjustment after the remediation begins and the true success rate and degree of homogeneity are known.

Confirmational sampling for the backfill program will be implemented to document an acceptable PCB level in the backfill as well as a sufficient thickness of material. Since this material will be essentially pristine prior to its placement on the river bottom, a lower rate of sampling is proposed, 15 cores per 5-acre unit. Like the dredging area sampling, the ultimate rate of sampling will need to be adjusted once the success rate and degree of homogeneity has been tested during the remediation itself.

The capping-plus-selective-removal scenarios will also require confirmational sampling. In those areas slated only for dredging, the sampling density will be the same as that for the regular dredging program. For all areas to be capped, confirmational coring is only required once the cap is in place. Areas to be partially dredged do not require post-dredge sampling since the sediment removal in these areas is only designed to permit the emplacement of the cap. Sampling density for the capped areas is estimated to be the same as the backfill scenario. Although the capping material is expected to be self-healing (*i.e.*, minor damage to the cap should be corrected by horizontal displacement of undamaged materials), core depths will be generally limited to 4 inches since the main point of this effort is to confirm acceptable PCB levels in the backfill material overlaying the cap.

G.4.3 Geophysical Surveying During Construction

This program is designed to document the physical volume of sediment removed and the backfill or capping material installed on the river bottom. This will be done via simple bathymetry as well as via acoustic imaging of the sediment type and thickness (side-scan sonar and multibeam). Table G-6d contains an outline of the program.

Bathymetry

Bathymetric surveys will be required for all areas of sediment removal to assess the degree of success in sediment removal. It is expected that bathymetric surveying will be completed prior to any confirmational sediment core collection. For the purposes of the cost estimate, a nominal survey unit of 10 acres has been assumed. The survey itself will consist of both cross-sectional and longitudinal sweeps so as to provide net-like coverage of the removal areas. Some manual bathymetric surveying will be required in very shallow water where access by the survey boat is limited.

Bathymetric surveys will also be performed to confirm the volume and thicknesses of backfill and capping material. For dredged areas, this represents a single additional survey after the backfill material has been installed. For the capped areas, two bathymetric surveys will be required. The first follows the emplacement of the cap itself to assess the success of the installation and the thickness installed. A second survey will be required after the backfill has been installed, to confirm that an appropriate thickness has been installed.

Side-Scan Sonar and Multibeam Surveys

This program has essentially the same goals as the bathymetric surveys. In this instance, however, the program will examine the changes in sediment texture as a basis for affirmation of a successful removal and installation. This survey also permits the review of the conditions in between the lines of the bathymetric coverage "net" and thus can identify additional areas where the removal, capping or backfill may have been incomplete. These surveys will be conducted from the same survey boat as the bathymetry and it is expected that a single provider will conduct both surveys. A side-scan sonar/multibeam survey will be completed with each of the bathymetric surveys described above. In all cases, both the bathymetric and side-scan sonar surveys will be conducted prior to confirmational core collection. It is expected that the geophysical data collected will assist in the selection of some coring locations. Both the bathymetric and side-scan sonar/multibeam surveys will use the design support geophysical surveys as a reference baseline in determining removal and capping success.

G.5 Post-Construction Monitoring

This program is viewed as a monitored natural attenuation program initiated after the remediation. Thus, it involves nearly all aspects of the monitored natural attenuation program. The program extends for 25 years after the completion of the construction period. Initially, the frequency of data collection is quite similar to that of the Monitored Natural Attenuation. Unlike Monitored Natural Attenuation however, it is anticipated that the need for frequent monitoring will decline several years after the remediation is completed. The anticipated rate of decline is based in part on the degree of expected PCB removal or isolation. The anticipated rate of decline is reflected in the planned duration of the scenario-specific monitoring programs. The programs are discussed by matrix below.

The purpose of the post-construction monitoring program is to document the success of the remedial measures in reducing PCB levels in the water, sediments and fish of the Hudson River. Thus this program involves the sampling of all three media. TablesG-7a through G-7d provide an outline of the program.

G.5.1 Surface Water Monitoring for Post-Construction

The design of the post-construction water-column program is identical to that of Monitored Natural Attenuation (compare Table G-7a with Table G-1a). In this instance, however, the results will document the impact of the remediation. Additionally, with the removal of PCBs from the Hudson, the monitoring required for PCBs in the water column should decline over time. It is expected that the monitoring requirements would decrease as the amount of PCB removed increases. Thus, for all removal scenarios, weekly water column and float survey studies are implemented for only the first 10 years following dredging. Note that due to the inherently less secure nature of the capping programs, the water column programs are continued throughout the 25 year post-construction period for these scenarios.

For the removal scenarios after the initial, intense ten-year monitoring period, monitoring decreases to quarterly time-of-travel monitoring and the float surveys are discontinued. Water column monitoring of suspended solids also declines from daily measurements to monthly. In each instance the decision to decrease the rate of monitoring will be made at the appropriate time. The periods specified above are best estimates needed for cost estimation.

G.5.2 Fish Monitoring for Post-Construction

The fish monitoring program for the post-construction period is identical to that of Monitored Natural Attenuation (compare Tables G-7b and G-1b) with the one exception discussed below. The purpose here is to closely monitor fish body burdens throughout the Hudson as they respond to the remedial efforts. These results will serve to document the anticipated decline in fish body burdens and provide the data needed by the NYSDEC to regulate and eventually reopen the Hudson fishery when appropriate. Because the recovery of fish body burdens is expected to take as much as a decade or more despite the remediation, the monitoring program was estimated for the entire 25-year period.

In addition to the regular fish monitoring described above, caged fish will also be deployed and collected in the post-construction period to monitor the impacts of water-column exposures to fish after construction. These data provide a basis for establishing the impact of the upstream dredging efforts on downstream fish exposure. This program will be implemented for 10 years.

G.5.3 Sediment Monitoring for Post-Construction

The sediment monitoring program consists of two tasks, the first designed to document the long-term response of the river to the remediation and the second to monitor changes in the remediation areas themselves. The first task is the collection of dated sediment cores, which has been previously discussed. Here the integrating nature of these cores will document the long-term recovery of the Hudson. The duration of this task for all removal scenarios extends nine years with coring events in years 1, 4, and 9. For capping scenarios, the program duration is 25 years, with coring events in years 1, 4, 9, 14, 19, and 24.

The second task involves the monitoring of the remediation areas to document the changes, if any, in the thicknesses of the backfill material and its level of contamination. It will also document any recontamination of surface sediments. Specific to the capping scenarios, this sampling should also verify that the integrity of the caps by showing that the capping material has not been exposed from under the backfill material. Thus the sediment sampling program is substantially larger and more frequent for the capping alternatives than for the dredging alternatives. Specifically, for the removal scenarios, 250 sites will be occupied on three separate occasions, years 1, 4 and 9 of the post-construction period. For the capping scenarios, the caps will be sampled approximately every five years at 500 locations throughout the post-construction period. This frequency is approximately the same as proposed under the Monitored Natural Attenuation scenario, *i.e.*, years 1, 4, 9, 14, 19, and 24 (see Table G-7b).

G.5.4 Geophysical Surveying for Post-Construction

Geophysical surveys will be conducted on a routine basis to monitor changes in the installed backfill and capping material and identify areas undergoing scour or deposition. These data will be particularly important to the capping option since they can be used to assess the integrity of the cap over time. The program is similar in structure to the geophysical survey planned for the construction monitoring program and will use the geophysical survey data from the construction monitoring program as a baseline for comparison. The frequency of sampling is the same as the sediment monitoring program. This program will be completed just prior to the sediment sampling as an aid in the selection of coring sites.

<u>Bathymetry</u>

Bathymetric surveys will be required for all areas of sediment remediation to assess the degree of change in installed materials. For the purposes of the cost estimate, a nominal survey unit of 10 acres has been assumed. The survey itself will consist of both cross-sectional and longitudinal sweeps so as to provide “net-like” coverage of the removal areas. Some manual bathymetric surveying will be required in very shallow water where access by the survey boat is limited.

Bathymetric surveys will be performed to monitor the elevation of the sediment-water interface in areas of backfill and capping. For the dredging scenarios, surveying is scheduled for the three years of sediment inventory coring described above since the contaminated sediments have largely been removed. The capping plus select removal scenarios will require more frequent surveying to ensure that the caps remain intact. Thus the geophysical surveying will be done once every three years coinciding with the sediment coring program for the capping scenarios.

Side-Scan Sonar /Multibeam Survey

This program has essentially the same goals as the bathymetric surveys. In this instance, however, the program will examine in the changes in sediment texture primarily as a basis to assess cap integrity. This survey also permits the review of the conditions in between the lines of the bathymetric coverage net and thus can identify additional areas where the cap integrity may be compromised. A multibeam survey will be completed with each of the bathymetric surveys described above. In all cases, both the bathymetric and side-scan sonar surveys will be conducted prior to sediment inventory core collection. It is expected that the geophysical data collected will assist in the selection of some coring location

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Table G-1a
Monitoring Program for Monitored Natural Attenuation Alternative
(Water Program)

Monitored Natural Attenuation

Duration 30 Yrs

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBS -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater Waterford, and Troy.	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12 / yr	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	Suspended Solids Monitoring	daily	13	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Fort Miller[1] Schuylerville Stillwater Waterford Moses Kill Snook Kill Batten Kill Fish Creek Hoosic River	13	-Total Suspended solids -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy. -Flow[3] on all major tributaries -Fraction organic carbon on TSS (20 times/yr)	Permanent monitoring stations at each station to continously measure flow and to collect daily TSS samples *to be done on 10% of the samples*	Establish solids balance for the Upper Hudson Determine whether each reach is net depositional Monitor variation in nature of suspended solids.
	TI Pool Float Survey[4]	4 / yr	25 cross-sections	Every 0.25 miles from Rogers Island to TI Dam plus Snook Kill Moses Kill	4 samples per cross-section = 100 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, -Flow[3] on all TI Pool tributaries	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.
	TI Dam to Lock 5 Float Survey[4]	4 / yr	30 cross-sections	Every 0.25 miles from TI Dam to Lock 5	4 samples per cross-section = 120 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, -Flow[3] at Schuylerville -Flow[3] on tributaries Moses Kill Snook Kill Batten Kill	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.

Notes:
1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Float survey entails sampling by drifting raft. Raft should be made to follow river flow. Water column samples include two from center channel (one at thalwig, one near-bottom) plus one in each of the shoals to either side of center.

Table G-1b
Monitoring Program for Monitored Natural Attenuation Alternative
(Fish Program)

Monitored Natural Attenuation

Duration 30 Yrs

Fish	Program	Frequency of Sampling (per year)	No. of Locations	Descriptions	Species per Station (spring/fall)	Samples Per Species	No of Samples/Year	Subtotal	Analytes	Objective
	Resident Species	2	5 (Fall) 8 (Spring)	NYSDEC Stations:					-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Examine long-term trend in PCB levels in fish throughout Hudson and assure that fish levels do not exceed unacceptable concentrations.
				Above Feeder Dam*	4/1	20	100			
				TI Pool*	4/1	20	100			
				Stillwater*	4/1	20	100			
				Albany/Troy*	4/1	20	100			
				Catskill	3/0	20	60			
				Poughkeepsie	2/0	20	40			
				Newburgh*	2/1	20	60			
				Tappan Zee	2/0	20	40	600		
	Striped Ba	2		Albany/Troy**	30/20	1	50		-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Examine long-term trend in PCB levels in striped bass throughout Hudson Monitor for possible reopening of commercial fishery
				Catskill	20/20	1	40			
				Poughkeepsie	20/20	1	40			
				Stony Point	40/40	1	80			
				Tappan Zee	40/40	1	80			
				George Washington	260	1	40			
								330		

Notes:
1. Add 5% additional samples per event for quality assurance.
* Fall stations for Young-of-year pumpkinseed
** Monthly sampling from June through October, 10 samples per month

Table G-1c
Monitoring Program for Monitored Natural Attenuation Alternative
(Sediment Program)

Monitored Natural Attenuation

Duration 30 Yrs

Sediment	Program	Frequency of Sampling	No. of Locations	Descriptions	No. of Stations/Zone	No of Samples/Station	No of Samples/Event	Analytes	Objectives
	Dated Cores	Years 1, 4, 9, 14, 19, 24, 29	12	Above Feeder Dam-RM 203 TI Pool RM 188.6 Schuylerville-RM 185.4 Stillwater-RM 177.6 Waterford-RM 168 Albany-RM 145.3 Stockport Flats-RM 124 Kingston-RM 88.6 Lents Cove-RM 44.6 Tappan Zee-RM 30 NYC Harbor-RM -1.7 Mohawk R -near Cohoes	1	25	300	Total PCBs-congener-specific Cesium-137 Berylium-7 Organic carbon	Monitor trend in sediment to assure that levels remain below unacceptable criteria. Montior to support or refute the lack of substantive dechlorination rates in PCB-contaminated sediments.
	Sediment Inventory	Every Five Years	8	Hot Spots/Dredge Zones 8, 14, 16, 25, 28, 34, 37, 39	260	5[2]	1440	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor trend in entire sediment inventory in several important areas to establish rates of change.
	Shallow Sediment Inventory	Every Five Years	1,000	Roughly replicate GE composite locations plus add additional composites	1	5 (0-5, 5-10, 10-15, 15-20, 20-25 cm)[3]	500	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor trend in shallow sediment inventory in several important areas to establish rates of change.

Notes:
1. Add 5% additional samples per event for quality assurance.
2. Be-7 in top 2 cm only. Cs-137 in bottom core segment.
   PCBs done on three main one-foot intervals.
3. 100 composite of 10 points each

Table G-1d
Monitoring Program for Monitored Natural Attenuation Alternative
(Geophysical Program)

Monitored Natural Attenuation

Duration 30 Yrs

Geophysical	Program	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Event	Analytes
	Bathymetry	Year 1 - quarterly Year 2-5 annually Year 6-30 every 5 years	Main contamination zones of the Upper Hudson from Rogers Island to Lock 2.	Bathymetric cross-sections of the river must be collected in identified areas of contamination to directly measure sediment accumulation or scour. Bathymetric survey must have sufficient control to be able to resolve a few centimeters of change between sampling events.	200 cross sections per event. Cross sections should be collected every 0.1 river miles to closely and accurately monitor changes in sediment bed elevation. To be completed prior to sediment surveys.	None
	Side-Scan Sonar / Multibeam Survey	Year 1 - quarterly Year 2-5 annually Year 6-30 every 5 years	Main contamination zones of the Upper Hudson from Rogers Island to Lock 2.	Side-scan sonar to document change in sediment elevation and changes in sediment texture over time.	Multibeam survey should cover roughly 260 To be completed prior to sediment surveys.	None

Table G-2a
Monitoring Program for Design Support
(Water Program)

Design Support

Duration 1 Yrs

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBS -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater Waterford, and Troy.	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12 / yr	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	Suspended Solids Monitoring	daily	13	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Fort Miller[1] Schuylerville Stillwater Waterford Moses Kill Snook Kill Batten Kill Fish Creek Hoosic River	13	-Total Suspended solids -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy. -Flow[3] on all major tributaries -Fraction organic carbon on TSS (20 times/yr)	Permanent monitoring stations at each station to continously measure flow and to collect daily TSS samples *to be done on 10% of the samples*	Establish solids balance for the Upper Hudson Determine whether each reach is net depositional Monitor variation in nature of suspended solids.
	TI Pool Float Survey[4]	4 / yr	25 cross-sections	Every 0.25 miles from Rogers Island to TI Dam plus Snook Kill Moses Kill	4 samples per cross-section = 100 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, -Flow[3] on all TI Pool tributaries	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.
	TI Dam to Lock 5 Float Survey[4]	4 / yr	30 cross-sections	Every 0.25 miles from TI Dam to Lock 5	4 samples per cross-section = 120 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, -Flow[3] at Schuylerville -Flow[3] on tributaries Moses Kill Snook Kill Batten Kill	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.

Notes:
1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Float survey entails sampling by drifting raft. Raft should be made to follow river flow. Water column samples include two from center channel (one at thalwig, one near-bottom) plus one in each of the shoals to either side of center.

Table G-2b
Monitoring Program for Design Support
(Fish Program)[1]

Design Support
Duration 1 Yr

Fish	Program	Frequency of Sampling (per year)	No. of Locations [3]	Descriptions	Species per Station	Samples Per Species	No of Samples/Year	Total Samples per Year [2]	Analytes	Objective
	Caged Fish	3	6	Upper Hudson only:					-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Establish baseline condition for this test to assist in its application during post-construction monitoring.
				Above Feeder Dam	1	3	9			
				TI Pool-north end	1	3	9			
				TI Pool-south end	1	3	9			
				Schuylerville	1	3	9			
				Stillwater	1	3	9			
				Waterford	1	3	9	54		

Notes:
1. Also included the fish monitoring program outlined in Table G-1b.
2. Add 5% additional samples per event for quality assurance.
3. Thiry day deployments, spring, summer and fall.

Table G-2c
Monitoring Program for Design Support
(Sediment Program)

Design Support

Duration 1 Yr

Note: Water column and fish sampling programs for monitored natural attentuation must begin prior to the remedial operation itself
This program is simply intended to define sediment areas for remediation

Sediment	**Program**	No. of Locations Program	Number[4]	Comments	No. of Samples/Stati	Analytes[4, 7]	Objectives
	Sediment Inventory	0/0/3[1] 0/10/10[2] 0/10/MNA[1] 3/10/10[2] 0/3/MNA[3]	7,531 5,502 4,807 7,565 5,214	• Samples set into one of 5 grids (0.4 to 8 cores per acre) for selected remediation zones plus an additional areas meeting screening criteria[5, 6] • Sampling for excluded areas at 2 cores per 5 acre unit below Lock 5 and 5 samples per 5 arce unit above Lock 5. • Sampling for scenarios requiring complete removal based on depth information needs only. These regions set to 40 cores per 10 acre-unit. (Nodal distance of 112 ft.)	5[7]	Total PCBs Cesium-137 Berylium-7 Organic carbon Cation Exchange Capacity	Establish current sediment inventory to allow for final selection of sediment zones for remediation via dredging or capping Assess general degeree of contamination and properties relating to treatment. (10 percent of samples)

Notes:
1. Dredging only scenario
2. Dredging or capping scenario
3. Capping only scenario
4. Includes five percent additional samples for quality assurance.
5. Smallest area unit is 5 acres.
6. Preselected areas sampled at 40 cores per 5 acres to establish contaminated sediment depth.
   Screened areas sampled at 36 cores per 5 acres to establish sediment concentrations.
   Areas of low potential for contamination sampled at 5 cores per five acres for the areas between Rogers Island and Lock 5.
   Areas of low potential for contamination sampled at 2 cores per five acres below lock 5.
   Sampling for full section dredging performed at 40 cores per ten acres
7. PCB sampling intervals at 1 ft for a total of three feet of core.
   Portion of top 2 cm sent for Be-7 analysis, Five inch segment below bottom PCB segment sent for Cs-137

Remediation Areas Dredge	Area (acres)	Cap	Unmodified Area (acres)	Total Area (acres)
0/0/3	938		2,966	3,904
0/10/10	608	0/10/10	3,297	
0/10/MNA	562		3,343	
3/10/10	389	3/10/10	3,515	
	603	0/3/MNA	3,301	

Table G-2d
Monitoring Program for Design Support
(Geophysical Program)

Design Support
Duration 1 Yr

Geophysical	**Program**	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	No of Samples/Event	Analytes
	Side-Scan Sonar / Multibeam Survey - Dredging	One extensive survey prior to onset of remedial operations.	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and effectivenes of dredge	One survey per 10 acres	Total area for survey varies by dredge scenario. Geophysical surveys must cover at least 25 percent more area than is slated for removal. Bathymetric cross-sections needed every 50 yards in areas slated for removal	None
	-Capping w/SM	One extensive survey prior to onset of remedial operations.	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Total area for survey varies by dredge scenario. Geophysical surveys must cover at least 25 percent more area than is slated for removal. Bathymetric cross-sections needed every 50 yards in areas slated for capping	None

Remediation Areas

Dredge	Area (acres)	Cap
0/0/3	938	
0/10/10	608	0/10/10
0/10/MNA	562	
3/10/10	389	3/10/10
	603	0/3/MNA

Table G-3

Proposed Dredge Zone Areas for Expanded Hot Spot and Hot Spot Remediation Scenarios (Rogers Island to Lock 5)

***Individual* Dredge Zone Areas (acres)**	**Exp. *Hot Spot* Areas**	***Hot Spot* Areas**
TI Pool	12.5	11.7
	58.6	29.8
	5.1	2.4
	1.7	1.7
	5.2	5.2
	121.5	26.0
	0.4	39.6
	3.9	2.0
	3.5	3.1
	4.8	3.3
	9.6	7.9
	5.3	17.6
	12.4	
	25.1	
Mean Number of Acres per Area	19.3	12.5
Count	14	12
Median	5.3	6.55
TI Dam to Lock 5	37.5	29.7
	5.2	4.7
	19.5	13.8
	23.1	3.6
	6.1	6.1
	4.8	4.8
	0.9	2.7
	2.7	3.5
	5.5	4.9
	8.3	
	1.7	
Mean Number of Acres per Area	10.5	8.2
Count	11	9
Median	5.5	4.8
Combined Areas		
Mean Number of Acres per Area	15.1	10.6
Count	28	24
Median	5.4	5.65

Table G-4
Potential Remediation Areas of Upper Hudson

		TIP	TID-Lk5	Below Lk5
Selected Area (40 cores/5 acres)	Exp. *Hot Spot*	271	115	134
	Hot Spot	145	74	46
Screened (36 cores/5 acres)	Exp. *Hot Spot*	241 [1]	115 [2]	134 [2]
	Hot Spot	146	74 [2]	46 [2]

Notes:

1. Includes 25 acres which do not meet criteria. Because of its location, this area was considered too small to be excluded from screening.
2. Screened area estimate is set equal to selected area value, based on relationship seen in TI Pool, wherein the total screening area is approximately equal to the area selected for remediation.
   Screened areas below TI Dam will include areas adjacent to selected areas as well as others to be identified by side-scan sonar surveys to be completed under Design Support monitoring.

Table G-5

Details of Design Support Sediment Sample Program [1]

	Area Type	River Section + Remediation Scenario: TI Pool (section 1) Full Section	TI Pool (section 1) Exp. Hot Spot	TI Dam to Lock 5 (section 2) Full Section	TI Dam to Lock 5 (section 2) Exp. Hot Spot	TI Dam to Lock 5 (section 2) Hot Spot	Below Lock 5 (section 3) Exp. Hot Spot	Below Lock 5 (section 3) Hot Spot	Below Lock 5 (section 3) MNA
Selected for Remediation	Area (acres)	534	270	488	115	74	134	46	
	Density of Sample Locations (cores per unit area)	40	40	40	40	40	40	40	
	Area unit (acre)	10	5	10	5	5	5	5	
	No. of Cores [2]	2242	2266	2052	620	620	1126	386	
	No. of PCB Samples [3]	6726	6798	6156	1857	1857	3379	1159	
Screened Areas	Area (acres)		270		115	74	134	46	
	Density of Sample Locations (cores per unit area)		36		36	36	36	36	
	Area unit (acre)	NA	5	NA	5	5	5	5	
	No. of Cores [2]		2039		870	557	1013	348	
	No. of PCB Samples[3]		6118		2610	1671	3039	1043	
Low Level Area (Outside)	Area (acres)		0		258	169	2614	2790	2882
	Density of Sample Locations (cores per unit area)		5		5	5	2	2	2
	Area unit (acre)	NA	5	NA	5	5	5	5	5
	No. of Cores [2]		0		271	177	1098	1172	1211
	No. of PCB Samples[3]		0		813	531	3294	3515	3630

Note:

1. These totals are summed to estimate the total samplng need for a given cleaning scenario. For Example, the 0/10/10 scenario requires a total of

section 1	section 2	section 3	
2242 +	(620+657+177) +	(386+348+1172)	=5502

For each scenario and river section, the preselected plus screended plus outside areas must be summed.

2. Includes an additional 5% QC samples
3. 3 PCB segments per core

Table G-6a
Monitoring Program for Construction
(Water Program)

Construction Monitoring

Duration 5+1 Yrs

Use the Monitored Natural Attentuation program prior to 2004, including the completion of one float survey.

Water	Program	Frequency of Sampling	No. of Location	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly[4]	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBS -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy.	Time-of-travel style sampling only (I.e. sample collected sequentially from upstream to downstream in acccordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are not increasing above expected levels.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12 / yr	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	On-site Turbidity Monitoring	Twice per day per dredge[5]	5 dredges	Upstream and downstream	20 samples per day	Turbidity at several depths at each station	Each dredge will be mointored twice per day by sampling upstream and downstream of the dredging area. Measurements will be obtained from at least three depths each time. Ten percent of samples to be nalyzed for Total Suspended Solids.	Monitor suspended solids releases and effectiveness of solids controls during remedial operations.
	Event-based PCB Water Column Monitoring	When required[5]	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBs PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy.	Time-of-travel style sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess impacts of spill or leakage events. A total of 50 events, 10 per year of operation, are assumed

Notes:
1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Years 1 through 6.
5. Years 2 through 6.

Table G-6b
Monitoring Program for Construction
(Fish Program)

Construction Monitoring

Duration 5+1 Yrs

Fish	Program	Frequency of Sampling (per year)	No. of Locations	Descriptions	Species per Station (spring/fall)	Samples Per Species	No of Samples/Year[1]	Subtotal	Analytes	Objective
	Resident Species	2 [2]	5 (Fall) 8 (spring)	NYSDEC Stations:					-Aroclor total PCBs	Examine long-term trends
				Above Feeder Dam*	4/1	20	100		-Congener-specific	in PCB levels in fish
				TI Pool*	4/1	20	100		total PCBs	throughout Hudson and
				Stillwater*	4/1	20	100		-Lipid content	assure that fish levels do
				Albany/Troy*	4/1	20	100			not exceed unacceptable
				Catskill	3/0	20	60			concentrations.
				Poughkeepsie	2/0	20	40			
				Newburgh*	2/1	20	60			
				Tappan Zee	2/0	20	40	600		
	Striped Bass	2 [2]		Albany/Troy**	30/20	1	50		-Aroclor total PCBs	Examine long-term trends
				Catskill	20/20	1	40		-Congener-specific	in PCB levels in striped
				Poughkeepsie	20/20	1	40		total PCBs	bass throughout Hudson
				Stony Point	40/40	1	80		-Lipid content	
				Tappan Zee	40/40	1	80			Monitor for possible
				George Washington B	20/20	1	40			reopening of commercial
								330		fishery

Notes:
1. Add 5% additional samples per event for quality assurance.
2. Years 1 through 6
* Fall stations for Young-of-year pumpkinseed
** Monthly sampling from June through October, 10 samples per month

Table G-6c
Monitoring Program for Construction
(Sediment Program)

Construction Monitoring
Duration 5+1 Yrs

Sediment	**Program**	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	No of Samples/Event[3]		Analytes
	Confirmational Core collection -Dredging	As necessary to demonstrate compliance with dredging residual criteria.	36 cores per unit remediated[2] Grabs only as a last resort	These samples to be placed in remediation zones. For five-acre units, samples set into an 84 ft grid (1 sample per 6,050 sq ft) .	90% @ 1 sample per station (0-4 in) 10% @ 3 samples per station (0-4, 4-12, 12-24 in)	Depends on scenario 0/0/3 => 0/10/10 => 0/10/MNA=> 3/10/10 =>	7,430 4,813 4,449 3,085	Total PCBs by immunoassay or field lab. 25% by conventional method for total PCBs cesium-137 and organic carbon.
	-Backfill	As necessary to demonstrate compliance with backfill residual criteria.	3 cores per acre remediated	These samples to be placed in remediation zones. 1 sample/14,500 sq ft	90% @ 1 sample per station (0-4 in) 10% @ 3 samples per station (0-4, 4-12, 12-24 in)	Depends on scenario 0/0/3 => 0/10/10 => 0/10/MNA=> 3/10/10 =>	- - - -	Total PCBs by immunoassay or field lab. 25% by conventional method for total PCBs and organic carbon.
	-Capping w/SM	As necessary to demonstrate compliance with capping+backfill residual criteria.	3 cores per acre remediated	These samples to be placed in remediation zones. 1 sample/14,500 sq ft	100% at 1 sample per station (0-4 in)	Depends on scenario 0/10/10 => 3/10/10 => 0/3/MNA =>	- - -	Total PCBs by immunoassay or field lab. 25% by conventional method for total PCBs and organic carbon.

Notes:
1. Add 5% additional samples per event for quality assurance.
2. Sampling density derived from same basis as design sampling.
3. Number of samples based on pre-selected areas plus 10 percent to allow for the additional of other areas for removal based on the design monitoring program.
   Number also based on a 5 acre unit area as applied in other programs.

Table G-6d
Monitoring Program for Construction
(Geophysical Program)

Construction Monitoring

Duration 5+1 Yrs [1]

Geophysical	**Program**	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	No of Samples/Event	Analytes
	Side-Scan Sonar / Multibeam Survey - Dredging	As necessary to demonstrate compliance with dredging goals	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and effectiveness of dredge	One survey per 10 acres	Assume 5 percent will need resurveying after re-dredging operation Total area for survey varies by dredge scenario	None
	- Backfill	As necessary to demonstrate compliance with backfill goals	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Assume 5 percent will need resurveying after re-backfill operation Total area for survey varies by dredge scenario	None
	- Capping w/SM	As necessary to demonstrate compliance with capping+backfill goals	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Assume 5 percent will need resurveying after re-backfill operation Total area for survey varies by capping scenario	None

Note:
1. Years 2 through 6 only

Table G-7a
Monitoring Program for Post-Construction Period
(Water Program)

Post-Construction Monitoring
Duration 25 Yrs

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly[5]	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater Waterford, and Troy.	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12/yr[5]	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	Suspended Solids Monitoring	4/yr[7]	13	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Fort Miller[1] Schuylerville Stillwater Waterford Moses Kill Snook Kill Batten Kill Fish Creek Hoosic River	260	-Total Suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy. -Flow[3] on all major tributaries	4 twenty-day sampling events, one event for each season, consisting of daily composite suspended matter samples. Spring event to correspond to peak flow event *This program will require at least five to seven years to simply begin to satisfy the objectives.*	Establish solids balance for the Upper Hudson Determine whether each reach is net depositional
	TI Pool Float Survey[4]	4/yr[6]	25 cross-sections	Every 0.25 miles from Rogers Island to TI Dam plus Snook Kill Moses Kill	4 samples per cross-section = 100 samples per event	-Congener-specific PCbs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, -Flow[3] on all TI Pool tributaries	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possibly the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments after remediation.
	TI Dam to Lock 5 Float Survey[4]	4/yr[6]	30 cross-sections	Every 0.25 miles from TI Dam to Lock 5	4 samples per cross-section = 120 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, -Flow[3] at Schuylerville -Flow[3] on tributaries Moses Kill Snook Kill Batten Kill	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possibly the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments after remediation.

Notes:
1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Float survey entails sampling by drifting raft. Raft should be made to follow river flow. Water column samples include two from center channel (one at thalwig, one near-bottom) plus one in each of the shoals to either side of center.
5. Decreases to quarterly monitoring after 5 years for 0/0/3 scenairo and after 10 years for all other removal scenarios.
6. Discountinued after 5 years for 0/0/3 scenario and after 10 years for all other removal scenarios.
7. Decrease to monthly sampling after 5 years for 0/0/3 scenario and after 10 years for all other removal scenarios.

Table G-7b
Monitoring Program for Post-Construction Period
(Fish Program)

Post-Construction Monitoring

Duration 25 Yrs

Fish	Program	Frequency of Sampling (per year)	No. of Locations	Descriptions	Species per Station (spring/fall)	Samples Per Species	No of Samples/Year	Subtotal	Analytes	Objective
	Resident Species	2	5 (Fall) 8 (Spring)	NYSDEC Stations:					-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Examine long-term trends in PCB levels in fish throughout Hudson and assure that fish levels do not exceed unacceptable concentrations.
				Above Feeder Dam*	4/1	20	100			
				TI Pool*	4/1	20	100			
				Stillwater*	4/1	20	100			
				Albany/Troy*	4/1	20	100			
				Catskill	3/0	20	60			
				Poughkeepsie	2/0	20	40			
				Newburgh*	2/1	20	60			
				Tappan Zee	2/0	20	40	600		
	Striped Bass	2		Albany/Troy**	30/20	1	50		-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Examine long-term trends in PCB levels in striped bass throughout Hudson Monitor for possible reopening of commercial fishery
				Catskill	20/20	1	40			
				Poughkeepsie	20/20	1	40			
				Stony Point	40/40	1	80			
				Tappan Zee	40/40	1	80			
				George Washington I	20/20	1	40	330		
	Caged Fish[2]	3	6	Upper Hudson Only:					-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Monitor for impacts of remedial activities on fish after construction is complete.
				Above Feeder Dam	1	3	9			
				TI Pool-north end	1	3	9			
				TI Pool-south end	1	3	9			
				Schuylerville	1	3	9			
				Stillwater	1	3	9			
				Waterford	1	3	9	54		

Notes:
1. Add 5% additional samples per event for quality assurance.
* Fall stations for Young-of-year pumpkinseed
** Monthly sampling from June through October, 10 samples per month
2. This program is run for 10 years.

Table G-7c
Monitoring Program for Post-Construction Period
(Sediment Program)

Post-Construction Monitoring

Duration 25 Yrs for capping alternatives
10 Yrs for removal alternatives

Sediment	Program	Frequency of Sampling	No. of Locations	Descriptions	No. of Stations/Zone	No of Samples/Station	No of Samples/Event[1]	Analytes	Objectives
	Dated Cores	Years 1, 4, 9, 14, 19, 24 for all CAP alternatives Years 1, 4, 9 for REM alternatives 3/10/10 0/10/MNA 0/10/10 0/0/3	12	Above Feeder Dam-RM 203 TI Pool RM 188.6 Schuylerville-RM 185.4 Stillwater-RM 177.6 Waterford-RM 168 Albany-RM 145.3 Stockport Flats-RM 124 Kingston-RM 88.6 Lents Cove-RM 44.6 Tappan Zee-RM 30 NYC Harbor-RM -1.7 Mohawk R -near Cohoes	1	25	300	Total PCBs-congener-specific Cesium-137 Berylium-7 Organic carbon	Monitor trend in sediment to assure that levels remain below unacceptable criteria. Montior to support or refute the lack of substantive dechlorination rates in PCB-contaminated sediment.
	Shallow Sediment Inventory -Removal only	Year 1.4.9	250	Examine shallowest of sediments only.		2 (0-5, 5-10 cm)	500	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor trend in shallow sediment inventory in several important areas to establish rates of change and impact of remediation.
	-Capping	Every three years for 25 capping	500	Examine shallowest of sediments only.		2 (0-5, 5-10 cm)	1000	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor cap/backfill integrity

Notes:
1. Add 5% additional samples per event for quality assurance.

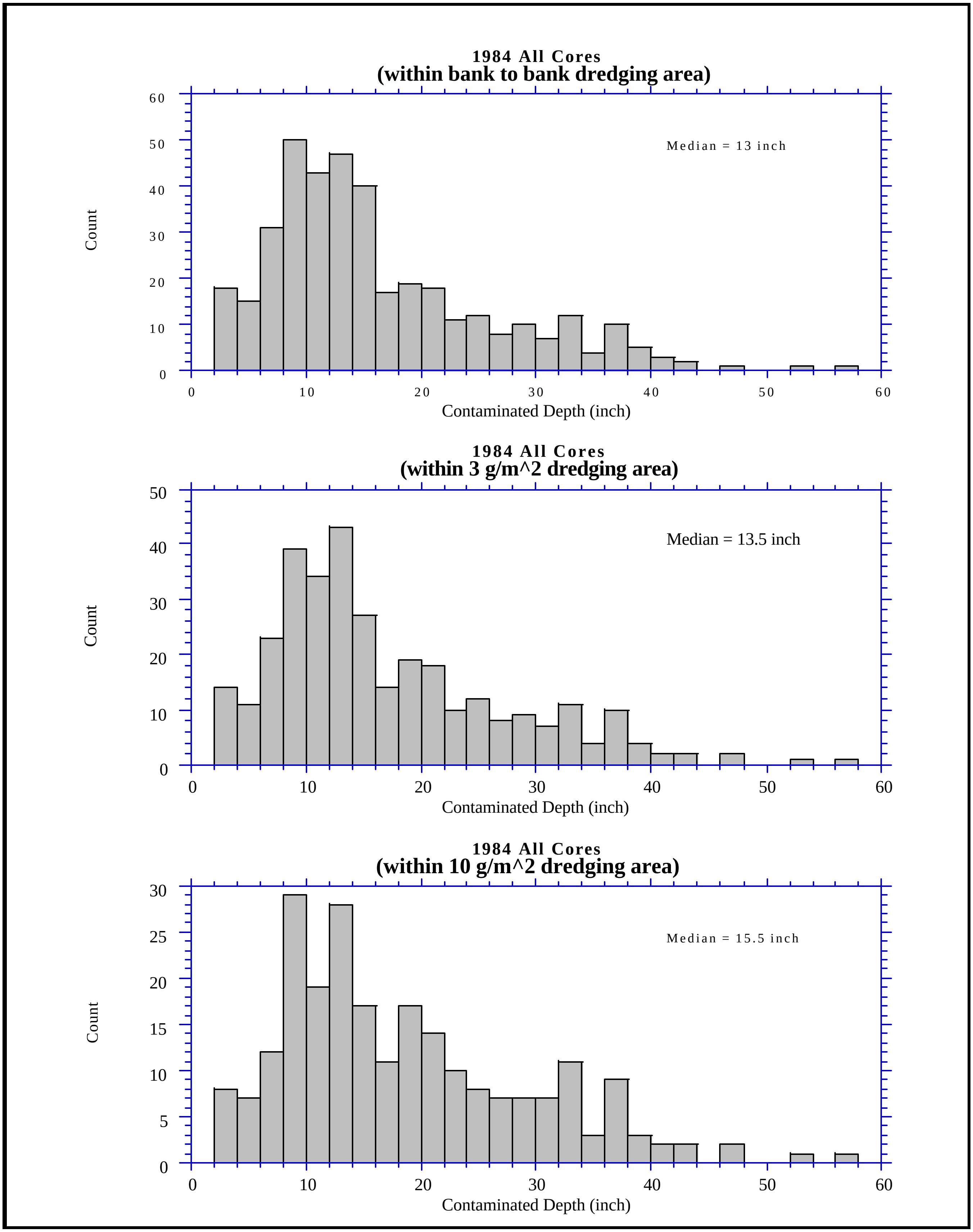
Table G-7d
Monitoring Program for Post-Construction Period
(Geophysical Program)

Post-Construction Monitoring

Duration 25 Yrs for capping alternatives
10 Yrs for removal alternatives

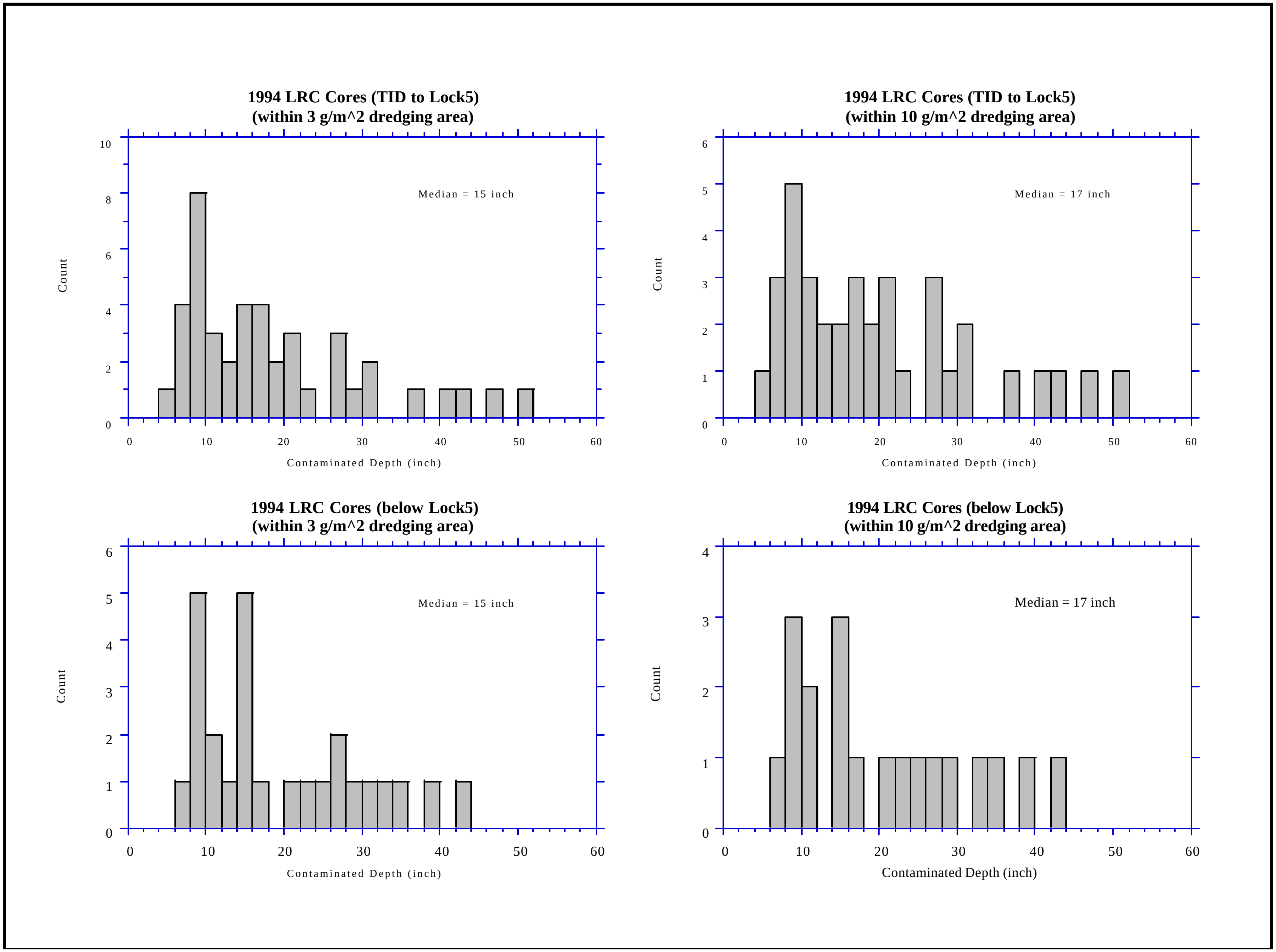
Geophysical	**Program**	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	Comment	Analytes
	Bathymetry Survey						
	- Dredging[1]	Year 1, 4, 9	Equal to number of dredge zones	Bathymetry to document change in sediment elevation with time.	One survey per 10 acres	Total area for survey varies by dredge scenario	None
	- Capping[2]	Years 1,4,9,14,19, 24, 29	Equal to number of dredge zones	Bathymetry to document change in sediment elevation and integrity of backfill plus cap	One survey per 10 acres	Total area for survey varies by capping scenario	None
	Side-Scan Sonar / Multibean Survey						None
	- Dredging[1]	Year 1, 4, 9	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and integrity of backfill plus cap.	One survey per 10 acres	Total area for survey varies by dredge scenario	
	- Capping[2]	Years 1,4,9,14,19, 24, 29	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Total area for survey varies by capping scenario	None

Notes:
1. Program ends after 9 years.
2. Program continues for entire period.



TAMS

Figure G-1
Depth of Contamination in Selected Sediment within TI Pool
(NYSDEC 1984 Results)



TAMS

Figure G-2
Depth of Contamination in Selected Sediments Below TI Dam
(USEPA 1994 Results)

Appendix G

Part B

Determination of Sampling Requirements to Assess Depth of Sediment Removal

1. Introduction

Depths of sediment removal have been estimated as part of this report for the purposes of estimating costs and selecting removal equipment. To this end, the various sediment surveys, particularly the 1976-1978 NYSDEC, the 1984 NYSDEC and the 1994 USEPA surveys have provided a useful basis for these estimates. In actuality, however, the processes internal to the river, deposition, scour, bed load transport and others may modify the local conditions and change the thickness of contamination at given location. For this reason, it will be necessary to sample the areas selected for removal prior to remediation, as part of the design support program.

The data requirements to determine removal depth depend upon the desired outcome. As noted in the main report in the removal zones, it is USEPA's intention to minimize the residual sediment PCB contamination after removal. For this reason, it will be necessary to estimate a upper limit (*i.e.*, maximum depth) on the vertical extent of contamination, and not the mean or median as is more typical. In estimating a removal depth for an area, this value will provide the desired degree of certainty that the majority of the PCB inventory has been removed.

2. Calculation of the Number of Cores for Determination of Sediment Removal Depth

The estimation of the sampling requirements to determine removal depth is derived from the sediment contamination depth information available in the USEPA low resolution core results. For the low resolution cores, the depth of contamination was defined as the depth to a PCB concentration less than 1 mg/kg. These data are summarized below:

Statistics on Low Resolution Cores Depth of Contamination

	TI Pool	TI Dam to Lock 5	Below Lock 5
Mean (inch)	14.5	17.5	18.5
Median (inch)	15.0	13.5	15.0
Upper 10% (inch)	22.8	37.4	37.6
Upper 5 % (inch)	26.5	32.2	43.8
N	71	48	40
Min	5	5	6
Max	30	51	47
Depth of 2 ft capture	94%	80%	76%

From these data it is evident that sediment contamination is shallower in the TI Pool than in areas downstream. It is unlikely that these differences are due to sampling site selection since the LRC program was intended to characterize contamination in areas of fine-grained sediment both in the TI Pool and downstream of the TI Dam.

The importance of the selection of an accurate removal depth is evident in the following calculation. Given a 100 ft^2 area with 95 percent of its surface underlain by 2 ft of contamination and 5 percent underlain by 3 ft, setting the removal depth to 2 ft yields the following:

Dredge volume	= 100 ft^2 * 2 ft	= 200 ft^3
	= (95 ft^2 at 2 ft and 5 ft^2 at 3 ft thick but only 2 ft of removal)	
Residual volume	= 5 ft^2 * 1 ft	= 5 ft^3
Total volume	= 200 + 5	= 205 ft^3
Volume fraction left behind	= 5/205	= 2.4%

If the PCBs are assumed to be equally distributed throughout the sediment, then 2.4 percent of the PCB mass would remain as well. On the resolution of 1 ft intervals, the assumption of a constant concentration is not overly conservative since deeper cores tend to have higher average concentrations.

If 75 percent of the 100 ft^2 area is contaminated to 2 ft and 25 percent extends to 3ft, the following is obtained:

Dredge volume	= 100 * 2	= 200 ft^3
Remaining Volume	= 25 *1	= 25
Fraction Remaining	= 25/225	= 11%

As evident in the summary table above, a removal depth of 2 ft in the TI Pool would leave behind PCB-bearing sediments in about 6 percent of the coring sites. If the sediment mass is proportional to PCB mass, this would leave roughly 3 percent of the PCB inventory. A similar depth downstream would yield a residual of about 10 percent of the PCB inventory in removal zones below TI Dam.

To minimize this occurrence, the USEPA's design support program will characterize sediment depths throughout the areas selected for removal. In this fashion, the most appropriate depth of removal will be applied to each removal zone, minimizing the residual PCB inventory and avoiding unnecessary sediment removal.

The derivation of the number of samples required is based on USEPA (1989). The desired number of samples (n_d)to determine whether a specific proportion of an exceeds some threshold is given by

$$n_d = \left\{ \frac{z_{1-b}\sqrt{P_1(1-P)_1} + z_{1-a}\sqrt{P_0(1-P_0)}}{P_0 - P_1} \right\}^2$$

Where:

n_d	The desired samples size for the statistical calculations.
a	The desired false positive rate for the statistical test to be used. The false positive rate for the statistical procedure is the probability that the depth of contamination in the study area will be declared to be at a specified depth when in fact it is deeper.
β	The false negative rate for the statistical procedure is the probability that the depth of contamination in the study area will be declared to be at a specified depth when in fact it is shallower and the true mean is P1. The desired sample size n_d is elected so that the statistical procedure has a false negative rate of β at P_1.
$z_{1-\beta}$ and $z_{1-\alpha}$	The critical values for the normal distribution with probabilities of 1- β and 1- α..
P_0	The criterion for defining whether the depth of contamination is above or below a given depth. According to the attainment objectives, the study area depth of contamination is declared to be less than the specified removal depth if the proportion of the study area with depth of contamination greater than the specified removal depth is less than P_0 (*i.e.*, the proposed removal depth is correct is correct if $P<P_0$).
P_1	The value of P under the alternative hypothesis for which a specified false negative rate is to be controlled. Think of P_1 as the value less than P_0 ($P_1 < P_0$) that designates a very shallow area that must, with great certainty, be designated as less than or equal to the proposed removal depth by the statistical test.

For the application to the TI Pool, it was assumed that α=0.05 and β=0.2. Additionally, the target probablilities were taken as:

$P_0 = 0.1$ (10% > 2ft)	A specified removal depth would be acceptable if less than 10 percent of the study area exceeded that depth.
$P_1 = 0.01$	A specified removal depth must be selected if less than 1 percent of the study area exceeds that depth.

Based on α =0.05 and β=0.2, $z_{1-\alpha}$= 1.645, $z_{1-\beta}$= 0.842.

Inserting these values into the equation above yields a requirement of

$$n_d = 41.4 \text{ samples}$$

Thus 41.4 or nominally 40 cores are required per study area to accurately assess the sediment removal depth. At this level of sampling, there is less than a 5 percent chance that more than 10 percent of the study area exceeds the removal depth. The value of 40 was applied to all identified removal zones in estimating the design support sampling requirements. For the Hot Spot remediation and Expanded Hot Spot remediation scenarios, this value was used on a 5-acre-unit basis. For the Full-Section, this value was applied on a 10-acre-unit basis.

REFERENCES

USEPA. 1989. Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media, Report No. PB89-234959. Prepared for the USEPA, Statistical Policy Branch (PM-223), Office of Policy, Planning, and Evaluation. February 1989.

Appendix G

Part C

Determination of the Sampling Requirements to Estimate the Median Tri+ Mass per Unit Area (MPA)

1. Introduction

As noted in the main body of this report, large areas of the Upper Hudson sediments have a reasonable possibility of containing relatively high levels of PCBs. The basis for selecting these areas for screening is described in a subsequent section of this appendix. Once selected, these areas need to be assessed via sampling in order to determine whether they do exceed the threshold criteria selected by the USEPA (*e.g.,* 3 g/m^2). The size of the target areas for the Hot Spot remediation and Expanded Hot Spot remediation sceanrios have been identified in Appendix G as part of the monitoring discussion. The estimation of the number of samples required per unit area is described below and was estimated from statistics derived from the 1984 NYSDEC survey of the TI Pool. These numbers were applied to all areas of potential sampling.

The analysis of the 1984 data showed the results to be log-normally distributed. As a result, the tests for meeting or exceeding the criteria are based on the geometric mean of the data since this parameter is a good estimate of the central tendency of the data (as opposed to the arithmetic mean). The following calculations are based on Gilbert (1987).

2. Sample Requirement Estimation

To estimate the true median of log-normal distributions, the number of independent observations, n, required from a population (*i.e.,* the number of cores from an area of study) is equal to

$$n = \frac{Z_{1-a}^{2} \quad S_{y}^{2}}{\left[\ln(d+1)\right]^{2} + Z_{1-a}^{2} \quad S_{y}^{2} \ / \ N}$$

where: S_y^2 = The variance of the data
Z = The Z-score based on α
α = Defined such that $100*(1-\alpha)$ is the confidence limit required
N = The total population
d = The error in the median which can be tolerated

Since the calculation is only concerned with exceedance of a threshold, a one-sided test is used.

For all 1984 samples falling in Expanded Hot Spot remediation areas, the variance of the PCB Tri+ mass per unit area (MPA) is:

$$S_y^2 = 2.144$$

The folllowing assumptions were made in the calculation:

1. Assume one-side upper 95% confidence limit

   Z = 1.65 (from Table A1)
2. Assume d = 0.5, *i.e.*, a 50 percent error in the estimate of the median is tolerable
3. Since N represents all possible cores from a study area (5 acres), N is very large and approaches infinity.

This yields:

$$n = \frac{1.65^2 * 2.144}{[\ln(0.5 + 1)]^2} = 35.5 \approx 36$$

Thus 36 cores are required per study area (5 acre unit) in order to estimate the median value of the Tri+ MPA to $\pm$50 percent with a 95 percent confidence level that the true median will not exceed the median plus 50 percent of its value.

REFERENCES

Gilbert, R.O. 1987. *Statistical Methods of Environmental Pollution Monitoring.* Van Nostrand Reinhold, New York.

Appendix G

Part D

Determination of the Screening Criteria for the Selection of Target Areas on the Basis of the Total PCB Mass per Unit Area (MPA)

1. Introduction

As noted in the main body of this report, large areas of the Upper Hudson sediments have a reasonable possibility of containing relatively high levels of PCBs. The basis for selecting these areas for removal or capping is derived from the remediation criteria selected by USEPA. Essentially, two of the three possible criteria described in this Feasibility Study use the PCB mass-per-unit-area (MPA) as a basis for the selection of an area for treatment. The following discussion relates the sampling results to be obtained from the design study to the cleanup criteria. That is, study areas (*i.e.*, 5-acre study areas) whose geometric mean values exceed these criteria have a real probability of an arithmetic mean that exceeds the clean-up criteria.. These values were also used as a basis for the selection of areas outside of the proposed remediation zones for screening via sampling as part of the design study. This analysis, combined with the data from the 1984 survey, provides the basis for the estimate of the total number of acres of river bottom to be screened during the design study. These areas were included in the estimates of sediment coring requirements for the Expanded Hot Spot and Hot Spot remediation scenarios.

As discussed earlier in this appendix, the number of samples required per unit area was estimated from statistics derived from the 1984 NYSDEC survey of the TI Pool. These numbers were applied to all areas of potential sampling. The analysis of the 1984 data showed the results to be log-normally distributed. As a result, the tests for meeting or exceeding the criteria are based on the geometric mean of the data. This parameter is a surrogate for the median of the population and is a good estimate of the central tendency of the data under a log-normal distribution (as opposed to the arithmetic mean). Since the sediment data are log-normally distributed, the individual measurements can be thought of as estimates of the geometric mean. The existing 1984 data can be used to identify the areas for screening by comparing the measured MPA values to the screening criterion since they are both related to the central tendency of the population. The following calculations are based on Gilbert (1987).

2. Screening Value Estimation

The goal of this calculation is to derive a threshold value for the median MPA for an area of study so as to define it as meeting or exceeding the USEPA cleanup standard with a predetermined degree of confidence. The screening values vary with the threshold standard (*e.g.*, 10 g/m^2) and must be calculated separately. Additionally, the selection of a screening criterion must take into account the fact that the MPA data are log-normally distributed. The screening value must also consider the uncertainties associated with the proposed sampling requirements described previously in this appendix.

Screening Criterion for the Hot Spot Remediation Scenario

The data to estimate a screening criterion for this scenario were obtained from the total PCB MPA values of 1984 samples falling in the Expanded Hot Spot remediation areas. This represents a larger data set than that for the Hot Spot remediation alone (approximately corresponding to the 10 g/m^2 threshold) since the larger sample set was considered more representative of the general nature of PCB contamination in the TI Pool in sediments requiring remediation. These samples yielded the following summary statistics:

Mean $Log_{10}(MPA)$ $\bar{Y} = 1.4903$

Variance $Log_{10}(MPA)$ $S_y^2 = 2.1441$

StandardDeviation $Log_{10}(MPA)$ $S_y = 1.4643$

Coefficient of Variation $S_y / \bar{Y} = 0.9825$

Given that the underlying distribution is log-normal, then the best estimate of the mean for the population is given by the minimum variance unbiased estimator (MVUE) as defined in Gilbert (1987). For the purposes of screening, it is desired to certify that the upper confidence limit on the MVUE does not exceed the clean-up criterion. The upper one-sided $100(1-a)\%$ confidence limit on the MVUE is given by (Gilbert 1987):

$$UL_{1-a} = \exp(\bar{Y} + 0.5S_y^2 + \frac{S_y H_{1-a}}{\sqrt{n-1}})$$

where

$\bar{Y},\ S_y^2,\ and\ \ S_y$ are defined as above,

n = the number of locations in the sample (*i.e.*, cores per study area)

$H_{1-\alpha}$ = a statistic for log-normal distribution, somewhat equavalent to the t-statitistic for a normal distribution

$UL_{1-\alpha}$ = the value of the upper confidence limit on the arithmetic mean of the population.

To determine a screening value for the Hot Spot remediation scenario, the value of 10 g/m^2, the MPA target value for this scenario, is substituted for the upper confidence limit on the arithmetic mean of the population ($UL_{1-\alpha}$,). Additionally, the product of the coefficient of variation and the mean log is substituted for the standard deviation as

$$S_y = Y * \text{Coeff.Var.}$$
$$S_y = Y * 0.9825$$
$$S_y^2 = Y^2 * 0.9825^2$$

In this fashion, the relationship between the standard deviation of the logs of the population and the mean log of the population (*i.e.*, the coefficient of variation) is preserved in the calculation. The equation is solved for Y, the value of the log of the geometric mean of the population:

$$10 = \exp(\overline{Y} + 0.5 * (0.9825)^2 \cdot \overline{Y}^2 + \frac{0.9825\,\overline{Y} H_{1-a}}{\sqrt{36-1}})$$

$$0.4827\,\overline{Y}^2 + (1 + 0.1661\,H_{1-a})\overline{Y} - 2.3 = 0$$
$$H_{1-a} = 2.562$$

The value for $H_{1-\alpha}$ is obtained from Gilbert (1987) and n is taken as 36, as derived from the discussion on the estimation of the median MPA, given previously in this appendix. This yields:

$$\overline{Y} = 1.587$$

$$S_y = 1.38$$

Geometric Mean MPA (g/m^2) = $e^{(1.58675)}$ = 3.2 g/m^2

This calculation is based on knowing the true geometric mean of the population. The calculation also needs to recognize that the geometric mean determined from the design sampling will have a uncertainty of $\pm$ 50 percent. Thus, the geometric mean value of the sample group (*i.e.*, the set of 36 cores) must be less than 3.2 g/m^2 by 50 percent and is given by:

$$\hat{Y} + 0.5 * \hat{Y} = 3.2$$

$$\hat{Y} = 2.1$$

where $\hat{Y}$ is the geometric mean of the sample group.

Thus the screening level for the Hot Spot remediation scenario is 2.1 g/m^2.

Screening Criterion for the Expanded Hot Spot Remediation Scenario

The data to estimate the screening criterion for this scenario were again obtained from the total PCB MPA values of 1984 samples falling in the Expanded Hot Spot remediation areas. Repeating the calculation for the MPA target value of 3 g/m^2 for this scenario:

$$3 = \exp(\overline{Y} + 0.5 * (0.9825)^2 * \overline{Y}^2 + \frac{0.9825\,\overline{Y} * H_{1-a}}{\sqrt{36-1}})$$

$$0.4827\,\overline{Y}^2 + (1 + 0.1661\,H_{1-a})\overline{Y} - 1.1 = 0$$
$$H = 2.040$$

The value for $H_{1-\alpha}$ is obtained from Gilbert (1987). This yields the following value for the mean log MPA and its standard deviation:

$$\bar{Y} = 0.6630$$

$$S_y = 0.6514$$

$$\text{Geometric Mean MPA (g/m}^2\text{)} = e^{(0.6630)} = 1.94 \text{ g/m}^2$$

Correcting for the design sampling uncertainty of ± 50 percent, the geometric mean value of the sample group (*i.e.,* the set of 36 cores) is given by:

$$\hat{Y} + 0.5 * \hat{Y} = 1.94$$

$$\hat{Y} = 1.3$$

Thus the screening level for the Expanded Hot Spot remediation scenario is 1.3 g/m^2

3. Screening Values for the Tri+ MPA

An approximate estimate of the Tri+ threshold criteria for screening can be obtained by applying the correction factor for the 1984 NYSDEC sediment data (0.944) derived in Phase 2 (USEPA, 1999).

Hot Spot remediation	2.1*0.944 = **2.0** g/m^2
Expanded Hot Spot remediation	1.3*0.944 = **1.2** g/m^2

Notably, this approach is not as accurate as applying the correction before the calculation of the criteria, but this is likely to represent only a very minor adjustment to the screening values.

4. Selection of Areas to be Screened

The above calculation provides values for selection of areas for removal/capping under the Expanded Hot Spot remediation and Hot Spot remediation scenarios. These values apply to all areas of sampling, both those pre-selected for removal as well as those being screened for possible removal. As discussed above, these criteria were also used as a basis to identify those areas to undergo screening. While this is not a completely correct application, it is likely that this approach will identify all likely areas of sufficient contamination and minimize the number of contaminated areas left unaddressed. Applying these criteria to the Upper Hudson substantially increased the overall area requiring sampling during the design support program relative to the pre-selected areas alone. The discussion on the monitoring program contained in this appendix provides the details concerning the actual number of acres to be screened in each section under each scenario.

REFERENCES

Gilbert, R.O. 1987. *Statistical Methods of Environmental Pollution Monitoring.* Van Nostrand Reinhold, New York

USEPA. 1999. Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS and TetraTech, Inc. February 1999.

Appendix G

Part E

NYSDEC Fish Monitoring Program

LONG TERM HUDSON RIVER

PCB ANALYSIS PROJECT

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Project Leader Ronald J. Sloan

Ronald J. Sloan, Ph.D.

Project Quality Assurance Officer: Robert W. Bauer 9/2/97

Robert W. Bauer

Date: Revised August 27, 1997
Revised October 22, 1997

1. Project Name: Long-Term Hudson River PCB Analysis Project

2. Revised Project Requested By: Ronald J. Sloan

3. Date of Request: December 19,1996

4. Date of Original Project Initiation: 1977

5. Project Leader: Ronald J. Sloan, Ph.D.

6. Quality Assurance Officer: Robert W. Bauer

7. Project Description:

A. Objective and Scope:

Since 1977 with the implementation of the Settlement Agreement between the General Electric Company and DEC, long-term monitoring of PCB in the Hudson River system was initiated. Major fish species, either resident or migratory, to the system were slated for annual monitoring. That effort has continued largely unchanged through 1996 with modifications subject to available funding and personnel. An intensive sampling of the upper Hudson River fish in 1991 and 1992 showed that PCB concentrations in fish were sensitive to perturbations of source conditions.
The finding and defining of PCB sources in the upper Hudson River (O'Brien and Gere 1994a, 1994b) were simultaneously coupled with an intense interest in the potential for changes in managing the recreational fishery. At the same time, PCB concentrations in portions of the river, particularly in the lower section below Poughkeepsie and specifically in striped bass, reflected levels that might signal considerations for the eventual re-opening of the commercial fishery for striped bass (Sloan et al. 1995). In keeping with the New York State policies on contaminants in fish (Horn and Skinner 1985, Kim 1990), a long-term monitoring strategy is defined herein commencing with the 1997 sampling year. It is anticipated that the General Electric Company will meet most analytical and a portion of sampling costs beginning in 1997.

Attention to the contminant conditions in the Hudson River has focused almost entirely on PCBs. It is recognized that other xenobiotics also exist and persist in the system but the available data are limited and are not up-to-date. Occasionally, it is desirable and necessary to evaluate these other materials, but to still recognize that PCBs are the dominant concern.

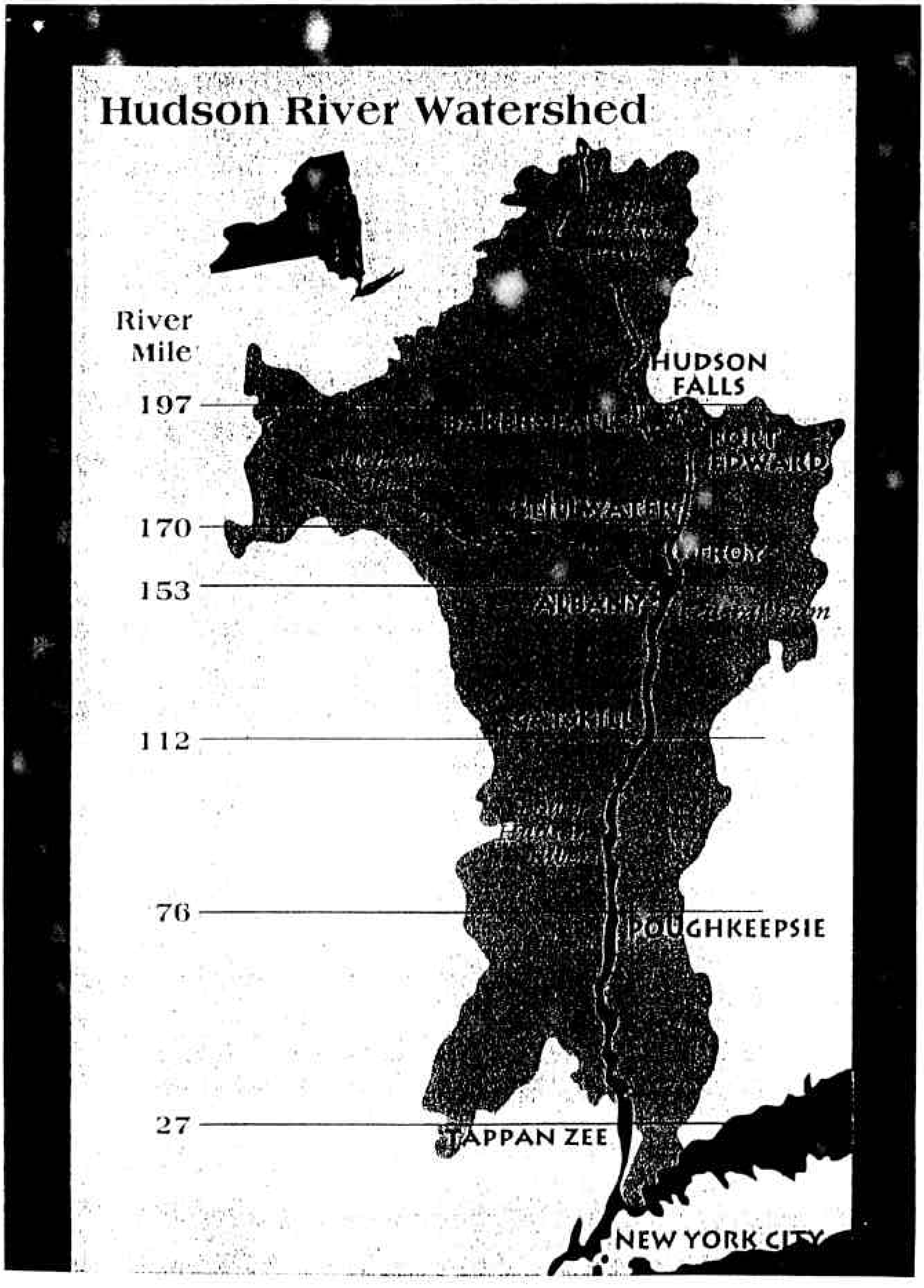
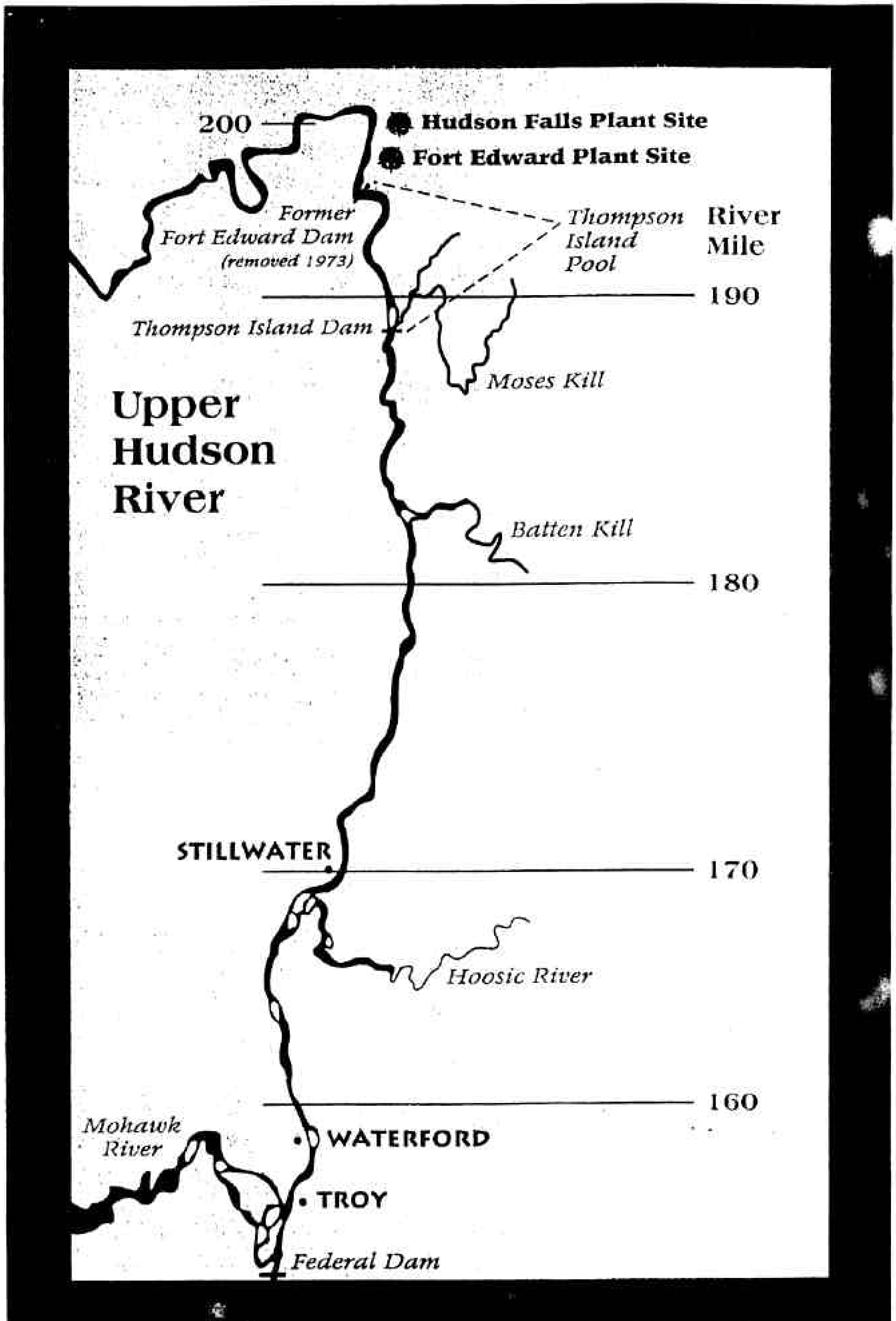


Figure 1. Locations and geographic reference points for the Hudson River used in the collection of fish for PCB analysis.



Hudson Falls Plant Site
Fort Edward Plant Site
200
Former
Fort Edward Dam
(removed 1973)
Thompson
Island
Pool
River
Mile
190
Thompson Island Dam
Moses Kill
Upper
Hudson
River
Batten Kill
180
STILLWATER
170
Hoosic River
160
Mohawk
River
WATERFORD
TROY
Federal Dam

The principal objectives are:

1. to assess temporal trends in PCB concentrations in selected resident species;

2. to evaluate spatial relationships in Hudson River PCB contamination as reflected by concentrations in the fish;

3. to ascertain PCB concentrations in the striped bass recreational and commercial fisheries for purposes of providing health advice through the New York State Department of Health and for regulating commercial fisheries when PCB levels exceed the accepted U.S. Food and Drug Administration tolerance level of 2 ppm;

4. to determine the current status of other chemical contaminants in the fishery resources of the Hudson River.

In 1988 the project plan was revised to specifically reflect three study segments since funding sources and the level of funding had varied so widely during the course of the project. Each segment was considered scientifically sound when used as an entity. The approach beginning in 1997 is to expand on these basic three segments. The expansion in 1997 is oriented toward specific questions -- better delineation of spatial and temporal gradients, a wider array of contaminants, and modifications of fishery management options. In future years, presumably by 1999, depending upon the results obtained, monitoring plans would revert to the pre-1997 effort.

B. Data usage:

The data for Segments I and II (below) are used to measure the effectiveness of PCB remedial activities and respond to the first two objectives of this project. In addition, Segment II data are useful for triggering re-evaluation of PCB in recreationally available resident fish species when levels decline significantly in key species at several locations. Segment II data are also used for health advisory assessments by the Department of Health. Segment III information is directed at evaluations for the reopening of the closed commercial striped bass fishery and relaxation of restrictive health advisories.

In addition, the data are used for reporting to state and federal agencies, interested public sectors (e.g. New York State Commercial Fishermen's Association and environmental groups), and scientific/technical groups including representatives of the General Electric Company.

C. Monitoring network design and rationale:

Over the course of the project, the species desired for collection, the numbers to be sampled, and the locations involved were updated to best reflect current estimates required for effective sample sizes, advisory needs, questions on commercial fisheries, and other resource concerns (e.g. species or sizes on which data were lacking). Major collection areas and geographic reference points pertinent to sampling are depicted in Figure 1. For 1997, all three segments are to be completed according to the activity schedules for each segment. A major change in segments I and II is the deletion of a reference (control) location above Corinth used in 1995 and 1996 since the source condition in the Sherman Island Pool was remediated in 1996 and the fish have apparently responded already with significant declines in PCB concentrations (Engineering Science 1996). Sampling above Corinth is also contraindicated since the habitat is not suitable for supporting an abundant, diverse fish community. Sampling in the pool above the Feeder Dam is once again envisioned as a "reference" location for Hudson River fish PCB conditions above Hudson Falls. A brief description highlighting each segment is presented as follows:

Segment I - Yearling Pumpkinseed

Yearling pumpkinseed are the primary indicators of PCB contamination in specific reaches of the Hudson River. This aspect of evaluating PCB contamination in the Hudson River was first implemented in 1979 to provide annual data that would indicate relatively short-term responses to perturbations in the system, and would generate suitable information for temporal and spatial trend purposes, yet would require relatively small sample sizes by utilizing a species available throughout the freshwater reaches of the river (Sloan et al. 1984). The established spatial gradient was oriented toward the predominant Hudson River PCB source located in the Ft. Edward/Hudson Falls area. Unlike other fish species sampled in the past and included in Segments II and III, the fish are relatively locally oriented in their behavior, thus are a good indicator of local PCB contamination. Any significant change in biologically available PCB will be most readily discerned by this species. Hence, in the event of limited funds for the three study segments in any sampling year, the yearling pumpkinseed were to receive first priority. Yearling pumpkinseed will maximize the amount of information gained per dollar expenditure.

Age 1+ pumpkinseed are collected at five locations:

DEC Region	Hudson River Location
5	Above Feeder Dam in West Glens Falls
5	Thompson Island Pool
5	Stillwater
4	Albany/Troy
3	Newburgh

Collect up to 25 (a target minimum of 15) yearling pumpkinseed from each location.

Originally, seventy-five (75) fish were to be collected at each location within a two week period surrounding September 30th of each collection year. Chemical analyses were to be conducted on whole fish composites (25 composites of three fish per composite from each location per year). The use of young, single-aged fish of a species having a limited home range and the use of composite sample analyses restricted data variability thereby permitting use of small numbers of sample groups to obtain spatial and temporal variability information for determining the eventual fate of PCB in the Hudson River with or without remediation measures being undertaken. In recent years, however, there was a marked decrease in pumpkinseed availability.

It is not clear whether the populations were reduced by annual sampling in restricted habitats or whether habitat conditions changed. In any event, adjusted sample size calculations based on the 1988 data indicate that 15 individual analyses for each location are sufficient to detect a 25 percent change in PCB concentrations. In the event variability is high enough that sample sizes greater than 15 are necessary, collection efforts and analytical budgets are established for a maximum of 25 fish from each location.

Sampling will occur annually. Sampling may be modified or incorporated into the monitoring requirements as part of remediation of hazardous waste site(s).

Scheduled tasks include:

Activity	Time
Sampling	September
Sample preparation	October
Transport to lab	October
Chemical analysis	November-December
Data analysis and reporting	January of year following sampling

In 1997, all samples will receive the standard PCB analysis, plus ten fish from each site will undergo mercury and cadmium analysis.

Segment II - Resident Species

Three species of fish monitored historically provide reliable indications of spatial and temporal trend information which supplement and substantiate yearling pumpkinseed data. Although their abundances have changed over the years, they have remained relatively available. In some situations, however, collection locations and methods require modification to obtain adequate numbers. These species, i.e. largemouth bass, brown bullhead, white perch plus goldfish/carp, are also species to which the public can readily relate and the data supplied will most directly affect potential modifications of fisheries use restrictions. Goldfish and carp were dropped in recent years as indicator species due to their general unavailability in the river. Reasons for their population declines are not clear but they may be related to improvements in water quality.

The recommended sampling regime is indicated in Table 1. A reference area is being added in 1997 above the Feeder Dam at West Glens Falls. This site is to replace the Corinth control location. Additionally other locations principally targeting white perch, white catfish and American eel are being added in 1997 to better correlate with the striped bass collections and their sampling locations. American eel may not be retained in the sampling plan in subsequent years if they are not readily available for sampling in 1997. Part of the rationale for the species selected is to provide commonality of species across locations so that major discontinuities in the spatial gradient do not occur.

Currently, the sampling frequency for Segment II is annual, since major changes in PCBs entering the river are anticipated, primarily reflecting ongoing and potential remedial efforts.

Scheduled tasks include:

Activity	Time
Sampling	June
Sample preparation	July
Transport to lab	August
Chemical analyses	August - October
Data analysis and reporting	January of year following collection

As conditions change in the river and it is deemed worthwhile, additional samples for other species from various locations will be considered for analysis. Examples of species for consideration may include, but are not limited to, American shad, blue crab, bluefish, blueback herring and alewife. Health advisories and fish management considerations are considered in modifying the sampling plan.

Scheduled tasks include:

Activity	Time
Sampling	
--Spring collections	April - June
--Summer collections	July - August
--Fall collections	October - November
Sample preparation	
--Spring collections	July - August
--Summer collections	September - October
--Fall collections	November - December
Transportation to lab	
--Spring collections	July - August
--Summer collections	September - October
--Fall collections	November - December
Chemical analysis	
--Spring collections	August - November
--Summer collections	September - December
--Fall collections	December - January of year following collection
Data analysis and reporting	January - February of year following collection

D. Monitoring parameters and frequency of collection:

The actual data items to be gathered and tabulated for purposes of computerization and/or producing hard copy records include: laboratory entry numbers; tag numbers; species; date collected; location of collection; collectors; method of collection; preservation method; age, sex and reproductive condition where possible and appropriate; total length; and weight.

Scales and the impressions therefrom,taken for the purposes of aging, are to become the property of the New York State Department of Environmental Conservation, Hudson River Fisheries Unit, New Paltz, NY upon the completion of the project or at the conclusion of the annual sampling period.

The analytical laboratory, in addition to supplying laboratory entry numbers, must indicate: PCB concentrations in parts per million on a wet weight basis for a range of Aroclors- 1242, 1248, 1254 and 1260, separately and as appropriate; organochlorine pesticides including the DDT complex, several compounds in the chlordane group, and dieldrin; hexachlorobenzene; the lipid content in the sample in percent; mercury and cadmium (as totals for each); and specimen tag numbers for purposes of cross-reference to DEC collection records. A recommended frequency of 10 percent for additional analyses on congeneric PCBs, dioxins, dibenzofurans and PAHs. General guidelines for collecting fish and the handling of specimens are provided in Appendix I. For this project, the general field collection procedures are applicable. Preparation methods for standard fillets and whole fish are also found in Appendix I.

The Data Dictionary, adopted and developed by the Bureau of Environmental Protection, for compiling data in a dBase or FoxPro format is detailed in Appendix III.

Table 1: Sampling design for resident fish species of the Hudson River. Species and collection numbers in bold type represent expanded efforts for long-term monitoring beginning in 1997.

Location	Region	Species[a]	Collection Numbers	Date ± 2 Weeks	Sizes (mm)	Remarks
Above Feeder Dam (reference area)	5	**Largemouth bass**[bm]	**20**	6/16	>305	
		Yellow perch*[cm]	**20**	6/16	>170	
		Brown bullhead[m]	**20**	6/16	>200	
		Goldfish/carp	**10**	6/16	>200	
Thompson Island Pool	5	Largemouth bass[lm]	20	6/16	>305	
		Brown bullhead[m]	20	6/16	>200	
		Goldfish/carp[b]	20	6/16	>200	May be mixed sample
		Yellow perch*[cm]	**20**	6/16	>170	
Stillwater	5	Largemouth bass[lm]	20	6/16	>305	
		Brown bullhead	20	6/16	>200	
		Goldfish/carp	20	6/16	>200	May be mixed sample
		Yellow perch*[cm]	**20**	6/16	>170	
Albany/Troy	4	White perch*[lm]	20	5/26	>160	
		Yellow perch*[cm]	**20**	5/26	>170	
		Largemouth bass[lm]	20	5/26	>305	
		Brown bullhead[m]	20	5/26	>200	
Catskill	4	White perch[lm]	20	5/26	>160	
		Largemouth bass[lm]	20	5/26	>305	
		American eel[m]	**10**	5/26	>150	
		White catfish[m]	**20**	5/26	>356	
Poughkeepsie	3	**White perch**[bm]	**20**	6/16	>160	
		White catfish[m]	**20**	6/16	>356	

Newburgh	3	**White perch[bm]** **White catfish[m]**	**20** **20**	6/16 6/16	>160 >356	
Tappan Zee	3	**White perch[bm]** **American eel[m]** **White catfish[m]**	**20** **10** **20**	6/16 6/16 6/16	>160 >150 >356	

*** Perch (White or Yellow) are listed due to lack of brown bullhead at Albany and goldfish/carp at Stillwater and the Thompson Island pool.**

[a] All samples are targeted for PCBs, and ½ the samples for organochlorine pesticides (largest sized individuals regardless of sex).

[b] Analyses expanded to include cadmium, polychlorinated dibenzodioxins and dibenzofurans, polycyclic aromatic hydrocarbons (PAHs), and congeneric PCBs for 1/4 of the targeted collection (largest sized specimens).

[c] Same as footnote "a" plus congeneric PCBs for 1/4 of the targeted collection (largest sized specimens).

[m] Samples also targeted for mercury.

Segment III - Striped Bass

Striped bass is the subject of one of the important commercial fisheries which has been closed due to Hudson River PCB contamination. They are also part of a growing recreational fishery which is clouded by the health advisory on limiting fish consumption due to excessive PCB concentrations. Due to their migratory nature, striped bass usually cannot be considered a good indicator of local PCB contamination, but through use of large sample sizes to counteract significant data variability, striped bass may be an indicator of relatively large scale spatial and temporal patterns of PCB contamination. Recent evaluations, however, provide some perspective on the capability of this species , even though migratory, to reflect localized source situations (Sloan et al. 1995, Skinner et al. 1996). However, the primary focus of contaminant analysis for this species has been to provide information for the proper regulation of commercial fisheries.

PCB concentrations in striped bass tend to be higher with increased distance upstream (i.e. closer proximity to the major PCB sources). A summary of results from 1994 are included herein which illustrate this point - (Table 2). In addition, there may be seasonal variations in PCB content of striped bass which also require evaluation. Therefore, any reopening of the commercial fishery will be phased in, based on data obtained for several years, seasons and locales.

Spring and Fall collections of striped bass (Table 3) are recommended annually from several locations (Figure 1). From the most recent data, 1996 and in particular 1997, the status of PCB contamination in the fish will be closely examined with regard to the possibility of managing a commercial fishery in the Hudson River. Consideration for and certification of the reopening of a once contaminated fishery is the responsibility of the New York State Department of Health under ECL 11-0325 and the "Final Environmental Impact Statement for Policy on Contaminants in Fish" (Horn and Skinner 1985). The N.Y.S. Department of Health criteria for considering the reopening of a commercial fishery are discussed in Appendix II. Any actions would also necessitate the establishment of the appropriate regulations and require the endorsement of the Atlantic States Marine Fisheries Commission.

Modifications for 1997 reflect an incresed sampling at Catskill. Further modifications will occur as necessary dependent upon the 1997 results.

Table 2. PCB concentrations in striped bass from the Hudson River in 1994

Location	Month Collected	No. of Fish	Length (mm) Ave.	Length (mm) Min. Max.	Weight (g) Ave.	Weight (g) Min. Max.	Lipid (%) Ave.	Lipid (%) Min. Max.	Lower-Cl (ppm) Ave.	Lower-Cl (ppm) Min. Max.	Higher-Cl (ppm) Ave.	Higher-Cl (ppm) Min.-Max.	Total PCB (ppm) Ave.	Total PCB (ppm) Min.-Max.
Albany/Troy (RM 153)	August	19	599	418 - 950	2392	680 - 8890	2.90	0.89 - 6.64	2.31	0.26 - 4.80	3.86	0.37- 6.60	6.17	0.63 -10.50
	October	10	589	492 - 730	2215	1200 - 4120	2.77	1.00 - 5.09	2.80	0.99 - 6.20	4.06	1.70- 7.40	6.86	2.82 -13.60
	All Dates	29	596	418 - 950	2311	680 - 8890	2.86	0.89 - 6.64	2.48	0.26 - 6.20	3.93	0.37- 7.40	6.41	0.63 -13.60
Catskill (RM 112)	May	21	659	470 - 960	3644	1100 - 9540	3.04	0.52 - 7.76	0.45	<0.05 - 2.20	2.60	0.52-11.60	3.05	0.59 13.80
Poughkeepsie (RM 76)	April	33	666	550 - 908	3273	1560 - 8940	4.97	1.53 - 9.88	0.39	<0.05 - 3.70	2.32	0.39-11.70	2.71	0.41 -15.40
	May	10	669	597 - 880	3090	2040 - 7260	5.62	2.64 - 8.57	0.30	<0.05 - 0.70	1.70	0.72- 4.80	1.99	0.91 - 5.50
	All Dates	43	667	550 - 908	3246	1560 - 8940	5.12	1.53 - 9.88	0.37	<0.05 - 3.70	2.18	0.39-11.70	2.34	0.41 -15.40
Croton Pt. (RM 40)	April	18	653	557 - 710	2887	1640 - 3900	4.32	2.41 - 6.54	0.18	<0.05 - 0.49	1.67	0.46- 3.90	1.85	0.48 - 4.39
	May	25	679	489 - 904	3452	1120 - 8560	4.47	1.41 - 7.58	0.20	<0.05 - 2.20	1.53	0.15- 7.00	1.73	0.20 - 9.20
	All Dates	43	668	489 - 904	3215	1120 - 8560	4.41	1.41 - 7.58	0.19	<0.05 - 2.20	1.59	0.15- 7.00	1.78	0.20 - 9.20
Tappan Zee Bridge (RM 27)	April	20	650	548 - 910	2981	1720 - 8760	4.49	1.43 - 7.34	0.24	<0.05 - 1.60	1.67	0.33- 6.30	1.91	0.38 - 7.90
	May	20	654	536 - 976	2997	1380 -10660	4.06	1.30 - 7.06	0.12	<0.05 - 0.62	1.07	0.31- 3.33	1.19	0.37 - 3.95
	All Dates	40	652	536 - 976	2989	1380 -10660	4.27	1.30 - 7.34	0.18	<0.05 - 1.60	1.37	0.31- 6.30	1.55	0.37 - 7.90
Lower Estuary (RM 12-76)	Spring	126	663	489 - 976	3154	1120 -10660	4.61	1.30 - 9.88	0.25	<0.05 3.70	1.72	0.15-11.70	1.97	0.23 -15.40
Haverstraw Bay/Tappan Zee(RM27-33)	November	46	646	495 - 820	3321	1400 - 6700	5.82	1.05 - 9.67	0.44	<0.05 - 1.40	1.92	0.44- 5.00	2.36	0.47 - 6.40
	December	53	628	514 - 865	2841	1500 - 5200	5.55	1.35 - 9.66	0.24	<0.05 - 1.70	1.15	0.31- 3.66	1.39	0.36 - 5.36
	All Dates	99	636	495 - 865	3064	1400 - 6700	5.67	1.05 - 9.67	0.33	<0.05 - 1.70	1.50	0.31- 5.00	1.84	0.36 - 6.40

Table 3: Sampling design for striped bass from the Hudson River. Seasons and collection numbers in bold type represent an expanded effort beginning in 1997.

Season	River-mile	Location	Collection* Numbers	Date (month)	Sizes* (mm)	Remarks
Spring - Fall	152	Albany/Troy	10[b] 10 10 10 10[b]	June July August September October	>457 >457 >457 >457 >457	
Spring (April, May & June only)	112	"Catskill" area	20 20[b]	Early run Late run	>457 >457	---- Collect 2 to 4 weeks after first collection
Spring	76	Poughkeepsie	20 20[b]	Early run Late run	>457 >457	---- Collect 2 to 4 weeks after first collection
Spring	40	Stony Point area	20 20	Early run Late run	>457 >457	---- Collect 2 to 4 weeks after first collection
Fall			20 20	~10/15 ~11/15	>457 >457	---- Collect 2 to 4 weeks after first collection
Spring	27	Tappan Zee Bridge	20 20[b]	Early run Late run	>457 >457	---- Collect 2 to 4 weeks after first collection
Fall			20 20[b]	~10/15 ~11/15	>457 >457	---- Collect 2 to 4 weeks after first collection
Spring	12	George Washington Bridge	20 20[b]	Early run Late run	>457 >457	---- Collect 2 to 4 weeks after first collection
TOTALS Sprg/Summer Fall All		Riverwide	 250 80 330		 >457 >457 >457	

*** Sizes are measured as total length (TL) in millimeters; 1/3 of total striped bass sample from each location should measure 24 inches TL (610 mm) or more; at least 10% of each sampling should be targeted to be over 33 inches TL (838 mm).**

[a] All samples targeted for PCBs and mercury; and ½ the samples for organochlorine pesticides (select the males largest to smallest; fill in with females if males are not available).

[b] Analyses expanded to include cadmium, polychlorinated dioxins and dibenzofurans, polycyclic aromatic hydrocarbons (PAHs) and congeneric PCBs for 1/4 of the targeted collection (largest males only; use females if males are not available).

E. Parameter Table:

For 1997, the maximum numbers of samples to be analyzed are 510 fillets from resident species, 330 fillets of striped bass, and 125 whole pumpkinseed. This is a maximum of 965 samples. The parameters being analyzed and pertinent analytical methods for fish preserved through freezing at -18°C or colder for a holding time of one year are:

Analyte	**Method**
Aroclor PCBs	Modified EPA 8080
Congener PCBs	ITS Environmental SOP (Modify to separate co-planar congeners;suggest procedure of Schwartz et al. 1993)
PAHs	Modified EPA 8310 (Method development might follow lines of some of the procedures reviewed by Howard and Fazio 1993)
Chlorinated dioxins/furans	EPA 8280/8290
Mercury	Modified EPA 7470
Cadmium	Modified EPA 7131
Lipid Content	En Chem SOP

Examples of general laboratory procedures using SOPs of the NYSDEC Hale creek Field Station are provided in Appendix IV.

Table 4. Data Quality Requirement and Assessments for fish tissue. A minimum of 5% of samples analyzed shall be quality assurance for spiked recoveries. A minimum of 10% of the samples analyzed shall be quality assurance for duplicates and standards.

Parameter	Detection Limit	Quantitation Limit	Estimated* Accuracy	Estimated** Precision (ppm)
Mercury	10 ng/g	50 ng/g	± 30%	0.063
Cadmium	10 ng/g	50 ng/g	± 30%	0.100
alpha-hexachlorocyclohexane (HCH)	1 ng/g	10 ng/g	± 24%	0.050
beta-HCH	1 ng/g	10 ng/g	± 24%	0.050
gamma-HCH (Lindane)	1 ng/g	10 ng/g	± 24%	0.050
delta-HCH	1 ng/g	10 ng/g	± 24%	0.050
cis-chlordane	1 ng/g	10 ng/g	± 24%	0.050
trans-nonachlor	1 ng/g	10 ng/g	± 24%	0.050
Oxychlordane	1 ng/g	10 ng/g	± 24%	0.050
p,p'-DDT	5 ng/g	10 ng/g	± 24%	0.033
p,p'-DDE	5 ng/g	10 ng/g	± 24%	0.033
p,p'-DDD	5 ng/g	10 ng/g	± 24%	0.033
Dieldrin	1 ng/g	10 ng/g	± 24%	0.050
Endrin	1 ng/g	10 ng/g	± 24%	0.050
Hexachlorobenzene (HCB)	1 ng/g	10 ng/g	± 24%	0.050
Heptachlor epoxide	1 ng/g	10 ng/g	± 24%	0.050
Mirex	5 ng/g	10 ng/g	± 24%	0.050
Oxychlordane	2 ng/g	10 ng/g	± 24%	0.050

PCB total	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1242	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1248	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1254	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1260	10 ng/g	50 ng/g	± 30%	0.649
Lipid	0.01 percent	0.01 percent	not applicable	0.10 %
2,3,7,8-TCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8-PeCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,7,8-HxCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,6,7,8-HxCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8,9-HxCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,6,7,8-HpCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,6,7,8,9-OCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
2,3,7,8-TCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8-PeCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
2,3,4,7,8-PeCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,7,8-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,6,7,8-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
2,3,4,6,7,8-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8,9-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,6,7,8-HpCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,7,8,9-HpCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g

1,2,3,4,6,7,8,9-OCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
Acenaphthene	50 ng/g	50 ng/g	to be determined	to be determined
Acenaphthylene	50 ng/g	50 ng/g	to be determined	to be determined
Anthracene	50 ng/g	50 ng/g	to be determined	to be determined
Benzidine	250 ng/g	250 ng/g	to be determined	to be determined
Benzo (a) anthracene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (a) pyrene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (a) fluoranthene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (g,h,i) perylene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (k) fluoranthene	50 ng/g	50 ng/g	to be determined	to be determined
Chrysene	50 ng/g	50 ng/g	to be determined	to be determined
Dibenzo (a,h) anthracene	50 ng/g	50 ng/g	to be determined	to be determined
Fluoranthene	50 ng/g	50 ng/g	to be determined	to be determined
Fluorene	50 ng/g	50 ng/g	to be determined	to be determined
Indeno (1,2,3-cd) pyrene	50 ng/g	50 ng/g	to be determined	to be determined
Naphthalene	50 ng/g	50 ng/g	to be determined	to be determined
Phenanthrene	50 ng/g	50 ng/g	to be determined	to be determined
Pyrene	50 ng/g	50 ng/g	to be determined	to be determined

* Accuracy is based on analysis of spiked samples. Spikes should be representative of the analyte concentration range expected in the fish samples.

In the dioxin and dibenzofuran groups, accuracy is estimated by use of selected radio-isotopes of internal, surrogate and alternate standards for each sample analyzed. Acceptance of specific results are measured against USEPA Method 8290 requirements.

** Precision is based on analysis of duplicate samples from the same specimen. If quantified values are greater than specified estimated precision than any duplicate analyses should be within ± 20 percent.

B. Project Organization and Responsibility:

Region 3 - Hudson River Fisheries Unit A. Kahnle - 914-256-3072 Region 4 - W. Keller - 607-652-7364 Region 5 - L. Strait - 518-891-1370	Sampling, storage, transportation and QC
Independent contractor - to be arranged	Sampling, storage, shipment prep, data management and QC
Suggested laboratories: En Chem, Inc. formerly Hazleton Environmental Services, Inc. Madison WI T. Noltmeyer 608-232-3310 (PCBs, organochlorine pesticides, mercury, cadmium, PAHs, lipids) ITS Environmental formerly Inchcape Testing Colchester VT (congeneric PCBs) Triangle Laboratories Research Triangle Park NC (Chlorinated dioxins and dibenzofurans)	Analyses, raw data management and reporting, billing and QC
Ronald J. Sloan, Ph.D. Project Leader 518-457-0756	Data processing and QC, laboratory data quality review, data management, data quality review, performance and system auditing
Robert W. Bauer 716-226-2466	Overall quality assurance
Ronald J. Sloan, Ph.D.	Overall project coordination
General Electric Company and other parties as needed	Fiscal resources for fish collections, technician services, laboratory analyses and project review

9. Data Quality Requirements and Assessments:

See Table 4 for analytical specifications.

Data representativeness: Fish samples shall consist of edible sizes or ages specified in the text and tables for each study segment.

Data comparability: Analyses will be performed for all fish with the exception of yearling pumpkinseed on a standard fillet. Comparisons will be made on both wet weight and lipid bases.

Data completeness: Data will be considered complete within any given study segment when all of the samples are collected dependent upon fish availability and all results are returned from the laboratory.

10. Sampling procedures:

Sampling will be by standard techniques of netting, electrofishing or angling. Fish must be of sizes or ages specified in the study segment descriptions. Yearling pumpkinseed are prepared and analyzed whole. Other species are analyzed as standard fillets. Collection data are to be recorded on the Fish/Wildlife Collection Record (Appendix I).

11. Sample custody procedures:

The Chain-of-Custody form (Appendix I) must accompany all samples to any temporary storage facility and to the Hale Creek Field Station for sample preparation and shipment. En Chem Chain-of-Custody Record and Analysis Request forms (Appendix I), only, accompany all samples shipped frozen via priority air freight to En Chem. The Analysis Request forms must be double checked for accuracy and to ensure that the shipment contents are properly accounted. Similar chain-of-custody procedures are followed when split samples are sent to other laboratories for special analyses (e.g., subsamples going to Triangle Laboratories for dioxin analyses).

12. Calibration procedures and preventive maintenance:

Normal operating procedures call for twice daily inspection of: chemical assay procedures and validation, reagent preparation and labelling, controls and standards, instrument calibration and maintenance, analytical results, data recording and analysis and archiving of data. An Internal Operating Procedure (IOP) manual detailing use, calibration and maintenance is kept with each item of analytical equipment.

13. Documentation, Data Reduction and Reporting:

A. Documentation: Raw laboratory data are stored in computer files at the laboratory. All results are generated electronically onto diskette and along with a hard copy report sheet are sent to Ronald Sloan for review and reporting. All data are checked for possible errors. As soon as data are error checked, they are provided to the General Electric Company via John Haggard, G.E. Project Manager, in hard copy and electronic format.

B. Data Reduction and Reporting: Raw data are compiled, using the DEC data dictionary format (Appendix III), tabulated, subjected to statistical analyses and reported as appropriate, usually with explanatory text. Information releases are coordinated with the General Electric Company as per the agreement between the NYSDEC and GE dated Oct. ,1997. A draft copy is attached as Appendix V.

14. Data validation:

All data, plus data from spiked recoveries, duplicates and blanks are reviewed by Ronald Sloan. Every 17 unknown samples are followed by one spiked recovery, one duplicate analysis selected at random and one blank.

15. Performance and System Audits:

The laboratories participate in performance evaluation studies conducted by the New York State Department of Environmental Conservation.

16. Corrective Action:

When a QC sample falls outside the control limits, the QC sample is rerun [if an error in calculation or reporting is not found]. If the QC sample is still outside the control limits, that segment of 17 unknown samples is voided and the samples rerun.

17. Reports:

The findings from this project will be reported in several public colloquia and as subjects of various scientific/technical manuscripts. The New York State Department of Environmental Conservation reserves the right to publish the results and findings in peer reviewed articles and publications.

18. Estimated Project Fiscal and Staff Requirements:

The following tables for each of the study segments and the overall project costs reflect the 1997 level of effort if DEC was to fully implement the plan.

Table I: SEGMENT I - YEARLING PUMPKINSEED - BUDGET PORTION FOR FY 1997 - 1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT.

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	8	$ 1,288
Research Scientist	8	1,840
Technicians	94	8,859
Fringe benefits (29.21% of personnel costs)		3,163
Subtotal personnel & fringe		15,150
Supplies and materials (s&m)		400
Travel		300
Subtotal s&m, travel		700
Total Sampling		$15,850

B. Contractual laboratory services		
PCBs, lipids		
-includes preparation, lipid analyses & shipping		
$155/sample X 125 samples		19,375
Quality Assurance		
$155/sample X 22 samples		3,410
PCB analyses subtotal		$22,785
Mercury		
$50/sample X 50 samples		2,500
Quality Assurance		
$50/sample X 9 samples		450
Cadmium		
$45/sample X 50 samples		2,250
Quality Assurance		
$45/sample X 9 samples		405
Metals analyses subtotal		5,605
Total analytical costs		28,390
C. Project oversight, data management and		
reporting	26	5,980
Research Scientist	3	616
QA Officer	3	682
Supervising Ecologist	3	255
Keyboard Specialist		
		7,533
Subtotal oversight		
		2,200
Fringe Benefits (29.21% of personnel)		
		9,733
Total Project oversight		
D. Indirect costs (31.2% of Department personnel costs)		7,764
TOTAL (A + B + C + D)		61,737

Table II: SEGMENT II - RESIDENT SPECIES - BUDGET PORTION FOR FY 1997-1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT.

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	8	$ 1,288
Research Scientist	8	1,840
Technicians	68	6,392
Fringe benefits (29.21% of personnel costs)		2,781
Subtotal personnel & fringe		12,301
Supplies and materials (s&m)		900
Travel		700
Subtotal s&m, travel		1,600
Total Sampling		13,901

B.	Contractual laboratory services		
	PCBs,lipids -includes preparation, lipid analyses & shipping $155/sample X 255 samples		39,525
	Quality Assurance $155/sample X 45 samples		6,975
	PCBs, organochlorine pesticides, lipids -includes preparation, lipid analyses & shipping $316/sample X 255 samples		80,580
	Quality Assurance $316/sample X 45 samples		14,220
	Mercury $50/sample X 440 samples		22,000
	Quality Assurance $50/sample X 78 samples		3,900
	Cadmium $45/sample X 55 samples		2,475
	Quality Assurance $45/sample X 10 samples		450
	Chlorinated Dioxins and Dibenzofurans - quality assurance is built into the analyses and is included in the data package $1250/sample X 55 samples		68,750
	Polycyclic Aromatic Hydrocarbons (PAHs) $190/sample X 55 samples		10,450
	Quality Assurance $190/sample X 10 samples		1,900
	Congeneric PCBs - quality assurance is built into the analytical package $825/sample X 75 samples		61,875
	Total analytical costs		313,100

C.	Project oversight, data management and reporting		
	Research Scientist	20	4,600
	QA Officer	2	410
	Supervising Ecologist	2	455
	Keyboard Specialist	2	170
	Subtotal oversight		5,635
	Fringe Benefits (29.21% of personnel)		1,646
	Total Project oversight		7,281
D.	Indirect costs (31.2% of Department personnel costs)		6,110
	TOTAL (A + B + C + D)		340,392

Table III. SEGMENT III - STRIPED BASS - BUDGET PORTION FOR FY 1997- 1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT.

		Staff days	Amount
A.	Sampling, processing and transportation		
	Personnel		
	Conservation biologists	15	$ 2,415
	Research Scientist	15	3,450
	Technicians	150	14,137
	Fringe benefits (29.21% of personnel costs)		5,843
	Subtotal personnel & fringe		25,845
	Supplies and materials (s& m)		1,400
	Travel		1,000
	Subtotal s&m, travel		2,400
	Total Sampling		$28,245

B.	Contractual laboratory services		
	PCBs, lipids -includes preparation, lipid analyses & shipping $155/sample X 165 samples		25,575
	Quality Assurance $155/sample X 30 samples		4,650
	PCBs, organochlorine pesticides, lipids -includes preparation, lipid analyses & shipping $316/sample X 165 samples		52,140
	Quality Assurance $316/sample X 30 samples		9,480
	Mercury $50/sample X 330 samples		16,500
	Quality Assurance $50/sample X 60 samples		3,000
	Cadmium $45/sample X 30 samples		1,350
	Quality Assurance $45/sample X 6 samples		270
	Chlorinated dioxins and dibenzofurans - quality assurance is built into the analyses and is included in the data package $1250/sample X 30 samples		37,500
	Polycyclic Aromatic Hydrocarbons (PAHs) $190/sample X 30 samples		5,700
	Quality Assurance $190/sample X 6 samples		1,140
	Congeneric PCBs - quality assurance is built into the analytical package $825/sample X 30 samples		24,750
	Total analytical costs		182,055

C.	Project oversight, data management and reporting		
	Research Scientist	43	$ 9,890
	QA Officer	13	2,670
	Supervising Ecologist	16	3,632
	Keyboard Specialist	16	1,360
	Subtotal oversight		17,552
	Fringe Benefits (29.21% of personnel)		5,127
	Total Project oversight		$22,679
D.	Indirect costs (31.2% of Department personnel costs)		15,139
	TOTAL (A + B + C + D)		248,118

Table IV. BUDGET FOR ALL STUDY SEGMENTS COMBINED FOR FY 1997-1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT - YEARLING PUMPKINSEED, RESIDENT SPECIES, AND STRIPED BASS

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	31	$ 4,991
Research Scientist	31	7,130
Technicians	312	29,388
Fringe benefits (29.21% of personnel costs)		11,787
Subtotal personnel & fringe		53,296
Supplies and materials (s& m)		2,700
Travel		2,000
Subtotal s&m, travel		4,700
Total Sampling		$ 57,996

B. Contractual laboratory services		
PCBs, lipids -includes preparation, lipid analyses & shipping $155/sample X 545 samples		84,475
Quality Assurance $155/sample X 97 samples		15,035
PCBs, organochlorine pesticides, lipids -includes preparation, lipid analyses & shipping $316/sample X 420 samples		132,720
Quality Assurance $316/sample X 75 samples		23,700
Mercury $50/sample X 820 samples		41,000
Quality Assurance $50/sample X 147 samples		7,350
Cadmium $45/sample X 135 samples		6,075
Quality Assurance $45/sample X 25 samples		1,125
Chlorinated Dioxins and Dibenzofurans - quality assurance is included in the analytical package $1250/sample X 85 samples		106,250
Polycyclic Aromatic Hydrocarbons (PAHs) $190/sample X 85 samples		16,150
Quality Assurance $190/sample X 16 samples		3,040
Congeneric PCBs - quality assurance is built into the analytical package $825/sample X 105 samples		86,625
Total analytical costs		$ 523,545

C.	Project oversight, data management and reporting		
	Research Scientist	89	$ 20,470
	QA Officer	18	3,696
	Supervising Ecologist	21	4,769
	Keyboard Specialist	21	1,785
	Subtotal oversight		30,720
	Fringe Benefits (29.21% of personnel)		8,973
	Total Project oversight		$ 39,693
D.	Indirect costs (31.2% of Department personnel costs)		29,013
	TOTAL (A + B + C + D)		$ 650,247

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