NUS CORPORATION
A Halliburton Company

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VOLUME I

FEASIBILITY STUDY

HUDSON RIVER PCBs SITE
NEW YORK

EPA WORK ASSIGNMENT
NUMBER 0·-2V84.0
CONTRACT NUMBER 38-01-6699

NUS PROJECT NUMBER 0723.01

APRIL 1984

NUS CORPORATION

Park West Two
Cliff Mine Road
Pittsburgh, PA 15275
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GLOSSARY

1 cfs (cubic feet per second) = 448.83 gpm (gallons per minute)

1 MGD (million gallons per day) = 694.4 gpm (gallons per minute)

1 l/min (liters per minute) = 0.26418 gpm (gallons per minute)

1 m^3/sec (cubic meters per second) = 15,850.3 gpm (gallons per minute)

1 ton/day (tons per day) = 730,480 lb/yr (pounds per year)

1 lb/yr (pounds per year) = 0.002738 lb/day (pounds per day)

1 lb/day (pounds per day) = 0.0417 lb/hr (pounds per hour)

1 lb/hr (pounds per hour) = 0.0167 lb/min (pounds per minute)

1 µg/day (micrograms per day) = 2.203 x 10^{-9} lb/day (pounds per day)

1 lb (pound) = 0.45359 kg (kilograms)

1 ppm (parts per million) = 1 µg/g (micrograms per gram)

1 ppb (parts per billion) ≈1 µg/l (micrograms per liter)

1 µg/g (milligrams per gram) ≈ 1 ppm (parts per million)

1 µg/l (micrograms per liter) ≈ 1 ppb (parts per billion)

1 mg/l (milligram per liter) ≈ 1 ppm (parts per million)

1 µg/m^3 (micrograms per cubic meter) = 1000 ng/m^3 (nanograms per cubic meter)

1 cu yd (cubic yards) = 0.76456 m^3 (cubic meters)

1 yd (yards) = 0.91440 m (meters)

1 ft (feet) = 0.30480 m (meters)

1 in (inches) = 2.540 cm (centimeters)

1 ac (acres) = 43,560 sq ft (square feet)

DEIS - Draft Environmental Impact Statement
EIS - Environmental Impact Statement
EPA - Environmental Protection Agency
F.D.A. - U.S. Food & Drug Administration
NEPA - National Environmental Policy Act
NIOSH - National Institute of Occupational Safety and Health
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
PCB - polychlorinated biphenyl
SDEIS - Supplemental Draft Environmental Impact Statement
SEQIS - State Environmental Quality Review Act Environmental Impact Statement
USGS - United States Geological Survey
DFS - Draft Feasibility Study
Receptor - Person or persons who could be potentially exposed to PCB occurring in air, water, sediment, soil, or biota.

EXECUTIVE SUMMARY

The Feasibility Study for the Hudson River PCB site is prepared in accordance with the rules of the National Contingency Plan (NCP) published pursuant to Section 105 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

The original Work Assignment issued by EPA was for the development of a Remedial Action Master Plan (RAMP). Before the RAMP was completed, the Hudson River PCBs Site was placed on the EPA's National Priorities List, and, as a result, became eligible for the funding of remedial actions. Since the elements required by the Work Assignment are equivalent to those for a feasibility study under CERCLA, the title of the document was changed to a Draft Feasibility Study (DFS).

The Draft Feasibility Study was submitted for public review in October of 1983, and was subsequently revised to reflect many of the concerns expressed in public comments. The final document includes those changes and is entitled "Volume I – Final Feasibility Study" although the title of RAMP is used in the text to eliminate wide-spread revision. A separate document contains detailed responses to individual comments and is entitled "Volume II – Responses to Comments, Feasibility Study, Hudson River PCBs Site, New York."

A significant amount of scientific and engineering information currently exists regarding the problems of PCBs in the Hudson River, and this information was used in the preparation of this document. Major objectives of the Feasibility Study were to reevaluate a previously prepared environmental impact statement and subsequently to compile a list of proposed and newly devleoped remedial alternatives. These alternatives were evaluated using a cost-effective approach consistent with the goals and objectives of CERCLA.

The Site

The Hudson River originates in the Adirondack Mountains in Essex County, New York, and empties into the Atlantic Ocean at the Battery in New York City. The river's 17 major tributaries drain 13, 365 square miles of land located in eastern New York State and in parts of Vermont, Massachusetts, and Connecticut. The Lower Hudson River, from its mouth in the upper New York harbor to its confluence with the Mohawk River near Albany, is a tidal estuary subject to periodic fluctuations in water level. This 150-mile reach is maintained and regulated as a Federal waterway by the U.S. Army Corps of Engineers to provide waterborne access to the port of Albany and the New York State Barge Canal. The river above Albany (Upper Hudson River) is a high-gradient, fresh-water stream confined by 15 dams. The 30-mile reach in the Upper Hudson River between Albany and Fort Edward is officially part of the New York State Barge Canal System and is maintained and regulated by the State Department of Transportation.

Over a 30-year period ending in 1977, two General Electric (GE) capacitor manufacturing plants near Fort Edward and Hudson Falls, New York discharged polychlorinated biphenyls (PCBs) to the Hudson River. Much of the PCBs in the discharges were trapped in sediments behind a 100-year-old dam at Fort Edward. After the removal of the dam in 1973, large spring floods scoured an estimated 1.1 million cubic yards of material from the former dam pool. Subsequent studies have revealed that the discharges, in combination with the removal of the Fort Edward Dam, have ultimately resulted in the dispersal of 887,000 to 1.1 million pounds of PCB throughout the entire Hudson River System south of Fort Edward. Today, it appears that much of this PCB has either been dredged or washed out to sea so that only 498,000 to 656,000 pounds remains in the river. GE is also reported to have placed an additional 528,000 to 745,000 pounds of PCB in upland dumps. The latter PCBs are not directly related to the Hudson River problem.

Action brought against GE by th New York State Department of Environmental Conservation (NYSDEC) in 1975 resulted in a 7-million-dollar program for the investigation of PCBs and the development of methods to reduce or remove the threat of PCB contamination. Subsequent sediment surveys revealed that the most extensive contamination was confined to 40 submerged PCB hot spots located in the river between Fort Edward and Albany and to five exposed remnant deposits located in the former dam pool. PCBs were also found to exist in dredge spoils on the banks of the Upper Hudson River and in sediments of the estuary. Other NYSDEC studies showed that minor quantities of PCBs were being released from river-bottom sediments to the water column and to the air and land adjacent to the river. The detection of severe PCB contamination in Hudson River fish resulted in a State-mandated ban on all fishing in the Upper Hudson River between Albany and Fort Edward and in restrictions on commercial and recreational fishing in the Lower Hudson. In addition, it was feared that the continued presence of PCBs might disrupt dredging activities needed to maintain the barge canal and Federal waterways and might curtail the development of the river for hydroelectricity. For these reasons, NYSDEC proposed a partial cleanup of the river by dredging selected PCB hot spots and containing them in a secure upland containment facility.

In September 1980, Congress passed an amendment to the Clean Water Act (CWA) under Title 1, Section 116(a) and (b), entitled, "The Hudson River PCB Reclamation Demonstration Project." Under this legislation, construction grant funds up to $20,000,000 could be authorized if the EPA Administrator determined that funds were not first available under Section 115 or 311 of the CWA or from the then proposed CERCLA. Congress authorized the EPA to make grants to the New York State Department of Environmental Conservation (NYSDEC) in order to carry out the intent of the Act.

As a result of Federal involvement and in accordance with the National Environmental Policy Act (NEPA) and requirements in Section 116, the EPA Region II, on May 8, 1981, issued a Draft Environmental Impact Statement (EIS) on the Hudson River PCB problem. This was followed by a Supplemental Draft EIS on August 18, 1981. After review of the Final EIS (issued October 8, 1982), the NEPA process was concluded on December 30, 1982 with a Record of Decision in which the EPA Administrator determined that funds for addressing this problem were available under CERCLA and that the problem rated sufficiently high to be considered for inclusion on the National Priorities List. The Hudson River PCBs Site was included on the currently proposed update of the National Priorities List issued in August 1983. Although the funding authorization of Section 116 was due to expire on September 30, 1983, the Administrator of EPA has extended the option to support a demonstration project with CWA funds under the conditions that NYSDEC develop a suitable disposal method and redefine the extent of river contamination.

Environmental Setting

The environment affected by the Hudson River PCB problem includes all waters, lands, ecosystems, communities, and facilities located in or immediately adjacent to the 200-mile stretch of river from Fort Edward to the Battery. This project focuses on, but is not limited to, the most heavily contaminated reach between Albany and Fort Edward (Upper Hudson River).

Problems and possible actions involving PCBs in upland dumps within the Upper Hudson River Basin are not within the scope of this study. Likewise, dredge spoils, although possibly contributing very minor quantities of PCBs to the present problem are not directly within the scope of the report since they are being addressed by NYSDEC and GE in a separate agreement, not related to the Hudson River project.

The surficial sediments near the Upper Hudson River vary in thickness from a few inches to more than 200 feet and consist of unconsolidated materials including till, glacial outwash deposits, proglacial lacustrine deposits, recent alluvium, and modern dredge spoils. The underlying bedrock is predominantly folded and fractured, black Ordovician shale.

The climate of the area is continental; however, seasonal variations in temperature and precipitation are often moderated by the maritime climate which prevails in the southeastern portion of the state. The annual average temperature of the area is 47°F and the annual precipitation totals an average of 30 inches.

The mean annual discharge at Stillwater, located midway between Fort Edward and Albany, is about 6,000 cubic feet per second (cfs). River flows are regulated by five reservoirs above Fort Edward. The mean annual flood flow at Stillwater (approximately 31,000 cfs) usually generates flow velocities sufficient to cause scouring of the banks and river bottom.

Land use in the Upper Hudson River area is predominantly agricultural. Petroleum refineries, grain bins, and paper mills are located at various sites along the river. Albany is the largest population center along the upper Hudson River. Other cities with populations greater than 25,000 are Troy, Poughkeepsie, Newburgh, and New York, New York, and Newark, New Jersey.

The Hudson River is an important source of hydroelectric power, public water supplies, transportation, and recreation. The Upper Hudson River is the greatest hydroelectric-producing area in the basin, with a total of 10 plants located above Fort Edward. Waterford, New York is supplied with drinking water by the Upper Hudson River. The city of Poughkeepsie, the Highland Water District, Port Ewen Water District, and the village of Rhinebeck take their water supplies directly from the Lower Hudson River. A water intake located at Chelsea, which is north of Beacon, New York, may be used to supplement New York City water supplies during periods of drought.

Environmental Concentrations

More than 1,200 core and grab samples from the Upper Hudson River bottom, taken by NYSDEC and other agencies in 1977 and 1978, revealed the following:

- That five exposed remnant deposits left in the former Fort Edward Dam pool, with average PCB concentrations ranging from 5 to 250 parts per million (ppm), contained from 63,820 to 139, 820 pounds of PCBs.[1]

[1] Since the removal of remnant area 3A in 1978, the estimate is 46,800 to 108,000 pounds.

- That 40 PCB hot spots located in the Upper Hudson River between Fort Edward and Albany contained from 158,000 to 170,000 pounds of PCBs. These hot spots were of limited areal extent and had average PCB concentrations in excess of 50 ppm.

- That extensive "cold areas" of the Upper Hudson River, with average PCB concentrations of 20 ppm, contained from 123,000 to 177,000 pounds of PCBs.

Separate sampling surveys by other NYSDEC consultants revealed that Lower Hudson River sediments had an average PCB concentration of about 10 ppm and contained from 169,000 to 200,000 pounds of PCBs.

The total mass of PCBs residing in Hudson River sediments and remnant deposits is estimated at 498,000 to 656,000 pounds. When every known source of PCB is considered, including PCBs in dredge spoils, and upland dumps, as well as those PCBs washed out to sea, the final total of PCB associated with GE is between 1.4 to 1.8 million pounds.

The United States Geological Survey (USGS) has periodically monitored river-water PCB concentrations in the Upper Hudson River at Glens Falls, Rogers Island, Stillwater, Schuylerville, and Waterford, New York since 1977. The amount and form of PCBs in the water column have been shown to vary with flow. During low flow periods, PCBs are present mostly in a desorbed form. At flows higher than 21,000 cfs at Waterford, large amounts of PCB are present in an adsorbed form on resuspended sediments. During average flows, however, PCB concentrations are much lower than at other times, probably because dissolved PCB is diluted and scour is occurring at a lower rate. During low flows at Waterford ($\leq$ 7000 cfs), PCB concentrations average between 0.6 and 0.7 parts per billion (ppb). At flows above 20,000 cfs, total PCB concentrations increase to about 1.0 ppb. During average flows, however, total PCB levels decrease to about 0.2 ppb. Low-flow average PCB concentrations have shown a significant decrease since 1977. Existing information is not sufficient to show whether the decreasing trends will continue.

A PCB transport model developed for NYSDEC has previously been used to estimate the annual PCB load at the Federal Dam at Troy, and to predict the time period over which PCB-contaminated material would exist in, and continue to be transported out of, the Upper Hudson River. The model was also used by NYSDEC to predict the change in PCB transport rate accompanying various proposed remedial activities. According to a reevaluation carried out in the Feasibility Study, however, the model, appears to overestimate PCB transport rates as well as to overstate the importance of high flows in PCB transport. The model also indicates deposition and scour in river reaches where sediment loads were actually conserved. Recent estimates of PCB transport, developed from USGS monitoring data, show that the annual rate of PCB transport has dropped to about 1500 to 2500 pounds per year. This may contradict the model, which projects a 20-year average PCB transport rate of 6,800 to 7,200 pounds per year.

In the Upper Hudson River, wet-weight average PCB concentrations in fish routinely exceeded the Food and Drug Administration (FDA) imposed limit of 5 ppm. PCB concentrations in the migrant marine species of the Lower Hudson River are usually much lower; however, severely contaminated individuals of some species (American eel, striped bass) can be found. The distribution of PCB concentrations in fish is log normal, indicating that the probability of catching a severely contaminated fish is much lower than that which the arithmetic mean would indicate. Lipid-based PCB concentrations in fish have shown a decrease of 50 to 90 percent since 1977, and the average PCB content of striped bass dropped to 4.8 ppm in 1983. This decrease, in most cases, may be due to the metabolic elimination of Aroclor 1016, a more volatile PCB compound. The decrease, however, may also be related to some physical cause such as a reduction in the release of dissolved PCB from bed sediments. It is not known whether exposure of more highly contaminated sediments after flood scouring could lead to an increase in fish contamination.

PCB levels in the atmosphere have occasionally been high near concentrated sources of PCB such as dumps, dredge spoils, and remnant sites; however, river-related air pollution such as that measured near riffles and dams has been quite low, usually less than 0.01 µg/cu m.

Treated drinking water from the Waterford supply system rarely exceeds 0.1 ppb according to USGS studies. According to results of 35 NYSDOH samples, the total PCB concentration of Waterford drinking water averages 0.06 ppb. No study of Waterford drinking water has ever found PCB in excess of 1 ppb, which is the maximum allowable exposure promulgated by the New York State Department of Health (NYSDOH).

The data base for the Hudson River PCB problem is quite extensive. There are, however, a number of technical problems with the information. Only one comprehensive sediment survey has been performed on the 40 miles of the Hudson River which contain hot spots. This analytical survey, completed in 1977 and 1978, consisted of 1200 core and grab samples taken along transverse transects 700 feet or more apart. Some deficiencies in this data are apparent. Because of the distance between transects and the size of the sampling area, only a very small percentage of the river was represented in the survey. It is possible that many areas of contaminated sediments have not been located. Also, the variability of PCB concentration is very large within relatively short distances. Therefore, hot-spot delineations are very subjective and the standing estimates of PCB mass in hot spots, as well as in cold areas, are probably subject to a high degree of error. There is no quantitative estimate of the amount of over or underestimation of PCB quantities.

Secondly, although the surveys may have been adequate for planning purposes in 1978, there are questions regarding its validity in 1983. The constant shifting and redistribution of sediments brought about by bedload movement and the seasonal patterns of scour and deposition may have significantly changed the shape, size, and location of hot spots.

Documentation of trends in fish contamination has been satisfactory, although other authors have questioned the validity of the statistical analysis performed on the data.

Documentation of PCB concentrations in ambient river water has also been satisfactory, and up-to-date information is readily accessible. Records of PCB concentrations in drinking water supplies at Waterford are available from NYSDOH and U.S.G.S. These data provided valuable information but are not as complete as might be desired. Records of PCB concentrations in other water supplies are not readily available.

Air monitoring for PCBs was performed in 1980-1981 near dump sites and remnant deposits, and also near dams where air transport was expected. Air monitoring near receptor sites, along the Hudson River, however, is lacking.

It should be emphasized that the results of the evaluation contained in this report are only as good as the original data provided. Given the lack of knowledge regarding the total quantity of contaminated sediments and their location in 1983, the authors of this Feasibility Study based their selection of alternatives on the 1977 data, assuming no movement. A limited amount of sampling was performed at selected hot spots in August 1983 for comparison with 1977 survey results. The 1983 data suggest that some hot spots may have shifted, while others stayed in place. Before any action is taken on this project, it is essential that a new and more complete series of PCB analyses in the river be performed so that an accurate knowledge of quantities and locations can be obtained.

Public Health Concerns

Potential public exposure to PCBs can occur via various routes due to the presence of the compounds in the sediments and in the remnant deposits of the Hudson River. Recorded levels of PCBs reached more than 500 ppm in the sediment hot spots, and some of the remnant deposits contain average PCB concentrations of more than 50 ppm.

While the contaminated sediments are the primary source of PCB, potential exposures will likely occur only through the atmospheric, aquatic, and biotic pathways.

Although the danger of groundwater contamination does not seem to be great, surface water contamination of the Hudson River with PCBs is a potential problem, because the river serves as a source of drinking water for various communities. However, PCB monitoring at the Waterford, New York, public water supply has shown no values above the NYSDOH guideline of 1.0 ppb in normally treated drinking water. In fact, the PCB concentration rarely exceeds 0.1 part per billion (ppb) in samples of treated water. At this level of contamination, the incremental risk due to exposures seems to be undetectably small.

Recreation on or nearby the Hudson River may cause human exposure to PCB levels. This may occur during swimming, where there is a risk of dermal and oral exposure, or by illegal fishing, which poses a risk if the contaminated fish are ingested.

At present, the only major health threat is posed by human consumption of aquatic organisms. Although the PCB concentration of fish and other organisms is decreasing with time, many individual organisms still contain PCB in excess of the 5 ppm limit set by the Food and Drug Administration. However, a continuation of fishing restrictions, in combination with the publication of advisories which suggest limiting the intake of seafood from the Hudson River, is a cost-effective remedy.

Results

Two points must be taken into consideration when assessing the public health risks associated with the remedial alternatives. First, although a large amount of information was gathered in 1977 and 1978 regarding PCBs in the Hudson River, very little of that information dealt with PCB concentrations at the receptors. Furthermore, the information which was developed at that time, may not reflect current conditions. Some limited information that is available relative to the receptors (i.e., Waterford water supply) does indicate that the risks associated with the site have decreased. While difficult to precisely delineate, some risk continues to exist at the present time. Second, the alternatives under consideration, including dredging, all contain some element of risk since no alternative can remove all of the PCBs in the Hudson River. Some alternatives may result in a short-term increase in public health risk during implementation. The cost-effective evaluation must consider the relative ability of each alternative to reduce the overall, long-term and short-term risk.

Cost-Effective Approach

A major objective of this study was to evaluate remedial alternatives using a cost-effective approach consistent with the goals and objectives of CERCLA. A cost-effective remedial alternative is defined in the National Contingency Plan (NCP) (40 CFR 300.68J) as "...the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or environment." The National Contingency Plan (NCP) outlines procedures and criteria to be used in selecting the most cost-effective alternative.

The first step is to evaluate public health and environmental effects and welfare concerns connected with the problem. Criteria to be considered are outlined in Section 300.68(e) of the NCP and include, among many others, such factors as actual or potential direct contact with hazardous material, degree of contamination of drinking water, and extent of isolation and/or migration of the contaminant.

The next step is to develop a limited list of possible remedial actions which could be used. The no-remedial-action alternative may be included on the list.

The third step in the process is to provide an initial screening of alternatives. The costs, possible adverse effects, relative effectiveness in minimizing threats, and reliability of the methods are reviewed here. The no-action alternative may be included for further evaluation when response actions may cause greater environmental or health damage than no-action responses. No-action alternatives may also be included if it is appropriate relative to the extent of the existing threat or if response actions provide no greater protection.

The next step is a detailed analysis of the remaining alternatives. This analysis requires a more detailed estimation of costs and engineering implementation and a closer assessment of the ability of alternatives to minimize or mitigate threats. In this study, the detailed analysis was aided by a cost effectiveness-matrix which was developed by independent consultants under the direction of EPA. The alternatives subjected to the matrix analysis and their estimated costs are given in Table ES-1.

The final step requires that the lead agency evaluate the cost-effectiveness of the selected response action against the need to respond to problems with hazardous materials at other sites. Thus, the fund-balancing theme of the NCP generally allows only for the implementation of proven technologies which can be shown to demonstrate a higher level of protection.

River Sediments

The matrix evaluation process was used to determine the cost-effective solution as provided for by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Based on the current data available on the PCB problem in the Hudson River, the result of a matrix analyses evaluation with respect to the contaminated sediments in the Hudson River is "no remedial action." The results of the analysis were interpreted to mean that the questionable and limited effectiveness of major action alternatives such as hot-spot dredging may not justify the expenditure of large sums of money in light of the present low impacts and improving conditions associated with the Hudson River PCB problem.

The findings of this study appear to be justified. The estimated cost of dredging all 40 previously identified hot spots is approximately $55,000,000 including disposal at a local secure containment site. The estimated cost of dredging Thompson Island pool hot spots, the reduced-scale alternative, is approximately $34,000,000 including disposal. If existing information is accepted as being reliable, we find that these programs will remove only an estimated 22 to 49 percent of the PCB in the Upper Hudson River and only an estimated 19 to 22 percent of all of the PCB in the river, excluding dredge-spoil and remnant-deposit PCB. With full-scale remedial dredging, it could take longer than 46 years for PCBs to be depleted, assuming a constant transport rate and a PCB source of about 350,000 pounds. By

TABLE ES-1

REMEDIAL ALTERNATIVES AND COST COMPARISONS
HUDSON RIVER PCB SITE, NEW YORK

	Remedial Alternative	Capital Costs	O&M Costs	Total Costs
1.	Detox. of Sediments with KOHPEG	$289,877,000	$ 0	$289,877,000
2.	Wet air oxidation of sediments	$109,340,000	$ 0	$109,340,000
3.	Incineration of sediments	$249,787,000	$ 0	$249,787,000
4.	Secure landfill disposal of sediments	$ 15,203,000	$ 1,887,000	$ 17,090,000
5.	Dredging of 40 hot spots	$ 54,987,000	$ 5,321,000	$ 60,308,000
6.	Reduced scale dredging	$ 34,048,000	$ 5,321,000	$ 39,369,000
7.	No remedial action, water supply not treated	$ 120,000*	$ 3,434,000	$ 3,434,000
8.	No remedial action, water supply treated	$ 114,000	$ 3,617,000	$ 3,731,000
9.	Total removal of all remnant deposits	$ 12,894,000	$ 1,887,000	$ 14,781,000
10.	Partial removal of remnant deposits	$ 6,917,000	$ 3,011,000	$ 9,928,000
11.	Restricted access to remnant deposits	$ 372,000	$ 1,124,000	$ 1,496,000
12.	In-place containment of remnant deposits	$ 2,324,000	$ 1,124,000	$ 3,406,000
13.	In-situ detoxification of remnant deposits	$ 66,696,000	$ 0	$ 66,696,000
14.	No action on #1, 2, &4/restrict access to #3 & 5	$ 154,000	$ 1,124,000	$ 1,278,000
15.	Partial removal/contaminant of remnant deposits	$ 9,010,000	$ 3,011,000	$ 12,021,000
16.	Partial removal/restricted access of remnant deposits	$ 7,144,000	$ 3,011,000	$ 10,155,000
17.	Partial containment/restricted access to remnant deposits	$ 1,053,000	$ 1,124,000	$ 2,177,000
18.	Partial containment/in-situ detoxification of remnant deposits	$ 38,878,000	$ 1,124,000	$ 40,002;000
19.	Partial removal/in-situ detoxification of remnant deposits	$ 42,622,000	$ 1,887,000	$ 44,509,000
20.	Partial detoxification/restricted access of remnant deposits	$ 36,853,000	$ 1,124,000	$ 37,977,000

*Includes Proposed Treatability Study

the same reasoning, it may take longer than 64 years for PCBs in the Upper Hudson River to be depleted, assuming maintenance dredging continues and removes a constant amount of PCB per year.

Even if these objectives are achieved, they may not result in a substantial improvement. Other factors should be considered. Hot-spot dredging is only a partial solution: some level of risk will continue to exist with or without hot-spot dredging. Furthermore it is not clear that the majority of the PCBs which enter the environment each year emanate from hot spots. Since hot spots cover only 8 percent of the total area, it is entirely possible that cold spots, although less highly contaminated, contribute the majority of dissolved and suspended PCBs due to their far greater surface areas.

Past studies have merely defined the extent and possible consequences of the PCB problem and cite dredging as the only alternative available. Few studies have attempted to measure the actual impact of the problem or tried to quantify the actual effectiveness of dredging in reducing these impacts. Six years after the initiation of PCB studies, this report finds that the actual health impacts appear to be lower than previously expected, and that environmental contamination is decreasing much more rapidly than had been anticipated. A review of studies into PCB-environmental interactions and PCB transport has left many questions unanswered but it has indicated that mechanisms are much too complex to conclude that dredging would lead to a measurable amout of improvement.

However, because of the inadequacies of present understanding, it is recommended that an in-depth health risk assessment be conducted, with future sampling and analysis focusing on PCB levels reaching human receptors rather than on environmental (e.g., sediment) concentrations. The following study programs are recommended:

- Air sampling at residences near dams and rapids on the rivers and near contaminated wetlands.

- Sampling of private wells which utilize groundwater immediately adjacent to the river.
- Sampling of the public water supplies withdrawing water from the Hudson River.
- Sampling of terrestrial vegetation

It is also suggested that a study be conducted to access the linkage of aquatic food chains to PCBs which reside in wetlands. Such a study would involve the sampling of wetland vegetation, macro organisms, fish, and sediment.

It is further recommended that a treatability or water supply replacement assessment be made for the Town of Waterford. The above investigations are estimated to cost over $500,000.

Sampling of sediments in proposed maintenance dredging areas should be performed prior to initiation of dredging. An environmental monitoring program should continue to be implemented. This program would monitor PCB concentrations in fish and river water, and in drinking water supplied by the Hudson River.

Remnant Deposits

The selected remedial action for the remnant deposits is in-place containment of remnant deposits. This response action would reduce the potential for direct contact with contaminated sediments and would reduce atmospheric pollution near the remnant sites. A Remedial Investigation should be performed to accurately delineate areas of contamination for covering. Those areas designated to be covered should have approximately 18 to 36 inches of subsoil followed by a 6-inch layer of topsoil placed on them. The cover will then be graded and seeded to minimize erosion. Where needed, bank stabilization will be placed along the riverbank to prevent scour. The estimated cost for the remedial action is approximately $2,300,000, and for the Remedial Investigation is $200,000.

1

1.0 INTRODUCTION

1.1 Background

This Remedial Action Master Plan (RAMP) is prepared in accordance with Subpart F, Sections 300.67 and 300.68 of the Final Rules of the National Contingency Plan (NCP) (47 CFR 137, July 16, 1982). This RAMP is intended to provide the United States Environmental Protection Agency (EPA) with a basis on which to decide, under the provisions of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), future actions to be taken with respect to the problems identified at this site.

The original Work Assignment issued by EPA was intended to begin the development of a Remedial Action Master Plan (RAMP). Before the RAMP was completed, the Hudson River PCBs Site was placed on the EPA's National Priorities List, and, as a result, became eligible for the funding of remedial actions. Since the elements required by the Work Assignment are equivalent to those for a feasibility study under CERCLA, the title of this document has been changed to a Feasibility Study. However, the title of RAMP will be used within the text when referring to the document, to eliminate extensive revisions to the document.

RAMPs are prepared exclusively from existing information. This information may include sampling data, maps, topographic information, site records, and previous regulatory and remedial actions. Since a significant amount of scientific and engineering information currently exists regarding the problems of PCBs in the Hudson River, this RAMP proceeded beyond the normal objectives of similar documents. Although normal RAMP guidelines were used during its preparation, a major objective of the Hudson River PCB Site RAMP was to reevaluate a previously prepared Environmental Impact Statement (EIS) which had been developed in accordance with the criteria of the National Environmental Policy Act (NEPA) and directed by requirements in Section 116 of the Clean Water Act regarding the relative public impact of long-term land storage of PCBs. The alternatives studied under the EIS were reevaluated in terms of the criteria established under CERCLA and the NCP. While NEPA requires evaluation in terms of the environmental impact of a particular proposal, CERCLA stresses the protection of public health, welfare, and the environment in the most cost-effective manner.

1.2 Setting

During a 30-year period ending in 1977, it is estimated that between 887,000 and 1.1 million pounds of PCBs were discharged into the Hudson River from two General Electric (G.E.) capacitor manufacturing plants at Fort Edward and Hudson Falls, New York. Much of the discharged PCBs were adsorbed by the bottom sediments of the river and accumulated behind the Fort Edward Dam. When the dam was removed in 1973 due to its deteriorating condition, a large amount of the PCB-contaminated sediments was released and migrated downstream. The downstream migration was further accelerated during subsequent flood situations, causing PCB-contaminated sediments to move down the entire length of the Hudson River.

Based on extensive river-sampling program studies conducted from 1977 to 1978, forty PCB "hot spots" were defined as sediments containing 50 parts per million (ppm) or more of PCBs. In addition, five PCB-contaminated remnant deposits were identified. The remnant deposits are sediment deposits which were exposed as a result of the removal of the Fort Edward Dam and subsequent drop in the water level of the river. PCB concentrations in two of these exposed remnant deposits average from 5 to 250 ppm.

In 1976, the New York State Department of Environmental Conservation (NYSDEC) and General Electric (G.E.) agreed on a $7,000,000 settlement agreement to conduct research studies on PCBs, investigate the extent of PCB contamination in the Hudson River, and develop methods to reduce and remove the threat of continued PCB contamination. As a result of investigations conducted by NYSDEC, a draft Environmental Impact Statement (SEQIS) was prepared in accordance with the State Environmental Quality Review Act. Recommendations of this study are presented in Table 1-1.

TABLE 1-1

NYSDEC* Recommended Program

Full-Scale	Reduced-Scale
Dredging of all 40 hot-spot areas in the river bed with containment in a secure upland site.	Reduction of the number of hot spots to be dredged, from 40 to approximately 20.
Design and construction of a secure upland containment site capable of long-term isolation of contaminated material.	Same, except for a reduction in capacity at the containment site.
Excavation of two remnant deposits (areas 3 and 5) located above the former Fort Edward Dam site, and removal to the upland containment site.	Deletion of remnant deposit removal and upland containment; instead, provision of top dressing and fencing for remnant deposits 3 and 5.
Provision for containment of material from three PCB-contaminated dump sites (old Fort Edward, Fort Miller, and Caputo) should removal be found more suitable than in-place containment.	Elimination of provision for the containment of PCB-contaminated material from Old Fort Edward, Fort Miller, and Caputo dump sites.
Provision for containment of contaminated materials from three NYSDOT** dredge spoil sites (212, 13 and 204 Annex).	Same
Destruction of the recovered PCBs at such time as a technologically and economically feasible procedure becomes available.	Same
Provision for funding of research studies related to environmental monitoring.	Reduction in the level of funding for research studies.

* New York State Department of Environmental Conservation
** New York State Department of Transportation

Source: DEIS, 1981

In September 1980, Congress passed an amendment to the Clean Water Act (CWA) under Title I, Section 116(a) and (b), entitled the Hudson River PCB Reclamation Demonstration Project. Under this legislation, construction grant funds up to $20,000,000 could be authorized by the EPA Administrator if it was determined that funds were not first available under Section 115 or 311 of the CWA or from the proposed CERCLA. Congress authorized the EPA to make grants to the New York State Department of Environmental Conservation (NYSDEC) in order to carry out the intent of the Act. The funding authorization which was due to expire on September 30, 1983, has been extended.

As a result of this Federal involvement and in accordance with NEPA and the requirements of Section 116 of the Clean Water Act, EPA-Region II issued a Notice of Intent to prepare an Environmental Impact Statement (EIS) on January 12, 1981 followed by the publication of a Draft EIS (DEIS) on May 8, 1981. Recommendations of the DEIS are presented in Table 1-2. In August of 1981, due to the State's development of detailed public health and environmental contingency and mitigation plans, EPA issued a Supplemental Draft EIS (SDEIS). On April 22, 1982, approximately eight months after the publication of the SDEIS, the New York State Hazardous Waste Facility Siting Board rendered its decision to approve the selected site for the disposal of PCB-contaminated sediments. After completing EPA's required "peer review" process and evaluating the Siting Board Decision, EPA issued the Final EIS on October 8, 1982.

The NEPA-EIS process was concluded on December 30, 1982 with a record of Decision in which the EPA Administrator determined that funds for addressing this problem were available under CERCLA and that the problem rated sufficiently high to be considered for inclusion on the National Priorities List.

At the end of April 1983, a Work Assignment for the Hudson River PCB Site RAMP was issued by EPA to NUS Corporation, the USEPA Zone 1 contractor for implementation of tasks. In June 1983, four Hudson River citizens' groups filed notice of an intent to sue to require that EPA utilize the funds appropriated under

TABLE 1-2

EPA-Recommended Program (DEIS) (May 1983)

Full-Scale	Reduced-Scale
Dredging or in-river containment of all 40 hot-spot areas in the river bed with containment in a secure upland site.	Reduction of the number of hot spots to be dredged or contained in-river.
Design and construction of a secure upland containment site capable of indefinite long-term isolation of contaminated material.	Same, except for a reduction in capacity at the containment site.
Deletion of remnant deposit removal and upland containment; instead, provision of secure cap and top dressing, and further bank stabilization if necessary.	Same
Elimination of provision for the containment of PCB-contaminated material from dump sites in the Fort Edward area.	Same
Provision for containment of contaminated materials from three New York State Department of Transportation (NYSDOT) dredge spoil sites (212, 13, and 204 Annex).	Same
Provision for dredging and containment operational standards and procedures, mitigation measures, monitoring programs, and contingency plans necessary to safeguard public health and agricultural resources.	Same
Provision for research studies/environmental monitoring programs necessary to demonstrate the improvement in the rate of recovery of the river and storage of contaminated material.	Same

Source: DEIS, 1981

the Clean Water Act Amendment to conduct the proposed demonstration dredging project. In July 1983, the New York State Department of Environmental Conservation filed a similar notice. These legal actions are in progress.

In August 1983, the New York State Hazardous Waste Siting Board's approval of the sediment disposal site was overturned by the New York State Supreme Court. Although the proposed PCB-disposal site is currently unavailable, this RAMP assumes the availability of this site or a similar site in the same vicinity for containment of dredge spoils.

1.3 Scope of Work

For the purposes of this study, the Hudson River PCB problem is defined by the PCBs contained within river-bottom sediments and the remnant deposits, as well as the environmental contamination which originated from these sources. PCBs contained within upland dumps are not within the scope of the report. PCBs in dredge spoils are being addressed by NYSDEC and are also not within the scope of this report.

The EPA Work Assignment required analysis of all previously prepared studies. It required reevaluation of all alternatives studied through the EIS process. It also required review of new technologies for PCB remediation developed since preparation of the EIS to determine if any were appropriate to the Hudson River problem. The Work Assignment required determination of one scheme of remedial actions which would meet the goals and objectives required by CERCLA. This scheme should be sufficiently developed so that design activities can begin upon conclusion of the RAMP. EPA is expecting development of a work plan for the preparation of plans, specifications, health and safety plans, QA/QC plans, and other plans and documents as needed for implementation. The RAMP must provide a cost estimate for both design activities and remedial actions, and a project schedule for design activities and remedial actions including appropriate milestones.

2

2.0 THE SITE

2.1 Location

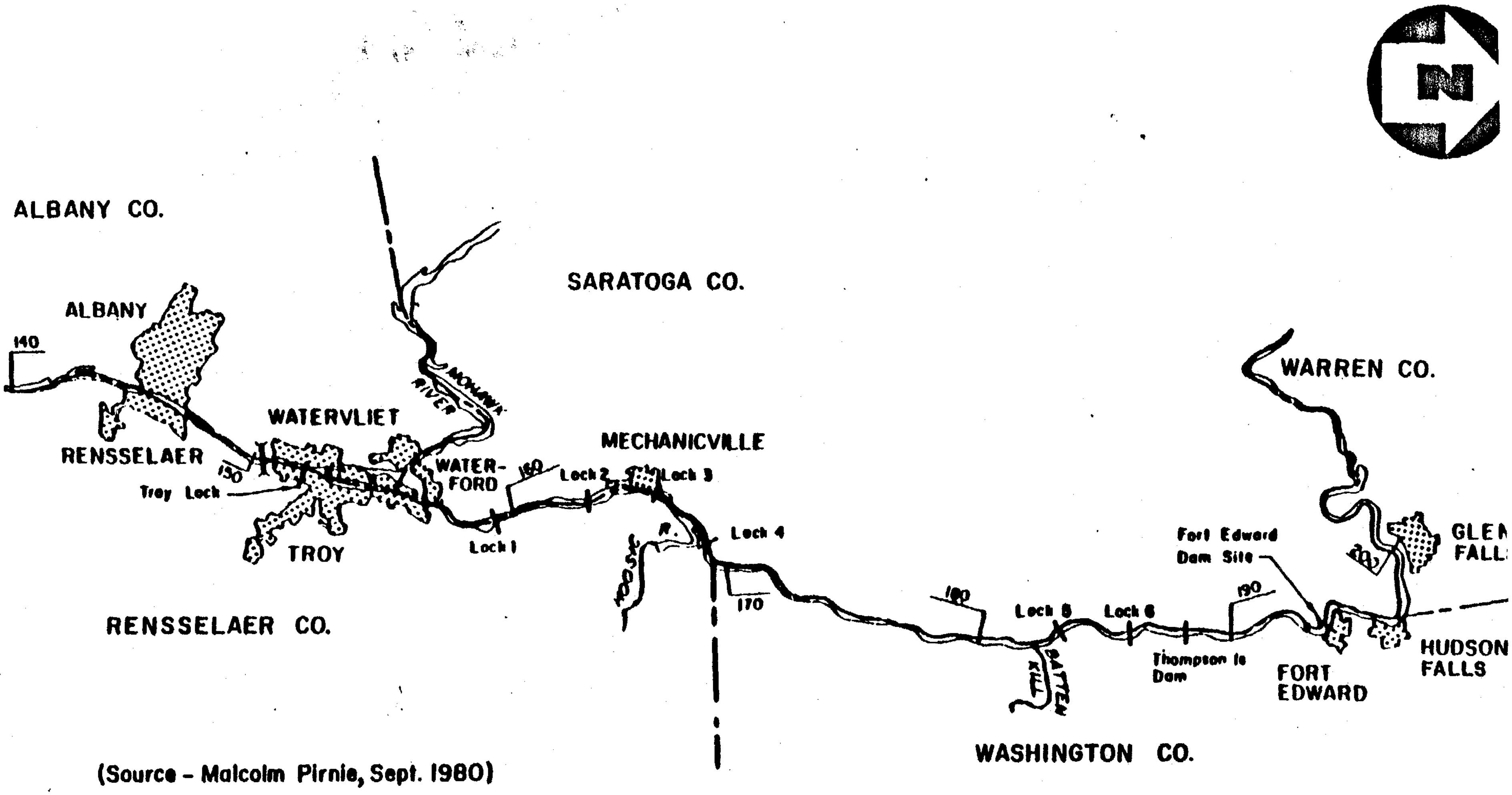
The Hudson River, a major transportation route for East Coast products, from its head-waters in Essex County at 43°15' North latitude and 74°00' East longitude, traverses 14 counties on its 300-mile journey through eastern New York State. Before emptying into New York Bay, the river flows through 7 locks, and over 15 dams and 3 natural waterfalls. Figure 2-1 shows the general layout of the Hudson River area and the nearby cities.

Pollution of the river sediments with polychlorinated biphenyls (PCBs) began in 1947 at a point approximately 200 river miles upstream of New York City. Contamination of the river originated from two General Electric capacitor manufacturing plants located in the Glens Falls, New York area, approximately three miles upstream of the former dam site at Fort Edward (see Figure 2-1).

The river has been arbitrarily divided into two sections; the upper and the lower Hudson River. The Upper Hudson (study area), where nearly two thirds of PCB contamination is located, covers a 40 river-mile length beginning at Glens Falls and ending at the Federal Dam at Troy (Draft EIS, 1981). Five miles south of Glens Falls is a former dam site at Fort Edward, which, when removed, left significant PCB concentrations termed remnant deposits. Also contained in the Upper Hudson are 40 "hot spots" (areas with PCB concentrations of 50 µg/g [ppm] or greater) which have been identified in this area by the New York State Department of Environmental Conservation (NYSDEC) as containing the majority of contamination located in the Upper Hudson (Phase I Engineering Report, December 1978). The Lower Hudson begins at the dam at Troy and continues downstream 160 river miles to the New York Bay.

Hudson River Basin topographic features include flat lowland areas near the coast and steep rolling hills throughout midstate New York. The headwaters of the

100260



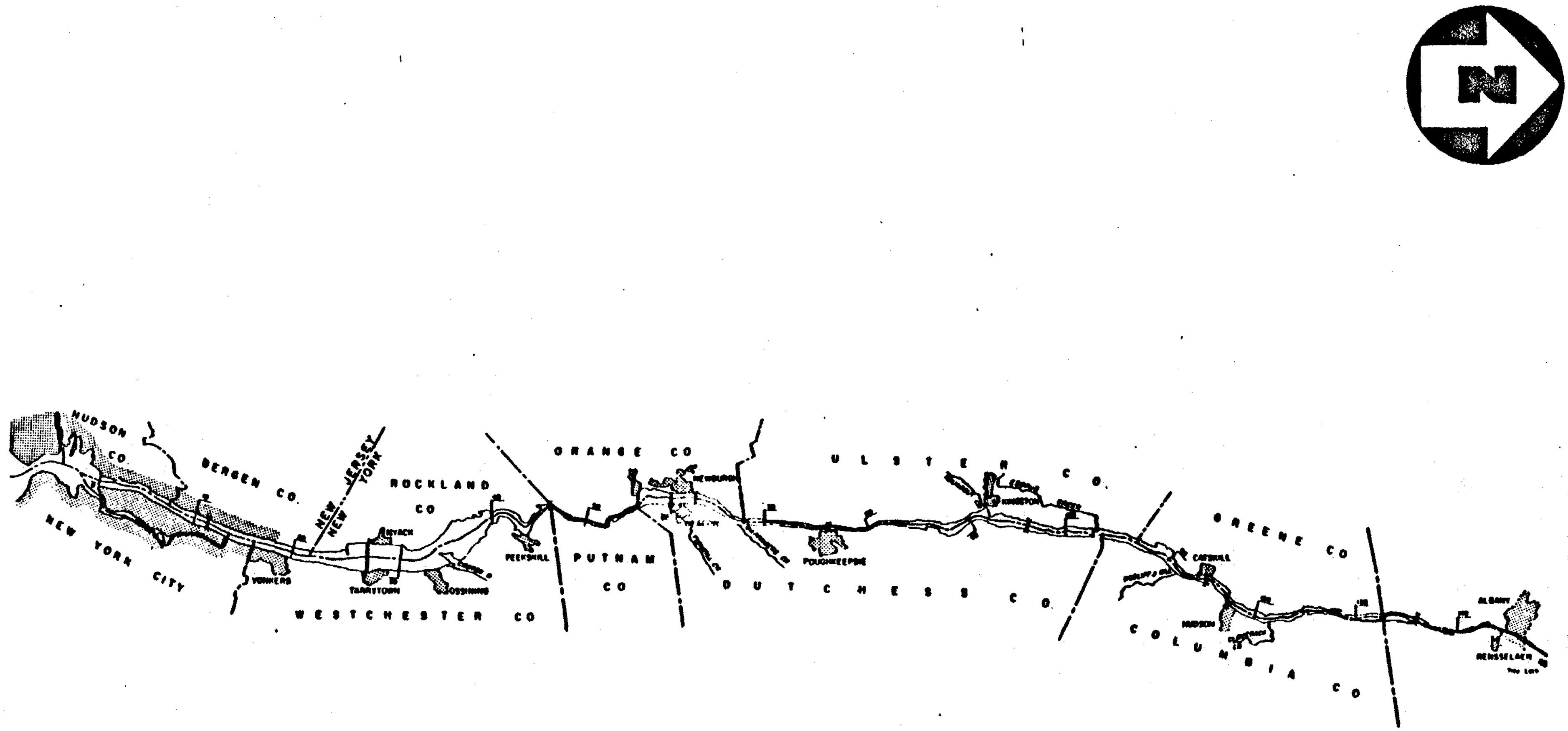
2-2

PROJECT AREA
UPPER HUDSON
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NOT TO SCALE

FIGURE 2-1a

NUS CORPORATION
A Halliburton Company



(Source - Malcolm Pirnie Sept. 1980)

PROJECT AREA
LOWER HUDSON
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

SCALE: 1" = 16 MILES

FIGURE 2-1b

NUS CORPORATION
A Halliburton Company

Hudson are found in the Adirondack and Catskill Mountain ranges, which are covered by large wilderness and forest areas. In the valleys and lowlands, urban and rural developments prevail.

2.2 Site History

Years of production of PCB-containing capacitors and disposal of PCB-laden waste have left more than 500,000 pounds of PCBs in the Hudson River (Malcolm Pirnie, Inc., 1980). This contamination has been traced to two General Electric manufacturing plants that used PCBs in manufacturing capacitors beginning in the late 1940s and ending in 1976. In December of 1972, General Electric applied for a discharge permit, stating that the two plants were discharging an average of 30 pounds per day of "chlorinated hydrocarbons," with a 47.6 pound per day maximum. As of January 1975, General Electric obtained approval to discharge its waste according to the permit request (DEC Technical Paper No. 51).

It was not until 1975 that polychlorinated biphenyls were discovered to be a problem in the Hudson River (Malcolm Pirnie, Inc., September 1980). Subsequently, five years of engineering and scientific studies were made, and 40 PCB hot spots were identified in the Hudson River (Draft EIS, 1981).

A large portion of the PCB waste in the river was, until 1973, contained behind the Fort Edward Dam at river mile 195. Much of this waste was transported downstream after the removal of the dam in the summer of 1973. Adding to the problem was an April 1976 (100-year) flood, which scoured approximately 260,000 cubic yards of additional material from the former dam pool (Malcolm Pirnie, Inc., September 1980). Sediment scouring also occurred in the spring of 1983, during an 80-year-occurrence river level.

Until 1970, navigational dredging removed approximately 23,000 cubic yards of sediment from the Upper Hudson. This sediment, along with 615,000 cubic yards of dredge between 1974 and 1978, is contaminated with PCBs, and has been placed in seven disposal sites along the river bank (Malcolm Pirnie, Inc., 1980).

2.3 Potential Sources of Contamination

The problem of PCBs in the Hudson River was discovered in 1975, when the United States Environmental Protection Agency (EPA) discovered high levels of PCBs in fish taken from the river. Sampling of the river by the NYSDEC produced evidence to implicate two General Electric capacitor manufacturing plants near Glens Falls, New York, as the major contributors of PCBs to the river sediments (DEC Technical Paper No. 58). These plants disposed of approximately 890,000 to 1.1 million pounds of PCBs into the river during a 30-year period. In addition to the in-river disposal, General Electric also landfilled transformers containing PCBs, adding approximately 528,000 to 745,000 pounds to the environment (Malcolm Pirnie, Inc., 1978).

The continued presence of PCBs in the Hudson River basin leads to a possibility of more widespread contamination through contaminant migration. The sources that continue to contribute PCB waste are (Weston, 1978):

- Sediment exposed or released upon the removal of the Fort Edward Dam
- Disposal areas for dredged bottom sediment contaminated with PCBs
- Landfills containing PCB liquids and impregnated solids
- Wastes containing PCBs unrelated to the General Electric plants

In the summer of 1973, the Fort Edward Dam was removed due to its advanced state of deterioration. Sediments that had collected behind the dam became exposed due to the lowering of the river. Portions were subsequently scoured by high river flows and transported down river. The exposed areas, known as remnant deposit areas, have high levels of PCB contamination. These areas are subject to erosion by the river, surface water runoff, or wind (only 2 of 5 remnant deposit areas have had bank stabilization work performed), as they have little or no vegetative cover on them.

The sediments that have been exposed to the higher river flows have been transported down river, with the majority of the contamination remaining in the

Upper Hudson region (Malcolm Pirnie, Inc., 1978). Sampling done in 1975-77 has delineated 40 hot spots where high levels of PCBs exist and could potentially move downstream, further contaminating the river.

Because of the increased amount of sediments in the river due to the removal of the dam, it became necessary to dredge some areas that were left unnavigable when large volumes of sediment were deposited in the river channel. Approximately 790,000 cubic yards of material were deposited in the channel near Rogers Island. During 1974 and 1975 the New York Department of Transportation (DOT) removed approximately two thirds of this material and placed the PCB-contaminated spoils in five riverside disposal sites. In 1977 and 1978 DOT removed additional deposits and increased the number of disposal sites by two. These disposal sites contain an estimated 103,000 to 160,000 pounds of PCBs, approximately 9 percent of the river basin total (Malcolm Pirnie, Inc., 1978).

While disposing of wastes in the river, General Electric also landfilled its old transformers which contained PCBs as a dielectric fluid. The amount of PCBs landfilled is approximately 528,000 - 745,000 pounds, or 40 percent of the basin total. The security and containment controls at these sites are minimal in some cases, thus leading to PCB transport due to groundwater flow and leaching, or erosional effects from surface water drainage (Weston, 1978). Table 2-1 shows the estimated overall distribution of PCBs in the Hudson River Basin.

PCB contamination from sources other than the two General Electric plants is unknown. No report of additional PCB contaminant sources has been made to date.

2.4 Response Actions to Date

The following is a list of response actions to date for the Hudson River. Included are physical, remedial, and legal actions as well as river sampling and testing.

TABLE 2-1

ESTIMATED MASS OF PCB IN THE HUDSON RIVER BASIN
ASSOCIATED WITH GENERAL ELECTRIC PLANTS NEAR
FORT EDWARD, N.Y.

UPPER HUDSON RIVER BASIN	
Remnant Deposits	46,820-108,600 pounds[1]
Thompson Island Pool Sediments[2]	
Hot Spots	97,700-105,800
Cold Areas	22,000-30,900
Remaining Upper Hudson Pools	
Hot Spots	60,600-64,100
Cold Areas	101,400-146,400
Subtotal, Upper Hudson River Sediments Only	
Hot Spots	158,300-169,900
Cold Areas	123,400-177,300
	281,700-347,200
Dredge Spoils	103,455-160,000
Dumps[3]	528,000-745,000
Subtotal, Upper Hudson River Basin Only	959,975-1,360,800
LOWER HUDSON RIVER BASIN	
Sediments	169,000-200,000
Dredged	86,000
Washed Out To Sea	200,000
TOTAL PCB	1,414,975-1,837,930

1 Remnant Deposit Totals do not include estimates for area 3A.
2 Thompson Island Pool totals include estimates for sediments above Lock 7.
3 Includes PCBs in the Moreau Facility.
Sources: Bopp et al. 1978; Hetling et al., 1978; Tofflemire and Quinn, 1979; Malcolm Pirnie, 1980.

Date	Response Action
1950-1974	Navigational dredging removes an average of 23,000 yards of sediment per year in Fort Edward Area.
1974 (Apr.-Dec.)	Dredging of 175,000 yd^3 of debris from main river channel at and downstream of Lock 7 by DOT maintenance forces.
	Dredging of 85,000 yd^3 of debris and sediments from Fort Edward Terminal Channel betwen Lock 7 and D & H Railroad Bridge by DOT maintenance forces.
1975 (Jan., May-Nov.)	New York State Department of Transportation (DOT) performed maintenance dredging, which included removal of debris and sediment that accumulated in the barge canal system.
July 974-June 1975	Removal of 180,000 yd^3 of debris and sediment from Fort Edward Terminal Channel upstream of D & H Railroad Bridge and northerly tip of Rogers Island and excavation of sediment trap of 70,000 yd^3 capacity.
Oct. 1974-Nov. 1975	Placement of Rock from cribs on banks of remnant pool deposits 3 and 4.
	Placement of dumped rock at remnant deposit 5.
1975	PCB levels in some Hudson River fish were found to exceed Food and Drug Administration levels (5 ppm maximum) during USEPA fish sampling.
May-Nov. 1975	Removal of 13,000 yd^3 of debris and sediment from west channel near Rogers Island.
September 8, 1975	Administrative proceedings were begun charging General Electric with the disposal of PCBs into the Hudson River.
September 8, 1976	Settlement agreed upon between the NYSDEC and G.E. for 7 million dollars to investigate the PCB problem in the Hudson River.
1976	New York State Department of Health certified that a human health problem existed due to consumption of fish taken from certain areas of the Hudson River. Fishing was banned in the Upper Hudson from the Troy Dam north to Fort Edward, N.Y.

Date	Response Action
1976 con't.	Dredging of 35,000 yd^3 of sediment near bouy 212 by DOT maintenance forces.
1977	As a result of the settlement with the NYSDEC, General Electric ceased all discharge of PCBs.
Fall 77 - Spring 78	Dredging of 170,000 yd^3 of sediment from channel near Rodgers Island and containment of these sediments in New Moreau Site.
	Additional bank stabilization measures at Site 3.
August-December 1977	Weston Environmental Consultants conducted a surface mapping of 12 PCB disposal sites. Weston concurrently conducted initial soil, water, and biotic sampling.
October 1978	Remnant deposit 3A (14,000 cubic yards) was excavated and transported to the New Moreau Site.
September 1980	Congress passed an amendment to the Clean Water Act under Title I, Section 116(a) and (b) authorizing the Hudson River PCB Reclamation Demonstration Project.
May 1981	USEPA prepared a Draft Environmental Impact Statement (EIS) addressing the dredging demonstration project.
August 1981	A supplement to the May EIS was prepared by the EPA. This Supplemental EIS included additional material omitted in the Draft.
September 16, 1982	The EPA conducted a Mitre model ranking of the Hudson River. As a result, the river was given a score of 54.66.
December 1982	The Final EIS was completed by the EPA. Included in this report were updates and comments on the earlier Draft and Supplemental EISs.
December 30, 1982	Funding for the project became available through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund).

3

3.0 ENVIRONMENTAL SETTING

3.1 Landforms

The Hudson River Basin lies in the Valley and Ridge Physiographic Province. It covers 13,365 square miles or 27 percent of the State of New York (Malcolm Pirnie, Inc., 1980). Ninety-five percent of the basin is in New York State, but its headwaters include small portions of Vermont, Massachusetts, and Connecticut. The basin topography includes steep and rolling hills, undulating land, and some mountainous areas. Landscape varies from wilderness in the Catskill and Adirondack Mountains to agricultural areas in the valleys (NYSDEC, 1979a).

The Hudson River itself is located in the Hudson-Champlain lowlands of the Valley and Ridge Physiographic Province. The lowlands are composed of a plain ranging from 1/4 to 2-1/2 miles in width that was once pro-glacial Lake Albany. Elevation of the lowland areas ranges from 100 feet to 400 feet above mean sea level.

3.2 Surface Waters

The Hudson River from New York Harbor to Albany is a tidal estuary of 150 miles in length. From the Federal Dam at Troy north to Fort Edward are eight dams with locks to accommodate New York barge traffic. The locks and dams in this area form a series of pools throughout this reach. From Fort Edward north to the Hudson-Sacandaga River junction are seven dams and three natural waterfalls that are used to generate hydroelectric power (Malcolm Pirnie, Inc., 1980).

Several reservoirs above Glens Falls are used to regulate flows in the Upper Hudson. These reservoirs are Indian Lake, Piseco Lake, Spier Falls Reservoir, Sherman Island Reservoir, and Sacandaga Reservoir. The Sacandaga Reservoir is the largest, with 760,000 acre-feet of storage (NYSDEC, 1979). Reservoir flow is regulated during low flows to maintain navigation, water quality, and hydroelectric power generation. During high flows, the reservoir is regulated to prevent excessive flooding. Water is released from the Sacandaga Reservoir to keep a minimum flow of 300 cubic feet per second (cfs) for maintaining navigation and power generation. A minimum depth of 12 feet is also maintained for barge navigation (Malcolm Pirnie, Inc., 1980).

The major tributaries to the Hudson River from New York Harbor in the south, to Troy in the north, are as follows: the Croton River, Moodna Creek, Fishkill Creek, Wappinger Creek, Rondout Creek, Esopus Creek, Roeliff-Hansen Kill, Catskill Creek, Kinderhook Creek, and the Normans Kill. The major tributaries north of Troy are the Mohawk River, Hoosic River, Fish Creek, Batten Kill, Champlain Canal, Schroon River, and Indian River.

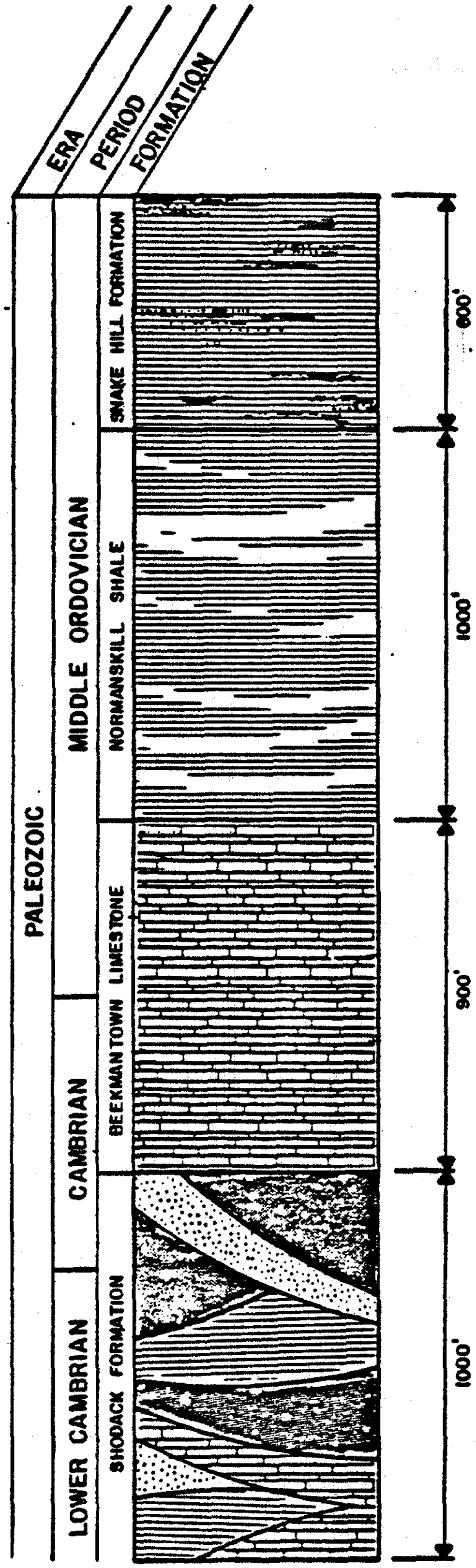
The drainage area of the Hudson River at Fort Edward is 2,818 square miles and increases at the Federal Dam at Troy to 8,090 square miles, including the additional 3,450-square-mile drainage of the Mohawk River.

3.3 Geology and Soils

The area of geologic study will be limited to the stretch of the Hudson River from Troy north to Hudson Falls encompassing the eastern quarter of Saratoga County, northwestern Rensselaer County, and southwestern Washington County. Geologic units in the study area are composed of both consolidated and unconsolidated deposits. Ordovician shales are the predominate bedrock, whereas Pleistocene glacial deposits comprise the unconsolidated surficial geology.

3.3.1 Bedrock Geology

The major bedrock formations in the study area are the Snake Hill Formation (shale), Normanskill Shale, Beekmantown Limestone, and the Schodack Formation (shale). The bedrock formations have a general northeast-southwest strike and southeasterly dip. These formations, with the exception of the Snake Hill, are not indigenous to the study area but belong to a series of formations deposited in a trough farther to the east and moved to their present position by folding and faulting along a multiple of thrust-fault planes. The folding and faulting created numerous fractures and fissures which control the movement of groundwater (Cushman, 1950). Figure 3-1 depicts a stratigraphic section of bedrock within the study area.



MOST RECENT FORMATION. LOCATED IN LOW-LYING ARE OF HUDSON RIVER VALLEY. CONSISTS OF DARK GRAY T BLACK, BLUISH AND BLACK CARBONACEOUS BANDS.

A MEMBER OF THE TACONIC SEQUENCE OF ROCKS CO PRISING THE HILLY AND MOUNTAINOUS AREAS OF WES ERN RENSSELAER AND WASHINGTON COUNTIES. SEPARAT FROM THE SNAKE HILL FORMATION TO THE WEST BY EASTWARD DIPPING THRUST FAULT PLANE. CONSISTS O A DARK-GREEN TO BLACK AGRILLACEOUS SHALE CON-TAINING WHITE - WEATHERING CALCAREOUS CHERT BED

UNDERLIES THE TACONIC SEQUENCE OF ROCKS AND OVERLIES SNAKE HILL FORMATION ALONG AN EASTWA DIPPING THRUST FAULT PLANE. CONSISTS OF MASSIV COARSE TO FINE-GRAINED DOLOMITIC LIMESTONE.

A UNIT OF THE TACONIC SEQUENCE OF ROCKS CONSIS OF A BRICK-RED WEATHERING GRIT, A CALCAREOUS SAN STONE, A THIN-BEDDED LIMESTONE, AND RED AND PUR PLE SHALE.

FIGURE 3-1

STRATIGRAPHIC SECTION-BEDROCK
HUDSON RIVER PCB SITE, HUDSON RIVER, NY
NOT TO SCALE

NUS CORPORATION
A Halliburton Company

The Snake Hill Formation is the most recent bedrock formation in the study area (Middle Ordovician). The Snake Hill is located in the low-lying areas of the Hudson River Valley and consists of dark, gray to black, bluish and greenish shales with thin sandy and black carbonaceous bands (Cushman, 1950). Beds in the Snake Hill are severely crumbled and contorted, and cut by cleavage planes as well as smoothed slip planes that give it a glazed appearance. In the vicinity of Hudson Falls, the Snake Hill lies almost flat and undisturbed, with a thickness near 600 feet (Cushman, 1953).

The Normanskill Shale (Middle Ordovician) is a member of the Taconic sequence of rocks that comprise the hilly and mountainous areas of western Rensselaer and Washington Counties. It is separated from the Snake Hill Formation to the west by an eastward dipping thrust fault plane. It consists of a dark-green to black argillaceous shale containing white-weathering, calcareous chert beds (Cushman, 1950). The Normanskill is highly folded and has a total thickness of approximately 1000 feet (Cushman, 1953).

The Beekmantown Limestone outcrops near the town of Middle Falls, underlies the Taconic sequence of rocks, and overlies the Snake Hill Formation along an eastward dipping thrust-fault plane. It forms a small ridge running north to south on the western foothills of the Taconic mountainous sequence of rocks. The Beekmantown Limestone also occurs north and northwest of Hudson Falls in the low-lying areas. It consists of massive, coarse to fine-grained dolomitic limestone with an average thickness of 900 feet and is Cambrian-Ordovician in age (Cushman, 1953).

The Schodack Formation is also a unit of the Taconic sequence of rocks and occupies a large part of the Taconic mountainous areas. The formation was formed during the Lower Cambrian Period and is composed of greenish-gray, fine-grained, siliceous shale presenting a highly folded appearance; locally it includes a brick-red weathering grit, a calcareous sandstone, a thin-bedded limestone, and red and purple shale. Total thickness of the Schodack Formation is believed to be 1000 feet (Cushman, 1950).

3.3.2 Surficial Geology

In most places within the study area, the bedrock is overlain by unconsolidated glacial materials and more recent materials that range in depth from a few inches to more than 200 feet. The unconsolidated sediments within the study area are glacial till, glacial outwash, lacustrine deposits, recent alluvium, and modern dredge spoils.

The glacial deposits of the study area are the result of the Wisconsin age glacial advancement, the most recent advance of the Pleistocene Epoch.

Till deposits occupy approximately 10 percent of the study area. Glacial till is a highly variable assortment of rock material that ranges in size from clay-size particles to rock fragments and boulders. The till usually occurs as ground moraines or drumlins of thickness varying from 30 to 100 feet (Cushman, 1950). Generally, the till is not stratified but local deposits of sand, gravel, silt, or clay within the till mass do occur as a result of local sorting. Deep till deposits in this area tend to be more dense than shallow deposits which have undergone more weathering (Malcolm Pirnie, Inc., 1978).

Glacial outwash deposits cover approximately a quarter of the study area. These deposits consist of sand and gravel left by glacial meltwater. They show a fair degree of sorting and frequently show cross-bedding and evidence of scour and fill (Cushman, 1950). Outwash is found on such landforms as outwash terraces, eskers, valley trains, kames, deltas, and outwash fans. These deposits are generally younger than (and commonly rest on) till. Valley-filled deposits were formed in local lakes or stream channels where spillways which were controlled by ice or glacial debris were located. The thickness of the deposits is influenced by the shape and bedrock of the valleys. These highly variable sediments are usually stratified, consisting of gravel, coarse through fine sand, and clay. Deltaic deposits are outwash formations that were built at points where streams laden with large rock debris entered the still waters of proglacial Lake Albany and spread out into a fan shape. Deltaic deposits are composed of material ranging in size from coarse gravel to fine sand and silt (Malcolm Pirnie, Inc., 1978).

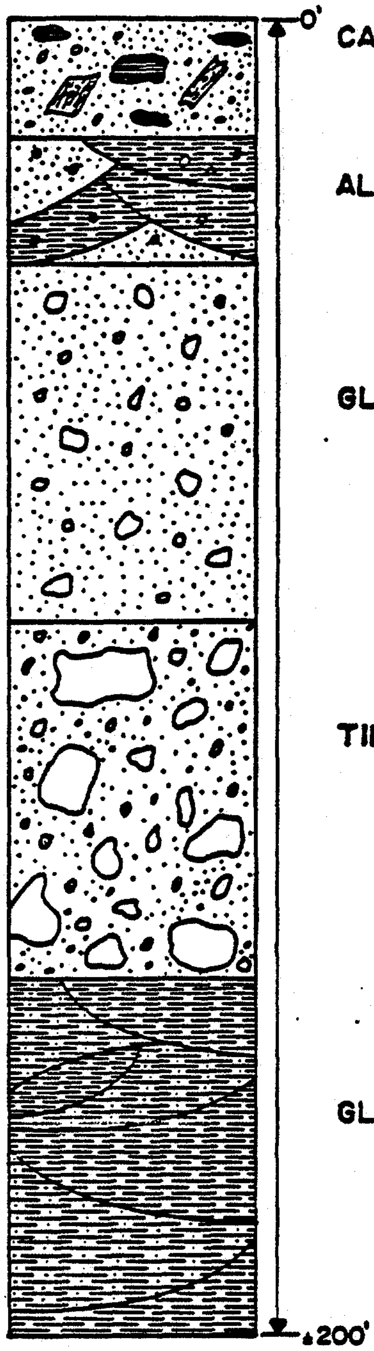
Glacial lacustrine sediments comprise over half of the study area. These sediments were deposited on the bottom of proglacial Lake Albany, which extended from Rensselaer County to Essex County some 10 to 15 thousand years ago. These clays were laid down in the quiet water of the glacial lake and were exposed as flat terraces or bottom lands when the lake drained, near the end of the Pleistocene Epoch. The formations occur along the Hudson River as terraces, covering flat to gently rolling valley floors. The lower beds are predominantly varved, fine-grained, bluish clays grading into yellowish-red silts (Malcolm Pirnie, Inc., 1978).

Recent river deposits or alluvium consist of various sediments deposited along streams. Alluvial deposits are composed of a veneer of silt, clay, sand, and some gravel that was laid down by streams (Cushman, 1950). These deposits are usually located on the flood plains within half a mile of the banks of the Hudson River and tributaries (Malcolm Pirnie, Inc., 1978).

Canal-dredging spoils deposited along the Hudson River constitute the man-made land encountered within the study area. These deposits are generally of a coarse nature, consisting of quartz-feldspar sands, cinders, and shale cobbles mixed with wood fragments of all sizes (sawdust to pieces several feet in length) (Malcolm Pirnie, Inc., 1978).

Figure 3-2 depicts a stratigraphic section of unconsolidated sediments within the study area.

Figures 3-3 and 3-4 depict surficial geology maps of the Hudson River in the northeastern region of Saratoga County and the southwestern region of Washington County, respectively.



CANAL DREDGE SPOILS: CONSITUTES THE MAN-MADE LAND ENCOUNTERED WITHIN THE STUDY AREA. CONSISTS OF QUARTZ-FELDSPAR SANDS, CINDERS, SHALE COBBLES MIXED WITH WOOD FRAGMENTS OF ALL SIZES.

ALLUVIAL DEPOSITS: NORMALLY LOCATED ON THE FLOOD PLAINS WITHIN A HALF MILE OF THE RIVER BANKS. CONSISTS OF CLAY, SILT, SAND, AND SOME GRAVEL.

GLACIAL OUTWASH DEPOSITS: COVER APPROXIMATELY 1/4 OF THE STUDY AREA. CONSISTS OF SAND AND GRAVEL DEPOSITED BY GLACIAL MELTWATER.

TILL DEPOSITS: COVER APPROXIMATELY 1/10 OF THE STUDY AREA. CONSISTS OF A HIGHLY VARIABLE ASSORTMENT OF ROCK MATERIAL RANGING IN SIZE FROM CLAY-SIZE PARTICLES TO ROCK FRAGMENTS AND BOULDERS.

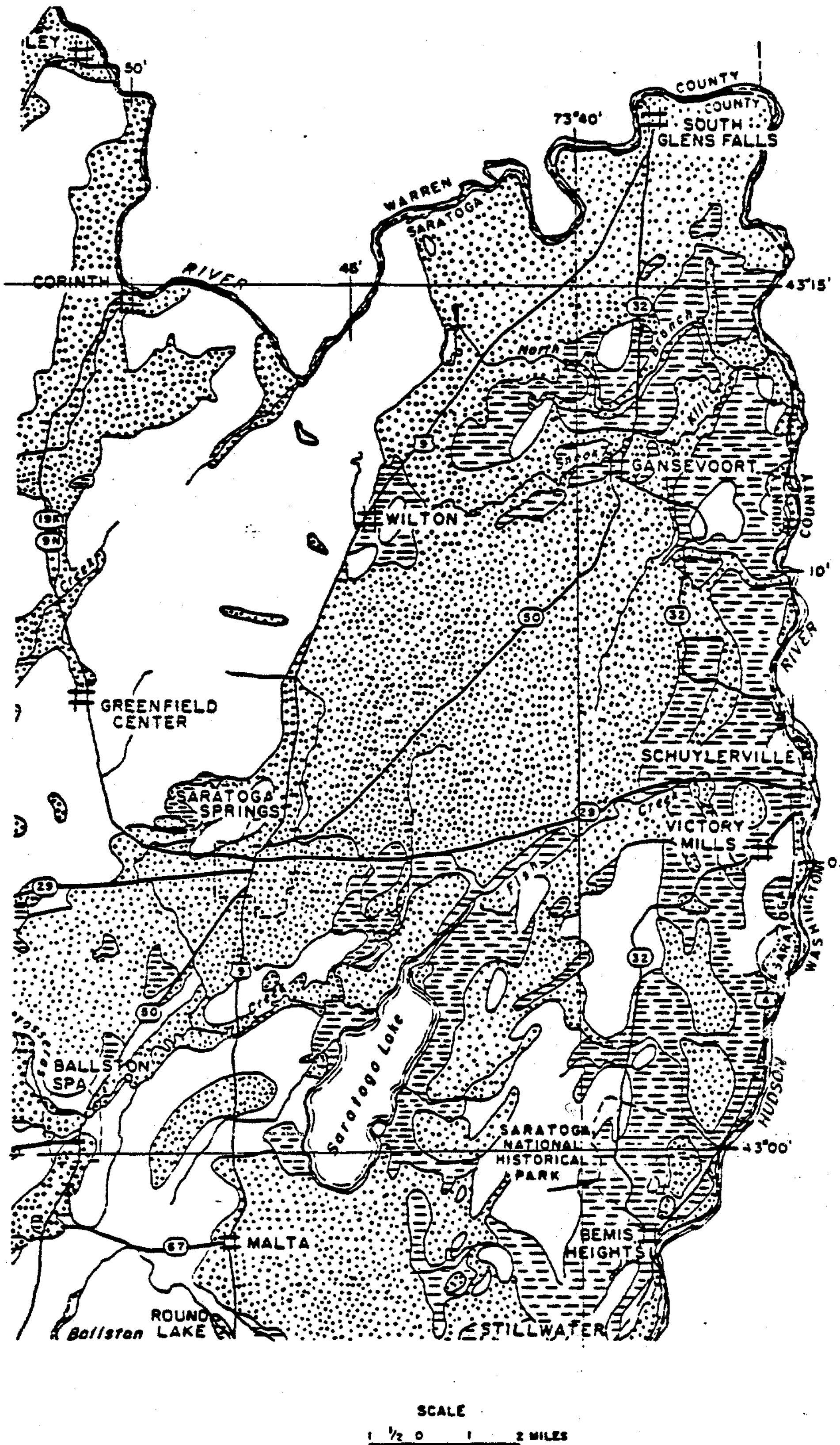
GLACIAL LACUSTRINE SEDIMENTS: COMPRISE OVER 1/2 OF THE STUDY AREA. CONSISTS OF BLUISH CLAYS AND YELLOWISH-RED SILT.

FIGURE 3-2

STRATIGRAPHIC SECTION
UNCONSOLIDATED MATERIAL
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NOT TO SCALE

NUS CORPORATION
A Halliburton Company



LEGEND

SAND AND GRAVEL

CHIEFLY SAND BUT INCLUDES SOME GRAVEL. SMALL ISOLATED DEPOSITS NOT SHOWN. YIELDS MODERATE TO LARGE SUPPLIES OF WATER.

CLAY AND SILT

YIELDS WATER, MAINLY TO LARGE-DIAMETER WELLS.

TILL

CHIEFLY AN UNSORTED MIXTURE OF ROCK FRAGMENTS RANGING IN DIAMETER FROM SMALL FRACTIONS OF AN INCH TO SEVERAL FEET. INCLUDES THIN SAND LENSES IN PLACES. BEDROCK OUTCROPS ARE COMMON BUT ARE NOT SHOWN. YIELDS SMALL SUPPLIES OF WATER TO LARGE-DIAMETER WELLS.

(REF: R.C. HEATH, ET AL, 1963)

FIGURE 3-3

SURFICIAL GEOLOGY OF SARATOGA COUNTY
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

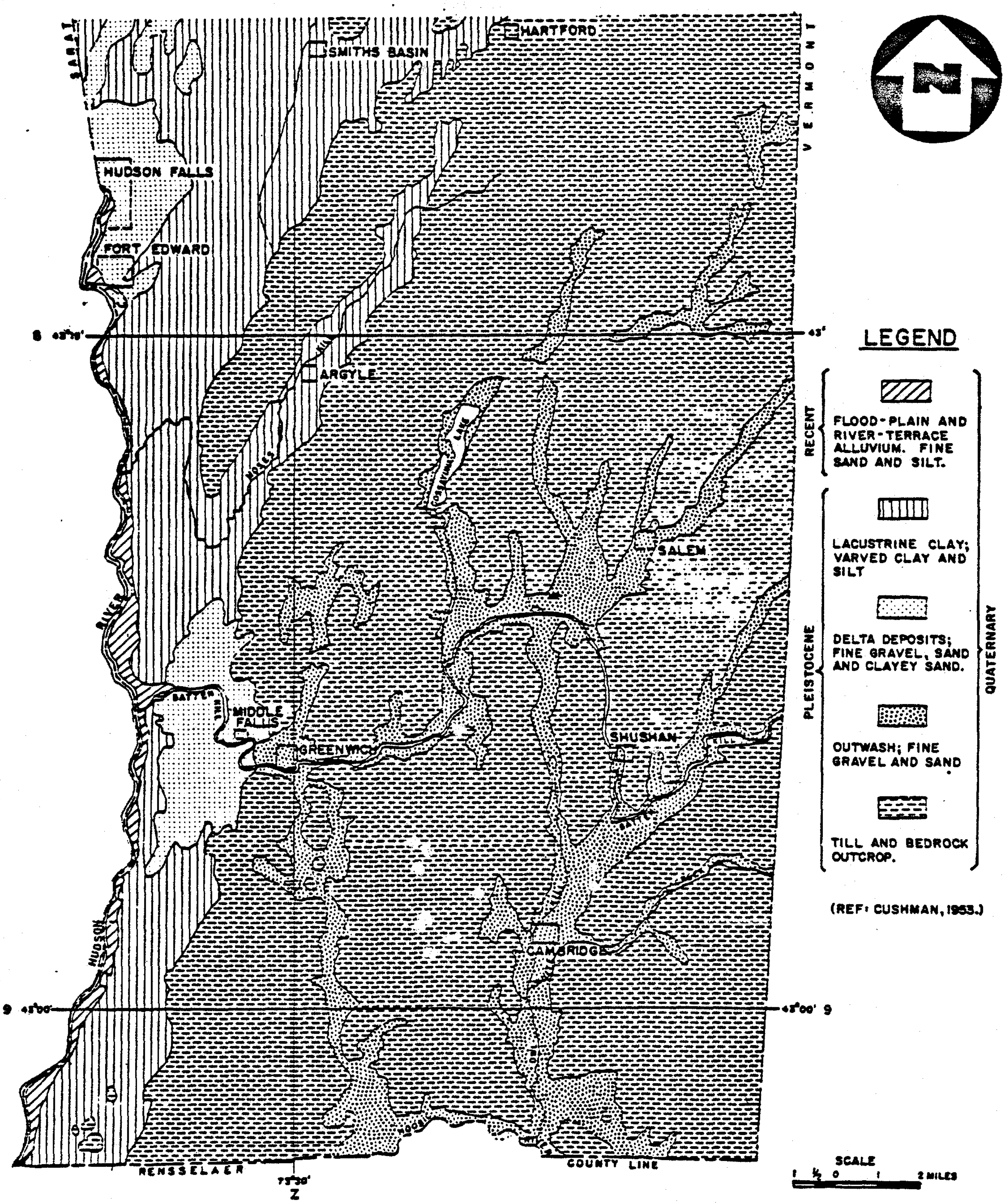


FIGURE 3-4

SURFICIAL GEOLOGY OF WASHINGTON COUNTY
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

3.3.3 Soils

Most of the soils within the study area have been formed in glacial drift that was deposited by the Wisconsin advance of the Pleistocene Epoch. Additional soils have been formed in more recent deposits of alluvium or dredge spoil.

Soils developed in till over bedrock are of minor occurrence within the study area. Depth to bedrock in these soils is shallow, ranging from 1 to 3.5 feet. These soils are usually found on undulating to hilly uplands. The drainage of these soils ranges from moderately well drained to somewhat excessively drained. Fragipan, a dense subsurface horizon which is low in organics and permeability that sometimes causes perching of the groundwater table, is often encountered in these soils (Malcolm Pirnie, Inc., 1978).

Soils in glaciolacustrine sediments on lake plains and valleys are extensive within the study area. These soils are found on nearly level, depressional, or very steep slopes. Glaciolacustrine soils are generally deep, 3.5 feet or more, and have variable drainage classes, ranging from somewhat poorly drained to well drained (Malcolm Pirnie, Inc., 1978). Wetness increases with depth in these clayey and silty deposits. Water contents as high as 60-70 percent have been reported (SCS, 1975).

The soils formed on plains, terraces, kames, eskers, and glacial outwash deposits in the valley are generally deep (6 feet or more), excessively drained, and coarse textured gravelly soils. Many of these soils are underlain by silt and clay lenses which impede their drainage.

Soils that are formed in recent river or alluvial deposits are 4 feet deep or more, and medium textured (high in silt and fine sand), with variable drainage classes (very poorly drained to well drained). These soils are subject to flooding except where the flow is regulated (Malcolm Pirnie, Inc., 1978).

3.4 Groundwater

Groundwater aquifers within the study area can be classified in either of two catagories: Ordovician and Cambrian consolidated rocks or Pleistocene unconsolidated sediments. The consolidated rocks generally have low effective primary porosities. In many consolidated formations, the presence of joints, fractures, and faults increases formation permeability greatly. The Pleistocene unconsolidated sediments generally yield greater amounts of water than the consolidated rocks due to high permeabilities.

The consolidated formations that yield noticeable amounts of water within the study area are the Snake Hill Formation, Beekmantown Limestone, Normanskill Shale, and the Schodack Formation. The Snake Hill Formation is the highest water-bearing consolidated formation within the study area. It is generally crumbled and contorted and cut by cleavage planes. Occasional sandy limestone strata within the Snake Hill help yield water at an average of 16 gallons per minute (gpm). Water yields are highly variable in these shales since permeability is dependent upon joints, fractures, and faults. The Beekmantown Limestone is generally a good source of water, with average well yields of 12.7 gpm. Joints are the chief water bearers in the Beekmantown. The Normanskill and Schodack Formations have average groundwater yields of 6 and 5 gpm, respectively. The yields within these formations are dictated by joints, and by cleavage and bedding plane fractures (Cushman, 1950, 1953; Malcolm Pirnie, Inc., 1983).

The Pleistocene unconsolidated sediments yield groundwater at various rates. The sediments that yield considerable amounts of water are glacial outwash and till. Other sediments that yield small amounts of water are lacustrine and alluvial deposits.

Glacial outwash deposits are the most productive water bearers in the study area. These high-permeability, stratified sands and gravels have water yields ranging from 15 gpm for unscreened wells to 300 gpm for screened and developed wells. Deltas are the most productive water-bearing glacial outwash deposits (Malcolm Pirnie, Inc., 1983).

Low porosity till yields water very slowly. The estimated average yield of these deposits is from 1 to 2 gpm (Malcolm Pirnie, Inc., 1983). The more productive wells obtain their water from thin sand lenses within the deposit and are suitable for domestic use. Till deposits are usually found on hillsides, highlands, and in small localized areas in the river valleys.

Other types of aquifers that yield small quantities of water in the study area are lacustrine deposits and alluvial deposits. Lacustrine deposits of clay and silt yield water very slowly and in negligible quantities. Alluvial deposits are not coarse enough or of sufficient thickness to be important sources of groundwater. Shallow wells that obtain water from the alluvium probably intersect lenses of sand.

The aquifers within the study area are generally bordered by or underlain by relatively impermeable silt, clay, till, shale, or crystalline bedrock. Therefore, migration from aquifer to aquifer is minimal. Measurements of streamflow in the area indicate that most of the streams are effluent. Accordingly, groundwater recharge is most likely to occur by way of precipitation, which readily enters the aquifers through the permeable surface. Average annual precipitation in the Glens Falls area is about 40 inches. Of this, 10 inches is estimated to recharge the sand aquifers from mid-fall to mid-spring (Giese, 1970). The remaining precipitation is probably direct runoff to surface water.

3.5 Climate and Meteorology

The average monthly temperature and precipitation figures for Albany County Airport, Albany, New York, for 1981 are shown in Table 3-1.

The climate at Albany is primarily continental in character but is subjected to some modification from the maritime climate which prevails in the extreme southeastern portion of New York State. The moderating effect on temperatures is more pronounced during the warmer months than in the cold winter season, when outbursts of cold air sweep down from Canada with greater vigor than at other times of the year. In the warmer portion of the year, temperatures rise rapidly

TABLE 3-1

CLIMATE AND METEOROLOGY
Albany County Airport

The average monthly temperature and precipitation figures for Albany County Airport, Albany, New York, for 1981 are shown below.

Month		Average Monthly Temperature (°F)		Average Monthly Rainfall (inches)
January		14.0		0.59
February		33.1		5.02
March		34.7		0.26
April		48.1		1.99
May		58.9		2.44
June		66.7		2.78
July		69.3		3.50
August		68.5		1.76
September		58.8		3.45
October		44.8		3.55
November		37.7		1.56
December		25.7		3.54
	Yearly Average	46.7	Total	30.44

during the daytime to moderate levels. As a rule, temperatures fall rapidly after sunset so that the nights are relatively cool. Occasionally the area experiences extended periods of oppressive heat up to a week or more in duration. The highest temperature of record is 104°F, but since 1874, 100°F temperatures have been recorded on only 15 days (National Oceanic and Atmosphere Administration (NOAA), 1981).

Winters are usually cold and occasionally severe. Maximum temperatures during the winter months often fall below freezing and nighttime low temperatures frequently drop to 10°F or lower. Subzero temperatures occur infrequently, about a dozen times a year. Yearly snowfall in the area is highly variable and some of the higher elevations experience accumulations in excess of 75 inches. Precipitation is sufficient to serve the regional economy in most years, and only occasionally do periods of drought become an environmental threat. A considerable portion of the rainfall in the warmer months is from showers associated with thunderstorms, but hail is usually not of any consequence (NOAA, 1981). Surface water runoff of the Hudson Basin varies from about 19 inches to 24.5 inches, with the remainder of the precipitation returning to the atmosphere through evapotranspiration (NYSDEC, 1979).

3.6 Land Use

The Hudson River Basin has a total population of 2.5 million. The basin borders the New York metropolitan area, which has an approximate population of 12 million (NYSDEC, 1979). Albany, the largest city in New York along the Hudson, has an approximate population of 100,000. Cities with populations greater than 25,000 in New York are Newburgh, Poughkeepsie, and Troy (Rand McNally, 1982).The major industries of the Hudson River Basin are agricultural, service, and manufacturing. Dairy farming and apple and pear orchards comprise a large part of the agricultural development. Petroleum refineries, grain bins, and paper mills are located at various sites along the river.

Significant portions of the Northern Hudson River Basin lie in the Adirondack Park, while portions of the southcentral basin are in the Catskill Park. Camping, hiking, and skiing are some of the forms of recreational activities available within the basin.

Several furbearers are abundant in the river valley. Mink, otter, and muskrat are valuable fur-bearing species. Common game species include deer, eastern cottontail rabbit, gray squirrel, and raccoon, as well as game birds, such as ruffed grouse, pheasant, and woodcock. Bears are also occasionally noted. The bobcat and coyote are much less common species in the Hudson River Basin (NYSDEC, no date). Birdlife in the Hudson River Valley is abundant and includes many common birds of the woodlands and open fields. The wild turkey, a game species, has been successfully reintroduced in New York and is found in upland areas along the Hudson River estuary (Malcolm Pirnie, Inc., 1983).

Several species of birds and plants are considered endangered by New York State and/or the U.S. Fish and Wildlife Service. Those bird species are the bald eagle, peregrine falcon, and osprey. The endangered plant species include heartleaf plantain (Plantago cordata), Nuttall's Micranthemum (Micranthemum micranthemoides), bur marigold (Bidens bidentoides) and golden club (Orontium aquaticum) (Malcolm Pirnie, Inc., 1983).

3.7 Water Use

3.7.1 Surface Water Use

The Hudson River has 2 million acre-feet of storage, most of which is in the upper basin. Various primary uses include hydroelectric power, public supplies, navigation, water recreation, and flood damage reduction.

The stretch of the Upper Hudson River from the Mohawk-Hudson Junction north to the Sacandaga-Hudson Junction is the greatest hydroelectric-producing area in the basin. A total of ten hydroelectric plants are located on the main-stem Hudson River, with most of these being on the Upper Hudson.

Several communities obtain drinking water from the Hudson River, including the City of Poughkeepsie, the Highland Water District, the Port Ewen Water District, the Village of Rhinebeck, and the Village of Waterford (Malcolm Pirnie, Inc., 1980). A water intake located at Chelsea, north of Beacon, New York, may be used to supplement New York City water supplies during periods of drought.

The Village of Waterford is the northernmost community that receives its water supply directly from the Hudson downstream from the General Electric outlets. The intake is located on the west side of the Hudson, at the northern end of the village limits. The daily withdrawal is approximately one million gallons. The water is treated by coagulation, flocculation, and settling, followed by rapid filtration, and chlorination (Malcolm Pirnie, Inc., 1978).

The Hudson River itself is a major industrial transportation route. Total tonnage of commerce on the Hudson River waterway has declined over the past 21 years of record, ranging from a high of 42,421,533 tons in 1957 to a low of 28,220,192 tons in 1977 (Corps of Engineers, 1972, 1977; Malcolm Pirnie, Inc., 1983). The cargoes consisted almost entirely of petroleum products enroute to communities on the Champlain Canal and Lake Champlain. The shipping season usually begins in late April and continues until early December (Malcolm Pirnie, Inc., 1978).

The Hudson River supports a variety of water-based recreational activities, which include sport fishing, waterfowl hunting, fur trapping, swimming, and boating. The recreational fishery of the mid-Hudson River, from the Federal Dam at Troy to Poughkeepsie, includes largemouth and smallmouth bass, brown bullhead, yellow perch, walleye, blueback herring, alewife, rainbow smelt, sunfish, and black crappie. Catches of striped bass and American shad have also been reported as far upriver as Troy Dam. Sheppard (1976) estimates fishing activity in this segment to be about 30,000 angler-days per year. The fishery of the lower Hudson south of Poughkeepsie includes striped bass, American eel, Atlantic tomcod, blue fish, white perch, white catfish, winter and summer flounder, blueback herring, and alewife. Important aquatic invertebrates include the freshwater mussel and the blue crab, the latter an important recreational species harvested from the shallow waters of Peekskill Bay. Based on aerial surveys in 1972 through 1974, the lower fishery supports an estimated 20,165 angler-days annually (Sheppard, 1976). As a spawning ground for striped bass and a nursery for bluefish, the Hudson also contributes to the marine fishery. Sheppard also estimates that the striped bass fishery supports 1,417,000 angler-days annually with an economic value of more than $28 million (Malcolm Pirnie, Inc., 1983).

The shortnose sturgeon, which is an endangered fish species, exists in the Hudson River estuary. This reach of the river is utilized as a spawning ground, a major overwinter area, a nursery area for young of the year fish, and as a summer feeding ground. The shortnose sturgeon is very susceptible to PCB contamination due to its occurrence and spawning in the highly polluted area located just below the Federal Dam at Troy (DEIS, 1981).

The flood control reservoirs within the Hudson River Basin are used to control river flows during flood or drought conditions in order to maintain barge navigation and hydroelectric power generation.

Some homes and farms along the Hudson River also use the river as a supplemental water supply for watering lawns and gardens, and for irrigating crops.

3.7.2 Groundwater Use

Several municipalities, industries, and private individuals obtain water from wells located adjacent to the Hudson River. The Town of Stillwater operates four wells, and Green Island draws water from infiltration galleries located on an island in the Upper Hudson River (Malcolm Pirnie, Inc., 1980). The amount of water drawn exclusively for industrial use is small and restricted mainly to light industries such as creameries and garages. Most of the heavy industry in the area is situated in or near the larger towns and cities and utilize municipal water supplies. In areas not served by a public water system, domestic water supplies are obtained almost exclusively from wells and springs. The domestic uses of water include drinking, cooking, washing, and sewage disposal, and these needs are normally met by dug or drilled wells of low yield. Water for cattle and other farm animals is also obtained by the same method, and in many cases where the number of stock to be cared for is small, one well may suffice for both the farm and the household. The average consumption from this type of well is generally less than 500 gallons per day (Cushman, 1950).

4

4.0 ENVIRONMENTAL CONCENTRATIONS

4.1 Concentrations, Distribution, and Trends

PCBs are water insoluble compounds which have a pronounced tendency to adsorb onto fine particulate matter. These chemicals have an especially high affinity for carbon-rich materials such as activated carbon, humus, and soil organic matter. Because of this property, a large portion of the PCBs in the General Electric discharges adhered to organic-rich sediments, particularly those that accumulated behind the Fort Edward Dam. Between 1974 and 1977, approximately 1.1 million cubic yards of PCB-contaminated sediments were released to the river during high flows following the removal of the dam in 1973. Since the court mandated elimination of PCBs from the G. E. discharges in 1977, these contaminated sediments and the exposed deposits in the former dam pool are believed to be the primary source of PCBs in the Hudson River environment. This section presents major conclusions of five years of scientific and engineering studies on PCB contamination in sediments, water, air, and biota of the Hudson River Basin.

4.1.1 Sediments

4.1.1.1 Remnant Sediment Deposits

The removal of the Fort Edward Dam left more than 1.5 million cubic yards of contaminated sediments in five discrete deposits exposed along the edges of the river in a 1.5 mile stretch upstream of Fort Edward. The locations of these remnant deposits are illustrated in Figure 4-1. Approximately 850,000 cubic yards of this material was scoured by high flows between July 1973 and July 1974 (Malcolm Pirnie, Inc., 1975). Another 260,000 cubic yards of sediment were transported during a 100-year frequency flood in April 1976--220,000 cubic yards of which came from the remnant deposits. In 1977-78 17,000 cubic yards of highly contaminated sediment from area 3A was removed to the New Moreau secure containment site, along with 170,000 cubic yards of material dredged from the channel just below the old dam site (Malcolm Pirnie, Inc., 1980).

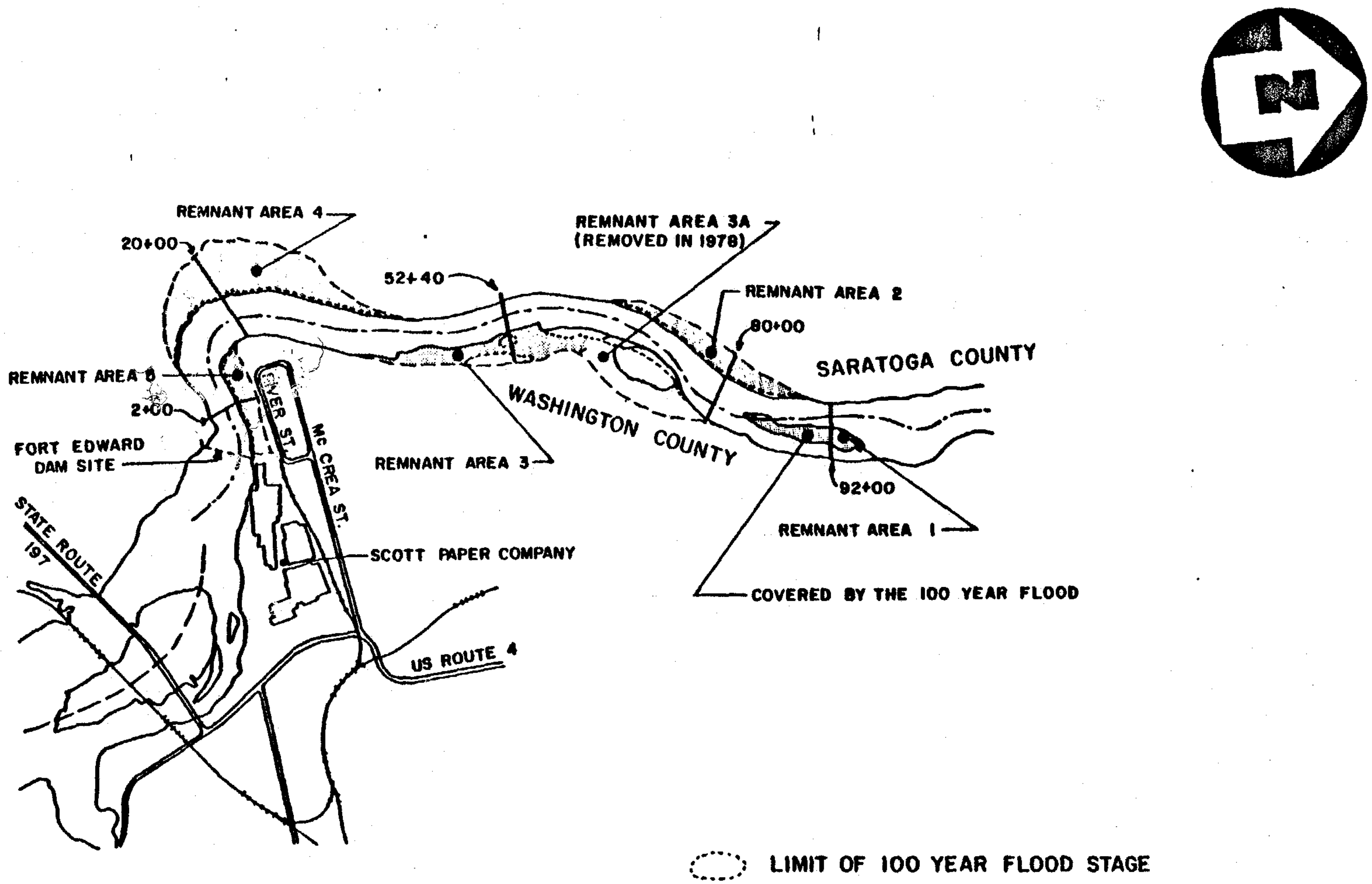


FIGURE 4-1

PLAN VIEW, REMNANT DEPOSITS
HUDSON RIVER PCB SITE, HUDSON RIVER, NY
SCALE: 1" = 2,000'

NUS CORPORATION
A Halliburton Company

Remnant deposits contain high amounts of sawdust, wood chips, and other debris remaining from a once thriving lumber industry. Because of their high organic carbon content and their proximity to the former G. E. discharge points, the remaining exposed deposits are among the most highly contaminated sediments in the river.

Results of core sampling by the NYSDEC and Malcolm Pirnie, Inc., are summarized in Table 4-1. The values in the table represent the latest volume and mass estimates by NYSDEC (Tofflemire, 1980a). Arithmetic average PCB concentrations on a dry-weight basis ranged from 5 to 1000 ppm. Estimates of the PCB mass in the remnant deposits ranged from 64,000 pounds to 140,000 pounds (Malcolm Pirnie, Inc., 1980).

The most highly contaminated sediments were generally found in the top few inches of the sample cores; however, significant contamination extended up to 10 feet below the surface. PCB levels ranged from 5620 ppm at the surface of a core from site 3a to less than 3 ppm, which was commonly found a few inches deep in many samples. PCB concentrations tended to increase with distance from the edge of the present bank to a maximum near the old pool shore. This trend is characteristic of the river below the remnant deposits and is related to velocity distributions and sediment characteristics as will be discussed later.

The remnant deposits were subjected to a number of remedial activities between 1974 and 1978, the most significant of which was the excavation and containment of area 3a. The unstable banks of areas 3 and 5 were graded and stabilized with stone riprap and these areas, along with area 2, were revegetated. An aerial inspection in 1983, however, revealed that the plantings had not taken well. Remnant deposit 1, which is an island, has not been subjected to any remedial action. The aerial inspection in 1983 showed it to be much smaller than before.

Figures 4-2a through 4-2e depict typical cross sections at the remnant deposits and relate contaminated material and remedial construction features to river stages.

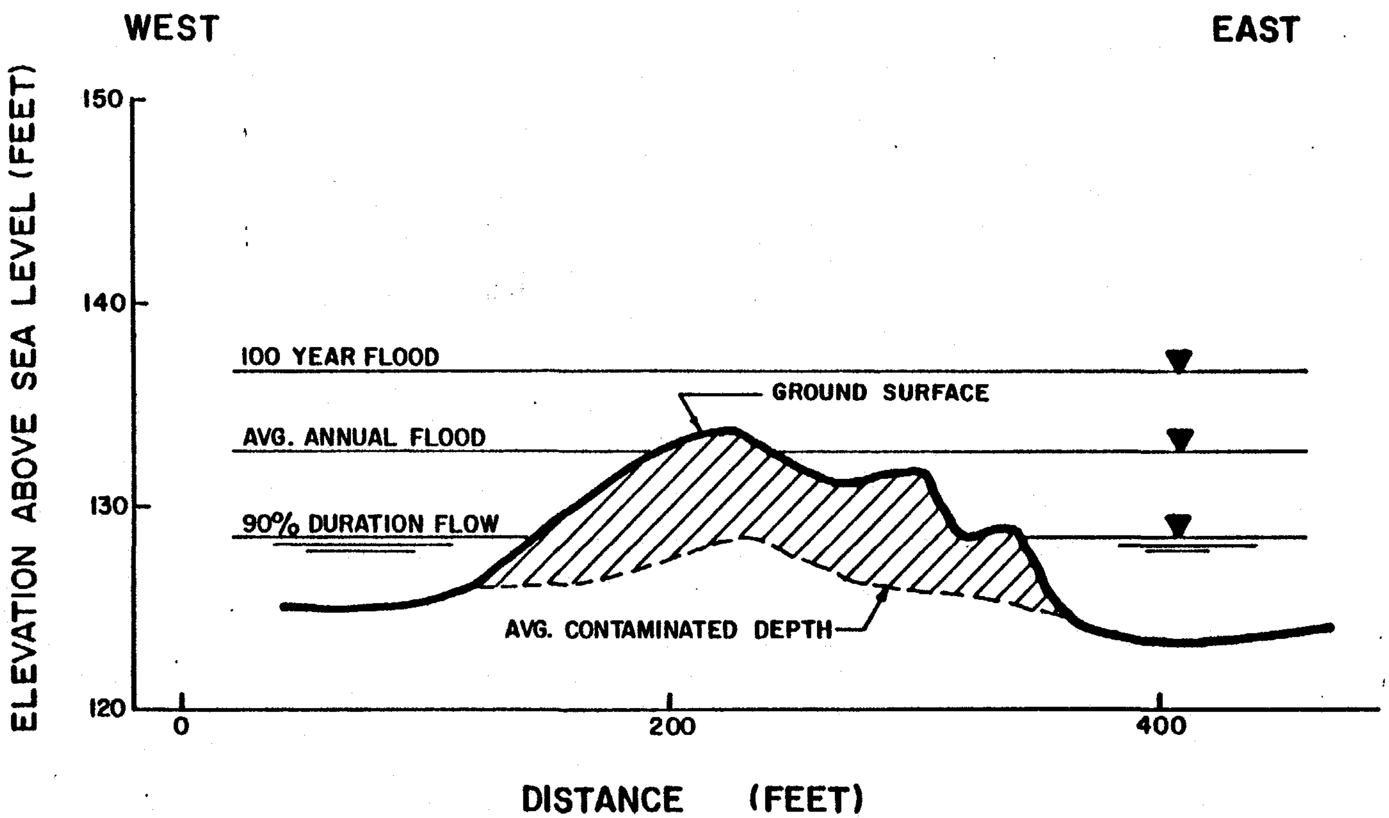
TABLE 4-1

PCB CONTAMINATION IN REMNANT DEPOSITS

Remnant Area	Area (acres)	Avg. PCB Concentration (ppm)	Contaminated Depth (ft)	Contaminated Volume (yd^3)	PCB Mass (lb)
1	4.0	20	2	12,900	450
2	8.0	5	5	64,530	570
3	13.3	65	8	160,925	18,550
3a	6.0	1000	1	9,680*	17,000*
4	12.0	25	2	38,720	1,700
4a	8.5	40	3	41,140	2,900
5	4.0	250	8	31,630	22,650
Total	55.8			359,525	63,820
Less Area 3a					17,000
Remaining					46,820

Source: (Tofflemire, 1980).

* The actual volume excavated from area 3a in 1978 was 14,000 yd^3. Based on an assumed bulk density of 65 $lb \cdot ft^{-3}$ the PCB mass removed from Area 3a could be 24,500 lb. The remaining mass of PCB, however, does not change.



SOURCE: TRANSECT 92+00, MALCOLM PIRNIE (1977)

FIGURE 4-2a

TYPICAL CROSS SECTION AT REMNANT DEPOSIT 1
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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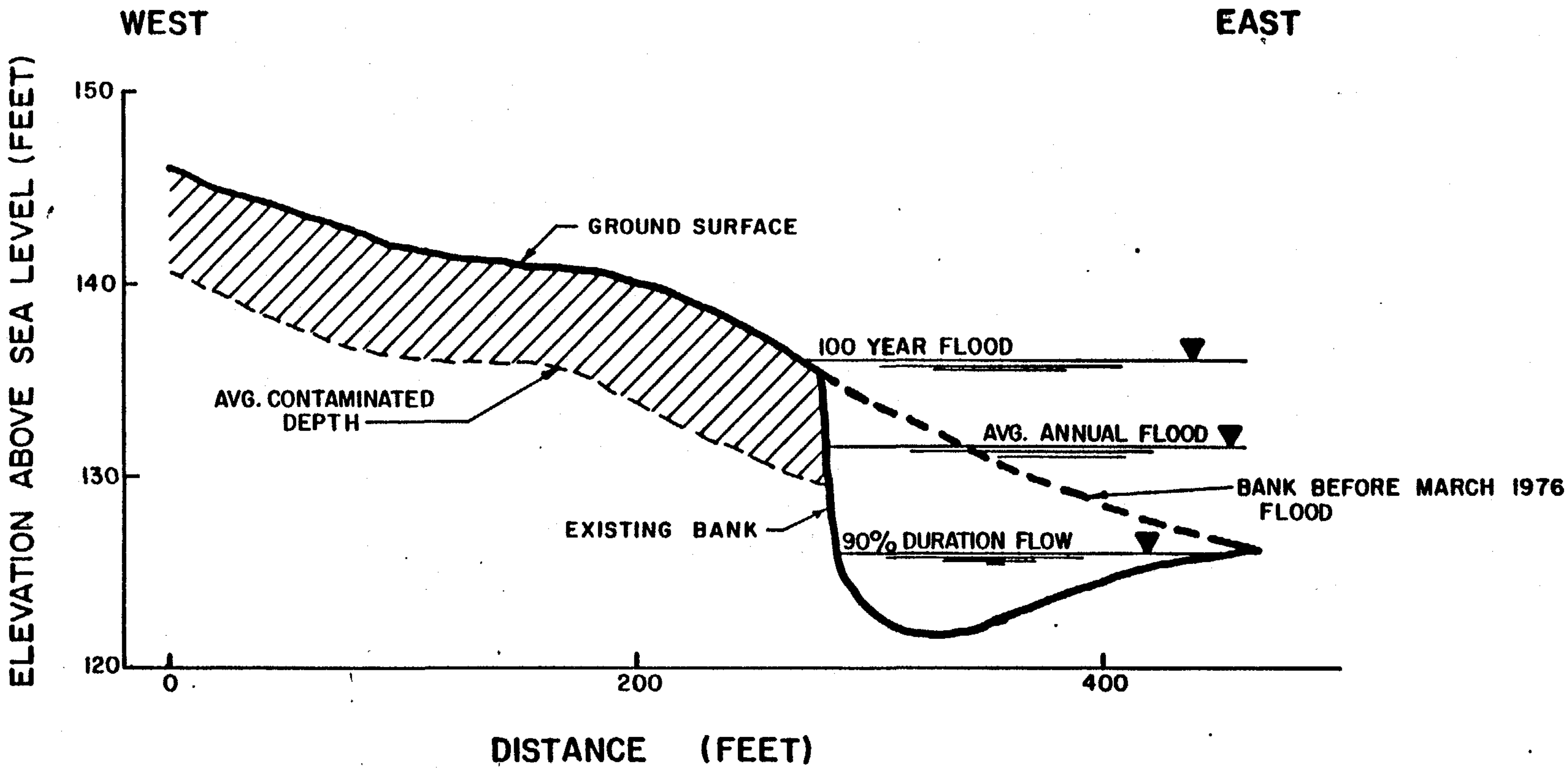
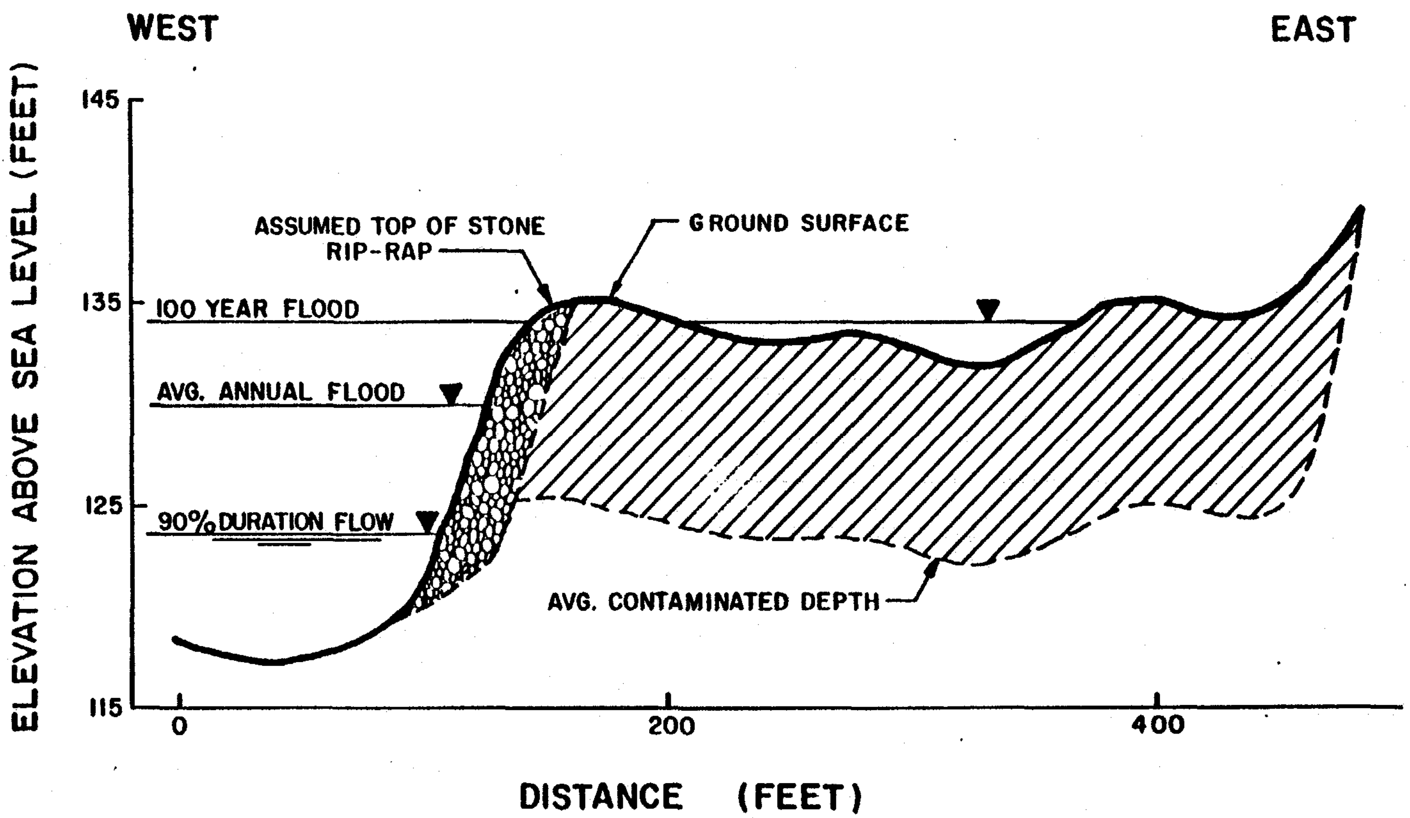


SOURCE: TRANSECT 80+00, MALCOLM PIRNIE (1977)

FIGURE 4-2b

TYPICAL CROSS SECTION AT REMNANT DEPOSIT 2
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company



SOURCE: TRANSECT 52+40, MALCOLM PIRNIE (1977)

FIGURE 4-2c

TYPICAL CROSS SECTION AT REMNANT DEPOSIT 3
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

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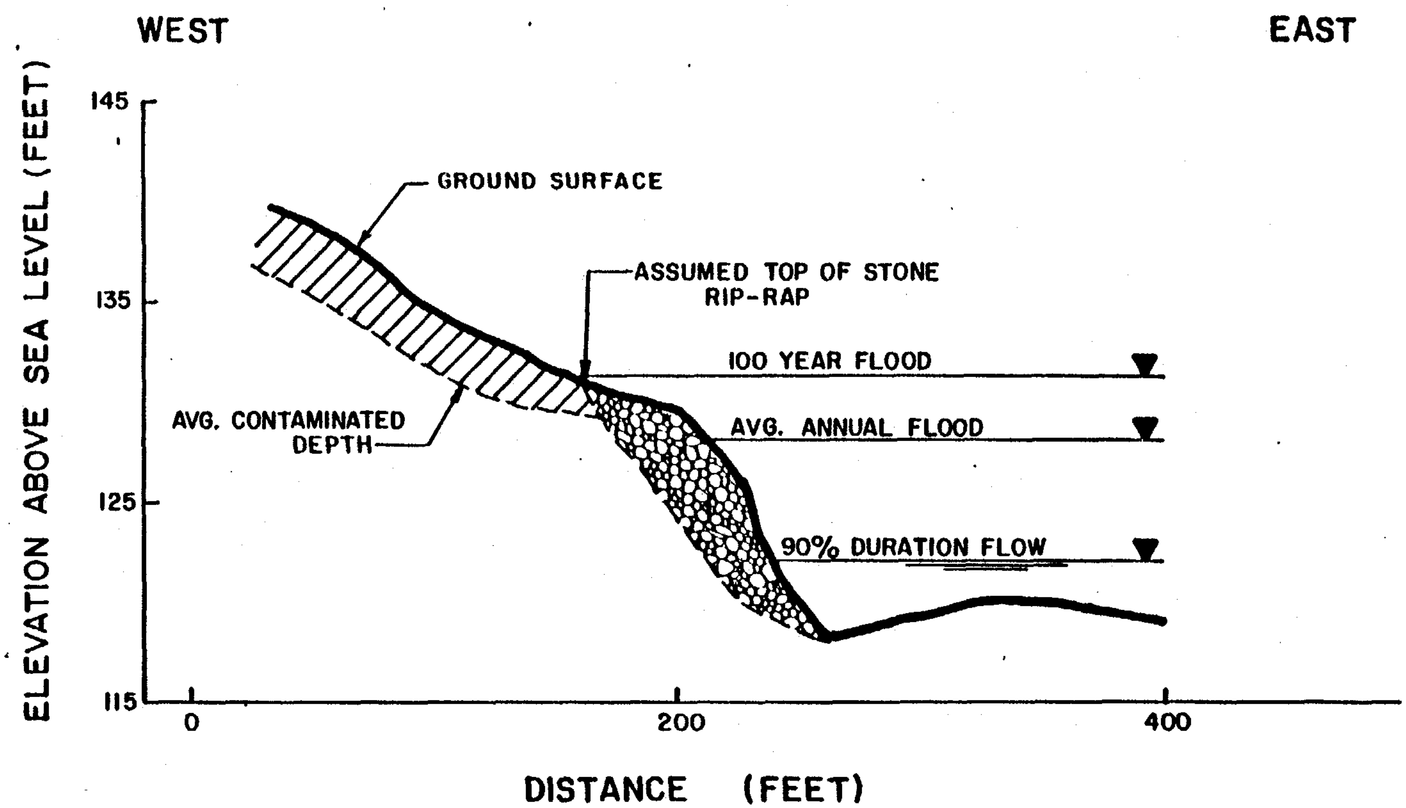
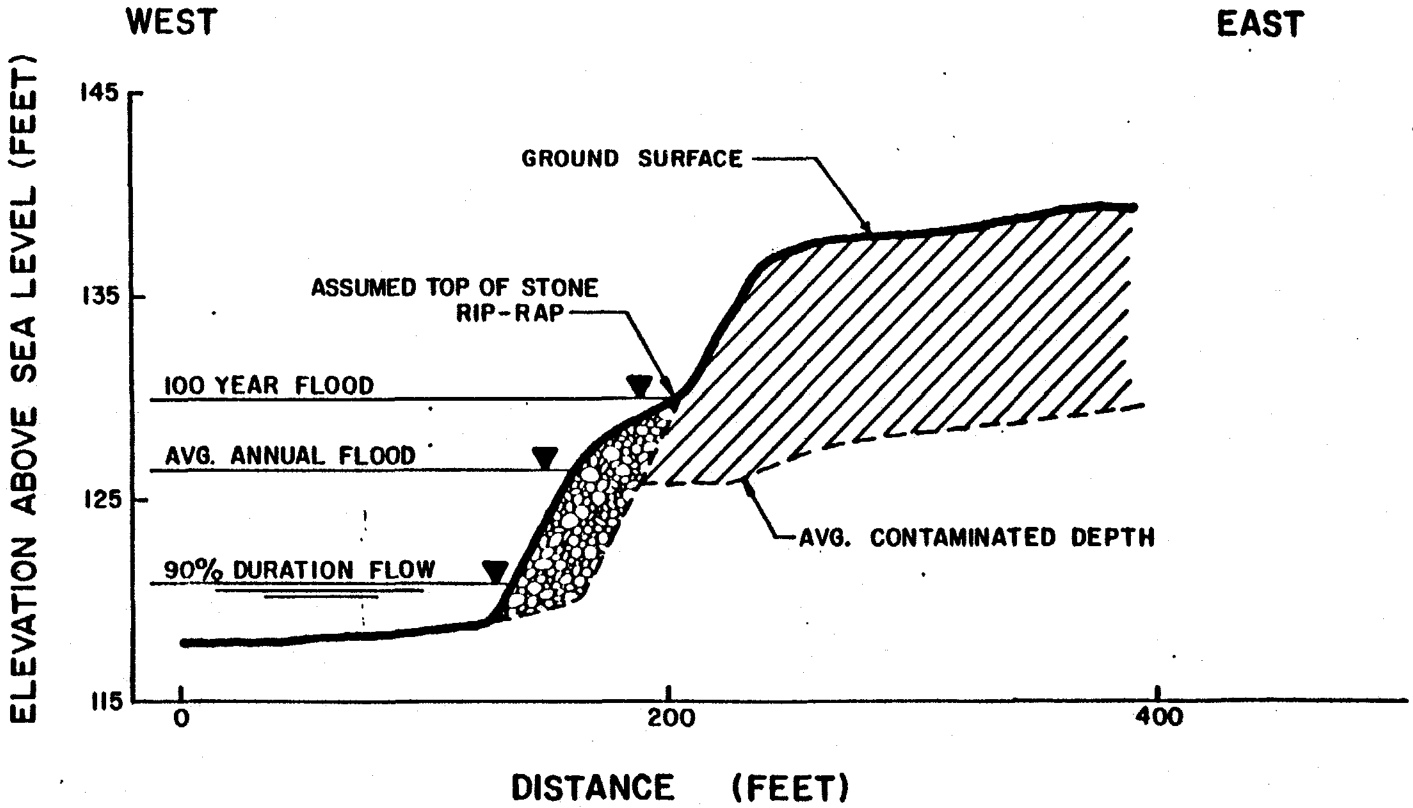


SOURCE: TRANSECT 20+00, MALCOLM PIRNIE (1977)

FIGURE 4-2d

TYPICAL CROSS SECTION AT REMNANT DEPOSIT 4
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company



SOURCE: TRANSECT 2+00, MALCOLM PIRNIE (1977)

FIGURE 4-2e

NUS CORPORATION
A Halliburton Company

TYPICAL CROSS SECTION AT REMNANT DEPOSIT 5
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

Ninety percent of the time the pool surface elevation is at or below the lower boundary of significant PCB contamination within the remnant deposits (Malcolm Pirnie, Inc., 1978). Thus, bank scour during periods of high flow is the principal mechanism responsible for the transfer of PCB to the lower reaches.

Infiltrating rain water and runoff, as well as groundwater movement, carry some desorbed PCBs to the river; however, this contribution is insignificant compared to the PCB load passing Rogers Island (see section 4.1.2.2 for a discussion of groundwater migration potentials). Remnant deposit saturation during floods would not contribute significant amounts of PCBs to the river since the hydraulic gradient would slope away from the river during these periods and desorbed PCBs would be carried inland where it would be attenuated by soil particles. Although air transport from the remnant deposits is surprisingly high, WAPORA, Inc., (1980) concluded that PCB redistribution in rainfall and dry deposition is not a significant component to the total PCB mass balance.

Malcolm Pirnie, Inc., (1978) estimated that approximately 8600 pounds of PCB per year were lost to the river from the remnant deposits before remedial activities were implemented. Tofflemire and Quinn (1979b) suggested that after remediation, the unstable bank areas of remnant deposit 4 presented the greatest potential for future erosion losses. The most highly contaminated deposits, areas 3 and 5, are not likely to erode because they are adequately protected against flows substantially higher than the average annual flood. Consequently, it is contended by some NYSDEC officials that the majority of the PCB contamination which moves into lower reaches comes from contaminated bottom sediments and not from remnant deposit scour, because the remaining unstable remnant areas are not highly contaminated.

4.1.1.2 Upper Hudson River Sediments

The NYSDEC and its consultants began an extensive survey in 1976 to determine the magnitude of PCB contamination in Upper Hudson River sediments. Over 1200 core and grab samples were taken from a 40 mile stretch of river from 1976 to 1981. Approximately 700 of these were analyzed for PCBs and a large number of samples were tested for particle size class distribution, volatile solid content, heavy metals, and the radioisotope cesium 137 (^{137}Cs).

The bulk of sediment sampling was completed in 1977. The main survey consisted of 640 grab samples collected along surveyed transects which were more common near Fort Edward and less closely spaced down river, plus an additional 200 core samples which were recovered randomly from soft near-shore deposits. A second survey in 1978 included 200 grab samples collected to refine the results of the 1977 sampling effort. No major sediment surveys (>50 samples with accompanying PCB analysis) have occurred since 1978. The major findings of numerous studies are discussed below.

Estimates of mean PCB concentrations and mass vary from report to report depending on the type of averaging used, how sectioned core samples were averaged, and the method used to determine depth and areal extent of contaminated deposits. Table 4-2 gives a summary of typical statistics collected from various sources characterizing deposits. The mean PCB concentrations in the table reflect frequently reported arithmetic means; yet it should be considered that the frequency distribution of PCB levels is log normal and these values may not be the best estimates of central tendency (Tofflemire and Quinn, April 1979).

The distribution of PCBs on the river bottom is extremely variable. Tofflemire and Quinn (April 1979) reported an overall standard deviation of 188.2 ppm for 434 grab samples with a mean of 66.7 ppm. Malcolm Pirnie, Inc., (1978) noted that very high PCB levels could be found close to extremely low values, for a single sampling curve they reported PCB levels ranging from 0.02 ppm at 28 inches in one core sample, to 2273 ppm at a 4-inch depth in a core that was recovered less than 1300 feet from the first. The highest single PCB concentration ever found was 3707 ppm, while values below detection limits have occasionally been observed in the contaminated zone.

The concentration of PCB decreases with distance below the former disharge points. The decreasing PCB gradient, however, is not regular. Average PCB concentration decreases from 86.2 ppm in the Thompson Island Dam pool to 14.2

TABLE 4-2

STATISTICAL CHARACTERISTICS OF PCB AND PCB MASS ESTIMATES FOR RIVER REACHES IN THE UPPER HUDSON RIVER

Reach[a]	Total[b] No. Samples	%[c] Samples >50 ppm	Sample[c] Density per mi^2	Arithmetic[b] Mean PCB (ppm)	Standard[b*] Deviation (ppm)	PCB Mass (lb) MPI[d]	PCB Mass (lb) NYSDEC[e]
9	6	--	--	297.2	--	900	3,000
8	301	25.1	430	86.2	245.3	133,700	117,600
7	86	30.0	253	64.0	63.3	18,900	15,600
6	126	37.0	300	76.0	141.2	41,600	48.900
5	98	12.2	50	14.2	17.2	62,100	42,600
4	35	22.0	69	39.7	74.9	23,700	15,200
3	18	14.3	35	42.7	105.7	24,800	18,000
2	18	12.5	27	13.4	17.8	16,900	13,500
1	18	14.0	20	9.6	12.0	23,800	12,500
Total	706			66.7*	188.2*	347,200	286.900

NOTE: Footnotes appear on Page 2 of this table.

TABLE 4-2
STATISTICAL CHARACTERISTICS OF PCB AND MASS ESTIMATES
FOR RIVER REACHES IN THE UPPER HUDSON RIVER
PAGE TWO

a.

Reach	Location	Length (in)	Average Width (ft)	Area
1	Troy Dam to Lock 1	5.5	845	560
2	Lock 1 to Lock 2	4.0	875	420
3	Lock 2 to Lock 3	2.6	1,050	330
4	Lock 3 to Lock 4	2.2	1,230	330
5	Lock 4 to Lock 5	15.2	690	1,260
6	Lock 5 to Lock 6	1.8	800	270
7	Lock 6 to Thompson IS (670) Dam	2.3	790	220
8	Thompson Is. Dam to Rogers Island	5.2	710	445
9	Rogers Island to Bakers Falls			

b. Source (Tofflemire and Quinn, April 1979).
c. Source (Malcolm Pirnie Inc., January 1978).
d. Source (Malcolm Pirnie Inc., September 1980).
e. Source (Tofflemire, March 1980).

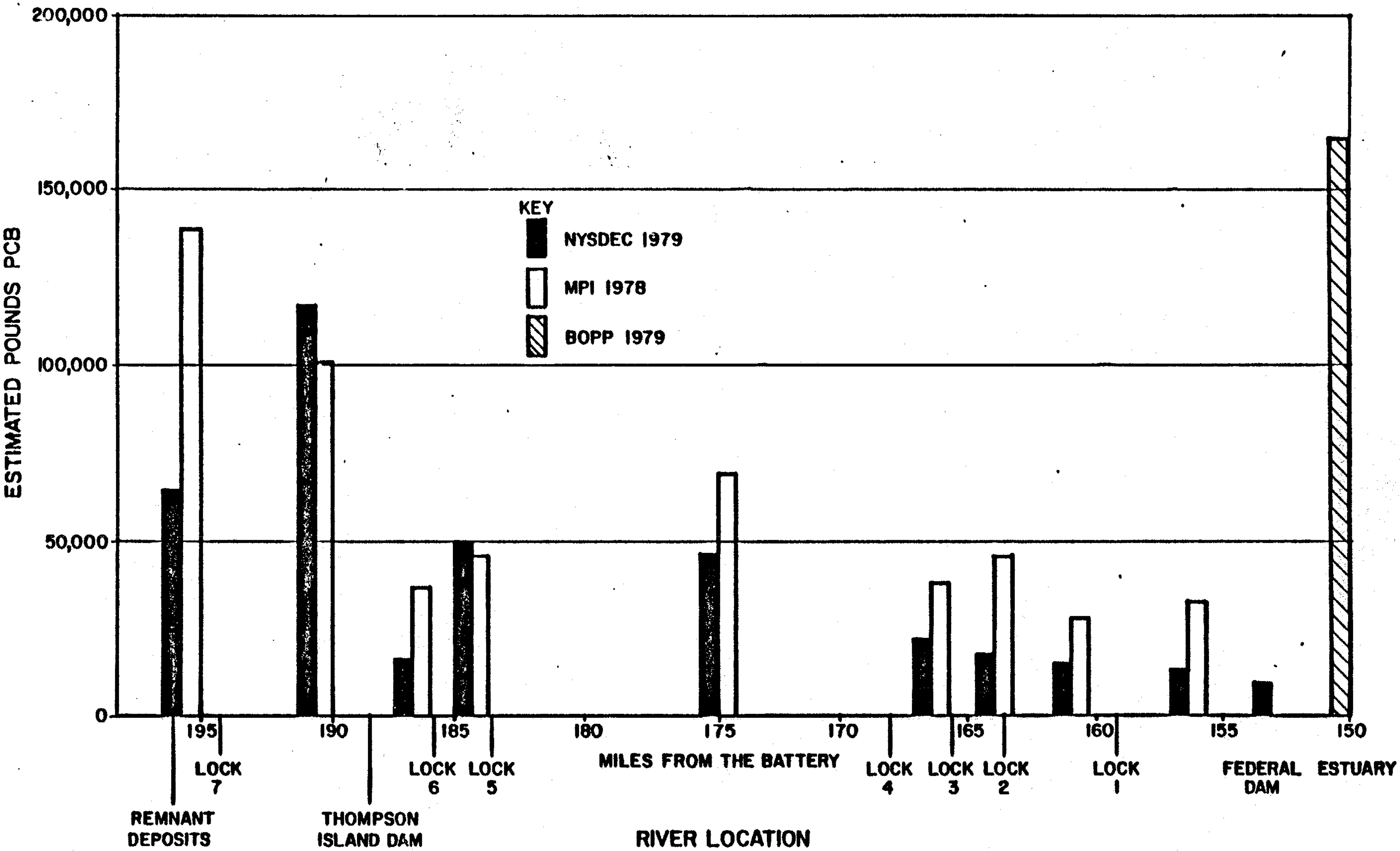
* Statistics for grab samples only.

ppm in the Lock 4 pool and then increases again in the Lock 3 and Lock 2 pools to 39.7 and 47.7 ppm, respectively. The smaller value for the Lock 4 pool may be related to the poor sampling density relative to adjacent sections. However, Tofflemire and Quinn (1979) proposed that the rate of deposition of PCB-contaminated sediments in the downstream reaches is high compared to the Lock 4 reach because of the wider channel and the presence of many low-velocity marsh areas where PCB-laden sediments tend to accumulate. They also suggest that unidentified additional PCB sources on the west side of the river near Mechanicsville may be responsible for the rise in PCB concentrations in the Lock 2 and 3 pool sediments.

Total PCB mass estimates also tended to decrease with distance downstream. Mass estimates for the Upper Hudson River varied betwen 290,000 pounds and 350,000 pounds (Malcolm Pirnie, Inc., 1980). The range in mass estimates for river reaches is illustrated in Figure 4-3.

The lateral distribution of PCB-contaminated sediments is influenced by a number of factors. Typically, PCB levels in channel sediments and along eroding banks are lower than those in soft, near-shore deposits (Malcolm Pirnie, Inc., 1980). This trend is related to sediment particle size and composition and the variation of flow velocities across the channel. Tofflemire and Quinn (1979) statistically determined that high PCB values are associated with finer sediments which are rich in organic carbon. These associations are attributed to the high "surface area to volume" ratio of the inorganic fraction and to the high affinity of PCBs for carbon. Organic "mucks" normally collect in low-velocity areas in marshes and backwaters and to a lesser extent near the shore. The NYSDEC has shown that mean $\log_{10}$ PCB levels of the outer two thirds of the river area are statistically higher than those of the middle third (Tofflemire & Quinn, 1979). Typically the PCB concentration of near-shore deposits ranged from 50 to 1000 ppm, while concentrations in the coarser sediments from the channel ranged between 5 and 20 ppm.

The variation of PCBs with depth in the sediment profile differs with the reach of the river considered. In the Thompson Island Dam pool, peak mean PCB levels of



SOURCE: (MALCOLM PIRNIE INC. 1980).

FIGURE 4-3

ESTIMATED PCB IN POUNDS BY RIVER POOL
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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A Halliburton Company

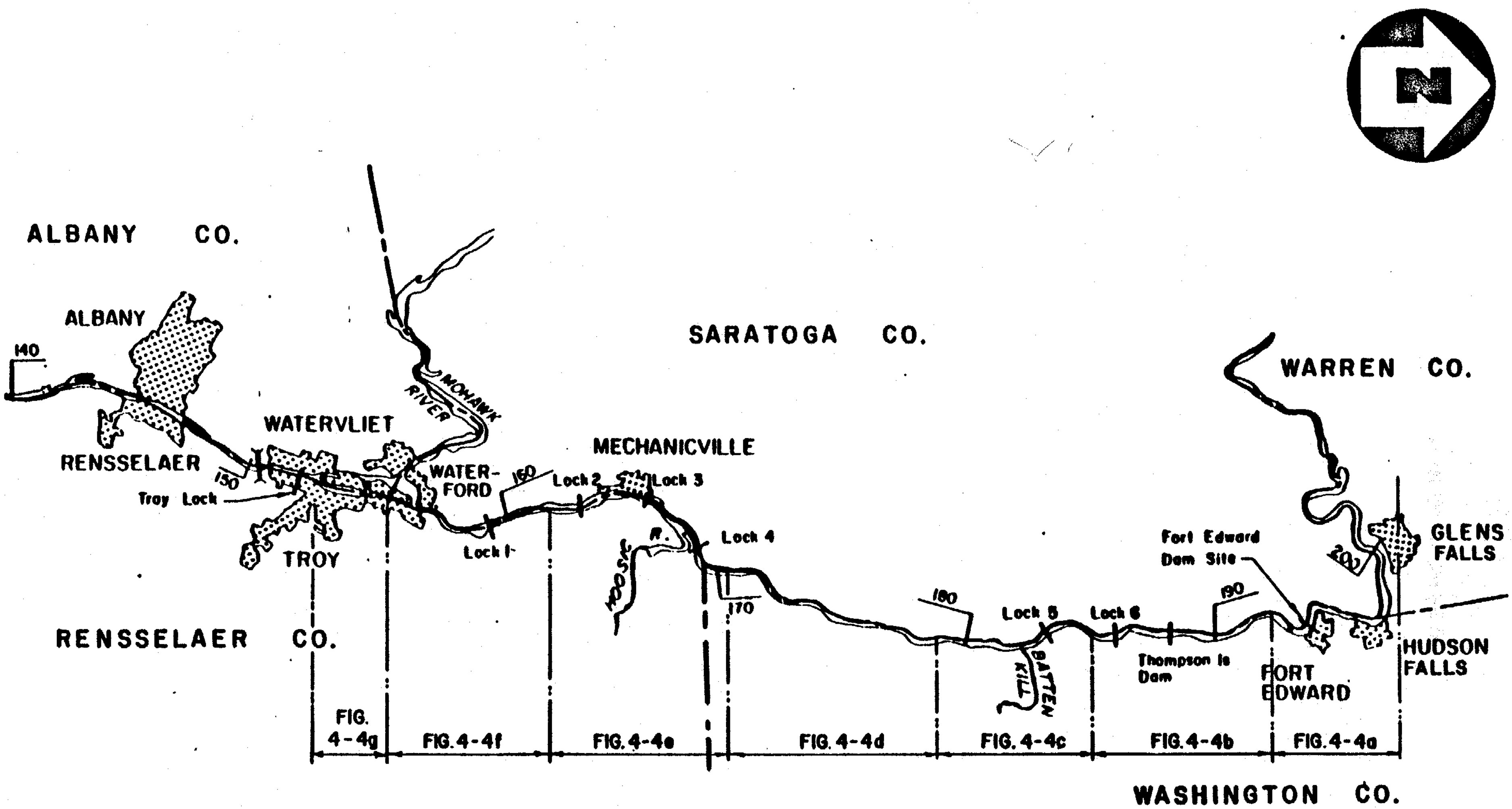
100302

133 ppm were found between 12 to 18 inches in depth. As distance below the Thompson Island Dam increased, peak mean PCB levels decreased, peak levels were found closer to the surface, and the distribution of PCBs within the profile became more homogeneous (Tofflemire and Quinn, 1979). Malcolm Pirnie, Inc., (1978) proposed a dredge depth of 24 inches for the Thompson Island Pool to avoid exposing highly contaminated sediments to the water. A 15-inch cut was proposed for all other areas.

To view the areal distribution of PCB contamination in the river, Tofflemire and Quinn (1979) plotted all survey data on "one inch to 200 feet" scale planimetric maps and drew isoconcentration contours to delineate PCB "hot spots". Sample points exhibiting a PCB concentration of 50 ppm or more were the primary criteria for drawing contours. Subjective judgments based on knowledge of sediment composition and river hydrology were used to locate boundaries when survey data were scarce. The arithmetic mean PCB concentration of all samples within a hot spot was compared with the mean value of the adjacent cold area, and the hot spot boundaries were adjusted until the average concentration was 50 ppm or more.

Using this method, 40 hot spots were identified within a 40-mile section of river stretching from Rogers Island to Mechanicsville. The location and configuration of NYSDEC PCB hot spots are shown in Figure 4-4. Tofflemire and Quinn's detailed tabulation of hot-spot concentration and mass estimates is reproduced in Table 4-3. From this table it is evident that hot spots as delineated by NYSDEC in 1978 contained 58 percent of the estimated PCB mass within the Upper Hudson River while only covering 8 percent of the area.

Hot spots are regarded as conservative but adequate estimates of the configurations of areas of major PCB contamination in the river in 1977 to 1978. PCB distributions around hot spot number 6 were further examined using a computer application of a digital extrapolation/interpolation technique. The program used gradient analysis and inverse distance methods to approximate PCB concentrations for points at 50-foot grid intervals. Isoconcentration contours were



(Source – Malcolm Pirnie Sept. 1980)

FIGURE 4-4

HOT SPOT AND REMNANT AREA LOCATIONS
HUDSON RIVER PCB SITE, HUDSON RIVER, NY
NOT TO SCALE

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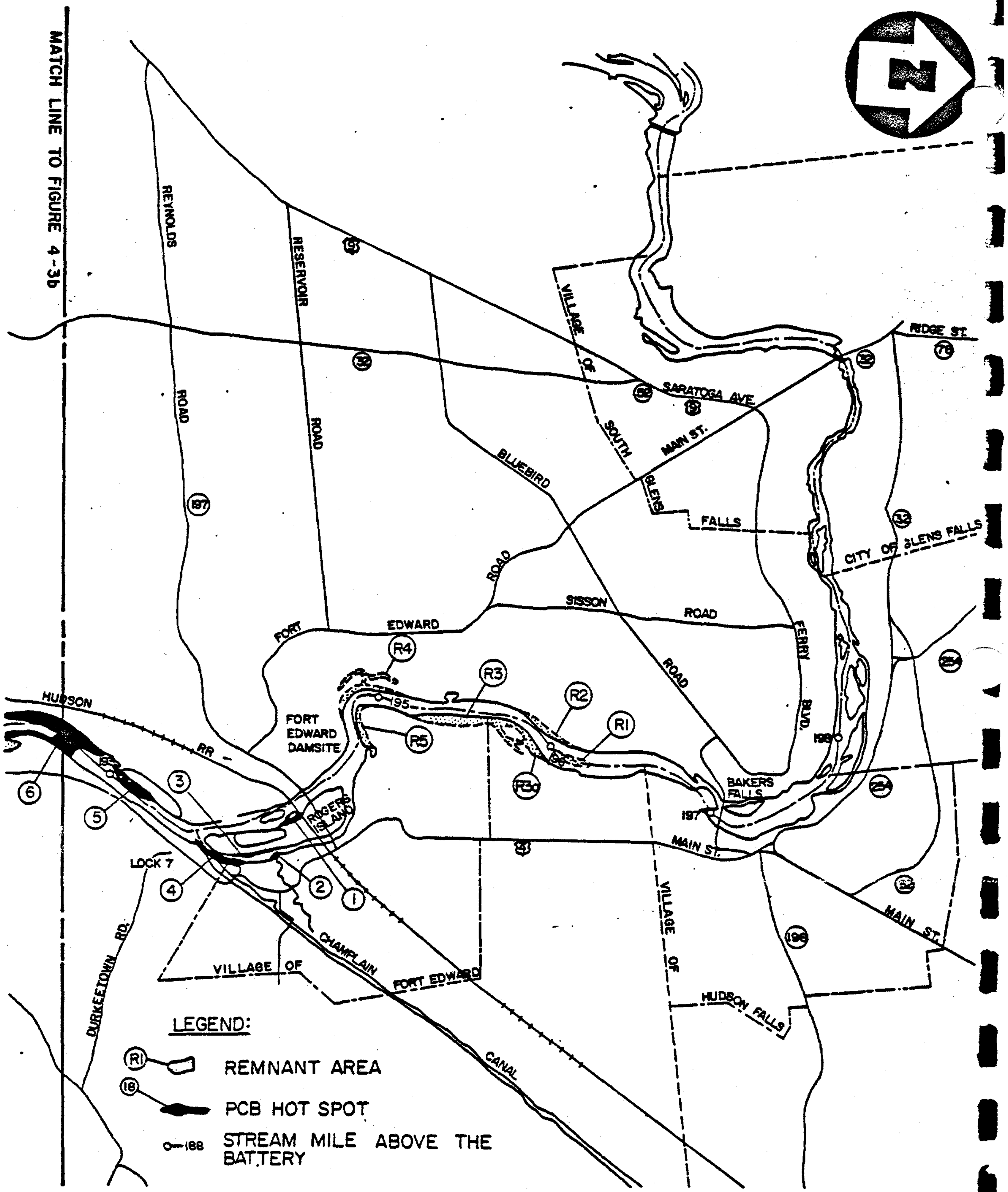

FIGURE 4 - 4a

PLAN VIEW UPPER HUDSON RIVER AREA

SCALE: 1¼" = 1 MILE

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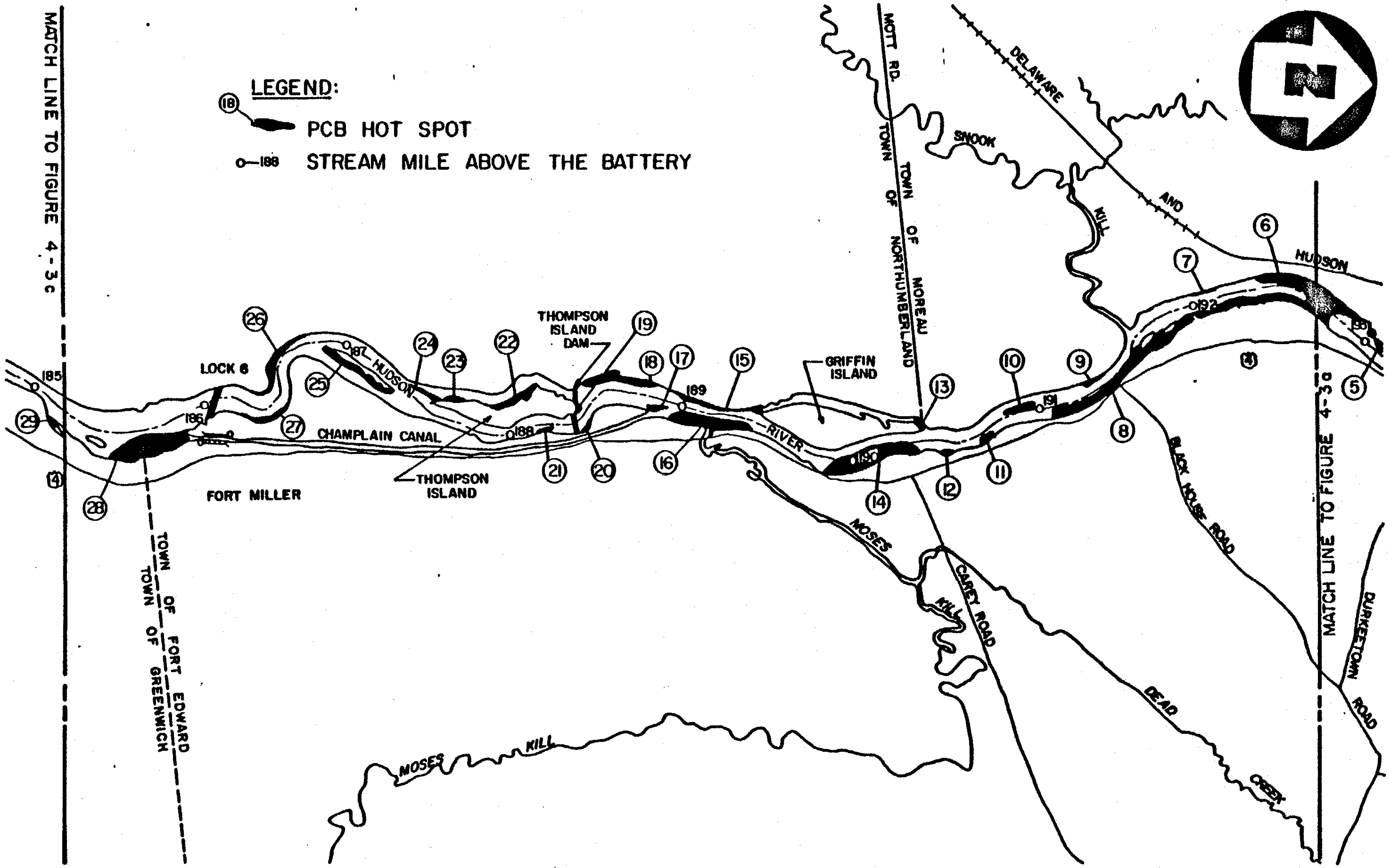

FIGURE 4-4b

NUS CORPORATION
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PLAN VIEW UPPER HUDSON RIVER AREA
SCALE: 1¼" = 1 MILE

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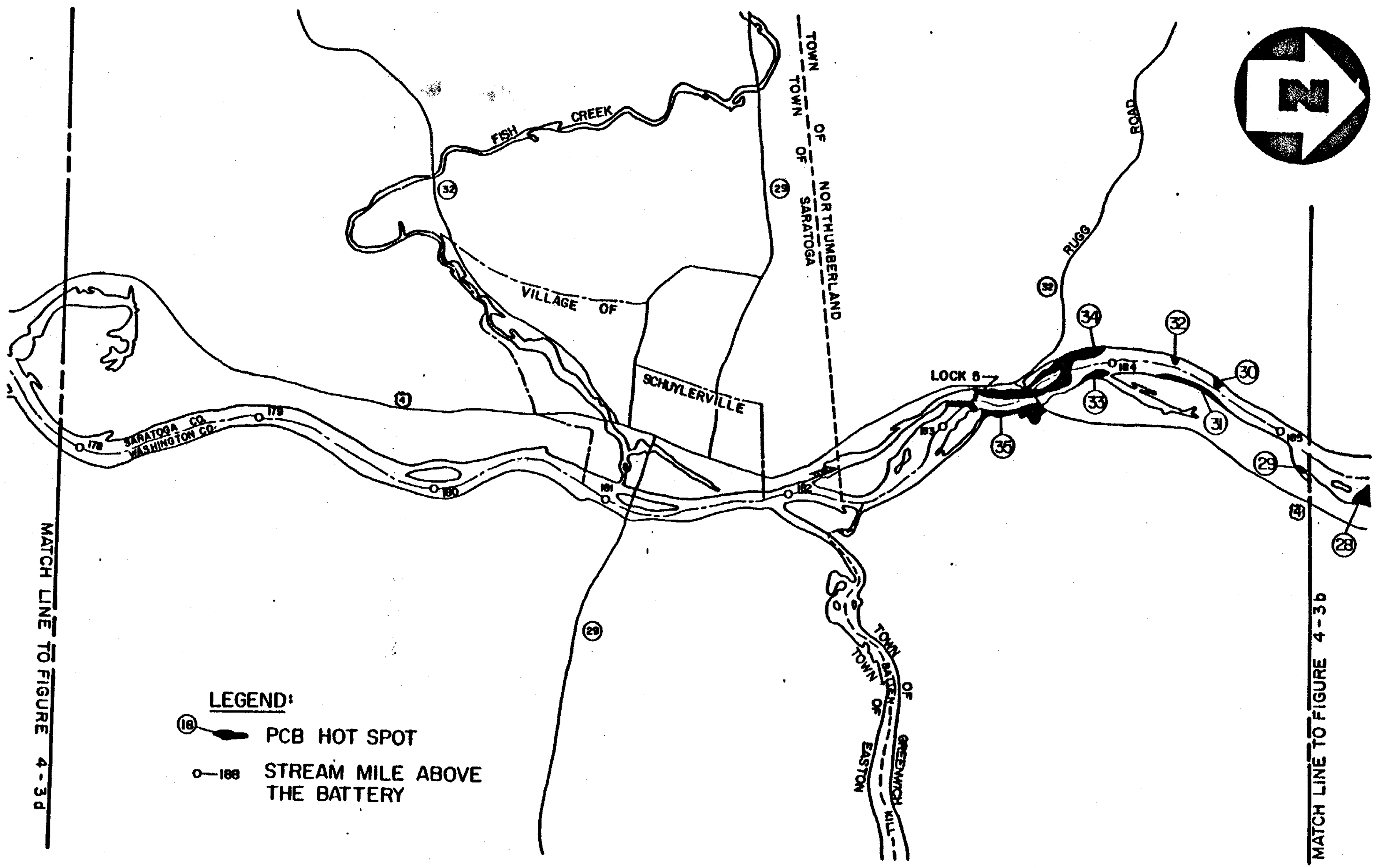

FIGURE 4-4c

PLAN VIEW UPPER HUDSON RIVER AREA

SCALE: 1¼" = 1 MILE

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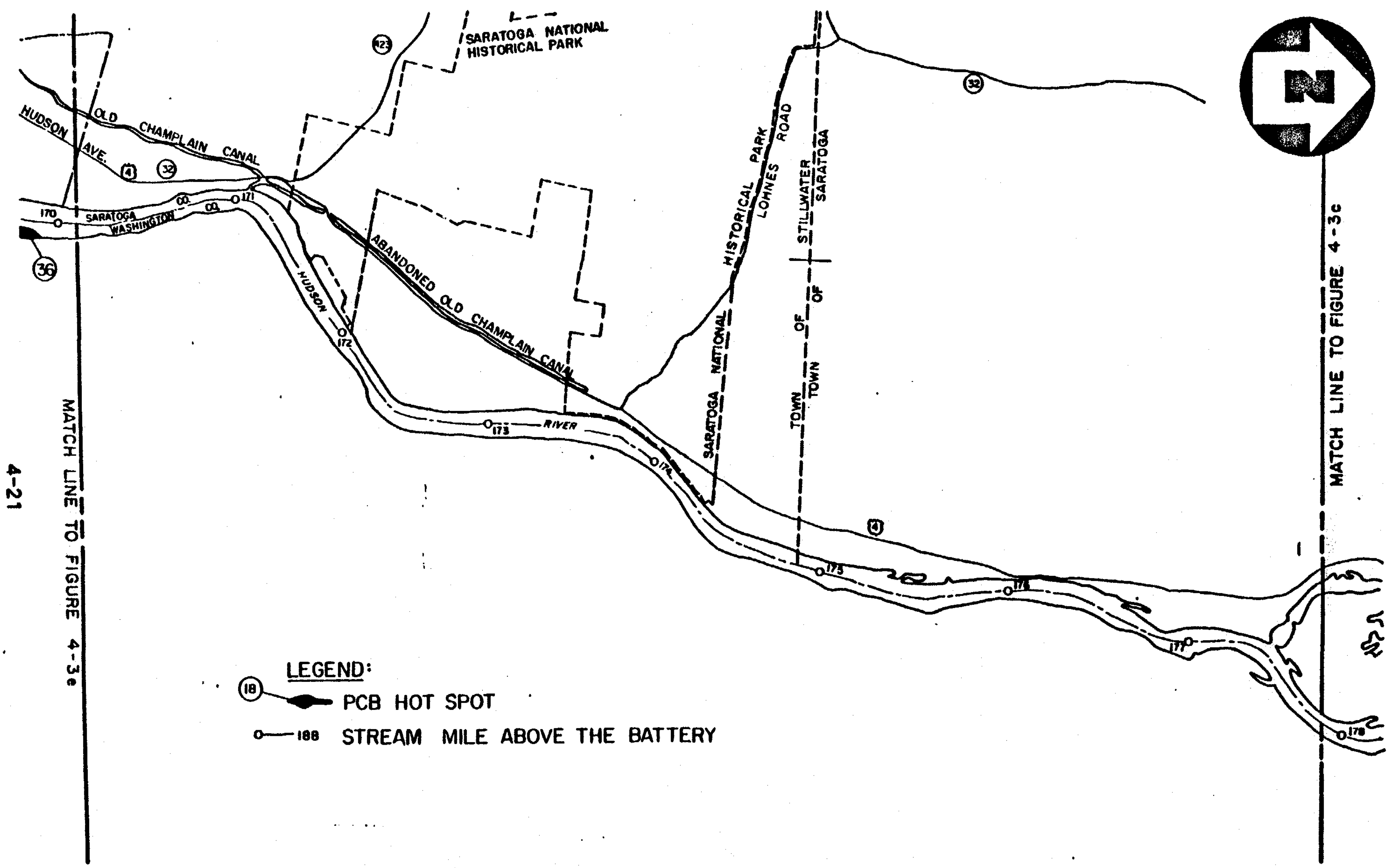

FIGURE 4-4d

PLAN VIEW UPPER HUDSON RIVER AREA

SCALE: 1¼" = 1 MILE

NUS CORPORATION
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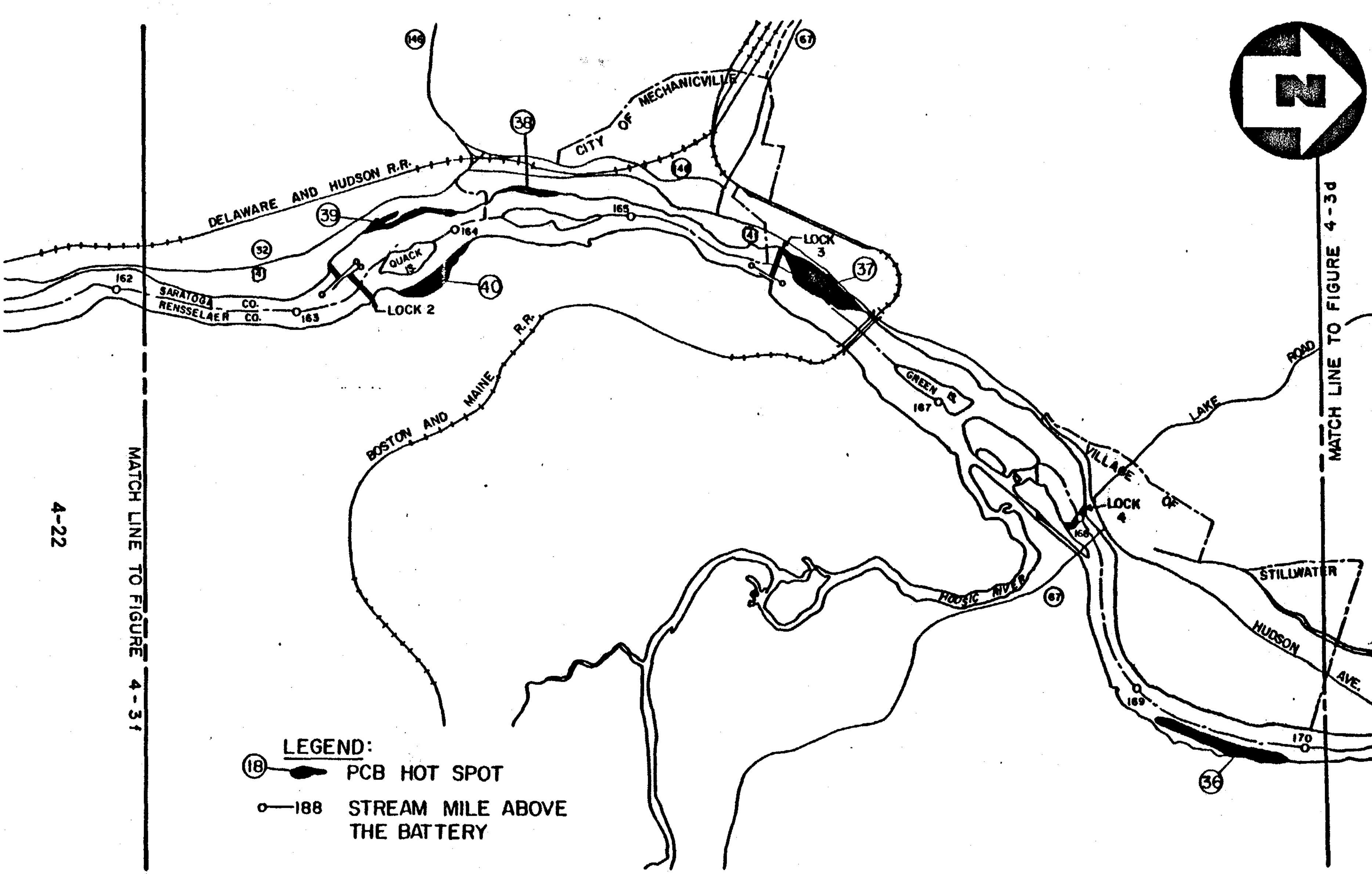

4-22

FIGURE 4-4e

PLAN VIEW UPPER HUDSON RIVER AREA
SCALE: 1¼" = 1 MILE

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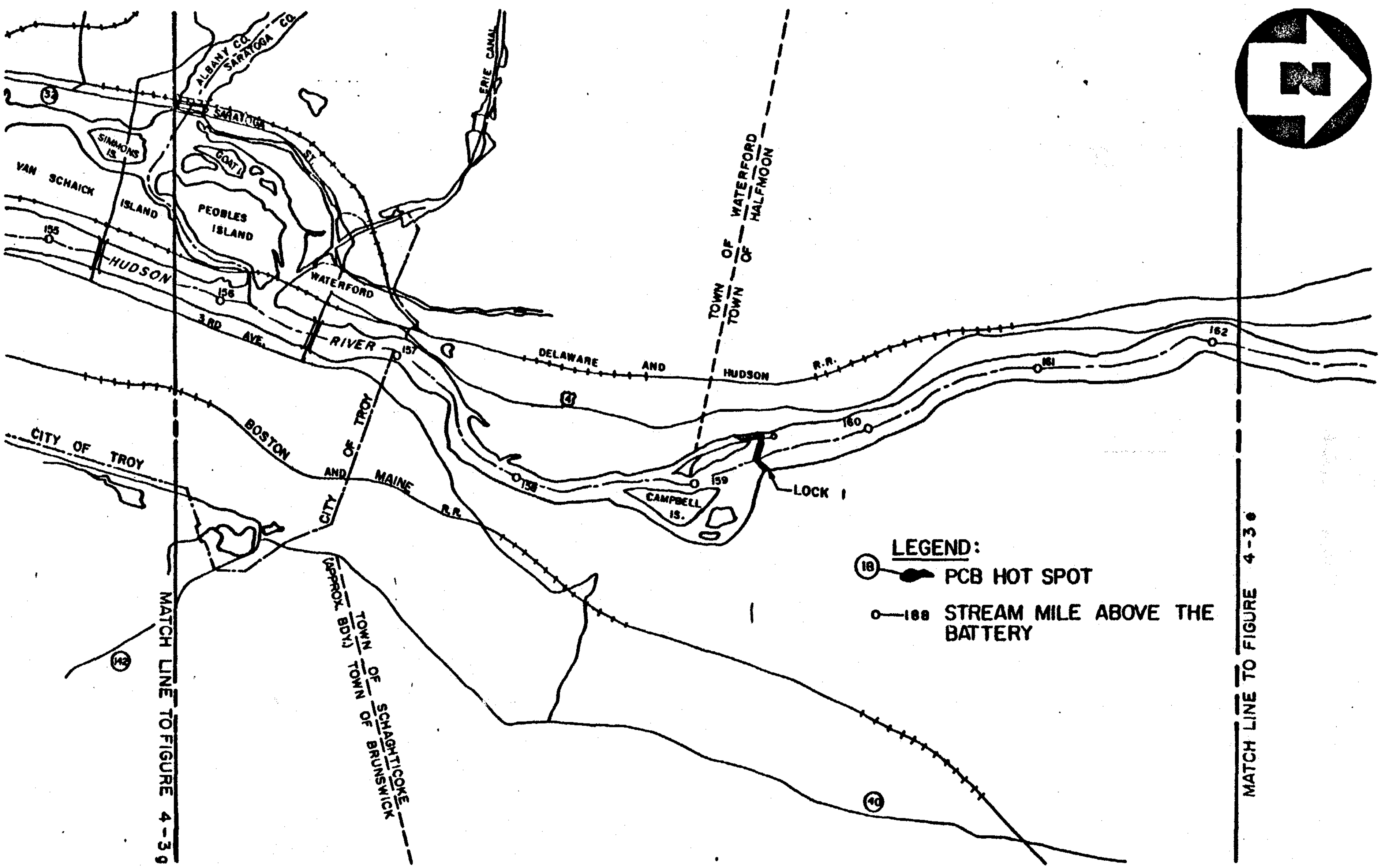

4-23

FIGURE 4 - 4f

PLAN VIEW UPPER HUDSON RIVER AREA

SCALE: 1¼" = 1 MILE

NUS CORPORATION
A Halliburton Company

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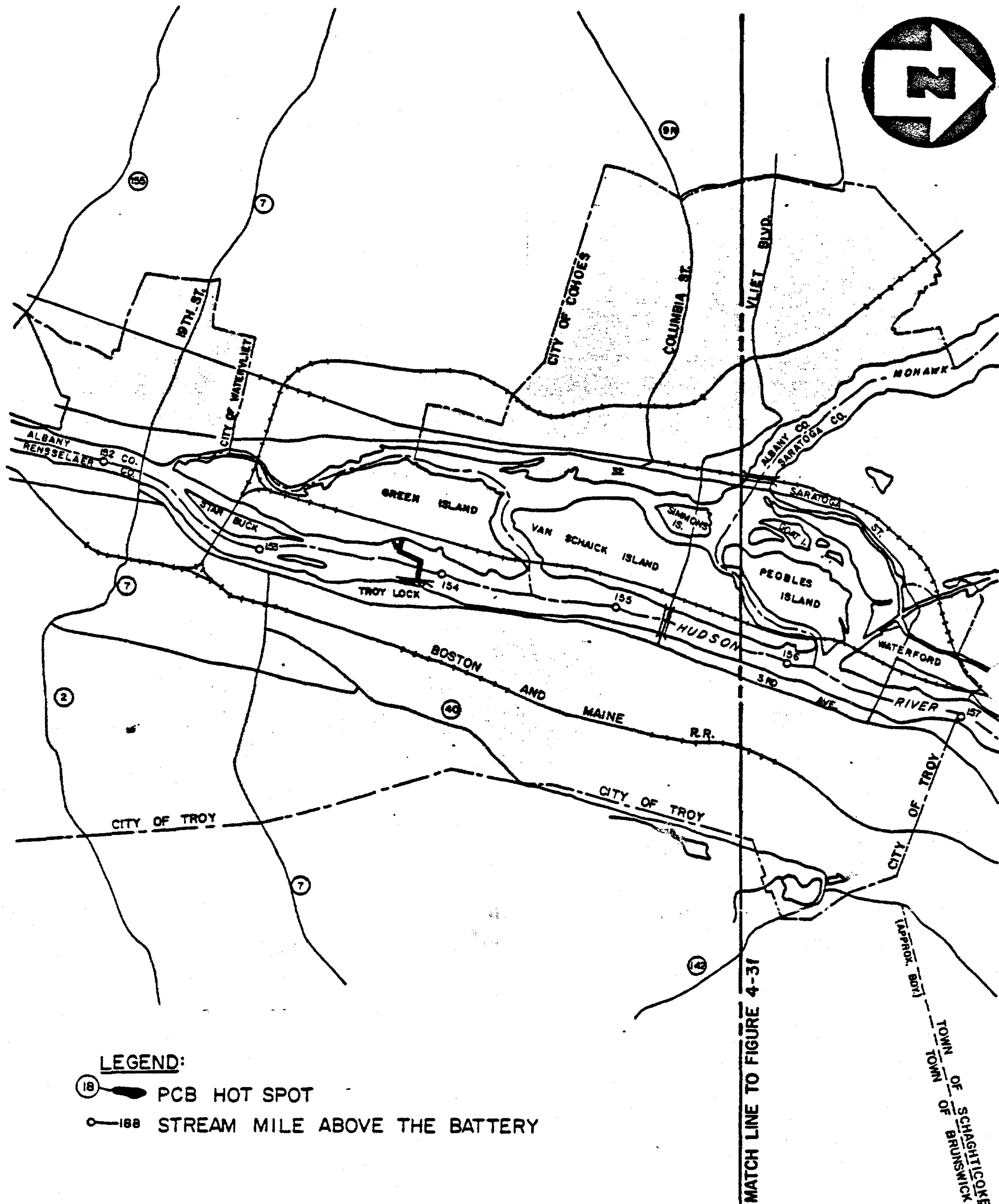

FIGURE 4-4g

PLAN VIEW UPPER HUDSON RIVER AREA

SCALE: 1¼" = 1 MILE

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TABLE 4-3

CONTAMINATED AND REMOVAL VOLUMES AND PCB QUANTITIES OF HOT SPOTS

Hot Spot (1) Area No.	Area (sq ft)	Contaminated (2) Volume (cu yd)	Mean (3) PCB Conc. (ppm)	PCB (4) Quantity (lbs)	Removal (5) Volume (cu yd)
1	66,600	3,100	63	340	7,400
2	21,200	1,000	81	140	2,350
3	38,300	1,750	46	140	4,250
4	78,800	3,650	50	320	8,750
Subtotal	204,900	9,500	57	940	22,750
5	460,400	34,100	62	3,710	51.150
6	1,033,700	76,550	69	9,270	114,850
7	110,600	8,200	39	560	12,300
8	1,462,700	108,350	99	18,830	162,500
9	118,500	8,800	38	590	13,150
10	191,200	14,150	78	1,940	21,250
11	57,100	4,250	39	290	6,350
12	45,700	3,400	71	420	5,100
13	28,000	2,050	89	320	3,100
14	974,200	72,150	279	35,330	108,250
15	286,600	21,250	103	3,840	31,850
16	446,500	33,050	380	22,060	49,600
17	83,200	6,150	256	2,770	9,250
18	201,700	14,950	94	2,460	22,400
19	42,000	3,100	83	450	4,650
20	62,700	4,650	249	2,030	6,950
Subtotal	5,604,800	415 150	144	104,870	622,700
21	30,800	1,450	143	360	3,400
22	97,600	4,500	75	600	10,850
23	44,000	2,[illegible]50	506	180	4,900
24	129,000	5,950	506	520	14,350
25	300,100	13,900	100	2,440	33,350
26	119,800	5,550	47	460	1,300
27	78,400	3,650	53	340	8,700
Subtotal	799,700	37,050	75	4,900	88,850

TABLE 4-3
CONTAMINATED AND REMOVAL VOLUMES AND PCB QUANTITIES OF HOT SPOTS
PAGE 2

Hot Spot (1) Area No.	Area (sq ft)	Contaminated(2) Volume (cu yd)	Mean(3) PCB Conc. (ppm)	PCB(4) Quantity (lbs)	Removal(5) Volume (cu yd)
28	1,026,800	47,550	109	9,090	114,100
29	32,700	1,500	81	220	3,650
30	54,400	2,500	155	690	6,050
31	194,300	9,000	516	8,150	21,600
32	41,200	1,900	51	170	4,600
33	119,400	5,550	98	950	13,250
34	955,800	44,250	159	12,350	106,200
35	245,400	11,350	105	2,090	27,250
Subtotal	2,670,000	123,000	155	33,710	296,700
36	1,207,500	55,900	51	5,000	134,140
37	1,239,700	57,400	116	11,860	137,750
38	318,850	14,750	506	1,300	35,450
39	284,000	13,150	161	3,720	31,550
40	743,550	34,400	62	3,750	82,600
Subtotal	1,346,400	62,300	80	8,770	149,600
Total	13,073,000	760,300	127	169,870	1,452,500

1. Hot Spot Area No.

		Reach
1-4	Above Lock 7	9
5-20	Thompson Is. Dam - Lock 7	8
21-27	Lock 6 - Thompson Is. Dam	7
28-35	Lock 5 - Lock 6	6
36	Lock 4 - Lock 5	5
37	Lock 3 - Lock 4	4
38-40	Lock 2 - Lock 3	3

2. Contaminated Volumes based on a contaminated depth of:
   15 in. - Above Lock 7
   24 in - TID - Lock 7
   15 in. - Lock 6 - TID
   15 in. - Lock 5 - Lock 6
   15 in. - Lock 4 - Lock 5
   15 in. - Lock 3 - Lock 4
   15 in. - Lock 2 - Lock 3

TABLE 4-3
CONTAMINATED AND REMOVAL VOLUMES AND PCB QUANTITIES
OF HOT SPOTS
PAGE 3

3. Mean PCB Conc. based on average concentration of all surface samples and weighted average concentration of core samples within the hot spot area.

4. PCB Quantity based on a bed material density of 65 lb/cu ft.

5. Removal Volume based on a 36 in. removal depth.

Source: Tofflemire and Quinn, April 1979.

then fitted to the grid points. As might be expected, hot spots appeared as localized cells of influence on the river bottom. However, a grouping of these cells corresponds with hot spot number 6 as mapped by NYSDEC.

PCB hot spots shown in Figure 4-4 are generally a manifestation of the trends described earlier in this section. Many hot spots encompass areas of fine, organic-rich-matter sediments isolated along quiet banks and in shallow, low velocity marsh areas. Often, however, highly contaminated deposits are found near the center of the channel and on the outside banks of bends where they would not normally be expected to occur. This characteristic is more pronounced closer to the old Fort Edward Dam site and is explained by the tremendous oversupply of sediment occurring after the removal of the dam. Normally a mature river such as the Hudson is in a dynamic equilibrium state with its basin such that the overland sediment supply neither greatly exceeds nor falls substantially below the sediment transport ability of the river (Chow, 1964). If the sediment supply suddenly increases as a result of dam removal, for example, the net effect is a steady sediment buildup over the entire river bed. This appears to be the case with the sediments in the Thompson Island pool, and the PCB profile within the sediment column provides support for this hypothesis. The fact that peak levels of PCB are relatively well defined and buried beneath 6 to 8 inches of cleaner sediment mirrors the effects of a mass release of highly contaminated sediments with the removal of the Fort Edward Dam and the deposition of less contaminated sediments corresponding to the virtual elimination of PCB from the G.E. discharges (Brown and Werner, 1983).

Downstream, highly contaminated PCB hot spots are found more often in classic low-velocity marsh areas and backwaters, and the homogeneous distribution of PCB with depth in the profile indicates a more uniform and diffuse dispersal of PCB-laden sediments. This is explained by the slow return of the Thompson Island pool to an equilibrium state after the removal of excess sediment supply with the stabilization of the remnant deposits. Consequently the flux of sediment to lower reaches is lower and substantial deposition does not occur except when suspended sediments are washed into low-velocity deposition areas. As the river sediments return to equilibrium, scour from the Thompson Island pool can be expected to decrease and the PCB load to the estuary should show a similar trend.

The transient nature of sediment deposits, however, cannot be overemphasized. The effects of excessively large flows on deposits in the Thompson Island pool, especially those now occupying high velocity areas, are unknown. Perhaps even the disturbance caused by barge traffic is enough to destabilize some hot-spot areas. It is possible that the hot-spot mapping done in 1978 may not be valid in 1983, especially with the return of flows exceeding 50,000 cfs at Waterford in May. Refer to Appendix E for a discussion of the results of recent sediment sampling in the Upper Hudson.

4.1.1.3 Lower Hudson River Sediments

Sediment sampling by the Lamont Doherty Geological Observatory has provided valuable information on PCB contamination in the reach below the Federal Dam at Troy. Their surveys routinely include analysis for the ^{137}Cs isotope which is useful as an independent indicator of the recent nature of sediments that can be used to date sediments and compute deposition rates (Bopp, 1979).

Lamont Doherty data (Table 4-4) show a regular decrease in PCB levels with distance below the Federal Dam (Bopp, 1979). Average concentrations ranged from 3 ppm in the Upper Harbor area to 30 ppm near Albany. The highest PCB concentration measured by Lamont Doherty was 140 ppm found in a core from the Albany turning basin. The overall average PCB concentration of the Lower Hudson River is about 10 ppm, which is considerably less than that of the Upper Hudson River, but which is one to two orders of magnitude more contaminated than other water bodies in the area (Bopp, 1979). Using the absence of ^{137}Cs as a stratigraphic indicator of pre-1954 conditions, Bopp estimated that pre-G.E. discharge PCB levels were 0.2-0.6 ppm, which is more in line with recent sediments from other rivers.

TABLE 4-4

CONTAMINATION OF PCBs (Aroclor 1242)
IN RECENT SEDIMENTS OF THE LOWER HUDSON RIVER

Cores (mile points)	No. of Samples averaged	PCB (1242) Concentration, Average ppm	Range ppm
146.3, 144.2, 143.4	21	30	(1.6-140)
109.5, 91.8, 83,2	24	10	(4.1-29)
53.8, 44.4, 43.2	25	6	(0.5-26)
6.0, 0.1, - 1.5	27	3	(0.7-5.8)

All samples with ^{137}Cs at least two standard deviations greater than zero were included in the average. This value may be somewhat misleading because of extremely high values in the top 60 cm of core 143.4. Eliminating this core gives an average of 16 ppm 1242, with a range from 7.6 to 35 ppm.

Source: Bopp, 1979

From basic data on PCB concentrations and sediment deposition rates developed from the Lamont Doherty data, Bopp, et al., (1980) estimated the areal distribution of PCB contamination and developed a rough PCB mass balance for the Lower Hudson River. The preliminary results of this analysis are presented in Table 4-5. Low deposition areas which accumulated little or no recent sediment, such as channel and subtidal banks, made up approximately 65 percent of the river area but contained only about 14 percent of the PCB burden associated with bottom sediments. Coves and broad shallow areas where deposition was on the order of 1 cm/yr accounted for 25 percent of the area and 35 percent of the PCB contamination. The remainder of the PCB-contaminated sediments had been deposited in frequently dredged areas where accumulation rates of 5-20 cm/yr were common. Most of this area was in the New York harbor, but other high deposition areas were identified in the river near Kingston and Germantown and in the Albany turning basin. Bopp estimated that between 1960 and 1980 over 86,000 pounds of PCB were removed from these areas by maintenance dredging. From data on PCB partitioning between sediment and water, Bopp further estimated that 200,000 pounds of PCB have left the river with the water.

The EPA obtained two sets of core samples for PCB analysis from 29 stations in the Lower Hudson in 1976 and again in 1981 (U. S. EPA 1977, 1981). For the most part, PCB levels in 1981 were less than half of those measured in 1976. In 1976, the highest total PCB values were 58.3 ppm (dry weight basis), measured in the Albany turning basin. In 1981, the Albany turning basin sample had a depth-weighted average of only 6.9 ppm. The overall average decrease in the top half of the cores was 11.3 ppm and the average decrease in the lower core segments was 10.5 ppm.

The only sample showing an increase in PCB concentration was collected at Foundry Cove, which is located north of West Point. PCB levels in the top portion of the cores increased from 11.07 ppm to 15.8 ppm, and PCB concentrations in the bottom sections increased from "not detected" to 0.06 ppm.

No explanation for the drastic decreases which were observed has been developed. Bopp (1979) has provided evidence which shows that the more highly chlorinated

TABLE 4-5

PRELIMINARY PCB BALANCE FOR THE LOWER HUDSON

Location	PCB Burden (pounds)
1. New York Harbor (in-situ)	54,000
2. Coves and Marginal Areas	
a. Coves and bays	24,000
b. Haverstraw Bay and Tappan Zee	36,000
3. Low Deposition Areas (Channel & Subtidal Bank)	24,000
4. Upstream Areas of High Deposition	
a. Albany Turning Basins, mp 109.5 and Lent's Cove	5,000
b. Kingston area	26,000
Total PCBs associated with sediments of the Lower Hudson (in-situ)	169,000
Total PCBs dredged from New York Harbor	86,000
PCBs washed out to sea	200,000
TOTAL	455,000

Source: Bopp et al., 1980

PCB isomers are preferentially adsorbed onto particles. Depletion of the more volatile Aroclors (1016 and 1242) in sediments may partly explain the decreases in PCB concentrations which occurred between 1976 and 1981. It is also possible that sediments had been disturbed and reworked or that contaminated sediments observed in 1976 had been buried under cleaner sediments. Although the variability of PCB levels in the sediment is high, it is unlikely that the differences in the results of the two EPA surveys were due to minor errors in relocating the sample stations since 28 of the 29 stations showed drastic decreases.

The results of the 1976 EPA survey suggested the existence of five PCB hot spots in the Lower River. These included, from north to south, the Albany turning basin, the Germantown reach, Foundry Cove, Peekskill Bay, and Pierport Marsh.

Table 4-6 compares the results of the 1976 EPA survey with the results of two other surveys in these areas. The values in the table do not agree well. Bopp, et al., (1980) maintain that PCB values obtained from these areas fall within the variability of the general patterns of contamination observed through the river and that the idea of anomalous hot spots is erroneous.

4.1.2 Water

4.1.2.1 Surface Water

PCBs entrapped in stream bed deposits are an environmental concern because of the potential for their uptake and biomagnification in the aquatic food chain. However, when these PCBs enter the water column via sediment scour, bioperturbation, or other physical or chemical processes, not only do they become available for direct uptake by a larger segment of the aquatic community, but they can now migrate by way of flowing water to previously uncontaminated areas or even to critical receptors such as potable water supply intakes. Further, the PCBs can enter the atmosphere, creating the potential for bioaccumulation in the terrestrial food chain and directly threatening air breathing organisms. It is for these reasons that PCB health criteria and related monitoring focus on the water column concentration of PCB rather than on the sediment PCB content.

TABLE 4-6

COMPARISON OF SURVEY DATA FROM SUSPECTED HOT SPOTS IN THE LOWER HUDSON RIVER

Location	EPA 1976 Survey (ppm)	Bopp 1979 ppm	EPA 1981 Survey ppm
Albany River miles 143-146	58.3	140	9.81
Germantown River miles 108-109	2.5	5	ND
Foundry Cove River miles 53-54	11.7	26	15.8
Peekskill Bay River miles 44-45	11.7	8	0.92
Pierpont Marsh River miles 22-24	56.4	4	0.33

ND - Not Detected (<0.01 µg/g).

Compilation by NUS Corporation, Pittsburgh, Pennsylvania, August 1983.

Since March 1977, the USGS has regularly collected PCB concentration and suspended sediment data from the Upper Hudson River at the Glens Falls, Rogers Island, Schuylerville, Stillwater, and Waterford gaging stations. The agency has also obtained limited records of PCB concentration data from the Lower Hudson River at stations near Castleton, Catskill, Staalsburg, Clinton Point, and Highland. This section presents and discusses the major conclusions of a number of previous studies that examined these data.

Filtration of raw river water samples and subsequent analysis of the two fractions (Table 4-7) has shown that the water column contains PCBs in both dissolved and adsorbed forms (Bopp, 1979; Turk and Troutman, 1981; Tofflemire, 1980). The adsorbed form is associated with sediment particles in transport. The amounts of dissolved PCBs are often surprisingly high (up to 0.50 ppb) considering the relatively insoluble nature of the compound. The predominant form in the water column at any given time is highly dependent on the flow rate. This relationship is addressed in depth in subsequent paragraphs. Unless otherwise noted the PCB concentrations of river water reported herein are total values reflecting the sum of both forms.

The concentration of PCBs in Hudson River water is related to flow rate in a manner that makes identification of trends extremely difficult. A plot of river discharge rate versus PCB concentration for three years of data collected at Stillwater and Schuylerville is shown in Figure 4-5. The plot shows that at low flows, PCB concentration decreases with increasing river discharge and that above a critical flow range, PCB concentration increases in direct proportion to discharge (Turk and Troutman, 1981). Similar relationships exist at all gaging stations on the Upper Hudson River.

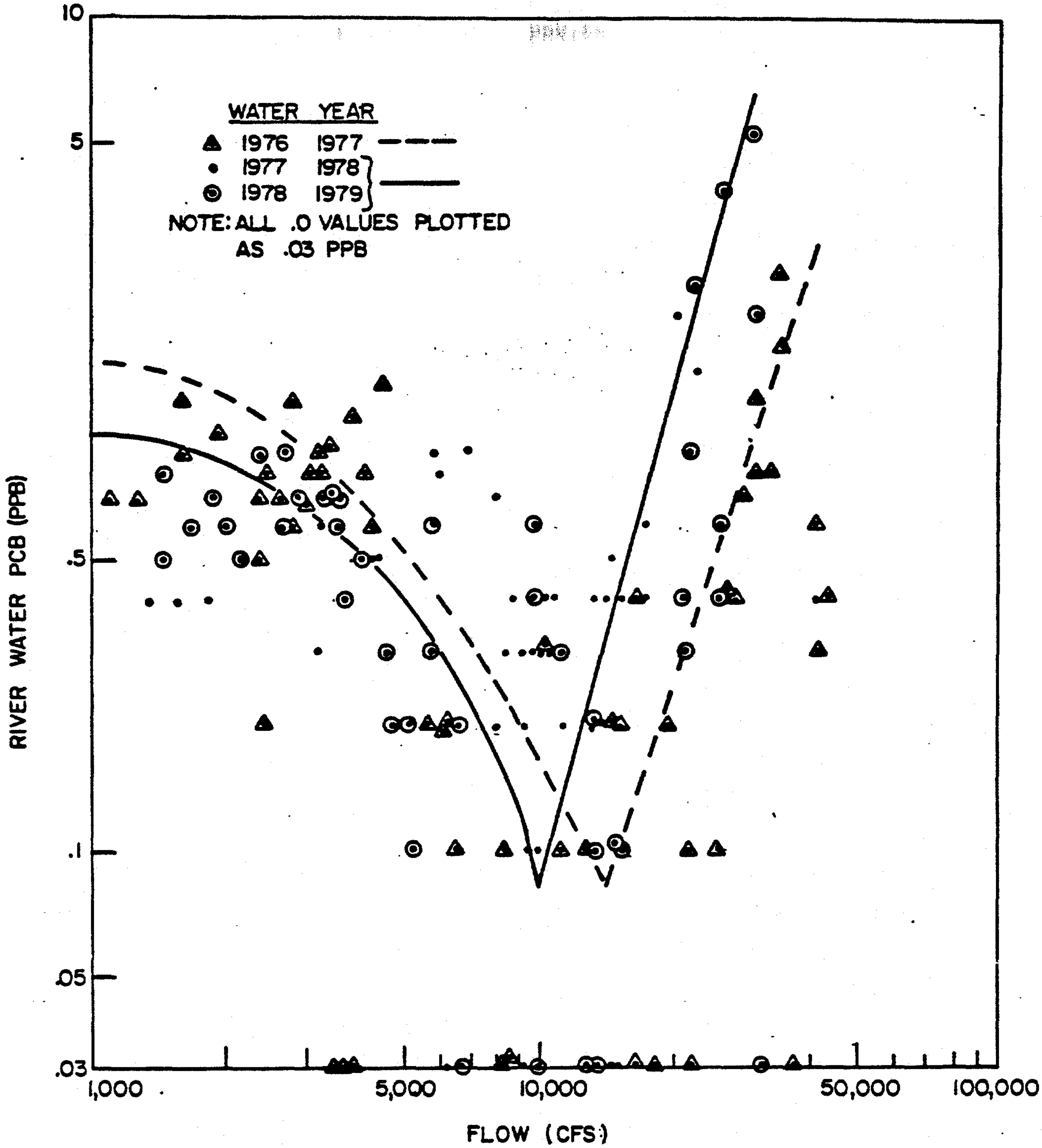
This bi-modal relationship is thought to correspond to two different processes affecting the transfer of PCB from contaminated-bed deposits to the water column. At low flows desorbed PCBs are introduced by physical-chemical processes which are not yet fully understood. This transfer occurs at an approximately constant rate and, therefore, as discharge increases, dilution takes place and the PCB concentration drops. The rate at which PCB is supplied to the

TABLE 4-7

PHYSICAL PHASE OF PCBs IN WATER COLUMN (WATERFORD)

Date		Discharge (ft. 3 sec $^{-1}$)	Concentration (µg/l)	
			Dissolved	Total
77 Mar	11	15,900	0.0	0.0
	13	24,400	0.0	0.0
	14	65,500	0.0	0.9
	15	70,500	0.0	1.4
	17	38,500	0.0	0.0
	23	16,400	0.2	0.2
78 Jul	5	580	0.5	0.6
	10	1,120	0.4	0.3
	17	1,160	0.3	0.4
79 Mar	6	30,400	0.0	0.8
	7	47,400	0.2	0.3
79 Jul	5	2,540	0.2	0.3
	16	1,810	0.4	0.4
	23	1,860	0.3	0.3
79 Aug	06	2,500	0.2	0.4
	9	2,800	0.0	0.5
	13	1,600	0.1	0.2
79 Nov	27	21,800	0.0	0.3
	28	27,200	0.0	0.4
80 June	23	1,550	0.1	0.2
July	4	1,100	0.2	0.4
	28	1,882	0.1	0.3

Source: Tofflemire, 1980



RELATIONSHIP BETWEEN FLOW RATE AND TOTAL PCB CONCENTRATION FOR SCHUYLERVILLE AND STILLWATER DATA
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-5

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water column at low flow was estimated by the USGS to be about 6.6 pounds per day (Turk and Troutman, 1981).

As discharge continues to increase, a flow velocity is reached wherein the tractive forces at the sediment-water interface begin to exceed the forces holding sediment particles in place. At this point, sediments are resuspended into the water column. Since the amount of reentrained PCB-contaminated sediment has been observed to be proportional to river discharge, the total PCB concentration likewise increases with flow rate.

Plume experiments on Hudson River sediments have shown that the critical velocity at which resuspension occurs for cohesive sediment is about 1.8 ft/sec. Resuspension of coarser particles was observed to take place at a lower flow velocity of 1.2 ft/sec (Zimmie, 1981). These flow velocities roughly correspond to the average annual flood stage.

The significance of these relationships is that at low flows, PCBs are present predominantly in a dissolved state, and at high flows PCBs are mostly associated with the suspended sediment load. The transition from one form of PCB to the other is not fixed at a certain discharge, and at intermediate flows, PCBs are thought to be present in both desorbed and adsorbed forms. Hand-fitted relationships such as those shown in Figure 4-5 reveal that the transition from one form of PCB to the other varies at flows ranging from 10,000 cfs to 20,000 cfs. However it is quite evident from Table 4-7 that significant sediment-borne PCBs can be present at flows as low as 1000 cfs.

Commonly, PCB concentrations at the Glens Falls station, which is located above this former discharge point, are less than USGS detection limits (0.1 ppb). At the downstream stations the USGS has reported PCB concentration ranging from detection limits to over 5 ppb. A significant part of this variability was due to the flow relationships discussed above; however, a large portion remains unexplained. When trying to assess public health concerns some of the data variation can be removed by separating the data into low, medium, and high flow regimes. Tofflemire (1980) has attempted this approach by computing means of several years of accumulated data at Rogers Island, Schulyerville, Stillwater, and Waterford using the 7,000 cfs and 20,000 cfs flow values to demonstrate the three flow regimes.

Tofflemire's summary (Table 4-8) shows that, at low flows, PCB concentrations averaged about 0.6 ppb. Medium-flow PCB concentrations dropped to about 0.2 ppb, and high-flow PCB concentrations rose to an average level of about 1.0 ppb.

Because of the variability of PCB transport during high-flow periods, the indentification of time-dependent trends is best limited to consideration of PCB concentrations at low flows. Table 4-9 presents arithmetic mean concentrations for water samples collected at discharge rates less than 12,000 cfs for the period 1976 to 1981. In this table, reproduced from Tofflemire (1983a), data for Stillwater and Schuylerville were combined, and Rogers Island data were divided between east and west channels. Low-flow concentrations at all stations have decreased since 1979, the decrease being statistically significant between 1979 and 1980. The decline ranged from 0.036 ppb in the west channel at Rogers Island to 0.537 ppb at the Stillwater and Schuylerville stations. Overall, the mean low-flow PCB concentration fell from 0.69 ppb in 1977 to 0.11 ppb in 1982 (Brown and Werner, 1983).

Even though comparisons between arithmetic averages within a selected range of flow can identify long-term trends and significant differences in the data, the results can also be misleading since the technique involves arithmetic averaging of data that range between one and two orders of magnitude (Figure 4-5). Further, the data at the various gages are not directly comparable due to varying frequency-flow relationships resulting from increased drainage areas and because the data were not collected concurrently at the respective gages. For example, the data for 1977-1979 appear to indicate that the mean low-flow rate at Waterford is less than the corresponding value at Schuylerville, which has only 55 percent as much drainage area. What is not obvious is that the 7,000 cfs upper cutoff value is exceeded only about 20 percent of the time at Schuylerville, but about 40 percent of the time at Waterford. Consequently, the reported PCB concentrations do not have a common frequency basis.

TABLE 4-8

AVERAGE PCB CONCENTRATIONS FOR THREE FLOW REGIMES
FOR 1977-1979 USGS DATA

	Low Flow <7000 cfs	Medium Flow 7000-20,000 cfs	High Flow >20,000 cfs
Schuylerville			
Mean Flow (cfs)	3306	12881	30064
Mean PCB (µg/l)	0.665	0.214	1.17
Stillwater			
Mean Flow (cfs)	3553	12583	27933
Mean PCB (µg/l)	0.594	0.206	1.08
Waterford			
Mean Flow (cfs)	3153	17119	41733
Mean PCB (µg/l)	0.384	0.230	.693

< = Less Than
> = More Than
Source: Tofflemire, 1980.

TABLE 4-9

LOW FLOW PCB CONCENTRATIONS

Parameter	3 yrs 1976-79 Low Flow	1 yr 1979-80 Low Flow	1 yr 1980-81 Low Flow	1 yr 1981-82 Low Flow
*Rogers Island, E.C.				
Observations	35	17	21	
mean PCB ug/g	0.229	0.200	0.067#	
mean flow cfs	--	--	--	
Rogers Island, W.C.				
Observations	61	18	22	
mean PCB ug/l	0.131	0.166	0.036#	
mean flow cfs	3056	2398	2877	
Stillwater - Schuylerville				
Observations	38+27	26	59	36
mean PCB/ug/l	0.594, 0.665	0.307	0.156#	0.092#
mean flow cfs	3550, 3306	2404	3282	3718
Waterford				
Observations	43	31	20	16
mean PCB ug/l	0.384	0.239	0.145#	0.111
mean flow cfs	3153	2298	3400	4615

Source: Tofflemire, 1980.

* For Rogers Island, the 3 year data base, is 1977-80; there is little data for the 1976-77 year.

\# The 1980-81 means are significantly lower than the 1979-80 means at the .05 probability level.

The latter shortcoming can be approximately accounted for by adjusting all data for the respective drainage areas under the assumption that average flows are roughly proportional to drainage area. This does not eliminate the extreme variability of the data, however, and any conclusions based on an averaging procedure must be very general and well scrutinized. An approach more consistent with the scatter of the data is to simply overlay the data from the various sources and to observe general trends and differences. This nonquantitative approach, which eliminates the potential for generating misleading numbers, proved worthwhile in the assessment of previous modeling studies (Section 4.3). A conclusion of that effort is that all the PCB concentration and load data from Schuylerville, Stillwater, and Waterford are indistinguishable within the scatter of the data when corrected for the respective drainage areas (refer to Figures 4-16 through 4-18). This would not be an obvious conclusion from the quantitative averaging reported in Tables 4-8 and 4-9.

PCB transport rates have shown declines corresponding to the decreases in PCB concentrations which have been observed. Figure 4-6 illustrates some estimates of average annual PCB transport rates based on USGS data from Waterford and Stillwater. Also shown in this figure is the 20-year average PCB transport rate predicted by the PCB transport model of Lawler, Matusky, and Skelly (1978).

Although the estimates in the figure show a substantially elevated transport rate for 1979, the general trend appears to be declining, with the most recent estimates apparently leveling off to a base loading rate. The trend seems to satisfy a logarithmic relationship with time.

The transport rate trends reported above are similar to those predicted by the Lawler, Matusky, and Skelly model for the corresponding years. The annual average transport rate from the model (7200 pounds per year), however, is substantially larger than average transport estimates calculated from measured

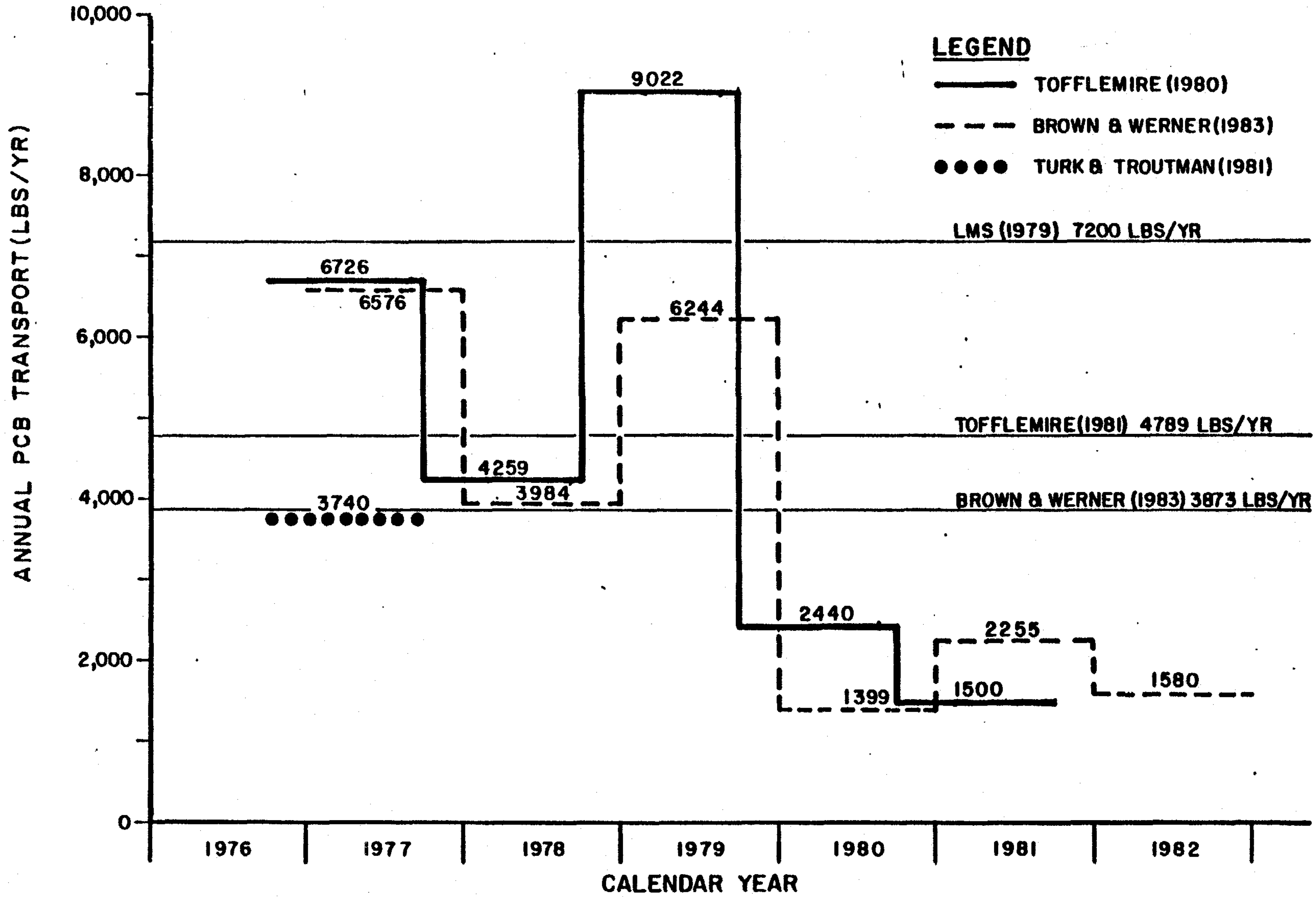

FIGURE 4-6

YEARLY PCB TRANSPORT ESTIMATES
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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values because of the high transport rates generated by the model in wet years. It is now suspected that model results are biased because it grossly overestimates PCB transport at high flows and underestimates transport at low flows (see Section 4.3). The possible effect of large river flows, however, is a concern which is discussed further in later paragraphs.

The elimination of industrial discharges, stabilization of the remnant deposits, and reduction in PCB releases from bed sediments are cited as the primary factors contributing to the overall decline in PCB concentrations observed in recent years (Brown and Werner, 1983). The flow regime and the processes controlling the transfer of PCBs from sediment to water will likely control PCB concentrations in the future. An assessment of the factors controlling the transfer process in relation to recent trends was made by Brown and Werner (1983). The authors found that mixing and covering contaminated deposits with cleaner sediment may have played a part in the declines in PCB concentrations which were observed. The writers further suggested that depletion of more readily volatilized PCB isomers may in part be responsible for the recent trends. It may be that decreases in PCB concentrations in the water column are directly related to decreases in the PCB content of the bed sediments. Recent sampling from the Upper Hudson River (see Appendix E) indicates a large decrease in the overall average PCB concentration of the sediments. This trend is as yet unconfirmed and possible mechanisms that might be responsible, including the degradation of PCB compounds due to environmental exposure, need to be investigated.

It remains to be seen how the flow regime influences trends in PCB contamination. It has been suggested that an absence of excessively high flows in recent years has resulted in the observation of misleading relationships (Sloan and Armstrong, 1980). Inherent in this suggestion is the idea that large floods will rework the sediments, disturb hot spots, and generally expose more highly contaminated sediments to the water interface, ultimately resulting in an overall increase in PCB concentration. Table 4-10 summarizes recent flow data from the gaging station at Stillwater. The maximum daily flow values at Stillwater have exceeded the 99 percent flow frequency value of 30,000 cfs in all of the calendar years shown except 1978 and

TABLE 4-10

RECENT FLOW DATA FROM THE GAGING STATION AT STILLWATER

Calendar Year	Annual Mean cfs	Maximum Mean Daily Flow cfs
1977	8,756	40,390
1978	6,250	17,302
1979	7,732	36,581
1980	4,837	26,094
1981	5,614	31,214
1982	6,497	33,721

Mean Annual Discharge = 5,000 cfs
99 percent flood frequency = 30,000 cfs

Source: Brown and Werner 1983

1980. With the exception of 1980, mean annual flows have been slightly above normal, indicating that the recent annual flow regimes have not been unusually low. The appearance of flow rates greater than 50,000 cfs at Waterford during May 1983 raised concern over the scouring of contaminated sediments. Flows in this range had not been observed at Waterford since March 1977, when peak flows of more than 70,000 cfs were recorded, and it was suggested that perhaps distribution of PCB contaminated sediments had been altered. Preliminary analysis of USGS data for the 1983 flood indicated that PCB transport rates during peak flows were from 175 to 250 pounds per day, which is three times more than usually picked up during annual high flows. Additionally, the ratio of suspended sediment to total PCB concentration indicated that the sediments in transport were three times more contaminated than in previous years, possibly indicating that some of the more contaminated sediments were being picked up. A plot of instantaneous PCB loads measured at Waterford during spring flood peaks (Figure 4-7), however, reveals that PCB transport in 1983 was in line with recent floods and substantially less than PCB transport in 1977.

It is interesting to note that measured PCB loads in 1979 were substantially higher for given flows than in other years. This may be residual effects of disturbances to the bottom occurring during dredging and the removal of remnant area 3a in 1978.

At present a definitive statement on the effects of large river flows on water column concentration, PCB transport, and sediment distributions is not possible. Additional monitoring data will be needed before such trends can be identified.

4.1.2.2 Groundwater

In 1980, there were approximately 630,000 to 900,000 pounds of PCBs stored in dredge spoil sites and upland municipal landfills in the Upper Hudson basin area (Malcolm Pirnie, Inc., 1980). Study and cleanup of many of these areas is not directly within the scope of this project. Some of these sites (Caputo Landfill, Old Moreau dredge spoil site) are Superfund projects and others (the remaining landfill sites) are being cleaned up as part of the agreement between G. E. and the NYSDEC. However, because they are situated on the banks of the river, the

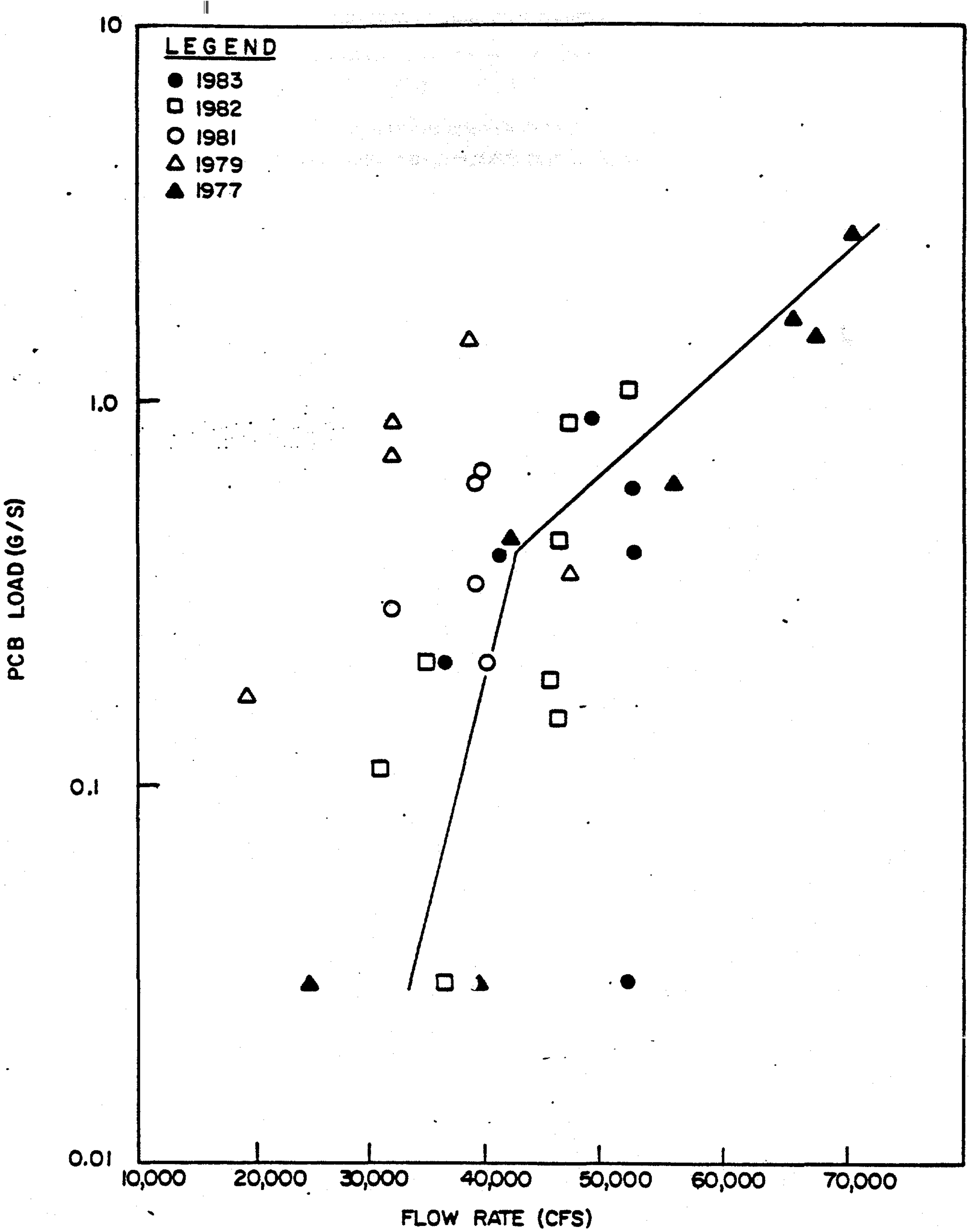

FIGURE 4-7

RELATION OF PCB LOAD TO FLOW RATE DURING SPRING FLOOD FLOWS AT WATERFORD HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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dredged disposal sites have a direct bearing on this study because of their PCB contributions to river water as well as their relation to the suitability of the proposed containment site.

Weston Environmental Consultants (1978) computed the PCB groundwater migration potential for 12 sites designated by NYSDEC as having significant amounts of PCBs contained in them. The PCB migration potential is the calculated quantity of PCBs leaving a site via groundwater after accounting for PCB adsorption onto soil particles. The calculations were based on preliminary field and laboratory data collected by Weston in 1977.

Table 4-11 summarizes the results of the Weston Study. PCB migration potentials were two to three orders of magnitude lower than annual PCB-contaminated groundwater discharge rates estimated with mass balance techniques which did not include the effects of soil attenuation. As a result of the PCB-porous media interactions, the PCB contamination plume was found to advance at velocities approximately two orders of magnitude slower than calculated groundwater flow velocities.

The Lock 1 and Lock 2 sites, Buoy sites 212 and 518, the Moreau sites, and special dredge area 13 are dredge spoil areas located on the banks of the Upper Hudson River. Assuming that all unattenuated PCBs that leave these sites in groundwater discharge enters the Hudson River, then, according to the values in Table 4-11, the total contribution of dredge spoil sites to the Hudson River PCB load is only 17.0 pounds per year. This is a relatively insignificant part of the annual PCB load at Rogers Island.

In comparison, PCB losses from these sites as a result of erosion outweigh the losses from groundwater transport. Weston estimates based on the Wischmeier equation (Baver, et al., 1979) and soil PCB content are summarized for dredge disposal areas in Table 4-12. The total PCB load from this mechanism of 20 pounds per year is still small in comparison with the total PCB balance of the system.

TABLE 4-11

CALCULATED PCB MIGRATION POTENTIAL FROM CONTAMINATED LANDFILLS AND DREDGE SPOIL AREAS IN THE UPPER HUDSON RIVER AREA

Site	Site Type*	Groundwater Flow Q MGD	PCB Concentration ppb	PCB Front Advance Velocity ft/yr	PCB Migration Potential lbs/yr
Lock Number 1	A	1.5×10^{-3}	37.4	1.3	3×10^{-4}
Lock Number 4	A	2.0×10^{-1}	37.4	11.7	4×10^{-2}
Caputo	B	2.7×10^{-3}	41.7	2.3	6×10^{-4}
Site 578	A	4.3×10^{-3}	37.4	9.9	8.8×10^{-4}
Site 212	A	2.2×10^{-1}	16.7	2.1	2.0×10^{-2}
Old Fort Edward	B	2.0×10^{-1}	693.0	23.4	7.5×10^{-1}
Fort Miller	B	1.5×10^{-6}	45.1	1.3×10^{-4}	3.5×10^{-7}
Kingsburg	B	1.3	580.1	24.3	3.8
Moreau	A	7.4×10^{-2}	55.4	2.3	2.2×10^{-2}
S.A. 13	A	2.9×10^{-1}	58.0	2.3	9×10^{-2}

* A - Dredged material disposal site
B - landfill site

Source: Weston Environmental Consultants 1978.

TABLE 4-12

PCB LOSSES TO THE RECEIVING STREAMS UNSECURE DREDGE DISPOSAL SITES

Site	Estimated Soil Loss to Watershed Receiving Stream Tons/Year	Total PCBs Lost to Watershed lb/yr
Lock 1	1.66	0.015
Lock 4	6.36	20.8
518	16.97	17.3
Buoy 212	41.05	24.2
Moreau	45.46	4.2
S.A. 13	27.24	4.5

Source: Weston Environmental Consultants, 1978.

The New Moreau site is a secure containment area designed to hold dredge spoils from remnant area 3a and from the terminal channel at Fort Edward. As such, it contains some of the most contaminated sediments in the study area. Details of the site's construction may be found on Malcolm Pirnie, Inc., contract D95278 drawings.

Because the designs and geologic settings are similar, monitoring results from the New Moreau site should reflect the behavior of the proposed Hot-Spot Dredging Program disposal site. PCB analyses are routinely made on samples taken from the leachate collection system and from an upgradient monitoring well. Unfortunately, there are no downgradient wells and an assessment of leaching cannot be made.

Three leachate samples have been collected from the internal drainage system (Treiling, July 1983), since 1978. PCB concentrations in these samples have ranged from less than 0.05 ppb to 1.5 ppb, with an average of 0.46 ppb. The maximum concentration of 1.5 ppb occurred in September 1979 and again in November 1982.

The upgradient monitoring wells have, surprisingly, yielded a higher average PCB concentration of 0.94 ppb for four samples collected between June through November 1982. These concentrations have ranged from less than 0.06 ppb to 3 ppb, which was found in the Weston well in November 1982. The Weston well is thought to be finished in the unsecure Old Moreau dredge spoil area, which may explain the relatively high PCB value. As of this time, there is not enough groundwater data available to properly assess the performance of the New Moreau containment design.

4.1.3 Air

Total suspended particulates have been monitored with high-volume air samplers at five locations in the Upper Hudson Valley. Results of the monitoring program are included in Table 4-13. Although most readings were within State and Federal standards, one of the Glens Falls stations exhibited readings that exceeded the standard for the annual geometric mean in 1973 and 1975. Readings obtained in 1976 were again in compliance with the State standard.

TABLE 4-13

TOTAL SUSPENDED PARTICULATES – HIGH VOLUME AIR SAMPLERS
SELECTED STATIONS – UPPER HUDSON RIVER
1976

Station	Fed. Std. (μg/m³)	NYS A.A.Q.S. G.M. (μg/m³)	Annual Geometric Mean – μg/m³ not to exceed A.A.Q.S					24 hour ave. μg/m³ not to exceed A.A.Q.S.(3)		
			1972	1973	1974	1975	1976	1st max.(4)	2nd max.	3rd max.
Glens Falls	75	55(2)	53	56(1)	47	63(1)	45	119(0)	114	112
Glens Falls	75	65	-	-	43	49	43	132(0)	117	93
Fort Edward	75	55	-	-	-	-	36	128(0)	108	91
Mechanicville	75	55	-	-	-	-	45	114(0)	111	107
Troy	75	65	52	55	53	46	39	112(0)	95	92

1. Denotes a violation of Ambient Air Quality Standards.

2. The State is divided by air quality priorities into four levels: Level I, denoting areas of least pollution to Level IV, areas of heaviest pollution. The two Glens Falls stations are located in different level areas, thus the difference in the A.A.Q.S. values.

3. State standard for 24 hour average is 250 μg/m³. Federal standard is 260 μg/m³.

4. 1st, 2nd, and 3rd maximum averages measured during 1976. The number in parenthesis indicates number of times 24 hour max. was exceeded.

Source: NYS Air Quality Report
Continuous and Manual Air Monitoring Systems
NYSDEC 1976
As Printed In: Malcolm Pirnie, Inc., January 1978

In 1977, PCB air sampling was conducted at five locations in the Upper Hudson Valley over an eight-month period. PCB readings in the Glens Falls and Warrenburg areas were generally less than 20 ng/m^3, while the stations in the Hudson Falls and Fort Edward areas recorded higher PCB levels. One of the Fort Edward stations, which was in close proximity to the General Electric Company facilities, recorded the highest concentrations, ranging from approximately 60 ng/m^3 to 3260 ng/m^3 (Malcolm Pirnie, Inc., 1978) (see Table 4-14).

Thirty-day dustfall jar tests were also conducted for PCBs at stations in the Fort Edward, Glens Falls, and Warrensburg areas in 1977. Results indicated that PCB contamination of settleable particulates was higher at the Fort Edward area than at either of the other two areas (Malcolm Pirnie, Inc., 1978).

About 1979, several field air samples were taken over dump or dredge sites. Sampling was generally conducted 3 to 4 feet above the ground and was repeated about 3 to 5 times. The data is presented in Table 4-15. Several background stations in the Fort Edward area had less than 20 ng/m^3, which is about the detection limit of the method for a 24-hour sample (NYSDEC, 1981).

Air samples taken in 1981 with a high volume sampler employing polyurethane sponges contained air PCB concentrations of roughly 5 ng/m^3 for farm fields near the Hudson River. Additional air sampling over the Lock 5 dam during the summer revealed PCB concentrations of 0.11 to 0.52 ng/m^3 (NYSDEC, 1981).

4.1.4 Biota

4.1.4.1 Fish

The PCB problem in the Hudson River was first detected in the late 1960's during a state-wide investigation of DDT contamination in fish (NYSDEC, 1983). Subsequent studies have provided a relative wealth of data for PCB concentrations in aquatic biota.

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TABLE 4-14

NEW YORK STATE - DEPARTMENT OF HEALTH
PCB AIR SAMPLING

ng PCB/m^3

Date	Glen Falls 5601-4	Warrensburg 5660-02	Hudson Falls 5726-01	Fort Edward I 5755-01	Fort Edward II 5755-02
1/1/77	R	R	R	R	<30
1/7/77	R	LA	40	R	R
1/13/77	R	R	≤190	1020	≤60
1/19/77	LA	<30	LA	530	<20
1/25/77	R	<40	R	1800	R
1/31/77	<20	<20	R	1800	<30
2/6/77	<20	<20	50	STB	<20
2/12/77	<20	<20	80	500	20
2/18/77	<20	<20	130	360	40
2/24/77	R	<20	<20	870	280
3/2/77	<50	<30	<20	≤600	80
3/14/77	<20	<20	190	≤ 60(1)	560(1)
3/20/77	R	<20	<20	≤320	<70
3/26/77	<20	<20	<20	140	240
4/1/77	<20	<20	<20	100	130
4/7/77	<20	NR	100	1210	<20
4/13/77	<20	<20	120	1180	160
4/19/77	<20	<20	160	740	200
4/28/77	<20	<20	260	3060	<20
5/3/77	<20	<20	30	330	210
5/13/77	<20	<20	<20	850	120
5/19/77	<20	<20	<20	580	100
5/25/77	R	<20	200	1140	130
5/31/77	<20	<20	100	970	<20
6/6/77	<20	<20	30	R	320
6/12/77	<20	<20	20	130	30
6/18/77	R	R	R	90	R
6/24/77	R	<20	R	R	30
6/30/77	<20	≤20	110	3260	<20
7/6/77	<20	<20	140(2)	150(2)	70
7/12/77	<20	<20	50	290	<20
7/18/77	<20	<20	50	350	<20
7/24/77	<20	<20	100	520	<20
7/30/77	<20	<20	30	590	<20

TABLE 4-14
NEW YORK - PCB AIR SAMPLING
PAGE TWO

Date	Glen Falls 5601-4	Warrensburg 5660-02	Hudson Falls 5726-01	Fort Edward I 5755-01	Fort Edward II 5755-02
8/5/77	R	<20	120	R	<20
8/11/77	R	<20	R	R	R
8/17/77	<20	<20	R	480	<20

5601-04 = Continuous Air Monitoring Station, Glens Falls
5660-02 = DEC Region 5 Suboffice, Warrensburg
5726-01 = Main Street School, Hudson Falls
5755-01 = Washington County Office Building, Fort Edward
5755-02 = Fort Hudson Nursing Home, Fort Edward

R = Reject
LA = Lab Accident
STB = Sampling Train Broken
NR = Not Run
< = Less Than
> = Greater Than
(1) = Appear to have been switched but can't be verified
(2) = Results are inconsistent with each other: 5726-01 is usually ten percent of 5755-01.

Source: NYSDEC Division of Air Resources, 1977. General Electric PCB Study - Fort Edward area (weekly laboratory reports).

As reprinted in: Malcolm Pirnie, Inc., January, 1978.

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TABLE 4-15

SUMMARY TABULATION OF AIR PCB DATA BY NYSDEC DIV. OF AIR RESOURCES
(Data taken at Temperature of 65-85°F)

Site	Comment	Air PCB µg/m³	Sediment µg/g	Ratio Air/sediment	Reference
Caputo Dump	Max.	300	10,000-50,000		Dr. Hawley 2/26/79 memo and original Air Resource Data
Caputo	Ave.	130	10,000-50,000	.0043	
Ft. Miller Dump	Max.	35	5,000-15,000		
	Ave.	24	5,000-15,000	.0024	
Remnant Area	Max.	10	1,000-2,000		
	Ave.	9	1,000-2,000	.006	
Moreau site with excavated 3A material	Max.	15	600-1,000		
	Ave.	5.6	600-1,000	.007	
Buoy 212 Site Summer 1979	One sample 85°F	0.7	50-100	.0093	Summer 1979 Air Resources Data
Old Moreau Site Summer 1979	Ave.	0.3	20-50	.0085	Summer 1979 Air Resources Data

Source: DEIS, 1981

An early paper (Hullar, et al., 1976) reported data gathered from 1972 to 1975 which showed that Hudson River fish contained the highest known PCB concentrations within the United States. The report also indicated that PCB contamination in fish decreased regularly with distance below Thompson Island.

A second report by Spagnoli and Skinner (1977) summarizes the results of a state-wide survey which showed that edible fish flesh from the Hudson River frequently contained wet-weight-basis PCB concentrations of 50 ppm or more and that concentrations up to 599 ppm could be found in the larger oil-rich species. A survey of Spagnoli and Skinner's data revealed that between Fort Edward, New York, and Waterford, New York, not a single member of the species studied exhibited an average PCB concentration less than the FDA temporary limit of 5 ppm (wet weight basis), and although the average concentrations appeared to decline with distance downstream, concentrations exceeding the limit could still be found below the Federal Dam at Troy, New York. Migrant marine species, such as American eel and striped bass, appeared to be especially susceptible to PCB contamination in the Lower Hudson estuary.

The New York State Bureau of Fish and Wildlife inferred temporal trends of PCB contamination in fish between 1976 and 1981 by collecting specimens from specific locations during the same annual time frame (Armstrong and Sloan, 1981; Sloan and Armstrong, 1981). In these studies it was discovered that lipid content rather than size or age was the primary factor determining PCB contamination. This relationship apparently confirmed that the aquatic biota was under the influence of a homogeneous, unidirectional flux of PCB. In order to provide meaningful trends for evaluation, analytical PCB levels based on wet tissue were converted to PCB concentration per unit-weight of lipid in individual fish. The results of these studies are discussed below.

Table 4-16 summarizes the Armstrong and Sloan data for fresh-water resident species collected from the river reach between Fort Edward and Catskill, New York. Fresh-water species showed an overall annual decline in total PCB content of 34.0 ± 12.6% for the interval between 1977 and 1980. This decline was due almost entirely to decreases in Aroclor 1016, which showed an average annual

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TABLE 4-16

LIPID-BASED AND WET-WEIGHT-BASIS PCB CONCENTRATIONS IN FRESH WATER RESIDENT FISH SPECIES

Location	Species	Year	Total PCB (ppm, wet)	Lipid-based PCB (ppm) AROCLOR 1016	Lipid-based PCB (ppm) AROCLOR 1254	Lipid-based PCB (ppm) Total PCB
Stillwater	Brown Bullhead	1977	106.5+49.2	1908+799	388+253	2508+1.056
		1979	8.97+12.26	734+359	589+567	1336+854
		1980	12.34+6.56	694+190	750+290	1479+466
	Goldfish	1977	559.4+506.8	3961+3065	589+467	5255+3700
		1978	273.6+237.4	2684+1278	565+330	3571+1645
		1980	72.62+55.42	537+326	660+424	1206+654
	Largemouth Bass	1977	70.72+62.04	4470+1589	1114+333	6010+2020
		1978	153.08+81.57	3135+1175	915+413	4318+1588
		1980	10.44+13.83	840+347	868+379	1735+722
	Yellow Perch	1977	12.60+8.85	2555+1295	851+353	3725+1690
		1980	0.84+0.60	450+171	507+272	957+420
Albany/Troy	Brown Bullhead	1977	37.90+27.90	676+422	185+115	904+511
		1978	25.16+10.46	359+117	101+38	515+146
		1979	7.15+9.20	169+88	136+75	306+139
		1980	2.09+1.66	96+63	88+64	206+135
	White Perch	1977	118.4+73.2	1066+840	182+146	1365+976
		1978	85.4+41.1	715+187	171+87	948+229
		1980	16.04+9.87	122+72	182+91	316+129
Catskill	Largemouth Bass	1977	29.56+19.33	1732+959	671+500	2436+1170
		1978	28.96+21.17	1034+649	539+450	1600+1056
		1980	1.08+0.69	119+76	183+133	350+223
	Redbreast Sunfish	1978	4.08+2.42	247+132	195+117	458+231
		1980	2.63+5.51	98+70	223+170	380+287
	Yellow Perch	1977	4.58+3.19	1080+741	367+334	1497+1081
		1980	0.54+0.31	67+75	164+141	277+168

Source: Armstrong and Sloan, 1981

decline of 147.3+ ± 10.0%, convertible to an approximate half-life value of 1.15 ± 0.38 years.

Declines in the more highly chlorinated homologs (Aroclor 1254) were less extensive, approximately 6.8 ± 17.5%. In some species--brown bullhead, goldfish, and redbreast sunfish--a small but significant increase in Aroclor 1254 was noted. The authors concluded that the heavier PCB homologs continued to contaminate fish flesh at rates roughly equivalent to those present years ago.

The moderate decline in Aroclor 1254 content was attributed to the higher stability of the compound relative to the lower chlorinated Aroclors, although the authors acknowledged that difficulties with analytical interpretation of Aroclor mixtures and possible secondary point sources may have been affecting the trends.

In 1982 monitoring data showed that lipid-based PCB concentrations in fresh water species had continued to drop. Mean PCB concentrations in brown bullhead, goldfish, and largemouth bass had reached 428, 310, and 1000 ppm, respectively (Brown and Werner, 1983), an overall decline of almost 90 percent since 1977.

The temporal and spatial trends of PCB in migrant marine species were not as obvious because of their complex life histories. For instance, some species, such as rainbow smelt, blueback herring, alewife, and American Shad, enter the river only to spawn and do not feed there. In such cases PCB contamination occurs principally by diffusion so relationships between PCB content and lipid content, or size, age, or sex, are not as clear. In other species having both migrant and resident populations, such as striped bass, trends are difficult to follow. Nevertheless, there have been notable decreases in total PCB content in all salt-water species since 1977.

Sloan and Armstrong's data for migrant marine species are summarized in Table 4-17. The overall annual decline for total PCB was 28 percent between 1977 and 1980. Most of the decline in PCBs was due to reductions in Aroclor 1016 just as it was for fresh-water fish (42 percent). The average annual decline in Aroclor 1254 was only 5 percent.

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TABLE 4-17

LIPID-BASED AND WET-WEIGHT-BASIS PCB CONCENTRATIONS IN MARINE SPECIES

Location	Species	Year	PCB (ppm) wet basis			Total PCB (ppm)-lipid basis
			Total	AR01016	AR01254	
Below Newburgh	Blue Claw Crab-Muscle	1976	<0.75	--	--	204
	Blue Claw Brab-Muscle	1979	<0.50 + 0.45	<0.10 ± 0.002	0.34 ± 0.44	179 ± 115
	" " - Hepatopancrease		6.70 ± 5.49	0.71 ± 0.56	5.91 ± 5.06	152 ± 70
	Atlantic Sturgeon					
Indian Pt.	- immature	1980	2.80 ± 2.02	0.65 ± 0.66	2.06 ± 1.55	280 ± 391
Catskill	- adult	1981	4.96	<0.20	4.76	31.5
	Shortnose Sturgeon					
Indian Pt.	- fillet	1980	1.83	0.19	1.54	165
	- liver		7.10	0.67	6.33	122
			29.6	2.62	25.9	148
Mohawk R.	Blueback Herring	1979	2.50 ± 0.95	1.06 ± 0.47	1.34 ± 0.60	75.1 ± 39.4
(Lock 7)		1978	3.91	1.78	1.67	49.9
Albany/Troy		1980	1.81	0.72	0.95	32.3
Albany/Troy	Alewife	1978	5.64	3.73	1.40	109
		1979	3.98 ± 1.28	1.77 ± 0.65	1.67 ± 0.51	50.1 ± 11.8
Catskill		1979	2.16 ± 0.99	0.66 ± 0.57	1.35 ± 0.56	45.0 ± 39.9
Saugertone		1979	2.41 ± 1.47	0.76 ± 0.58	1.40 ± 0.71	44.0 ± 18.2
Kingston		1979	2.50 ± 1.04	0.69 ± 0.45	1.71 ± 0.84	31.7 ± 12.8
		1980	3.02	0.70	2.22	32.8
Newburgh		1979	2.60 ± 1.12	0.61 ± 0.44	1.84 ± 0.73	33.8 ± 13.6

TABLE 4-17
PCB CONCENTRATIONS IN MARINE SPECIES
PAGE TWO

Location	Species	Year	PCB (ppm) wet basis: Total	PCB (ppm) wet basis: AR01016	PCB (ppm) wet basis: AR01254	Total PCB (ppm)-lipid basis
Albany/Troy	American Shad	1980	1.72 ± 1.52	0.96 ± 1.04	0.63 ± 0.44	26.6 ± 7.7
Catskill	- male	1980	2.38 ± 1.02	0.95 ± 0.50	1.05 ± 0.47	20.3 ± 10.3
	- female		0.92 ± 0.35	0.21 ± 0.12	0.52 ± 0.21	10.4 ± 5.8
Poughkeepsie	- male	1977	7.04 ± 2.88	--	--	--
	- female		5.51 ± 2.23	--	--	--
	- male	4/20/78	3.98 ± 1.90	2.89 ± 1.54	0.85 ± 0.46	24.2 ± 10.6
	- female		1.66 ± 0.86	0.90 ± 0.59	0.53 ± 0.30	12.4 ± 5.7
	- male	5/5/78	4.21 ± 1.79	2.03 ± 1.50	0.90 ± 0.50	20.7 ± 9.2
	- female		1.63 ± 0.77	1.06 ± 0.55	0.36 ± 0.23	8.6 ± 4.0
	- female	5/16/78	3.25 ± 2.46	2.15 ± 1.92	0.79 ± 0.48	17.3 ± 7.1
	- male	5/9/00	2.46 ± 1.21	1.02 ± 0.79	1.16 ± 0.61	19.4 ± 15.1
	- female		1.20 ± 0.41	0.36 ± 0.28	0.64 ± 0.23	12.0 ± 7.2
Peekskill	- female	1978	2.23 ± 1.16	1.19 ± 0.74	0.61 ± 0.47	15.4 ± 9.6
	- male	1980	2.98	1.36	1.32	27.5
	- female		1.22 ± 0.79	0.22 ± 0.18	0.54 ± 0.17	10.5 ± 6.7
Tappan Zee Bridge	- male	1977	3.55 ± 1.11	--	--	--
	- male	4/13/78	3.28 ± 2.13	2.14 ± 1.73	0.67 ± 0.37	10.1 ± 12.1
	- female		2.73 ± 5.44	1.23 ± 2.71	1.14 ± 2.62	19.2 ± 28.8
	- male	5/12/78	3.18 ± 1.83	1.89 ± 1.51	0.88 ± 0.43	17.9 ± 8.6
	- female		1.46 ± 0.48	0.49 ± 0.37	0.60 ± 0.12	10.4 ± 3.4
	- male	1979	1.54 ± 0.68	0.71 ± 0.33	0.84 ± 0.40	8.7 ± 4.1
	- female		1.17 ± 0.44	0.37 ± 0.11	0.80 ± 0.35	7.0 ± 2.1
	- male	1980	1.93 ± 1.09	0.75 ± 0.51	0.83 ± 0.47	16.3 ± 11.1
	- female		1.22 ± 0.67	0.33 ± 0.29	0.63 ± 0.33	10.1 ± 4.9

TABLE 4-17
PCB CONCENTRATIONS IN MARINE SPECIES
PAGE THREE

Location	Species	Year	PCB (ppm) wet basis Total	AR01016	AR01254	Total PCB (ppm)-lipid basis
Poughkeepsie	American eel	1981	13.1 ± 11.81	0.93 ± 0.56	12.24 ± 11.46	129 ± 134
Peekskill		1981	10.70 ± 9.68	0.73 ± 0.66	9.85 ± 9.08	184 ± 333
Indian Point - Nyack		1978	73.9 ± 66.7	39.9 ± 41.6	33.2 ± 28.6	612 ± 418
		1980	9.07 ± 8.61	0.46 ± 0.29	8.51 ± 8.25	190 ± 64
		1981	10.83 ± 6.22	0.49 ± 0.33	10.23 ± 5.97	109 ± 79
		1980	8.15 ± 4.30	0.53 ± 0.23	7.52 ± 4.10	71.0 ± 13.8
Pier 40 (NYC)		1980	5.89 ± 2.50	0.38 ± 0.19	5.41 ± 2.33	66.0 ± 23.9
Verrazano Bridge		1980	6.76 ± 12.89	0.22 ± 0.14	6.44 ± 12.79	98.4 ± 87.8
Queensboro Bridge		1980	7.13 ± 8.73	0.44 ± 0.32	6.57 ± 8.52	78.2 ± 55.2
Kingston	Rainbow Smelt	1979	4.07 ± 2.34	1.31 ± 0.75	2.64 ± 1.59	184 ± 70.6
Newburgh		1979	4.51 ± 2.78	1.32 ± 0.79	3.10 ± 1.93	213 ± 89.3
		1980	4.33	1.22	3.01	185
		1980	2.36 ± 0.31	0.65 ± 0.27	1.61 ± 0.12	121 ± 17.7
Poughkeepsie	Atlantic tomcod	1979	0.46 ± 0.35	0.22 ± 0.24	0.14 ± 0.11	246 ± 87.7
		1980	0.66 ± 0.21	0.25 ± 0.09	0.31 ± 0.13	119 ± 34.3
Indian Point		1977	0.96 ± 0.74	0.65 ± 0.55	0.21 ± 0.20	166 ± 81.4
Haverstraw Bay		1980	]0.37 ± 0.08	]0.14 ± 0.05	]0.13 ± 0.05	86.8 ± 40.1
Riverwide	Striped Bass	1978	18.10 ± 28.22	9.64 ± 18.32	7.70 ± 10.34	270.24 ± 417.95
		1980	6.13 ± 7.43	1.68 ± 2.95	4.28 ± 4.83	168.38 ± 144.13
		1981	4.81 ± 5.98	1.02 ± 2.20	3.50 ± 3.94	152.00 ± 186.29
Peekskill	Bluefish	1979	3.15 ± 1.74	0.62 ± 0.31	2.43 ± 1.48	227 ± 84.0

Source: Sloan and Armstrong 1981

The authors cautioned that the new decreases could be artificial since the study was carried out during a period of exceptionally stable river flows and, therefore, the data did not reflect possible responses to increased PCBs in the water column occurring during extreme flood conditions. They also pointed out that PCB concentrations in fish should not continue to substantially decline under present conditions because of the depletion of Aroclor 1016. In conclusion, the authors state that even with the declining trend, most fresh-water species contained PCB contamination exceeding the FDA-recommended limit and that current contamination (Table 4-18) in marine species is well above background levels.

Brown and Werner (1983) caution that due to the distribution of various-sized fish in annual samples and the positive correlations between fish length or weight and PCB concentrations, PCB contamination on a wet-weight basis is skewed to the low end of the distribution. Therefore the arithmetic means shown in the tables (for wet-weight concentrations only) are considerably higher than either the median value or the $\log_{10}$ mean PCB concentration.

Brown and Werner also argue that because large flood events in the Upper Hudson River are infrequent, it is the low-flow water column PCB concentrations which control fish contamination. Because of this, large floods will increase PCB concentrations in fish flesh only if scour exposes more highly contaminated sediments at the sediment-water-interface. They further point out that PCB-laden suspended sediment is likely to control fish contamination in the Lower Hudson because of the long residence time of flood peaks in the estuary.

4.1.4.2 Invertebrates

In 1981, the NYSDEC Division of Water Research studied PCB in the fresh water clam Elliptio complanatus in connection with DOT dredging in contaminated sediments (NYSDEC, 1981b). Clean sets of clams were exposed both upstream and downstream of the dredge site and a third set of clams was maintained upstream of Glen Falls as a control.

TABLE 4-18

CURRENT APPROXIMATE AVERAGE TOTAL PCB CONCENTRATIONS IN HUDSON RIVER MIGRANT/MARINE FISH (WET BASIS) ENCOUNTERED BELOW TROY

Species	Year Analyzed	Approximate Average PCB (ppm) Value
Blue Claw Crab-Muscle	1979	<1
- hepatopancreas		>5
Atlantic Sturgeon-immature	1980	2-5
- adult	1981	~5(a)
Shortnose Sturgeon	1980	<2(b)
Blueback Herring	1980	2-5
Alewife	1980	2-5
American Shad	1980	1-3
American Eel	1981	~10
Rainbow Smelt	1980	3-5
Atlantic Tomcad	1980	<1
Striped Bass	1981	~5
Bluefish-Immature	1979	~3

(a) Only one analyzed.
(b) Endangered species; possession is prohibited.
< = Less than
> = Greater than
~ = Approximately

Source: Sloan and Armstrong, 1981

After a two-week exposure, the dredge site clams had accumulated an average lipid-based PCB concentration of 75.5 ppm compared to 6.0 ppm in the control sample. After a 2-week depurification period the PCB concentration in the contaminated clams decreased to an average of 12.4 ppm, and the corresponding value in the control sample dropped to less than 0.02 ppm. There did not appear to be a significant difference in the PCB concentrations between contaminated clams above or below the dredge site.

Results of a Department of Health freshwater macroinvertebrate study appear in a NYSDEC Report (NYSDEC, 1982). This study included PCB analyses of a number of aquatic insects in the Upper Hudson, the Lower Hudson, and above Glens Falls. The results for caddis fly larva, the most frequently sampled species, are reported below.

In the control area (above Glens Falls), PCB concentration on a dry-weight basis averaged less than 5.3 ppm between 1979 and 1981. The average PCB content of the insect in the Upper Hudson reach dropped from a high of 50.14 ppm in 1979 to 27.59 ppm in1980. In 1981 the PCB content of the species in the reach rose slightly to 28.57 ppm. PCB contamination of the caddis fly was less in the Lower Hudson reach, dropping from 21.66 ppm to 11.60 ppm between 1980 and 1981. This decreasing trend is consistent with that observed in fish over the same period.

A number of PCB analyses for blue claw crabs, the only marine invertebrate to be studied, appear for 1979 samples in NYSDEC Technical Report No. 81-1 (1981). Results show PCB concentrations both for muscle tissue and for the hepatopancreas, which is consumed by many local people as a delicacy (Sloan and Armstrong, 1981). PCB contamination in muscle tissue is relatively low, ranging from less than 0.34 to less than 0.40 ppm on a lipid-based measure for various areas. Contamination of the hepatopancreas, however, is more serious, with PCB concentrations ranging from an average of 9.64 ppm at Foundry Cove to a low of 4.62 ppm at Havestraw Bay. Concentrations as high as 20.21 ppm were found in hepatopancreas tissues. These values, however, represented a substantial reduction in PCB since 1976 (Armstrong and Sloan, 1980, 1981).

4.1.4.3 Vegetation

In 1977, Weston, Inc., documented the presence of PCB contamination in plants around PCB dumps and dredge spoil sites of the Upper Hudson River. PCB levels of up to 2800 ppm were found in the leaves of plant species growing on PCB dumps, while undetectable concentrations were generally found in plants from other areas (NYSDEC, 1981).

Boyce Thompson Institute later determined that measurable PCB accumulations in foliage extended as far as 700 to 1000 meters from highly contaminated local sources. The following table presents measured PCB content of leaves of trembling aspen, as determined along an easterly transect from the Fort Miller dump site, and the considerably lower levels of PCB content found in aspen leaves east of Buoy 212 dredge spoil site and east of a riffle area in the Hudson River near Lock 6. It must be noted, however, that PCB uptake varies markedly among different plant species (NYSDEC, 1981).

PCB content in trembling aspen leaves (Populus tremuloides Michx.) along easterly transects from three local sources of volatile PCBs, the Fort Miller dump site, the Buoy 212 dredge spoil site, and a Hudson River riffle area near Lock 6, Fort Miller, New York, is as follows:

Dump Site		Dredge Site		Riffle Area	
Distance (m)	Content (ppm)	Distance (m)	Content (ppm)	Distance (m)	Content (ppm)
on site	180	on site	2.52	on site	N.A.
41	6.58	30	0.89	10	1.26
55	4.18	50	0.44	40	0.45
92	1.96	110	0.26	450	0.11
148	0.90	400	0.19	1500	0.12
250	0.54	700	0.18		
370	0.26	1300	0.17		
530	0.25	2300	0.10		
820	0.15				
960	0.13				
1600	0.12				

4.2 Adequacy of Existing Data Base

The data base on PCB contamination of sediments, water, air, and biota of the Hudson River area is quite extensive. In addition, substantial research into sediment PCB transport and PCB contaminant trends has been performed; yet after 5 years of study and the expenditure of more than $7 million dollars, there are still important questions and deficiencies which must be addressed.

4.2.1 Remnant Deposits

The extent of the contamination in the remnant deposits is known only through approximately two dozen core samples. PCB mass estimates for these areas vary from 45,000 to 150,000 pounds. Most of the sampling at these areas was done in 1978. No recent data documenting the amount or distribution of PCB in these deposits is available.

Current information on river hydrology as it relates to remnant deposit scour appears to indicate that most remnant deposits are adequately protected from flows up to the 100-year flood stage. A comparison between aerial photographs between 1978 and 1983 reveals that massive erosion at remnant site 1 may have occurred. However, this site is an isolated island with a low PCB content and it may not be contributing much PCB to the river. Sampling should be done to confirm this conclusion.

4.2.2 Sediment

The present understanding of PCB distributions in submerged sediment comes from a single comprehensive analytical survey completed in 1977 and 1978. This survey consisted of approximately 700 PCB analyses from 1200 core and grab samples taken along cross-river transects which were spaced a minimum of 700 feet apart in the Thompson Island pool and farther apart south of the Thompson Island Dam.

This data base has several serious problems. One problem concerns the variability of PCB contamination on the river bottom and the accuracy of hot spot delineation. Measured PCB concentrations varied widely within short distances, exhibiting almost no regionalized trends. Very high PCB concentrations were found adjacent to and in the same hot spot with concentrations less than 50 ppm. This may indicate that hot spots are actually very localized phenomena consisting of contaminated sediments which have settled in small depressions and pockets in the river bottom. In some cases, hot spot delineations have been based on one or two high concentration samples, and intuitive assumptions on sediment deposits based on particle size distribution and river hydrology. There is a distinct possibility that delineated hot spots contain extensive areas of sediments containing less than 50 ppm of PCB. If this is the case, then PCB mass estimates based on hot spot area and average concentrations may be extremely misleading.

At this time, there is no cost-effective statistical method appropriate for estimating the degree of error involved with mapping PCB hot spots.

A more serious implication of this problem is that many small, localized hot spots may have been missed by the survey. In looking at the original survey data, about a dozen PCB concentration values which could have been included in hot spots were not. The sampling density for the 5-mile stretch of the river above the Thompson Island Dam is low and it decreases as the distance downstream from the Ft. Edward Dam increases. A 1983 aerial survey revealed many shallow areas which could contain hot spots that had not been heavily sampled. The possibility is great that a substantial amount of high concentration sediments was missed while high volumes of low concentration sediments were included in hot spots.

Another problem with the survey concerns the dynamic nature of the river system and the age of the survey. A certain amount of sediment reworking is expected over the 5 years since the survey was completed, especially with the occurrence of an 80-year return period flood in May of 1983. Suspended sediment transport estimates calculated from U.S.G.S. measurements have shown that, up to 1982, the amount of PCB removed from the Upper Hudson River by suspended sediment transport over the Troy Dam has been relatively small. The amount of sediment reworking by bed-load movement in individual pools is completely unknown. Many of the more extensive contaminated deposits, especially those in the Thompson Island pool, appear to be located in unprotected high velocity areas where even during an average annual flood, flow velocities may be sufficient to cause scour.

A third problem concerns the quality of PCB analysis performed on the sediments. Even today, PCB quantification is a difficult process subject to a high degree of error. Some of the methods used by the original contractors may have been faulty since information in some NYSDEC publications shows that ratios of the results of some duplicate samples were at least 1 to 3. This is a source of variation which adds to the uncertainty about the amount and concentration of PCBs in delineated hot spots.

Many of these problems were recognized by State officials, which is why they had proposed an extensive sampling survey prior to the implementation of a dredging program. However, it must be pointed out that PCB mass estimates, cleanup operations, and most other conclusions are based on hot-spot delineations and sediment PCB data, with a significant amount of uncertainty associated with it in 1977. This data is even more uncertain in 1983.

A limited sampling program was conducted in August of 1983 in the upper hot spots to try to determine whether movement of the contaminated sediments had occurred. The results and analysis of this survey can be found in Appendix E. The results showed movement in some but not all of the hot spots. They also appeared to show a decrease in the concentrations of PCBs in those hot spots sampled.

4.2.3 Water

The water-column data generated by the USGS has some minor problems which have already been mentioned. It is generally sufficient for environmental monitoring. There are, however, two important aspects of PCB water-column concentrations which have not been addressed.

The first is the amount of water-column PCB originating from hot spots and cold areas. Since highly contaminated hot spots cover only 8 percent of the river bottom, it is not known whether water column and air PCB concentrations, as well as fish contamination, will lessen significantly if hot spots are removed. The relative contribution of areas of relatively small extent with high concentrations compared to the contributions of extensive areas of moderate contamination (average 20 µg/g) needs to be assessed.

The second area that has not been addressed is the concentration of PCBs in water supplies. This type of data has not been provided in NYSDEC publications.

4.2.4 Air

As with PCB concentrations in water, the PCB concentration in air has not been extensively studied at receptor sites.

4.2.5 Biota

The data base for PCB contamination of Hudson River biota is sufficient for indicating trends. Some authors have questioned the validity of reporting wet-weight PCB concentrations as an arithmetic mean since wet-weight concentrations are skewed to the low end of the scale. Median values for most fish species are substantially lower than reported arithmetic averages, which means that the probability of obtaining a highly contaminated fish is much less than the arithmetic mean would indicate. However, as long as highly contaminated individual fish do exist, the public health concerns cannot be ignored.

4.3 Evaluation of PCB Transport Model

Mathematical models of the fate of PCBs in a natural water system can potentially cover a wide spectrum of empiricism versus theory, and simplicity versus complexity. The principal reason for such a diversity of models is that the dynamics of PCBs are governed by many disciplines in which a complete understanding of basic processes and their rates is still lacking. Hydrodynamics, chemistry, and biology represent the major sciences involved. At one extreme are attempts to incorporate available kinetic descriptions of simple systems from each discipline into one "ultimate" predictive model. The drawback of this approach is that when models from various disciplines are interfaced, a compounding of the uncertainties of each submodel may lead to overall results in which one can have little confidence. The other extreme is the empirical approach, which could involve either a rigorous analysis of available data or a comparison of parameter values for the case under study with similar parameters for water bodies previously studied. In the empirical approach, no a priori consideration is given to the basic physical, chemical, and biological processes governing the observed responses, although the processes are often cited to explain observed trends.

Almost all modeling studies lie between these two extremes, with the relative position commonly dictated by the available data base, budgetary constraints, and the imposed schedule of performance. The Hudson River model under review appears to be no exception, and thus to judge its adequacy one must carefully consider whether the selected modeling framework is consistent with the available data, modeling objectives, and ultimate use of the results. In order to best track the reports on which this review is based (Lawler, Matusky, and Skelly (LMS), 1978-1979), the hydraulic, sediment transport, and PCB inventory submodels will be addressed separately in the following sections. Model selection (and/or development), calibration, and validation will provide the primary points of discussion.

4.3.1 Hydraulic Submodel

The hydraulic submodel, which was provided via the generalized computer program HEC-6 ("Scour and Deposition in Rivers and Reservoirs"), has its basis in the computational algorithms of the computer program HEC-2 ("Water Surface Profiles"). Where applicable, these programs are widely accepted for engineering studies and have been thoroughly tested and validated in various applications over the years.

Two principal technical concerns related to the direct application of the HEC hydraulic model to the Hudson River study have been identified. These include the one-dimensionality of the model, and the artificial control imposed by the locks and dams on the hydraulics of the river system. The one-dimensional limitation of the model is important in that it prohibits both a differentiation between the computed average streamflow velocity and the local bottom velocity that is critical to the sediment-water interchange, and a resolution of lateral velocity variations that would be of value in explaining observed depositional patterns and assessing proposed remediation of "hot spot" areas. The lack of vertical resolution is directly related to the locks and dams issue, as the primary concern is whether the hydrodynamic effects of the resultant backwater pools would negate the use of a one-dimensional model when the local bottom velocity is of ultimate importance to sediment transport.

In the case of the Hudson River above the Federal Dam at Troy, the latter concern is minimized because the length of each reach (at least two miles) is large relative to the dam height (generally less than 10 feet). The significant hydrodynamic effects in the vertical direction are thus limited to river zones immediately upstream and downstream of the structures, with a large portion of each reach exhibiting velocity distributions similar to those of a free-flowing river. The increased depth of flow created by the backwater from the dam does result in an increased cross-sectional area of flow, however, and thus a lesser velocity than would occur under natural flow conditions. This decrease in velocity represents the primary effect of the dams on the sediment transport process and is adequately treated in the HEC hydraulic algorithms (McArthur, 1983).

The one-dimensionality of the model generally remains a technical drawback relative to a comprehensive assessment of alternative courses of action. Two- or three-dimensional hydrodynamic models are available within the state of current practice that could potentially generate a refined understanding of velocity profiles. However, the effective use of such models requires an extensive hydrologic and hydrographic data base that is not currently available for the Hudson River. In addition, a hydrodynamic modeling effort at this level of refinement would be inconsistent with the current state of modeling of the sedimentation and erosion behavior of organic and cohesive materials; that is, an interfaced modeling effort is only as reliable as its weakest component, and to go beyond the one-dimensional hydrodynamic model would not be technically or financially effective when less understood sediment transport and PCB interaction processes also play principal roles in PCB transport.

Given this affirmative judgment as to the suitability of the HEC hydraulic model for the case under study, the remaining issue is model calibration. The only comparative data available in the Hudson River study report (LMS, 1978) is for the reach between Lock 7 and Thompson Island Dam. For each of the three flows tested, the water surface elevation from the model exceeded the mean observed elevation (see Figure 4-8). The primary source of these differences appears to be the rating curve (i.e., the initial condition) at the dam, since in each case the water surface elevation within the drawdown curve at the dam already exceeds the observed elevation at the upstream end of the reach. In order to assess the potential error of this level of calibration, the mean flow rate was plotted against the elevation of the observed water surface with respect to the dam crest elevation (see Figure 4-9). A relatively linear relationship is observed on the log-log plot, as would be expected under weir flow conditions. (Note that this analysis is approximate since the observed elevations are at the upstream end of the reach, but nevertheless the linear relationship appears to be satisfied.) The respective flow rates corresponding to the water surface elevations from the model are also noted on Figure 4-9, and are observed to be consistently about 30 percent higher than measured values. Even though no documentation of the calibration was available for this review, improvement in hydraulic model performance could likely have been achieved. The eventual result of this discrepancy is that the cross-sectional area of flow for a given discharge is overestimated to a comparable degree, and in turn the resultant average velocities that drive the sediment transport model are underestimated. This observation could be important with respect to a recommended remedial measure to modify the channel geometry in order to reduce the scour velocity. It is doubtful whether any channelization that would reduce stream velocity in excess of the perceived modeling discrepancy could be implemented, at least cost-effectively.

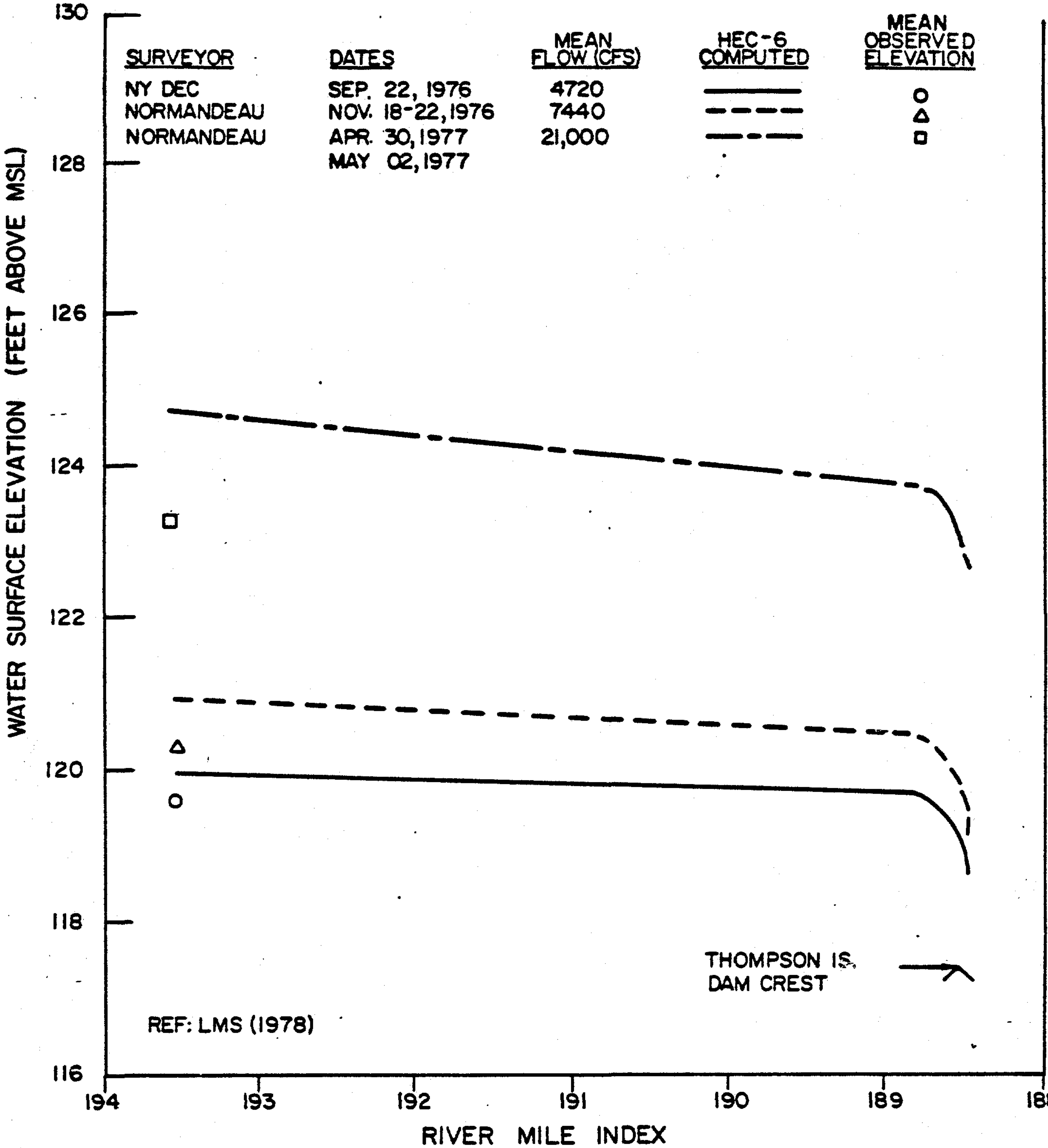

FIGURE 4-8

HEC-6 HYDRAULIC CALIBRATION
LOCK 7 TO THOMPSON IS. DAM REACH
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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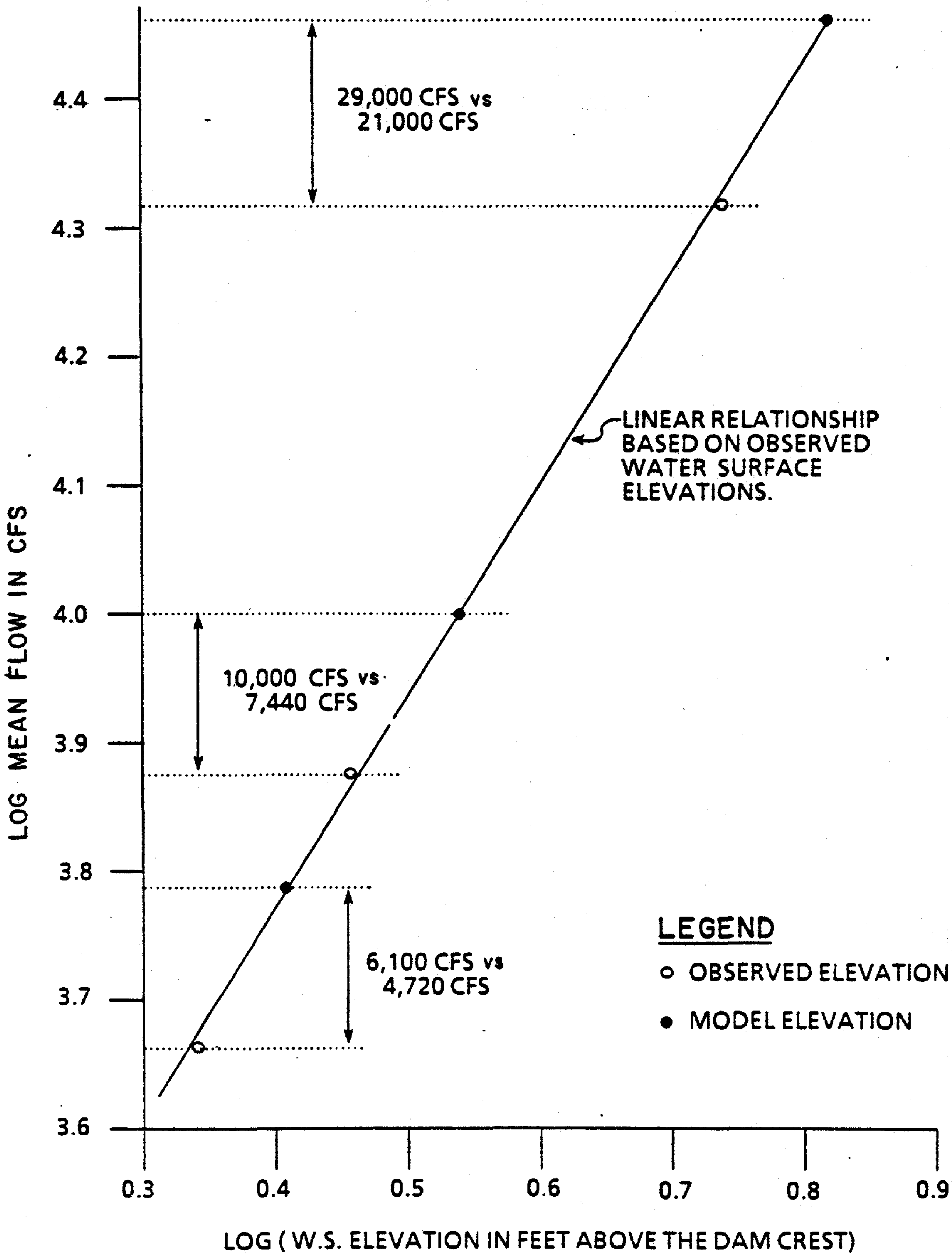

FIGURE 4-9

APPROXIMATE RATING CURVE TO ILLUSTRATE DEFICIENCIES IN HYDRAULIC SUBMODEL CALIBRATION HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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4.3.2 Sediment Transport Submodel

The HEC-6 sediment transport model is intended primarily for studies involving coarse or noncohesive sediments. Therefore, to realistically apply the model to a situation such as the Hudson River, in which organic and fine-grained cohesive materials play an important role, becomes problematical. This limitation was addressed by the model-study authors but was not considered by them to be a fatal flaw in model usage since high flow conditions corresponding to the transport of noncohesive sands were found to dominate total PCB transport. If the latter finding was indeed the case, then the use of the model could be justified, given the lack of basic knowledge of the physical-chemical processes of organic and cohesive sediment transport, and the paucity of site-specific data. However, as will be discussed in subsequent paragraphs, there is evidence from the baseline data that suggests otherwise.

In order to assess the sediment transport model, only those river sites for which data were available will be considered. Intermediate reaches for which only model results of sediment behavior are provided will be ignored since there is no field data to test the reliability of the respective results. Calibration plots of sediment load versus flow for the four points of interest are reproduced as Figures 4-10a through 4-10d. At Glens Falls, a regression relationship is simply imposed onto the data to establish an initial condition for Lock 7, and as such, is inherently an excellent fit to the data (Figure 4-10a).

The next point is at Lock 4 (Stillwater) and represents the model performance through the first four reaches (Figure 4-10a). The model is observed to consistently underestimate measured sediment concentrations by an approximate factor of two at high flows and by at least an order of magnitude at low flows. This initial test of the model is extremely poor and led to a decision by the modelers to suppress the use of the model output from Lock 4 as input to the next reach. Rather, the actual field data was substituted for use as a starting condition for the remaining reaches. The primary reason given by the authors for this poor model performance was the lack of data differentiating the fractions of silts and clays that would affect low-flow predictions. However, two points are noteworthy.

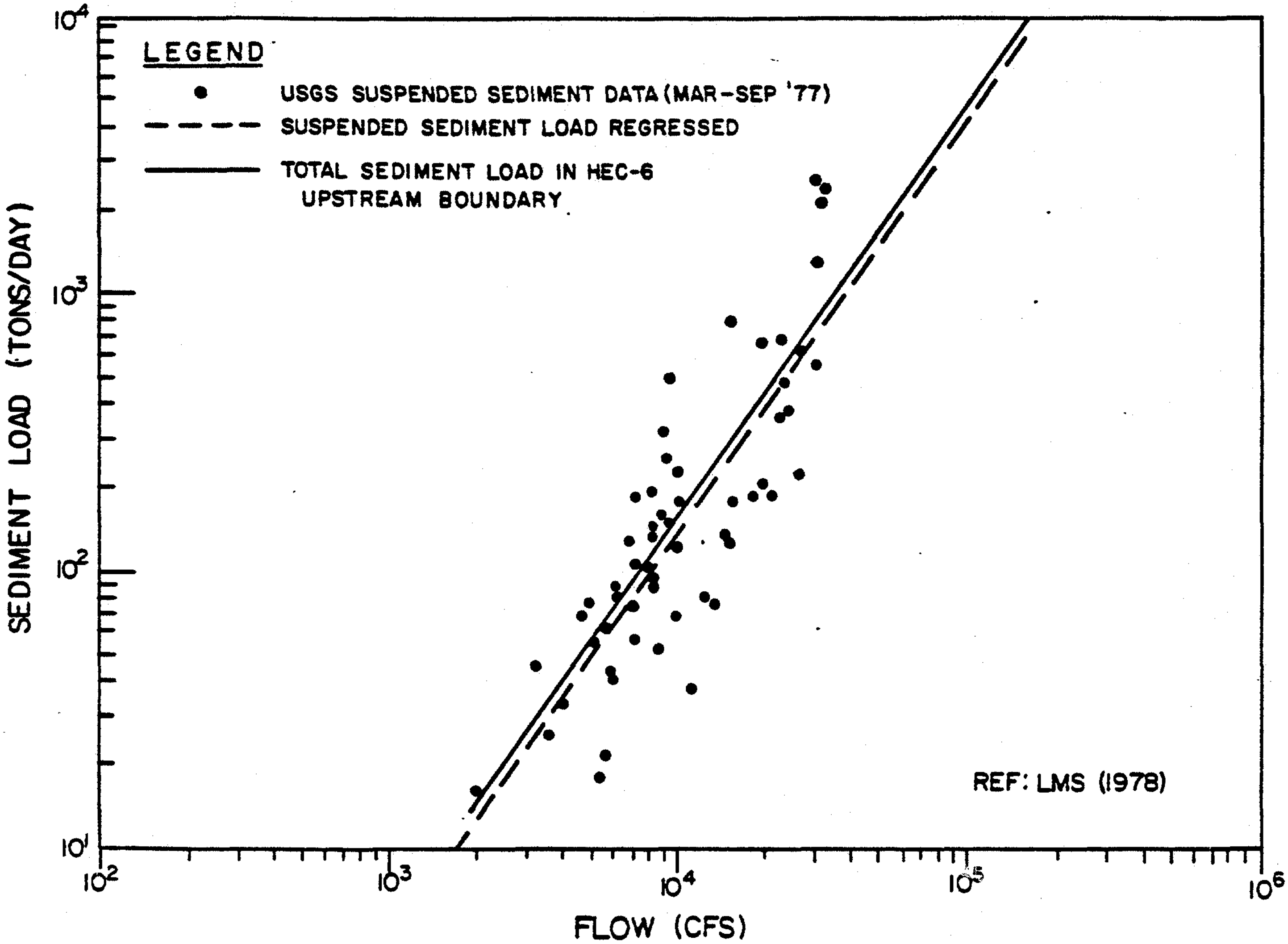

FIGURE 4-10A

SUSPENDED AND TOTAL SEDIMENT LOAD VS FLOW
HUDSON RIVER, GLENS FALLS, NY
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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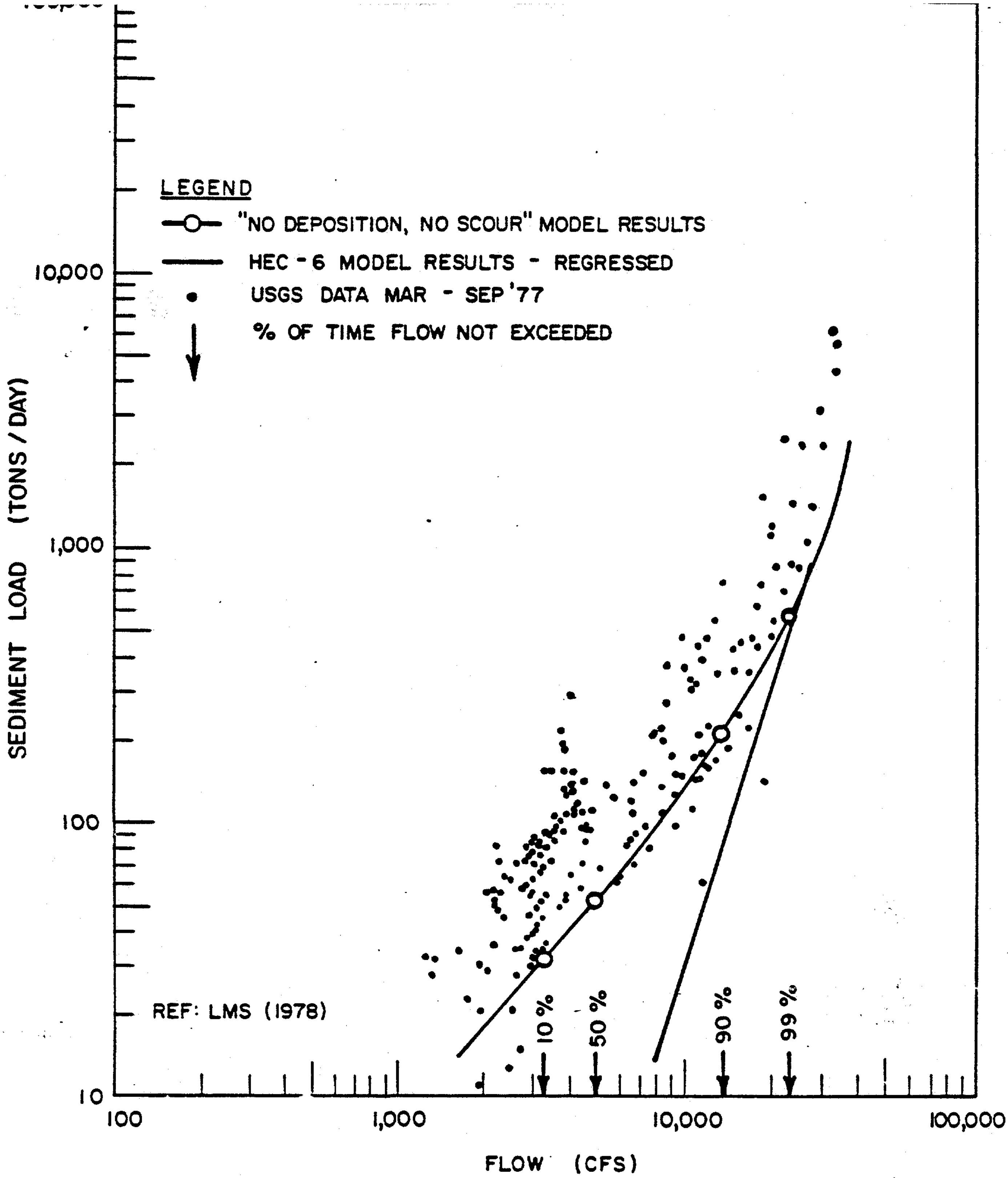

TOTAL SEDIMENT LOAD VS FLOW
MODEL CALIBRATION PERIOD DEC '76-MAY '77
USGS DATA (STILLWATER)-RMI 168.5
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-10B

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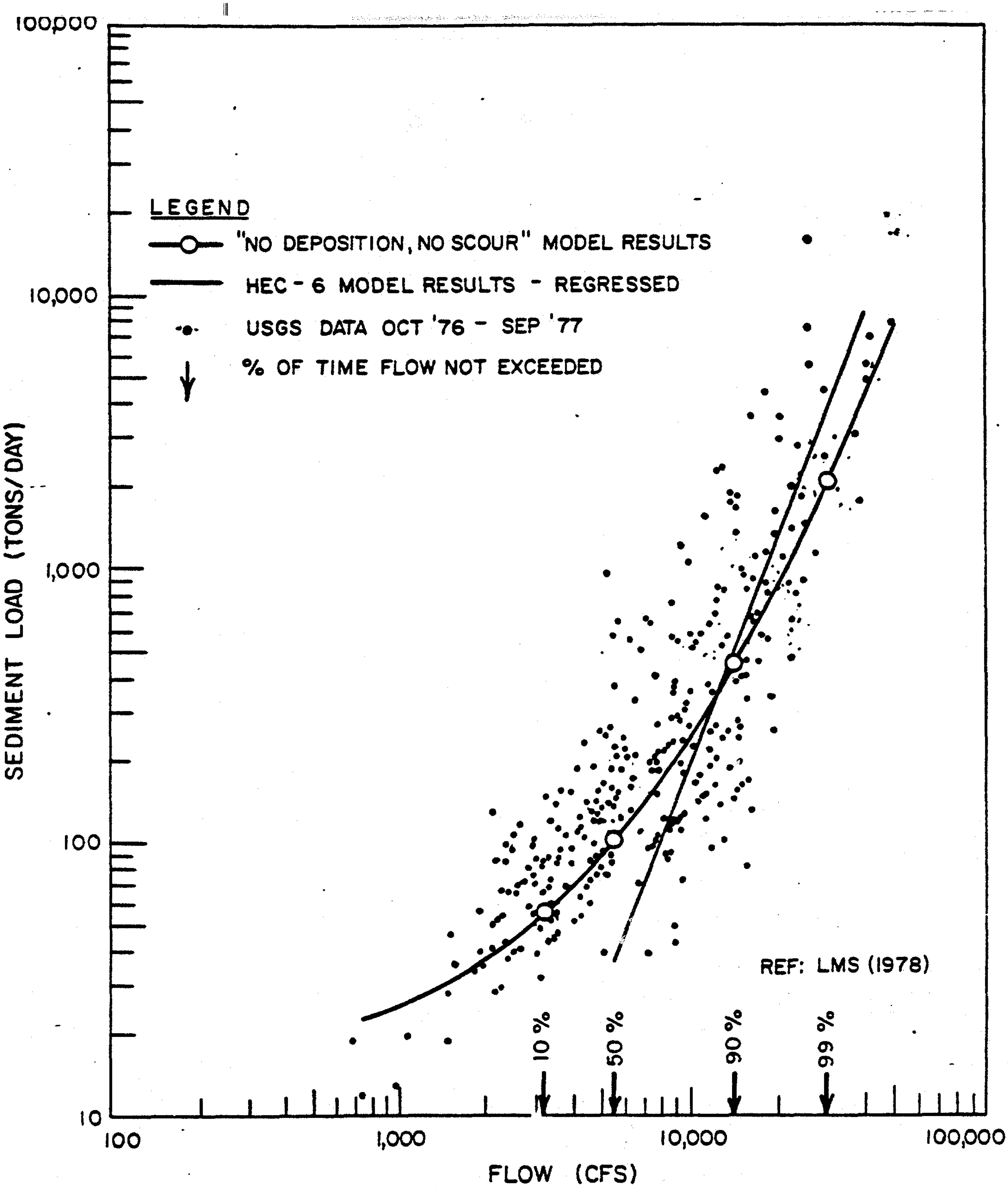

TOTAL SEDIMENT LOAD VS FLOW
MODEL CALIBRATION PERIOD DEC '76 - MAY '77
USGS DATA (WATERFORD) - RMI 157.2
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-10C

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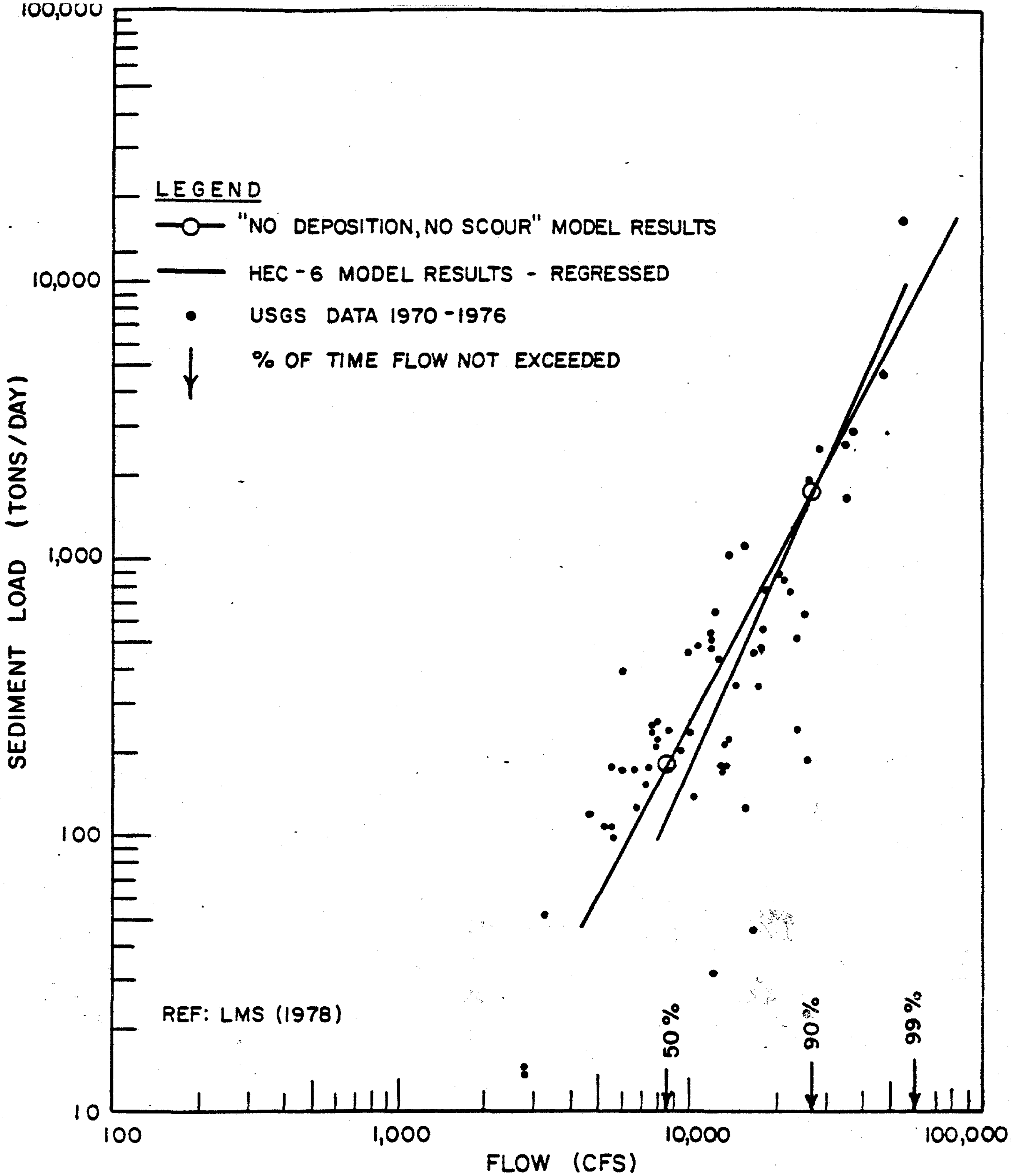

TOTAL SEDIMENT LOAD VS FLOW
MODEL CALIBRATION PERIOD DEC '76-MAY '78
USGS DATA (GREEN ISLAND)-RMI 153.9
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-10D

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First, the model at each intermediate reach predicted a net deposition of sediment for all flows less than the 1 percent exceedance value. This is inconsistent with field data that indicate a net increase in sediment concentration for essentially all flows, as discussed below. Second, even though the modelers recognized that the silt component reported as a single value in the data base ranged in size from 0.004 mm to 0.062 mm, they assigned all silt to the coarsest model category (0.032 mm to 0.062 mm). This contributed to the low-flow problems, and it is questionable why this "unknown" distribution of grain size was not used as a model-fitting parameter.

An alternative test of model performance is to compare the suspended sediment data at Lock 4 with the results of a simple model that assumes that neither deposition nor scour is occurring between Lock 7 and Lock 4. Under this assumption, the concentration of suspended sediment at Locks 7 and 4 would remain constant for a given frequency of flow, and the total suspended sediment load would be proportional to the flow rate (under the assumption that all inflow between the two points, as approximated by drainage area scaling, enters with the same concentration as occurred at Lock 7). The results of this simple "no deposition, no scour" model are also shown in Figure 4-10b. The results satisfactorily follow the trend of the data, but even in this case the observed sediment load is underestimated. This indicates that either significant scour is occurring or else tributary inflows are relatively high in suspended sediment due, for example, to local variations in erosion factors such as soil type or vegetative cover. This raises serious doubts about the HEC-6 model that predicts sediment deposition throughout the reaches between Lock 7 and Lock 4.

The HEC-6 model appears to perform more reliably between Lock 4 and Lock 1 (Waterford), but even in this case the model develops problems below the 50 percent flow value (Figure 4-10c). A better fit is achieved by an extension of the simple "no deposition, no scour" model from Lock 4 to Lock 1. The results shown in Figure 4-10c for the simple model are based on the curve at Lock 4 that underestimated sediment loads at that point, and as such even a better fit could be achieved at Lock 1 if the actual field data from Lock 4 was used, as was done in the HEC-6 model. The reason that the HEC-6 model performs well at the higher flows is that the shallower reaches between Lock 4 and Lock 1 produced higher velocities that inhibited deposition for flows greater than 10,000 cfs.

Both the HEC-6 and "no deposition, no scour" models are shown to perform well between Lock 1 and Green Island (Figure 4-10d). The primary reason for this result is that the Mohawk River contributes a large percentage of the sediment load, and actual field data rather than model predictions were utilized to account for this contribution. For example, the sediment load at the 99 percent flow value increased fivefold, from 2,000 pounds/day at Lock 1 to almost 10,000 pounds/day at Troy Dam, due primarily to the sediment input from the Mohawk River. Consequently, the final model results at Green Island are relatively insensitive to upstream model results and do not provide a good test of HEC-6 model reliability.

In general, the HEC-6 sediment transport submodel, as utilized in the Hudson River study, appears to have overstated the importance of the deposition and scour processes to net sediment transport. A model based solely on an assumption of "no deposition and no scour" is shown to perform more reliably. To further illustrate this point, sediment data reported in the earlier modeling study (LMS, 1978) have been corrected for increasing downstream flow (under the assumption of constant sediment concentration in all inflows) and are plotted on Figure 4-11. Also included is the "best fit" line for 1978-1979 data from Rogers Island, as reported in the 1979 LMS reference. (Note that 1978-1979 data for other sites were not provided in LMS, 1979, but a statement was made that the more recent data conformed to the earlier data plotted on Figure 4-11.) It is observed that the measured sediment load is conserved between Glens Falls and Rogers Island, approximately doubles prior to reaching Lock 4 (possibly as a result of unstable sediment deposits in the Thompson Island pool), and then again is conserved between Lock 4 and Lock 1. Because the overall sediment budgets predicted by the HEC-6 model were not consistent with even this observed regional pattern, concern must be expressed as to the reliability of model predictions related to very localized deposition and scour patterns within the reaches. For example, to place

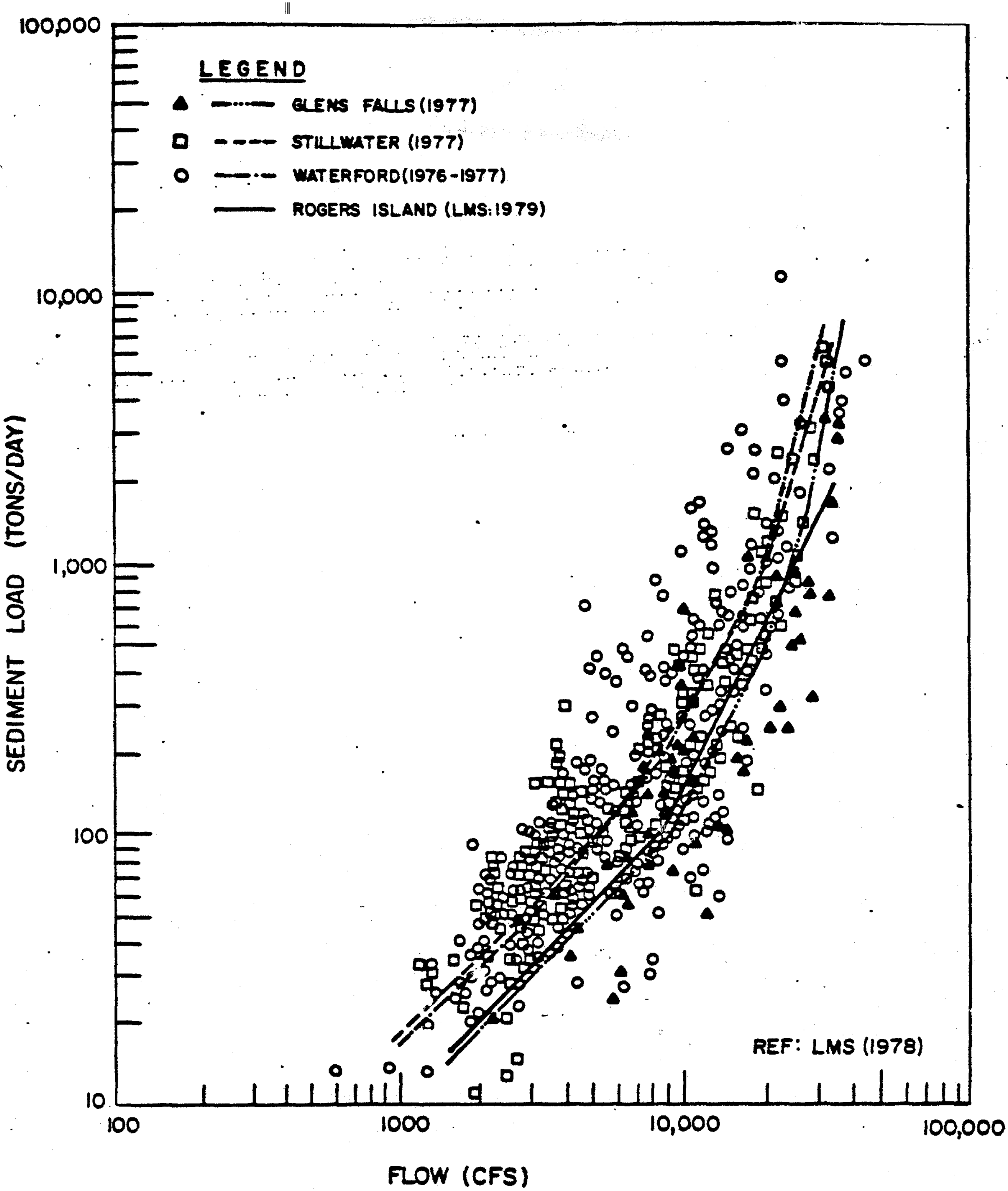

FIGURE 4-11

COMPARISON OF SEDIMENT LOAD VS FLOW RELATIONSHIPS AT VARIOUS MONITORING STATIONS HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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significance on model results that indicate net deposits of tenths of a foot within the Thompson Island pool is meaningless when field data indicate both a general increase in resuspended sediment load in the water column and spatial variations of several feet in bed elevations within the pool.

A more serious concern of poor model performance is that the predicted sediment loads represent a principal forcing function for the PCB inventory model and consequent recommendations for future actions, which are addressed in the next section.

It is noteworthy that an update of the Hudson River PCB model was provided in 1979 (LMS, 1979). However, most of the reported recalibration appears to have involved the PCB submodel, and no update or revisions to the sediment transport submodel were documented.

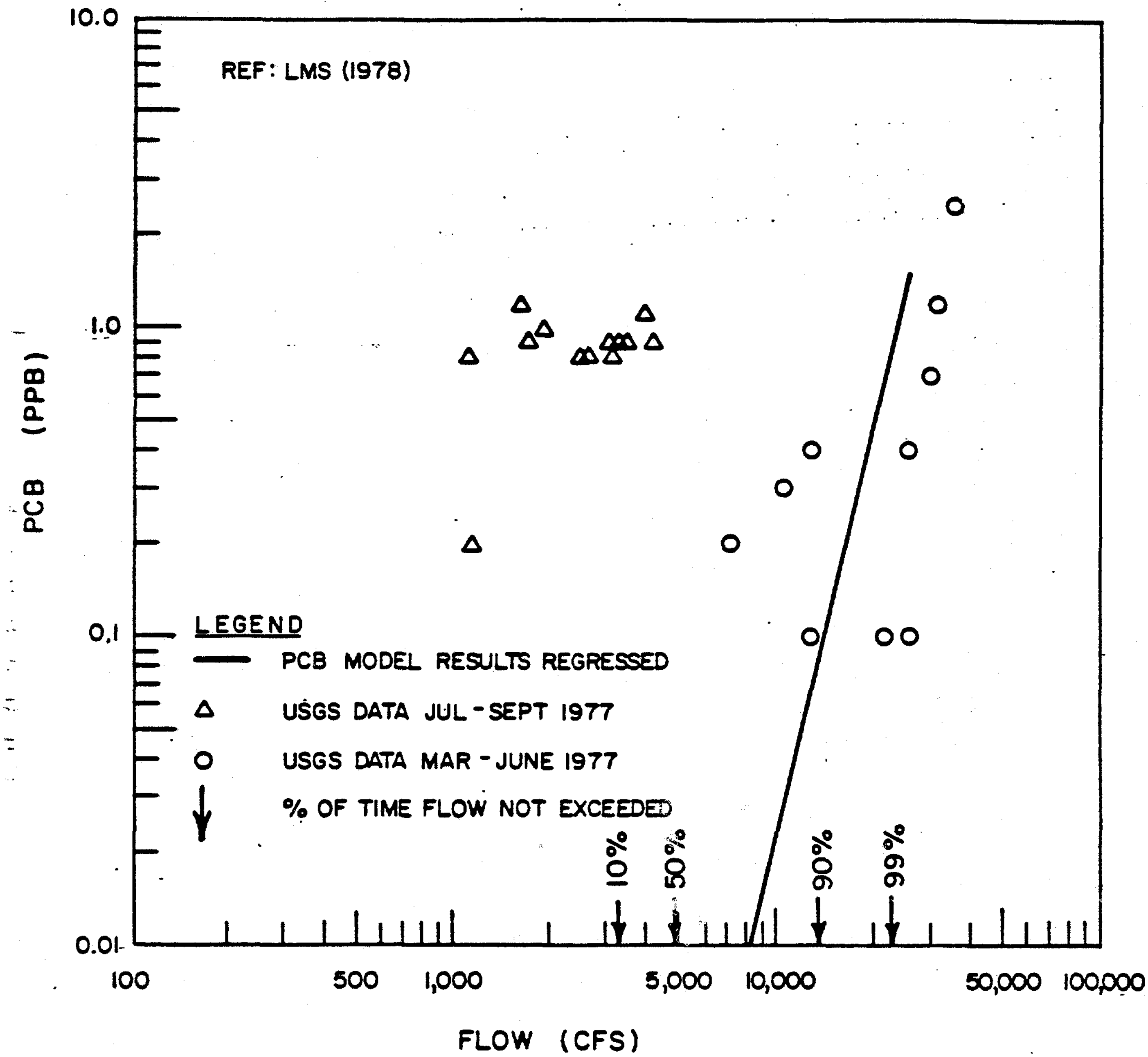
4.3.3 PCB Inventory Submodel

The PCB inventory submodel represents a simple mass balance approach that, in theory, is appropriate to the Hudson River problem under study. However, because adequate data are not available to empirically define the principal forcing functions under all current and future scenarios, the ultimate performance of the PCB submodel is highly dependent on both the reliability of output from an independent mathematical model of the governing physical process (i.e., the sediment transport submodel) and a proper interpretation of available PCB data. The performance of the sediment transport submodel has already been discussed in the previous section. In the following paragraphs, the data used as input to the PCB submodel will be assessed. These include the PCB concentration in the suspended material that forms the bed of each reach, and the initial PCB versus flow rate relationship that provides an upstream boundary condition. A general discussion of the overall impacts on the conclusions and recommendations of the modeling study will then be presented.

An assessment of the input data on PCBs in bed sediments is made difficult by the widespread variation of PCB concentration in the lateral, longitudinal, and even vertical directions. However, results of the PCB submodel presented in LMS, 1978 and 1979, indicate that any errors introduced into the model by a lack of data on bed sediments would not significantly alter the overall modeling study results. For example, the predicted PCB load versus flow rate relationship at each station closely parallels the results of the sediment transport model. This indicates that it is the physical transport of PCB-laden sediments that dominates model results rather than local variations in the concentration of PCBs in the deposits on scoured sediments. It is also indicated that the suspended material being transported across the upstream boundary represents a large percentage of the PCBs being accounted for in the mass conservation model within each reach. The PCB versus flow relationship would, therefore, be a more critical input factor than PCBs in the bed sediments.

The initial modeling effort reported in the 1978 LMS reference utilized four data points relating PCB concentration to flow at Fort Edward to establish the upstream boundary condition. The available data points, which included only flows greater than 8,000 cfs, exhibited a definite trend of decreasing PCB concentration with decreasing flow. A linear regression relationship (on a log-log basis) for these data points was extrapolated to other lower and higher flow values to comprehensively treat the range of flows under consideration. It is now recognized that PCB concentrations do not continue to decrease for decreasing flows in the intermediate and low-flow range. In fact, PCB concentration begins to increase with decreasing flows within the low flow range. In retrospect, the adopted PCB versus flow relationship introduced serious errors into intermediate and low-flow model results, as for example at Stillwater (Figure 4-12). This modeling deficiency was aggravated by the previously discussed underestimation of sediment loads. As a result, an empirical low-flow correction was eventually imposed on the model output at Green Island.

At the time of the earlier study, the low and intermediate flow results were not considered to be a significant shortcoming of the model since the overall transport of PCBs was thought to be dominated by high flow events. Nevertheless, as more



PCB WATER COLUMN CONCENTRATION VS FLOW COMPARISON: MODEL PCB RESULTS & USGS DATA MODEL CALIBRATION PERIOD DEC '76-MAY '77

USGS DATA (STILLWATER) RMI 168.5

HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-12

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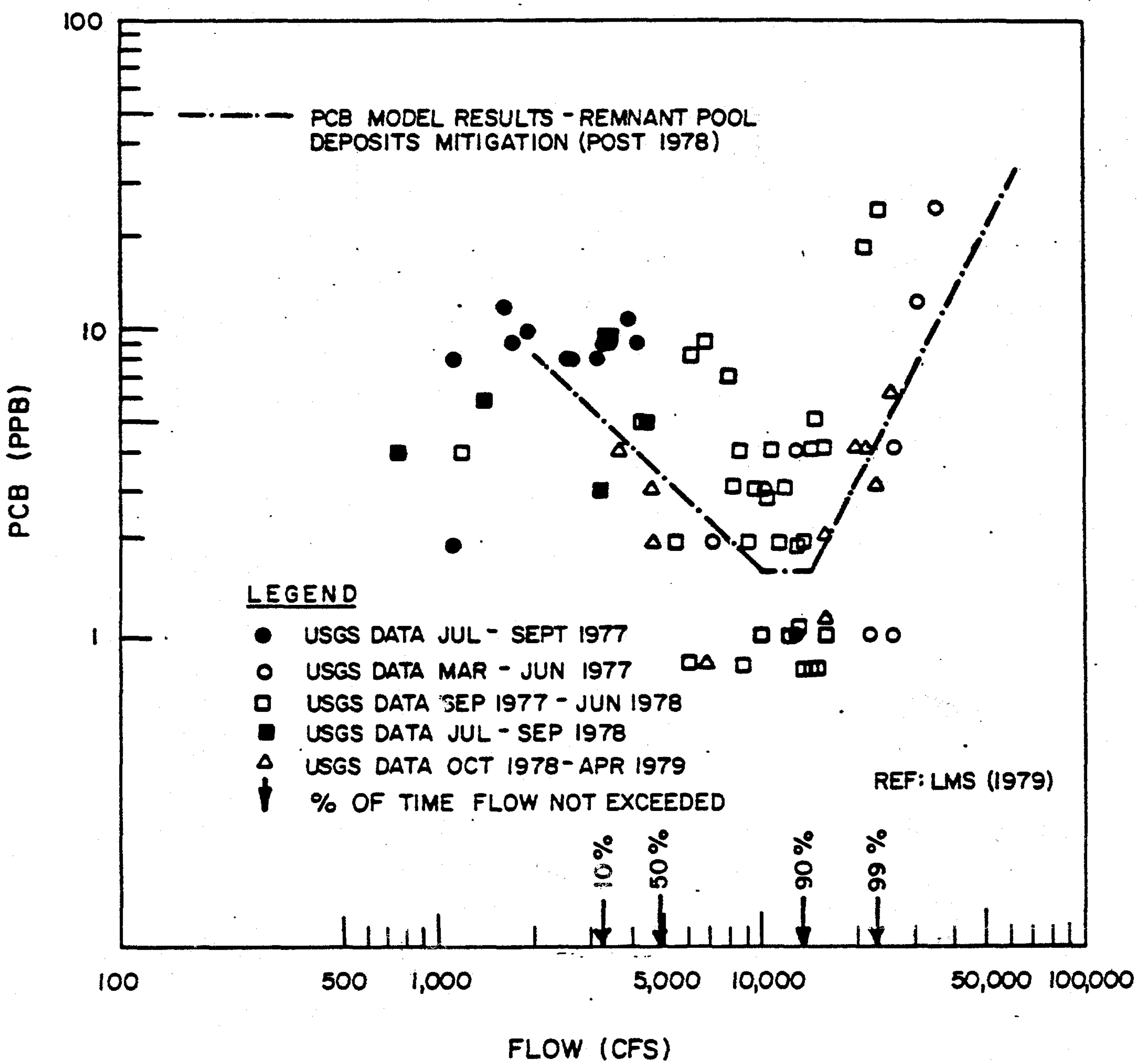
data on PCB concentration at low and intermediate flows became available at Rogers Island, a recalibration of the upstream boundary condition was performed (LMS, 1979). This provided a much more satisfactory fit to the PCB concentration data, as exemplified by the Stillwater data (Figure 4-13).

The critical output of the PCB inventory submodel is the current and projected PCB load over the Federal Dam at Troy. Based on the model results shown in Figure 4-14, the study estimated that an average of 6,500 pounds of PCB per year passes over the dam at Troy, with only a few percent of this total due to flows which occur about 80 percent of the time (i.e., flows less than 20,000 cfs). The low-flow correction adds 1,500 pounds per year to the total, resulting in 23 percent of all PCB flux due to flows less than 20,000 cfs.

Because no field data on PCBs exist at Troy, a direct evaluation of these model projections is prohibited. However, model results indicate that the PCB load passing Troy Dam is approximately equal to the load passing Waterford for each flow-frequency value, which is consistent with the assumption of no significant PCB contribution from the Mohawk River. Under this scenario, the validity of the model at Troy should mirror the validity of the model at Waterford for which field data exist. Figure 4-15 presents both the results of the PCB inventory model and a best-fit regression line through the available data at Waterford. The figure shows that the model overestimates PCB loads by almost an order of magnitude at high flows, with an even more serious underestimation of loads at low flows. This introduces considerable error into the model projections at Troy Dam, as illustrated by a comparison of the model results in Figure 4-14 to the load curve corresponding to the best-fit regression line at Waterford. The introduction of the low-flow correction achieves a better fit, but the resultant model still overestimates both the total contribution of PCBs to the lower estuary and the proportion of the load carried by high flows. Field data generally support neither conclusion that the total PCB load nor the distribution of this load among flow ranges is adequately predicted by the PCB transport model. For example, the U.S. Geological Survey has estimated a total PCB load of 3,740 pounds passing



PCB WATER COLUMN CONCENTRATION VS FLOW
COMPARISON: PCB MODEL RESULTS & USGS DATA
LOCK 4

USGS DATA (STILLWATER) RMI 168.5

HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-13

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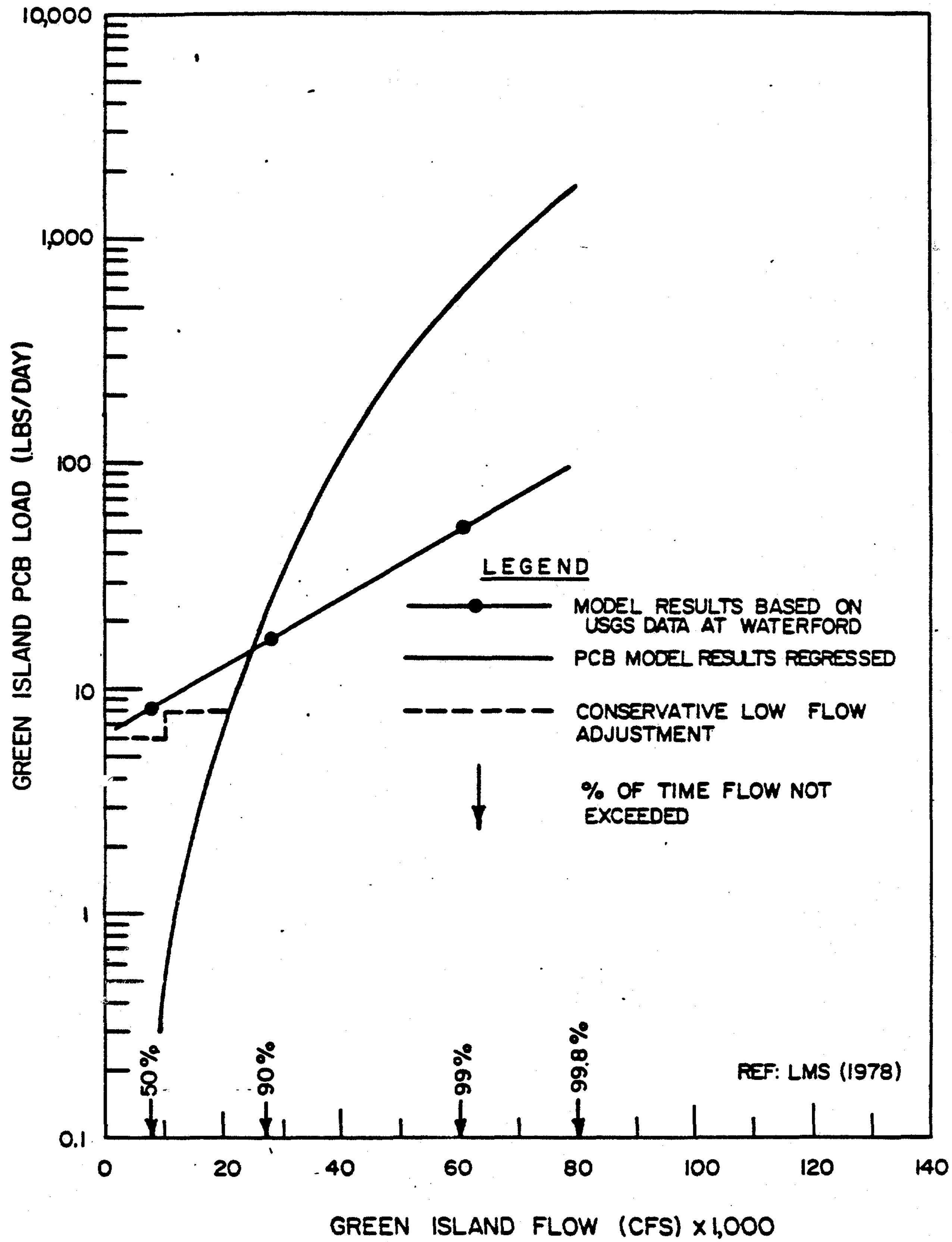
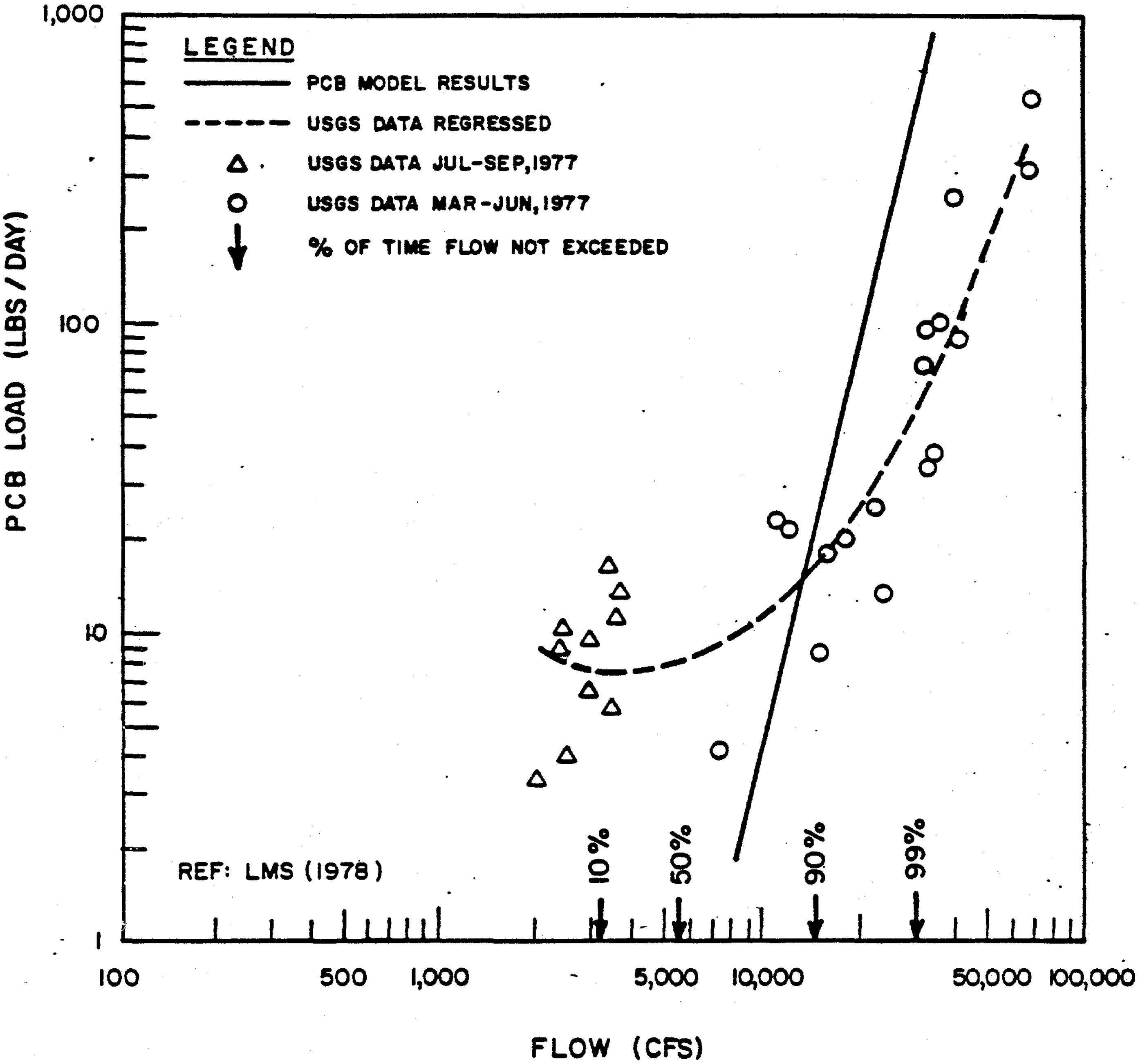


FIGURE 4-14

GREEN ISLAND, PCB LOAD VS FLOW
MODEL CALIBRATION PERIOD DEC '76-MAY '77
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company



TOTAL PCB LOAD VS FLOW
COMPARISON: PCB MODEL RESULTS & USGS DATA
MODEL CALIBRATION PERIOD DEC '76- MAY '77
USGS DATA (WATERFORD) RMI 157.2
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-15

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100377

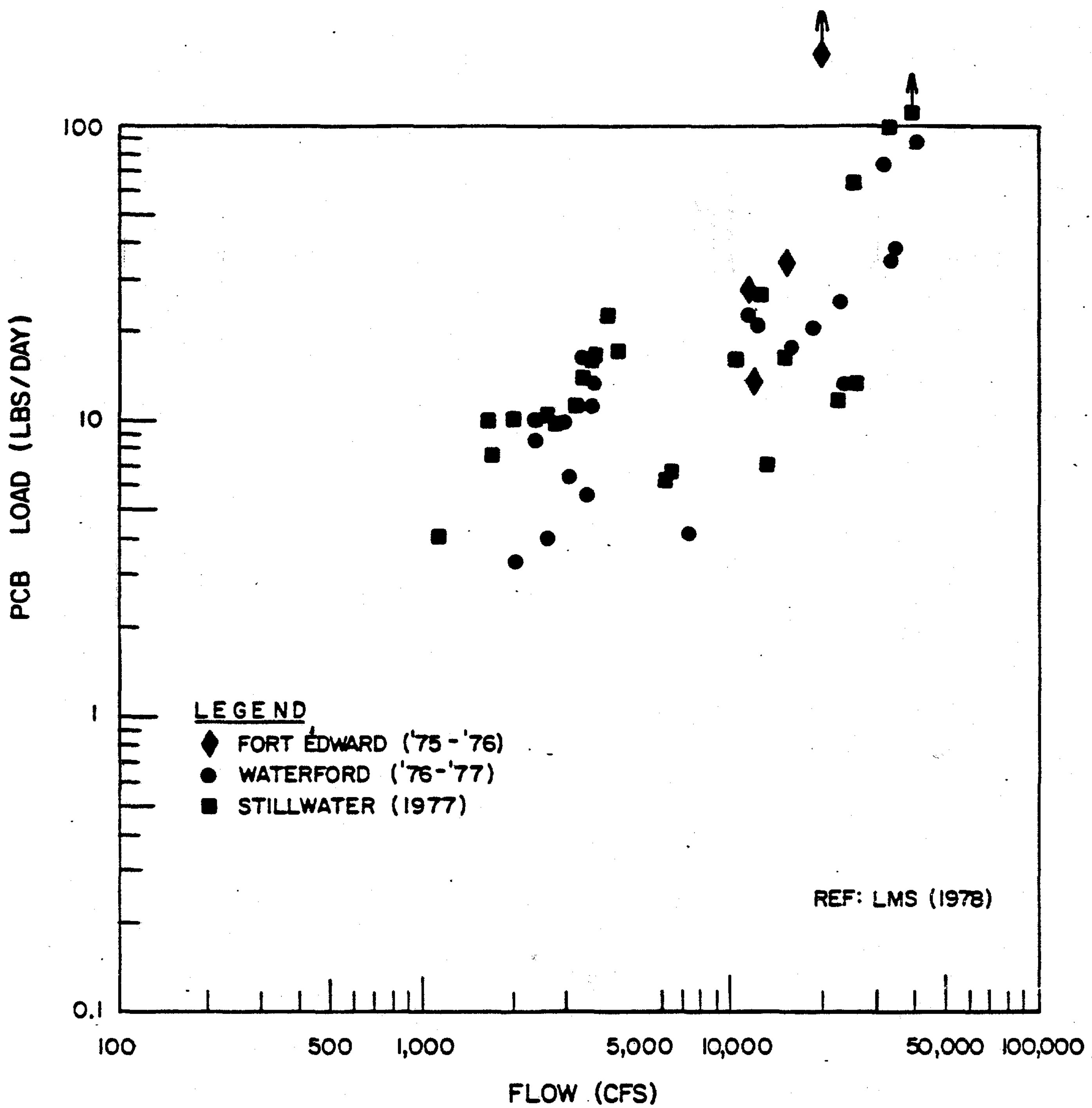
Waterford during the 1977 water year (Turk, Troutman, 1981), a year in which the expected 4 percent exceedance flow of 20,000 cfs (600 m^3/sec) was actually exceeded on 28 days (8 percent exceedance). This load is approximately half of the average annual load "predicted" by the model using the low-flow correction.

It is of interest at this point to consider the simple "no deposition, no scour" model in relation to PCB load data. Recall that this model provided a satisfactory fit to observed sediment loads throughout the study area, with the exception of underestimating the load at Lock 4 (Stillwater). Under the assumption that tributary and lateral inflows do not contribute significant quantities of PCB to the Hudson River system, two conditions would test the reliability of the model. These are:

1. The overall mass rate of flow of PCBs (i.e., the PCB load) should remain essentially constant at each monitoring station for the respective flow frequency values.

2. PCB concentration should decrease approximately in proportion to river flow (i.e., to drainage area) as one proceeds downstream, or alternatively, for purposes of this study, the PCB concentrations should remain constant if corrected by drainage area scaling.

Figure 4-16 presents all PCB-load data reported in Lawler, Matusky, and Skelly (1978) for the period November 1975 to September 1977. Figure 4-17 depicts PCB concentration data for the same period, while Figure 4-18 presents all PCB concentration data reported in Lawler, Matusky, and Skelly (1979) for the period October 1977 to April 1979. With few exceptions, all the data from the various stations follow the same trend and can be considered indistinguishable within the scatter of the data. The exceptions are high PCB concentrations and loads at Fort Edward (Figures 4-16 and 4-17), and particularly low values of PCB concentration at Rogers Island (Figure 4-18). Since only the Fort Edward data are from the 1975-



COMPARISON OF TOTAL PCB LOAD VS FLOW AT VARIOUS MONITORING STATIONS (OCTOBER, 1975-SEPTEMBER, 1977) HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-16

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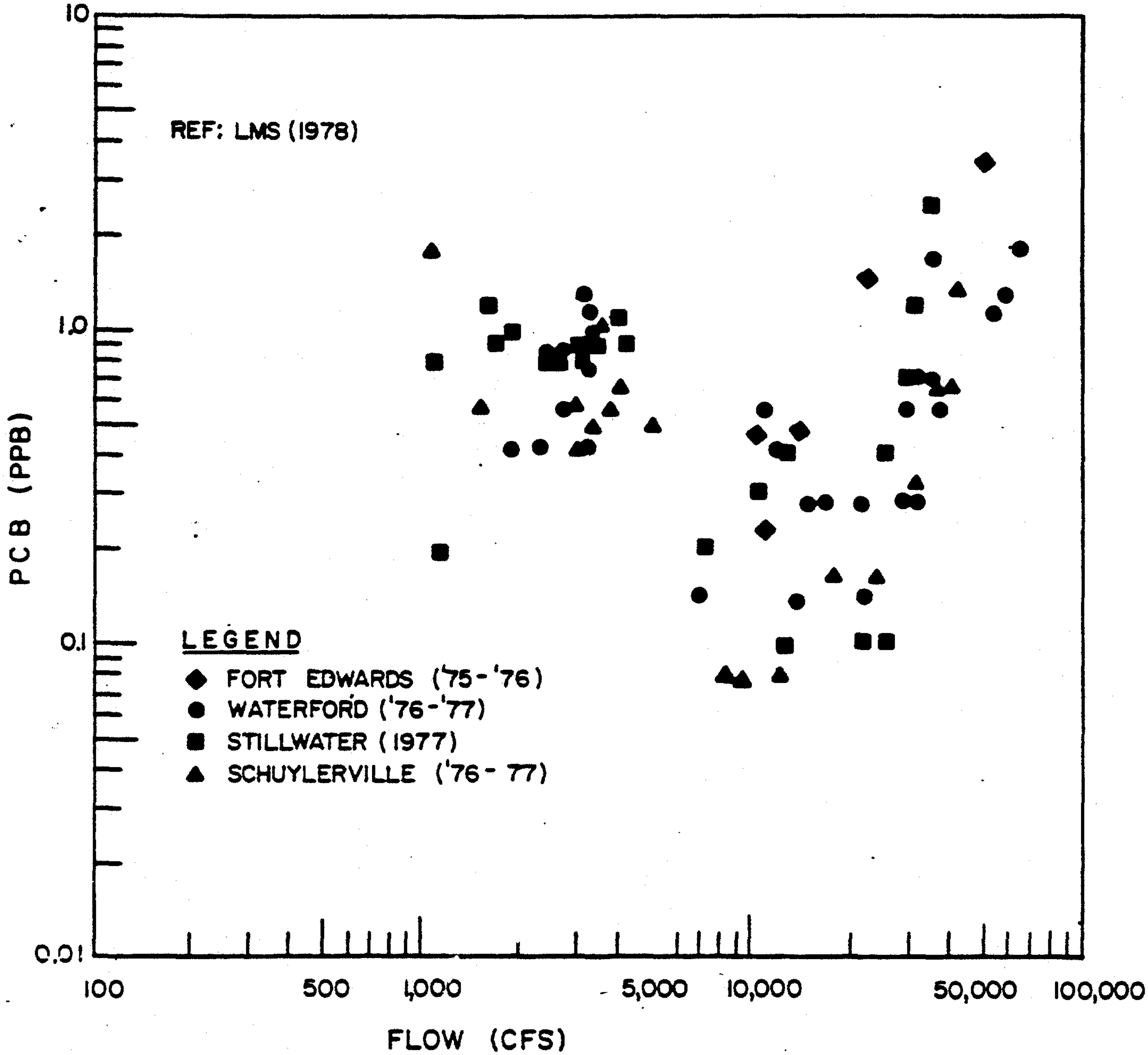

FIGURE 4-17

COMPARISON OF PCB CONCENTRATION
VS FLOW AT VARIOUS MONITORING STATIONS
(OCTOBER, 1975-SEPTEMBER, 1977)
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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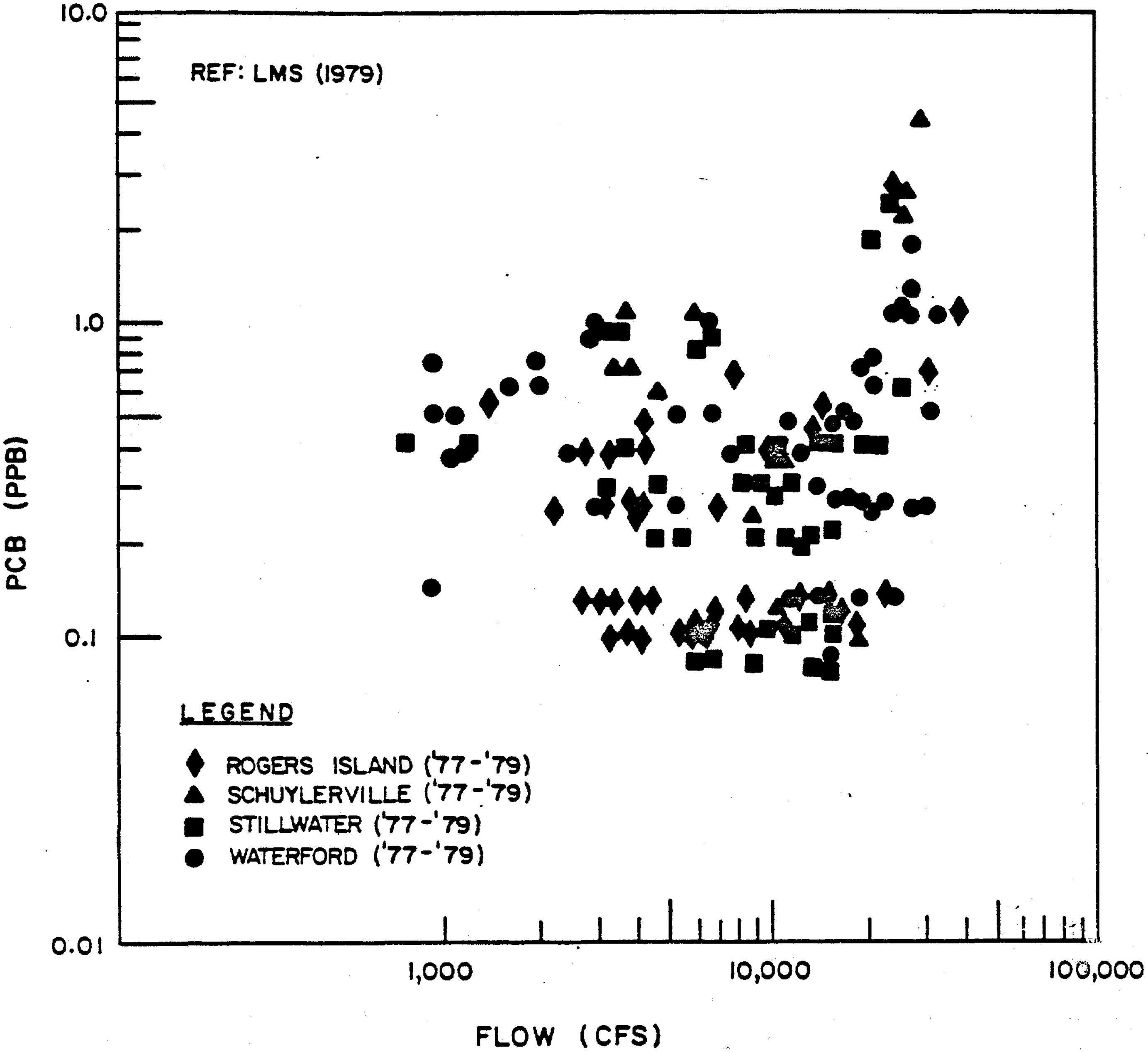

COMPARISON OF PCB CONCENTRATION
VS FLOW AT VARIOUS MONITORING STATIONS
(OCTOBER, 1977-APRIL, 1979)
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE 4-18

NUS CORPORATION
A Halliburton Company

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1976 period, the relatively high PCB values could reflect short-term residual effects from removal of the dam and subsequent dredging activities. The lower PCB values at Rogers Island, on the other hand, can be explained by the efforts to mitigate the remnant pool deposits prior to data collection.

More recent data indicate that the same overall trend in PCB transport rates, from a relatively low value at Rogers Island to a generally constant value at Schuylerville, Stillwater, and Waterford, has continued through 1981. These same data show that Rogers Island PCB loads have remained relatively constant between 1978 and 1981, whereas the loads at each of the downstream points have been significantly decreasing.

These data observations, which support the simple "no deposition, no scour" model, provide an interesting scenario of PCB transport in the Hudson River that is generally consistent with historical activities. From a historical perspective, removal of the Fort Edward Dam and subsequent dredging caused a large quantity of PCB-contaminated sediment to enter the Thompson Island pool and, to a lesser degree, other downstream pools. With subsequent mitigation measures completed upstream of Rogers Island, the overall transport of PCB across this point was quickly reduced. However, the large slug of sediment deposited in the Thompson Island pool would not have immediately stabilized, thereby causing an increased concentration and flux of sediments and PCBs across the Thompson Island Dam that continues at a reduced rate today. The material being transported, including the associated PCBs, appears to remain in suspension with little loss or gain prior to being discharged over the Federal Dam at Troy. This would explain the measured increase in both suspended sediment and PCB loads between Rogers Island and Lock 4, and the approximate conservation of each parameter between Lock 4 and Waterford. (Recall that no data exist between the Fort Edward Dam and Lock 4 to document where the transition from increasing to conserved sediment load actually occurs.) The progressive decrease in PCB loads with time at the various monitoring points indicates the gradual return of Thompson Island and other pools to their more stable, natural state. The previously documented hot spots near bends in the downstream channel reaches could be remnants of a slug release of PCB-contaminated sediments, due, for example, to dam removal or subsequent short-term flood events that scoured the unstable, highly contaminated sediments in the pools above Fort Edward and Thompson Island.

In summary, available data indicate that deposition and scour of bed sediments within the reaches under study are currently not dominant processes in the overall transport of PCBs to the Hudson River estuary. An exception is the Thompson Island pool, which appears to contribute PCB-contaminated sediments to downstream reaches as a consequence of a historical overload of sediment inflow to the pool. Recent data trends indicate that stabilization of the Thompson Island pool is occurring as sediment is progressively lost from the pool. Many of the PCB transport-model results appear to be in conflict with field observations and the analysis thereof. These will be itemized in the next section.

4.3.4 Summary and Conclusions

The PCB transport model for the Upper Hudson River is composed of three distinct submodels - a river hydraulics submodel, a sediment transport submodel, and a PCB inventory submodel. The HEC-6 hydraulics submodel selected for use is considered to be suitable for Hudson River conditions, but deficiences in model calibration are judged to exist. However, because errors in the overall PCB transport model appear to be more sensitive to shortcomings in the sediment transport submodel, any adjustments to the hydraulics submodel would not have significantly altered the final results and conclusions. The sediment transport component of the HEC-6 model is problematical as applied to the current study because organic and fine-grained materials that play a dominant role in PCB transport are not adequately treated in the model. This deficiency was recognized during the modeling study but was not believed by the modelers to introduce significant errors into the overall study results. This conclusion is now being disputed, and in general the sediment transport submodel is thought to have introduced serious errors into the overall PCB transport predictions. The PCB inventory submodel is a simple PCB mass conservation accounting procedure that, in itself, is adequate for the current level of study. However, the reliability of the results of the submodel is highly dependent on the input data and the results of the sediment transport submodel that have been shown to be deficient.

The various shortcomings of the three submodels collectively yield results that are inconsistent with field data. The following discrepancies highlight the unsatisfactory performance of the overall PCB transport model and the implications thereof with respect to the study conclusions and recommendations.

1. Model Result: The low flow contribution is a relatively small portion of the overall PCB transport.

   Data From This Study: The model seriously overestimated high flow contributions. Approximately 50 percent of the PCB load is contributed by low and intermediate flows.

   Implications: The recommended alternative of reservoir development to reduce flood flows may have less effect on overall PCB transport than was originally estimated. Also, the influence of PCB loadings on Hudson River fish would be more significant since it is the consistent, low-flow concentrations rather than short-term, storm-related loadings that are more important in this regard.

2. Model Result: Roughly 60 percent of the load over the Federal Dam at Troy originates upstream of the Thompson Island Dam.

   Data From This Study: Most of the PCB load at Troy originates upstream of the Thompson Island Dam, with a significant portion originating within the pool downstream from Rogers Island.

   Implications: Dredging of the hot spots within the Thompson Island pool could accelerate a stabilization and reduction of PCB loads to the Lower Hudson River estuary.

3. Model Result: Ten percent of the PCB load passing the Thompson Island Dam results from scour within the pool.

Data From This Study: The PCB transport model overestimated the PCB flux across the upstream boundary (Lock 7) and predicted a net deposition of sediments within the Thompson Island pool except during high flows. This is inconsistent with available data, and leads to an underestimation of the relative PCB contribution from the Thompson Island pool.

Implication: Based on the 10 percent PCB contribution from the Thompson Island pool, the modeling study concluded that hot-spot dredging within this highly contaminated pool would be more costly but no more effective in reducing PCB loads at Troy than dredging in other pools. The relative contribution of PCBs from the Thompson Island pool is now judged to be more significant than the model results indicate.

4. Model Result: Over the 20-year projection period, 80,000 pounds of PCBs will pass over the Thompson Island Dam and 130,000 pounds of PCBs will pass over the Troy Dam. A related issue is that dredging the scourable deposits in the lower reaches that contribute to the 50,000-pound increase would effectively reduce PCB loads.

   Data From This Study: The PCB load is relatively conserved once it passes the Thompson Island Dam. That is, there appears to be little net loss or gain of the PCB load between the Thompson Island Dam and Troy Dam.

   Implication: This reinforces the notion that dredging within the Thompson Island pool would be more effective than dredging within downstream pools.

5. Model Result: Total "cleanup" of PCB-contaminated sediment sources upstream from Lock 7 could reduce the PCB load at Troy by 54 percent.

   Data From This Study: Recent data indicate very little PCB contributions from above Lock 7 for low and intermediate flow conditions. Data for high flow conditions which erroneously dominated the model results exhibit considerable scatter but also appear to contribute less PCBs than previously predicted.

Implication: The removal of remnant deposits 3 and 5 above Lock 7 may not provide PCB load reductions to the extent projected by the model.

5

5.0 PUBLIC HEALTH CONCERNS

In examining the public health concerns for the Hudson River PCBs Site, two points must be taken into consideration. First, although a large amount of information was gathered in 1977 and 1978 regarding PCBs in the Hudson River, very little of that information dealt with PCB concentrations at the receptors. Furthermore, the information which was developed then may not reflect current conditions. Limited recent information which is available relative to the Waterford water supply does indicate that the risks associated with the site are low. While difficult to precisely delineate, some risk continues to exist at the current time.

Second, all the alternatives under consideration, including dredging, contain some element of risk since no alternative can remove all of the PCBs in the Hudson River. Some alternatives may result in a short-term increase in public health risk during implementation. The remedial alternatives evaluation must consider the relative ability of each alternative to reduce the overall, long-term and short-term risks.

5.1 Discussion of PCBs

PCBs have been found in the water of the Hudson River, in the air above and near the Hudson, in contaminated sediments, and in remnant deposit areas. Concentrations detected in hot spots and wetlands are shown in Table 5-1. Potential public exposure to these PCBs can occur via the following routes:

- Ingestion of drinking water from the Hudson River.
- Ingestion of fish and other aquatic life contaminated with PCBs.
- Dermal and possible oral exposure during use of the Hudson River for recreational purposes such as swimming.
- Inhalation of PCBs adsorbed onto particulate matter.

TABLE 5-1

HUDSON RIVER PCBs SITE
PCB CONCENTRATIONS
HOT SPOTS AND WETLANDS

Hot Spot	Mean PCB Concentration ug/g (ppm)	Contaminated Volume m^3 (yd^3)
1-7 (1)	39-81	98,150 (128,350)
8 (1)	99	82,850 (108,350)
9-12 (1)	28-78	23,400 (30,600)
13 (1)	89	1,550 (2,050)
14 (1)	279	55,150 (72,150)
15-17 (1)	103-380	46,200 (60,450)
18 (1)	94	11,450 (14,950)
19,20 (1)	83-249	5,950 (7,750)
21,24	75-143	10,650 (13,950)
25	100	10,650 (13,900)
26,27	47-53	7,050 (9,200)
28	109	36,350 (47,440)
29-34	51-516	[illegible]9,450 (67,700)
35	105	8,700 (11,350)
36	51	42,750 (55,900)
37	116	43,900 (57,400)
38	501	11,300 (14,750)
39	161	10,050 (13,150)
40	62	26,300 (34,400)

Note (1): These hot spots are in the Thompson Island pool.
Source: Malcolm Pirnie, 1980d.

- Ingestion of terrestrial wildlife feeding on vegetation from contaminated marshlands.

In addition to the existing concentrations of PCBs, sediment dredging may cause desorption of PCBs from their adsorption sites, with solubilization of certain PCBs into river water.

In the ensuing discussion of public health concerns, the following factors were considered:

- Concentration of PCBs found at a site (river, sediment, etc.)
- Types of PCBs present
- Exposure routes
- Water flow conditions, rates, and patterns
- Nature and stability of sediments and remnant deposits
- Nature of surrounding soil
- Location of persons "at risk"

PCBs are usually present as a mixture of various chlorinated biphenyls, which differ in number and sites of attachment of chlorine atoms. Tests on animals indicate that oral exposure to PCBs at a 1300 ppm level may result in changes in liver pathology and/or function and in changes in female reproductive capacity. Exposure of the skin to PCBs may result in chloracne and possible tumor formation. Absorption of PCBs can occur via respiratory, dermal, or oral routes. By nature, PCBs are lipophilic and this lipid solubility seems to increase as the number of chlorine atoms bound to the molecule increases. PCBs have been shown to concentrate in fatty tissue of animals and humans and to cross the blood/brain barrier in man. When considering the toxic effect cited above, the contribution of dibenzofurans, a contaminant found in PCBs, must be considered.

Metabolism of PCBs seems to occur predominantly via the liver-mixed function oxidase system of enzymes which results in hydroxylation at one or more positions of the PCB molecule. PCBs may alter the body's metabolism of other toxic compounds.

The Draft Environmental Impact Statement (DEIS, May 1981) gave a "worst case" value of about 1 milligram per day of PCBs if contaminated fish were eaten and background PCB exposure levels were at least 9 µg/day (EIS, 1981). The report concluded that at this level, sensitive individuals could possibly experience deleterious effects, although these effects were not specified. At this level of exposure, immune system suppression might also occur. Since evidence of tumor formation in mammals by PCBs has been found, there can be no zero effect-level presently calculated.

Several toxicology studies elsewhere have found PCBs in milk of pregnant and nursing women, a situation which poses a possible danger to nursing infants. A possible danger may exist to the unborn fetus whose mother has been or is being exposed to PCBs since some transfer of PCBs by maternal blood may occur and since induction of the maternal microsomal oxidase system of enzymes may lead to increased fetal exposure to toxic metabolites.

5.2 Air Pollution

It is believed that air pollution consists mainly of PCBs adsorbed on particulate matter which may be subsequently inhaled. Under the current situation, it is estimated that the air transport rate of PCBs is approximately 3000 lbs/yr from sediments and from the water column (DEIS, 1981).

Volatilization of PCBs is dependent upon vapor pressure of the various compounds which, in turn, is a function of the temperature. Volatilization is generally very low. Transport of the PCBs is dependent upon wind conditions and presence or absence of particulate matter. Remedial measures such as dredging and excavation can be expected to dislodge PCBs from sediments and remnant deposits and to enhance the amount of PCBs transported. This may yield concentrations

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(*TWA = Time Weighted Average).

Time Weighted Average (TWA) is the time weighted average concentration for up to a 10-hour workday, 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

exceeding the National Institute of Occupational Health (NIOSH) TWA[1] value of 1 µg/m^3, and the New York State Department of Health (NYSDOH) recommended maximum of 1.0 µg/m^3 for ambient air at "...occupied residences and other sensitive receptors...." Data cited in the Malcolm Pirnie report indicate onsite values from <1 µg/m^3 after 1977, to 8-9 µg/m^3 during excavation at remnant deposit area 3A. In addition, remnant deposits, especially those on the east side of the river, are in fairly close proximity to residential areas. Some of the remnant deposits are also accessible to the public. No sampling has been conducted to determine the levels of PCB concentrations of the residences or at the undisturbed remnant sites.

PCBs are readily absorbed through the lungs. The NIOSH recommendation of a maximum value of 1 µg/m^3 was based on potential liver damage, adverse reproductive effects, and potential carcinogenicity.

5.3 Sediment Contamination

Contaminated sediment represents the largest possible source of PCBs in the Hudson River. There is an estimated 281,700 to 347,200 pounds of PCBs in the bed and banks of the Upper Hudson, of which an estimated 34 percent (134,000 lbs) was located in the Thompson Island pool in 1977. Remnant deposits are estimated to contain between 46,820 and 108,600 pounds of PCBs.

A certain amount of PCBs are removed from the sediments by the processes of desorption or erosion, and enter the water. The rate at which this occurs is dependent upon water flow conditions. Erosion is thought to be the primary mechanism of PCB transport in the Upper Hudson River during high water flows. Desorption predominates at low flows. The process is also dependent upon the nature and stability of the sediments. Organic-rich sediment tends to adsorb PCBs more strongly than less organic-rich sediments. High surface area-to-volume ratio sediment particles will also trap PCBs more effectively than lower surface area-to-volume ratio particles because of an increased number of adsorption sites.

Some analyses cited by the Malcolm Pirnie report showed concentrations of 5-20 ppm PCB in the river center and along eroding banks, and 50-100 ppm in fine-grained sediment along the depositional shore. The average core or surface concentration of the 20 cited "hot spots" in the Thompson Island pool was 142 ppm.

The potential risk to the public from exposure to these PCBs lies in:

- Continuous desorption and erosion, causing PCB solubilization and presence of PCBs in water supplies that use intakes on the Hudson River.

- Storm events and high flow conditions that would cause resuspension and downstream movement of PCB-laden sediments.

- Consumption of PCBs by bottom-feeding organisms with entrance of PCBs into food chain.

Contaminated sediments may make PCBs available for uptake by the aquatic life. These sediments may be, at least in part, responsible for the levels of PCBs (1980) exceeding the FDA temporary tolerance level of 5 ppm in many fish. (Note: The FDA has proposed reducing the PCB human consumption limits for fish and shellfish from 5 ppm to 2 ppm.) Fishing has been banned in most of the Upper Hudson River, although illegal fishing does occur. The total daily intake of PCBs (ingestion) may be expected to be about 1 mg if contaminated fish are eaten on a regular basis (Draft EIS, 1981).

5.4 Groundwater Contamination

Groundwater contamination occurs from dredge spoil sites and upland municipal landfills in the Upper Hudson basin area. Transport of PCBs from dredge spoil sites via groundwater to the Hudson River is calculated to be 17 pounds per year. Those sites contributing are Lock 1 and 2 sites, Buoy sites 212 and 518, Moreau sites, and special dredge area 13. Loss of PCBs from the areas via erosion was calculated at 20 pounds per year.

Various wells used for domestic supplies are located in the area of the proposed sediment containment site. These wells range in depth from 25 to 190 feet (8 to 58 meters) (Draft EIS, 1981) and produce up to 76 liters per minute (20 gallons per minute) of potable water. However, the clays in the area of the site are described as "slowly permeable," and thin lenses of fine sand are present wherein the groundwater is supposed to be essentially immobilized.

There is no data showing PCB concentrations in well water in the area. The danger of contamination of these wells from containment site groundwater does not seem to be great, but more data is needed to substantiate this fact.

5.5 Surface Water Contamination

Surface water contamination of the Hudson River, with PCBs emanating from contaminated sediments and remnant deposits, may pose a concern.

Hudson River water is used by a number of communities as a source of drinking water. This includes the Village of Waterford, Port Ewen Water District, Village of Rhinebeck, City of Poughkeepsie, and the Highland Water District. In addition, numerous private individuals obtain water from wells near the river.

Since the Hudson River serves as the source for the drinking supply of various communities, human consumption of PCBs is possible. The New York State Department of Health guidelines for maximum PCB concentration in drinking water is 1.0 ppb based on health considerations. Using an average daily water consumption for a person of 2 liters per day, then this translates into a maximum possible 2.0 µg per day oral intake of PCBs from drinking waters. The oral intake via water must then be added to PCBs inhaled or ingested via fish and aquatic life, and any other background PCB levels.

The drinking water supply of Waterford has been periodically sampled by the NYSDOH and by the U.S.G.S. In addition, O'Brien and Gere, a consulting firm, was retained by the State to evaluate the treatability of Hudson River water and in the course of the report presented PCB concentrations for raw and untreated water.

NYSDOH results and the O'Brien and Gere (1981) data list are presented in Tables 5-2 and 5-3. It should be noted that in a very recent report dated January 18, 1984 the NYSDOH reported different levels of PCB for approximately the same time interval. Those values are presented in Table 5-4. The U.S.G.S. did not tabulate their data but an inspection of Figure 4 in Schroder and Barnes (1983) reveals that treated water in their samples usually contained less than 0.1 µg/l of PCB and that out of 46 samples only one contained PCB in excess of 0.3 µg/l (0.62 µg/l).

U.S.G.S. data also shows that raw river water did not usually go above 0.7 µg/l in PCB concentration. The concentrations did not approach or exceed 1 µg/l except in a few samples taken at unusually high flow conditions.

A level of 0.16 µg/l has been calculated by NYSDOH to represent a lifetime cancer risk of one in one million (10^{-6}). The maximum acceptable exposure level promulgated by NYSDOH is 1.0 µg/l, although the department does not list what health effects it is designed to protect against.

A stricter recommended limit and risk level may be derived from the EPA Ambient Water Quality Criteria for PCB (45 Federal Register No. 231). The derivation is as follows:

The concentration of PCBs in ambient water and aquatic organisms which may result in one additional cancer-related death per every 100,000 individuals (10^{-5}) is 0.79 ng/l. This value assumes that 99 percent of the PCB intake is from the consumption of fish and also assumes a bioconcentration factor (BCF) of 31,200 in the fish. The BCF is the number of times an organism is capable of bioconcentrating a chemical over the ambient concentration of the chemical in the environmental pathway in which the organisms were exposed.

Therefore, at this level of health risk the unit PCB concentration of fish is:

> (0.79 ng/l) (31,200) = 24.648 µg/l or 24.648 µg/kg, assuming 1 liter of water has a mass equivalent to 1 kilogram.

TABLE 5-2

PCB LEVELS IN THE VILLAGE OF WATERFORD DRINKING WATER

Organic Chemical	Samples Analyzed	Sampling Period	High Value ug/l	Low Value ug/l	Average Value ug/l
Arochlor 1221	3	9/29/77 6/1/83	<0.05	<0.05	0
Arochlor 1016/1242	3	9/29/77 6/1/83	0.3	<0.05	0.10
Arochlor 1254	3	9/29/77 6/1/83	0.5	<0.05	0.16
Arochlor 1260	2	10/22/81 6/1/83	<0.05	<0.05	0
Arochlor 1248	1	6/1/83	<0.05	<0.05	0
PCB Total	23	11/15/76 9/27/77	0.01	0	0.02

No value was above the 1 ug/l guideline for PCBs, set by NYSDOH.

Source: NY State Department of Health, September 1983. Letter to S. Pedersen, NUS Corporation, Pittsburgh, Pennsylvania.

TABLE 5-3

PCB CONCENTRATION OF UNTREATED
AND FINISHED DRINKING WATER

Poughkeepsie, New York

Date	Untreated (ug/l)	Finished (ug/l)
7/19/78	0.10	
8/2/78	0.07	
8/29/78	<0.01	
9/28/78	<0.01	
10/13/78	0.30	<0.01
10/25/78	0.10	<0.01
11/2/78	0.14	0.02
12/6/78	<0.01	
1/15/79	0.06	
2/16/79	0.07	

Waterford, New York

Date	Untreated (ug/l)	Finished (ug/l)
8/29/78	0.20	<0.01
9/13/78	0.70	<0.01
10/3/78	0.30	<0.01
10/12/78	0.40	0.10
11/15/78	0.02	
12/8/78	0.02	
1/4/78	0.06	
2/16/79	0.20	
5/11/79	0.05	
5/17/79	0.03	
5/24/79	0.03	
5/31/79	0.10	
6/7/79	0.01	
6/12/79	0.11	
6/21/79	0.01	
6/28/79	0.14	
7/5/79	0.08	
7/17/79	<0.01	
8/2/79	0.07	
8/15/79	0.06	
8/30/79	0.08	
10/10/79	0.03	
10/22/79	0.01	

Source: O'Brien and Gere, April 1981. Hudson River Water Treatability Study, prepared for NYSDEC, Albany, NY

TABLE 5-4

PCB LEVELS IN WATERFORD DRINKING WATER

Polychlorinated biphenyls	No. of Samples	Dates	Not Detected in # Samples	High µg/l	Low µg/l	Mean µg/l
Aroclor 1016/1242	11	9/77-6/83	4	0.3	< 0.5	0.07
Aroclor 1254	11	9/77-6/83	4	0.5	<0.05	0.06
PCB (total)	51	6/74-10/81	36	0.6	0.	0.06

Source: NYSDOH. January 1984. Cancer Incidence in Waterford, New York, Final Report.

When fish or seafood is consumed at a rate of 6.5 g/day, the daily PCB dosage at this level of risk is:

$$(24.648\ \mu g/kg)(0.065\ kg/day) = 1.6\ \mu g/day$$

This is the daily dose at the 10^{-5} cancer risk level regardless of the route of exposure. The PCB concentration of water associated with this level of risk is computed by assuming the consumption of 2 liters of water per day:

$$\frac{1.602\ \mu g/day}{2\ liters/day} = 0.80\ \mu g/l$$

The 0.80 µg/l concentration is the recommended limit for the 10^{-5} cancer risk level for consumption of PCB contaminated water only. This means that on the average, one additional person out of 100,000 people may get cancer if the population drinks 2 liters of water per day with 0.80 µg/l of PCB in it. PCB concentrations in Waterford water are generally much lower than this. Given that the average rate of cancer is one person out of 10, the incremental risks due to PCB in the water seem to be undetectably small. This is also the conclusion of recent U.S.G.S. reports and NYSDOH reports. It should be realized that this limit does not account for other pollutants in the water or for consumption of PCB in other sources. For this reason an in-depth health impact study and treatability study for Waterford is recommended.

Waterford should represent the worst-case health risk since it is the community closest to the highly contaminated areas. The health risk here appears to be low and it should be even lower in other communities.

5.6 General Risk Assessment

There are high PCB concentrations present in the 40 PCB hot spots and in the remnant deposits. Recorded levels reach 500 ppm (µg/g) in hot spots (see Table 5-1). PCB movement can occur in the Hudson River via desorption or erosion and consequent solubilization. Conditions of high river flow and scour may cause resuspension of PCB-laden sediments and movement downstream. Increased release of PCBs from remnant deposits due to erosion may also occur under these conditions. Floods and high flow conditions may rework the sediments, disturb hot spots, and expose more highly contaminated sediments to the water interface, making them available to bottom-feeding organisms.

The risk to those exposed to PCBs in drinking water alone is low. The PCB concentration of drinking water has never exceeded either the State-set standard or the EPA-recommended levels for PCB exposure. It appears that incremental risks due to PCBs in drinking water alone are undetectably small.

Contaminated fish represent the most serious human health hazard. Many fish levels undoubtedly continue to exceed the FDA-imposed tolerance limit of 5 ppm. The current ban on fishing, in addition to State advisories, is presently designed to eliminate hazards which would be caused by eating fish.

Communities situated near concentrated sources of PCB such as dumps and remnant deposits could be exposed to deleterious concentrations of PCB in the atmosphere. Such locations should be monitored. Air contamination is nearly negligible near river sources such as riffles and dams and probably does not represent a problem. Groundwater contamination has not been shown to be serious, but insufficient data are available.

In summary, PCBs are present in sediments, remnant deposits, and fish. They are also found, to a very limited extent, dissolved in the river. Given the properties of biomagnification, bioaccumulation, chemical persistence, and stability of PCBs, chronic exposure is of concern. Remnant deposits could pose a hazard to people crossing over them through direct contact with the contamination. Further data is needed, including, as a minimum, air monitoring at potential receptors, and monitoring of water samples from private drinking wells and from public water supplies, and biotic assays. Remedial actions should be designed to deal with these concerns.

6

6.0 HEALTH AND SAFETY PROCEDURES

6.1 Personal Health and Safety Protection

6.1.1 Remedial Investigation

Personnel in the Remedial Investigation stage will be involved in the sampling of sediments, air and water. Level of protection is based upon the following:

- PCBs are lipid soluble and can be absorbed through the skin. Lipid solubility increases as the degree of chlorination increases.

- Some PCBs may be carcinogenic in humans.

- Other toxic chemical compounds such as dibenzofurans may be found associated with PCBs.

- Workers sampling water can be expected to come into contact with water containing about 0.3 µg of PCBs/l (the average concentration found in the river).

- Workers doing air sampling near residences may encounter air concentrations of 0.05 - 0.32 µg PCBs/m^3.

Workers sampling sediment are recommended to have PCB-resistant, hooded, Saranex-coated Tyvek suits with butyl rubber aprons (ankle length with sleeves); inner surgical gloves with outer butyl rubber or neoprene gauntlets; and neoprene boots with disposable outer boot covers. Contact with PCBs and PCB-containing material is likely as the samplers are pulled from the water and contaminated water and sediment drip out.

Workers sampling water are advised to have Saranex-coated, hooded, Tyvek suits with butyl rubber aprons (ankle length with sleeves); inner surgical gloves with outer butyl rubber or neoprene gauntlets; and neoprene boots with disposable outer boot covers. Contact with PCBs may occur as integrated depth sampling bottles are pulled from the water and contaminated water drips out.

Workers sampling air near residences would not be required to have special protective clothing, because of the low levels expected to be encountered.

Decontamination procedures should be implemented for personnel who are sampling sediment and/or water. These personnel should refrain from eating, drinking, or smoking until after they have undergone decontamination, showered, changed clothes, and left the areas of suspected contamination. In addition, people conducting air sampling should also shower and change clothes as soon as possible. They should refrain from eating, drinking, or smoking until they have done so, and have gone off site.

6.1.2 Remedial Action

Personnel in this stage may be involved in the following activities:

- Removal of contaminated sediments.
- In-place covering of sediments.
- Detoxification or destruction of contaminated sediments.
- Fencing of remnant areas to restrict access.
- Landfilling of contaminated sediments.

Decision as to the level of protection necessary is based upon the following:

- PCBs are lipid soluble and can be absorbed through the skin. Lipid solubility increases as the degree of chlorination increases.

- Some PCBs may be carcinogenic in humans.

- Other toxic chemical compounds such as dibenzofurans may be found associated with PCBs.

- The majority of PCBs in the air are adsorbed onto particulate matter.

- The New York State Department of Health maximum acceptable exposure level is 1 $\mu g/m^3$ for ambient air at "... occupied residences and other sensitive receptors ...," (24 hour average applicable to Hudson River reclamation project only).

- The NIOSH recommended permissible exposure limit for PCBs is 1 $\mu g/m^3$ in air averaged over a work shift of up to 10 hours per day, 40 hours per week, with chlorodiphenyls containing 42% chlorine and 54% chlorine being regulated as occupational carcinogens. These guidelines are for workplace situations.

- Workers may come into contact with air concentrations of PCBs exceeding 1 $\mu g/m^3$.

Personnel working at the remnant areas are recommended to have PCB-resistant, Saranex-coated, hooded Tyvek suits with butyl rubber aprons (ankle length with sleeves); inner surgical gloves with outer butyl rubber or neoprene gauntlets; and neoprene boots with disposable outer boot covers. Respiratory protection should consist of a full-face cartridge respirator for particulates. Hard hats should be worn over Tyvek hoods. Contact with PCBs and PCB-containing materials can occur as PCB-laden dirt is stirred up during the clearing and cutting and as winds stir up PCB-contaminated dirt.

Workers involved in the placement of fill at the remnant areas are recommended to have PCB-resistant, Saranex-coated Tyvek suits; neoprene or butyl rubber gloves; and disposable outer boot covers over work boots. Respiratory protection consists of a full-face, cartridge respirator for particulates which should be put on if wind blows PCB contaminated soil, or if sampling indicates measurable PCB levels in air. Hard hats should also be worn. Exposure to PCB containing materials can occur if winds stir up PCB-contaminated soil and the dumping process stirs up PCB-contaminated soil.

Bulldozer operators at the remnant areas are recommended to have PCB-resistant, Saranex-coated Tyvek suits; rubber or neoprene gloves; and disposable outer boot covers over work boots. Respiratory protection consists of a full face, cartridge respirator for particulates which should be put on if wind blows PCB-contaminated soil or if sampling indicates measurable PCB levels in air. Hard hats should also be worn.

Exposure to PCB-contaminated material can occur during operations if the bulldozer stirs up PCB contaminated soil or winds may stir up PCB contaminated soil. In addition, the bulldozer operator may have to exit the cab onto the remnant area in event of mechanical failure, thus allowing for further exposure to PCB-contaminated soil.

Workers involved in fencing off remnant areas are recommended to have PCB-resistant, Saranex-coated, hooded Tyvek suits with butyl rubber aprons (ankle length with sleeves); inner surgical gloves with outer butyl rubber or neoprene gauntlets; and neoprene boots with disposable outer boot covers. Respiratory protection should consist of full-face cartridge respirators for particulates. Hard hats should be worn over Tyvek hoods.

Decontamination of major equipment will be performed according to the procedure outlined in the NUS Quality Control Procedures Manual (NUSQCP 11-11). Personnel decontamination will be performed according to the NUS Health and Safety Manual. These procedures may be modified, depending on site conditions.

Decontamination procedures must be implemented for all personnel mentioned in Section 6.1.2. Personnel should refrain from eating, drinking, or smoking until after having undergone decontamination, showered, changed clothes, and left work areas.

6.2 Health and Safety Monitoring

Periodic monitoring of air, water, and sediment samples for PCBs is needed to ensure protection of personnel. Use of a respirable dust monitor may also be warranted. All workers expected to come into contact with PCBs or PCB-contaminated material should have a blood PCB analysis performed prior to working on site and following completion of their task.

7

7.0 REVIEW OF NEW TECHNOLOGY

In the past few years there has been a strong interest in the development of PCB treatment technologies. The impetus of this search for new disposal methods is the need to eliminate the vast quantities of PCBs presently in storage throughout the United States. Incineration at high temperatures (2,000°F and above) has been the only procedure recommended by the EPA to date. One problem that this presents is that there are only two EPA-approved incinerators, one in Texas and the other in Arkansas. These incinerators are non-mobile and would require substantial transportation costs for the shipment of Hudson River sediments. This establishes the need for portable, more cost-effective PCB destruction methods. This review of new technologies will include chemical treatment methods, advanced thermal (non-incineration) techniques, and biological treatment methods.

For this purpose, a literature search was conducted to locate advances in PCB treatment (Detoxification, Degradation, Destruction) and analysis technologies since 1980, which is the year in which the NYSDEC prepared its EIS. The criteria for the evaluation of these technologies were based upon the state of development and the effectiveness of a process for treatment of Hudson River sediments. Three categories of treatment processes were studied as listed below:

- Biological systems
- Dechlorination processes
- Destruction processes.

Microbial degradation or biodegradation of PCBs in river sediments is dependent on the degree of chlorination and the position of the chlorine atom on the biphenyl molecule. At least 20 different bacteria are believed to be capable of breaking down PCBs into water and carbon dioxide, in a period of 90 to 130 days (Chemical Engineering, 1983). This process has shown only limited success during laboratory work for wastewater treatment processes.

The dechlorination process involves the removal of the chlorine atoms from the biphenyl molecule. The process mechanism includes bringing the PCBs in contact with a sodium or potassium compound that will bond to the chlorine. The end products of this method are reportedly hydrocarbons and a salt. The processes looked at in this study are listed below:

<u>Processes found to be applicable for the dechlorination of PCBs in contaminated sediments</u>

- Acurex
- Hydrothermal
- KOHPEG
- NaPEG
- PCBX
- Goodyear

<u>Processes with which dechlorination treatments could not be used with contaminated sediments</u>

- LARC - Light Activated Reduction of Chemicals
- Photodecomposition

PCB destruction mechanisms are all essentially the same, with one exception: wet oxidation (Wet Air Oxidation). The destruction process involves the thermal annihilation or chemical oxidation of PCBs. Only one of these processes, rotary kiln incineration, has been demonstrated on a full scale and is permitted by the EPA. The following is a listing of those destruction processes which were considered.

<u>Processes found to be applicable for destruction of PCBs in sediments</u>

- Plasma Arc
- Pyromagnetics Incinerator
- Rotary Kiln
- Thagard HTFW (High Temperature Fluid Wall) Reactor
- Wet Air Oxidation

Destruction processes inapplicable for use with contaminated sediments:

- Molten Salt Incinerator
- Controlled Air Incineration
- Fluidized Bed Incineration
- Ozonation
- Ultraviolet/Ozone

7.1 Treatment Processes

The following subsection includes descriptions of PCB treatment technologies. A short description of the process is given, along with a discussion of the applicability of the process to contaminated sediments.

7.1.1 Acurex

The Acurex system is a dechlorination process using a sodium reagent in a nitrogen atmosphere to decompose PCBs. A portable batch unit using the sodium-based reactant is used to change PCBs in transformer oil to NaCl and polyphenyl (Mille, 1982). PCB-contaminated sediments must first be solvent washed to extract the PCBs before entering the reactor. The solvent is later reclaimed for reuse.

This process should prove applicable for use with contaminated sediments although it has been tried only at the laboratory level. Large-scale use should follow, pending approval of current testing (Baker 1983).

7.1.2 Biological Systems

Biological degradation of various PCB species has met with only limited success (National Research Council, 1979). Highly chlorinated biphenyls (6^{+} chlorines) undergo negligible degradation due to biological processes, while the lesser chlorinated compounds (1-5 chlorines) decompose much more readily. This inconsistency is explained by the fact that no specific microorganism has been discovered that will selectively oxidize or degrade the higher chlorinated compounds (Baker, 1983).

7.1.3 Controlled Air Incinerator

The Los Alamos National Laboratory has modified a controlled-air, radioactive waste incinerator to burn PCB waste. The incinerator is a conventional dual-chamber, controlled-air design with operating temperatures for PCB destruction ranging from 1,600°F (Chamber No. 1) to 2,000°F (Chamber No. 2). Attempts are currently under way to obtain a permit for a PCB test burn (Fradkin, 1982); however, the state of development renders this process unsuitable for use on contaminated sediments.

7.1.4 Fluidized Bed Incinerator

PCB destruction is obtained with this method at a temperature of 1250°F using a chromic oxide and aluminum catalyst. Rockwell International's (the developer) fluidized bed incinerator recently underwent a successful one-gallon test burn of PCBs (at 700°F) for the EPA (Fradkin, 1982). Although this process has been proven useful for PCB destruction, there are no plans to develop this system any further, or to use it in connection with contaminated sediments.

7.1.5 Goodyear

The Goodyear system includes a non-mobile, exothermic process using sodium naphthalide in an inert atmosphere for the destruction of PCBs in oil. Operating at ambient temperatures, the system destroys PCBs in 5 minutes, producing sodium chloride and nonhalogenated polyphenyls as by-products (Berry, 1981). Treatment of sediments would first require solvent extraction so that the PCBs would be in a liquid medium.

7.1.6 Hydrothermal

The Japanese-developed Hydrothermal PCB decomposition process has, in the laboratory, replaced the chlorine atoms of PCBs with hydroxyl groups in the presence of methanol and sodium hydroxide. Operating at a temperature of 570°F and a pressure of 2,560 pounds per square inch, this process is reportedly safe, simple, and rapid. Since much testing and development need to be done, this process will most likely not be available for use with this project in the near future.

7.1.7 KOHPEG

The KOHPEG process uses polyethylene glycols and potassium hydroxide to destroy PCBs in nonpolar liquids. This process is reportedly more reactive and tolerant of impurities than the similar process, NaPEG (Brunelle, 1983). The reaction conditions are mild, with complete PCB degeneration in 2 hours at temperatures of 170°F to 250°F. This technology is apparently applicable to contaminated sediments, although testing has not yet been completed (Baker, 1983).

7.1.8 LARC

The Light Activated Reduction of Chemicals (LARC) process, developed by the Atlantic Research Corporation, uses ultraviolet light (UV) and hydrogen gas to effect dehalogenation (Fradkin, 1982). This process involves a stepwise dechlorination of the biphenyl, with the formulation of a lesser chlorinated and eventually dechlorinated compound (Valentine, 1982). Its use on river sediments is restricted by UV light-absorbent materials present in the water, and the requirement of a constant hydrogen source. The process is patented but has not been proven useful on contaminated sediments (Baker, 1983).

7.1.9 Molten Salt Incinerator

The molten salt incineration process, demonstrated by Rockwell International, destroys PCB waste by injecting a mixture of the waste and air into a sodium carbonate/molten salt mixture at 1450°F to 1800°F (Johnson, 1982). By mid-1983, a portable incinerator rated at 225 pounds per hour should be available. Very good results have been achieved for PCB removal using this method, but this system has not been recommended by Rockwell for use with organic river sediments (a high ash material) due to the high flow requirements needed for transport through the sodium carbonate solution (Baker, 1983).

7.1.10 NaPEG

The NaPEG (trademark) system, developed by the Franklin Research Institute, uses molten sodium metal dispersed in a polyethylene glycol solution to treat PCB-contaminated oils. This process, which is insensitive to moisture or air, was successful in laboratory bench-scale testing of PCB breakdown in soils. The reaction products are oxygenated organics, sodium chloride, and polyglycol or glycols that do not bioaccumulate and will biodegrade (Fradkin, 1982). Although the EPA is optimistic about the use of NaPEG with contaminated sediments, testing results will not be available for some time (Baker, 1983).

7.1.11 Ozonation

The ozonation of PCB-contaminated waste is a Canadian process in which ozone is used to destroy PCBs in liquids (oils and water). Laboratory work shows that 95 percent of PCBs in wastewater is destroyed by this process. This process is currently in the developmental stage, and has not been applied to contaminated sediments. Accordingly, it is not known if it will be available for use with the Hudson River project (Berry, 1981).

7.1.12 PCBX

The PCBX system is a mobile system used for the destruction of PCBs found primarily in transformer oils. This system was developed by Sun Ohio, and was the first chemical PCB-treatment-method approved by the EPA. The system reportedly uses sodium salts of organic compounds in an amine solution to effect PCB destruction (Fradkin, 1982). The use of this system for contaminated sediments is possible, although more tests must be conducted before a recommendation can be made (Baker, 1983). Solvent extraction of the PCBs from the sediment would be required.

7.1.13 Photodecomposition

Photodecomposition of PCBs in liquids occurs when PCBs are irradiated by light in the presence of an amine. Tests on contaminated soils showed that no significant reduction of PCBs occurred after irradiation of the soils (Battelle, 1982).

7.1.14 Plasma Arc

The plasma arc process is a dechlorination technique developed for PCB solids destruction by molecular fracture (Fradkin, 1982). The plasma arc is produced by a low-pressure gas through which an electric current (arc) is passed. The by-products that result from passing PCBs through this arc are simple because the final states are atomic (Cl, H, C atoms) (Barton; Arsenault, 1981). This process is expected to work on contaminated sediments and has the advantage of not requiring a solvent extraction of the solids. The development of a soil/sediment facility is still in the future, with the expectations of an energy-efficient process (Baker, 1983).

7.1.15 Pyromagnetics Incinerator

This incinerator, developed by the Pyromagnetics Corporation, is a portable unit for the detoxification of approximately one ton per hour of total solids. The destruction process uses 5,000 pounds of molten iron at 2,600 to 2,700°F in a primary chamber into which 200-300 pounds of sand in addition to the contaminated sediments are added (per hour). The volatiles are removed and burned in a second chamber at 4,000°F, while the nonvolatiles are slagged off with the molten sediment and sand (Fradkin, 1982). EPA approval has yet to be given to this process since a test with PCBs has not been completed. One problem that may be encountered is the likelihood of the byproducts being greater in volume than the contaminated feedstock (Baker, 1983).

7.1.16 Rotary Kiln

The rotary kiln is a high-temperature PCB destruction technique currently available to the market. Two facilities have EPA permits (Texas and Arkansas) to operate incinerators in the 1800 to 2,200°F temperature range. In addition, a test by the EPA is underway using a mobile rotary kiln that will operate at a temperature of 2,200 °F (Fradkin, 1982).

7.1.17 Thagard HTFW

Thagard Research Corporation has developed a high-temperature-fluid wall reactor (HTFW) that completely pyrolyzes PCBs, and fixes the residues into nonleachable glasses (Matovich, 1982). This reactor maintains a high temperature (4,000°F) by radiant heat emanating from a gaseous fluid envelope (generally nitrogen), operating without catalysts, and thus unaffected by impurities in the feed (water, sulfur, metal). Laboratory tests using hexachlorobenzene (HCB) as a surrogate for PCBs showed a destruction order of 99.9999 percent upon a 0.1 second reaction time (Hornig, 1981).

7.1.18 Ultraviolet/Ozone

The technique of using ultraviolet light and ozone to destroy PCBs in wastewater is currently in the pilot plant stage. The process costs are reported to compare favorably with carbon adsorption and incineration (Arismen; Music, 1980). A deterrent to the use of this system on river sediments is that this method cannot handle wastes where the ultraviolet light cannot penetrate the contaminated material (Edwards, et al., 1981).

7.1.19 Wet-Air Oxidation

The wet-air oxidation system uses a co-catalyst and moderate temperatures to achieve 99 plus percent destruction of even highly chlorinated biphenyls (Randall, 1981; Miller, et al., 1980). One method uses a bromide and nitrate anion catalyst in an acidic aqueous solution. Additional information is proprietary although it is reported that this system would be very useful for soil/sediment detoxification (Randall, 1981).

7.2 Analytical Process

A new technique has been developed for the analysis of PCBs in soils and sediments. The process, developed by EPA Region I, uses solvent extraction to remove the PCBs from the soil or sediment, and sample analysis is effected by gas chromotography and electron capture detection. Accuracy levels of 0.5 parts per million (ppm) are obtainable in field work using an Analytical Instruments Development Inc. (AID) 511 portable gas chromatograph (Porco, 1983).

The extraction process is a three-step process beginning with the addition of water to the soil/sediment sample. A second phase is then added--either methyl or ethyl alcohol--and the sample agitated. After the final phase--hexane--is added and agitated, the hexane phase is separated and then analyzed. The analytical process is accomplished by injecting the sample into a heated column where component separation takes place. PCBs are then detected by electron capture.

The use of the analytical method in the field should be very useful for obtaining quick turnarounds when many samples must be taken or when results are needed in a hurry.

8

8.0 INVESTIGATION OF REMEDIAL ALTERNATIVES

8.1 Review of Previously Developed Alternatives

8.1.1 Alternatives for PCBs in River Sediments

8.1.1.1 No-remedial-action Alternative

The following two options are available under the no-remedial-action alternative:

- No Remedial Action with Continued Routine Dredging

  This alternative assumes that no remedial action will be taken, and routine channel maintenance dredging will be continued by New York Department of Transportation. It is estimated that such dredging would remove PCBs at an approximate rate of 5,000 lb/yr (Hetling et al., 1978).

  The PCB transport model developed by Lawler, Matusky, and Skelly (1978) has previously been used to estimate the annual average PCB load at Troy Dam and to predict the time period over which significant amounts of contaminated sediment would exist in and continue to be transported from the Upper Hudson River. The model was later used to estimate the change in PCB transport rate brought about by various remedial activities. More recently the model results were adjusted to account for PCB losses due to routine maintenance dredging and atmospheric PCB transfer. The analysis of Section 4.3 indicated a number of shortcomings in the model. One problem was that the model overestimated sediment PCB transport at high flows and underestimated it at low flows. Some recent calculations of PCB transport from USGS monitoring data indicates that the current transport rate may be leveling to about 1,500 lbs/yr (Section 4.0). Table 8-1 compares PCB transport projections using the model results and recent estimates of PCB transport from measured values for various alternatives. The projections in the table account for

TABLE 8-1

PCB TRANSPORT PROJECTIONS USING LMS* MODEL DATA
COMPARED WITH TRANSPORT PROJECTIONS USING CURRENT ESTIMATED
TRANSPORT RATE (SECTION 4)

	Transport Rate (lb/yr)	Years to Exhaust PCB Supply	Year	PCB Transport (lbs)	PCB Volatilized (lbs)	PCB Dredged (lbs)
		No Remedial Action - Discontinued Maintenance Dredging[1]				
LMS Model	7200	40	2018	290,000	60,000	--
RAMP	1500	117	2095	175,000	175,000	--
		No Remedial Action - Continued Maintenance Dredging[1]				
LMS Model	7200	31	2009	225,000	78,000	47,000
RAMP	1500	64	2042	96,000	95,000	159,000
		Reduced-Scale Dredging Alternative[2]				
LMS Model	6700	25	2003	170,000	47,000	105,000[4]
RAMP	1500	55	2033	82,500	62,500	205,000[4]
		Full-Scale Dredging Alternative[3]				
LMS Model	5700	21	1999	127,000	20,000	205,000[4]
RAMP	1500	46	2024	69,000	41,300	240,000[4]

Table computations assumed:

350,000 pounds of PCB in storage.

Negligible contribution of PCB by remnant deposits.

A base year of 1978.

48 percent removal under full-scale alternative and 30 percent removal under reduced-scale alternative.

*Lawler, Matusky and Skelly.
Footnotes continued on page 8-3.

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TABLE 8-1
PCB TRANSPORT PROJECTIONS
PAGE TWO

1. Assumes dredge removal rate of 2,500 lb/year of PCB. Also assumes air transport rate of 1,500 lb/year of PCB.

2. Assumes 5 years to complete cleanup, during which transport rates, air transport rates, and dredge removal rates are equal to no-action. After clean-up, air transport rates and dredge removal rates are 70 percent of original.

3. Assumes 5 years to complete cleanup, during which transport rates, air transport rates, and dredge removal rates are equal to no-action. After clean-up, air transport rates and dredge removal rates are 62 percent of original.

4. Includes amount of PCBs dredged during remedial action.

PCB losses due to maintenance dredging and atmospheric transport. The average annual volatilization rate of 1,500 lb/yr and the average annual dredge removal rate of 2,500 lb/yr adopted in the DEIS are assumed.

According to Table 8-1, the number of years it would take to deplete the PCB stored in the Upper Hudson River, with no remedial action and continued maintenance dredging, will vary from 31 to 64 years. During this time, between 96,000 and 225,000 pounds of PCB would be transported to the estuary.

Currently, the PCB-removal rate due to dredging in the New York Harbor is estimated at 4,000 lb/yr (DEIS, 1981). Earlier work (DEIS, 1981) estimated that if this rate is maintained and if 100 percent of the PCB mass at Troy enters New York Harbor, then the average PCB concentration in harbor sediments would increase to approximately 6 ppm by the year 2013. This analysis involved the assumption that the PCB concentration of the sediments being dredged remains the same regardless of the effects of deposition and dredge spoil removal. This is a faulty assumption because dredging generally removes only the most recently deposited sediments, and according to Bopp (1982), the recent material being deposited in the Harbor area has been dramatically decreasing in PCB content.

It is in no way certain that all of the PCB-contaminated material in the Upper Hudson will be removed and transported to the harbor in the time periods specified. It is estimated that dredging in the vicinity of Albany (between milepoints 140 and 150) removes between 1,500 and 1,800 pounds of PCB per year. This removal rate equals the current estimated transport rate at Troy. In any event, it is likely that PCBs will continue to migrate to the harbor in decreasing amounts for a greatly extended period of time. It is expected that, at the worst, the concentration of PCBs in previously-deposited harbor sediments will remain at current levels, and that the level of PCBs in fresh dredge material will decrease.

The previously used sediment transport model (Lawler, Matusky, and Skelly, 1978) was used for quantitative evaluation of PCB transport. However, the model does not evaluate the effects of uneven downstream deposition. A knowledge of the distribution of the sediment deposition is critical for the evaluation of potential for deposition near potable water intakes, fish spawning grounds, navigational channels, and docking areas (DEIS, May 1981).

- <u>No Remedial Action with Discontinued Routine Dredging</u>

This alternative assumes that no remedial actions will be taken, and that routine channel maintenance dredging in the Upper Hudson River will be discontinued to eliminate the need for secure containment sites.

According to the projections in Table 8-1, between 175,000 and 290,000 pounds of PCB will be transported to the estuary if routine dredging is discontinued. Approximately 40 to 117 years would be needed for cleanup of the Upper Hudson to be completed. Most of the difference in the projections of Table 8-1 lies in the fact that over a period of 117 years, twice as much PCBs will be transported into the air.

Earlier work (DEIS, 1981) reported that resultant PCB concentrations in the Albany turning basin would increase, but that concentrations in the New York Harbor sediments would not. However, as was pointed out in the previous section, the current removal rate of PCBs near Albany equals the currently estimated transport rate.

Should routine channel maintenance be discontinued, PCB transport will be more significant than the preceeding no-remedial-action alternative. Between 30 and 80 percent more PCBs would be transported into the estuary, and transport would continue to 2018 at the least and possibly extend until 2095 and beyond. It also should be noted if navigational channels were not maintained, that all shipping would eventually cease due to sediment build-up.

8.1.1.2 River Sediment Dredging

These alternatives assume that various portions of the contaminated sediments will be removed by mechanical or hydraulic dredging. Three different dredging alternatives have been investigated:

- Bank-to-bank dredging

- Full-scale dredging of 40 hot spots (EPA recommendations vs NYSDEC recommendations)

- Reduced-scale dredging of a portion of the hot spots

Bank-to-Bank Dredging

Bank-to-bank dredging would require a much greater amount of operating equipment, operating time, and a much larger containment area than would be required for either of the other two less extensive dredging alternatives. The estimated total cost is on the order of $250,000,000 (DEIS, 1981).

Full-scale Dredging of 40 Hot Spots

The full-scale dredging of the 40 hot spots would be expected to occur over a 2-year period. During the first year of operation, the 20 hot spots in the Thompson Island pool would be dredged using either the hydraulic or clamshell method. All waste materials would be disposed of in the containment site, and the filled portion of the containment area would be covered at the end of the season. During the second year, the remaining hot spots in the lower pools would be dredged using the clamshell method. The waste material would be disposed of in the containment site, and the rest of the containment area covered and sealed (DEIS, 1981).

As a result of the full-scale dredging program, it is expected that approximately 48 percent of the total PCBs would be removed from the river. After the cleanup action, it would take from 16 to 41 years for a total of between 69,000 and 127,000 pounds of PCB to be transported to the estuary (Table 8-1).

Both landfilling and detoxification methods have been considered for the disposal of contaminated sediments. Those methods include:

- Detoxification/Destruction - Incineration has been recommended as the most effective and best understood means of destruction of liquid PCBs. Biological degradation has been found to be successful on lower Aroclors. However, no organism has yet been found to degrade PCBs within a reasonable time span. PCBX has been demonstrated on transformer oils but not on contaminated sediments (DEIS, 1981).

- Containment - A 250-acre site has been selected by NYSDEC near Fort Edward for use as a secure containment site. Previously conducted field investigations indicated that subsurface conditions at the proposed site were suitable for construction of a secure landfill. Both gravity and mechanical methods of sediment dewatering were considered; gravity dewatering was expected to require from 1 to 2 years for completion, whereas mechanical dewatering would incur additional costs on the order of $5,000,000 (DEIS, 1981).

Following the second season of dredging, the landfill is to receive a clay cap in order to reduce both infiltration and volatilization. A design capacity of 2,260,000 yd^3 was selected for the full-scale dredging of 40 hot spots (DEIS, 1981).

Reduced-scale Dredging of a Portion of the Hot Spots

Because of Federal funding limitations under the Clean Water Act, it was necessary to consider a reduced-scale dredging project. The Thompson Island pool would be selected as the first dredge site since transportation and treatment costs are low compared to other hot areas. The selection of hot spots to be dredged in the lower pools will proceed following an evaluation of results from a proposed probing and sampling program. Due to cost constraints, a clamshell dredge with hydraulic pumpout systems may be required for the dredging in the Thompson Island pool (DEIS, 1981). In addition, remnant deposits 3 and 5 would be provided with top covering and fencing, rather than removed and disposed into the containment site (DEIS, 1981).

It is expected that the reduced-scale project would allow for the removal of approximately 30 percent of the PCBs from the river. Under the reduced-scale dredging alternative it would take from 20 to 50 years after cleanup for some 82,500 to 170,000 pounds of PCB to be transported to the estuary (Table 8-1). This is between 14,000 and 55,000 fewer pounds of PCB transported to the estuary than would be transported if the no-remedial-action/continued maintenance dredging alternative were to be implemented. Alternately, approximately 32,000 pounds less PCB will be transferred to the atmosphere and from 46,000 to 58,000 pounds more PCB will be dredged under the reduced-scale dredging option.

Sediment disposal alternatives are the same as those discussed under the full-scale dredging project. Should a secure containment site be chosen, it is expected that a capacity of about 1,100,000 yd^3 would be required.

8.1.1.3 Control River Flows

In order to reduce PCB migration during high river flows, this alternative suggests controlling the Upper Hudson River flows from the Great Sagandaga Lake at the Conklingville Dam. Flows from the Conklingville Dam account for approximately 28 percent of the total flow at Fort Edward during normal flows and approximately 20 percent during the 100-year flood (DEIS, 1981). There are no other flow controls on the Upper Hudson River.

PCB concentration data obtained from U.S.G.S. monitoring stations have indicated that PCB concentrations in the Upper Hudson River are flow-dependent. Considering the load of PCBs in the river water column, it appears that flows of less than 12,000 cfs between Schuylerville and Stillwater carry very low loads of PCBs, on the order of less than 20 lb/day (DEIS, 1981). Accordingly, it would be necessary to maintain river flows of 12,000 cfs or less in order to avoid substantial transport of PCBs.

Since the water flow over the Conklingville Dam constitutes only 20 to 28 percent of the total flow at Fort Edward and since flows greater than 12,000 cfs occur 10 percent of the time between Schuylerville and Stillwater, it is apparent that either a substantial reduction of flow from Great Sagandaga Lake or additional dams would be required. Such a reduction may have a deleterious impact on the generation of hydroelectric power, maintenance of navigable flows, and protection of recreational value of the lake (DEIS, 1981).

8.1.1.4 In-River Detoxification

The in-river detoxification alternatives include techniques used to isolate or destroy the PCBs without removing them from the river. Major alternatives include:

- Degradation by ultraviolet ozonation
- Chemical treatment
- Bioharvesting
- Activated carbon adsorption

Degradation by Ultraviolet Ozonation

The technique of ultraviolet ozonation encompasses two consecutive chemical reactions: (1) use of ultraviolet radiation to decompose ozone which has been previously added to the waste, and (2) formation of highly reactive radicals to oxidize the PCBs. However, this technique is currently only applicable to effluent water treatment (Malcolm Pirnie, 1980d), and is therefore not suitable for neutralization of PCBs in contaminated river sediments.

Chemical Treatment

In-river chemical treatment has not been extensively investigated. It is expected that it would be difficult to selectively treat the river sediments without affecting the water column. All of the potential treatment techniques examined for this RAMP have not yet been developed beyond the laboratory stage (Malcolm Pirnie, 1980d).

Bioharvesting

This technique includes the removal of all aquatic organisms from the Hudson River which have accumulated high PCB concentration, and subsequent disposal in an environmentally acceptable manner. It has been estimated that this method may require from 100 to 10,000 years to complete. (DEIS, 1981).

Activated Carbon Adsorption

Carbon adsorption is presently the most widely used process for the removal of PCBs from industrial wastewater (Malcolm Pirnie, 1980d). To apply the principle to river sediments, it has been proposed that a magnetized granular activated carbon media be applied to the bottom sediments. The media would then be retrieved with a continuous belt-type collection device (DEIS, 1981).

It has been estimated that costs for utilization of this alternative would be within the range of $300/acres to $3,000/acres, excluding the cost of storage and destruction of the contaminated carbon (DEIS, 1981). However, the concept has not been fully developed and applied to a river system.

8.1.1.5 In-River Containment of Hot Spots

In-river containment of PCB hot spots has been considered for depositional areas that are not located in the main channel. This alternative could reduce the possibility of PCB transport and dispersal from contaminated areas.

For relatively shallow deposits, in-river containment can be accomplished by a variety of methods including:

- Earthen dikes or berms. These structures would be built parallel to the river bank, separating the contaminated sediments from the deeper river channel. A clay cap could additionally be utilized to further isolate the PCBs from the active environment. Wetland vegetation would be planted to stabilize the site (Supplemental Draft Environmental Impact Statement (SDEIS), 1981).

- Spur dikes. This method consists of the placement of riprap along the upstream shoreline of the wetland and the construction of a dike at the end of the riprap, angled downstream and outward into the river. Riprap is also placed on the face of the downstream end of the dike for scour protection (SDEIS, 1981).

- Bulkheads, which are constructed of pilings and sheetings and are used similarly to dikes or berms (SDEIS, 1981).

- Sheet pilings, which are driven into the river bottom parallel to the direction of flow. The pilings then form a relatively impervious boundary by an interlock of the sheet pile edges.

- Impermeable liner. Hot spots would be covered with an impermeable material which is resistant to scour.

The preceding methods are suitable for hot spots which are located in areas with a history of deposition. Typical areas would include:

- Backwater or eddy deposits, commonly formed behind projecting points of stable land (SDEIS, 1981).

- Deposits at the mouths of tributaries (SDEIS, 1981).

- Historically stable deposits on the insides of meander bends (SDEIS, 1981).

- Areas of partially restricted flow conditions resulting from the disposal of dredge spoil during routine channel maintenance (SDEIS, 1981).

The cost-effectiveness of stabilizing two wetland hot spots (hot spots 8 and 35) was evaluated by the SDEIS (1981). It was determined that earthen diking of these areas would, on the average, be slightly more expensive than dredging and containing the contaminated sediments. In areas that are less than 6 feet below the mean river stage, earthen diking may be slightly less costly than dredging. However, in-place stabilization by earthen dikes would not be effective in reducing scour at river flows higher than the 5 year flood, and the transfer of PCB to the water column and aquatic biota during low flows would not be abated.

Another alternative, which is applicable to deep as well as shallow deposits, has been considered for in-river containment of PCB hot spots. The recommended procedure would be to cover the contaminated sediments with a plastic liner, silt and rocks. However, during high flows, the silt may be scoured free and the liner ruptured with a subsequent release of contaminated sediments (SDEIS, 1981).

8.1.2 Alternatives for PCBs in Remnant Deposit Areas

8.1.2.1 No Remedial Action

This alternative assumes that no additional remedial actions will be taken at the remnant areas; bank stabilization, seeding, and material removal measures of varying degrees have already been taken between 1975 and 1978. Volatilization, high-river-flow scour, and long-term erosion would be allowed to continue. This action is proposed as a component of the reduced-scale dredging project (DEIS, 1981).

8.1.2.2 Restricted Access

Under this alternative, measures would be taken to deter access of people, vehicles, animals, etc., to the remnant deposits. Measures that would be taken include:

- Construction of chain-link fences on the landward sides of the deposits.
- Signs, which warn of the presence of toxic wastes, would be placed on all sides of the deposits.
- Continued maintenance of fence and signs.
- Grass seeding of disturbed and unvegetated areas.
- Safety precautions for workers at the sites.

Although this alternative would reduce the potential for human contact with PCB-contaminated sediments, it would not prevent losses from high flows and long-term erosion (DEIS, 1981).

8.1.2.3 In-Place Containment of Remnant Deposits

To encapsulate the contaminated remnant areas, the following construction procedures would be required:

- Placement of an impermeable cover, either man-made or clay or soil.
- Construction of a protective blanket, composed of graded material and designed to withstand flood flow velocities.
- For complete encapsulation, installation of a curtain wall to deter groundwater infiltration.

Associated construction costs can be expected to be extensive, as access roads would be required and between 5,000 and 10,000 truck trips would be needed to transport materials to the sites (Malcolm Pirnie, 1980d).

This alternative would reduce river contamination from the remnant sites, protect against scouring under flood conditions, and nearly eliminate volatilization. However, the remnant areas would still remain a long-term risk dependent on erosional changes of the river channel. Continual maintenance and monitoring would be required. Also, the construction of a surging dam at Fort Edward would submerge and eventually destabilize the remnant deposits, resulting in further release of PCBs (DEIS, 1981).

8.1.2.4 Removal of Contaminated Materials at Remnant Deposit Areas

These alternatives assume that all or a portion of the remnant deposit areas will be removed.

- Complete Removal of all Remnant Deposit Areas

  Complete excavation of all of the remnant deposit sites would require the movement of approximately 370,000 cubic yards of contaminated sediments, and between 20,000 and 40,000 truck trips would be required for transportation. About 46,000 pounds of PCBs would be removed from the site, which would account for 14 percent of the total PCB mass believed to be in the Hudson River (DEIS, 1981).

  The major disadvantage of this concept is the removal of sediments with low levels of contamination, resulting in low cost-effectiveness.

- Complete Removal of Deposit Areas 3 and 5

  Complete excavation of remnant deposits 3 and 5 would require the movement of approximately 215,500 cubic yards of contaminated sediment and require between 11,000 and 22,000 truck trips to remove the material. No additional measures would be taken at remnant sites 1, 2 and 4 (Malcolm Pirnie, 1980d).

Under this alternative, several advantages become apparent, including:

- Removal of the material (remnant sites 3 and 5) with the highest concentration of PCBs in the Hudson River system.

- Substantial reduction of a potential long-term source of contamination.

- Substantial reduction of PCB volatilization.

- The lower cost of PCB removal compared to the costs associated with removal or containment of PCBs at other contaminated sites in the Hudson River system (DEIS, 1981).

• Partial Removal of Deposit Areas 3 and 5

The NYSDEC has considered, as an alternative, removing only a portion of the contaminated sediments from remnant deposits 3 and 5. It was suggested that deposit 5 be excavated to a depth of 8 feet. Also, it was recommended that deposit 3 be excavated to a depth of 1.5 feet and/or to an elevation of 134 feet, and, at the southern end of the deposit, to the depth of the water table. A total of about 73,400 cubic yards of contaminated sediment would be removed from the two remnant deposit sites (DEIS, 1981).

Lawler, Matusky, and Skelly (LMS) have also proposed a partial removal plan for remnant deposits 3 and 5 which would excavate all material above an elevation of 134 feet in the remnant areas. Under this proposal, approximately 44,500 cubic yards of contaminated sediments would be removed (DEIS, 1981), and roughly 3,700 to 7,400 truck trips would be required (Malcolm Pirnie, 1980d).

The LMS proposal was planned to accommodate the potential reconstruction of the Fort Edward Dam. Fluctuations in dam pool elevations would tend to wash PCBs from remnant deposits of equal elevation. Correspondingly, excavation to an elevation of 134 feet would remove all contaminated sediments in the area of pool fluctuation which would be between 136 and 142 feet (Malcolm Pirnie, 1980d).

Partial removal of remnant deposit 3 is an advantageous alternative since a large mass of PCBs could be removed by excavation of a relatively small amount (13 percent) of the remnant deposit. Hauling costs would be substantially reduced from the complete removal alternative. Additionally, it would be possible to seal the remaining PCBs and contaminated sediment in place.

8.2 Review of New Alternatives

An evaluation of the treatment technologies discussed in Section 7.0 indicated that although all of the technologies proved to be useful--or potentially so--for removing PCBs from oils, not all of the treatment methods could be used in connection with PCB-contaminated sediments. Twelve of the treatment technologies were found to be applicable to sediment decontamination, but none of these could be used to treat sediments in river. A breakdown of these technologies by applicability and stage of development can be found in Table 8-2. Only two processes, KOHPEG and NaPEG, were found to be applicable as an in-situ solution. This in-situ solution refers only to those sediments that are exposed (not covered by water), as is the case with the remnant deposits. For all of the other treatments the sediments must first be exposed--by dredging or by river-level reduction--and treatment takes place after dewatering.

In addition to the in-river containment systems previously discussed, a new containment option will be considered. This in-place capping option has been

TABLE 8-2

TECHNOLOGY STATUS AND APPLICABILITY

	Applicability		Status		
	Can be used in connection with Contaminated Sediments	Not Applicable for Sediment Decontamination	Laboratory	Developmental	Production
Acurex	X		X		
Biological Systems	X			X	
Controlled Air Incinerator		X		X	
Fluidized Bed Incinerator		X	X		
Goodyear	X				X
Hydrothermal	X			X	
KOHPEG	X			X	
LARC		X		X	
Molten Salt Incinerator		X		X	
NaPEG	X			X	
Ozonation		X	X		
PCBX	X				X
Photodecomposition		X	X		
Plasma Arc	X		X		
Pyromagentics Incinerator	X			X	
Rotary Kiln	X				X
Thagard HTFW	X		X		
Ultraviolet/ozone		X		X	
Wet Oxidation	X			X	

proven useful in deep as well as shallow ocean waters. The method, discussed in a study presented to the U.S. Army Corps of Engineers, states that a sand cap placed over the ocean bottom will provide good stability to covered sediments even during very high energy conditions (O'Connor, December 1982).

An in-river application of the method would be accomplished by placing a layer of sand over contaminated river bed sediments. The placement of a cover would be accomplished to immobilize PCB-contaminated sediments by preventing their movement through the river system, and preventing the interchange of sediments and accompanying organic material with the water column. The uncertainty associated with this method is its applicability to a dynamic river system, especially when considering the thickness of the cover needed (4 feet).

Another new alternative considered was in-river solidification. This process involves the mixing of contaminated sediments with a thermoplastic, cementitious or resinous material for in-place (under water) containment. The layering of this material over the contaminated sediments for erosion control was also considered.

8.3 Review of Possible Combinations of Alternatives

The combination of remedial alternatives for PCB-contaminated sediments allows for the maximization of an effective solution. This initial review of the alternative combinations will incorporate only the general aspects of compatability and effectiveness. After an evaluation and preliminary screening (Section 8.4), the remaining alternatives and combinations of alternatives will undergo an in-depth analysis according to criteria outlined in the National Contingency Plan, as will be discussed in Section 9 (NCP, Federal Register, 1982).

In keeping with previous discussions of alternatives, a review of alternative combinations for river sediments (40 hot spots) and remnant deposits will be treated as separate and independent actions.

8.3.1 River Sediments

The alternatives discussed in this section will include those combinations applicable to contaminated riverbed sediments.

8.3.1.1 Detoxification of River Sediments In Combination with Control of River Flows

The control of river flows would be accomplished to allow for the maximum exposure of river sediments throughout numerous reaches of the Hudson. By lowering the river level in a reach, many of the hot spots would become exposed and an in-situ detoxification method could be applied. The reasoning behind the need to lower the river levels is that there are no in-situ detoxification methods available that will work in an underwater environment. By constructing (or reconstructing) numerous dams on the river and adding flow control gates, water levels could be controlled to any desirable level.

Unexposed sediments would not be removed under this alternative because of the detoxification limitations. The same dams--and additional upstream dams--would later be used to control river flows so that the remaining contaminated sediments would not undergo transport due to high river flows.

8.3.1.2 Dredging in Combination with:

- Control of River Flows

  River flow controls would be undertaken with similar objectives as those for the previous method. With this alternative the exposed sediments would be removed before treatment and/or landfilling.

  Conventional river dredging techniques could be employed for the unexposed sediments, while a dragline would be used to remove the exposed sediments. The advantage to be gained by this combination will be an increased access to the sediments, and the facilitated removal of dried sediments (lower volume) by the more efficient dragline. The control of river flows can be used in connection with the bank-to-bank, 40 hot spot, or reduced-scale dredging alternative.

- In-River Containment

  This pairing should optimize the use of the dredging and containment alternatives; however, the bank-to-bank dredging alternative will not be considered, for obvious reasons. Wetland and shallow (a maximum depth of 6 feet below mean river stage) hot spots would be contained by the use of barriers, etc., and the deeper sediments (where this containment is not possible) would be dredged and the spoils removed from the system. The advantage to be gained by this method is a cost savings realized by the use of in-river containment methods instead of an initially more costly dredging program. A major drawback to the use of the containment alternative is that there will be a continual maintenance cost associated with each contained area.

8.3.1.3 Control of River Flows in Combination with In-River Containment

In-river containment would--as stated in the previous alternative--be used for those hot spots located in the shallow (6-foot or less) areas along the banks and islands of the Hudson. In addition, a river flow control program would be instituted to reduce river velocities during periods of high river flows. This would serve to prevent or reduce contaminated sediment transport during periods of high river flows. To accomplish this, a system of up-river dams (new and existing) would be used to control high river flows. By adjusting the drawdown of the reservoirs during low flow periods to increase retention capacity, high flows could be reduced by holding back some of the flow in the dam pool (Draft EIS, 1981).

Because a large dredging project would not be needed, a significant savings could be realized in this area; however, the modification of existing dams and the construction of new dams would prove to be a very expensive procedure.

8.3.1.4 Multiple Combination of Partial Dredging, Detoxification of Spoils, Control of River Flows, and Partial Containment

By implementing each component of the alternative in its most productive and efficient way, a significant cost savings could result. While containment practices could most efficiently be used in the shallow areas (6-foot water levels or less), dredging could be more effectively used for deeper river sediments. To facilitate the removal and containment processes, a river flow control program could be implemented as discussed in previous sections. Finally, the removed sediments would be detoxified, thus eliminating the need for a secure landfill.

8.3.2 Remnant Deposits

The alternatives discussed in this section will include those combinations applicable to contaminated remnant deposit sediments.

8.3.2.1 Partial Removal of Remnant Deposits in Combination with:

- In-Place Containment

  For this alternative, the most highly contaminated sediments would be removed. The remaining remnant deposits would be contained in-place. This combination would remove the highest concentrations of PCBs while containing those areas where the health risk is not as severe. The advantage to be gained here would be a cost savings associated with the reduction of truck trips needed to relocate the contaminated sediments.

- Restricted Access

  This alternative is similar to the previous alternative in that the highly contaminated sediments would be removed, but the difference would be that the remaining sediments would not be contained. Measures would be taken at the remaining areas that would limit or prohibit access to these areas by the public or wildlife.

- Detoxification

  In-place detoxification of sediments with PCB concentrations greater than 50 ppm would be accomplished with the KOHPEG or NaPEG methods, and the other contaminated sediments would be removed from the sites.

8.3.2.2 <u>In-Place Containment in Combination with</u>:

- Restricted Access

  With the addition of public access restrictions to contained and uncontained areas, the problem of potential contact with contaminated sediments should be greatly reduced. Those remnant areas with PCB concentrations of 50 ppm and above would be contained using methods described in Section 8.1. Security fences and warning signs would be constructed around all of the remnant areas--contained or otherwise--to limit public and wildlife access to the site.

- Detoxification

  In-place detoxification of sediments with PCB concentrations greater than 50 ppm would be accomplished with the KOHPEG or NaPEG methods. After detoxification, the sediments would be solidified or contained by dikes or berms on site for an environmentally safe and cost-effective solution.

8.3.2.3 <u>Restricted Access in Combination with Detoxification</u>

Those remnant deposits that are located above the river level would be detoxified using the KOHPEG or NaPEG methods. Those areas that cannot be detoxified or have PCB concentrations of less than 50 ppm would be restricted to public and wildlife by fencing and posting of warning signs.

8.3.2.4 The Combination of Removal, Restricted Access, and Detoxification

For this alternative, the sediments having PCB concentrations greater than 50 ppm would be removed, treated (either incinerated, or detoxified), and either landfilled or replaced. The final approach to the problem would be to limit all public and wildlife access to the remaining sediments with fences, barriers, and signs.

8.3.2.5 The Combination of Removal, Restricted Access, and Partial Containment

Removal of the most highly contaminated (50 ppm PCB and over) sediments from the remnant areas would be the initial phase of the implementation of this alternative. The remaining sediments--those that would be too difficult or expensive to remove--would be stablized by using those methods discussed in Section 8.1.1.5. The final measure taken would be by fencing and posting signs around the areas to limit public or wildlife contact with these sediments where contaminated sediments remain.

8.3.2.6 The Combination of Removal, Restricted Access, Detoxification, and Partial Containment

This alternative combination would be similar to the previous alternative except that the removed sediments would be treated or detoxified by one of the methods described in Section 8.2. Other areas--less contaminated--could be either contained or detoxified as dictated by cost or implementation problems. Finally, all areas where contaminated sediments remain would be fenced and posted (except for remnant area number 1) to limit access, except for remnant area number 1) which is located in the middle of the river.

8.4 Preliminary Screening of Alternatives

An initial screening of alternatives is required in order to eliminate obviously infeasible or inappropriate technologies from consideration as viable remedial actions. The remaining alternatives will then undergo a detailed evaluation in order to determine the cost-effective alternative.

The NCP has established three criteria for the initial screening of remedial alternatives:

- Acceptable engineering practices
- Effects of the alternative
- Cost

A flow chart of the proposed screening process is presented in Figure 8-1. In the technical screening phase, all infeasible, unapplicable, or unreliable technologies will be eliminated. The remaining alternatives will then enter the environmental/public health/institutional (i.e., social concerns, legal concerns, etc.) screening phase, where technologies that have significant adverse effects or do not contribute substantially to the protection of health, welfare, or the environment will be eliminated. This includes all remaining technologies/alternatives whose costs are relatively expensive and do not offer substantial benefits. Alternatives which have passed the previous screenings will enter into a much more detailed evaluation/cost analysis.

8.4.1 Screening of Detoxification or Destruction Techniques

Because the majority of the following technologies are still in the early stages of development, little information is known about the environmental effects and cost of each alternative. Acceptable engineering practices were weighted the highest during the screening, with an advantage going to those processes that are fully developed or nearly so. EPA screening criteria state that any alternative that relies on unproven technology will be rated low. Those alternatives which passed the initial screening process are further discussed in Chapter 9.

- Acurex - removed from further consideration

  This process, although available for use, is difficult to implement and is not permitted by the EPA for use on PCB-contaminated sediments.

- Biological Destruction - removed from further consideration

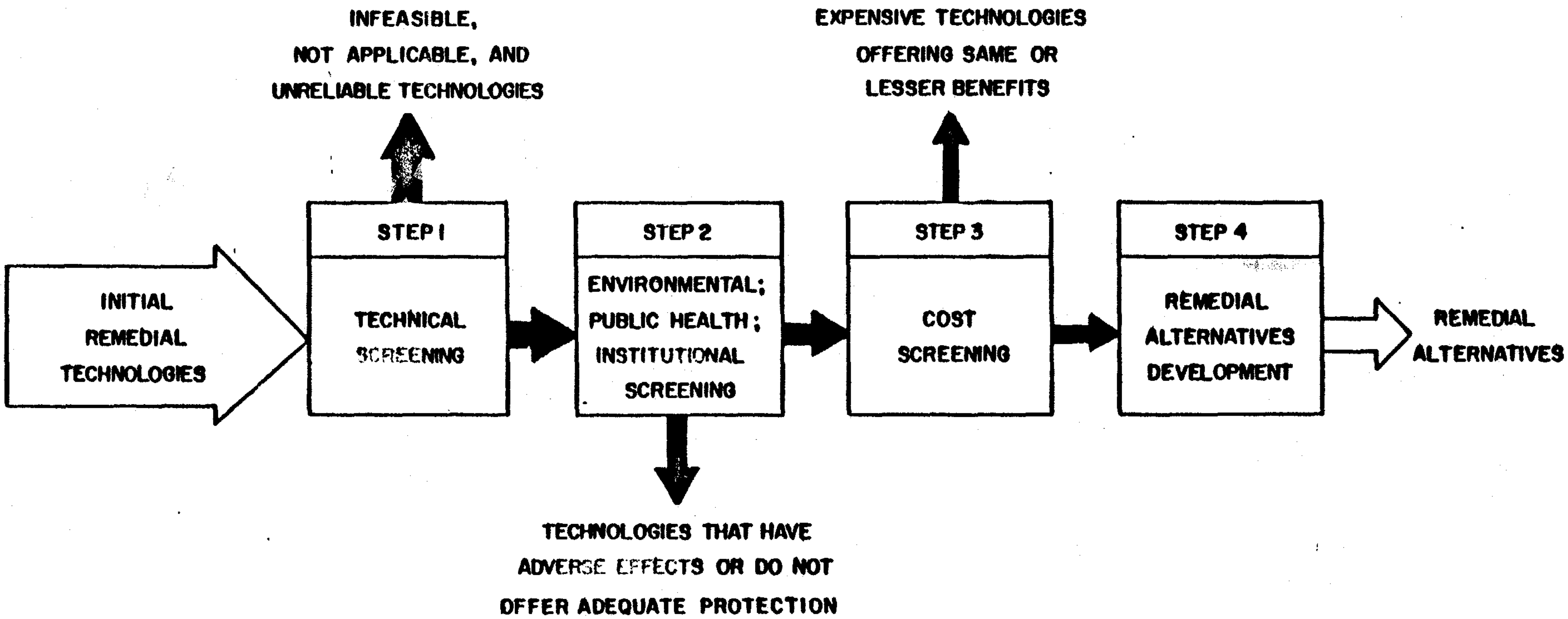

FIGURE 8-1

FLOW CHART OF INITIAL SCREENING PROCESS
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

Because this system has not proven itself effective for use on the highly chlorinated biphenyls, it will not undergo any additional evaluation.

- Goodyear – removed from further consideration

  This process is non-mobile and is difficult to use in conjunction with contaminated sediments, and therefore has been removed from further evaluation.

- Hydrothermal – removed from further consideration

  Because work on this process is still in the early developmental stage, it would not be available in the near future for use with Hudson River sediments.

- KOHPEG – passed initial screening

  Although testing has not been completed for this process, the EPA is optimistic that this process will be effective. It is being included in the final screening since it may be approved as a result of field testing by the time this RAMP is implemented.

- NaPEG – removed from further consideration

  This process would involve similar costs and effects as the KOHPEG process, but it is not as reactive and is more sensitive to impurities; thus it was removed from further evaluation.

- PCBX – removed from further consideration

  The PCBX system has not been approved by the EPA for use on PCB-contaminated sediments. In addition, the fact that the process requires a solvent extraction of the sediments poses difficulties for onsite implementation and thus removes this technology from further evaluation.

- Plasma Arc - removed from further consideration

  This process is still in the laboratory stage, and is thus considered too preliminary for use with this project.

- Pyromagnetics Incinerator - removed from further consideration.

  This process is currently relying on unproven technology, and the existing unit is too small to be useful for the large volumes of Hudson River sediments.

- Rotary Kiln - passed initial screening

- Thagard HTFW reactor - removed from further consideration

  Because this reactor is a non-mobile unit, the associated high operating costs preclude further evaluation of this technology.

- Wet Air Oxidation - passed initial screening

8.4.2 Screening of Single Alternatives

8.4.2.1 In-river Sediments

- Dredging - bank-to-bank - removed from further consideration

  Bank-to-bank dredging would be difficult to implement, would incur large capital costs, and would be destructive to the ecology of the river. It was eliminated on this basis.

- Dredging - 40 Hot Spots - passed initial screening

- Dredging - Reduced-Scale - passed initial screening

- In-river Containment - removed from further consideration

  The containment option offers no advantage over the dredging option and, after implementation, has more drawbacks. Although the initial costs associated with in-river containment are approximately equal to that of dredging, maintenance and monitoring costs would continue and would perpetually add costs to the project (DEIS, 1981).

  Although experimental capping of contaminated mud deposits with clean sediments and sand in the New York Bight has proven successful (O'Conner, 1982), capping of contaminated deposits in a river system has not been studied. Three problems would hamper the use of such an alternative in the Hudson River. First, uncontaminated sediments and sand would have to be transported a great distance since any such material found above Glens Falls is not accessible by barge, and suitable material may not be available downstream in the Hudson River. Secondly, future maintenance dredging could disturb the liner over many of the larger hot spots. Only a few isolated wetland hot spots would be suitable. Thirdly, silt and sand would not provide enough protection against scour and, therefore, large volumes of expensive gravel and stone would be required. For this reason in-river containment will not undergo further evaluation.

- Control of River Flows - removed from further consideration

  The cost of constructing the numerous dams necessary for this program was considered too expensive for the limited benefits produced.

- No-Action - routine dredging ceases - removed from further consideration

  Although this would be a cost-effective solution, the economic losses would be too great after the cessation of commercial shipping in the river as a result of sediment-blocked channels.

- No-Action - routine dredging continues, with water treatment - passed initial screening

- No Action - routine dredging continues, without water treatment - passed initial screening

8.4.2.2 Remnant Deposits

- Removal - total - passed initial screening

- Removal - partial - passed initial screening

- Detoxification - In-situ - passed initial screening

- In-place Containment - passed initial screening

- Restricted Access - passed initial screening

- No Action - passed initial screening

8.4.3 Screening of Combinations of Alternatives

8.4.3.1 River Sediments

- Detoxification in combination with control of river flows - removed from further consideration

  Although the detoxification of river sediments exposed by low river levels is possible, the construction of enough dams to accomplish this project would be cost prohibitive.

- Dredging in combination with control of river flows - removed from further consideration

The decision to remove this alternative from consideration was based upon excessive construction costs. Included in this screening were all three alternatives for dredging: bank-to-bank, 40 hot spot, and reduced-scale.

- Bank-to-bank dredging in combination with in-river containment -removed from further consideration

  Bank-to-bank dredging has been removed from consideration during the initial screening of alternatives as too costly a project.

- Dredging of the 40 hot spots in combination with in-river containment - removed from further consideration

  Because the in-river containment option offers no advantage over dredging--as discussed before--this alternative will not be evaluated further.

- Reduced-scale dredging project in combination with in-river containment - removed from further consideration

  In-river containment would offer no advantage over dredging for a reduced-scale project as well as the full-scale project. This alternative was therefore removed from consideration.

- Control of river flows in combination with in-river containment - removed from further consideration

  The control of river flows alternative has been eliminated as a non-cost-effective alternative.

- The combination of partial dredging, control of river flows, and partial containment - removed from further consideration

This alternative will no longer be considered due to the removal of the control of river flow alternative.

8.4.3.2 Remnant Deposits

- Partial removal in combination with in-place containment - passed initial screening

- Partial removal in combination with restricted access - passed initial screening

- Partial removal in combination with detoxification (in-situ) - passed initial screening

- In-place containment in combination with restricted access - passed initial screening

- In-place containment in combination with detoxification (in-situ) - passed initial screening

- Restricted access in combination with detoxification (in-situ) - passed initial screening

- The combination of partial removal, detoxification (in-situ), and restricted access - removed from further consideration

  This alternative was removed from further consideration because there is not enough information available at this time about the location of PCBs to determine where each technique would be appropriate.

- The combination of partial removal, partial containment, and restricted access - removed from further consideration

  Removed by the same reasoning as discussed above.

- The combination of partial removal, detoxification (in-situ), partial containment, and restricted access - removed from further consideration

Removed by the same reasoning as discussed above.

9

9.0 EVALUATION OF ALTERNATIVES

9.1 Methodology for Evaluation of Alternatives

After completion of the initial screening of alternatives, a detailed evaluation of the remaining alternatives was conducted in order to recommend a cost-effective alternative. The cost-effective alternative is the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment (47 Federal Register 137). A trade-off matrix was used for evaluating the cost-effectiveness of the remedial actions. The candidate alternatives were rated according to several measures of effectiveness and cost. Weighting factors were applied to the various measures as a technique to assign relative importance to each measure. The final scores (sum of ratings times weighting factors for the cost and effectiveness measures) were then compared in order to determine the recommended alternative.

9.2 Criteria for Evaluation of Alternatives

9.2.1 Effectiveness Measures

The critical components of effectiveness measures were determined to be: technical feasibility as well as public health, institutional, and environmental effects. Particular emphasis was placed on the following:

- Technical Feasibility
  - Proven or experimental technology
  - Risk of failure

- Public health effects

  - Reduction of health and environmental impacts
  - Degree of cleanup

- Institutional effects

  - Legal requirements, institutional requirements
  - Community impacts
  - Impacts on fishing, navigation, and generation of hydroelectric power
  - Approval of land use

- Environmental effects

  - Impact of failure
  - Length of time required for cleanup
  - Amount of environmental contamination with respect to acceptable levels

Based on these components, a set of independent "effectiveness measures" were synthesized, as follows:

- Technology Status
- Risk and Effect of Failure
- Time Required to Achieve Cleanup/Isolation
- Ability to Meet Public Health & Environmental Criteria
- Degree of Cleanup/Isolation Achievable
- Ability to Meet Legal and Institutional Requirements
- Ability to Minimize Community Impacts
- Commercial Impacts -

9.2.1.1 Technology Status

Technologies involved in a remedial alternative are either proven, widely used, or experimental when applied to uncontrolled hazardous waste sites. Generally, a proven and widely used technology is to be rated highest, and experimental technologies lower. For some specific pollution problems, the only technology available for use at uncontrolled sites may be in the experimental stage. In such a case, an experimental technology may be chosen as cost-effective if it is highly rated with respect to the other effectiveness measures.

Special attention should be paid to whether experience in other less demanding situations is applicable to a remedial action situation.[1]

9.2.1.2 Risk and Effect of Failure

The risk factor is the product of the probability of failure and the consequences of such a failure. A high risk is associated with high probability of failure and significant impacts. At most uncontrolled hazardous waste sites, a "no action" alternative would be considered a high risk. Alternatives with a low probability of failure and relatively minor potential impacts resulting from failure are considered low-risk alternatives.[1]

9.2.1.3 Level of Cleanup/Isolation Achievable

In the context of this methodology, cleanup implies that pollutants are removed from the site and/or the environment by the remedial action alternative. Isolation means that the transport of pollutants from the site to the environment is stopped or slowed.[1]

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[1] This definition has been extracted from a methodology manual entitled Evaluating Cost-Effectiveness of Remedial Actions of Uncontrolled Hazardous organizing citzens' groups to review the remedial action, seeking legal advice, and attending public meetings.

9.2.1.4 Ability to Minimize Community Impacts

A community impact is broadly defined as any change in the normal way of life which can be directly or indirectly attributed to the execution of the remedial action. These changes include those actions which people would not normally undertake, such as moving permanently from a condemned property, moving to temporary lodging during the remedial action, or undergoing health monitoring.

The above impacts are in some cases merely a source of irritation to a community. However, some possible community impacts are clearly negative, such as increased noise during the action, traffic congestion, loss of access to the site or to roads near the site, decline in property values, and stress related to all of the above and to uncertainty about health risks.[1]

9.2.1.5 Ability to Meet Relevant Public Health and Environmental Criteria

This measure compares the remedial alternatives in terms of how well they attain relevant public health and environmental standards such as those under the Safe Drinking Water Act, Clean Water Act, or Clean Air Act. Alternatives would be compared on level of attainment rather than just attainment or non-attainment.[1]

9.2.1.6 Ability to Meet Legal and Institutional Requirements

This measure assesses the ability of a given remedial measure to meet requirements of local, State, and Federal permits; and suitability of the measure to meet other pertinent legal requirements.

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[1] This definition has been extracted from a methodology manual entitled Evaluating Cost-Effectiveness of Remedial Actions of Uncontrolled Hazardous Waste Sites produced by the Radian Corporation, Austin, Texas, in 1983.

9.2.1.7 Time Required to Achieve Cleanup/Isolation

The time required for a remedial action alternative to achieve its designed degree of cleanup or isolation may range from weeks to many years, depending on the technology and site conditions.[1]

9.2.1.8 Commercial Impacts

This measure evaluates the impacts of the remedial alternatives on the commercial environment of the Hudson River. Important factors may include the effects on transportation, fisheries, public water supplies, hydroelectric power generation, future construction, and agriculture.

9.2.2 Costs

According to CERCLA, a total cost estimate for a remedial action must include both construction costs and annual operation and maintenance costs. The Total Construction Cost can be defined as the sum of the Total Direct Capital Cost and the Total Indirect Capital Cost (Radian Corp., January 1983).

Direct capital costs may include the following cost components:

Construction Costs - Components include equipment, labor (including fringe benefits and workman's compensation), and materials required to install a remedial action.

Equipment Costs - In addition to the construction equipment cost component, remedial action and service equipment should be included.

Land and Site-Development - Costs include land-related expenses associated with purchase of land and development of existing property.

Buildings and Services - Costs include process and non-process buildings and utility hook-ups.

Indirect Capital Costs may include the following components:

Engineering Expenses - Components will include administration, design, construction surveillance, drafting, and testing of remedial action alternatives.

Legal Fees and License/Permit Costs - Components will include administrative and technical costs necessary to retain licenses and permits for facility installation and operation.

Relocation Expenses - Relocation expenses should include costs for temporary or permanent accommodations for affected nearby residents.

Start-up and Shake-down Costs - Costs incurred during remedial action start-up for long-term activities should be included.

Contingency Allowances - Contingency allowances should correlate with the reliability of estimated costs and experience with the remedial action technology.

The operation and maintenance cost may include the following components:

Operating labor costs - Include all wages, salaries, training, overhead, and fringe benefits associated with the labor needed for post-construction operations.

Maintenance materials and labor costs - Include the costs for labor, parts, and other materials required to perform routine maintenance of facilities and equipment for the remedial alternative.

Auxiliary materials and energy - Include such items as chemicals and electricity needed for treatment plant operations, water and sewer service, and fuel costs.

Purchased services - Include such items as sampling costs, laboratory fees, and professional services for which the need can be predicted.

Disposal costs - Costs should include transportation and disposal of any waste materials, such as treatment plant residues, generated during remedial operations.

Administrative costs - Cover all other O&M costs, including labor-related costs not included under that category.

Insurance, taxes, and licensing costs - Include such items as: liability and sudden and accidental insurance; real estate taxes on purchased land or right-of-way; licensing fees for certain technologies; and permit renewal and reporting costs.

Maintenance reserve and contingency funds - Represent annual payments into escrow funds to cover anticipated replacement or rebuilding of equipment and any large, unanticipated O&M costs, respectively.[2]

Construction costs and operation and maintenance costs were estimated for the above criteria. For operating and maintenance costs, a "present-value" analysis was used to convert the annual costs to an equivalent single value. Operation and maintenance costs were considered over a 20 year period; a 10 percent discount rate and 0 percent inflation rate were assumed. For the Hudson River PCBs Site, costs for an environmental monitoring program were included as operation and maintenance costs where appropriate. Estimated costs and supporting calculations are included in Appendix C.

9.2.3 Weighting Factors

Weighting factors were previously defined as a means of assigning relative importance to the cost and effectiveness measures. A high weighting factor, which identifies an important measure, increases the effect of that measure with respect

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[2] The above definitions have been extracted from a draft Superfund Feasibility Study Guidance Document compiled by JRB Associates, McLean, Va., 1983.

to the final evaluation. Correspondingly, a low weighting factor reduces the effect of a "low importance" measure with respect to the final evaluation. Selected weighting factors are presented in Table 9-1. Weighting factors were developed by an internal technical group using EPA guidance documents.

It was the decision of the evaluation committee that operation and maintenance costs were more critical to the final ranking than construction costs. Correspondingly, a higher weighting factor was assigned to operation and maintenance costs (1.2) than to construction costs (1.0).

9.3 Evaluation of Alternatives

9.3.1 Examination of Remaining Alternatives

Alternatives which passed the initial screening were further examined/developed so that the alternatives could later be evaluated with respect to each of the previously discussed effectiveness measures.

These examinations are summarized in the following subsections.

9.3.1.1 Remedial Alternative: Detoxification of Removed Sediments with KOHPEG

Description: Potassium hydroxide (KOH) and polyethylene glycols (PEG) react with and destroy polychlorinated biphenyls (PCBs), producing reaction products of aryl polyglycols and biphenyls. The presence or absence of air apparently has little effect on the reaction. Reaction time is reduced with increased temperature; however, the reaction will proceed under ambient conditions.

KOHPEG has not been applied in the field to soils containing PCBs, but application to dredged sediments conceptually might proceed as follows. The dredged material would be placed in a lagoon for dewatering to a suitable water content level. The water would be decanted, tested, and possibly treated before discharge. Dredging would only proceed until the calculated depth of dewatered sediments would not

TABLE 9-1

WEIGHTING FACTORS FOR EFFECTIVENESS MEASURES

Effectiveness Measures and Costs	Weighting Factors
Technology Status	0.6
Risk & Effect of Failure	1.1
Level of Cleanup/ Isolation Achievable	1.0
Ability to Minimize Community Impacts	0.6
Ability to Meet Relevant Public Health and Environmental Criteria	0.6
Time Required to Achieve Cleanup/Isolation	0.5
Ability to Meet Legal and Institutional Requirements	0.5
Commercial Impacts	0.4
Construction Cost	1.0
Operation & Maintenance Cost	1.2

exceed the effective treatment depth of one application of KOHPEG. Dredging would be staged to meet this requirement. An initial assumption of a one-foot depth could be made. KOHPEG could then be sprayed over the area, followed by rototilling. The application rate would be a weight of reagent equal to 6 percent of the weight of the removed sediment being treated. One full summer should be allowed for the reaction to proceed. Testing could then be done to determine whether the PCBs have been destroyed. The sequence of operations could then be repeated, with the dredged sediments being placed over the decontaminated sediments. Adjustments in the amount of dredging, application rate, and rototilling on subsequent cycles could be made, based upon the results of the previous cycle.

An alternative method could also be used. The dredging could be completed in one operation, with all material going to a lagoon for dewatering. The destruction of PCBs would then follow the plan for the remnant deposit sites. In summary, this would be the application of KOHPEG, rototilling, testing to determine the depth at which the PCBs had been destroyed, excavating that material, and then repeating the sequence until the full depth of dredged sediments had been treated.

Applicability: The detoxification of contaminated materials with KOHPEG could be applicable to river sediments having a high PCB concentration.

Technology Status: The KOHPEG system is still in the laboratory stage, where work that has been done on PCBs contained in transformer oils and soils seems to show promise. Laboratory work indicates that PCBs contained in soils with significant organic content will be destroyed, but may take several months. The treatment system will tolerate some water in the soil, but the limit has not been established. Use on dredged sediments will require testing to establish the limiting water content level. A field application test is expected to begin in the summer of 1984, and it is estimated that 12 to 18 months will be required for development of techniques for large-scale application. Additional research is required to establish dilution ratios for the reagent, dosage rates, and methods of application and to develop procedures that will assure contact of the reagent with the contained PCBs.

Risk and Effect of Failure: The probability of failure of KOHPEG is dependent upon the degree to which the solution comes in contact with the PCBs. Assuming the solution is rototilled into the sediments properly, the PCBs should become detoxified and, hence, present no risk to the public. Should this assumption prove invalid, the sediments will remain hazardous and must be treated as such.

Time Required to Achieve Cleanup/Isolation: It may take several months for the reagent to destroy the contained PCBs, and the speed of the reaction increases with increasing temperatures. It follows that it will likely require at least one summer season for destruction of PCBs in a treated area. It is unlikely that all sediment areas would be dredged at the same time, and dewatering before treatment may be required. In addition, the time required to treat all dredged sediment areas to the full depth of contamination will depend upon availability of adequate quantities of reagent and upon the manpower commitment to treat several areas concurrently. It is not possible at this time to predict the total elapsed time.

Ability to Meet Public Health and Environmental Criteria: Acute toxicity tests have been performed on the reaction products which result from the destruction of PCBs in transformer oils. The products were found to have no biological activity other than being a mild eye irritant, but no long-term biological tests have been performed. Polyethylene glycols in the laboratory have been degraded by anaerobic bacteria. It is expected that reaction products will be biodegradable since they contain oxygen. Analyses of transformer oil and the reaction products after treatment of PCB-contaminated transformer oil were unable to detect PCBs, polychlorinated dibenzofurans (PCDF) or polychlorodibenzodioxins (dioxins).

Degree of Cleanup/Isolation Achievable: Using this method, essentially 100 percent cleanup of the contaminated sediments can be obtained.

Ability to Meet Legal and Institutional Requirements: The treatment process may require a Hazardous Waste Management Facilities permit as well as a National Pollution Discharge and Elimination System (NPDES) permit for the discharge of decanted water. Additional State permits may be required for the construction of treatment facilities and the transport, discharge, and disposal of hazardous wastes. Local building permits may also be required for land use.

Ability to Minimize Community Impacts: This process will minimize community impacts if no digging of the dredged sediments is required for the reagent to contact all contained PCBs. There may be some volatilization of PCBs if the soil requires rototilling, but it should be minimal. No transport or treatment off site would be required.

Commercial Impacts: The periodic dredging of sediments may interrupt traffic on the river. Once the treatment is completed; however, the river will eventually be restored to a less contaminated state. This will enable it to be used once more for recreation and commercial fishing.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.2 Remedial Alternative: Detoxification of Removed Sediments with Wet Air Oxidation

Description: Wet air oxidation (WAO) is a commercially proven technology for the destruction of organics in wastewater and sludges; however, it is expected that higher temperatures and pressures will be needed to destroy more environmentally persistent chlorinated organic compounds. This difficulty apparently can be overcome with the use of catalysts. WAO using catalysts will destroy chlorinated compounds, such as PCBs, at relatively low temperatures, and will oxidize essentially all organic materials.

In this application, the dredged sediments would have to be routed to a storage basin because the dredge removal rate to attain an optimum solids and organic content likely will exceed the WAO processing rate. As the organic content of the waste increases, the amount of external heat required in the reaction is reduced. However, the slurry needs to be fluid in order to be handled by the reactor. Literature reports that the process can be self-sustaining at organic concentrations which range from 1 to 4 percent. Actual sediment analyses show an average organic content of 5 percent on a dry-weight basis. Since dredging typically provides a material with a solids content of 10 to 30 percent, "as removed" dredged material will have an organics content of 0.5 to 1.5 percent. The high end of this range appears to be adequate for sustaining WAO without using external energy for heating and is judged to be a pumpable slurry. Therefore, it is likely that the storage basin would have to be mixed in order to maintain a pumpable slurry. For cost estimating purposes, it was assumed that the basin inlet and slurry discharge to the WAO process will be about 25 percent solids and have an organic content of 1.25 percent. The slurry will be pumped into a continuously stirred tank reactor containing the catalysts. Here, the air is sparged into the reactor to oxidize organics, with the heat of reaction driving off water. The developer of the open system indicates that catalyst poisoning has not been observed. The destruction products of PCBs are water, carbon dioxide, lower volatile acids, and inert solids. A heat exchanger will be used to preheat feed slurry. Condensed steam may contain oxidation product intermediates and thus may require further polishing before discharge. Solids removed from the reactor should be inert if process performance can be optimized; however, further testing will be required to assure that a suitable disposal option is employed.

Applicability: Catalyzed WAO is applicable to the destruction of chlorinated organics contained in slurries or sludges, although pilot work on PCBs in such materials has not been done.

Technology Status: The work on WAO as applied to PCBs has been on a laboratory scale only. It is believed that catalyzed WAO will destroy PCBs in soil because of success in destroying other chlorinated organics. Production units in operation are limited to two units treating 10 gallons per minute of liquid waste containing 40 grams per liter of COD. Units to treat soils containing PCBs could be made portable. Large-scale production facilities for the use intended in this study have not been constructed or tested.

Risk and Effect of Failure: A relatively high risk is associated with the implementation of this alternative.

Time Required to Achieve Cleanup/Isolation: A process design for a 25 gallon per minute unit has been conceptualized. With a slurry containing 15 percent solids, 31 pounds of sediments per minute would be treated. Such a unit operating around-the-clock would process about 100 cubic yards of sediment per day. It is proposed that sufficient WAO units be used in order to maintain a detoxification rate equal to the dredging rate. Therefore, the detoxification process should be completed shortly after completion of dredging operations.

Ability to Meet Public Health and Environmental Criteria: Reportedly, catalyzed WAO should completely destroy PCBs contained in soils and thus present no violations of public health and environmental criteria. Testing has not been done on production-scale units to establish the fate of other potentially hazardous materials that might be present in the sediments before treatment.

Degree of Cleanup/Isolation Achievable: Catalyzed WAO should completely destroy the PCBs contained in the river sediments.

Ability to Meet Legal and Institutional Requirements: The treatment process may require a Hazardous Waste Management Facilities permit as well as an NPDES permit for the discharge of decanted water. Additional State permits may be required for the construction of treatment facilities and the transport, discharge, and disposal of hazardous wastes. Local building permits may also be required for land use.

Ability to Minimize Community Impacts: There will be no transport or spill impact on the community because the sediments will not be transported off site. The potential for possible air contamination by materials other than PCBs contained in the sediments is unknown. Disposal of dredged sediment after application fo the process should present no problems since it could be used as clean fill, etc.

Commercial Impacts: Once the treatment is completed, the river will eventually be restored to a less contaminated state. This will enable it to be used once again for commercial fishing and recreational purposes.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.3 Remedial Alternative: Destruction of Removed Sediments by Incineration

Description: In order to develop the costs for this alternative, an incineration system which is technically feasible has been proposed. It includes the following operations: de-watering of the influent, batch feeding of the solids into the incineration unit, incineration, disposal of the residue, and air pollution control. The original design of the system uses a movable incinerator with the thought that this may minimize transportation costs of the dredge spoils. A movable rotary kiln has been selected which could be either batch fed or continuously fed. Since the possibility of installing the unit on a barge is also under consideration, the decision was made to use the batch-feed option. Some coagulation and dewatering procedures have been included in order to put the dredge spoils slurry into a form suitable for incineration. The residue expected after incineration would be a sterile, clean material.

Applicability: This process is applicable to processing dewatered sediments or remnant deposits which contain adsorbed PCBs.

Technology Status: This technology has been in use for years and is considered to be standard technology.

Risk and Effect Failure: This risk factor will be low for the following reasons:

- In order to provide a common costing basis, the incineration was required to be completed within two years. This resulted in a number of units being used rather than just one. Although the use of multiple units provides a redundancy factor, the result is that breakdown of individual units will not halt the incineration process.

- The technology is common, and is not liable to fail.

As a result, the proposed system should be considered to be a low-risk alternative.

Time Required to Achieve Cleanup/Isolation: It is proposed that the incineration be completed within two dredging seasons; that is, as the sediment is dredged, it is almost immediately incinerated.

The Ability to Meet Public Health and Environmental Criteria: As long as the incineration process is operated to meet Federal requirements regarding temperature and dwell time, this alternative will completely destroy the PCBs and the sediments.

Degree of Cleanup/Isolation Achievable: The incineration alternative should completely eliminate the PCB's in the sediments incinerated.

Ability to Meet Legal and Institutional Requirements: The treatment process may require a Hazardous Waste Management Facilities permit as well as an NPDES permit for the discharge of air pollution control water and water from the de-watering process. Additional State permits may be required for the construction of treatment facilities and the transport, discharge and disposal of hazardous waste. State and/or Federal permits may be required for the air emissions. Local building permits may also be required for land use.

Ability to Minimize Community Impacts: Since multiple units will be required, a number of sites can be located along the river. This would minimize transportation of waste on the roads and reduce community impact. However, there will be increased noise as a result of the operation of the incinerators. In addition, there will also be increased traffic required by delivery of supplies and fuel, and removal of the incinerated residue to an unsecure landfill. There may also be some air pollution due to dust and steam from the incineration operations.

Commercial Impacts: This alternative will result in complete elimination of the PCBs. It will reduce the requirements for disposal capacity to approximately one third of that needed for disposal of non-incinerated dredge spoils. In this way the amount of agricultural land taken out of service will be reduced.

Costs: Detailed costs were estimated and were included in Appendix C.

9.3.1.4 <u>Remedial Alternative: Secure Landfill Disposal of Removed Sediments</u>

Description: This alternative includes siting, design, construction, operation, closure and post-closure monitoring and maintenance of a single, multi-celled, controlled access, dredged, PCB-laden sediment landfill. According to Malcolm Pirnie, Inc., Containment Site No. 10, near Fort Edward, New York, appears to be the most favorable site (see Figure 4-3). The basic design, construction, operation, closure, and post closure monitoring and maintenance are described by Malcolm Pirnie, Inc. (September 1980, Dredging System Report Program No. 2; September 1980, Design Report; September 1981, Contract No. 1, Containment Site-Specifications) and U.S. EPA (August 1981, Supplemental Draft EIS; October 1982, Final EIS).

This alternative provides an encapsulated, stable, dewatered, monitored, and secured containment area which is essentially equivalent to, or exceeds, appropriate regulatory requirements and commonly acceptable engineering practices for PCB landfills.

The following is a description of the proposed 250-acre containment site provided by Malcolm Pirnie, Inc.:

Containment Area - The containment area is an earthen basin bisected by a cross dike. It occupies approximately 63 acres in area at its maximum water surface and its total containment volume at the maximum water surface is 2,260,000 cu yds. This volume is sufficient to hold all of the 40 hot spot sediments, the remnant deposits, and the DOT spoil areas, if necessary.

The containment area will be designed for long-term encapsulation of PCB-contaminated materials, and will therefore be capped with a clay cover after each season of dredging.

Roughing and Storage Pond - The roughing and storage pond (R&SP) is an earthen basin with a maximum water surface area of approximately 12 acres.

After the slurried dredge material is pumped into the containment area, weir overflow is transported via pipeline to the R&SP. The primary purpose of this basin is to ensure efficient sedimentation near the end of each dredging season as the effective overflow rate in the containment area increases. The R&SP also provides protection for the subsequent treatment units from any upsets in the containment area which might lead to transient escape of dredged material.

A small portable dredge will be operated to recycle settled dredged material back into the containment area.

The R&SP is not a permanent containment unit. At the end of the dredging program, all of the contaminated material in the R&SP will be relocated to the containment area and the pond will be filled in and regraded.

Surge Pond - The surge pond is an earthen basin with a maximum water surface area of 2.4 acres. This pond receives weir overflow from the R&SP. Its purpose is to buffer the treatment plant units from surges in the dredging process and to provide a convenient, sediment-free point for treatment feed and recycle supply pump suctions if a recycle dredging procedure is implemented. A detailed discussion of dredging options is presented in the Containment Site Design Report.

Water Treatment Plant - The water treatment plant consists of two earthen basins: the flocculation basin and the settling basin, with maximum water surface areas of 0.1 and 1.0 acres, respectively. The plant has a capacity of 13 million gallons per day (mgd) and consists of coagulation, flocculation, and sedimentation units. The purpose of the water treatment plant is to reduce PCB concentration in the dredge return flow before discharge to the river.

The water treatment plant is expected to achieve effluent suspended solids of less than 4 milligrams per liter and turbidity of less than 10 Nephelometric Turbidity Units (NTU) with proper chemical doses. The average PCB concentration in the discharge is expected to be in the 10-20 microgram per liter range.

Pump Station - The pump station consists of three mixed-flow pumps, each with a capacity of 4500 gallons per minute (gpm). One of the three pumps functions as a standby. The pump station's function is to provide a reasonably constant influent feed to the water treatment plant.

Leachate Collection System - The leachate collection system is a network of perforated drainage piping laid in gravel-filled, filter-cloth-lined collection trenches at the base of the containment area. The bottom of the containment area is sloped to transmit flow towards the trenches.

The leachate collection system will be utilized in two phases: short-term dewatering and long-term percolation.

Valves, collection and sampling wells, and a flow metering and monitoring manhole are provided to determine the quantity and concentration of PCBs in the leachate. Discharge to the Hudson River will only be permitted if the observed leachate quantities and concentrations will have no adverse impact on the river. If river discharge proves unacceptable, the leachate will be collected and treated.

Stormwater Drainage System - The stormwater drainage system will intercept and convey stormwater runoff that will directly affect the containment site. Runoff on the containment site and from the watershed north of the containment site, will be transported by the drainage system to the Hudson River.

The components of the drainage system entail a combination of swales, open channels, and closed conduits.

Access Road - An access road will be provided between Route 4 and the chemical feed building. This roadway will permit access to tank trucks delivering bulk chemicals, as well as access and parking for contractor, engineering, and DEC personnel.

Chemical Feed System - The pumps, piping, tanks, and dilution water needed for the chemical feed system for the treatment of the dredged slurry will be housed in a chemical feed building.

Appurtenances - Also included in the construction site requirements are electrical services, fencing, seeding, clearing and grubbing of wooded areas, and establishment of monitoring wells.

Applicability: This alternative applies to long-term storage of PCB-laden remnants and sediments which are dredged from the Upper Hudson River. The alternative is well suited in this application because of the location and specific siting and design criteria which have evolved during its development.

Technology Status: This alternative requires technology which is generally available, routine, and nonexperimental. Key elements, which are surface dewatering, landfill design, treatment of leachate, collection and routing of leachate, and closure and post-closure maintenance, are widely practiced in the management of hazardous waste sites. The integration of these elements, though not commonly applied to hazardous waste sites because hydraulic loading is generally not a factor, is very commonly applied and integrated in well-established industrial waste management. Such industry experience is common for red-mud aluminum waste, papermill waste, and copper mining wastes.

Risk and Effect of Failure: This alternative has a very low probability of failure and very low probability of risk, and is therefore an extremely low-risk alternative. This assessment is based on the fact that it is technically feasible to contain and store PCB-laden sediments in a properly designed landfill as proposed, and that the consequences of failure to contain are slight because of site factors, such as abundance of native clay subsoil, and distance to potential health vectors.

Time Required to Achieve Cleanup/Isolation: The construction of the containment site and treatment plant facilities would occur during the first year of the dredging program. Dredging will begin in the second year and will be completed in the third year. Final cover and regrading of the site and destruction of the earthen dikes for the roughing and storage pond and surge pond will take place in the fourth year. Therefore, the containment of PCB-laden sediments will require a total of four years.

Ability to Meet Public Health and Environmental Criteria: This alternative meets or exceeds current appropriate regulatory requirements, environmental standards, and public policies under current enforcement guidelines. These requirements, standards, policies and guidelines are dynamic and subject to future change.

Degree of Cleanup/Isolation Achievable: Based upon review of the design for the containment site, the degree of isolation appears to be high to very high.

Ability to Meet Legal and Institutional Requirements: This alternative should meet the requirements under RCRA for a PCB landfill. However, the containment area as designed will not meet groundwater or liner requirements, because of the proximity to groundwater, and a waiver from the EPA administrator would be required. In addition, a NPDES permit would be required for any discharge from the leachate collection system. State permits may be required for the construction of the containment site and the transport and disposal of hazardous material. Land use may also require local building permits.

Ability to Minimize Community Impacts: This alternative has a moderate ability to minimize community impacts. There is current litigation and citizen-group organization, but these are not necessarily negative impacts.

Commercial Impacts: This alternative will have a very low impact on the offsite commercial sector after completion, with a moderate impact during construction and operation. The site itself would not have wildlife or agricultural value equivalent to its earlier potential use.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.5 Remedial Alternative: Dredging of 40 Hot Spots

Description: The alternative addressed in this section is essentially a combination of activities comprising the removal phase of the 40-hot-spot dredging program set forth by NYSDEC in the Draft Environmental Quality Review Document of September 1980. This program called for the use of conventional hydraulic and mechanical dredging systems to achieve the removal of the 40 hot spots which were identified in the Upper Hudson River.

The first year of the program is to be spent resampling and remapping the bottom sediments to afford more accurate and up-to-date hot-spot delineations and sediment characterizations. It is recognized by State officials that it will not always be desirable to dredge contaminated wetlands because of their valuable contributions to river species diversity and bioproduction. Therefore, in the year prior to dredging, an analysis of PCB losses from wetlands due to volatilization, scour, and biouptake is to be made so that the ecological value of wetlands can be weighed against the risks posed by the continued presence of PCBs.

In the second year of the program, both hydraulic cutterhead suction dredges and clamshell dredges with mechanical pumpout systems are to be employed in removing the hot spots in the Thompson Island Pool. In the third year, the clam shell dredge/hydraulic pumpout system alone is to accomplish the removal of the 20 remaining hot spots in the Lock 6 through Lock 1 pools.

Detailed, contractually binding, mitigating measures designed to limit adverse environmental impacts and to maximize the efficiency of PCB removal are to be incorporated in the final design specifications. Mitigating measures applicable to dredging and transportation of dredged material include:

- Hot Spot Delineation - Additional sediment samples would be taken prior to any remedial dredging to better define the depth and areal extent of contamination. The existing sediment PCB data-base is accurate enough for planning, but not for implementation of a hot-spot dredging program. The data are fairly complete for the upper pools, but become more intermittent with distance downstream. Additional data are desirable to more precisely define the hot spots in order to ensure accurate removal of contaminated material.

- Overcutting - when possible, a removal depth of approximately 36 inches will be maintained to ensure the removal of all contaminated sediments and to avoid the direct exposure of highly contaminated strata to the water.

- Scheduling - Dredging would take place during the low-flow period between May 15 and September 15 (or until higher flows resume in the fall) to minimize downstream PCB losses.

- Operator Precautions, Hydraulic Dredge - PCB losses from the hydraulic dredge would be minimized by contractual control of the cutter and swing speed.

- Operator Precautions, Clamshell Dredge - PCB losses from the clamshell dredge would be reduced by limiting the hoisting speed through the water column, and by positioning the dredge and receiving barge so as to minimize the length of bucket swing about the water. A dredge bucket with a capacity of at least 5 cu yd will be specified to ensure the proper depth of cut. Overlapping of dredge cuts will be specified to ensure that contaminated sediments which slough into the previous cut will be recovered.

- Hydraulic Dredge Modifications - The feasibility of placing a shroud over the top of the cutter in order to increase suction efficiency and to limit the escape of suspended material will be examined carefully in the design phase. Other innovative approaches, including installation of a dustpan-type head, will be examined.

- Clamshell Dredge Modifications - Tight seals on the bucket lips will be required. The feasibility of placing a shroud over the top of the bucket or completely enclosing the bucket to reduce washout during hoisting will be assessed in the design phase.

- Floating Boom - Where dredging results in a floating scum, a floating boom would be positioned downstream from the work site. The employment of such a boom should not impede navigation and would be dependent on favorable current conditions. The boom would be cleaned at least daily, and the trapped material placed in the disposal site.

- Silt Curtain - Where dredging results in an extensive surface plume, a silt curtain may be required. The curtain would extend from the water surface to a point midway in the water column.

- Marsh Restoration - If it is determined that the benefits of dredging a particular contaminated marsh hot-spot outweigh the adverse impacts of habitat loss, and one or more wetlands are removed, marsh restoration may be a feasible mitigating measure. Malcolm Pirnie (1980) has outlined the steps required for marsh replacement following dredging. These steps are summarized below:

  - Dredged areas would be filled with uncontaminated sediments to predetermined, above-grade elevation.

  - Following settling and consolidation, areas would be filled and/or graded to final elevation.

  - Upstream structures may be required in order to minimize scour; downstream silt screens may be needed to minimize sediment loss.

  - After final grading, nursery-grown stock or sprigs from nearby marshes would be transplanted and maintained for at least one season.

Malcolm Pirnie noted that replacement plants must be set out at the same elevations that pre-existing or nearby plants of the same species are established. Avoidance of areas subject to high velocity and scour is necessary in achieving successful restoration.

Pirnie reported successful regeneration of wetlands with Peltandra virginica (arrow arum), Pontederia cordata (pickerel weed), Sagittaria latifolia (duck potato), Scirpus americanus (American three square), Typha sp. (cattail) and Leersia oryzoides (rice cut grass). All of these species are found in the existing Upper Hudson marshes.

- Shoreline Conditions - During the dredging design phase, detailed field studies and analyses will be undertaken to minimize interferences with overhanging trees and to avoid river bank instability.

- Hydraulic Dredge Pipeline - Where navigation may be impeded, it would be necessary to submerge the pipeline.

- Pipeline Leaks - While small leaks are inevitable, operation would be stopped immediately if a major leak or a break occurred.

- Hydraulic Pumpout of Barges - In order to reduce leakage, welded connections would be used in the pipeline construction, and a check valve installed at the pumpout station to prevent backflow.

- Loading of Barges - Sufficient freeboard must be maintained inside the barge to prevent overflow or spillage during transport. Alternatively, a splashboard could be installed around the top of the barge, permitting complete filling and thereby maximizing productivity.

Applicability: This alternative is applicable to contaminated river bottom sediments only.

Technology Status: Standard mechanical and hydraulic dredging equipment has been in use for years and is currently used in the study area for routine channel maintenance. The application of conventional dredging equipment for removal of contaminated sediments for a natural waterway has not been tested on a large scale.

The Mudcat dredge, a small hydraulic dredge with a horizontal cutting bar, has, in recent years, been successfully employed in removing toxic sludges from industrial waste impoundments. In the Lower Hudson River, a Mudcat was used to attempt the cleanup of cadmium-contaminated sediment in Foundry Cove . After multiple passes and removal of 5,000 cu yd of sediment, the dredge was found to have removed an estimated 5-6 tons of cadmium, while leaving nearly 50 tons still remaining. Dredging by this method was judged to be ineffectual.

The Pneuma dredge, a small flexible pneumatic system, has been used to clean up PCB-contaminated sediments from the Duwamish River estuary in Washington. This dredge, in combination with hand dredging, effected 90 percent recovery of 265 gallons of Aroclor 1242. Unfortunately the conclusions of this study are not applicable to Hudson River dredging since the Duwamish problem was one of a fresh PCB liquid spill confined to a relatively small area of soft, fine sediment.

Dredging system alternatives have been evaluated by Malcolm Pirnie, Gahagan and Bryan, and WAPORA, and the conclusions were that a combination of cutterhead suction dredging and mechanical clamshell dredging with hydraulic unloading of hopper barges was the most appropriate method available. A brief discussion of each is provided below.

Hydraulic dredges mix ambient water with subaqueous material to form a slurry which is pumped through a floating or submerged pipeline to its destination. Cutterhead suction dredges of the type specified for the program make use of rotating, circular cutter blades at the end of a suction pipe. With the cutterhead, a wide variety of material, from fine silts to decomposed rock fragments, may be removed. The use of such dredges is advantageous for dredging in the Upper

Hudson River, where a heterogeneous mixture, including chunks of wood, is expected to be encountered.

This system offers the additional advantage of one-time handling of material between the dredging operation and disposal area. Subsequently, large volumes of material are moved economically because of a virtually continuous operating cycle. Continuous handling also minimizes the potential for accidental spills.

One of the technical drawbacks of the suction dredge system is that it requires approximately one booster pumping station for each mile of pipe through which the dredge material must be transported. Under the original program, the operation of the hydraulic system was to have been limited to the Thompson Island pool because of the high costs associated with booster stations and long pipelines needed to connect the proposed containment area with the dredge operation in remote pools. With the availability of the proposed containment site in question, the use of hydraulic dredges can be considered for downstream pools, if multiple sites are used.

Gahagan and Bryan report that the operation of a single, 16-inch cutterhead suction dredge would require one derrick barge, two 16-inch booster pumps, two bulldozers, one small tug, one tender tug, one fuel barge, one work barge, pipeline, and miscellaneous machinery.

Clam shell dredges consist of a barge-mounted crane equipped with a heavy, double-leaved, hinged bucket which is lowered into the sediment. The bucket is then hoisted above the hopper, and excavated material is loaded into adjacent hopper scows for transport to the disposal area. A hydraulic pumpout system is to be used to transfer dredged material from the barge to the handling area. This is preferable to mechanical handling since it speeds up handling and reduces spillage. To operate the hydraulic pumpout system, the sediment in the hopper scow is mixed either with ambient river water or recycled water from the treatment plant to form a 15 percent slurry. The slurry is then pumped to the handling area.

The clam shell dredge has the advantages of being easily obtainable and very mobile. When the clam shell dredge/hydraulic pumpout system is used with recycled treatment plant water, it has the advantage of avoiding the contamination of large volumes of river water.

Clam shell dredges are less precise than hydraulic dredges, and the potential for loss of contaminated material is greater. Clam shell dredge buckets also have problems with penetrating compacted layers of sediment. These disadvantages can be minimized by a skilled operator and the specified use of certain mitigating measures.

Under the proposed plan this system would require two clam shell dredges, two work barges, five hopper scows, one 800 hp tug boat, two tender tugs, pumpout and unloading machinery and piping, plus miscellaneous equipment .

Since all equipment needed is currently available and all mitigating measures and special modifications require no substantial research and development, the technical feasibility is high.

Risk and Effect of Failure: It was contended by NYSDEC and their consultants that this program was the most implementable and cost-effective approach, achieving the greatest reduction in sediment PCB-load per dollar expended and per acre of riverbed exposed. Considering the expected PCB losses during the dredging operation in addition to the uncertainties in PCB recovery due to the hot-spot scour and analytical and sampling variability, the risk of failure to achieve the objective may be moderate.

In the long term, failure to achieve the objective will not result in a level of environmental damage or public health risk which is substantially higher than that which now exists. Short term problems, in the form of elevated water and air concentrations and increased fish contamination as a result of the disturbance of highly contaminated sediments, are a distinct possibility. The project expenditures in the case of failure will not be a total loss since valuable information regarding the cleanup of contaminated waterways will be obtained.

Time Required to Achieve Cleanup/Isolation: Writing and reviewing technical specifications, bidding, making contractual arrangements, and obtaining all necessary permits will take a minimum of one year. During this time resampling and wetland analysis can take place. Actual dredging operations will take two seasons. The completion of the project can therefore take place within a minimum of three years.

Ability to Meet Public Health and Environmental Criteria: The rationale behind the 40-hot-spot dredging program assumes that river bed contributions to water, biota, and air pollution are related to the sediment PCB concentration and that, all factors being equal, elimination of the areas of highest contamination will achieve a reduction in biouptake, desorption, resuspension, and volatilization of PCBs.

It is reasonable to assume that PCB contributions to the water column by bottom sediments are heavily dependent on concentration. On a system-wide basis, however, the relative areal extent of highly contaminated sediments versus less contaminated areas should be considered. The areal extent of cold areas is nearly 17 times the total area of hot spots. The relative contributions of extensive cold areas with average PCB concentrations of 20 µg/g should be weighed against the contribution of a relatively small area with an average concentration of 127 µg/g. Moreover, when the contention is accepted that hot spots, by their nature, form in protected, low-velocity, low-turbulence areas; then it must also be accepted that scouring during high flows would be less for hot spots than for cold areas, and also that during low flows the dispersal of desorbed PCBs is less because turbulent and diffusive transfer mechanisms are reduced. In the short term, removal of PCB hot spots may not reduce water column concentrations, and hence PCB volatilization rates as dramatically as expected. In the long run, removal of hot spots will reduce the amount of PCBs in the river and possibly the time of exposure of the environment to PCB contamination.

Removal of PCB hot spots could reduce fish contamination. Much of the microfauna and small fish biomass on which the larger species feed is produced in shallow, protected areas, many of which are highly PCB-contaminated. Removal of these areas would substantially reduce the potential for biouptake and accumulation. Removal of only hot spots would ensure that not all of this critical habitat would be destroyed.

Simplified food-web modeling by consultants of NYSDEC revealed that the Upper Hudson hot-spot dredging could possibly reduce fish PCB body burdens by 50 percent. Unfortunately this still leaves an average PCB concentration of 20-40 ppm, and it is estimated that fish concentrations may not reach acceptable levels in less than a decade unless the ambient water concentration is reduced to 0.01 ppb. A strong connection between hot spot removal and the recovery of the fishery, however, has never been made.

Degree of Cleanup/Isolation Achievable: The hot-spot dredging program will attempt to recover 1,453,000 cu yds of sediment contaminated with 170,000 pounds of the 290,000 pounds of PCB estimated to be in the Upper Hudson River bottom sediments. Factors detrimental to the achievement of this goal include:

- Sediment losses to the dredge plume.
- PCB-contaminated sediments missed by the bucket or dredgehead.
- Accidental spills and pipeline breaks.
- Hot-spot movement.
- Accuracy of hot-spot delineations.

Inaccuracies in dredge cut positioning and depth control, sediment sloughing, and difficulties with obstructions and debris will cause any dredging project to be less than 100 percent effective in retrieving all of the desired material. In addition, the operations themselves generate plumes of suspended material, most of which may never by recovered.

A review of common dredging practices in relation to the recovery of contaminated sediments revealed that during normal operations, efficiencies may be as low as 65 percent. On the other hand, implementation of double-pass dredging to obtain the remaining contamination yields a substantial amount of uncontaminated sediment which must be treated as hazardous material. Tofflemire concluded by recommending the consideration of preplanned overlaps and dredge cuts controlled with the aid of modern electronic locating equipment.

In another study, Tofflemire reported that conventional dredges in the Hudson River often created a highly PCB-contaminated surface scum. This scum could be contained with a floating boom positioned downstream from the dredge.

Malcolm Pirnie, Inc., estimated that unrecovered sediment resulting from these loss mechanisms would total about six percent of the amount of material to be dredged when a depth of 36 inches was specified. Assuming that the percentage of PCBs missed or lost during the dredging operation is equal to the percentage of sediment missed or lost, approximately 10,000 pounds of the estimated 170,000 pounds of PCBs residing in hot spots will not be recovered.

The amount of PCBs missed or lost during the dredging operation can be minimized if the mitigating measures which have already been specified are followed. In addition, a comprehensive monitoring plan will be implemented which will require an immediate cessation of dredging activities if specific water quality criteria indicate excessive losses.

Accidental spills and pipe breaks are distinct possibilities. Such losses could be minimized by requiring the immediate halt to activities if such an event occurs. In addition, incentives for secure operating procedures will be offered.

The effectiveness of the 40-hot-spot dredging program will depend heavily on the degree of scour and amount of movement which has occurred in the river since the initial survey was completed in 1978. According to estimates presented earlier in this report, approximately 25,000 pounds of PCBs have been transported over the Federal Dam at Troy. Assuming that the locations of hot spots have not changed substantially and that the transported PCBs originated from turbulent, high-velocity "cold areas," then the maximum amount of PCBs which could be removed (with dredge losses at 6 percent) is about 160,000 pounds, or 55 percent of the total PCB burden of the sediments in the Upper Hudson River. If, on the other hand, the 25,000 pounds of transported PCBs came from the hot spots, then the maximum amount which could be recovered would be 136,000 pounds. This is still 47 percent of the total PCB burden.

The accuracy of hot-spot delineation is an unknown quantity which may substantially influence the effectiveness of the dredging alternative. The ratio of low-to-high PCB analysis results for duplicate samples is at least 3 to 1. This fact casts some doubt about the quality of the data with which hot spots were mapped. The variability of PCB concentration in the sediment itself is extremely high. It is suspected that because low PCB values are often found very close to high concentration values, hot deposits are actually very localized phenomena. It is possible that many more small areas of high PCB concentrations may exist which were never detected. It is also possible that much of the material in designated hot spots need not be removed.

Ability to Meet Legal and Institutional Requirements: If contaminated sediments exceeding 50 ppm of PCB concentrations are removed, they are subject to the regulations and standards under TSCA (Toxic Substances Control Act). In addition, a permit authorized under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act would be required. State permits would be required for the dredging and transport of contaminated sediments and for the disturbance of wetlands.

Ability to Minimize Community Impacts: Excessive noise during the dredging process is a possible adverse community impact. The State estimated that residents within a radius of 1600 feet may experience annoying levels of noise, especially at night. The population density along the project area, however, is low, and dredging should not extend beyond several weeks in any one location. Furthermore, noise levels will be minimized by equipment maintenance and by mufflers.

Removal of PCB-contaminated sediments will cause an adverse community impact in the form of anxiety about PCB volatilization, contaminated cash crops, lower market values for adjacent properties, and general inconvenience. This problem was made clear in the lawsuit against NYSDEC. This lawsuit seeks to overturn the state's decision to grant siting and operating permits. It is likely that many of these fears will not be quieted by scientific reasoning and that the final outcome will be decided by litigation. Therefore the ability of the project to minimize community impacts is low.

Commercial Impacts: Dredging of 40 hot spots in the Upper Hudson River will improve the rate of recovery of the fishery, but the time it will take before the fish population becomes suitable for use is unknown. In the short term, dredging equipment may interfere with river traffic; however, the future use of the river for transportation and hydroelectric power would be assured. Therefore, the effects of the 40-hot-spot program on the commercial environment is favorable.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.6 Remedial Alternative: Reduced-Scale Dredging

Description: The original 40-hot-spot dredging program was rescoped, and substantial changes were made to increase the cost-effectiveness of the dredging alternative. Cost analyses by Malcolm Pirnie, Inc., have shown that the costs of dredging, transport, and treatment of the sediments in the 20 hot spots of the Thompson Island pool are the lowest of any other pool in the Upper Hudson River.

Dredging of Thompson Island Dam pool hot spots is advantageous for a number of reasons; these deposits have, with few exceptions, the highest PCB concentrations per unit area when compared to other hot spots. Studies have also shown that hot spots in this reach are the most susceptible to scour. Only one hot spot (number 18) is associated with a major wetland. Finally, if the proposed containment site is approved, transportation difficulties will be minimized by the close proximity of the site.

The reduced-scale dredging program will proceed along the lines outlined by Malcolm Pirnie, Inc., for the 40-hot-spot dredging program. Sampling and wetland analysis will take place during the first year before dredging. Both hydraulic and clamshell dredging systems, similar to those outlined above, will be used to dredge the hot spots in the second season. If the program is highly successful, information and experience gained can be used to evaluate the cost-effectiveness of dredging hot spots in lower reaches.

Applicability: The reduced-scale project is applicable to bottom sediments between the Thompson Island Dam and Rogers Island.

Technology Status: Applicable dredging technology has already been reviewed and shown to be suitable for recovering contaminated sediments. Essentially no dredging process design changes are required for the reduced-scale project.

Risk and Effect of Failure: The reduced-scale project does not introduce additional risks beyond those of the original 40-hot-spot program. In fact, the reduced-scale project will have less of a conflict with wetland destruction than the original plan.

The effects of failure, in terms of cost, will be reduced because of the lower expenditures.

Time Required to Achieve Cleanup/Isolation: As in the original project, probing and sampling the sediments will take approximately one year. The dredging of the Thompson Island pool will require one season. Therefore, the cleanup and isolation of the desired material will take less than two years to accomplish.

Ability to Meet Public Health and Environmental Criteria: As with the full scale project, the relative contribution to PCB buildup of the hot spots, compared to the contribution of cold areas, should be evaluated. However, the reduced-scale project will attempt to clean up a relatively larger area for the amount of money expended. Therefore, even though the degree of environmental cleanup may be less for the reduced-scale project, the amount of improvement per dollar expended should be greater than for the full-scale project.

Degree of Cleanup/Isolation Achievable: Dredging of the Thompson Island pool will attempt to remove 645,000 cu yds of material and 106,000 pounds of PCBs. Assuming a 6 percent loss of material, which is proportional to the amount of PCBs missed or lost, the maximum amount of PCBs which could be removed is 99,000 pounds, or 35 percent of the total PCB burden of Upper Hudson River bottom sediments.

Movement and scour of hot spots in the Thompson Island Dam Pool is liable to be much more severe than in other pools. If hot-spot dispersal has occurred, it may not be desirable to implement the reduced-scale project unless new hot spots have been formed and can be located. A limited sampling program designed to detect changes in hot spots has recently been completed. Analysis of the data showed that some hot spots may have moved while others did not, confirming the need for sampling if any in-river remediation is taken (see Appendix E).

In light of the possible changes in hot spots in the Thompson Island pool, it might be desirable to consider the dredging of hot spot number 34 in the lock 5 pool. This is a massive deposition area which is located at the mouth of lock 6. It is possible that if substantial scouring has occurred in the Thompson Island pool, much of the transported material may have settled in that area.

Ability to Meet Legal and Institutional Requirements: If contaminated sediments exceeding 50 ppm of PCB concentrations are removed, they are subject to the controls under TSCA (Toxic Substances Control Act). In addition, a permit authorized under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act would be required. State permits would be required for the dredging and transport of contaminated sediments and for the disturbance of wetlands.

Ability to Minimize Community Impacts: Reduction in the amount of sediment to be removed is expected to reduce those community concerns that were outlined in the 40-hot-spot alternative. Therefore the ability to minimize community impacts is only moderate to low.

Commercial Impacts: Dredging in one pool will not require any barge traffic through the lock system; therefore, the impact of the reduced-scale project on commercial shipping may be lower than for the 40-hot-spot project.

It is believed that most of the PCB-contaminated material which moves into the estuary originates from the Thompson Island Dam pool. Cleanup of sediment in this area, if the expected amount of material can be recovered, should have the same effect on the lower Hudson River fishery as the 40-hot-spot program. The dredging of the 20 Thompson Island pool hot spots, however, may not substantially improve the recreational fishery in the Upper Hudson below the Thompson Island Dam.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.7 Remedial Alternative: No-Action for River Sediments, Routine Dredging Continues, Water Supply is Not Treated

Description: Routine channel-maintenance dredging would remove approximately 5,000 lbs of PCBs per year over the next 10 years or about 15 percent of the estimated Hudson River PCBs according to estimates in the DEIS. No other action will be taken with respect to the contaminated sediments.

Applicability: Routine channel dredging is necessary for navigational purposes.

Technology Status: The technology for dredging currently exists; routine dredging is currently performed.

Risk and Effect of Failure: No PCBs are being removed under this alternative except those PCBs removed by routine dredging. The possible impacts of this alternative are reviewed in Chapter 5.

Time Required to Achieve Cleanup/Isolation: None

Ability to Meet Public Health and Environmental Criteria: The concerns expressed in Chapter 5 will still exist. Natural mechanisms will predominate in the reduction of PCB levels. Fish-flesh PCB levels will remain elevated, and monitoring of PCB levels in air, drinking water, and fish flesh will have to be maintained.

Degree of Cleanup/Isolation Achievable: None.

Ability to Meet Legal and Institutional Requirements: None needed.

Ability to Minimize Community Impacts: Short-term, construction-related effects would be avoided. Long-term effects due to concern about the presence of the contamination in the river would continue.

Commercial Impacts: Commercial and recreational fisheries of the Hudson River would still be threatened. A potential impact of increased contamination of the Lower Hudson River sediments would require routine monitoring.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.8 Remedial Alternative: No Action for River Sediments, Routine Dredging Continues, Water Supply is Treated

Description: Routine channel maintenance dredging would remove approximately 5000 pounds of PCBs per year over the next 10 years or about 15 percent of the estimated Hudson River PCBs. Water treatment can reduce PCB content in drinking water by 40-80 percent using granular activated carbon filtration, reducing PCB levels from the present approximate level of 0.02 ppb to an undetectable level.

Applicability: Granular activated carbon filtration is applicable to removal of PCBs from potable water supplies; this method is currently being used.

Technology Status: The technologies currently exist and are well established.

Risk and Effect of Failure: Failure of the granular activated carbon filtration would result in higher PCB concentration in water for human consumption. Concentrations would be expected to increase to the present level of about 0.02 ppm.

Time Required to Achieve Cleanup/Isolation: The total time required would depend on the time required to design and bid the water-supply granular-activated-carbon filtration system. This alternative could be implemented within one month.

Ability to Meet Public Health and Environmental Criteria: Under this alternative, exposure to PCBs could still occur by:

- Ingestion of contaminated fish and aquatic life

- Inhalation of PCBs absorbed onto particulate matter

- Dermal and possible oral exposure through use of the Hudson River for recreational purposes

- Ingestion of terrestrial wildlife feeding on contaminated materials

Monitoring of air and fish flesh will be required on a continuing basis.

Degree of Cleanup/Isolation Achievable: This alternative will virtually eliminate PCBs in the potable water system at Waterford. It will not affect the PCBs in the river.

Ability to Meet Legal and Institutional Requirements: No permits would be required.

Ability to Minimize Community Impacts: Short-term, construction-related effects would be avoided. Long-term effects due to concern about the existence of the PCBs in the river will continue to exist.

Commercial Impacts: Commercial and recreational fisheries of the Hudson River would still be adversely affected. Because of the potential for increased contamination of sediments in the Lower Hudson River, routine monitoring would be required.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.9 Remedial Alternative: Total Removal of all Remnant Deposits

Description: Total removal of the remnant deposits would entail movement of 370,000 cubic yards of contaminated material containing some 49,000 lb of PCBs. This alternative would include removal of materials with low levels of contamination. The contaminated material would have to be disposed of by hauling to a secure containment site or by detoxification or incineration. This alternative would involve an extensive amount of sampling for PCBs on exposed sediment banks above the former Fort Edward Dam to ensure that all contaminated sediments were removed.

Applicability: Total excavation of the remnant sites is applicable to all material which contains PCBs upstream from the former Fort Edward Dam. This would include, but not be limited to, the five previously defined remnant deposits.

Technology Status: Complete excavation and removal of contaminated soils is a proven technique for remediation of uncontrolled hazardous materials.

Risk and Effect of Failure: Failure could occur due to missed small PCB deposits, from contaminated areas formed during hauling, from contamination at the containment site, or from incomplete disposal methods. The impacts of these failures would be minimal because they should be very small in scale.

Time Required to Achieve Cleanup/Isolation: This alternative would require the clearing, grubbing, and construction of haul roads; excavation, hauling, and disposal of contaminated sediments; and regrading and revegetation of the disturbed areas. Assuming that construction proceeds simultaneously at all five remnant deposit sites, the construction phase would probably require two construction seasons to complete. This period does not include the completion of a containment site which may or may not be constructed concurrently.

Ability to Meet Public Health and Environmental Criteria: Total removal of the remnant deposits may lead to slight decreases in the PCB contamination levels in the Hudson River. It will reduce the possibility that humans could be directly exposed to contaminants by walking on the site.

Degree of Cleanup/Isolation Achievable: Complete cleanup of the contaminated material in the remnant deposits is possible through this alternative.

Ability to Meet Legal and Institutional Requirements: Regulations under TSCA will be applicable to the removal of sediments with PCB concentrations greater than 50 ppm. A State permit would be required for the transport of contaminated material from the remnant deposit sites. Local permits might also be required.

Ability to Minimize Community Impacts: If implemented, this alternative would have separate effects during construction and after construction. During construction, if disposal of the hazardous material involves trucking, there may be impacts on traffic, roads, air pollution levels, noise levels, and the employment in the surrounding communities. Employment opportunities may increase regardless of the alternative chosen; however, the alternative with the largest quantity of work will provide the most stimulation of the local economy. Other post-construction impacts include rise in property values and higher health standards.

Commercial Impacts: Impacts on the commercial industry should be positive. Future construction along the river below Glens Fall would be more likely because the threat and notoriety of PCBs would be reduced.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.10 Remedial Alternative: Partial Removal of Remnant Deposits

Description: With an assumed cut-off point of 50 ppm for PCB concentration, partial removal of the remnant deposits will entail removal of material from deposits 3 and 5. Deposit 3a has previously been removed, while deposits 1, 2, and 4 have an average PCB concentration of below 50 ppm throughout the deposits and would not require removal.

Applicability: This alternative is applicable to remnant sites 3 and 5, since they meet the assumed requirements of PCB concentrations higher than 50 ppm. If the 50 ppm requirement is changed for any reason, the sampling information must be reviewed.

Technology Status: The partial removal of the remnant deposits would have a high technology rating according to state-of-the-art procedures. This alternative leads to complete or nearly complete removal of PCBs above 50 ppm within the remnant deposits.

Risk and Effect of Failure: If proper construction and safety techniques are followed, there is a very small risk of PCBs entering the environment from deposits 3 and 5. Problems could occur from exposed PCBs at the remaining deposits and from PCB remaining at deposits 3 and 5, but the low concentrations in these areas make it unlikely that they will be serious.

Time Required to Achieve Cleanup/Isolation: In order to excavate, haul, and dispose of the sediments, and to regrade and revegetate the disturbed areas, one construction season would be required, assuming that operations would proceed simultaneously at both remnant deposit sites.

Ability to Meet Public Health and Environmental Criteria: Partial removal of the remnant deposits will prevent public contact with highly contaminated soils. Although deposits 1, 2, and 4 will not be removed, their relatively low PCB concentrations pose decreased public and environmental threats. One concern is the increased air and (to a lesser degree) water contamination by PCBs due to direct handling of the contaminated material during construction, and potential spills during transport. This should be a short-term environmental effect.

Degree of Cleanup/Isolation Achievable: If the results of the testing program are updated sufficiently to allow for correct estimates of PCB concentrations versus depth, this alternative should eliminate high-level PCB concentrations in the remnant deposits. It will not eliminate public access to remnant areas with less than 50 ppm PCBs.

Ability to Meet Legal and Institutional Requirements: Regulations under TSCA will be applicable to the removal of sediments with PCB concentrations greater than 50 ppm. A State permit would be required for the transport of contaminated material from the remnant deposit sites. Local permits may also be required.

Ability to Minimize Community Impacts: Community impacts will result from the truck traffic while contaminated material is removed and topsoil replaced. Leaving some sites untouched may cause concern among the residents in the areas.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.11 Remedial Alternative: Restricted Access to Remnant Deposits

Description: Under this alternative, measures would be taken to deter access of people, vehicles, and wildlife to remnant deposits. The measures would include:

- Fencing of landward edge of all remedial areas
- Seeding of remnant sites

Applicability: This is applicable to remnant sites with concentrations of PCBs or other hazardous waste materials, and to general cases of restriction from public contact.

Technology Status: Restricted access methods are proven, well-established methods. They are easily implemented in a situation similar to this, but in the same manner they are easily removed through such acts as vandalism.

Risk and Effect of Failure: A relatively low-to-medium probability of failure is associated with these measures. Problems may arise from human ignorance or error, such as ignoring warning signs or incorrect construction techniques. The probability of these types of problems is highly variable.

Time Required to Achieve Cleanup/Isolation: One construction season will be required to install the fences and signs and to seed the remnant deposits.

Ability to Meet Public Health and Environmental Criteria: Restricting access to the remnant deposits does curb public contact with PCBs, but does not affect PCB movement into the environment.

Degree of Cleanup/Isolation Achievable: This alternative will provide only minimal isolation.

Ability to Meet Legal and Institutional Requirements: No requirements are expected with the possible exception of local permits.

Ability to Minimize Community Impacts: Community impacts from construction would be low due to the ease of construction for the alternative; however, the impacts would be high due to concerns resulting from the PCBs remaining.

Commercial Impacts: Commercial impacts will be very low from this alternative.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.12 Remedial Alternative: In-Place Containment of Remnant Deposits

Description: This alternative entails the placement of a 2-foot-thick layer of soil over the existing remnant deposits, seeding the soil, and protecting the associated river banks with riprap. Remnant deposits 3 and 5 have previously been regraded and "riprapped" so this action will be required at deposits 2 and 4 only.

Applicability: This alternative is applicable to the remnant sites upstream from the former Fort Edward Dam. Remnant deposit 3a has already been removed, thereby eliminating it. The exact extent of the deposits will have to be determined in the field during Remedial Investigation to assure complete containment of the hazardous material.

Technology Status: Use of an impermeable cover and bank reinforcement to contain hazardous wastes has proven adequate in the past. Proper equipment and procedures must be maintained during placement of the cover, while bank reinforcement material must be properly placed and sized to prevent scour and erosion.

Risk and Effect of Failure: A relatively low probability of failure exists if proper engineering and construction techniques are followed. PCB-contaminated material may enter the environment through groundwater movement beneath the proposed cap; however, the likelihood of contamination spreading would be decreased if a soil cover were emplaced.

Time Required to Achieve Cleanup/Isolation: This alternative would require the clearing, grubbing, and construction of haul roads; development of a borrow site; excavation, hauling, and placement of topsoil, subsoil, and riprap; and revegetation of the remnant deposit areas. Approximately two construction seasons may be required for the simultaneous containment of all five deposits.

Ability to Meet Public Health and Environmental Criteria: In-place containment of the existing remnant deposits will reduce PCB losses into the environment. This alternative is also beneficial from an environmental standpoint since contaminated sediments should not be stirred up during construction.

Degree of Cleanup/Isolation Achievable: This alternative will prevent public contact with the PCB-contaminated remnant material. It will not prevent the such material from entering the environment.

Ability to Meet Legal and Institutional Requirements: Federal permitting may be applicable under RCRA. State construction permit(s) may also be required for the placement of soil cover. Local permits may be applicable as well.

Ability to Minimize Community Impacts: This alternative will minimize community impacts. Traffic noise and pollution will last only during construction.

Commercial Impacts: Covering the remnant areas will have minimal commercial impact.

PCB entry into the river will be reduced, thus reducing the threat of increased contamination in the lower estuary.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.13 Remedial Alternative: In- Situ Detoxification of Remnant Deposits By Use of KOHPEG System

Description: Potassium hydroxide (KOH) and polyethylene glycols (PEG) react with and destroy polychlorinated biphenyls (PCBs), producing reaction products of aryl polyglycols and biphenyls. The presence or absence of air apparently has little effect on the reaction. Reaction time is reduced with increased temperatures; however, the reaction will proceed under ambient conditions.

KOHPEG has not been applied in the field to soils containing PCBs, but application to remnant sites conceptually might proceed as follows. KOHPEG could be sprayed on the remnant site, followed by rototilling. The amount of reagent to be applied would be equal to 6 percent of the weight of remnant deposits being treated. This weight could be determined initially by assuming a depth of treatment, perhaps 12 inches. The best time for applying the reagent would be late spring in order for the reaction to have the benefit of the warm temperatures during a full summer. The following year, testing could be done to establish the level at which PCBs have been destroyed, and that layer of decontaminated remnants could be removed for disposal.

This sequence of operations could be repeated until the full depth of the remnant deposits had been decontaminated. Adjustments in the application rate and the frequency of rototilling (or perhaps even deleting rototilling) on subsequent applications could be made, based on the results obtained from the previous application.

Applicability: The in-situ detoxification of remnant deposits could be applicable to all five remnant deposit areas, if it were to be used.

Technology Status: The KOHPEG system is still in the laboratory stage, where work has been done on PCBs contained in transformer oils, sands, and soils.

The use of KOHPEG to destroy PCBs contained in soils seems to show promise. While PCBs contained in sand have been destroyed in the laboratory in a few days, PCBs in soils containing significant organics take significantly longer, perhaps several months. A field application test is expected to begin in the summer of 1984, and a projection is that 12 to 18 months will be required for development of techniques for large-scale application. Additional research is required to establish dilution ratios for the reagent, dosage rates, and methods of application, as well as to develop procedures that will assure contact of the reagent with the contained PCBs.

Risk and Effect of Failure: The probability of failure of KOHPEG is dependent upon the degree to which the solution comes in contact with the PCBs. Providing sufficient contact is made for the required period of time, virtually all PCBs will be destroyed. In the event of failure, however, the PCBs may possibly become exposed to the atmosphere and to the general public, or may be transported into the river through erosion.

Time Required to Achieve Cleanup/Isolation: It may take several months for the reagent to destroy the contained PCBs, and the speed of the reaction increases with increasing temperatures. It would follow that it will likely require at least one summer season for destruction of PCBs after the reagent is applied. The time to treat all remnant areas to full depth of contamination will depend upon the availability of adequate quantities of reagent and upon the manpower commitment to treat several areas concurrently. It is not possible at this time to predict the total elapsed time.

Ability to Meet Public Health and Environmental Criteria: Acute toxicity tests have been performed on the reaction products from the destruction of PCBs in transformer oils, and they were found to have no biological activity other than being a mild eye irritant. No long-term biological tests have been performed. Polyethylene glycols in the laboratory have been degraded by anaerobic bacteria. It is expected that reaction products will be biodegradable since they contain oxygen. Analyses of transformer oil and the reaction products after treatment of PCB-contaminated transformer oil revealed no evidence of PCBs, polychlorinated dibenzofurans (PCDF), or polychlorodibenzodioxins (dioxins).

Degree of Cleanup/Isolation Achievable: Assuming that the KOHPEG mixture comes in contact with all PCBs present, essentially 100 percent cleanup is achievable.

Ability to Meet Legal and Institutional Requirements: No requirements are expected.

Ability to Minimize Community Impacts: This process will minimize community impacts if no digging of the contaminated remnants is required for the reagent to contact all contained PCBs. There may be some volatilization of PCBs during rototilling, but it should be minimal. No transport or treatment off site would be required.

Commercial Impacts: The commercial impacts resulting from the implementation of this alternative will be minimal.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.14 Remedial Alternative: No-Action on Remnant Deposits with Restricted Access to Deposits 3 and 5.

Description: This alternative entails no action on remnant deposits 1, 2, and 4; and restricting access to deposits 3 and 5. Under this assumption, remnant deposits 3 and 5 will require fencing, warning signs, and reseeding.

Applicability: The restricted-access portion of this alternative is applicable to remnant deposits 3 and 5, while no action will be taken on deposits 1, 2 and 4.

Technology Status: There is no technology status involved with the no-action portion of this alternative. The restricted-access portion of the alternative is a well established method. It can be easily implemented for deposits such as those encountered behind the former Fort Edward Dam.

Risk and Effect of Failure: The no-action portion would not appreciably remove or decrease the current PCB concentrations in the environment. Concentrations of PCBs would decrease slowly and it would be many years before the PCBs would finally be flushed from the system.

Restricted access to remnant deposits 3 and 5 would have a low to medium probability of failure. Problems may arise due to human ignorance, error, or vandalism. Major flooding would also cause problems, such as scour and destruction of the chain-link fence and of warning signs. This destruction process would allow the public to be in direct contact with the PCBs.

Time Required to Achieve Cleanup/Isolation: Isolation could easily be achieved in a matter of one construction season.

Ability to Meet Public Health and Environmental Criteria: With no action performed at remnant sites 1, 2, and 4, there will be no restrictions on the availability of PCBs to the environment.

Restricting access to remnant deposits 3 and 5 does curb public contact with the PCBs, but does not allow for decreasing stream concentrations of the substance. As stated in the Risk and Effect of Failure section, scour allows for direct contact of PCBs with the environment. In addition the levels of PCBs will not be significantly reduced in the Hudson River and PCBs can still leach from the remnant areas.

Degree of Cleanup/Isolation Achievable: Since 17.3 out of 50 acres of the remnant deposits will have restricted access, approximately 35 percent of the hazardous materials will be eliminated from direct contact with the public. There will be very little reduction of PCBs in the water system since all of the areas are still uncovered and rainwater can infiltrate the contaminated sediments, washing them into the groundwater system and eventually into the Hudson River. It is therefore assumed that a minimal isolation of the PCBs will be achieved.

Ability to Meet Legal and Institutional Requirements: No requirements are expected with the possible exception of local permits.

Ability to Minimize Community Impacts: Since minimal isolation of PCBs from the environment occurs, there would be a large number of community impacts. It is possible that property values will decrease and individual stress levels increase. If implemented, this alternative would have a noticeable impact on the community.

Commercial Impacts: Impact on the recreational and fishing industries would cause continued losses. Commercial impacts would not be signficantly reduced by this alternative.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.15 Remedial Alternative: Partial Remnant Deposit Removal/Partial In-Place Containment

Description: Under this alternative, remnant deposits 3 and 5 (deposits with PCB concentrations greater than 50 ppm) would be excavated and removed from the site. The remaining deposits would be contained in-place with a soil cover layer and reseeded.

Applicability: This alternative is suitable for all existing remnant deposit areas. As previously mentioned, sediments with PCB concentrations of greater than 50 ppm would be removed, and the remaining contaminated sediments would be contained in place.

Technology Status: Excavation and removal of contaminated soils or sediment is a well established and widely used technology. Surface capping is also a widely utilized construction technique, commonly used for isolation of hazardous wastes in landfills. The overall technology status rating is consequently very high.

Risk and Effect of Failure: Essentially no failure risk is present for removal of contaminated deposits. Proper engineering/construction techniques must be followed to ensure satisfactory performance of a soil cap. There is increased potential for surface water infiltration if the cap is improperly installed or maintained, and a corresponding release of PCBs to the environment may result. Overall, the risk and effect of failure could be low to moderate.

Time Required to Achieve Cleanup/Isolation: It is expected that two construction seasons may be required to complete both simultaneous removal of remnant deposits 3 and 5 and simultaneous containment of deposits 1, 2 and 4.

Ability to Meet Public Health and Environmental Criteria: A combination of removal and in-place containment will largely eliminate the release of PCBs into the environment. Air transport should be greatly reduced by the covering of the remaining deposits. Surface infiltration will be negated, and development of leachate in groundwaters would be minimized.

Degree of Cleanup/Isolation Achievable: Assuming proper construction/placement of the protective coverings, nearly 100 percent of the PCBs in the remnant deposits will be isolated or removed from the environment.

Ability to Meet Legal Institutional Requirements: Requirements under TSCA will be applicable to the removal of sediments with PCB concentrations greater than 50 ppm. State permits might be required for the transport of contaminated material and placement of the soil covers. Local permits may apply.

Ability to Minimize Community Impacts: This alternative will result in low to moderate impacts on the community. It can be expected that traffic congestion and noise will be present at moderate levels during the construction phase. Additionally, it is likely that some public concern about potential health risks may arise since not all of the contaminated material will be removed from the vicinity. There is a possibility of spills during transport and of dust dissemination during excavation activities.

Commercial Impacts: No negative commercial impacts are expected as a result of this alternative. There will be a decreased threat of high PCB levels in navigational dredge spoils requiring secure containment sites for disposal (with a resultant increase in navigation costs). A commercial fishery in the Hudson can be reestablished more quickly than if no remedial action is taken as a result of this option.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.16 Remedial Alternative: Partial Remnant Deposit Removal/Partial Restricted Access

Description: This alternative involves the removal of remnant deposits 3 and 5, which have PCB concentrations above 50 ppm, and restricted access to all remaining contaminated sediments. Access would be restricted by means of fences on the landward sides of the deposits and by placement of warning signs on all sides of the deposits. Additionally, the surfaces of all deposits would be reseeded to induce the establishment of turf.

Applicability: This alternative is applicable to all existing remnant deposit sites. Only the deposit portions with average PCB concentrations above 50 ppm will be removed. Access will be restricted from the remaining contaminated areas.

Technology Status: Both excavation and access restriction techniques are well established and commonly used. The technology status is therefore very high.

Risk and Effect of Failure: Contaminated sediment removal offers minimal "risk of failure". The restricted access methods previously discussed should be sufficient to eliminate the potential for people or animals to come in contact with contaminated sediments. However, the access restriction methods do little to prevent surface water infiltration or high flow scour of the unremoved sediments. As a result, PCBs may be introduced into groundwater or reintroduced into the river system. Accordingly, the overall risk and effect of failure of the combined alternative is moderate.

Time Required to Achieve Cleanup/Isolation: This alternative would require less than one construction season to restrict access to deposits 1, 2 and 4. However, removal of deposits 3 and 5 may require two construction seasons for completion, assuming that operations at both sites are conducted simultaneously.

Ability to Meet Public Health and Environmental Criteria: Up to 88 percent of the total remnant-area PCB mass can be expected to be removed from the remnant deposit areas as a result of this alternative. The remaining contaminated sediments will be subject to surface infiltration, high flow scour, and volatilization. Since these areas constitute a small portion of the overall contamination, the environmental effects should be minimal. Additionally, the restricted access should negate any public contact with the remaining sediments.

Degree of Cleanup/Isolation Achievable: The removal of a large portion of the highly contaminated sediments is proposed. Access by people, animals, and vehicles would be minimized from the remaining contaminated sediments, but scour during high river flows and surface water infiltration into the contaminated sediments would not be controlled in these areas. On the whole, the degree of isolation achievable would still be high since a very large percentage of the PCB mass would be removed from the immediate environment.

Ability to Meet Legal and Institutional Requirements: Regulations under TSCA will be applicable to the removal of sediments with PCB concentrations greater than 50 ppm. A State permit may be required for the transport of contaminated material; local permits may also be applicable.

Ability to Minimize Community Impacts: During the excavation/construction phase of this alternative both noise and traffic congestion are likely to be present to a moderate degree. Public concern is likely since not all of the contaminated sediments will be removed, and the signs and fences will be a constant visual reminder of the presence of hazardous materials in the community. Dust created during excavation and spills during transport could adversely affect the community.

Commercial Impacts: No negative commercial impacts are expected as a result of this alternative. Beneficial impacts could result in that there would be a lower risk of having to deposit dredge spoils in a secure landfill, and quicker reestablishment of the commercial fishery in the river.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.17 Remedial Alternative: Partial Remnant Deposit In-Place Containment/Partial Restricted Access

Description: Under this alternative, access will be restricted from remnant deposits 1, 2, and 4, which contain PCBs in concentrations less than 50 ppm, by chain-link fencing and by warning signs. Remnant deposits 3 and 5 have PCB concentrations in excess of 50 ppm and will be covered by a soil layer and seeded.

Applicability: This combination of alternatives is applicable to the remnant deposits to control the transport of PCBs into the environment.

Technology Status: In terms of state-of-the-art solutions, restricting access and in-place containment of hazardous waste deposits have proven to be a successful approach. Although complete removal or total containment would prove to be more effective in eliminating future PCB contamination, this alternative has a relatively high technology status.

Risk and Effect of Failure: The risk of failure associated with the restricted access to deposits 1, 2, and 4 is high simply because PCBs are still able to come in contact with the environment. Conversely the risk of failure for deposits 3 and 5 would be relatively low, with only the removal alternatives providing a lower risk of failure. PCBs from deposits 3 and 5 would be able to enter the environment if scouring of the impermeable cap occurred as would PCBs from groundwater movement.

Time Required to Achieve Cleanup/Isolation: It is expected that both the containment of remnant deposits 3 and 5 and access restriction to the other deposits can be completed in one construction season if deposits 3 and 5 are covered simultaneously.

Ability to Meet Public Health and Environmental Criteria: The combination of restricted access and in-place containment will result in various public health and environmental effects. Restricting access only prevents direct contact with PCBs by the public. The problems of water and air pollution will not be solved. Selection of this remedial measure will leave the fishing and recreational activities with their current restrictions.

Degree of Cleanup/Isolation Achievable: This particular combination of alternatives will achieve isolation from the environment at deposits 3 and 5, and very little isolation at deposits 1, 2, and 4. Thus 41,000 out of the 47,000 lbs will be isolated, or 88 percent of the PCBs contained in the five remnant deposits.

Ability to Meet Legal and Institutional Requirements: State construction permit(s) may be applicable for the placement of the soil cover. Local permits may also be applicable.

Ability to Minimize Community Impacts: Reduction of community impacts from high-level PCB concentrations will be achieved. PCBs from deposits 1, 2, and 4 will be able to enter the environment at the same rate as is presently being experienced. This situation may lead to decline in property values, health monitoring programs, and increased stress related to these impacts. It is also possible that due to scouring and groundwater movement, small concentrations of PCBs may enter the environment from areas 3 and 5, resulting in the same effects previously mentioned. In all, even though the overall PCB availability is being decreased, there will still be PCBs entering the environment.

Due to the large volume of material which has to be hauled to remnant deposits 3 and 5, traffic problems and roadway damage may occur.

Commercial Impacts: This alternative results in a decrease in PCB movement from the remnant deposits; however, there is very little commercial impact overall.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.18 Remedial Alternative: Partial Remnant Deposit In-Place Containment/Partial In-Situ Detoxification

Description: The combined alternative, in-place containment and in-situ detoxification, will be designed to detoxify those areas with greater than 50 ppm PCB concentrations (remnant areas 3 and 5) with KOHPEG and to contain or isolate those areas with PCB concentrations less than the 50 ppm level (1, 2, and 4) with a soil cover layer.

This combination offers the advantage of detoxification of the most contaminated sediments and isolation of those sediments which are not governed by the Toxic

Substances Control Act (TSCA). The recommended detoxification method is the KOHPEG process and the recommended containment process is that described in Section 9.3.1.12. The final result is that all of the PCBs located in the remnant area will be either detoxified or stabilized and contained.

Applicability: This combination alternative will be applicable to all of the remnant sites and will detoxify or contain all of the PCB's. The detoxification process - KOHPEG - will be used on remnant areas 3 and 5, while areas 1, 2, and 4 will undergo containment and stabilization measures.

Technology Status: The technologies to be used for the containment of the remnant deposits are widely used methods for hazardous waste containment. If correct and accurate measures are taken to assure the integrity of the cover and bank reinforcement, there should be no problems with the PCB's leaching or being scoured during periods of high river flows.

The KOHPEG process is based on technology which is currently experimental in nature. This process is the best suited technology for the in-situ detoxification of remnant sediments. EPA is encouraged by this process and is optimistic about its results.

Risk and Effect of Failure: There is some risk associated with the in-place containment of remnant deposits because PCBs would not be removed from the river system. If a containment liner or erosion control measure were to fail, a PCB release would result. There is not enough information available at this time to determine what effect a release would have, although any release could be a cause for concern.

The risk involved with the use of the KOHPEG process would entail knowing what by-products were formed as a result of the dechlorination process as well as what by-products may result from other contaminants located on site. An additional risk the process poses is that a contaminated source may still exist if 100 percent detoxification is not achieved (due to process or operational errors).

Overall a low risk would result from decontamination of remnant areas 3 and 5, but the critical factor to consider is the status of the technology. Because the KOHPEG process is a laboratory-scale project, the process must be assigned a high risk factor (See Section 9.1.1.2).

Time Required to Achieve Cleanup/Isolation: The in-place containment of remnant deposits 1, 2 and 4 should be completed in one construction season. However, it is likely that the detoxification process will require at least one summer season for destruction of PCBs after the reagent is applied, and it is not possible at this time to accurately predict the total elapsed time.

Ability to Meet Public Health and Environmental Criteria: Environmental and public health criteria can be met with adherence to a strict Quality Control and Quality Assurance program. If the actions are constructed as final designs indicate, no major releases of PCBs should result.

The implementation of this alternative will not reduce the PCB levels already in the river system; it will reduce PCB releases from the remnant sites. In the past, scouring and erosion has removed contaminated sediments from these sites, adding PCBs to the environment. The level of reduction of PCB addition from scouring and erosion cannot be fully determined at this time.

Degree of Cleanup/Isolation Achievable: Estimates of work done with the KOHPEG process shows that when used on contaminated soils or sediments, a 100 percent detoxification of PCBs is achievable. This process would be used to detoxify those sediments in areas 3 and 5.

Remnant areas 1, 2, and 4 could effectively be 100 percent isolated from potential scouring or leaching.

Ability to Meet Legal and Institutional Requirements: State construction permit(s) may be applicable for the placement of the soil cover. Local permits may also apply.

Ability to Minimize Community Impacts: Community impacts should be moderate. While detoxification or covering of the remnant areas will reduce community concern in the long-term, anxiety may be increased due to the use of an experimental procedure. Increased traffic and noise will occur during implementation.

Commercial Impacts: There are no foreseeable negative commercial impacts associated with the implementation of this project. Positive impacts would result from securing or destroying the PCBs. The commercial fishery on the Hudson may be reestablished in a somewhat shorter period of time, since some PCBs are being destroyed.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.19 Remedial Alternative: Partial Removal of Remnant Deposits/Partial In-Situ Detoxification

Description: This alternative entails the removal of material in remnant deposits 1, 2, and 4 and detoxifying deposits 3 and 5 with KOHPEG. The estimated volume of material to be removed is 157,300 yd^3, which leaves a volume of 192,600 yd^3 to be treated.

The in-situ detoxification method to be considered is KOHPEG, which involves applying a mixture of potassium hydroxide and polyethylene glycol to the contaminated materials and mixing with a rotary tiller. This process dechlorinates the PCBs, producing compounds which are either biodegradable or non-bioaccumulative.

Applicability: The removal segment of this alternative applies to remnant deposits 1, 2, and 4, while the in-situ detoxification segment will be applied to remnant deposits 3 and 5, which have the highest concentration of PCBs.

Technology Status: The technology used for the removal of PCB-contaminated materials is well-accepted practice for hazardous waste disposal, when state-of-the-art procedures are used. The KOHPEG process has proved promising during the experimental stages, although it has not yet been used on a large-scale project.

Risk and Effect of Failure: There is minimal risk involved with removing the contaminated materials from deposits 1, 2, and 4, provided that strict safety and construction techniques are utilized. Some volatilization of PCBs may occur during removal, but the effects of this disturbance should be minimal.

A greater risk is involved with the KOHPEG method of detoxification, however, since it has not been demonstrated on a larger scale. Crucial to its success is the degree to which the detoxifying agents can be mixed with and come in contact with the PCBs.

Time Required to Achieve Cleanup/Isolation: It is expected that at least one construction season may be required to complete the simultaneous removal of remnant deposits 3 and 5. Detoxification of deposits 1, 2 and 4 would require at least two construction seasons.

Ability to Meet Public Health and Environmental Criteria: The combined actions of removing and detoxifying the contaminated materials in the remnant deposits should virtually eliminate the presence of PCBs in these areas if performed correctly.

Degree of Cleanup/Isolation Achievable: The removal and detoxification of the remnant deposits will be theoretically capable of eliminating all of the PCBs from these areas, provided strict quality control practices are followed during implementation.

Ability to Meet Legal and Institutional Requirements: A State permit may be required for the transport of contaminated material from the remnant deposit sites. Local permits may also be required.

Ability to Minimize Community Impacts: Some impacts on the surrounding communities will be felt during the removal of contaminated materials and the application of KOHPEG. Truck traffic will have significant effects on the traffic patterns and road conditions in the community. Long-term effects will be beneficial due to the elimination of the PCBs.

Commercial Impacts: Commercial impacts will be limited. Elimination of the PCBs will improve chances of river edge construction above Fort Edwards. It will reduce the PCB inventory in the Upper Hudson River, helping to speed up the PCB flush-out.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.1.20 Remedial Alternative: Partial In-Situ Detoxification of Remnant Deposits/Partial Restricted Access

Description: This alternative involves detoxifying remnant deposits 3 and 5 (deposits having the highest PCB concentrations) and restricting access to those deposits which are not detoxified. The detoxification will be performed in situ using the KOHPEG method. Access to the remaining deposits will be restricted by chain-link fences on the landward sides of the remnant deposits and warning signs placed on all sides of the deposits.

Applicability: Detoxification of the remnant deposits is applicable to deposits 3 and 5, where PCB concentrations are greatest, a volume of approximately 192,600 $yd.^3$. Access to areas 1, 2, and 4 will be restricted to prevent people, animals, and vehicles from entering the areas. The total area to be restricted is approximately 32.5 acres.

Technology Status: In-situ detoxification of PCBs using KOHPEG has been successful in the experimental stages; however, it has not yet been demonstrated on a larger scale. Restricting access to the deposit areas is done with well-established methods which are easily implemented. Acts of vandalism, however, can easily destroy the components of this method and render the site insecure.

Risk and Effect of Failure: The probability of failure of the KOHPEG method is dependent on the degree to which the detoxifying agents can come in contact with the PCBs. If all PCBs are not destroyed, they will adversely affect the public and the environment through volatilization, surface water/sediment transport, and groundwater and biota effects.

A relatively low-to-medium probability of failure is associated with restricting access to the remnant deposit areas. Problems may arise due to incorrect construction techniques, human ignorance of the warning measures, and intrusion onto the sites by wild animals. The probability of these problems is highly variable. The risk associated with these problems would be to those who come in direct contact with the area.

Time Required to Achieve Cleanup/Isolation: Access restriction to remnant deposit areas 1, 2 and 4 could be completed in one construction season. Detoxification of deposits 3 and 5 would be conducted simultaneously in one summer season.

Ability to Meet Public Health and Environmental Criteria: If performed correctly, the combined effects of detoxifying the higher concentrations of waste materials and restricting access to the other remnant areas should protect the public from direct contact with the hazardous materials on site. However, the materials still have the potential of coming in contact with rising river waters or being eroded and carried downstream.

Degree of Cleanup/Isolation Achievable: A high degree of cleanup is expected for those deposits treated with KOHPEG. For the remainder of the deposits, isolation of PCBs from the environment will not be accomplished.

Ability to Meet Legal and Institutional Requirements: No requirements are expected with the possible exception of local permits.

Ability to Minimize Community Impacts: The surrounding communities would feel the impact of the implementation of this alternative during the application of

KOHPEG. Trucks will be needed to bring the materials to the deposit areas. Noise from implementation may disturb the community. Reduction in anxiety will not be as great as total removal or destruction because some PCBs will remain.

Commercial Impacts: The commercial impact should be minimal.

Costs: Detailed costs were estimated and are included in Appendix C.

9.3.2 Evaluation Procedure

Using the previously discussed effectiveness measures and weighting factors, the trade-off matrix was established for the evaluation of the remedial alternatives. An example of the cost-effectiveness matrix is presented as Figure 9-1.

The evaluation procedure was conducted in the following manner:

1) The appropriate remedial alternatives were entered into the matrix.

2) Each alternative was then rated relative to the measures of effectiveness, on a 1-to-5 scale; a 5 was used as a maximum rating, while 1 was used as a minimum rating.

3) Construction costs and operation and maintenance costs were calculated for each alternative (see Appendix C). Each alternative was rated relative to the measures of cost on a 1.0 to 2.0 scale; a 2.0 was used to represent the maximum construction or operation and maintenance cost, while 1.0 represented zero cost. Intermediate costs were rated to the nearest one-tenth.

4) The final ratings for each effectiveness measure and cost measure were computed by multiplying the rating by the corresponding weighting factor.

5) The final ratings of the cost measures were summed for each alternative. Likewise, the final ratings of the effectiveness measures were summed.

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	EFFECTIVENESS MEASURES: RISK AND EFFECT OF FAILURE	EFFECTIVENESS MEASURES: LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	EFFECTIVENESS MEASURES: ABILITY TO MINIMIZE COMMUNITY IMPACTS	EFFECTIVENESS MEASURES: ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	EFFECTIVENESS MEASURES: ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	EFFECTIVENESS MEASURES: TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	EFFECTIVENESS MEASURES: COMMERCIAL IMPACTS	EFFECTIVENESS MEASURES: Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
	INITIAL RATING													
	WEIGHTED RATING													
	INITIAL RATING													
	WEIGHTED RATING													
	INITIAL RATING													
	WEIGHTED RATING													

FIGURE 9-1

COST EFFECTIVENESS MATRIX

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A Halliburton Company

6) The overall cost-effectiveness score was obtained by dividing the final effectiveness rating sum by the final cost rating sum. The cost-effective alternative was thereby determined as the alternative with the highest score.

Initially, the remedial alternatives for disposition of removed river sediments/remnant deposits were evaluated. After selection of the cost-effective alternative, the corresponding cost data was included with the river dredging and remnant deposit alternatives. A separate evaluation was conducted for single and combined alternatives for in-river sediments, and a separate evaluation was conducted for single and combined alternatives for the remnant deposits. The final recommendation was based on the cost-effective remedial alternative from each of the two analyses. A flow diagram which depicts the evaluation procedure is presented as Figure 9-2.

Completed matrices used in the cost-effectiveness analyses are presented in Appendix B. A summary of the cost-effectiveness ratings is presented as Table 9-2.

9.3.3 Selection of Cost-Effective Alternative

A review of previously developed and new alternatives is detailed in Chapter 8 of this report. Those alternatives that were maintained following the initial screening underwent detailed evaluation as described in Section 9.3.1. The selection of the cost-effective alternative is a result of the evaluation procedure summarized herein.

During the final evaluation, it became obvious that although the KOHPEG process had passed the initial screening, the detailed analysis found that the process was extremely costly. For this reason, and also because the process was unproven, the KOHPEG process was screened out.

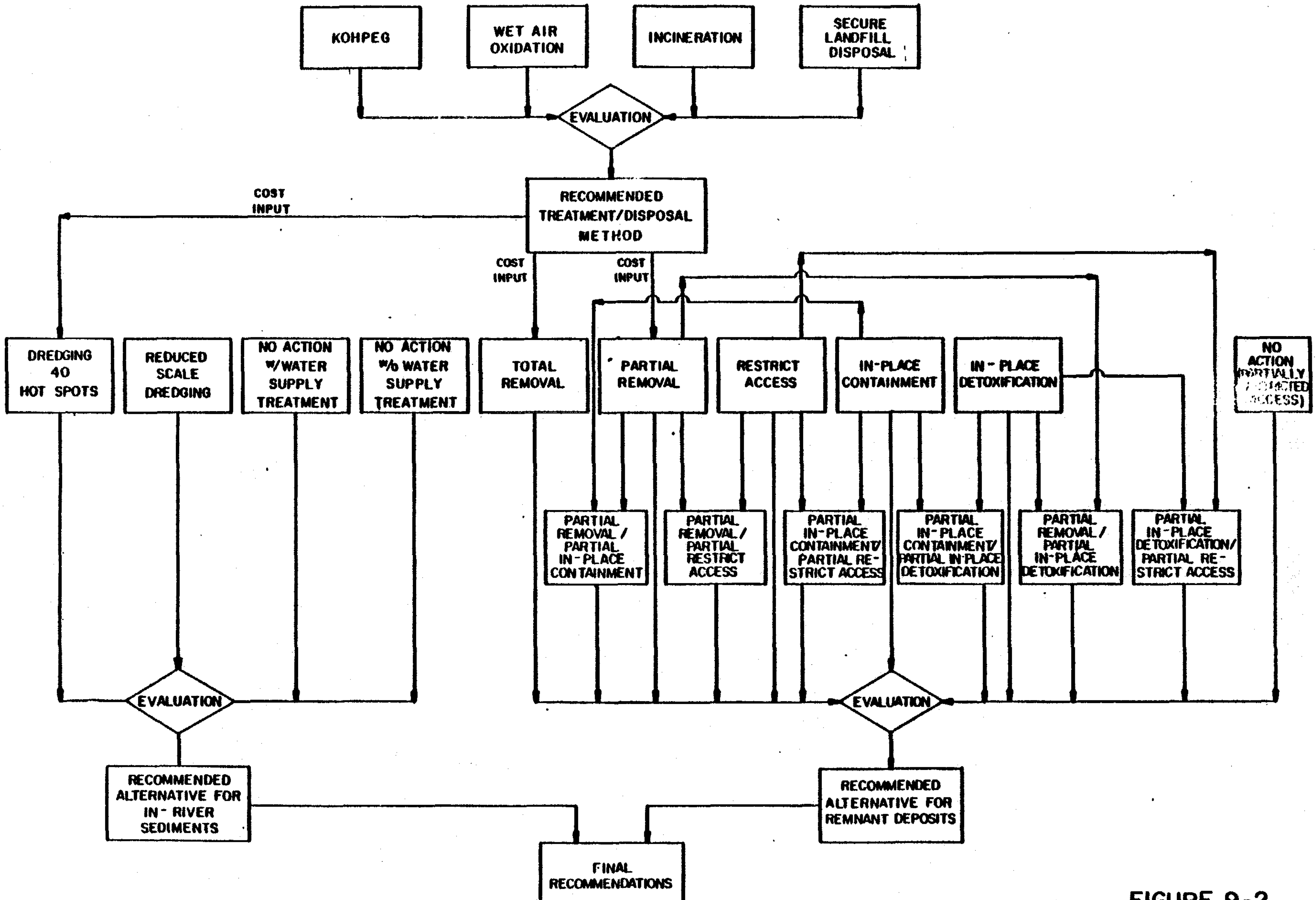

FIGURE 9-2

REMEDIAL ALTERNATIVE EVALUATION - FLOW DIAGRAM
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

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100515

TABLE 9-2

SUMMARY OF COST-EFFECTIVENESS RATINGS

DISPOSAL ALTERNATIVES

Alternative	Cost-Effectiveness Rating
Detoxification with KOHPEG	-
Detoxification with Wet Air Oxidation	6.6
Destruction by Incineration	7.1
Secure Landfill Disposal	7.1

RIVER SEDIMENT ALTERNATIVES

Dredging of 40 Hot Spots	5.3
Reduced Scale Dredging	5.9
No Action, Water Supply is Not Treated	7.9
No Action, Water Supply is Treated	7.9

REMNANT DEPOSIT ALTERNATIVES

Total Removal	7.5
Partial Removal	6.1
Restricted Access	5.6
In-Place Containment	8.3
In-Situ Detoxification	-
Partial No Action/Partial Restricted Access	5.3
Partial Removal/Partial In-Place Containment	7.0
Partial Removal/Partial Restricted Access	6.4
Partial In-Place Containment/Partial Restricted Access	7.3
Partial Containment/Partial In-Situ Detoxification	-
Partial Removal/Partial In-Situ Detoxification	-
Partial Restricted Access/Partial In-Situ Detoxification	-

The evaluation matrices for the alternatives which were considered are found in Appendix B. Alternatives for disposal, dredging, and remnant areas were evaluated separately. As discussed before, a rating of 5 was given to those alternatives as the maximum favorable ranking. The cost-effective alternative was selected from the overall cost-effectiveness score by ranking the cost and effectiveness ratings.

The alternatives listed below are the conclusions resulting from the matrix analysis for the Hudson River PCB site.

- Disposal of Contaminated Material: Secure Landfill. If, as a result of the other two evaluations, contaminated material was removed and had to be disposed of, landfilling and incineration would be found to be approximately equal in terms of cost-effectiveness. However, since incineration is an order of magnitude more expensive than landfilling, the secure landfill disposal alternative will be the recommended remedial action for disposal.

- River Sediments: No Immediate Corrective Action with Further Study. It was found that the "no remedial action" alternative was the cost-effective solution although further sampling will be required to adequately determine the effects of contaminated sediments upon the local inhabitants. Based on existing data, the contamination in its current location does not appear to pose undue risk to local inhabitants and may not justify the large sums of money needed to accomplish removal. Because, available data is sparse and/or outdated, a two-phase remedial investigation should be performed to further characterize the locations, pathways, and quantities of PCBs present. During the initial phase, drinking water, air, wetlands, terrestrial vegetation, and fish samples should be taken to define the impact of PCBs on potential receptors. If analysis of Phase I data shows a major health impact, the second phase of the Remedial Investigation may be implemented, which would consist of sediment sampling and bed-load movement analysis. An environmental monitoring program should be implemented to monitor concentrations of PCBs in drinking water, fish flesh, and dredge spoils. A treatability assessment of the Waterford water supply will be conducted on the basis of historical information and data obtained from the recommended sampling program.

- Remnant Deposits: In-Place Containment. In-situ capping of the contaminated deposits was determined to be the cost-effective alternative for the remnant areas. The capping would include the placement of 18 inches of subsoil, followed by 6 inches of topsoil and revegetation. These measures would serve to minimize erosion, leaching, and air transport of PCBs. In addition, all appropriate river banks would be "riprapped," in order to eliminate remnant deposit scour during high-river flows. Biannual inspection of the cover is also recommended in order to identify any erosion/damage of the cover material.

9.3.4 Sensitivity Analyses

Sensitivity analyses were conducted in order to assess the potential effects of variation of the numerical elements within the cost-effectiveness matrix on the overall rankings of the alternatives. The variations were intended to reflect the uncertainty of the assumptions made during the rating of the alternatives, since these assumptions were based on the accuracy of investigative/sampling data and on the prediction of the future behavior of the remedial technology. Elements of the cost-effectiveness matrix which were varied include:

- weighting factors
- costs
- numerical ratings of effectiveness measures

The weighting factors were individually varied in both an upward and downward direction, as were the individual cost and effectiveness ratings. A separate analysis was conducted for the detoxification/destruction/disposal alternatives, river sediment alternatives, and remnant deposit alternatives.

- Detoxification/destruction/disposal alternatives: It was previously determined that landfilling and incineration scored equally in terms of cost-effectiveness. Accordingly, small changes in the cost and effectiveness weighting factors, on the order of 0.1, were found to vary the overall rankings. Similar variations were observed when changes of 0.1 were made in the cost ratings, or changes of 1.0 were made in the effectiveness ratings.

- River sediment alternatives: The sensitivity analysis indicated that the selection of one of the two no-action alternatives, as opposed to the two dredging alternatives, was not sensitive to large changes in the weighting factors or ratings. Variations of the weighting factors by 0.5, the cost ratings by 0.5, or the effectiveness ratings by 2 had no effect on the recommendation of a no-action alternative. However, the two no-action alternatives received equal overall ratings. Accordingly, variations as small as 0.1 in the effectiveness weighting factors, 0.1 in the cost ratings, or 1 in the effectiveness ratings were significant to the final ranking of these two alternatives.

- Remnant deposit alternatives: It was determined that the selection of the in-place containment alternative was not influenced by large variations of the cost/effectiveness weighting measures (variations of up to 0.5) or effectiveness ratings (variations of up to 2). Variations of greater than 0.2 in the cost ratings of the in-place containment alternative were found to switch the top ranking to the total remnant deposit removal alternative, however.

9.3.5 Summary

In summary, the authors have applied the guidelines of the NCP to identify a series of cost-effective remedial actions which are applicable to the Hudson River PCB problem.

In Sections 3.0 through 5.0 of the Feasibility Study, the authors drew upon existing information to evaluate public health and environmental effects and health and welfare concerns associated with the problem. A major conclusion of that effort was that the present health impacts associated with PCB in air and water were low. Another conclusion was that although PCB contamination in fish, as well as other organisms, was high, previously imposed State regulations on fishing and State advisories on consumption of fish could be a cost-effective remedy, particularly in view of the fact that such measures would likely be required for some period after any type of remedial action. It was also concluded that levels of PCB in fish and air, as well as PCB transport, have declined much more rapidly than had been anticipated. It was concluded that the impact of the PCB problem in activities such as routine maintenance dredging had been overstated.

In the next step (Sections 7-8), the authors drew-up a list of possible remedial alternatives. This list included all previously proposed methods, as well as some newly developed alternatives--including some promising PCB detoxification destruction techniques. The reliability, technological feasibility, possible adverse effects, and relative effectiveness in minimizing threats of the methods were reviewed. As a result, only technically feasible and promising processes were passed on to the next level of screening.

Four disposal alternatives were proposed for further study: 1) Detoxification of Removed Sediments with KOHPEG; 2) Detoxification of Removed Sediments by Wet-air Oxidation; 3) Destruction of Removed PCBs by Incineration; and 4) Secure Landfill Disposal. Twelve remedial alternatives were proposed for the remnant deposits. These alternatives consisted of various combinations of 1) No-Remedial-Action; 2) Restricted Access; 3) In-place containment; 4) In-situ Detoxification; and 5) Removal methodologies. Also, four river-sediment alternatives, two dredging options, and two No-Remedial-Action options were considered. The No-Remedial-Action alternatives were included in the final analysis on the premise 1) that present public health impacts appeared to be low; 2) that environmental effects appeared to be decreasing without any remedial action; 3) that limited clean-up afforded by other alternatives might not result in a significant improvement over no-remedial action; and 4) that removal and dredging options could produce adverse short-term effects.

In Section 9, a detailed analysis of the proposed alternatives was carried out. This analysis required the development of a conceptual design for each alternative, a more detailed estimation of costs, and a closer assessment of engineering implementation in relation to the ability of alternatives to satisfy the effectiveness criteria used in the evaluation. The detailed screening used a cost-effectiveness matrix analysis developed for the EPA specifically for the Superfund program.

The evaluation resulted in a recommended alternative for covering the remnant sites with 18 inches of subsoil, six inches of top soil, and revegetating; and performing an analysis to assess the need and design parameters for upgrading the Waterford Water Supply.

The matrix evaluation also resulted in the identification of a no-remedial-action alternative for river sediments as the most cost-effective option. This was interpreted to mean that the limited improvement which might be expected after a dredging program does not justify the cost to implement such a program, especially in light of the present low and decreasing health and environmental impacts of the PCB problem.

A sensitivity analysis was performed on the matrix analysis to determine what effect changes in costs or effectiveness measures might have on the recommended alternatives. It was found that significant changes either in cost or in effectiveness ratings would not change the recommended alternative for river sediments. Changes in effectiveness measures by a factor of 2 and in the costs by a 20 percent variance would not change the recommended alternative for remnant deposits.

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10.0 REMEDIAL ACTION PLANNING ACTIVITIES

10.1 Site Remediation Objectives

One objective of the site remediation activities discussed in the Hudson River PCBs Site RAMP is to eliminate direct human contact with contaminated remnant deposits by covering or restricting access to them. Another objective is to assess possible health impacts from the contaminated sediments through one phase of a Remedial Investigation (Section 9.3.3).

In the event studies identify a significant health impact in the Upper Hudson River area, the second phase of the Remedial Investigation should be conducted. The purpose of this phase should be to locate PCBs in the river sediments and to identify bed-load transport rates. Details on the proposed Remedial Investigation can be found in Section 10.3, Section 10.4, and Appendix D.

10.2 Remedial Action for the Hudson River PCBs Site

10.2.1 Final Design

The remedial action selected as a result of the remedial alternative evaluation consists of: (1) covering 4 remnant areas (areas 2, 3, 4, and 5) with approximately 18 inches of subsoil and about 6 inches of topsoil, and subsequently revegetating these areas; and (2) no remedial action on the contaminated river sediments. However, it is recommended that a Remedial Investigation be conducted to better quantify any potential health or environmental impacts associated with the sediments. In addition, a treatability assessment of the Waterford Public Water supply is recommended. It is also recommended that the NYSDEC and USGS fish and riverwater sampling programs be continued. The Remedial Investigation includes monitoring of drinking water, air, terrestrial vegetation and sediments proposed for routine maintenance dredging. A wetlands study, including the collection and analysis for PCBs of vegetation, macroinvertebrates, and fish, should be implemented to determine the importance of wetlands (which in many cases are highly contaminated) in the present PCB problem with the Hudson River fishery.

The remnant area remedial action includes a Remedial Investigation of the remnant areas in order to delineate the areal extent of the contaminated sediments. Elements which should be included in the proposed Remedial Investigation are described in Section 10.3. Once the Remedial Investigation is completed, detailed design specification activities will take place. A suitable borrow area from which soil will be taken will be searched for and located and negotiations will be conducted for its use. Quantities of fill and schedules for work will be finalized once the total area to be covered has been determined.

The estimated capital cost of the remedial activities at the remnant sites is approximately $2,323,930. Operation and maintenance at the remnant deposits sites for a 20-year period will have an approximate present worth value of $1,123,790.

The estimated cost for Remedial Investigation activities at the remnant sites prior to design activities is approximately $186,000 including laboratory analyses. Environmental monitoring under the proposed Remedial Investigation is estimated to cost about $396,000 excluding costs of the NYSDEC fish monitoring program, the USGS river monitoring program and additional sediment sampling.

The treatability study is estimated to cost about $120,000. Detailed cost breakdowns may be found in Appendix C under the no-action and in-place containment of remnant deposit options and in Appendix F.

10.2.2 Implementation

During this stage contractors will be procured and development of the borrow area will begin. This development should begin at the start of the construction season. The borrow area will be cleared and grubbed, and topsoil will be scraped off and stockpiled for future use. Subsoil will be removed and transported to the remnant areas. While the borrow area is being developed, clearing of the remnant sites should begin. No grubbing is recommended at remnant areas 2 and 3 since growth over these areas is sparse at this time. Stormwater diversion should be installed in order to prevent erosion of the remnant areas as well as to divert stormwater from running over the remnant site. Fill from the borrow area should be placed in 6-inch lifts on the remnant sites. Once the subsoil has been placed, a 6-inch layer of topsoil should be placed, followed by seeding. At the borrow area the slopes should be graded and the exposed soil should be seeded.

Following construction, a continuing inspection program will be conducted of storm water diversion and of bank stabilization and erosion in order to determine the need for maintenance or repairs.

The final Feasibility Study recommends a Treatability Study for the Waterford water supply. It is likely that this study would be tied in with the drinking water study of the Environmental Monitoring Program, however it is not included as part of the Remedial Investigation. It is estimated that this study would cost about $120,000.

10.2.3 Environmental Monitoring

An environmental monitoring program, including the existing NYSDEC fish and U.S.G.S. river-water monitoring programs, should be continued. Monitoring of the public water supplies obtaining water from the Hudson should be conducted on a representative basis. This would involve baseline sampling at selected public water supplies on at least a quarterly basis for two years. In addition, two other samples should be obtained: one following a major storm event during the spring season and a second similarly during the low-flow season. A number of private drinking water wells in the Upper Hudson River area should be selected and sampled also. During the following years, two or three public supplies should be selected for monitoring during high flows and low flows (spring and summer respectively) as a check to ensure that there is no dramatic increase in PCB concentrations. Air monitoring, vegetation sampling, and wetlands sampling should be carried out as described in Tasks 11, 12, and 13 under Section 10.4.3. Finally, sampling should be conducted at any proposed maintenance dredging area to determine the concentration of PCBs in the sediments proposed for dredging. This sampling is necessary in order to determine the degree of contamination and appropriate method for disposal of the sediments.

The Remedial Investigation proposed in Section 10.4 includes only the air, drinking water, wetlands, and terrestrial vegetation sampling programs. It is assumed that the regular U.S.G.S. river-water and NYSDEC fish monitoring programs will continue. It is also assumed that the State will insure that all proposed dredging areas will be adequately sampled.

10.3 Preliminary Work Plan Outline for the Remedial Investigation of the Remnant Deposit Sites

A work plan shall be prepared by the Contractor, prior to the start of the Remnant Area Remedial Investigation (RI) of the Hudson River PCBs Site. A Preliminary Outline of the proposed work plan is presented below.

10.3.1 Work Plan Summary

The Work Plan Summary will present an overview of the technical, financial, and logistical requirements of the Remedial Investigation. Subsections will include:

- Remedial Investigation Objectives
- Scope of Work
- Manpower Estimates and Cost
- Schedule

10.3.2 Problem Assessment

The majority of information to be included in the problem assessment has been included in this RAMP. The level of detail in this section should be sufficient to acquaint the reader with the problems associated with the site. This section will be developed from all available information, but it is not designed to be an assessment of all existing data.

10.3.3 Scope of Work

An outline and specific description of each work task needed for the Remedial Investigation is provided in this section. Individual task descriptions will be expanded during the preparation of a Work Plan for the Remedial Investigation of the Hudson River. The discussion of those tasks pertaining to site activities which parallel current actions will include the description of these activities. The final task will include the Remedial Investigation report.

10.3.3.1 Preliminary Remedial Investigation Activities

A total of 10 tasks have been identified during the investigation of preliminary remedial activities. These activities are required before the site Remedial Investigation activities can be initiated. Additional tasks may be added during the preparation of the work plan as determined necessary due to project schedule and budget constraints.

Task 1 - Prepare Remedial Investigation Work Plan

The Work Plan outlines those activities of the Remedial Investigation necessary to delineate the limits and extent of contamination. Detailed manpower estimates, a schedule of remedial actions, and project costs will be provided in the Work Plan. This activity may require 450 man-hours to complete and is estimated to cost $18,930.

Task 2 - Perform Community Relations Support Functions

Community relations support provided by the contractor will be at the request of the EPA and may include logistical support for the planning and execution of the activities at the site and technical support to ensure that all information is accurate and current. Due to the nature of public involvement, community relations input must be flexible to accommodate fluctuations in public interest. Community relations input must also remain flexible to dovetail with technical progress at the site.

The Contractor will assist the EPA in presenting the findings of the RI to the public. It is estimated that this task will require about 250 manhours and will cost about $13,900.

Task 3 - Collect and Evaluate Existing Data

It may be necessary to collect and evaluate additional information which was not available for the preparation of the RAMP. These data will be used in conjunction with existing reports to establish additional testing, sampling, and analyses necessary to successfully complete the RI. Additional data requirements not addressed by this Work Plan will be identified and used to complete the sampling plan. This task may require 150 man-hours, and is expected to cost about $6,700.

Task 4 - Perform Health, Safety, and General Site Reconnaissance

An initial site reconnaissance will be conducted by an investigation team to fully evaluate the existing site conditions. Several objectives have been identified for the site reconnaissance:

- Conduct onsite start-up meeting with EPA and NYSDEC
- Perform health and safety reconnaissance
- Locate physical hazards and features
- Evaluate site conditions for location of initial sediment sampling points

This task will require about 90 man-hours to complete and will cost an estimated $6,300.

Task 5 - Secure Permits, Rights of Entry, and Other Authorizations

Access to the work areas will be obtained by EPA prior to initiation of site activities. A verification of property boundaries will be made to identify all property owners within the projected work area. Permits for Remedial Investigation activities and onsite treatability studies will be obtained by EPA where necessary. This task may cost approximately $2,800.

Task 6 - Procure Subcontractors

The ground surveying program for the purposes of the determination of sample point locations and the development of topographic map(s) may be subcontracted. The subcontractors will be obtained using normal Superfund procurement procedures. The process of advertising for and evaluating bids will begin upon receipt of EPA authorization. Subcontracting arrangements will require an estimated 200 man-hours and cost an estimated $7,700.

Task 7 - Develop Site-Specific Health and Safety Plan

A site-specific Health and Safety Plan will be developed for the remnant deposit sites, based on guidelines established in the contractor's Health and Safety Manual and EPA's Occupational Health and Safety Manual. The Health and Safety Plan could require approximately 40 man-hours to complete and cost about $2,300.

The purpose of the plan will be to:

- Provide safety protection requirements and procedures for site field crews and subcontractors.

- Ensure adequate training and equipment to perform expected tasks.

- Provide ongoing site monitoring to verify preliminary safety requirements and revise specific protection levels as required.

- Protect the general public and the environment.

Task 8 - Develop Site-Specific Quality Assurance Plan

A Quality Assurance Plan will be developed based upon the Contractor's Quality Assurance Project Plan. The plan will refer to or include site-specific details on sampling; field testing; surveying; chain-of-custody; sample handling, packaging, preservation and shipping; record keeping and documentation. Analysis requirements, in addition to those listed in the Contract Laboratory Program (CLP), will be given along with any other procedures needed for the Remedial Investigation. It is estimated that this task will cost about $3,500.

Task 9 - Develop Site-Specific Sampling Plan

A site-specific sampling plan will be developed. The plan will be related to the Health and Safety and Quality Assurance Plans and will include procedures for sampling various media expected to be found on site.

If possible, definite sampling locations will be established. These locations will be based on site data obtained during the field reconnaissance and from detailed review of existing reference sources. This task will cost about $2,800.

Task 10 - Mobilize Field Equipment

The equipment needed during the Remedial Investigation will be provided by the Contractor or by subcontractors. Equipment scheduled for use may include:

- Surveying equipment
- Sampling tools and equipment
- Health and safety equipment
- Decontamination equipment

Mobilization of field equipment is estimated to cost about $500.

10.3.3.2 Site Remedial Investigation Activities

Task 11 - Perform Ground Survey

A ground survey will be performed to:

- verify property lines
- determine sample point locations
- obtain data for the development of topographic maps

Sample points will be located on a 100-foot grid and corresponding elevations will be determined for use in the preparation of topographic maps. The costs for this task are based on 40 hours of effort and is estimated to cost $13,800.

Task 12 - Prepare Topographic Map

A topographic map will be prepared using the data obtained during the ground survey.

The product of this task shall be a single, scribed, double matte, 3 mil, washoff mylar with reversed image. The product shall have a horizontal scale of 1 inch = 50 feet and a contour interval of 1 foot. A grid coordinate system will be established based on the highest order of accuracy control points available in the immediate vicinity of the site. Control points to be considered include, but are not limited to, State plane coordinate system, U.S.G.S. monuments, Army map service monuments, county highway monuments, or, in rural areas, local monuments. Mapping and ground surveys will be completed in accordance with the National Map Accuracy Standards for the scale indicated. The preparation of a topographic map may require 60 man-hours and is estimated to cost $6,700.

Task 13 - Collect Surface Soil Samples

Soils will be sampled to determine the extent and degree of surface soil contamination. The area of the remnant deposits is about 60 acres. Samples will be taken from a 100-foot grid sampling regime at each of the remnant deposits. It is therefore assumed that a total of approximately 300 surface soil samples will be collected using either trowels or shovels. Sample depths will vary from 0 to 12 inches. All samples will undergo PCB analyses. The cost of this task is estimated to be $56,000.

Task 14 - Reduce and Evaluate Data

Following the applicable RI tasks, data generated during the study will be reduced and evaluated. The evaluation will be used in the production of a report to be submitted following the completion of all RI tasks. In addition, continuous data reduction and evaluation during the RI can also provide input for succeeding RI tasks. This task is expected to cost an estimated $31,900.

Task 15 - Prepare Remedial Investigation Report

After completion of the field investigations, all pertinent field and laboratory data will be assembled into a detailed report of the Remedial Investigation. This report will include the following items:

- Objectives of the Remedial Investigation.

- A description of the study areas based on the field investigations and the results of the laboratory testing.

- Conclusions and recommendations of the study.

Maps, figures and tables will be prepared to support the text. The Remedial Investigation report is estimated to cost $12,200.

10.3.4 Management Plan

The management plan shall include the administrative and management requirements for performing the RI work activities. The principal sections of the management plan are described below.

10.3.4.1 Project Organization and Staffing

This section describes the project's organizational plan with regard to personnel as well as the level of effort required to complete each task. The project manager will be identified as well as other key project personnel.

10.3.4.2 Project Reports

The reporting requirements, including the quantity and distribution, will be specified in this section. The reporting requirements for technical submittals, as well as financial and progress reporting requirements, will be specified.

Other components include:

- Procurement
- Meetings
- Change Orders
- Community Relations Program
- Quality Assurance
- Health and Safety

10.3.5 Costs and Schedule

The Remedial Investigation at the remnant sites will last about 32 weeks and is estimated to cost about $186,000. A detailed breakdown of costs for each task in the Remedial Investigation will be included in the costs and schedule section of the Work Plan. Also, a Remedial Investigation project schedule will be presented. Preliminary project schedules and cost estimates are provided in Appendix F.

10.4 Preliminary Work Plan Outline for Phase I of the Remedial Investigation of the River

Prior to the start of the Remedial Investigation (RI) of the Hudson River PCBs Site, a Work Plan shall be prepared by the contractor. A preliminary outline of the proposed work plan is presented below.

10.4.1 Work Plan Summary

The Work Plan Summary will present an overview of the technical, financial, and logistical requirements of the Remedial Investigation. Subsections will include:

- Remedial Investigation Objectives
- Scope of Work
- Manpower Estimates
- Schedule

10.4.2 Problem Assessment

The majority of the information to be included in the problem assessment has been included in this RAMP. The level of detail in this section should be sufficient to acquaint the reader with the problems associated with the site. This section will be developed from all available information, but it is not designed to be an assessment of all existing data.

10.4.3 Scope of Work

An outline and specific description of each work task which is needed for the Remedial Investigation is provided in this section. Individual task descriptions will be expanded during the preparation of the Work Plan (Task 1) for the Remedial Investigation of the Hudson River. In addition, the delineation of those tasks which parallel current sampling programs will include a description of the current work and an explanation of any additional work needed to complete the task. The final task will include the preparation of the Remedial Investigation report.

10.4.3.1 Preliminary Remedial Investigation Activities

A total of nine tasks have been identified during the investigation of preliminary remedial activites. These tasks must be performed before the site remedial investigation activites can be initiated. Additional tasks may be added during the preparation of the work plan as determined necessary due to project schedule and budgetary constraints.

Task 1 - Prepare Remedial Investigation Work Plan

The Work Plan outlines those activities of the Remedial Investigation necessary to update existing data on PCB concentrations in the river and ecosystem. Detailed manpower estimates, a schedule of remedial actions, and project costs will be provided in the Work Plan. This activity may require 450 man-hours to complete and is estimated to cost $19,000.

Task 2 - Perform Community Relations Support Functions

Community relations support provided by the contractor will be at the request of the EPA and may include both logistical support for the planning and execution of the activities at the Hudson River PCBs Site and technical support to ensure that all information is accurate and current. Because of the nature of public involvement, community relations input must be flexible to accommodate fluctuations in public interest.

The contractor will assist the EPA in presenting the findings of the Remedial Investigation to the public. It is estimated that this task will require about 250 man-hours and cost approximately $14,000.

Task 3 - Collect and Evaluate Existing Data

It may be necessary to collect and evaluate additional information which was not available during the preparation of this RAMP. These data will be used in conjunction with existing reports to establish additional testing, sampling, and analyses necessary to successfully complete the RI.

After collection of all available information, an evaluation of the data base adequacy will be made regarding area contamination. Additional data requirements not addressed by this Work Plan will be identified and used to complete the sampling plan. This activity may require about 150 man-hours and is estimated to cost about $6,700.

Task 4 - Develop Site-Specific Health and Safety Plan

A site-specific Health and Safety Plan will be developed based on the available site information, guidelines established in the contractor's Health and Safety Manual, and EPA's Occupational Health and Safety Manual.

The purpose of the plan will be to:

- Provide minimum safety protection requirements and procedures for onsite field crews and subcontractors.

- Ensure adequate training and equipment to perform expected tasks.

- Provide ongoing site monitoring to verify preliminary safety requirements and to revise specific protection levels as required.

- Protect the general public and the environment.

The Health and Safety Plan will cost an estimated $5,500.

Task 5 - Develop Site-Specific Quality Assurance Plan

A site-specific Quality Assurance Plan will be developed based on the available site information and the guidelines established in the contractor's Quality Assurance Manual.

The Quality Assurance Plan will be designed to incorporate the following objectives:

- To maintain the evidentiary value of the data produced.

- To ensure the integrity of the results of site investigations, laboratory analyses, and technical reports.

- To provide assurance that remedial designs and assessments are properly prepared and reviewed.

- To control the activity of subcontractors, consultants, and support agencies or organizations to ensure that they maintain the same quality standards applied to the NUS activities.

This task may require 60 man-hours and is expected to cost approximately $2,800.

Task 6 - Develop Site-Specific Sampling and Analyses Plan

A site-specific sampling plan will be developed. The plan will be related to the Health and Safety and Quality Assurance Plans and will include procedures for sampling various media expected to be found in the river basin.

Definite sampling locations will be established, if possible, for the air, surface water, groundwater, and sediment samples. Locations will also be determined for the fish, macroinvertebrate, and vegetation surveys. These locations will be based on site data obtained from a review of existing data and additional data obtained from personal observation. The site-specific Sampling and Analysis Plan will require an estimated 200 man-hours and is estimated to cost $2,800.

Task 7- Procure Subcontractor(s)

Bid documents (Plans & Specifications) will be developed and competitive bids will be solicited from prequalified firms for each task to be subcontracted. The process of advertising for and evaluating bids will begin upon receipt of EPA authorization. The Contractor will review the bids and select the subcontractor. The EPA Contracting Officer will review and approve the subcontractor selection prior to award of the subcontract.

The following elements of work are under consideration for subcontracting:

- Wetland study
- Model development for assessment of PCB movement in the wetlands.

Subcontracting arrangements are estimated to cost approximately $8,900.

Task 8 - Secure Permits, Rights of Entry, and Other Authorization Requirements

Access permission to the work areas will be obtained prior to initiation of site activities. Permits for Remedial Investigation activities and onsite treatability studies will be obtained where necessary. This task is estimated to cost $5,900.

10.4.3.2 Site Remedial Investigation Activities

Task 9 - Mobilize Field Equipment

The equipment needed during the Remedial Investigation will be provided by the Contractor or by subcontractors. Equipment scheduled for use includes:

- Field office
- River transportation
- Surveying equipment
- Sampling tools and equipment
- Health and Safety equipment
- Decontamination equipment

Equipment may be stored on site in a secure field office trailer. The placement of the trailer will be specified in the site-specific Health and Safety Plan. Mobilization may cost approximately $500 although this cost depends on the availability of NYSDEC equipment already purchased for the monitoring the Hudson River PCB problem.

Task 10 - Collect Drinking Water Samples

Present Sampling Efforts

There is, at present, only limited potable-water monitoring of public or residential water supplies.

Description

The sampling of public and residential potable-water supplies for PCBs will be conducted to determine whether any health hazard exists in the use of water from surface or groundwater resources. Public water supplies are drawn from surface water intakes along the river, while private supplies are drawn from local aquifers.

Public drinking-water sampling should be conducted quarterly and also during periods of high (spring) and low (fall) flows. This should be done to include those periods of high-sediment PCB transport potential (high-river flows) and high dissolved PCB-transport potential (low-river flows). It may only be necessary to sample residential wells once during the low-flow period when dissolved PCB is most prevalent in the river.

Method

Residential wells should be sampled at the well head or just before the holding tank. Before taking the sample, the water should be run for five minutes to ensure that a true sample of the aquifer is taken. Sampling techniques should conform to those specified in the Contractor's Quality Control Procedures Manual (NUS QCP 11-1, 1983). It will be necessary to conduct a well-location survey to determine which wells should be sampled. Approximately 30 wells are suggested.

Public water system sampling will include the influent, effluent, and waste discharge waters. At least three supplies, including Waterford should be sampled. Each sample should be taken at the same approximate time during each sample visit. Sampling techniques will be similar to those mentioned above, as referenced in the Contractor's Quality Control Procedures Manual. Costs for this task ($35,000) are for one year only and are based on 300 manhours and 75 samples. Costs could change if local technicians are to be used.

Task 11 - Collect Air Monitoring Samples

Present Sampling Efforts

There are, at present, no ongoing air monitoring programs to detect volatile or particulate-borne PCBs in the Hudson River Basin.

Description

The transport of PCBs into the air is accomplished by two mechanisms: volatilization, and suspension on dust or other small particles. An air monitoring program will be conducted to determine the extent of PCB volatilization or particulate suspension throughout specifically designated areas of the Upper Hudson. Ambient levels of PCBs will be determined for residential and agricultural areas. This monitoring will be conducted during the months of highest potential PCB volatilization (July and August).

The following is a list of suggested areas of study.

- Thompson Island and local dams and pools, including the following:
  - area homes
  - shore areas/farmland
  - riffles or rapid areas

Methods

A sampling program of this nature should include four sampling sessions (every other week) in approximately 10 to 15 sampling locations. The focus of this effort should include those areas having the highest potential for airborne PCB concentrations. Those areas of greatest concern would include homes or farmland near riffle or rapid areas, and those areas directly below high turbulent areas, such as dams.

Each sample should be collected by drawing air through a Fluorasil tube in which volatile PCBs are trapped. Particulates laden with PCBs are adsorbed next on a filter. After exposure, the sample tube and filters will be shipped to a lab where the PCBs will be desorbed from the cartridge with hexane. The resulting solution will be analyzed by gas chromatography (GC)(NIOSH, 1983).

In addition to the sampling for PCBs, local weather conditions should be measured. The parameters included should be: wind speed and direction, temperature, dew point, solar radiation, rainfall, and barometric pressure. This task is estimated to cost $24,000. Again, costs could change if local technicians are used.

Task 12 - Perform Wetland Study

Subtask 1 - Fish Sampling

Present Sampling Efforts

There are at present no fish sampling programs being conducted specifically for fish which feed in the wetlands.

Description

The game fish that feed in the wetland areas of the Hudson represent a large part of the recreational fishing potential of this area. These fish consume the majority of their total food intake in the wetlands, and along with that, possibly the largest portion of their PCB intake. To determine this, a modeling program will be conducted including all the elements of the wetland food chain. At this time, the wetlands to be studied are unknown. For costing purposes it has been assumed that nine wetlands with differing characteristics would be studied. The selection of wetlands will be made in cooperation with NYSDEC biologists.

The objective of this study will be to determine the extent to which recreational and commercial fish are adversely affected by PCBs originating in the sediments of the wetlands. For this purpose an attempt will be made to correlate fish-flesh PCB concentrations with sediment (subtask 4) and "lower food chain organism" (subtask 2) PCB concentrations. A determination should then be made as to the importance of the wetlands in regard to the PCB balance in the aquatic food chain.

Method

The methods to be used for the fish sampling are similar to those described in the NYSDEC Environmental Monitoring Plan (NYSDEC, April 1982). Sampling will involve the electro-shocking of wetland game fish. The fish will be collected and frozen for later analysis. The fish will first be counted, then separated according to species; later the flesh of each fish will be analyzed for its PCB content. In addition the stomach of each fish will be analyzed to determine the dietary content and the PCB concentration of the food. This analysis, in combination with the results of the study of Hudson River macroinvertebrates (subtask 2), can be used to determine PCB transport through the wetland food chain. Costs for this subtask ($70,000) are based on 480 hours of effort and 180 samples. Costs could change depending on the availability of State equipment and technicians.

Subtask 2 - Macroinvertebrate Study

Present Sampling Efforts

New York State each year conducts a macroinvertebrate study of the Hudson River, but this study is not specifically designed for wetland macroinvertebrates.

Description

The wetland benthic community may comprise a large component of the Hudson River game fish diet. The community is potentially a continuous source of PCB contamination in these fish, and, in effect, the predators of these fish (animals, birds, larger fish) as this contamination moves up the food chain. By equating wetland macroinvertebrate PCB content with fish-flesh and stomach analysis results (subtask 1), a relationship may be determined (via modeling), revealing the mechanism of PCB transport through the food chain.

Method

Wetland sampling will be conducted according to the schedule currently followed by the State. Samples are collected at 5-week intervals during the sampling season (June-September) (NYSDEC, April 1982). Macroinvertebrate organisms will be collected by three methods: multiplate, dipnet, and bottom dredge sampling.

Used to collect a large variety of insect larva, the multiplate sampler consists of a series of parallel concentric plates, which act as an artificial substrate for the development of macroinvertebrate communities. Placed under water in the wetlands for approximately two weeks, small colonies develop on the hardboard plates of the sampler. After the removal of the sampler from the river, the plates are separated and an inventory of the colonized organisms is taken--identifying species diversity--and afterward representative samples of the organisms are taken and analyzed for PCB content (NYSDEC, April 1982).

Caddisfly larvae (not collected by the multiplate sampler) are collected with a D-frame aquatic dipnet or by picking the larvae directly off rocks removed from the river (NYSDEC, April 1982). An inventory and analysis is performed as noted above.

In addition, organisms living in the sediments will be sampled using a bottom dredge (small mechanical clam-shell), and the organisms will be separated from the sediments by screening. Samples will first be separated according to species and later analyzed for PCB content. This subtask is estimated to cost about $34,000.

Subtask 3 - Wetland Vegetation Sampling

Present Sampling Efforts

Presently there is no information on the PCB content of wetland vegetation. Malcolm Pirnie (1980) indicated that PCB uptake by marshland vegetation would be minimal. PCB analysis of terrestrial vegetation, however, indicates that absorption of airborne PCBs can result in PCB levels in foliage which are significantly higher than background levels.

Description

Wetland vegetation sampling will consist of compositing stem and foliage samples from species occupying each of the wetland areas in question and analyzing them for PCBs.

Methods

At each wetland area, 20 stem and leaf subsamples from resident species will be collected and composited to form two samples for analysis. Collections will be made near the end of the growing season in September so the total accumulation of PCB will be determined. Sample preparation and analysis will be done according to the procedures described under terrestrial vegetation sampling. Costs for this subtask are based on 18 samples and are estimated at $26,000.

Subtask 4 - Wetland Sediment Sampling

Present Sampling Efforts

There are, at present, no sediment sampling programs being conducted to quantify PCB contamination in the wetlands.

Description

A sediment sampling and analysis program will be conducted to determine the extent of PCB contamination throughout certain wetland areas of the Upper Hudson. The results of this sampling, used in conjunction with the results of the other sampling programs (subtasks 1 through 3), will be used to determine the pathways and amount of PCB transport through the food chain from the wetlands.

The sediment sampling effort is paramount to the other tasks in that, without an adequate determination of PCB concentrations in the organic sediments of the wetlands, an accurate trace of PCB movement through the food chain would be impossible. In other words, large errors made in the determination of PCB concentrations and volumes in the sediments indigenous to the wetlands will invalidate any assumptions made about the importance of the wetlands in the food chain transport system.

To effectively establish an adequate data base, the sampling program should include extensive sample coring and wetland staking efforts. The sample cores will be taken to quantify the distribution and depth of contamination, while a staking program will delineate net deposition or scour in given wetland areas.

Method

Sample cores will be taken in relatively undisturbed areas of the wetlands. Samples should be taken as close as possible to predetermined grid locations. At each location a three-foot core (approximately) will be taken and split by layers into subsamples, yielding three or four samples each. All of the samples will be analyzed for PCB content. In addition some of the samples will also be analyzed for particle-size class and organic content. The exact Aroclors to be analyzed for and the method for reporting total PCBs will be specified in the Work Plan.

A staking program will be conducted in all wetland areas. Metal stakes will be placed at specific locations in the wetlands and the depth to the sediment (from the top of the stake or a predetermined mark) will be measured on a monthly basis.

As the sediment levels rise or fall in each area, an indication of net deposition or scour will be determined for areas of individual wetlands. Costs for this subtask are based on approximately 135 analyses. The estimated cost is $53,000.

Task 13 - Collect Terrestrial Vegetation Samples

Present Sampling Efforts

In 1978 and 1979, sampling of foliage from 10 plant species (both annual and perennial types) was conducted throughout Washington and Saratoga Counties to assess the levels of accumulation of PCBs in plants. In addition, background levels of PCB in forage and row crops in four replicate plots near the proposed containment area have been studied since 1981. These studies have revealed PCB contamination significantly higher than background levels in species growing near heavily contaminated PCB disposal sites. Evidence shows that PCB contamination of plants and crops increases with decreasing distance from the river, and that these trends are related to atmospheric PCB concentrations; however, the data are inconclusive because there is no corresponding information on air monitoring.

Description

Foliage will be collected near the end of the growing season along road transects corresponding to those studied by Buckley (1980), near Lock 6 (Callahan Road, East Road), and up-river from Griffin Island (Clark Road). Plants along these transects have shown increases in PCB content with decreasing distance from the river. These transects also correspond to air sampling that will be performed in the area.

The species to be studied include alfalfa, red clover, field corn, trembling aspen, large-toothed aspen, timothy, staghorn sumac, brome grass, orchard grass, and goldenrod. Background levels and PCB trends for these species have been reported by Buckley (1980).

Multiples of background levels (MBL) (Buckley 1980) as an expression of PCB content in plants will be examined and used if appropriate.

Methods

From 5 to 10 sampling stations will be selected at distances corresponding to previous studies on transects placed perpendicular to the river. Vegetation sampling will take place within ± 10 percent of the specified distance from the river. A minimum of 20 subsamples from each species will be taken to comprise one composite sample. Appropriate duplicate samples will be taken.

Sample preparation and analysis will be conducted according to methods described in the Monitoring Plan (NYSDEC, 1982). This task requires the analysis of 100 composite samples and will cost approximately $18,800.

Task 14 - Reduce and Evaluate Data

Following applicable RI tasks, data generated during the study will be reduced and evaluated. The evaluation will be used in the production of a report (Task 15) to be submitted following the completion of all RI tasks.

The data reduction and evaluation process is necessary to ensure that all data obtained will be usable in the course of making conclusions or data comparisons. In addition, continuous data reduction and evaluation during the RI can provide input for succeeding RI tasks. This task will require an estimated 1,620 man-hours of effort and will cost approximately $60,800.

Task 15 - Prepare Remedial Investigation Report

After completion of the field investigations, all pertinent field and laboratory data will be assembled into a detailed draft report of the Remedial Investigation. This report will include the following items:

- Objectives of the Remedial Investigation

- Groundwater and surface water quality in the study area

- A model evaluation of PCB transport through the wetland food chain

- A discussion of the current levels of PCB transport to the environment via air, water, and biotic pathways as well as the health impacts of this transport.

- Conclusions and recommendations of this study

The Remedial Investigation Report is estimated to cost $11,500.

10.4.4 Management Plan

The management plan shall include the administrative and management requirements for performing the RI work activities. The principal sections of the management plan are described below.

10.4.4.1 Project Organization and Staffing

This section describes the project's organizational plan with regard to personnel as well as the level of effort required to complete each task. The project manager will be identified as well as other key project personnel.

10.4.4.2 Project Reports

The reporting requirements, including the quantity and distribution, will be specified in this section. The reporting requirements for technical submittals, as well as financial and progress reporting requirements, will be specified.

Other components of the Management Plan include:

- Procurement
- Meetings
- Change Orders
- Community Relations Program

- Quality Assurance
- Health and Safety

10.4.5 Costs and Schedule

The Remedial Investigation of the Hudson River will require about 55 weeks to complete and will cost an estimated $396,000. These times and costs do not include NYSDEC- and USGS-sponsored fish and water monitoring programs nor do they consider additional sediment sampling. A detailed breakdown of costs for each task in the Remedial Investigation will be included in the Costs and Schedule section of the Work Plan. Also, a Remedial Investigation project schedule will be presented. Preliminary project schedules and cost estimates are provided in Appendix F.

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APPENDICES

A

APPENDIX A

SITE CHRONOLOGY
HUDSON RIVER PCBs SITE, NEW YORK

APPENDIX A

SITE CHRONOLOGY

HUDSON RIVER PCBs SITE, NEW YORK

1822	Fort Edward Dam completed.
1898	Fort Edward Dam reconstructed.
1950-1970	Navigational dredging removes an average of 23,000 cubic yards of sediment per year in Ford Edward area.
1950-1976	General Electric discharges approximately 500,000 pounds of PCBs into Hudson River from two capacitor plants in Hudson Falls.
1969	Elevated levels of PCBs were first discovered in Hudson River biota.
December 18, 1972	General Electric applies for a discharge permit, for an average discharge of 30 pounds/day of "Chlorinated Hydrocarbons." Permit became effective January 1975.
Spring 1973	30,000 cubic yards of sediment dredged by contractor to Scott Paper Company.
July-October 1973	Fort Edward Dam was removed because of its deteriorating condition.
July 1973-July 1974	850,000 cubic yards of sediment are scoured from former dam pool and 790,000 cubic yards deposited in east and west channels near Rogers Island.

1974-1975	615,000 cubic yards of sediment dredged by NYSDOT from east and west channels near Rogers Island.
April 1974	Attorney General of State of New York brought suit against Niagara Mohawk Power Corporation for permit violation due to excessive downstream transport of sediment and debris following removal of Fort Edward Dam.
August 1974	USEPA found PCB levels in fish as high as 350 ppm in the Upper Hudson River.
October 1974-July 1975	Timber rock cribs removed; rock placed to stabilize remnant deposits 3 and 4; banks shaped; dumped rock stabilized remnant deposit 5.
January 1975	G.E. permit to discharge 30 pounds/day of "Chlorinated Hydrocarbons" became effective.
September 8, 1975	NYSDEC brought suit against GE for PCB contamination of the Hudson River.
1975-1976	PCB levels in all species of fish sampled in some areas of the Hudson River were found to be exceeding the U.S. Food and Drug Administration tolerance level of 5 ppm.
1976	35,000 cubic yards dredged in the vicinity of buoy 212 by NYSDOT; fishery closed.
February 9, 1976	Hearing Officer found that DEC had presented overwhelming evidence of GE's responsibility for PCB contamination of Hudson River.

April 2, 1976	100-year flood occurs; additional 260,000 cubic yards of sediment scoured from unstabilized areas in former dam pool.
Summer 1976	Survey of Hudson River begins and lasts until 1978 from which 40 hot spots were identified.
September 8, 1976	Settlement of Hudson River PCB contamination hearing was reached.
September 1976	General Electric reduces daily PCB discharges to 454 g (1.0 lb) into Hudson River from the capacitor plants in Hudson Falls and Fort Edward.
July 1977	General Electric reduces daily PCB discharges to less than 0.0022 lb into Hudson River from two capacitor plants in Hudson Falls and Fort Edward.
September-December 1977, April-June 1978	180,000 cubic yards of sediment dredged from east channel and placed in new Moreau site, along with material removed from remnant deposit 3a.
April 1978	NYSDEC issued summary of Hudson River PCB study results.
June-August 1978	Banks of remnant deposits 3 and 5 were restabilized.
October 1978	NYSDEC removed 14,000 cubic yards of sediment from the most contaminated remnant pool deposits and deposited them in the Moreau Landfill.
September 1980	Clean Water Act (CWA) amendment entitled Hudson River PCB Reclamation Demonstration Project was

passed by Congress; EPA was authorized to spend up to $20,000,000 toward a proposed demonstration/reclamation project for removal and disposal of PCB-contaminated sediments from the Hudson River.

September 1980	Malcolm Pirnie issued Environmental Impact Statement on PCB Hot Spot Dredging Program, Upper Hudson River, New York.
October 1980	CWA Section 10 Amendments passed, which authorized EPA to make grants to the NYSDEC for the Hudson River PCB Reclamation Demonstration Project.
January 12, 1981	EPA - Region II issued Notice of Intent to prepare an E.I.S.
May 8, 1981	EPA - Region II issued draft Environmental Impact Statement on Hudson River PCB Reclamation Demonstration Project.
June 23-25, 1981	EPA and Army Corps of Engineers co-chaired public hearings on the Draft E.I.S.
August 28, 1981	EPA - Region II issued Supplemental Draft to E.I.S.
April 22, 1982	NYS Hazardous Waste Facility Siting Board rendered decision to approve a site for the disposal of PCB-contaminated sediments.
October 8, 1982	EPA - Region II issued final E.I.S. on Hudson River PCB Reclamation Demonstration Project.

December 30, 1982	EPA - Region II issued Record of Decision for the Environmental Impact Statement on the Hudson River PCB Reclamation/Demonstration Project, which switched project funding from CWA to CERCLA.
April-May 1983	Return of flood flows approaching the 80-year recurrence frequency.
April 27, 1983	Remedial Action Master Plan (RAMP) was assigned to NUS Corporation by EPA.
May 19, 1983	Four environmental groups and a Weschester County, New York, Congressman sue EPA for release of CWA authorized cleanup funds.
June 1983	NYSDEC files intent to sue EPA for release of CWA authorized cleanup funds.
August 1983	Site permit overturned.
September 8, 1983	EPA added the upper Hudson River to the CERCLA list for New York State.
September, 1983	Court order drops September 30, 1983 deadline for commitment or loss of CWA funds assigned to New York.

B

APPENDIX B

COST EFFECTIVENESS MATRICES

HUDSON RIVER PCBs SITE, NEW YORK

100573

B-1

DISPOSAL ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	EFFECTIVENESS MEASURES: RISK AND EFFECT OF FAILURE	EFFECTIVENESS MEASURES: LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	EFFECTIVENESS MEASURES: ABILITY TO MINIMIZE COMMUNITY IMPACTS	EFFECTIVENESS MEASURES: ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	EFFECTIVENESS MEASURES: ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	EFFECTIVENESS MEASURES: TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	EFFECTIVENESS MEASURES: COMMERCIAL IMPACTS	EFFECTIVENESS MEASURES: Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.1 DETOXIFICATION OF REMOVED SEDIMENTS WITH KOHPEG*	INITIAL RATING	—	—		—	—	—	—	—	—	—	—		
	WEIGHTED RATING	—	—	—	—	—	—	—	—	—	—	—	—	—
9.3.1.2 DETOXIFICATION OF REMOVED SEDIMENTS WITH WET AIR OXIDATION	INITIAL RATING	1.4	1.0		2	1	5	4	4	4	3	4		
	WEIGHTED RATING	1.4	1.2	2.6	1.2	1.1	5.0	2.4	2.4	2.0	1.5	1.6	17.2	6.6
9.3.1.3 DESTRUCTION OF REMOVED SEDIMENTS BY INCINERATION	INITIAL RATING	2.0	1.0		4	5	5	4	4	4	3	4		
	WEIGHTED RATING	2.0	1.2	3.2	2.4	5.5	5.0	2.4	2.4	2.0	1.5	1.6	22.8	7.1

* REMOVED FROM FURTHER CONSIDERATION DURING REMEDIAL ALTERNATIVES EVALUATION PROCESS

FIGURE B-1

COST EFFECTIVENESS MATRIX

HUDSON RIVER PCB SITE, NY

NUS CORPORATION

A Halliburton Company

DISPOSAL ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	CONSTRUCTION (Cost Measures)	OPERATION & MAINTENANCE (Cost Measures)	Σ COST RATINGS (Cost Measures)	TECHNOLOGY STATUS (Effectiveness Measures)	RISK AND EFFECT OF FAILURE (Effectiveness Measures)	LEVEL OF CLEANUP/ISOLATION ACHIEVABLE (Effectiveness Measures)	ABILITY TO MINIMIZE COMMUNITY IMPACTS (Effectiveness Measures)	ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA (Effectiveness Measures)	ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS (Effectiveness Measures)	TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION (Effectiveness Measures)	COMMERCIAL IMPACTS (Effectiveness Measures)	Σ EFFECTIVENESS RATINGS (Effectiveness Measures)	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.4 SECURE LANDFILL DISPOSAL OF REMOVED SEDIMENTS	INITIAL RATING	1.0	1.0		5	4	3	1	3	2	3	1		
	WEIGHTED RATING	1.0	1.2	2.2	3.0	4.4	3.0	0.6	1.8	1.0	1.5	0.4	15.7	7.1
	INITIAL RATING													
	WEIGHTED RATING													
	INITIAL RATING													
	WEIGHTED RATING													

FIGURE B-2

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

NUS CORPORATION
A Halliburton Company

100574

RIVER SEDIMENT ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES			EFFECTIVENESS MEASURES									
		CONSTRUCTION	OPERATION & MAINTENANCE	Σ COST RATINGS	TECHNOLOGY STATUS	RISK AND EFFECT OF FAILURE	LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	ABILITY TO MINIMIZE COMMUNITY IMPACTS	ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	COMMERCIAL IMPACTS	Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.5 DREDGING OF 40 HOT SPOTS	INITIAL RATING	2.0	1.1		4	3	3	3	3	5	2	4		
	WEIGHTED RATING	2.0	1.3	3.3	2.4	3.3	3.0	1.8	1.8	2.5	1.0	1.6	17.4	5.3
9.3.1.6 REDUCED SCALE DREDGING	INITIAL RATING	1.6	1.1		4	3	2	4	2	5	4	3		
	WEIGHTED RATING	1.6	1.3	2.9	2.4	3.3	2.0	2.4	1.2	2.5	2.0	1.2	17.0	5.9
9.3.1.7 NO ACTION FOR RIVER SEDIMENTS, ROUTINE DREDGING CONTINUES, WATER SUPPLY IS NOT TREATED	INITIAL RATING	1.0	1.0		5	4	1	2	4	5	5	1		
	WEIGHTED RATING	1.0	1.2	2.2	3.0	4.4	1.0	1.2	2.4	2.5	2.5	0.4	17.4	7.9

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

FIGURE B-3

NUS CORPORATION
A Hallib[illegible] Company

RIVER SEDIMENT ALERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	EFFECTIVENESS MEASURES: RISK AND EFFECT OF FAILURE	EFFECTIVENESS MEASURES: LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	EFFECTIVENESS MEASURES: ABILITY TO MINIMIZE COMMUNITY IMPACTS	EFFECTIVENESS MEASURES: ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	EFFECTIVENESS MEASURES: ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	EFFECTIVENESS MEASURES: TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	EFFECTIVENESS MEASURES: COMMERCIAL IMPACTS	EFFECTIVENESS MEASURES: Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.8 NO ACTION FOR RIVER SEDIMENTS, ROUTINE DREDGING CONTINUES, WATER SUPPLY IS TREATED	INITIAL RATING	1.0	1.0		5	4	1	2	5	5	4	1		
	WEIGHTED RATING	1.0	1.2	2.2	3.0	4.4	1.0	1.2	3.0	2.5	2.0	0.4	17.5	7.9
	INITIAL RATING													
	WEIGHTED RATING													
	INITIAL RATING													
	WEIGHTED RATING													

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

FIGURE B-4

NUS CORPORATION
A Halliburton Company

REMNANT DEPOSIT ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	RISK AND EFFECT OF FAILURE	LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	ABILITY TO MINIMIZE COMMUNITY IMPACTS	ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	COMMERCIAL IMPACTS	Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.9 TOTAL REMOVAL OF REMNANT DEPOSITS	INITIAL RATING	2.0	1.1		5	5	5	4	5	4	4	5		
	WEIGHTED RATING	2.0	1.3	3.3	3.0	5.5	5.0	2.4	3.0	2.0	2.0	2.0	24.9	7.5
9.3.1.10 PARTIAL REMOVAL OF REMNANT DEPOSITS	INITIAL RATING	1.5	1.2		5	2	3	3	4	4	4	3		
	WEIGHTED RATING	1.5	1.4	2.9	3.0	2.2	3.0	1.8	2.4	2.0	2.0	1.2	17.6	6.1
9.3.1.11 RESTRICTED ACCESS TO REMNANT DEPOSITS	INITIAL RATING	1.0	1.0		5	1	1	2	1	5	5	1		
	WEIGHTED RATING	1.0	1.2	2.2	3.0	1.1	1.0	1.2	0.6	2.5	2.5	0.4	12.3	5.6

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

FIGURE B-5

NUS CORPORATION
A Hallibu[illegible] Company

REMNANT DEPOSIT ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	EFFECTIVENESS MEASURES: RISK AND EFFECT OF FAILURE	EFFECTIVENESS MEASURES: LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	EFFECTIVENESS MEASURES: ABILITY TO MINIMIZE COMMUNITY IMPACTS	EFFECTIVENESS MEASURES: ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	EFFECTIVENESS MEASURES: ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	EFFECTIVENESS MEASURES: TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	EFFECTIVENESS MEASURES: COMMERCIAL IMPACTS	EFFECTIVENESS MEASURES: Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.12 IN-PLACE CONTAINMENT OF REMNANT DEPOSITS	INITIAL RATING	1.1	1.0		5	3	3	4	3	5	4	3		
	WEIGHTED RATING	1.1	1.2	2.3	3.0	3.3	3.0	2.4	1.8	2.5	2.0	1.2	19.2	8.3
9.3.1.13 IN-SITU DETOXIFICATION OF REMNANT DEPOSITS WITH KOHPEG*	INITIAL RATING	—	—		—	—	—	—	—	—	—	—		
	WEIGHTED RATING	—	—	—	—	—	—	—	—	—	—	—	—	—
9.3.1.14 NO ACTION ON REMNANT DEPOSITS WITH RESTRICTED ACCESS TO DEPOSITS 3 AND 5	INITIAL RATING	1.0	1.0		5	1	1	1	1	5	5	1		
	WEIGHTED RATING	1.0	1.2	2.2	3.0	1.1	1.0	0.6	0.6	2.5	2.5	0.4	11.7	5.3

* REMOVED FROM FURTHER CONSIDERATION DURING REMEDIAL ALTERNATIVES EVALUATION PROCESS

FIGURE B-6

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

NUS CORPORATION
A Halliburton Company

100578

REMNANT DEPOSIT ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	EFFECTIVENESS MEASURES: RISK AND EFFECT OF FAILURE	EFFECTIVENESS MEASURES: LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	EFFECTIVENESS MEASURES: ABILITY TO MINIMIZE COMMUNITY IMPACTS	EFFECTIVENESS MEASURES: ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	EFFECTIVENESS MEASURES: ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	EFFECTIVENESS MEASURES: TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	EFFECTIVENESS MEASURES: COMMERCIAL IMPACTS	EFFECTIVENESS MEASURES: Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.15 PARTIAL REMNANT DEPOSIT REMOVAL/PARTIAL IN-PLACE CONTAINMENT	INITIAL RATING	1.7	1.2		5	4	4	4	4	4	4	4		
	WEIGHTED RATING	1.7	1.4	3.1	3.0	4.4	4.0	2.4	2.4	2.0	2.0	1.6	21.8	7.0
9.3.1.16 PARTIAL REMNANT DEPOSIT REMOVAL/PARTIAL RESTRICTED ACCESS	INITIAL RATING	1.5	1.2		5	3	3	3	4	4	4	3		
	WEIGHTED RATING	1.5	1.4	2.9	3.0	3.3	3.0	1.8	2.4	2.0	2.0	1.2	18.7	6.4
9.3.1.17 PARTIAL REMNANT DEPOSIT IN-PLACE CONTAINMENT/ PARTIAL RESTRICTED ACCESS	INITIAL RATING	1.0	1.0		5	2	2	3	3	5	4	2		
	WEIGHTED RATING	1.0	1.2	2.2	3.0	2.2	2.0	1.8	1.8	2.5	2.0	0.8	16.1	7.3

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

FIGURE B-7

NUS CORPORATION
A Halliburton Company

REMNANT DEPOSIT ALTERNATIVES

ALTERNATIVES	TYPE OF RATING	COST MEASURES: CONSTRUCTION	COST MEASURES: OPERATION & MAINTENANCE	COST MEASURES: Σ COST RATINGS	EFFECTIVENESS MEASURES: TECHNOLOGY STATUS	EFFECTIVENESS MEASURES: RISK AND EFFECT OF FAILURE	EFFECTIVENESS MEASURES: LEVEL OF CLEANUP/ISOLATION ACHIEVABLE	EFFECTIVENESS MEASURES: ABILITY TO MINIMIZE COMMUNITY IMPACTS	EFFECTIVENESS MEASURES: ABILITY TO MEET RELEVANT PUBLIC HEALTH & ENVIRONMENTAL CRITERIA	EFFECTIVENESS MEASURES: ABILITY TO MEET LEGAL AND INSTITUTIONAL REQUIREMENTS	EFFECTIVENESS MEASURES: TIME REQUIRED TO ACHIEVE CLEANUP/ISOLATION	EFFECTIVENESS MEASURES: COMMERCIAL IMPACTS	EFFECTIVENESS MEASURES: Σ EFFECTIVENESS RATINGS	Σ EFFECTIVENESS RATINGS / Σ COST RATINGS
	WEIGHTING FACTORS →	1.0	1.2		0.6	1.1	1.0	0.6	0.6	0.5	0.5	0.4		
9.3.1.18 PARTIAL REMNANT DEPOSIT IN-PLACE CONTAINMENT/PARTIAL IN-SITU DETOXIFICATION *	INITIAL RATING													
	WEIGHTED RATING													
9.3.1.19 PARTIAL REMNANT DEPOSIT REMOVAL/PARTIAL IN-SITU DETOXIFICATION *	INITIAL RATING													
	WEIGHTED RATING													
9.3.1.20 PARTIAL RESTRICTED ACCESS TO REMNANT DEPOSITS/PARTIAL IN-SITU DETOXIFICATION *	INITIAL RATING													
	WEIGHTED RATING													

* REMOVED FROM FURTHER CONSIDERATION DURING REMEDIAL ALTERNATIVES EVALUATION PROCESS

COST EFFECTIVENESS MATRIX
HUDSON RIVER PCB SITE, NY

FIGURE B-8

NUS CORPORATION
A Halliburton Company

100580

C

APPENDIX C

ALTERNATIVE COST ESTIMATES

HUDSON RIVER PCBs SITE, NEW YORK

The estimated costs used in the matrix evaluation of remedial alternatives are exhibited in Appendix A. The Capital Cost items are presented for each alternative, in order of appearance of alternatives in Chapter 9, on pages C2-C21. Operation and maintenance cost items are presented on pages 22 through 41.

.1.1 DETOX. OF SEDIMENTS WITH KOHPEG

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MOB/DEMOB	1	3,000	3,000	
CONTAINMENT BASIN	3	25,000	75,000	
OPERATING COST	2	150,000	300,000	
TREATMENT COST	1,450,000	100	145,000,000	
TESTING AND MONITORING	1	45,000	45,000	
LANDFILL OF REFUSE	1	9,200,000	9,200,000	
HEALTH & SAFETY	145,348,000	.25	36,337,000	
SUBTOTAL				190,960,000
20% CONTINGENCY				38,192,000
				229,152,000
10% OVERHEAD AND PROFIT				22,915,200
				252,067,200
15% ENGINEERING				37,810,080
AL CAPITAL COST				289,877,280

9.3.1.2 WET AIR OXIDATION OF SEDIMENTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MOB/DEMOB	1	3000	3000	
CONTAINMENT BASIN	1	75,000	75,000	
OPERATING COST	2	150,000	300,000	
SCREENING	1	20,000	20,000	
OPERATING COST	1,452,000	1	1,452,000	
CRUSHING AND SLURRYING	1	5,000	5,000	
OXIDATION UNITS	25	2,000,000	50,000,000	
TREATMENT COSTS	127,000,000	.066	8,382,000	
TESTING AND MONITORING	1	45,000	45,000	
LANDFILL OF REFUSE	1	9,200,000	9,200,000	
HEALTH & SAFETY	10,187,000	.25	2,546,750	

SUBTOTAL				72,028,750
20% CONTINGENCY				14,405,750

				86,434,500
10% OVERHEAD AND PROFIT				8,643,450

				95,077,950
15% ENGINEERING				14,261,693

TOTAL CAPITAL COST				109,339,643

9.3.1.3 INCINERATION OF SEDIMENTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
DIRECT COSTS:			0	
KILNS/ANCILLARY UNITS	1	118,895,000	118,895,000	
RESIDUE DISPOSAL	1	500,000	500,000	
MOB/DEMOB	3	1,000	3,000	
LABOR			0	
OPERATING LABOR	2	8,736,000	17,472,000	
MAINTENANCE	1	5,969,750	5,969,750	
SUPERVISORY	1	4,688,350	4,688,350	
MATERIALS			0	
FLOCCULANT	2	116,500	233,000	
MAINTENANCE	1	5,969,750	5,969,750	
UTILITIES			0	
ELECTRICITY	2	50,000	100,000	
FUEL OIL	2	1,543,000	3,086,000	
SECONDARY WASTE DISPOSAL	2	300,000	600,000	
HEALTH & SAFETY	28,133,100	.25	7,033,275	

SUBTOTAL				164,550,125
20% CONTINGENCY				32,910,025

				197,460,150
10% OVERHEAD AND PROFIT				19,746,015

				217,206,165
ENGINEERING				32,580,925

TOTAL CAPITAL COST				249,787,090

9.3.1.4 SECURE LANDFILL DISPOSAL OF SEDIMENTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
SITE CONSTRUCTION	1	5,843,000	5,843,000	
COVER COSTS	1	1,740,000	1,740,000	
SITE MODIFICATIONS AFTER CLOSURE	1	426,000	426,000	
			0	
MOB/DEMOB	3	1,000	3,000	
HEALTH & SAFETY	8,012,000	.25	2,003,000	
SUBTOTAL				10,015,000
20% CONTINGENCY				2,003,000
				12,018,000
10% OVERHEAD AND PROFIT				1,201,800
				13,219,800
15% ENGINEERING				1,982,970
TOTAL CAPITAL COST				15,202,770

9.3.1.5 DREDGING OF 40 HOT SPOTS

MPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
PREDREDGE SAMPLING	1	1,370,000	1,370,000	
DREDGING:			0	
THOMPSON ISLAND	1	7,204,000	7,204,000	
LOCK #6	1	838,000	838,000	
LOCK #5	1	2,800,000	2,800,000	
LOCK #4	1	1,318,000	1,318,000	
LOCK #3	1	1,360,000	1,360,000	
LOCK #2	1	1,446,000	1,446,000	
MAT'L REHANDLING	1	441,000	441,000	
SEDIMENT DISPOSAL	1,452,000	8.4	12,196,800	
MOB/DEMOB	5	1,000	5,000	
HEALTH & SAFETY	28,978,800	.25	7,244,700	
SUBTOTAL				36,223,500
20% CONTINGENCY				7,244,700
				43,468,200
10% OVERHEAD AND PROFIT				4,346,820
				47,815,020
% ENGINEERING				7,172,253
TOTAL CAPITAL COST				54,987,273

9.3.1.6 REDUCED SCALE DREDGING

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
PREDREDGE SAMPLING	1	1,370,000	1,370,000	
DREDGING:			0	
THOMPSON ISLAND	1	7,204,000	7,204,000	
LOWER POOL	1	3,503,000	3,503,000	
MAT'L REHANDLING	1	441,000	441,000	
SEDIMENT DISPOSAL	645,450	8.4	5,421,780	
MOB/DEMOB	4	1,000	4000	
HEALTH & SAFETY	17,943,780	.25	4485945	

SUBTOTAL				22,429,725
20% CONTINGENCY				4,485,945

				26,915,670
10% OVERHEAD AND PROFIT				2,691,567

				29,607,237
15% ENGINEERING				4,441,086

TOTAL CAPITAL COST				34,048,323

9.3.1.7 NO REMEDIAL ACTION, WATER SUPPLY NOT TREATED

TREATABILITY ASSESSMENT	120,000
TOTAL CAPITAL COST	120,000

9.3.1.8 NO ACTION, WATER SUPPLY TREATED

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CARBON ADSORPTION TREATMENT	1	75,000	75,000	
			0	
SUBTOTAL				75,000
20% CONTINGENCY				15,000
				90,000
10% OVERHEAD AND PROFIT				9,000
				99,000
15% ENGINEERING				14,850
TOTAL CAPITAL COST				113,850

9.3.1.9 TOTAL REMOVAL OF ALL REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CONSTRUCT HAUL ROADS	27,000	3	81,000	
CLEAR & GRUB FOR ROADS	.9	45	40.5	
EXCAVATION	350,200	6	2,101,200	
HAULING	350,200	4	1,400,800	
REGRADING	80,650	3	241,950	
REVEGETATION	49.8	1000	49,800	
MOB/DEMOB	5	1000	5,000	
SECURE LANDFILL DISPOSAL			0	
OF #1-5	350,200	8.4	2,941,680	
HEALTH & SAFETY	6,690,630	.25	1,672,657.5	

SUBTOTAL				8,494,128
20% CONTINGENCY				1,698,826

				10,192,954
10% OVERHEAD AND PROFIT				1,019,295

				11,212,249
15% ENGINEERING				1,681,837

TOTAL CAPITAL COST				12,894,086

9.3.1.10 PARTIAL REMOVAL OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
EXCAVATION OF #3 & 5	192,700	6	1,156,200	
REGRADING OF #3 & 5	28,000	3	84,000	
REVEGETATION OF #3 & 5	17.3	1,000	17,300	
MOB/DEMOB	2	1,000	2,000	
CLEAR & GRUB FOR ROADS	.2	45	9	
HAULING OF #3 & #5	192,700	4	770,800	
SECURE LANDFILL DISPOSAL			0	
OF #3 & 5	192,700	8.4	1,618,680	
HEALTH & SAFETY	3,631,680	.25	907,920	

SUBTOTAL				4,556,909
20% CONTINGENCY				911,382

				5,468,291
10% OVERHEAD AND PROFIT				546,829

				6,015,120
15% ENGINEERING				902,268

TOTAL CAPITAL COST				6,917,388

9.3.1.11 RESTRICTED ACCESS TO REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CHAINLINK FENCE-LANDWARD	12,100	12.5	151,250	
MAN GATES	8	250	2,000	
VEHICLE GATES	8	650	5,200	
SIGNS	257	75	19,275	
REVEGETATION	49.8	1000	49,800	
MOB/DEMOB	5	1000	5,000	
HEALTH & SAFETY	49,800	.25	12,450	
SUBTOTAL				244,975
20% CONTINGENCY				48,995
				293,970
10% OVERHEAD AND PROFIT				29,397
				323,367
15% ENGINEERING				48,505
TOTAL CAPITAL COST				371,872

9.3.1.12 IN-PLACE CONTAINMENT OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTAL
CONSTRUCT HAUL ROADS	35,000	3	105,000	
SUBSOIL (1.5 FT THICK)	93,000	7	651,000	
TOPSOIL (0.5 FT THICK)	30,300	9	272,700	
RIP-RAP OF 2 & 4	7,000	22	154,000	
REGRADING OF 2 & 4	7,000	3	21,000	
REVEGATATION	37	1,000	37,000	
CLEAR & GRUB FOR ROADS	0.9	45	40.5	
MOB/DEMOB	5	1,000	5,000	
HEALTH & SAFETY	1,140,700	0.25	285,175	
SUBTOTAL				1,530,916
20% CONTINGENCY				306,183
				1,837,099
10% OVERHEAD AND PROFIT				183,710
				2,020,808
15% ENGINEERING				303,121
TOTAL CAPITAL COST				2,323,930

9.3.1.13 IN-SITU DETOXIFICATION OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
B/DEMOB	5	1,000	5,000	
TREATMENT	350,000	100	35,000,000	
TESTING & MONITORING	200	150	30,000	
ACCESS ROADS	27,000	3	81,000	
REVEGETATION	49.8	1,000	49,800	
CLEAR & GRUB ROADS	.9	45	40.5	
HEALTH & SAFETY	35,084,800	.25	8,771,200	
SUBTOTAL				43,937,041
20% CONTINGENCY				8,787,408
				52724449
10% OVERHEAD AND PROFIT				5272445
				57,996,893
15% ENGINEERING				8,699,534
TOTAL CAPITAL COST				66,696,427

9.3.1.14 NO ACTION ON #1,2 & 4/RESTRICT ACCESS TO #3 & 5

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CHAINLINK FENCE-LANDWARD			0	
ON #3 & 5	5,300	12.5	66,250	
MAN GATES	4	250	1,000	
VEHICLE GATES	4	650	2,600	
SIGNS	100	75	7,500	
REVEGETATION ON #3 & 5	17.3	1,000	17,300	
MOB/DEMOB	2	1,000	2,000	
HEALTH & SAFETY	19,300	.25	4,825	
SUBTOTAL				101,475
20% CONTINGENCY				20,295
				121,770
10% OVERHEAD AND PROFIT				12,177
				133,947
15% ENGINEERING				20,092
TOTAL CAPITAL COST				154,039

9.3.1.15 PARTIAL REMOVAL/CONTAINMENT OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CONSTRUCT HAUL ROADS	27,000	3	81,000	
EXCAVATION OF #3 & 5	192,700	6	1,156,200	
REGRADING OF #1, 2 & 4	11,700	3	35,100	
REVEGETATION OF #1-5	49.8	1000	49,800	
MOB/DEMOB	5	1000	5,000	
SUBSOIL ON #1,2 & 4	79,000	7	553,000	
TOPSOIL ON #1,2 & 4	26,400	9	237,600	
RIP-RAP #1,2 & 4	11,700	22	257,400	
CLEAR & GRUB FOR ROADS	.9	45	40.5	
HAULING	192,700	4	770,800	
DISPOSAL (SECURE LANDFILL)			0	
OF #3 & 5	192,700	8.4	1,618,680	
HEALTH & SAFETY	4,683,580	.25	1,170,895	

SUBTOTAL				5,935,516
20% CONTINGENCY				1,187,103

				7,122,619
10% OVERHEAD AND PROFIT				712,262

				7,834,880
15% ENGINEERING				1,175,232

TOTAL CAPITAL COST				9,010,113

9.3.1.16 PARTIAL REMOVAL/RESTRICTED ACCESS OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
EXCAVATION	192,700	6	1,156,200	
REGRADING OF #3 & 5	28,000	3	84,000	
REVEGETATION OF #1-5	49.8	1,000	49,800	
CHAINLINK FENCE-LANDWARD	6,800	12.5	85,000	
MAN GATES	4	250	1,000	
VEHICLE GATES	4	650	2,600	
SIGNS	157	75	11,775	
MOB/DEMOB	5	1,000	5,000	
HAULING OF #3 & 5	192,700	4	770,800	
CLEAR & GRUB ROADS	.2	45	9	
DISPOSAL OF #3 & 5	192,700	8.4	1,618,680	
HEALTH & SAFETY	3,684,480	.25	921,120	
SUBTOTAL				4,705,984
20% CONTINGENCY				941,197
				5,647,181
10% OVERHEAD AND PROFIT				564,718
				6,211,899
15% ENGINEERING				931,785
TOTAL CAPITAL COST				7,143,684

9.3.1.17 PARTIAL CONTAINMENT/RESTRICTED ACCESS OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
BSOIL (1.5 FT THICK)	42,000	7	294,000	
TOPSOIL (0.5 FT THICK)	14,000	9	126,000	
REVEGETATION	49.8	1,000	49,800	
CHAINLINK FENCE-LANDWARD	6,800	12.5	85,000	
MAN GATES	4	250	1,000	
VE CLE GATES	4	650	2,600	
SI S	157	75	11,775	
M DEMOB	5	1,000	5,000	
C R & GRUB FOR ROADS	.2	45	9	
TH & SAFETY	474,800	.25	118,700	
OTAL				693,884
2 CONTINGENCY				138,777
				832,661
10% OVERHEAD AND PROFIT				83,266
				915,927
15% ENGINEERING				137,389
TOTAL CAPITAL COST				1,053,316

100600

9.3.1.18 PARTIAL CONTAINMENT/IN-SITU DETOX OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CONSTRUCT HAUL ROADS	27,000	3	81,000	
SUBSOIL FOR #1,2 &4	79,000	7	553,000	
TOPSOIL FOR #1, 2 & 4	26,400	9	237,600	
RIP-RAP OF #1, 2 & 4	11,700	22	257,400	
REGRADING OF #1,2 & 4	11,700	3	35,100	
REVEGETATION	49.8	1,000	49,800	
MOB/DEMOB	5	1,000	5,000	
CLEAR & GRUB FOR ROADS			0	
TO #2, 3 & 4	.9	45	40.5	
DETOXIFICATION W/ KOHPEG	192,700	100	19,270,000	
TESTING & MONITORING	110	150	16,500	
HEALTH & SAFETY	20,424,400	.25	5,106,100	
SUBTOTAL				25,611,541
20% CONTINGENCY				5,122,308
				30,733,849
10% OVERHEAD AND PROFIT				3,073,385
				33,807,233
15% ENGINEERING				5,071,085
TOTAL CAPITAL COST				38,878,318

9.3.1.19 PARTIAL REMOVAL/IN-SITU DETOXIFICATION OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CONSTRUCT HAUL ROADS	27,000	3	81,000	
EXCAVATION	157,500	6	945,000	
REGRADING OF #1, 2 & 4	52,700	3	158,100	
REVEGETATION	49.8	1,000	49,800	
MOB/DEMOB	5	1,000	5,000	
CLEAR & GRUB FOR ROADS	.9	45	40.5	
HAULING OF #1, 2 & 4	157,500	4	630,000	
DISPOSAL (SECURE LANDFILL)			0	
OF #1, 2 & 4	157,500	8.4	1,323,000	
DETOXIFICATION W/ KOHPEG	192,700	100	19,270,000	
TESTING & MONITORING	110	150	16,500	
HEALTH & SAFETY	22,397,400	.25	5,599,350	
SUBTOTAL				28,077,791
20% CONTINGENCY				5,615,558
				33,693,349
10% OVERHEAD AND PROFIT				3,369,335
				37,062,683
15% ENGINEERING				5,559,403
TOTAL CAPITAL COST				42,622,086

9.3.1.20 PARTIAL DETOX/RESTRICTED ACCESS OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CHAINLINK FENCE-LANDWARD	6,800	12.5	85,000	
MAN GATES	4	250	1,000	
VEHICLE GATES	4	650	2,600	
SIGNS	157	75	11,775	
REVEGETATION OF #1-5	49.8	1000	49,800	
MOB/DEMOB	5	1000	5,000	
CLEAR & GRUB FOR ROADS	.2	45	9	
DETOXIFICATION W/ KOHPEG	192,700	100	19,270,000	
TESTING & MONITORING	110	150	16,500	
HEALTH & SAFETY	19,341,300	.25	4,835,325	
SUBTOTAL				24,277,009
20% CONTINGENCY				4,855,402
				29,132,411
10% OVERHEAD AND PROFIT				2,913,241
				32,045,652
15% ENGINEERING				4,806,848
TOTAL CAPITAL COST				36,852,500

3.1.1 DETOX. OF SEDIMENTS WITH KOHPEG

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
NO O&M COSTS			0	

TOTAL ANNUAL COST (20 YEAR PERIOD)				0
PRESENT WORTH (10% DISCOUNT RATE)				0
20% CONTINGENCY				0

TOTAL OPERATION AND MAINTENANCE COST				0

9.3.1.2 WET AIR OXIDATION OF SEDIMENTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
NO O&M COSTS			0	

TOTAL ANNUAL COST (20 YEAR PERIOD)				0
PRESENT WORTH (10% DISCOUNT RATE)				0
20% CONTINGENCY				0

TOTAL OPERATION AND MAINTENANCE COST				0

3.1.3 INCINERATION OF SEDIMENTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
NO O&M COSTS			0	
TOTAL ANNUAL COST (20 YEAR PERIOD)				0
PRESENT WORTH (10% DISCOUNT RATE)				0
20% CONTINGENCY				0
TOTAL OPERATION AND MAINTENANCE COST				0

9.3.1.4 SECURE LANDFILL DISPOSAL OF SEDIMENTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
GROUNDWATER MONITORING:			0	
SAMPLING	1	16,000	16,000	
TESTING	64	200	12,800	
LEACHATE MONITORING:			0	
SAMPLING	1	2,000	2,000	
TESTING	4	200	800	
INSPECTIONS	2	1,000	2,000	

TOTAL ANNUAL COST (20 YEAR PERIOD)				33,600
PRESENT WORTH (10% DISCOUNT RATE)				286,056

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
S.T. LEACHATE MONITORING:			0	
SAMPLING	1	210,000	210,000	
TESTING	936	400	374,400	
AIR MONITORING:			0	
SAMPLING	1	72,000	72,000	
TESTING	650	125	81,250	
VEGETATION MONITORING:			0	
SAMPLING	1	3,000	3,000	
TESTING	4	150	600	

TOTAL ANNUAL COST (2 YEAR PERIOD)				741,250
PRESENT WORTH (10% DISCOUNT RATE)				1286467

	286,056
	1,286,467

TOTAL PRESENT WORTH	1,572,523
20% CONTINGENCY	314,505

TOTAL OPERATION AND MAINTENANCE COST	1,887,027

3.1.5 DREDGING OF 40 HOT SPOTS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
FISH MONITORING:			0	
COLLECTION	1	63,000	63,000	
ANALYSIS	1	70,000	70,000	
LABOR	8	7,628	61,024	
RAW WATER SAMPLING			0	
& TESTING	1	110,000	110,000	
WATER SUPPLY MONITORING:			0	
SAMPLING	1	5,000	5,000	
TESTING	24	150	3,600	
DREDGE SPOIL MONITORING:			0	
SAMPLING	1	16,000	16,000	
TESTING	50	150	7,500	
TOTAL ANNUAL COST (20 YEAR PERIOD)				336,124
PRESENT WORTH (10% DISCOUNT RATE)				2,861,613
20% CONTINGENCY				572,323
MONITORING OF SECURE LANDFILL DISPOSAL				1,887,027
TAL OPERATION AND MAINTENANCE COST				5,320,963

9.3.1.6 REDUCED SCALE DREDGING

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
FISH MONITORING:			0	
COLLECTION	1	63,000	63,000	
ANALYSIS	1	70,000	70,000	
LABOR	8	7,628	61,024	
RAW WATER SAMPLING			0	
& TESTING	1	110,000	110,000	
WATER SUPPLY MONITORING:			0	
SAMPLING	1	5,000	5,000	
TESTING	24	150	3,600	
DREDGE SPOIL MONITORING:			0	
SAMPLING	1	16,000	16,000	
TESTING	50	150	7,500	

TOTAL ANNUAL COST (20 YEAR PERIOD)				336,124
PRESENT WORTH (10% DISCOUNT RATE)				2,861,613
20% CONTINGENCY				572,323
MONITORING OF SECURE LANDFILL DISPOSAL				1,887,027

TOTAL OPERATION AND MAINTENANCE COST				5,320,963

9.3.1.7 NO ACTION FOR SEDS., ROUTINE DREDGING, WATER NOT TREATED

MPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
FISH MONITORING:			0	
COLLECTION	1	63,000	63,000	
ANALYSIS	1	70,000	70,000	
LABOR	8	7,628	61,024	
RAW WATER SAMPLING			0	
& TESTING	1	110,000	110,000	
WATER SUPPLY MONITORING:			0	
SAMPLING	1	5,000	5,000	
TESTING	24	150	3,600	
DREDGE SPOIL MONITORING:			0	
SAMPLING	1	16,000	16,000	
TESTING	50	150	7,500	

TOTAL ANNUAL COST (20 YEAR PERIOD)				336,124
PRESENT WORTH (10% DISCOUNT RATE)				2,861,613
20% CONTINGENCY				572,323

TOTAL OPERATION AND MAINTENANCE COST				3,433,936

9.3.1.8 NO ACTION FOR SEDS., ROUTINE DREDGING, WATER SUPPLY TREATED

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
FISH MONITORING:			0	
COLLECTION	1	63,000	63,000	
ANALYSIS	1	70,000	70,000	
LABOR	8	7,628	61,024	
RAW WATER SAMPLING			0	
& TESTING	1	110,000	110,000	
WATER SUPPLY MONITORING:			0	
SAMPLING	1	5,000	5,000	
TESTING	24	150	3,600	
DREDGE SPOIL MONITORING:			0	
SAMPLING	1	16,000	16,000	
TESTING	50	150	7,500	

TOTAL ANNUAL COST (20 YEAR PERIOD)				336,124
PRESENT WORTH (10% DISCOUNT RATE)				2,861,613

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
CARBON CHANGEOUT	1	83,000	83,000	

PERIODIC COST, 4 YEAR INTERVAL (20 YEAR PERIOD)				83,000
PRESENT WORTH (10% DISCOUNT RATE)				152,257

	2,861,613
	152,257

TOTAL PRESENT WORTH	3,013,870
20% CONTINGENCY	602,774

TOTAL OPERATION AND MAINTENANCE COST	3,616,644

9.3.1.9 TOTAL REMOVAL OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF SECURE LANDFILL DISPOSAL	1	1,887,027	1,887,027	
TOTAL OPERATION AND MAINTENANCE COST				1,887,027

9.3.1.10 PARTIAL REMOVAL OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	
ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
MONITORING OF SECURE LANDFILL DISPOSAL				1,887,027
TOTAL OPERATION AND MAINTENANCE COST				3,010,817

9.3.1.11 RESTRICTED ACCESS TO REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	
TOTAL ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
TOTAL OPERATION AND MAINTENANCE COST				1,123,790

9.3.1.12 IN-PLACE CONTAINMENT OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	

TOTAL ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298

TOTAL OPERATION AND MAINTENANCE COST				1,123,790

..3.1.13 IN-SITU DETOXIFICATION OF REMNANT DEPOSITS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
NO O&M COSTS			0	

TOTAL ANNUAL COST (20 YEAR PERIOD)				0
PRESENT WORTH (10% DISCOUNT RATE)				0
20% CONTINGENCY				0

TOTAL OPERATION AND MAINTENANCE COST				0

9.3.1.14 NO ACTION ON #1,2 & 4/RESTRICT ACCESS TO #3 & 5

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110000	110000	
TOTAL ANNUAL COST (20 YEAR PERIOD)				110000
PRESENT WORTH (10% DISCOUNT RATE)				936492
20% CONTINGENCY				187298
TOTAL OPERATION AND MAINTENANCE COST				1123790

9.3.1.15 PARTIAL REMNANT DEPOSIT REMOVAL/IN-PLACE CONTAINMENT

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
NITORING OF RIVER	1	110,000	110,000	
ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
MONITORING OF SECURE LANDFILL DISPOSAL				1,887,027
TOTAL OPERATION AND MAINTENANCE COST				3,010,817

9.3.1.16 PARTIAL REMNANT DEPOSIT REMOVAL/RESTRICTED ACCESS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	
ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
MONITORING OF SECURE LANDFILL DISPOSAL				1,887,027
TOTAL OPERATION AND MAINTENANCE COST				3,010,817

9.3.1.17 PARTIAL REMNANT IN-PLACE CONTAINMENT/RESTRICTED ACCESS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	
TOTAL ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
TOTAL OPERATION AND MAINTENANCE COST				1,123,790

9.3.1.18 PARTIAL REMNANT IN-PLACE CONTAINMENT/IN-SITU DETOXIFICATION

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	
TOTAL ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
TOTAL OPERATION AND MAINTENANCE COST				1,123,790

9.3.1.19 PARTIAL REMOVAL OF REMNANT DEPOSITS/IN-SITU DETOXIFICATION

MPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF SECURE LANDFILL DISPOSAL	1	1,887,027	1,887,027	

TOTAL OPERATION AND MAINTENANCE COST				1,887,027

9.3.1.20 PARTIAL IN-SITU DETOX. OF REMNANT DEPOSITS/RESTRICTED ACCESS

COMPONENT	UNITS	UNIT COST	SUBTOTALS	TOTALS
MONITORING OF RIVER	1	110,000	110,000	
TOTAL ANNUAL COST (20 YEAR PERIOD)				110,000
PRESENT WORTH (10% DISCOUNT RATE)				936,492
20% CONTINGENCY				187,298
TOTAL OPERATION AND MAINTENANCE COST				1,123,790

D

APPENDIX D

PHASE II, REMEDIAL INVESTIGATION OF THE HUDSON RIVER

APPENDIX D

PHASE II, REMEDIAL INVESTIGATION OF THE HUDSON RIVER

The following are two Remedial Investigation tasks scheduled to proceed in Phase II of the Remedial Investigation of the Hudson River. Phase II will proceed only if it is determined from the results of Phase I that PCB contamination of the sediments pose a significant health threat to area residents and that further remedial action will be required. The alternatives presented here are only suggested alternatives, and it may be determined later that additions or deletions will be required.

D.1 Sediment Sampling Survey

Present Sampling Efforts

The present information on the distribution of PCB-contaminated bed sediments stems from NYSDEC surveys completed in 1977 through 1978. These surveys consisted of 1200 core and grab samples (approximately 700 of which were analyzed for PCBs) distributed over 40 miles of river. The only recent results come from an EPA-sponsored survey consisting of core samples from 66 stations which duplicated approximately 45 earlier NYSDEC sampling locations. This survey was conducted in August 1983. Preliminary results of the August survey indicate that, in some areas, the older data are still reliable, while in other areas the distributions of PCB-contaminated sediments have changed. There are a number of important questions which must be answered by additional sampling before efficient planning can take place.

Description

The proposed comprehensive sampling program will have the following objectives:

- Validating the PCB hot-spot theory. This objective will investigate questions such as:

- Do continuous areas of highly contaminated sediments actually exist?

- Are contaminated sediments confined to localized packets, but clustered in a way that, in effect, simulates continuous areas of high contamination?

- Are contaminated sediments confined to localized pockets and distributed in a manner that makes remedial actions infeasible?

- If contaminated sediments actually do exist as localized pockets, what is the probability that a large number of these have been missed by sampling?

• The distribution of contaminated sediment deposits suitable for remedial actions. This objective would assume a PCB action level of 50 µg/g and investigate better methods of sampling and mapping, leading to the accurate delineation of contaminated sediments.

• The total error involved with sampling, analytical, and mapping procedures. This objective would result in the expression of a confidence level or interval which would be used in critical evaluations of PCB mass estimates, hot spot delineations, and remedial designs.

• Correlations between PCB contamination and stream channel or sediment characteristics. This objective is essential for a strong conceptual understanding which would be invaluable for further work in the Hudson River and in other contaminated waterways.

• The mobility status of the features which are being sampled. This objective refers to the determination of the likelihood of scour or deposition at the area of interest. This type of information will be used to generate estimates of the time period over which the data is valid, how soon remedial actions should be completed, or to what extent PCB-contaminated deposits can be left alone.

To efficiently meet the objectives specified above, the proposed plan will be carried out in two stages. Stage I will concentrate a large number of samples in previously delineated hot spots representing the following conditions:

- Upstream hot spots
- Downstream hot spots
- Large hot spots covering bank and channel areas
- Small localized hot spots

The study will investigate the variation of PCBs with distance from the center of contamination, with depth in the sediment, and with other parameters, including sediment characteristics, channel characteristics, and other toxic materials. Studies in these areas will be described in detail in other sections. Bed-load movement to and from selected areas will also be measured.

Strengthened relationships or lack of relationships developed from Stage I studies will dictate the procedures in Stage II. The second stage will essentially be a comprehensive survey of the sediments in the Upper Hudson River from the Glens Falls area to Albany. This stage will address the accurate delineation of contaminated sediments, and estimation of PCB amounts located in these areas.

Methods

Stage I will consist of obtaining relatively undisturbed sample cores, at least 3 feet in length, from locations specified by 100-foot sampling grids imposed on the selected hot spots. The sampling grids will extend past the present hot-spot boundaries to include cold areas. All sample stations will be required to have accurate and precise locations assigned to them; however, it will not be necessary to prelocate the sample station exactly on the intersections. The proposed sample location can initially be estimated from maps but it will be necessary to get an accurate position on the station once the core is retrieved. This is easily done with electronic survey equipment. Base-line survey information is adequate in the Thompson Island pool area; however, base-lines may have to be surveyed in lower pools.

Hot spots 6, 14, 20, 28, and 35 are tentatively selected for the Stage I study. Approximately 275 sample stations will be required to cover this area in detail. Each 3-foot core will be subsampled according to its morphologic layers. Approximately 3 to 4 subsamples each may be expected. Half of the cores from each study area will be analyzed for particle size class and organic content, and selected samples will be analyzed for priority pollutants. Other data which will be recorded include river stage, depth to sample, and flow velocities.

Bed load transport studies (described in another section) will also be done in selected areas.

The analysis and quantification of PCBs is subject to a great deal of misinterpretation. Therefore every effort will be made to acquire the most highly qualified contractor using the most accurate and up-to-date analytical methods. The exact Aroclors to be analyzed and the method for reporting total PCBs will be specified. Appropriate field duplicates, spikes, and blanks will be specified. To ensure comparability, analytical methods will not be modified for the duration of the study.

To handle the great amounts of information generated in the study and to aid data analysis, a computerized data base management system will be used, which will be compatable with appropriate mapping and statistical software. Each data point will be screened for quality and authenticity to ensure that only quality data will be used in later analyses.

Bed-load Transport Studies

Present Sampling Efforts

Cursory measurements of bed-load transport were made by Rensselaer Polytechnic Institute in 1977. This information, however, is not sufficient for interpreting local patterns of deposition and scour. Presently, only suspended sediment transport is being measured. Bed-load transport is an important factor controlling the micro-relief of the river bottom surface. In a low-velocity river such as the Hudson, this process may have a large influence on the distribution and movement of PCB-contaminated sediment.

Description

Bed-load transport will be measured across the river above and below selected hot spot areas studied in Stage I of the bed sediment survey. Bed-load transport will also be measured in the Champlain Canal above Lock 6. The canal location is important because substantial amounts of contaminated sediments, helped along by large traffic and lock operation, could move through Lock 6 to lower reaches of the river. Transport rates will be measured at each location at low, medium, and high flows. Channel cross-section measurements and a full range of flow measurements will be made so that measured bed-load transport can be compared with estimates calculated from various bed-load transport formula.

Analysis of bed-load transport data will reveal the dynamics of the river in critical areas and aid in the evaluation of the stability of hot spots and the likelihood that contaminated deposits will either be buried or exposed.

Methods

Structure-type sediment traps with sliding, water-tight lids, which are inserted into the sediment so that the trap openings are even with the surface of the bed, will be used. Two rows of traps will be installed across the river at each test reach. It should be possible to use digging frames to install all traps; however, divers may be needed to place traps in deeper water. If operation of these traps becomes problematical, then simpler but less efficient pan type or pressure difference type samplers will be used. Bed-load samples will be collected for an extended period of time during low, medium, and high flow periods. The flow velocity profile, depth, mean channel slope, and water temperature will be recorded to facilitate the calibration of the bed-load functions which will be used. Suspended-sediment transport measurement above the transects is also desirable.

E

APPENDIX E

ANALYSIS OF 1983 SAMPLING DATA

APPENDIX E
ANALYSIS OF 1983 SAMPLING DATA

In August 1983 Upper Hudson River sediments were resampled at selected locations to update the 1977-1978 sediment data. Fifty-four core samples and twelve grab samples were recovered from 66 locations along a 9-mile stretch of river between Rogers Island and a point approximately 1/2 mile south of Lock 6. Sample station locations in 1983 were surveyed in and plotted on 1:4200 planimetric maps courtesy of NYSDEC. Plotted sampling locations are provided in Attachment 1.

Core samples were subdivided according to visible strata, and each subsection was sampled for PCB analysis. PCB analytical procedures similar to those used for the NYSDEC survey were used to maximize comparability. Sample preparation procedures and analytical methods are outlined in Attachment 2.

A summary of the 1983 sampling results is presented in Table E-1. Only depth-weighted average PCB concentrations and maximum PCB values are reported. Forty-two of the sixty-five samples were located on or within the boundaries of PCB hot spots that were delineated on maps received from NYSDEC. A total of 15 hot spots were sampled. The arithmetic mean PCB concentration of hot spot samples was 52.6 ppm. The corresponding mean for the 24 samples from cold areas was 13.3 ppm.

Fifteen of forty-two samples taken from PCB hot spots contained concentrations greater than 50 ppm in some part of the core, and twelve cores showed depth-weighted averages greater than 50 ppm. Two cores taken from cold areas below Griffin Island had depth-weighted averages that exceeded 50 ppm.

The depth of maximum concentration within the cores was equally distributed between surface and deeper layers, but the more highly contaminated sediments

TABLE E-1

1983 SAMPLING RESULTS
HUDSON RIVER PCB SITE, NEW YORK

Sample Number	Location	Depth-Weighted Average PCB Concentration (ppm)	Total Depth (inches)	High Concentration (ppm)	Depth Interval of High Concentration (inches)
1		5.8	14	11.0	0 - 7
3		7.7	12	13.0	6 - 12
4		2.6	22	6.0	15 - 22
5		13.8	15	65.0	0 - 3
6	Hot Spot 2	29.9	22	36.4	5 - 14
7	Border Line, Hot Spot 6	ND	Grab Sample		
8A	Hot Spot 4	39.8	20	120.0	0 - 5
9		6.7	Grab Sample		
10	Hot Spot 5	58.6	16	71.2	4 - 16
11	Hot Spot 5	11.0	Grab Sample		
12	Hot Spot 5	21.6	Grab Sample		
13	Hot Spot 6	5.0	15	5.0	0 - 3
14	Hot Spot 6	9.0	8	12.0	0 - 4
15	Hot Spot 6	24.6	Grab Sample		
15A	Hot Spot 6	7.9	8	9.0	4 - 8
16	Hot Spot 6	41.0	Grab Sample		
17	Border Line, Hot Spot 6	55.0	Grab Sample		
18	Hot Spot 6	240.0	33	683.0	15 - 23
19		3.3	7	3.5	0 - 4
21	Hot Spot 8	255.0	18	307.0	0 - 9
22		3.2	Grab Sample		
23	Hot Spot 8	8.2	10	11.3	5 - 10
25	Hot Spot 8	89.1	13	110.0	3 - 13
26	Border Line, Hot Spot 9	25.1	18	24.8	0 - 3

TABLE E-1
1983 SAMPLING RESULTS
HUDSON RIVER PCB SITE, NEW YORK
PAGE TWO

Sample Number	Location	Depth-weighted Average PCB Concentration (ppm)	Total Depth (inches)	High Concentration (ppm)	Depth Interval of High Concentration (inches)
26A	Border Line, Hot Spot 8	8.9	28	8.0	0 - 12
27		3.9	9	3.9	3 - 9
28	Hot Spot 10	35.5	6	54.6	3 - 6
28A	Hot Spot 10	23.7	15	29.1	3 - 15
29	Hot Spot 10	433.0	7	641.0	3 - 7
30	Hot Spot 11	28.6	12	65.3	4 - 7
32		3.1	10	3.1	0 - 4
33	Hot Spot 12	12.8	14	20.9	5 - 10
34A	Hot Spot 14	58.6	20	125.0	8 - 17
36	Hot Spot 14	11.9	Grab Sample		
37	Hot Spot 14	11.7	9	22.2	0 - 3
38		0.3	14		
39	Hot Spot 14	7.6	9	7.6	0 - 3
40	Hot Spot 14	25.0	9	25.0	0 - 9
41B		4.0	Grab Sample		
42B		9.0	29	9.0	0 - 3
43B		135.0	20	240.0	3 - 4
44		9.0	7	9.0	0 - 3
44B		87.0	12	7.0	0 - 6
45B	Hot Spot 16	161.0	13	200.0	3 - 13
46B	Border Line, Hot Spot 16	17.8	16	31.0	4 - 8
47A	Hot Spot 16	1.0	9	2.0	0 - 3
48		4.0	5	0.0	0 - 2
49	Border Line, Hot Spot 17	41.0	15	41.0	0 - 15
50	Hot Spot 18	167.0	15	210.0	7 - 15

TABLE E-1
1983 SAMPLING RESULTS
HUDSON RIVER PCB SITE, NEW YORK
PAGE THREE

Sample Number	Location	Depth-weighted Average PCB Concentration (ppm)	Total Depth (inches)	High Concentration (ppm)	Depth Interval of High Concentration (inches)
51B		0.9	15	0.9	0 - 3
52		0.7	Grab Sample		
54		4.0	17	4.0	0 - 3
55		4.0	10	4.0	0 - 3
57		1.0	Grab Sample		
59	Hot Spot 20	86.6	10	90.0	2 - 11
63		3.9	11	4.0	0 - 3
64	Hot Spot 28	58.7	16	130.0	3 - 6
65		1.9	21	6.1	2 - 7
66	Hot Spot 28	25.7	20	27.8	3 - 20
70		4.8	13	6.0	4 - 13
71	Hot Spot 15	11.0	22	11.0	0 - 5
P-3-15-1	Hot Spot 18	0.6	17	0.6	0 - 3
P-3-15-2	Hot Spot 18	4.4	35	4.4	0 - 3
P-3-15-3	Hot Spot 18	1.0	18	1.0	0 - 3
P-3-15-4	Hot Spot 18	3.3	27	10.6	0 - 3
P-3-15-5	Hot Spot 18	2.0	15	5.1	0 - 3

Depth-weighted Average = $\sum_{i}^{i} (C_i * d_i)/D$

where C_i = concentration of layer i
d_i = length of layer i
D = total depth
Layers where PCB was identified below detection limit were assigned a concentration equal to the concentration of the next least contaminated layer.

ND - Not Detected

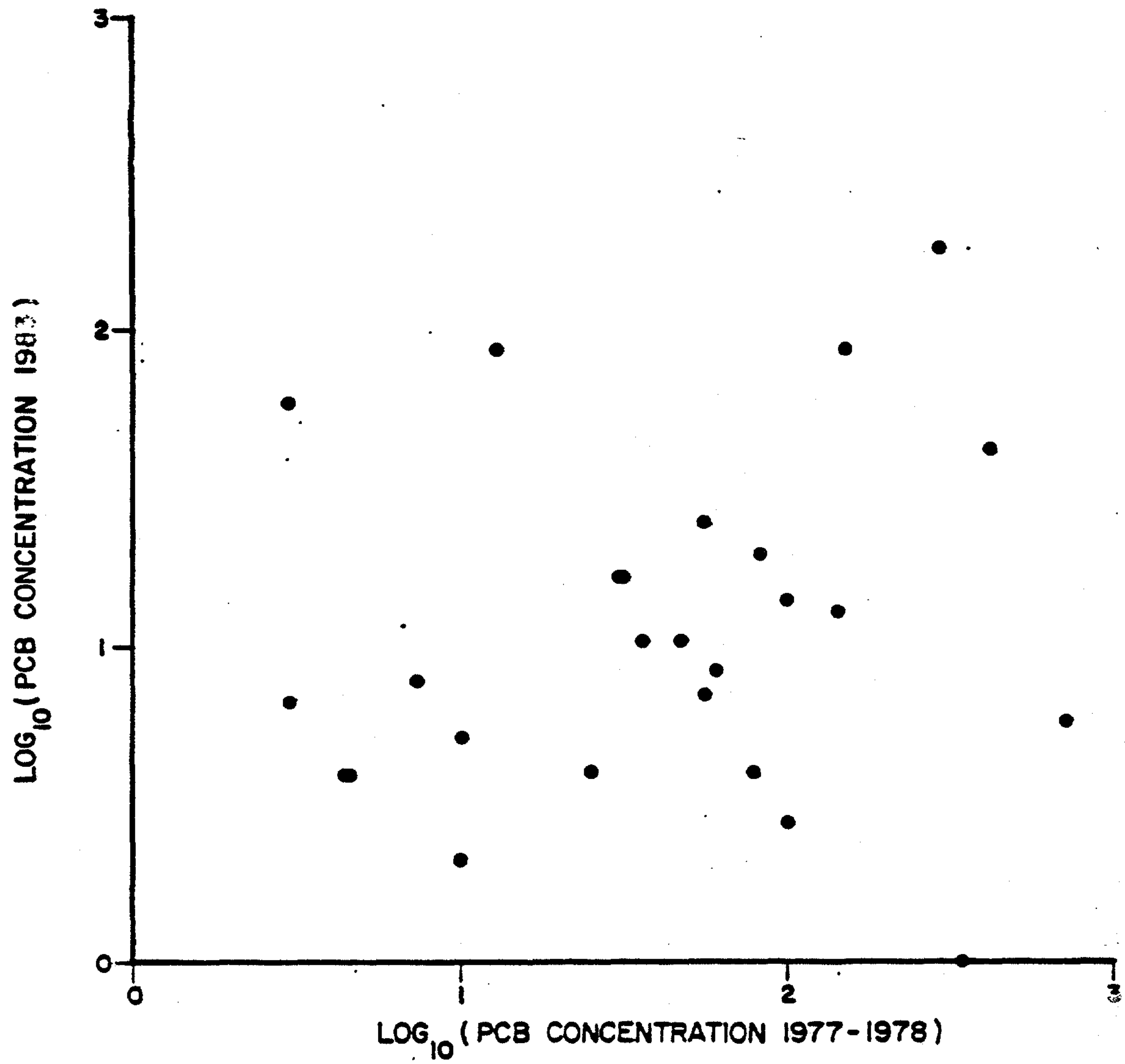
were usually found deeper than 3 inches in depth. The core samples averaged 15 inches long.

An arbitrary distance of 100 feet was set as the limit over which 1983 and older data could be compared. Overall, there were 62 NYSDEC survey points within a 100-foot radius of 1983 sample stations. Comparisons were made strictly on a depth-related basis. For example, PCB values from grab samples were compared only with the results from the first 3 inches of a core, and different length cores would be compared only when depth-weighted averages could be computed for depths comparable within plus or minus 5 inches. Most of the older data used in the comparisons were from grab samples.

The new data were compared to 1977-1978 data for locations within both 50 and 100 feet of the new sample locations, and then were plotted on log-log plots. These plots are presented in Figures E-1 and E-2. Since both surveys were theoretically sampling the same population, on the average, there should be a one to one correspondence between the data sets, and a line of slope 1.0 should fit the points on a log-log plot. Practically speaking, a perfect fit would be unrealistic because of the naturally high variability of PCB-contaminated sediment deposits and the low number of comparisons which are available.

There is some correlation between the two data sets indicating that in 1983, the higher concentrations are generally found where high concentrations were found in 1977-78. This relationship is reflected in the cold- and hot-spot means reported above. The spread of the data, however, on the log-log plots indicates that real PCB concentration values may differ by up to 1 or 2 orders of magnitude within 100 feet. Also, in 53 cases, the values from the 1977-1978 survey are substantially higher than PCB values from the 1983 survey. Only 9 of the 62 comparisons in 1983 showed higher results in 1983 than in 1977-1978.

Such a bias in the data could be caused by many mechanisms. Differences in the analysis and quantification of PCB Aroclors and the method of expressing total



ALL POSSIBLE COMPARISONS WITHIN A 50' RADIUS; 1977-1978 vs. 1983 SEDIMENT DATA - HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE E-1

NUS CORPORATION
A Halliburton Company

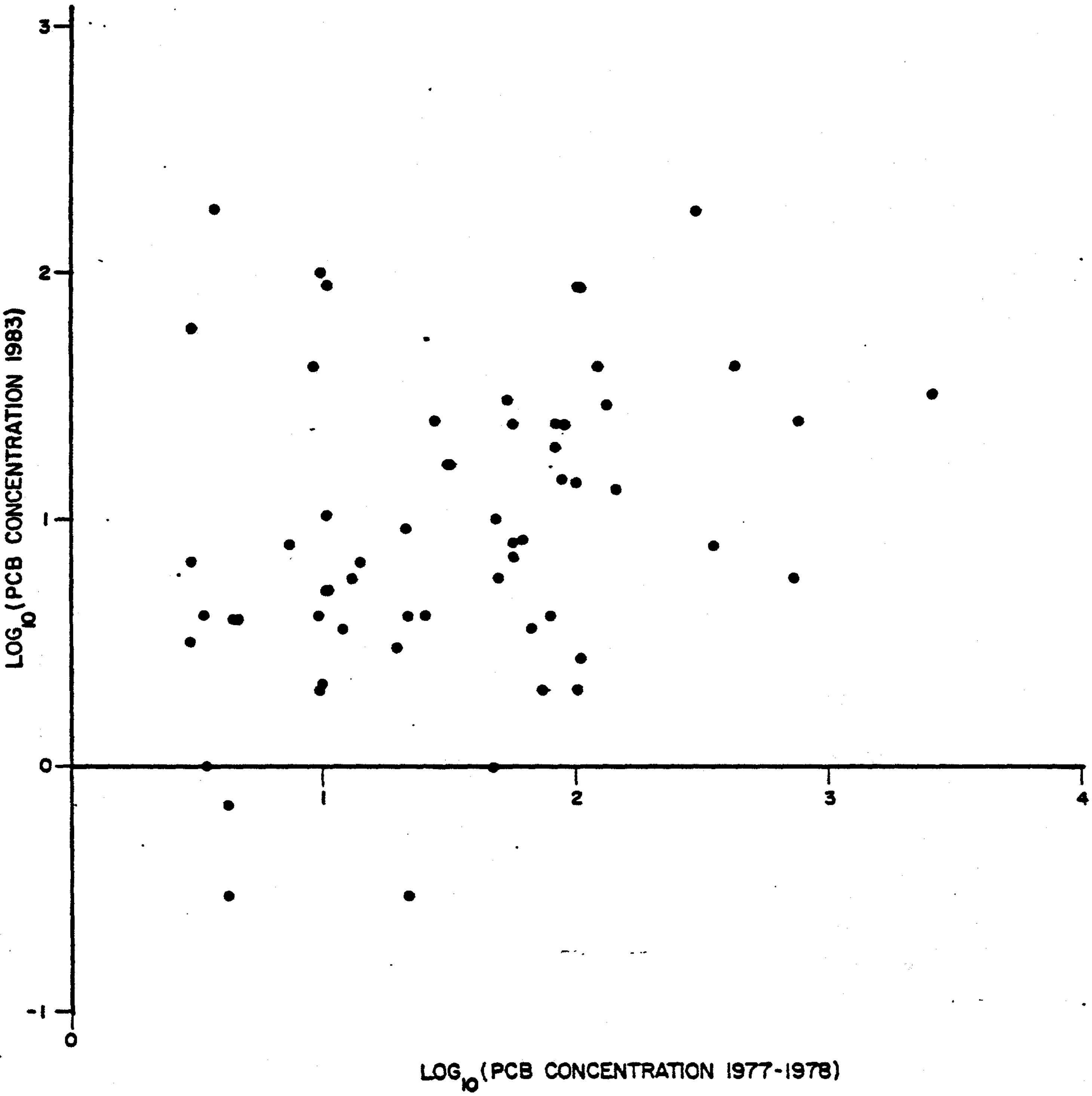


FIGURE E-2

ALL POSSIBLE COMPARISONS WITHIN A 100' RADIUS; 1977-1978 vs. 1983 SEDIMENT DATA - HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

PCB may introduce large differences in the data sets. Without a detailed evaluation and comparison of analytical methods used in each survey, a quantification is impossible. Mechanisms including desorption and removal of PCBs from the sediments, chemical degradation of PCB compounds, and the dilution of contaminated sediments through mixing during deposition and shifting of contaminated sediments, could also account for the drop in PCB contamination.

Differences of the magnitude indicated by this analysis could substantially affect the interpretation of the Hudson River PCB problem. Unfortunately, the limited amount of 1983 data prohibits a determination of whether the decrease in PCB concentration is real, as well as identification of possible physical chemical processes which could be responsible. The problem warrants further investigation.

A brief discussion of results from some critical areas may give some qualitative insight into the stability and movement of PCB hot spots.

Hot spot number 20 is a small marshland hot spot north of the eastern portion of Thompson Island Dam. This area has exhibited extremely high PCB values in the past. The 1983 sample from this area had a depth-weighted average of 86.6 ppm with a high value of 90 ppm occuring between 2 and 12 inches in depth. The closest NYSDEC sample point contained a depth-weighted average PCB concentration of 323 ppm. Although the later value shows much less PCB, it appears that this area is still hot.

Five samples were taken near the Thompson Island Dam to detect contaminated sediments which might have collected there. No samples were recovered from two of the stations because the bottom was either too hard or too rocky to recover sediment. The other three samples turned up no appreciable contamination. Unfortunately none of these samples fell within the boundaries at hot spot number 19. Two of the samples fell within 20 feet of previous grab samples which had indicated PCB contamination of 79.4 and 25 ppm. It may be that the drawdown behind the dam maintains a swift current which scoured the previously contaminated material and prevents further buildup of sediments.

Hot spot 18 is a large, highly contaminated deposit associated with a major riverbank wetland. Seven core samples were collected from this deposit in areas where PCB concentrations of between 68 and 300 ppm had been previously found. In 1983 highly contaminated sediments (170 ppm) were found near the upstream portion of the hot spot. However, six core samples collected over a small area within the lower half of the hot spot contained concentrations of less than 5 ppm. It is not known why highly contaminated sediments were not found in the downstream portion of this hot spot. Field observations indicated that the current over this deposit was rapid even though the area was surrounded by aquatic and emergent vegetation. It is possible that contaminated sediments found here in the past have moved.

Highly contaminated sediments (135 ppm) were found in a core collected near the center of the channel at the south end of Griffin Island. This area had not been sampled before, and shore line samples near this area had not indicated any appreciable contamination. Since this is a channel location subject to high velocities, it may be that the contaminated sediments found here in 1983 have been recently deposited material from upstream hot spots.

Hot spot 14 was an extensive, heavily contaminated area which contained a relatively large mass of PCB. Nearly every previous sample from this area contained PCBs in excess of 50 ppm and many contained concentrations higher than 100 ppm. Of the five samples taken from this area in 1983, only one at the extreme upstream end of the deposit contained concentrations in excess of 50 ppm. The other samples contained less than 15 ppm. Members of the survey in 1983 indicated that the river bottom where they attempted to take samples was composed of hard or decomposing shale fragments. They also indicated that the current over the lower end of this area was relatively swift. The highly contaminated channel deposits reported above were found immediately downstream of hot spot 14. It is suggested that the fine sediments found in hot spot 14 in 1977–1978 have been moved downstream and that some of them have been deposited near the end of Griffin Island.

One core sample retrieved from hot spot twelve, less than 20 feet from a previous NYSDEC sample, contained 12.8 ppm PCBs where the previous sample contained PCBs at about 100 ppm. This may be a reflection of the extreme variability in the distribution of contaminated sediments or it may be due to other mechanisms.

Hot spot number 10 is a mid-channel deposit which was expected to show some signs of degradation or scour. However, three core samples taken within the boundaries of this hot spot, reveal that highly contaminated sediments still exist here. It is not known why this particular channel deposit has remained stable while others appear to have shifted.

Four samples were retrieved from hot spot 8. Two samples had concentrations of more than 50 ppm and two did not. This deposit, however, is so large that a definitive statement or its status cannot be made. This is also the case with hot spot 28, which is located below Lock 6.

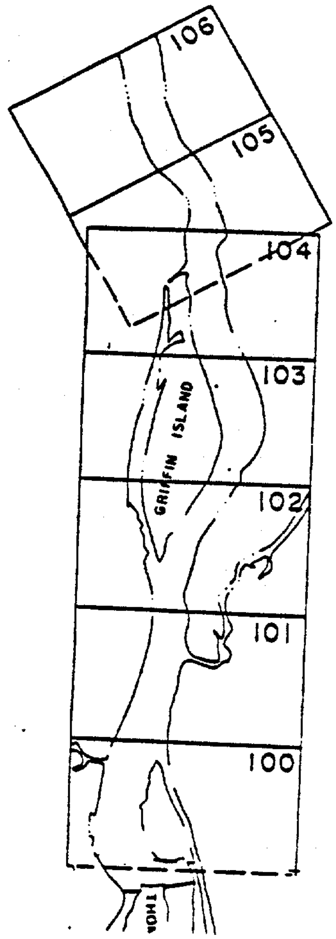
Hot spot 6 is a large hot spot which traverses the river at its upstream end and extends down both banks for a quarter of a mile. The 1983 survey's most highly contaminated samples were found in the east bank areas of hot spot 6. Four sediment grabs from the upstream channel areas of this hot spot, however, did not show the level of contamination that had been previously found. Current surface PCB concentrations in this area are only about 20 ppm. It is not known if contaminated sediments exist below the surface because the information came from grab samples. Thus it cannot be determined if the reduction in surface concentration found in the upstream portion of hot spot 6 is due to scour or the deposition of less contaminated sediment.

The discussions and conclusions presented above are only one interpretation of data collected from an extremely variable medium. The analysis indicates that, due to unknown mechanisms, the concentrations and distributions of PCB-contaminated sediments have undergone some degree of change since the completion of the 1977-1978 survey. Some contaminated deposits, namely parts of hot spots 18, 14, 12 and

6, each of which contained relatively large amounts of PCBs, appear to have undergone some reduction in contamination. Other areas--particularly the hot spots 20, 17, 15, 11, 10, 5 and 4 and parts of hot spots 6, and 18--are still highly contaminated.

APPENDIX E

ATTACHMENT 1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105
104
103
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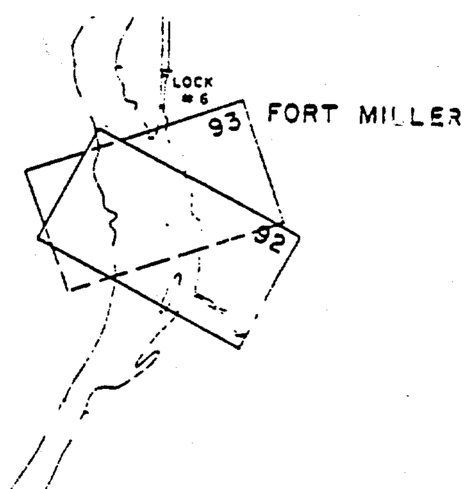
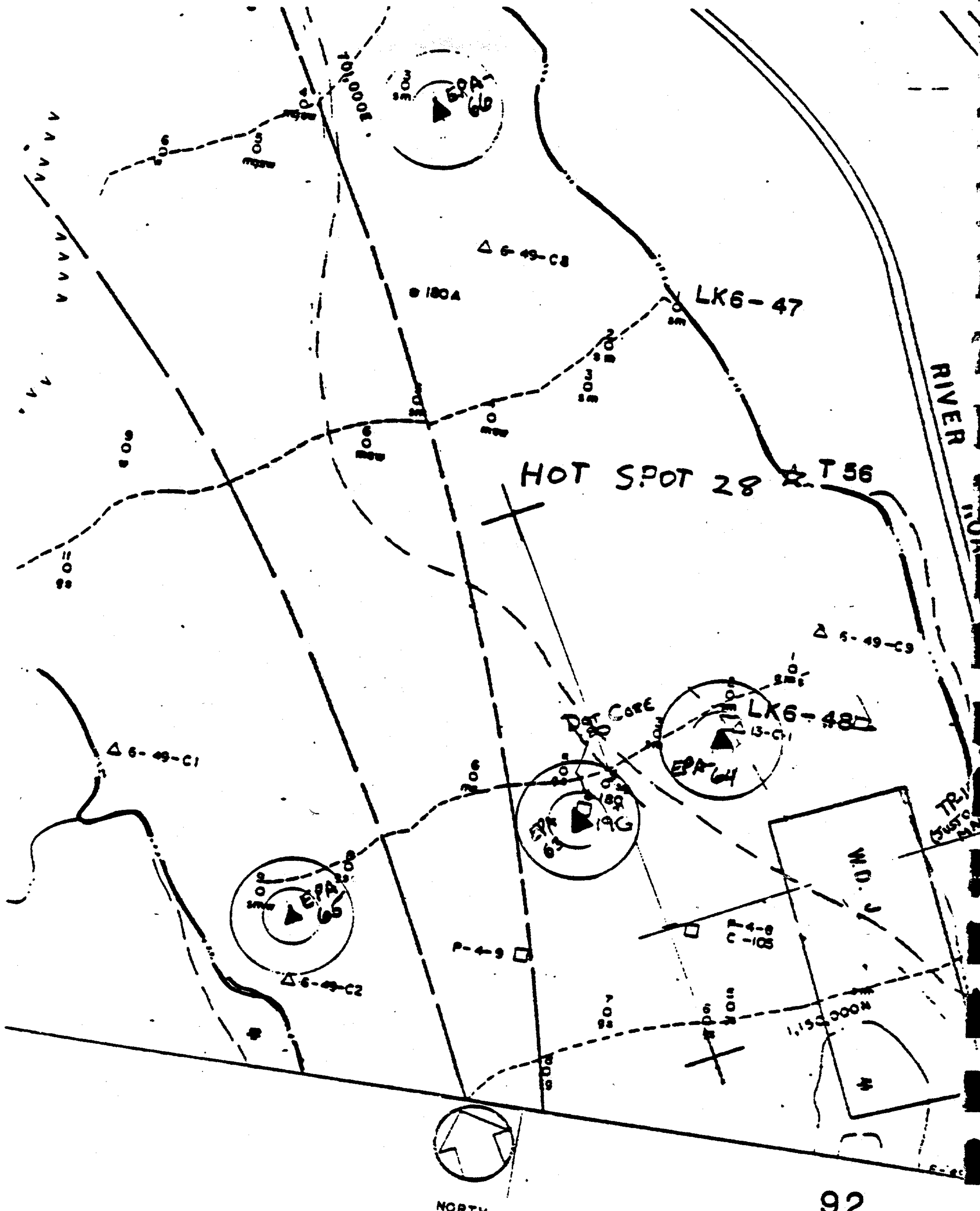
102
101
100


LOCK #6
93
FORT MILLER
92



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LK6-48
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EPA 64
EPA 63
19G
6-49-C1
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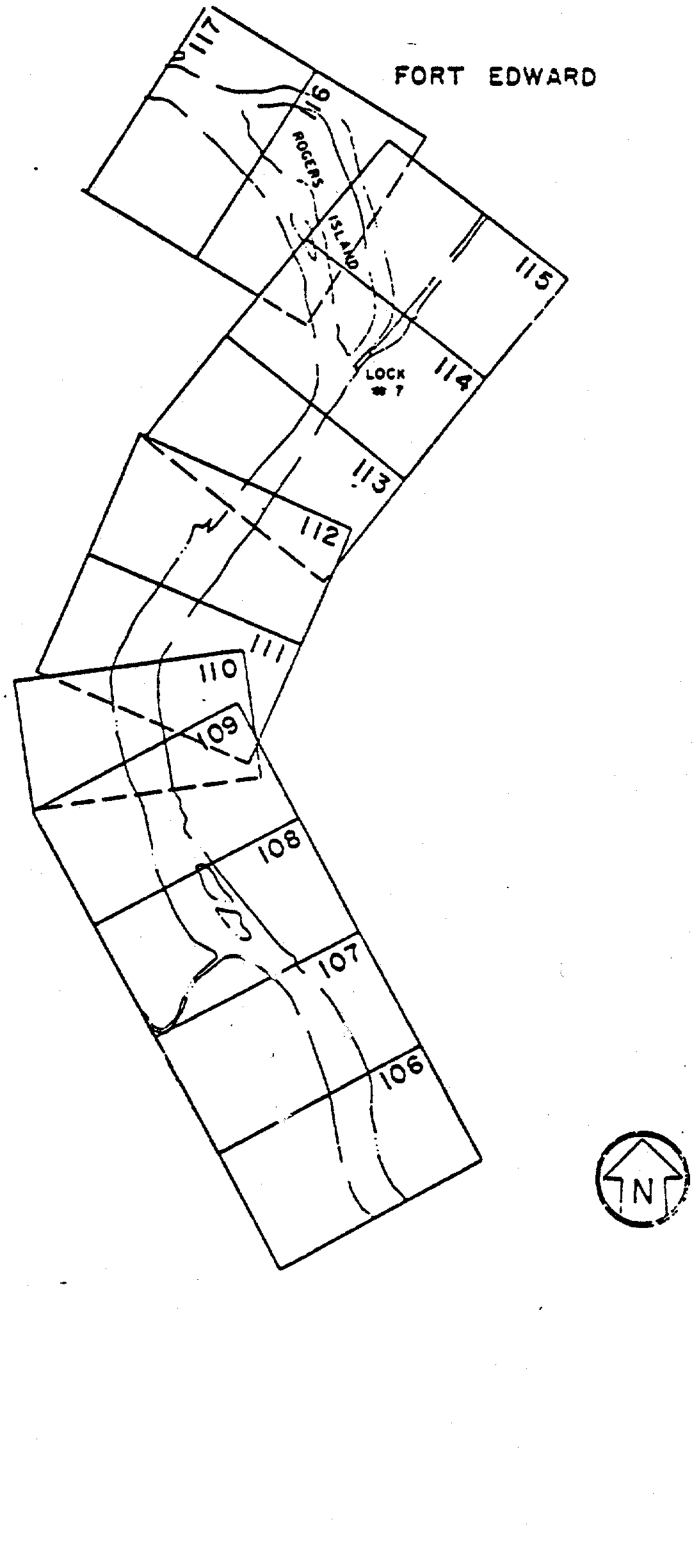
C-105
W.D. J
1,150,000N
NORTH

92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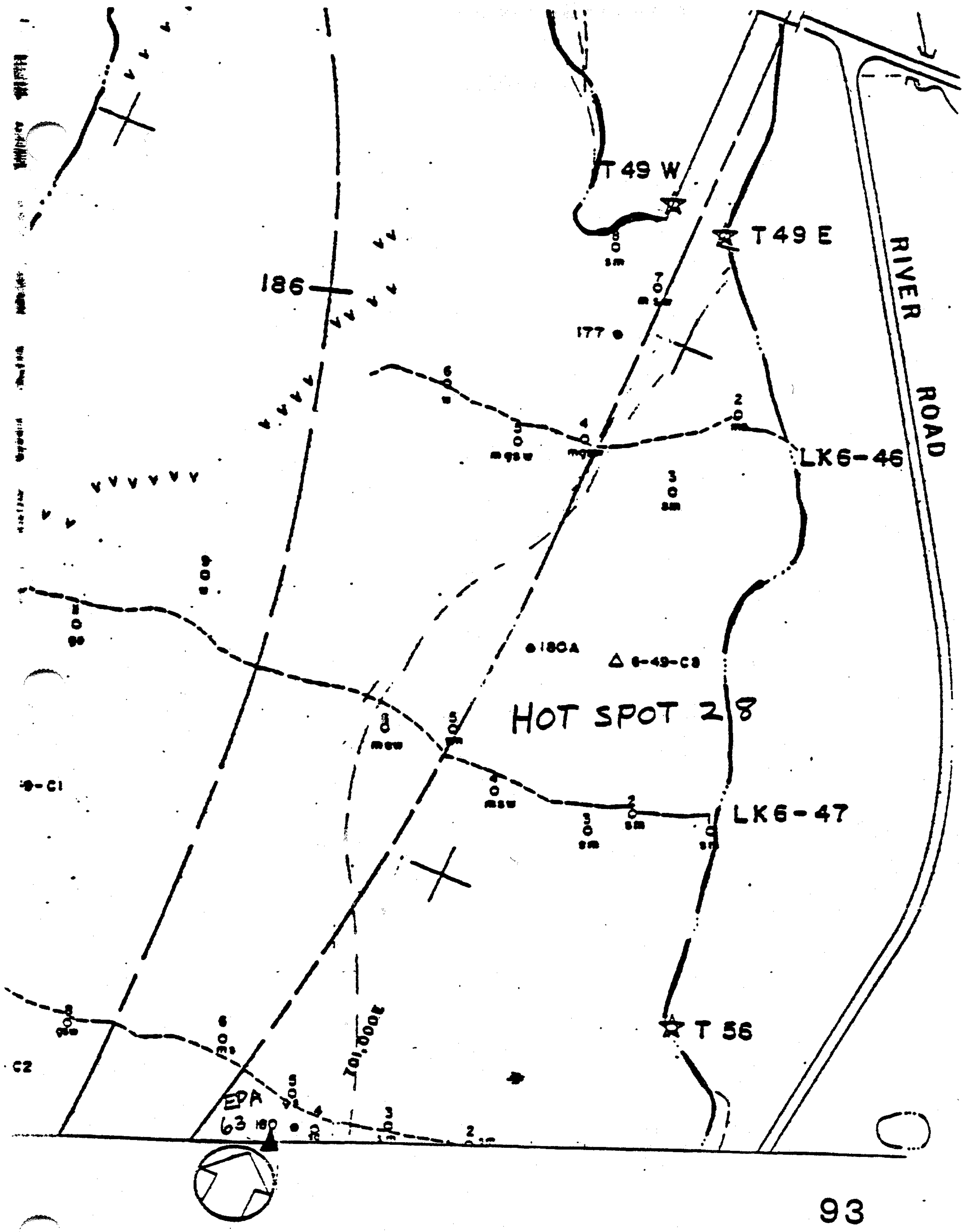
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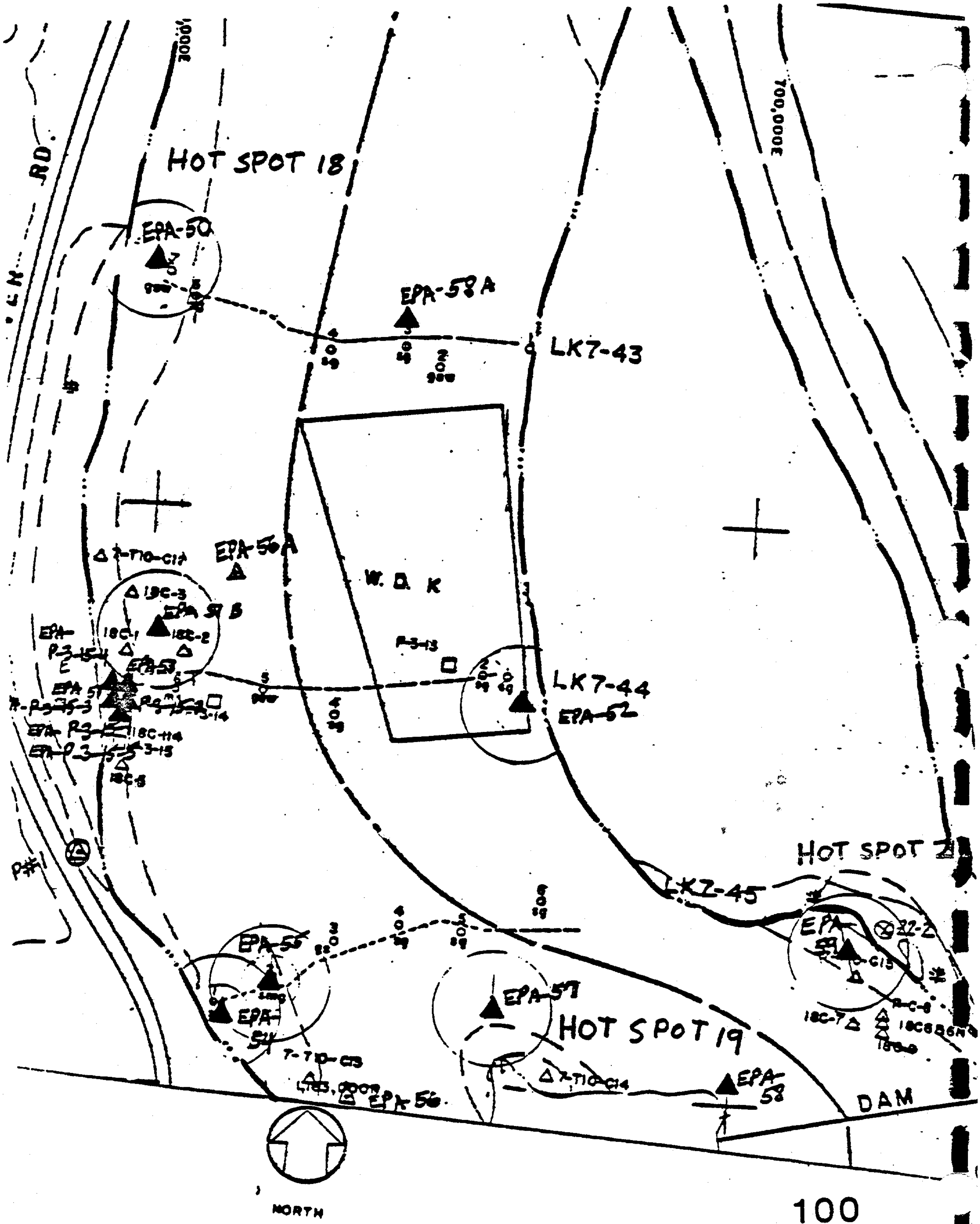

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LK7-45
EPA-59
22-2
EPA-55
EPA-57
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EPA-58
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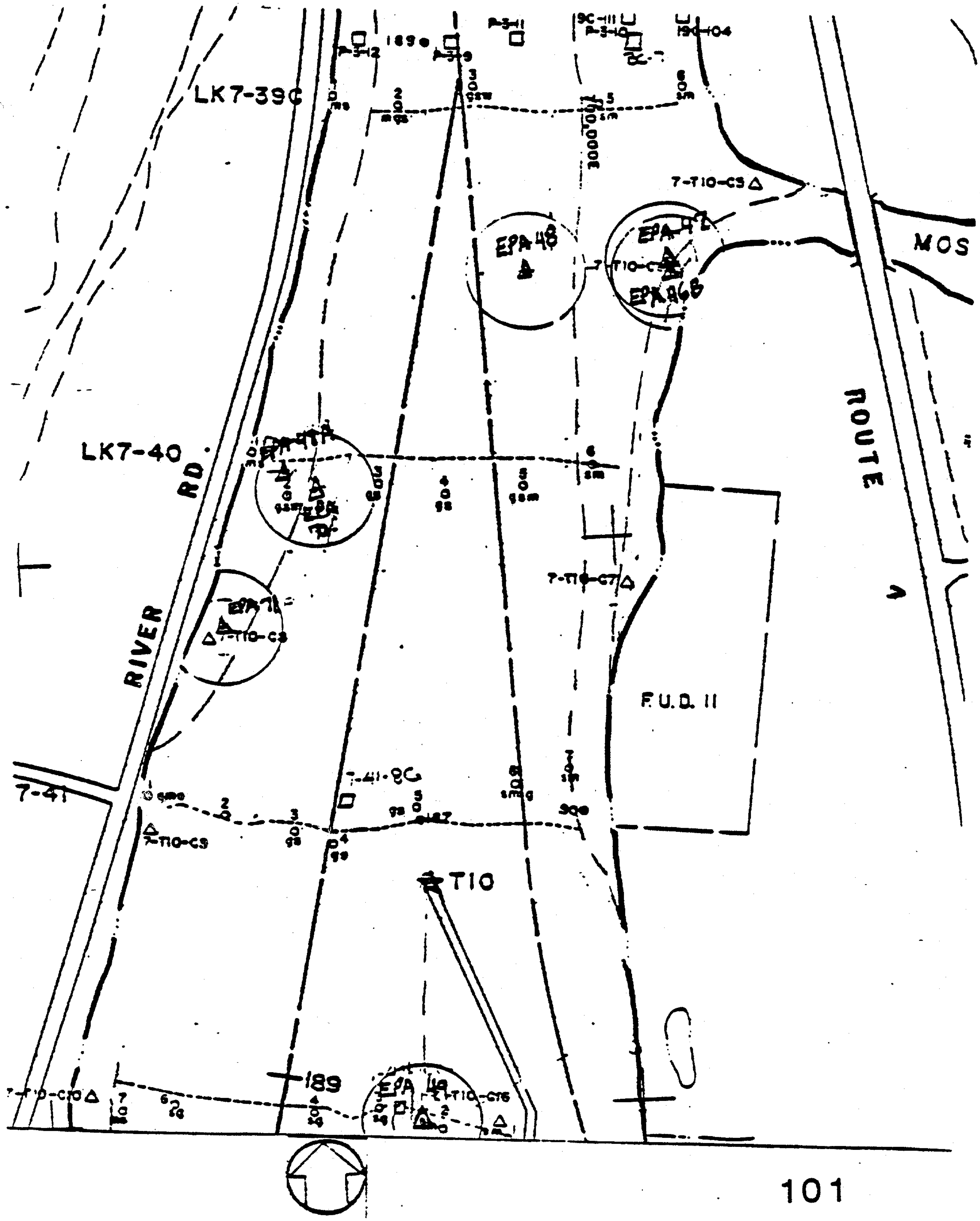
NORTH

100

100649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7-T10-C16
EPA 48
EPA 47
EPA 46B
EPA 49
T10
189
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F.U.D. II
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MOS
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P-3-9
P-3-11
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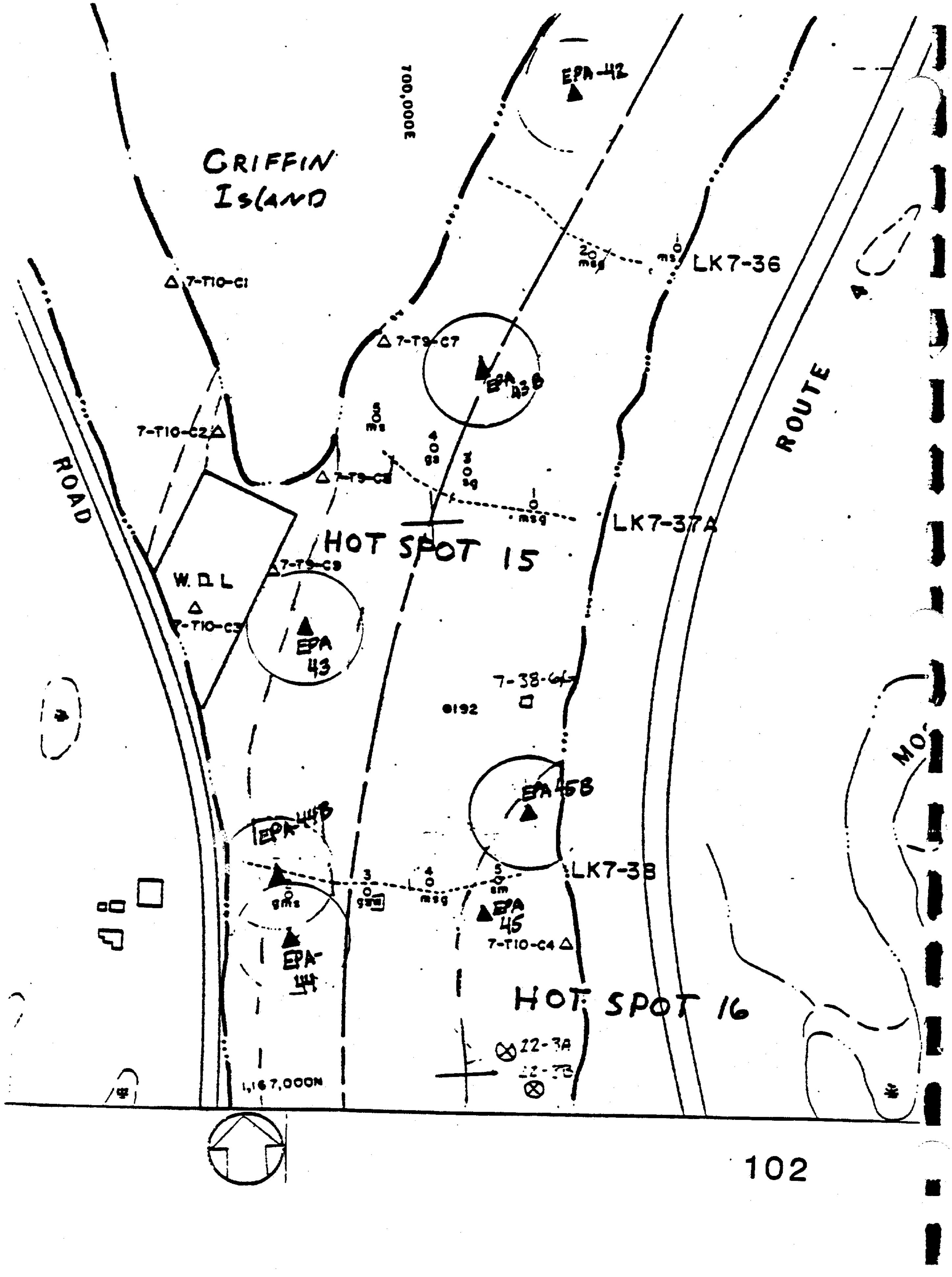
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EPA 44
EPA 45
EPA 45B
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7-T10-C2
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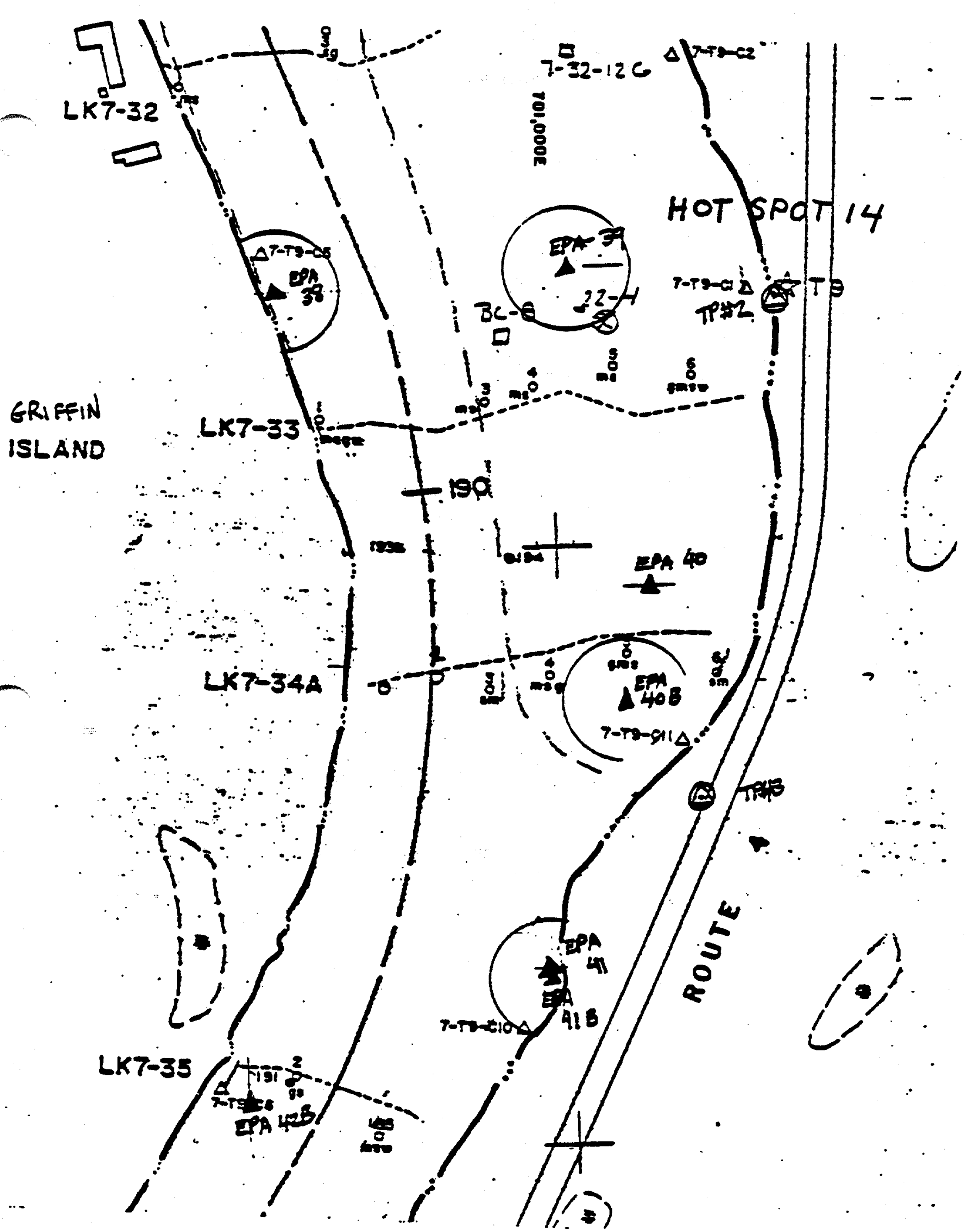
100651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T9
TP#2
BC-6
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EPA 40
LK7-34A
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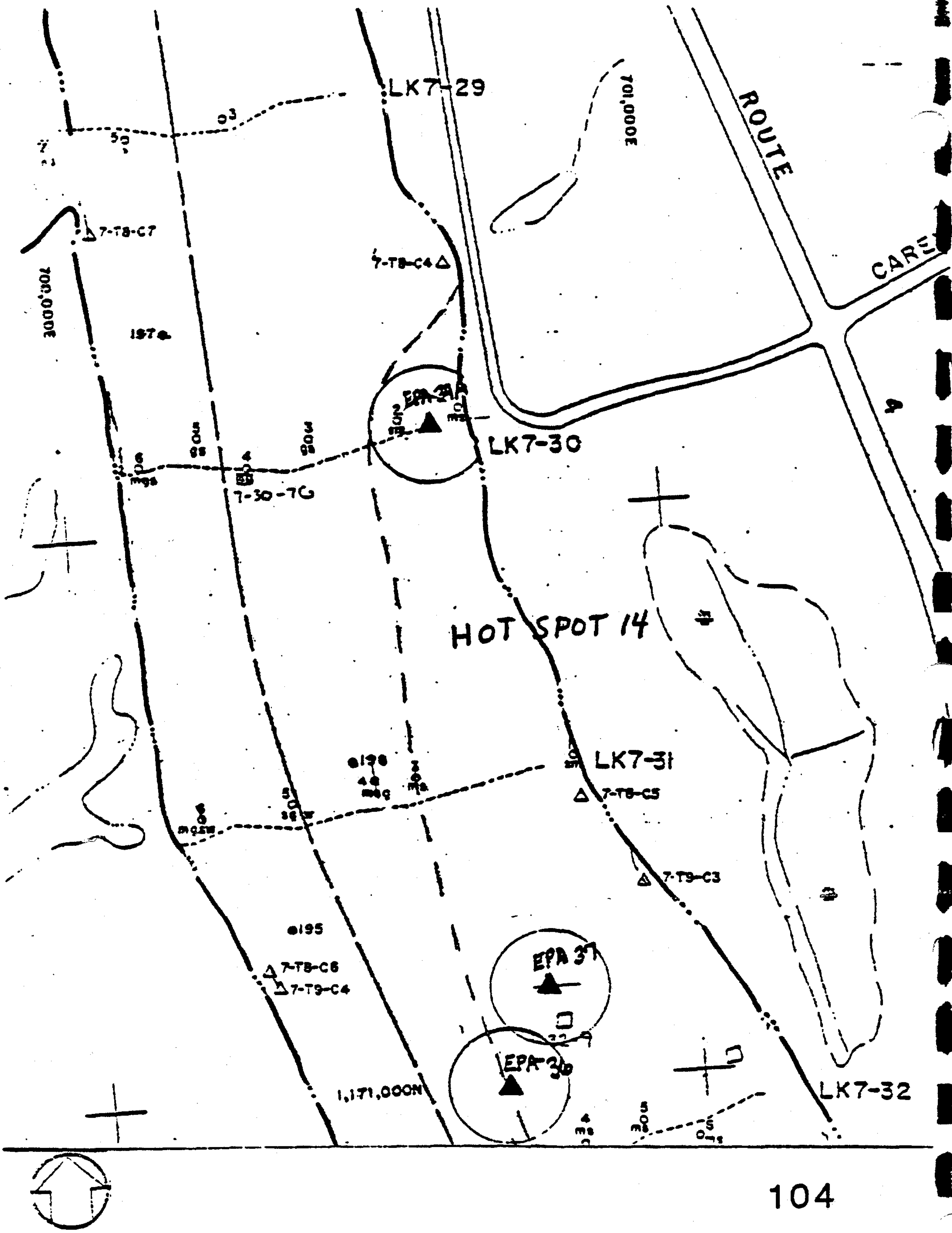
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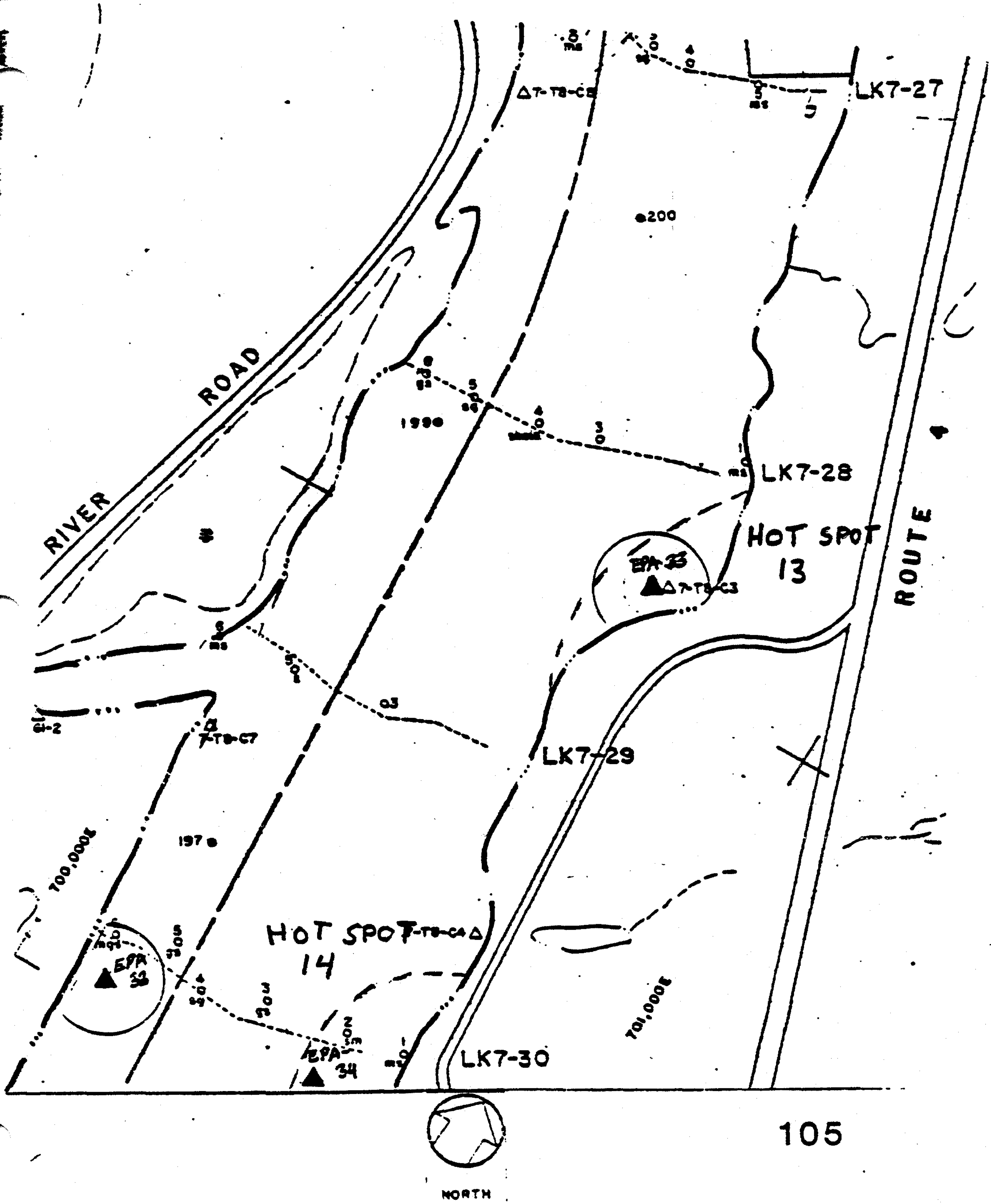
100653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ROUTE 4
LK7-27
LK7-28
LK7-29
LK7-30
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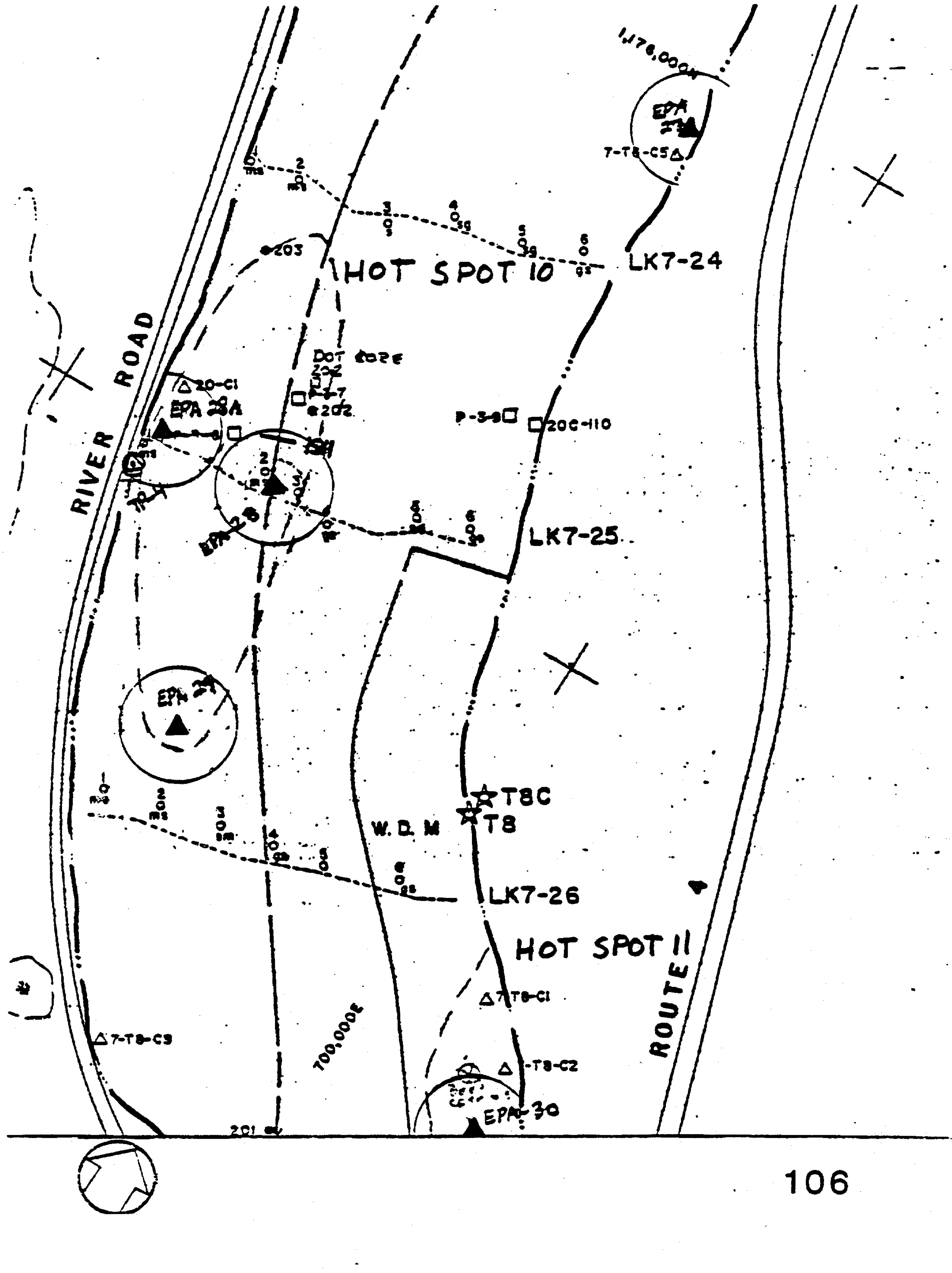
HOT SPOT 14
EPA 33
EPA 34
200
1990
197
700,000E
701,000E
NORTH

105

100654



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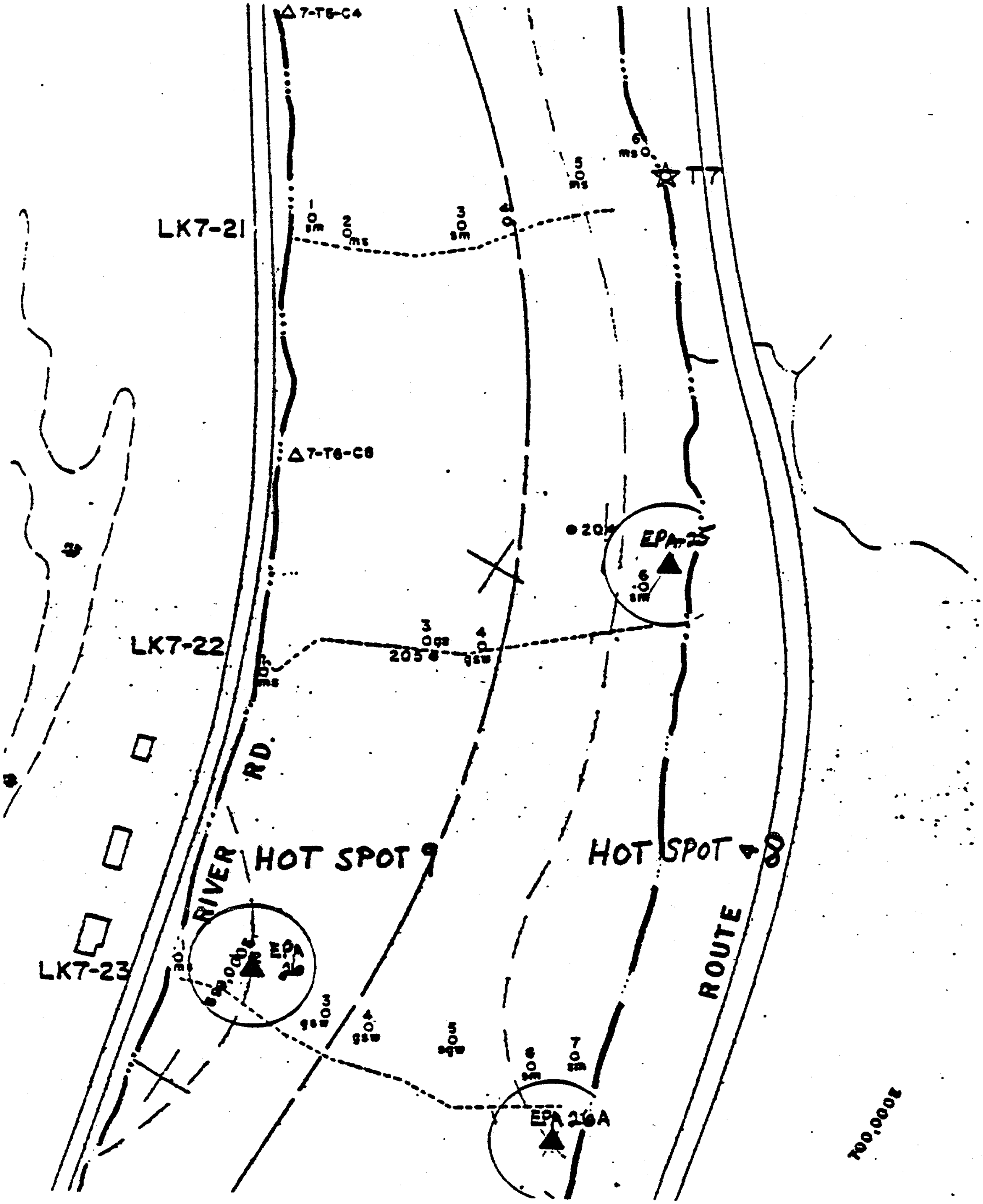
EPA
7-T8-C5
LK7-24
HOT SPOT 10
203
DOT
202
P-3-8
20C-110
20-C1
EPA 28A
202
LK7-25
EPA
W. D. M
T8C
T8
LK7-26
HOT SPOT 11
7-T8-C1
7-T8-C3
700,000E
T8-C2
EPA-30
201
RIVER ROAD
ROUTE

106

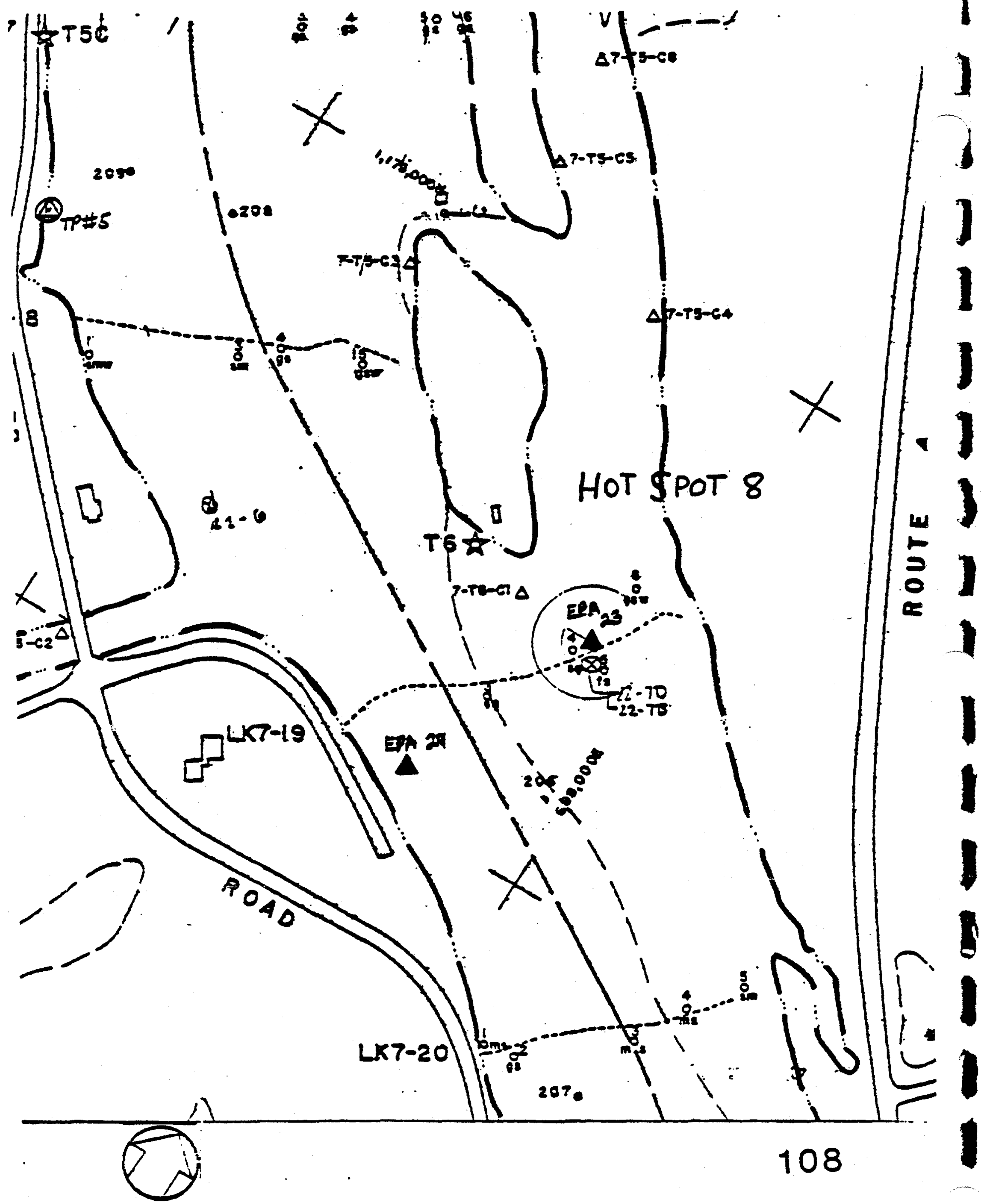
100655

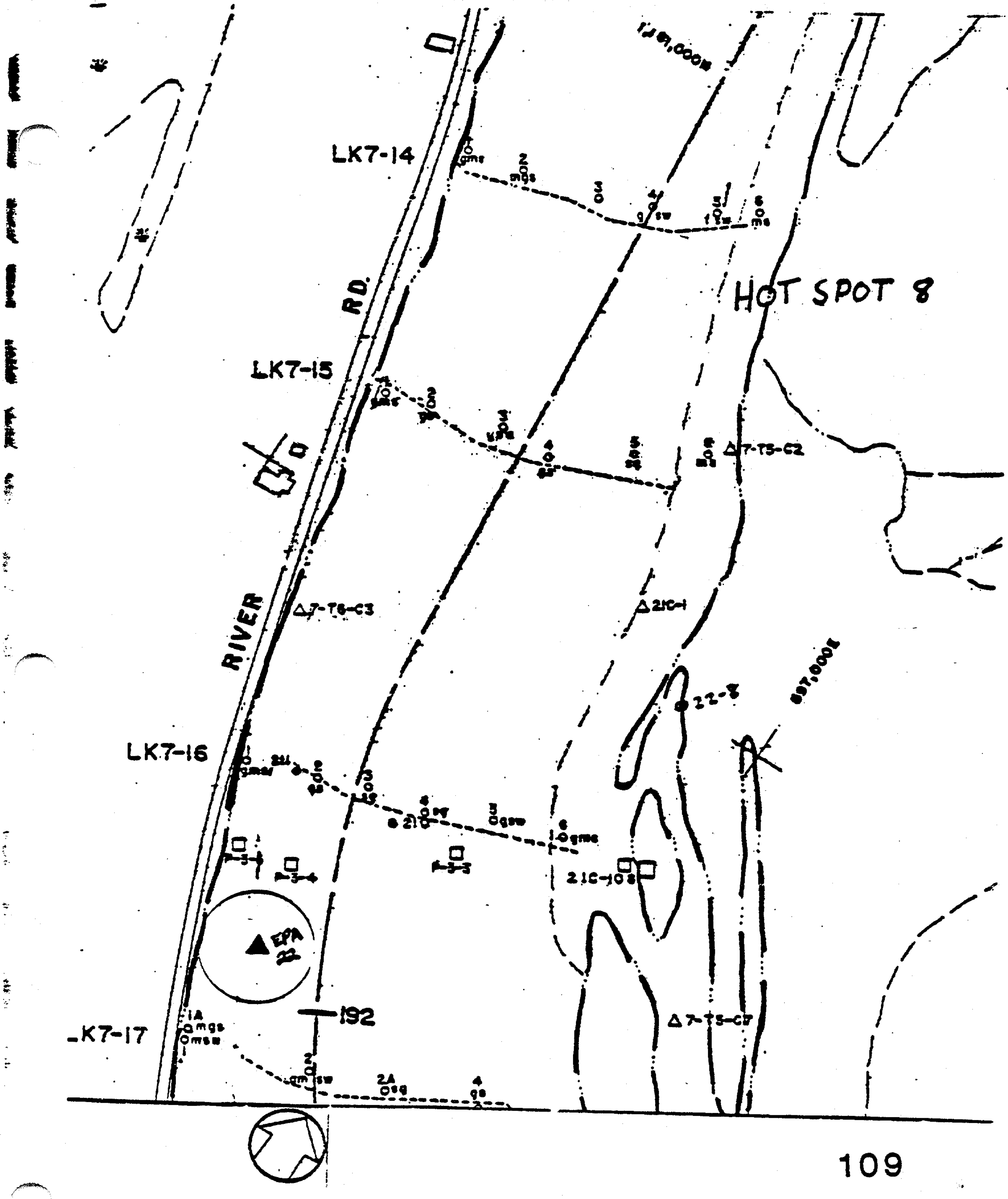


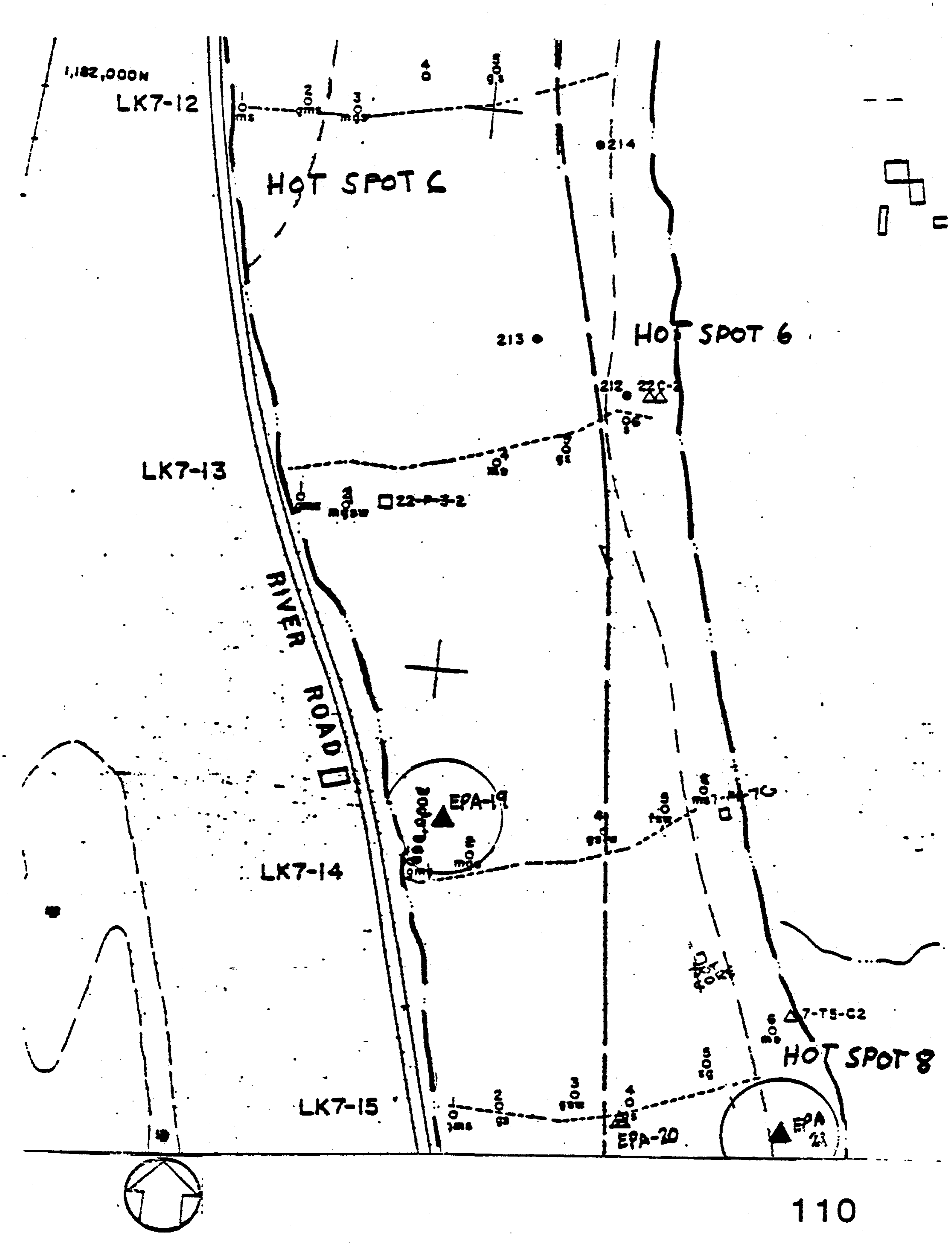
7-T6-C4
T7
LK7-21
7-T6-C8
EPA 25
LK7-22
205
RIVER
RD.
HOT SPOT 9
HOT SPOT 4
ROUTE
LK7-23
EPA 216A
700,000E

107

100656


T5C
TP#5
7-T5-C8
7-T5-C5
7-T5-C3
7-T5-C4
HOT SPOT 8
T6
7-T5-C1
EPA 23
22-TD
22-TB
LK7-19
EPA 2R
ROAD
LK7-20
ROUTE 4
5-C2
108
100657


HOT SPOT 8
LK7-14
LK7-15
LK7-16
-K7-17
RIVER
RD.
Δ7-T6-C3
Δ21C-1
Δ7-T5-C2
Δ7-T5-C7
22-8
21C-10 8
EPA 22
192
897,000E
109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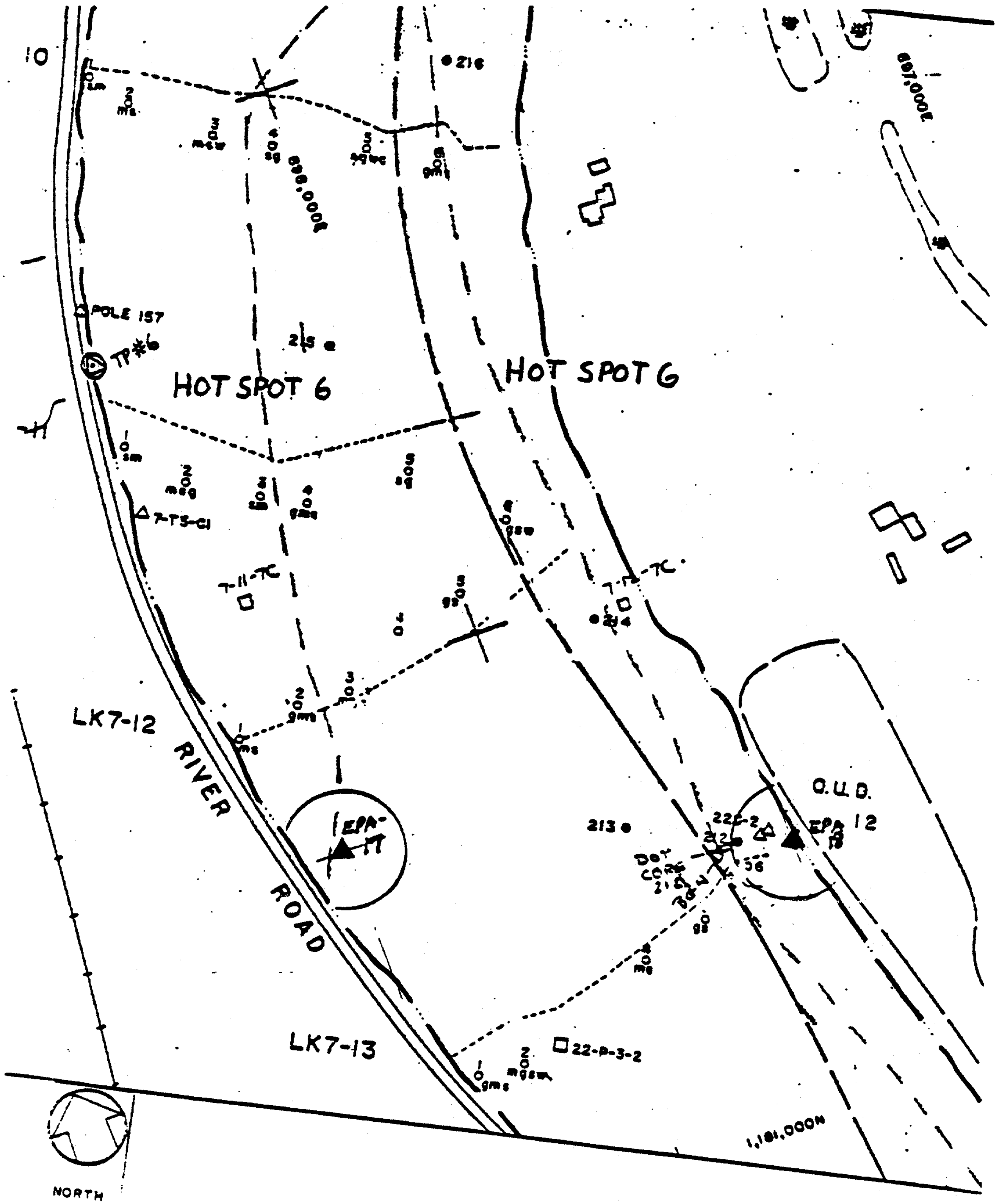
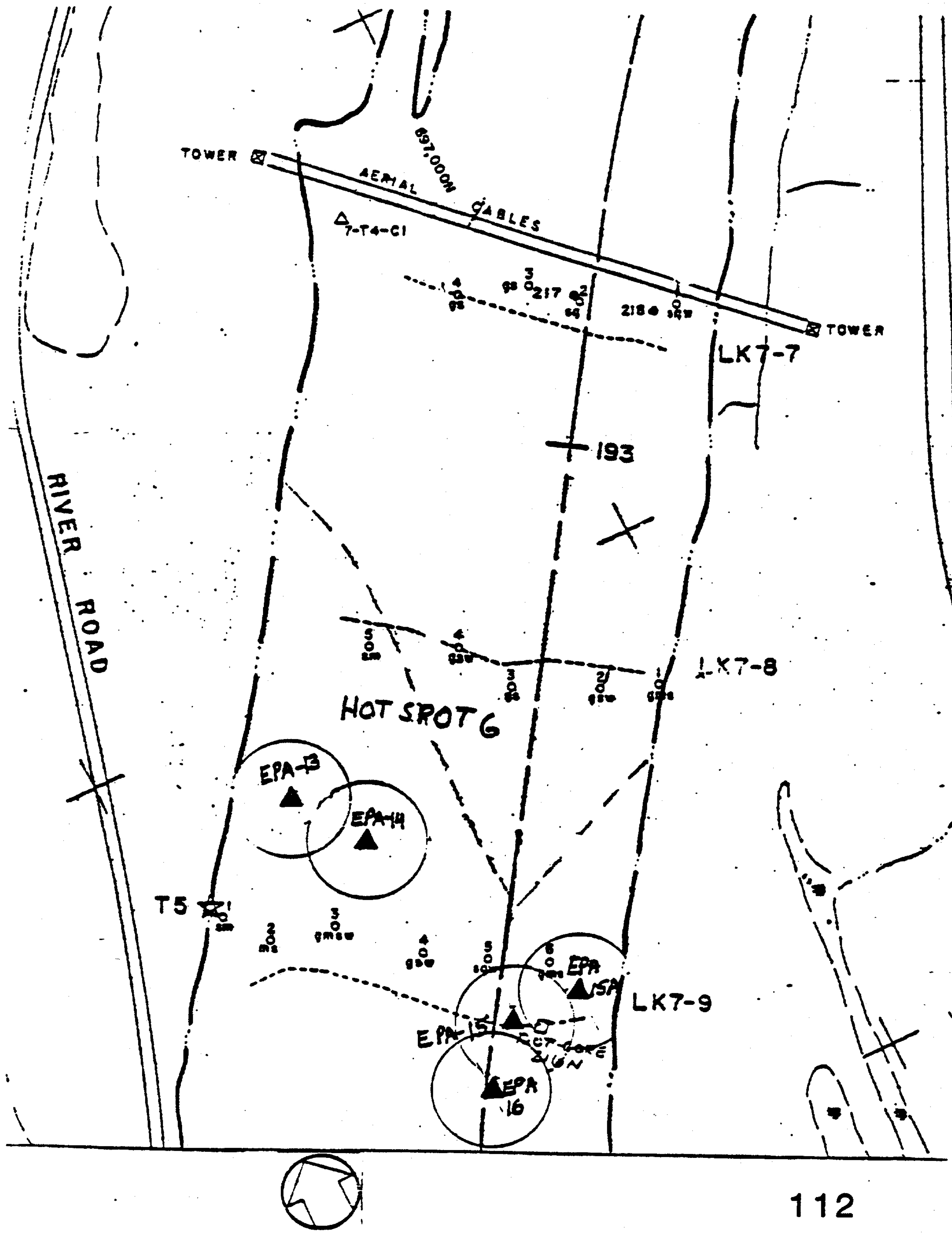
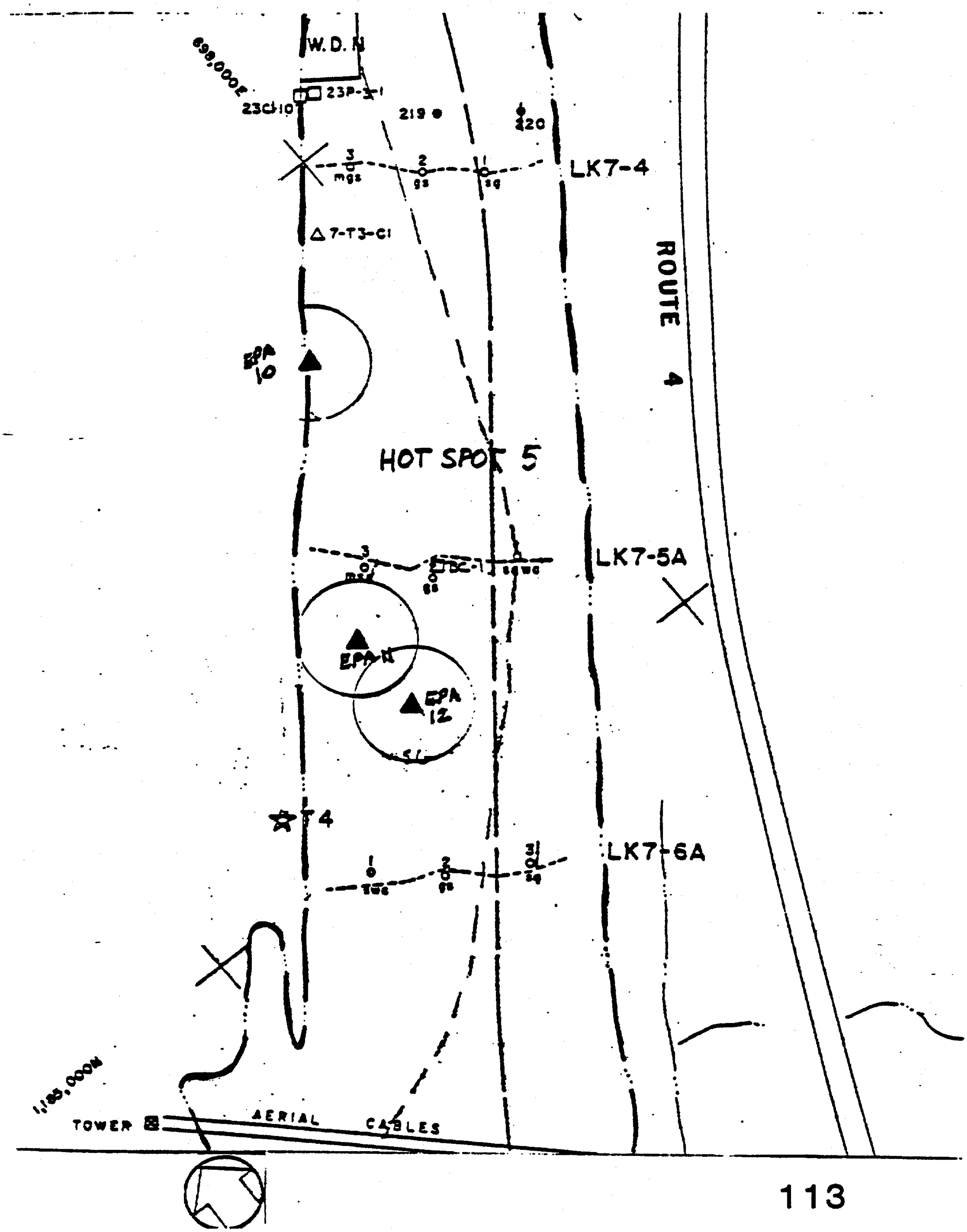
LK7-13
LK7-14
LK7-15
HOT SPOT 6
HOT SPOT 6
HOT SPOT 8
RIVER ROAD
EPA-19
EPA-20
EPA 23
213
214
212
22-P-3-2
7-T5-C2
110

100659


10
HOT SPOT 6
HOT SPOT G
POLE 157
TP#6
7-TS-CI
7-11-TC
7-T-TC
216
215
214
213
LK7-12
RIVER ROAD
LK7-13
EPA-17
EPA 12
O.U.D.
22-P-3-2
DOT CORE
698,000E
697,000E
1,181,000N
NORTH


TOWER
AERIAL CABLES
TOWER
697,000N
7-T4-C1
217
218
LK7-7
193
LK7-8
HOT SPOT 6
EPA-13
EPA-14
T5
LK7-9
EPA 15A
EPA-15
EPA 16
RIVER ROAD

100661


W.D.N
698,000E
23P-3-1
23C-10
219
220
3 mgs
2 gs
1 sg
LK7-4
7-T3-C1
ROUTE 4
EPA 10
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EPA 11
EPA 12
T4
LK7-6A
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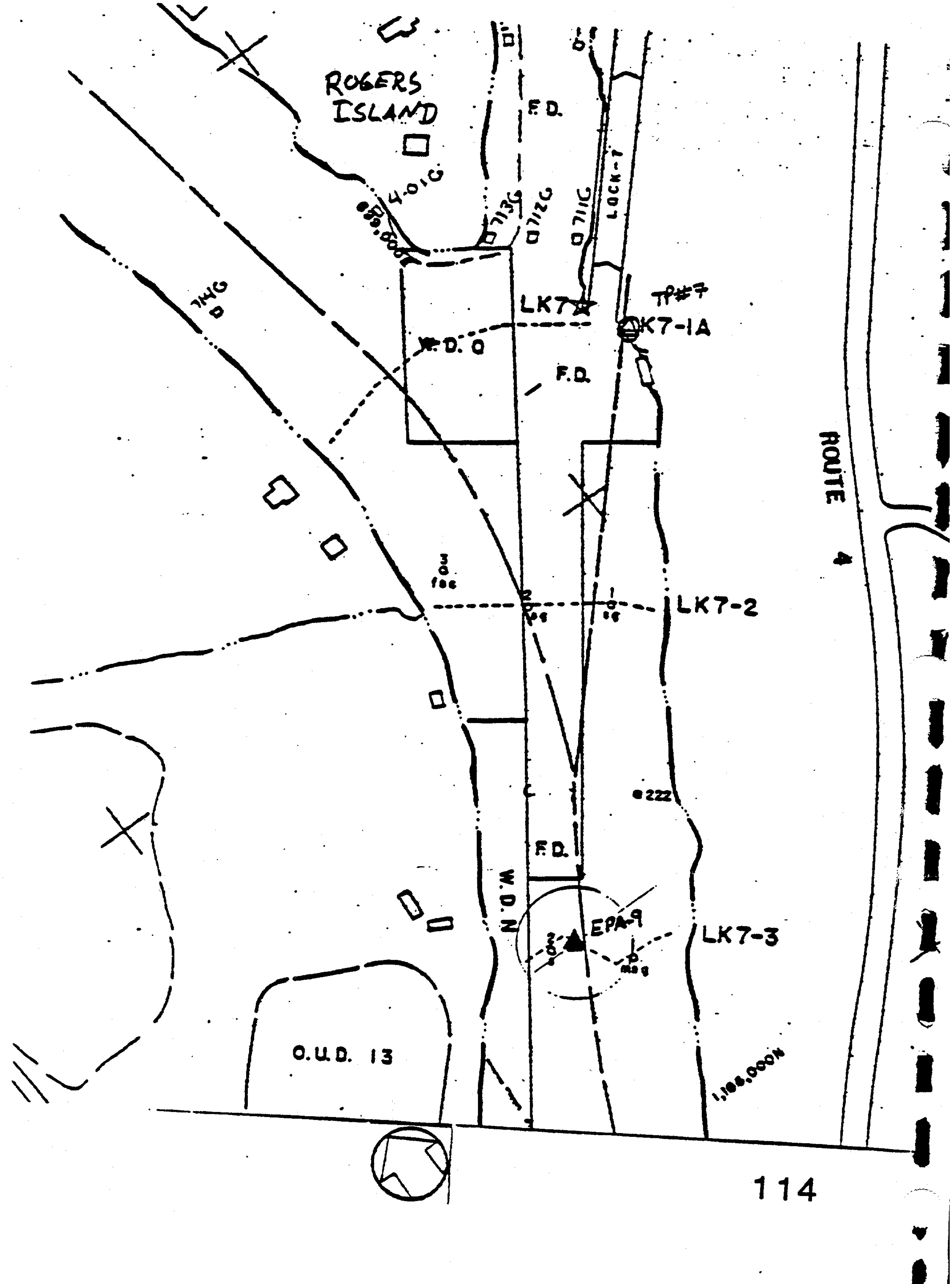
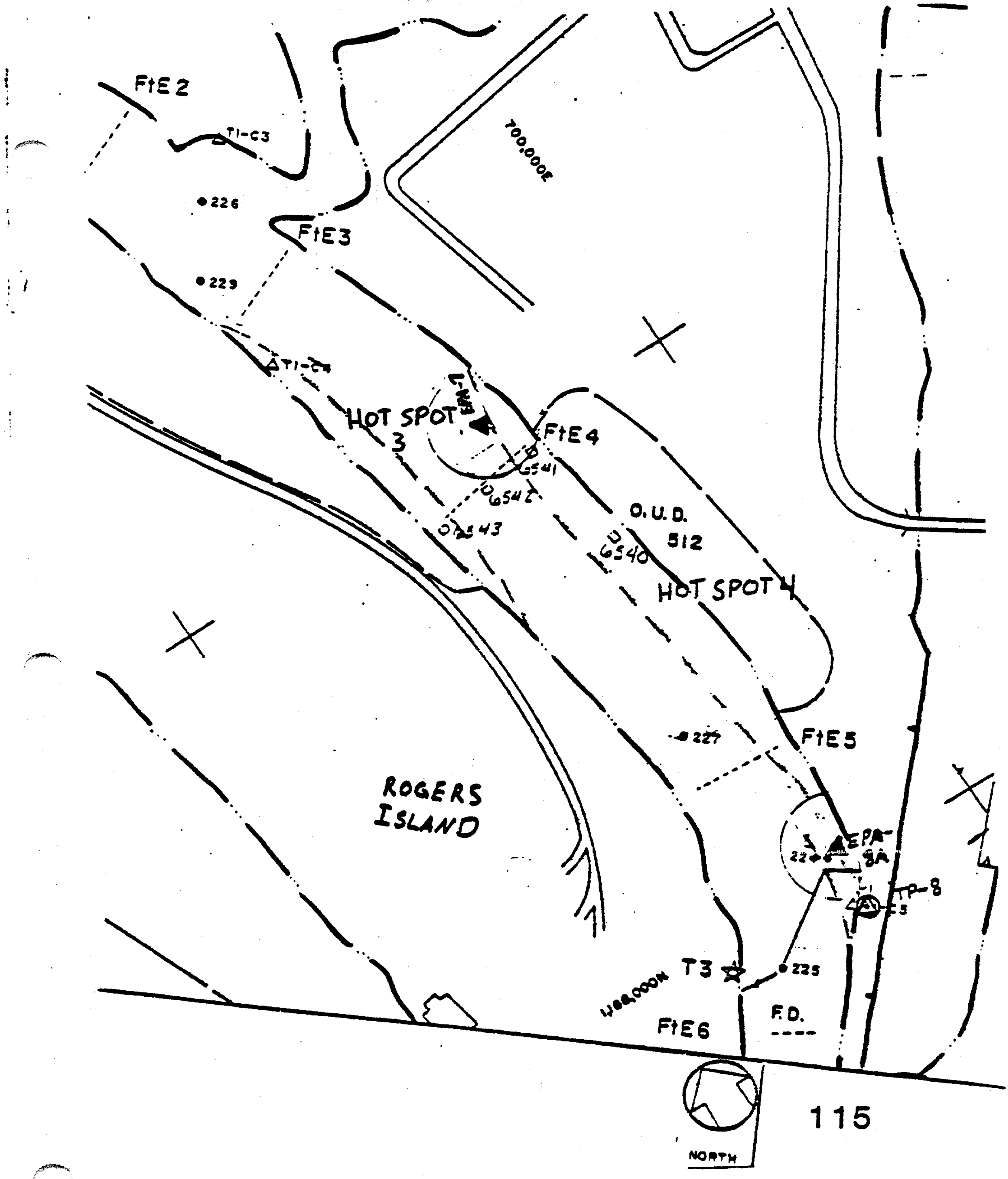
TOWER
AERIAL CABLES

100662

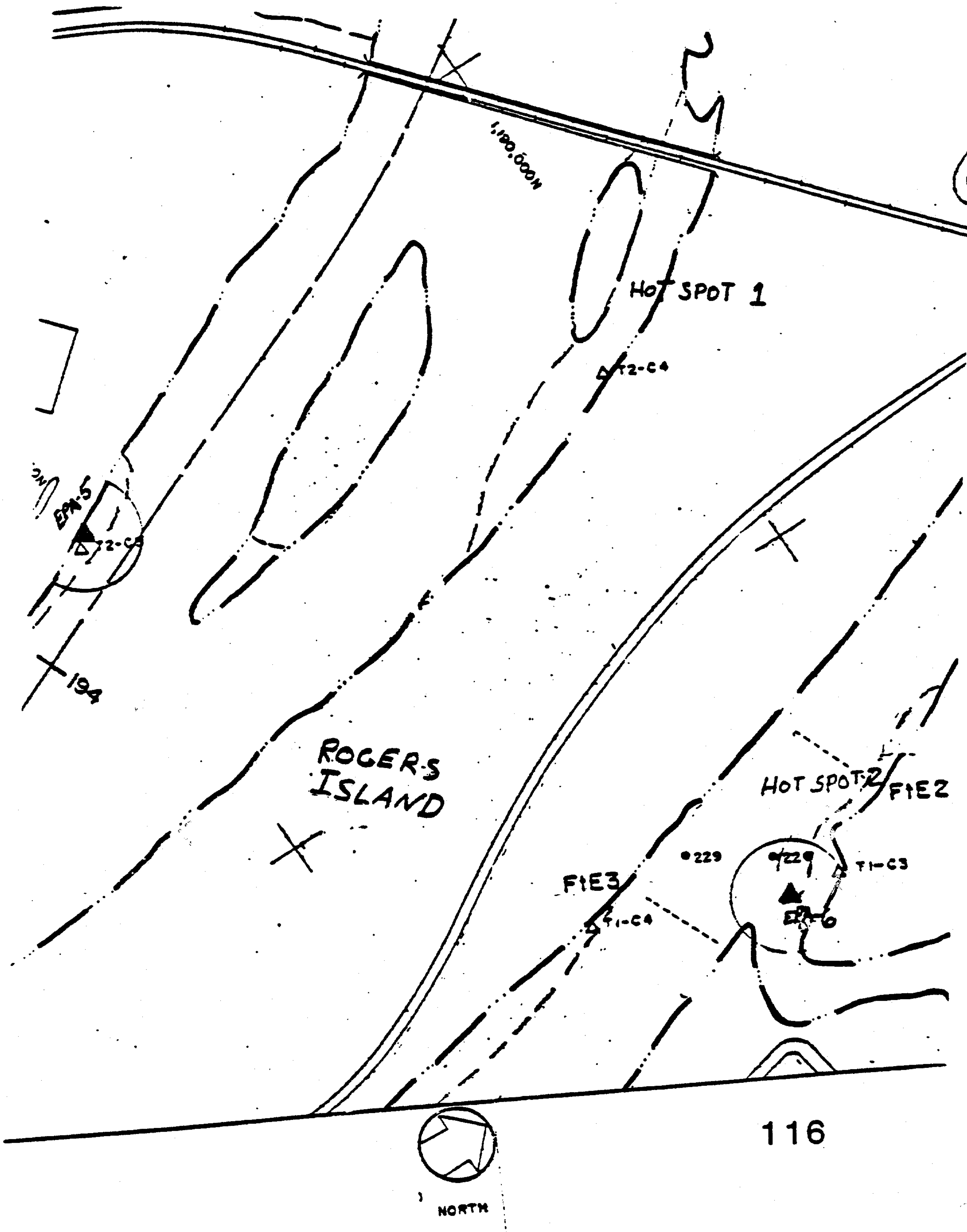

ROGERS ISLAND
F.D.
LOCK-7
4.01G
713G
712G
711G
714G
LK7
TP#7
LK7-1A
W.D. Q
F.D.
ROUTE 4
LK7-2
fss
ps
ss
222
F.D.
W.D.N
EPA-9
LK7-3
mss
O.U.D. 13
1,188,000N

114

100663

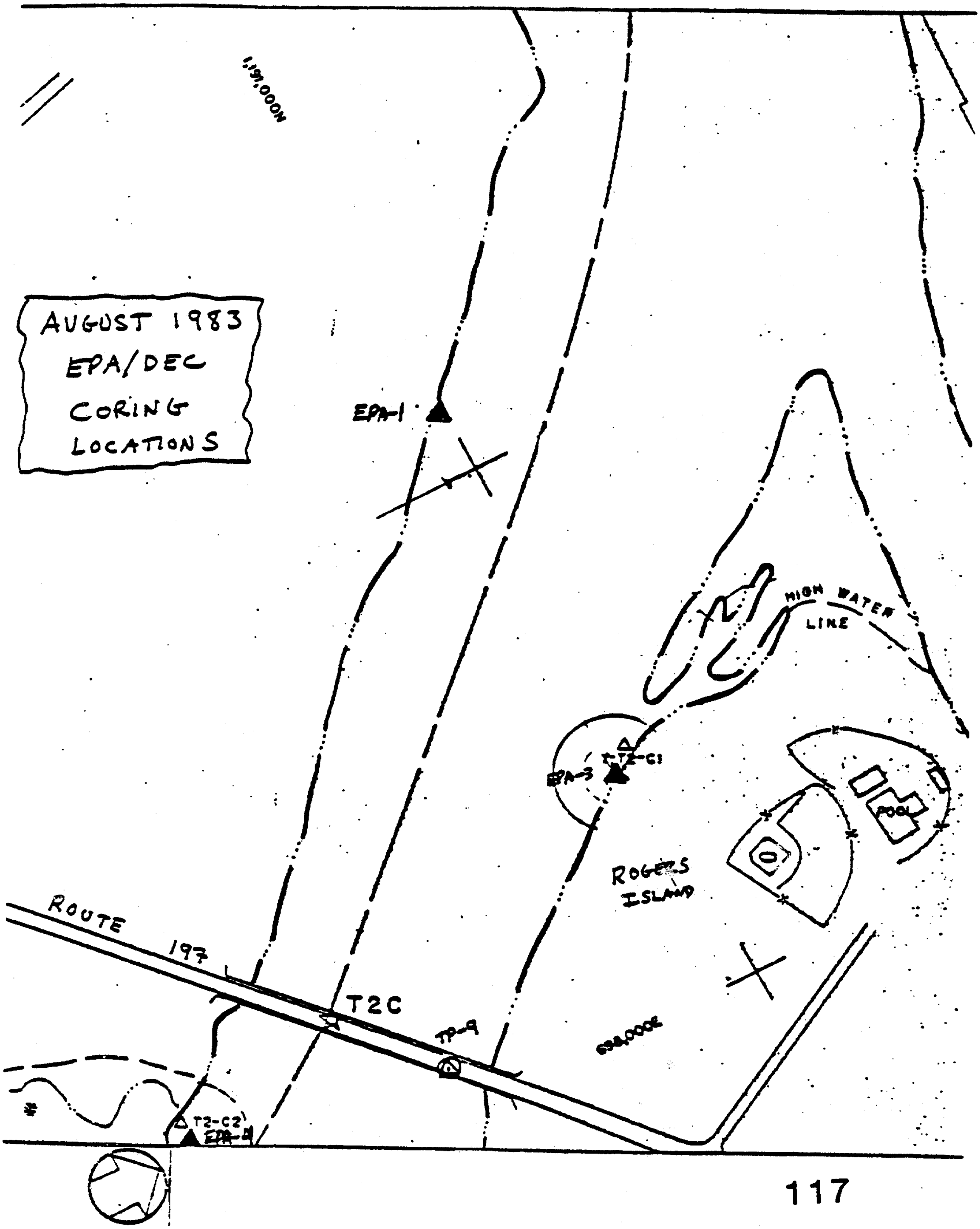

FtE2
T1-C3
700,000E
226
FtE3
229
T1-C4
HOT SPOT 3
EPA-7
FtE4
G541
G542
G543
O.U.D. 512
G540
HOT SPOT 4
227
FtE5
ROGERS ISLAND
EPA 8A
TP-8
T3
225
F.D.
FtE6
NORTH

100664



HOT SPOT 1
T2-C4
EPA-5
T2-C3
194
ROGERS ISLAND
HOT SPOT 2
FtE2
FtE3
229
229
T1-C3
T1-C4
EPA-6
116
NORTH

100665


AUGUST 1983
EPA/DEC
CORING
LOCATIONS
EPA-1
HIGH WATER
LINE
EPA-3
POOL
ROGERS
ISLAND
ROUTE
197
T2C
TP-9
T2-C2

APPENDIX E

ATTACHMENT 2

UPPER HUDSON RIVER PCB SURVEY

Procedure for Segmenting Core Samples

Objective

Core samplers are used to collect essentially undisturbed samples which represent the profile of strata in sediments or sludges. Core samples will be taken from Upper Hudson River sediments and analyzed for PCB contamination.

Methodology

Every effort will be made in the field to insure the integrity of core samples. Each sample will be marked in the field 'Top' and 'Bottom' and stored upright. Core samples requiring segmenting or subsampling will be frozen overnight prior to processing. Each core will be examined, measured and photographed prior to processing. The condition of the core and the color, texture and relative position of any strata will be recorded.

Core liners will be cut with a pipe cutting tool. The tool should only be used to cut the liner and should not enter the core sample to any appreciable degree. A stainless steel spatula or knife will be used to subsample the sediment. Laboratory tools and work area will be cleaned with distilled water, acetone and methylene chloride between each sample.

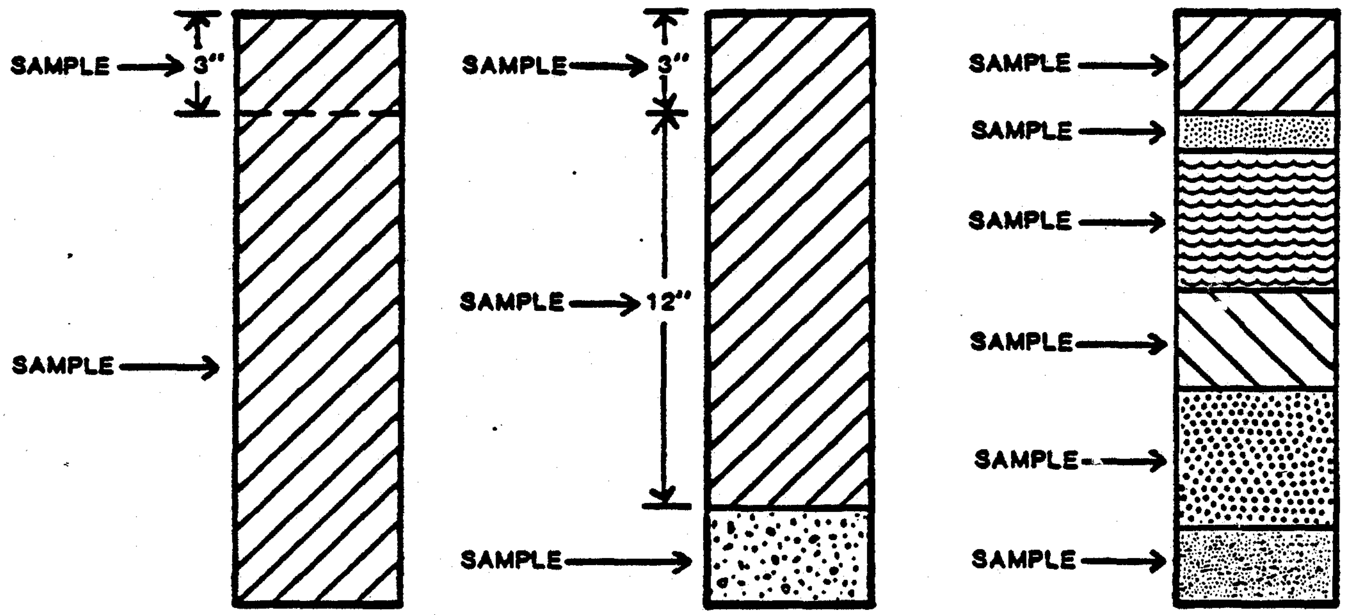
Figure 1 provides a schematic of the procedure for segmenting core samples. To ensure comparability of data collected with the existing data base, cores will be segmented in the following manner.

- Uniform Core - one sample taken from the top 3"; one sample from the remainder of the core.
- Uniform Core top 12" with strata below - one sample taken from the top 3"; one sample taken from the remainder of the strata and one each from each remaining strata.
- Stratified Core - one sample from each strata.

Stratification within the core shall be defined by significant changes in texture, color or grain size of sediments. Strata will be recognized through gross examination of cores and sampled when sufficient volumn is present for laboratory analysis.

Samples taken from the various cores will be placed into 8 oz. glass jars and shipped using normal chain of custody procedures.

TOP



Individual sample from top 3" and sample from remainder of the core.

Individual sample from each strata.

PROCEDURE FOR

SEGMENTING CORE

SAMPLES

FIGURE 1

NUS CORPORATION

100669

ANALYSIS OF PCBs IN HUDSON RIVER SEDIMENTS

SAMPLE PREPARATION AND EXTRACTION

1. Thoroughly mix the sample.
2. Accurately weigh and record the desired quantity of prepared sample, commonly 50 gm.
3. In a 250 ml Erlenmeyer flask, mix the sample and a sufficient quantity of 1:1 (v/v) acetone-hexane to produce a slurry.
4. Place on a mechanical shaker for thirty minutes.
5. Decant the solvent to a separatory funnel containing 500 ml distilled water.
6. Add 25 ml of 1:1 (v/v) acetone-hexane to the flask and shake for an additional 30 minutes.
7. Repeat Steps 5 and 6 and combine all extracts.
8. Discard the aqueous layer, wash with two 500 ml portions of distilled water and discard the washings.
9. Add sufficient quantity of anhydrous sodium sulfate to give crystals that are free flowing upon swirling.
10. Concentrate volume to 10 ml in a Kuderna-Danish evaporator.
11. Proceed with step10.3 of the attached Method for Polychlorinated Biphenyls (PCBs) in Water and Wastewater published in EPA 600/4-81-054, Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater, Sept. 1978.

NOTE: Report results in terms of ug/g dry weight based upon weight loss obtained by drying at 60°C. Report the individual PCBs and total PCBs.

METHOD FOR POLYCHLORINATED BIPHENYLS (PCBs) IN WATER AND WASTEWATER

1. Scope and Application

1.1 This method covers the determination of various polychlorinated biphenyl (PCB) mixtures in water and wastewater.

1.2 The following mixtures of chlorinated biphenyls (Aroclors) may be determined by this method:

Parameter	Storet No.
PCB-1016	34671
PCB-1221	39488
PCB-1232	39492
PCB-1242	39496
PCB-1248	39500
PCB-1254	39504
PCB-1260	39508

1.3 The method is an extension of the Method for Chlorinated Hydrocarbons in Water and Wastewater (1). It is designed so that determination of both the PCBs and the organochlorine pesticides may be made on the same sample.

2. Summary

2.1 The PCBs and the organochlorine pesticides are co-extracted by liquid-liquid extraction and, insofar as possible, the two classes of compounds separated from one another prior to gas chromatographic determination. A combination of the standard Florisil column cleanup procedure and a silica gel microcolumn separation procedure (2)(3) are employed. Identification is made from gas chromatographic patterns obtained through the use of two or more unlike columns. Detection and measurement is accomplished using an electron capture, microcoulometric, or electrolytic conductivity detector. Techniques for confirming qualitative identification are suggested.

3. Interferences

3.1 Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts and/or elevated baselines causing misinterpretation of gas chromatograms. All of these materials must be demonstrated to be free from interferences under the conditions of the analysis. Specific selection of reagents and the purification of solvents by distillation in all-glass systems may be required. Refer to Appendix I.

3.2 The interferences in industrial effluents are high and varied and pose great difficulty in obtaining accurate and precise measurement of PCBs and organochlorine pesticides. Separation and clean-up procedures are generally required and may result in the loss of certain organochlorine compounds. Therefore, great care should be exercised in the selection and use of methods for eliminating or minimizing interferences. It is not possible to describe procedures for overcoming all of the interferences that may be encountered in industrial effluents.

3.3 Phthalate esters, certain organophosphorus pesticides, and elemental sulfur will interfere when using electron capture for detection. These materials do not interfere when the microcoulometric or electrolytic conductivity detectors are used in the halogen mode.

3.4 Organochlorine pesticides and other halogenated compounds constitute interferences in the determination of PCBs. Most of these are separated by the method described below. However, certain compounds, if present in the sample, will occur with the PCBs. Included are: Sulfur, Heptachlor, aldrin, DDE, technical chlordane, mirex, and to some extent, o,p'-DDT and p,p'-DDT.

4. Apparatus and Materials

4.1 Gas Chromatograph - Equipped with glass lined injection port.

4.2 Detector Options:

4.2.1 Electron Capture - Radioactive (tritium or nickel-63)

4.2.2 Microcoulometric Titration

4.2.3 Electrolytic Conductivity

4.3 Recorder - Potentiometric strip chart (10 in.) compatible with the detector.

4.4 Gas Chromatographic Column Materials:

4.4.1 Tubing - Pyrex (180 cm long X 4 mm ID)

4.4.2 Glass Wool - Silanized

4.4.3 Solid Support - Gas-Chrom Q (100-120 mesh)

4.4.4 Liquid Phases - Expressed as weight percent coated on solid support.

4.4.4.1 SE-30 or OV-1, 3%

4.4.4.2 OV-17, 1.5% + QF-1 or OV-210, 1.95%

4.5 Kuderna-Danish (K-D) Glassware

4.5.1 Snyder Column - three-ball (macro) and two-ball (micro)

4.5.2 Evaporative Flasks - 500 ml

4.5.3 Receiver Ampuls - 10 ml, graduated

4.5.4 Ampul Stoppers

4.6 Chromatographic Column - Chromaflex (400 mm long x 19 mm ID) with coarse fritted plate on bottom and Teflon stopcock; 250-ml reservoir bulb at top of column with flared out funnel shape at top of bulb - a special order (Kontes K-420540-9011).

4.7 Chromatographic Column - pyrex (approximately 400 mm long x 20 mm ID) with coarse fritted plate on bottom.

4.8 Micro Column Pyrex - constructed according to Figure 1.

4.9 Capillary pipets disposable (5-3/4 in.) with rubber bulb (Scientific Products P5205-1).

4.10 Low pressure regulator - 0 to 5 PSIG - with low-flow needle valve (see Figure 1, Matheson Model 70).

4.11 Beaker - 100 ml

4.12 Micro Syringes - 10, 25, 50 and 100 ul.

4.13 Separatory funnels - 125 ml, 1000 ml and 2000 ml with Teflon stopcock.

4.14 Blender - High speed, glass or stainless steel cup.

4.15 Graduated cylinders - 100 and 250 ml.

4.16 Florisil - PR Grade (60-100 mesh); purchase activated at 1250^{o}F and store in the dark in glass containers with glass stoppers or foil-lined screw caps. Before use, activate each

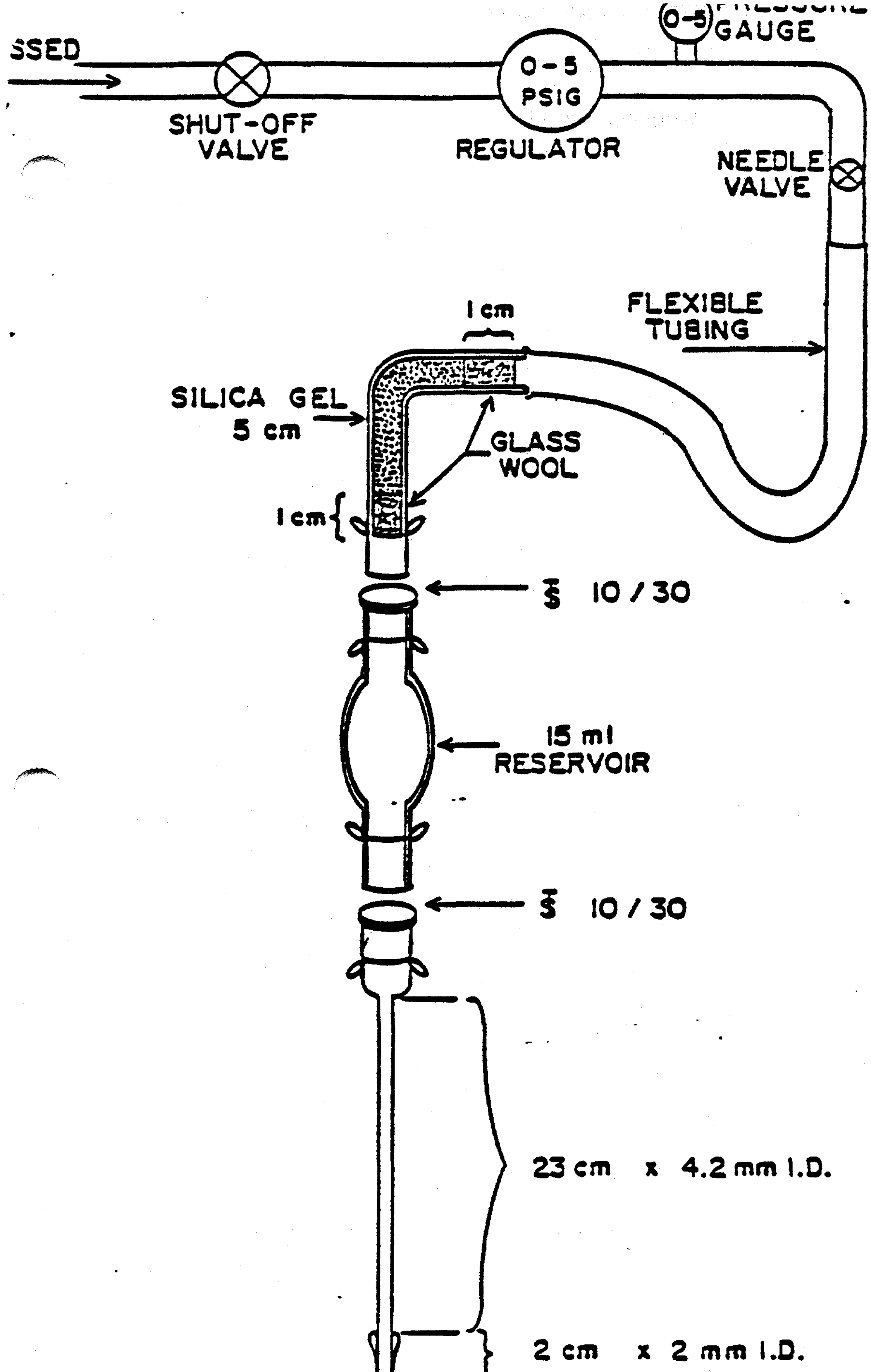


FIGURE 1. MICROCOLUMN SYSTEM

batch overnight at 130°C in foil-covered glass container.
Determine lauric-acid value (See Appendix II).

4.17 Silica gel - Davison code 950-08008-226 (60/200 mesh).

4.18 Glass Wool - Hexane extracted.

4.19 Centrifuge Tubes - Pyrex calibrated (15 ml).

5. <u>Reagents, Solvents, and Standards</u>

5.1 Sodium Chloride - (ACS) Saturated solution in distilled water (pre-rinse NaCl with hexane).

5.2 Sodium Hydroxide - (ACS) 10 N in distilled water.

5.3 Sodium Sulfate - (ACS) Granular, anhydrous (conditioned at 400° C for 4 hrs.).

5.4 Sulfuric Acid - (ACS) Mix equal volumes of conc. H_2SO_4 with distilled water.

5.5 Diethyl Ether - Nanograde, redistilled in glass, if necessary.

5.5.1 Must be free of peroxides as indicated by EM Quant test strips. (Test strips are available from EM Laboratories, Inc., 500 Executive Blvd., Elmsford, N.Y. 10523).

5.5.2 Procedures recommended for removal of peroxides are provided with the test strips.

5.6 n-Hexane - Pesticide quality (NOT MIXED HEXANES).

5.7 Acetonitrile, Hexane, Methanol, Methylene Chloride, Petroleum Ether (boiling range 30-60°C) - pesticide quality, redistill in glass if necessary.

5.8 Standards - Aroclors 1221, 1232, 1242, 1248, 1254, 1260, and 1016.

5.9 Anti-static Solution - STATNUL, Daystrom, Inc., Weston Instrument Division, Newark, N.J., 95212.

6. Calibration

6.1 Gas chromatographic operating conditions are considered acceptable if the response to dicapthon is at least 50% of full scale when ≲ 0.06 ng is injected for electron capture detection and ≲ 100 ng is injected for microcoulometric or electrolytic conductivity detection. For all quantitative measurements, the detector must be operated within its linear response range and the detector noise level should be less than 2% of full scale.

6.2 Standards are injected frequently as a check on the stability of operating conditions, detector and column. Example chromatograms are shown in Figures 3 through 8 and provide reference operating conditions.

7. Quality Control

7.1 Duplicate and spiked sample analyses are recommended as quality control checks. Quality control charts (4) should be developed and used as a check on the analytical system. Quality control check samples and performance evaluation samples should be analyzed on a regular basis.

7.2 Each time a set of samples is extracted, a method blank is determined on a volume of distilled water equivalent to that used to dilute the sample.

8. Sample Preparation

8.1 Blend the sample if suspended matter is present and adjust pH to near neutral (pH 6.5-7.5) with 50% sulfuric acid or 10 N sodium hydroxide.

8.2 For sensitivity requirement of 1 µg/1, when using microcoulometric or electrolytic conductivity methods for detection take 1000 ml of sample for analysis. If interferences pose no problem, the sensitivity of the electron capture detector should permit as little as 100 ml of sample to be used. Background information on the extent and nature of interferences will assist the analyst in choosing the required sample size and preferred detector.

8.3 Quantitatively transfer the proper aliquot into a two-liter separatory funnel and dilute to one liter.

9. Extraction

9.1 Add 60 ml of 15% methylene chloride in hexane (v:v) to the sample in the separatory funnel and shake vigorously for two minutes.

9.2 Allow the mixed solvent to separate from the sample, then draw the water into a one-liter Erlenmeyer flask. Pour the organic layer into a 100-ml beaker and then pass it through a column containing 3-4 inches of anhydrous sodium sulfate, and collect it in a 500-ml K-D flask equipped with a 10 ml-ampul. Return the water phase to the separatory funnel. Rinse the Erlenmeyer flask with a second 60-ml volume of solvent; add the solvent to the separatory funnel and complete the extraction procedure a second time. Perform a third extraction in the same manner.

9.3 Concentrate the extract in the K-D evaporator on a hot water bath.

9.4 Qualitatively analyze the sample by gas chromatography with an electron capture detector. From the response obtained decide:

a. If there are any organochlorine pesticides present.

b. If there are any PCBs present.

c. If there is a combination of a and b.

d. If elemental sulfur is present.

e. If the response is too complex to determine a, b or c.

f. If no response, concentrate to 1.0 ml or less, as required, and repeat the analysis looking for a, b, c, d, and e. Samples containing Aroclors with a low percentage of chlorine, e.g., 1221 and 1232, may require this concentration in order to achieve the detection limit of 1 µg/l. Trace quantities of PCBs are often masked by background which usually occur in samples.

9.5 If condition a exists, quantitatively determine the organochlorine pesticides according to (1).

9.6 If condition b exists, PCBs only are present; no further separation or cleanup is necessary. Quantitatively determine the PCBs according to step 11.

9.7 If condition c exists, compare peaks obtained from the sample to those of standard Aroclors and make a judgment as to which Aroclors may be present. To separate the PCBs from the organochlorine pesticides, continue as outlined in 10.4.

9.8 If condition d exists, separate the sulfur from the sample using the method outlined in 10.3 followed by the method in 10.5.

9.9 If condition e exists, the following macro cleanup and separation procedures (10.2 and 10.3) should be employed and, if necessary, followed by the micro separation procedures (10.4 and 10.5).

10. Cleanup and Separation Procedures

10.1 Interferences in the form of distinct peaks and/or high background in the initial gas chromatographic analysis, as well as the physical characteristics of the extract (color, cloudiness, viscosity) and background knowledge of the sample will indicate whether clean-up is required. When these interfere with measurement of the PCBs, or affect column life or detector sensitivity, proceed as directed below.

10.2 Acetonitrile Partition - This procedure is used to remove fats and oils from the sample extracts. It should be noted that not all pesticides are quantitatively recovered by this procedure. The analyst must be aware of this and demonstrate the efficiency of the partitioning for the compounds of interest.

10.2.1 Quantitatively transfer the previously concentrated extract to a 125-ml separatory funnel with enough hexane to bring the final volume to 15 ml. Extract the sample four times by shaking vigorously for one minute with 30-ml portions of hexane-saturated acetonitrile.

10.2.2 Combine and transfer the acetonitrile phases to a one-liter separatory funnel and add 650 ml of distilled water and 40 ml of saturated sodium chloride solution. Mix thoroughly for 30-45 seconds. Extract with two 100-ml portions of hexane by vigorously shaking about 15 seconds.

10.2.3 Combine the hexane extracts in a one-liter separatory funnel and wash with two 100-ml portions of distilled water. Discard the water layer and pour the hexane layer through a 3-4 inch anhydrous sodium sulfate column into a 500-ml K-D flask equipped with a 10-ml ampul. Rinse the separatory funnel and column with three 10-ml portions of hexane.

10.2.4 Concentrate the extracts to 6-10 ml in the K-D evaporator in a hot water bath.

10.2.5 Analyze by gas chromatography unless a need for further cleanup is indicated.

10.3 Florisil Column Adsorption Chromatography

10.3.1 Adjust the sample extract volume to 10 ml.

10.3.2 Place a charge of activated Florisil (weight determined by lauric-acid value, see Appendix II) in a Chromaflex column. After settling the Florisil by tapping the column, add about one-half inch layer of anhydrous granular sodium sulfate to the top.

10.3.3 Pre-elute the column, after cooling, with 50-60 ml of petroleum ether. Discard the eluate and just prior to exposure of the sulfate layer to air, quantitatively transfer the sample extract into the column by decantation and subsequent petroleum ether washings. Adjust the elution rate to about 5 ml per minute and, separately, collect up to three eluates in 500-ml K-D flasks equipped with 10-ml ampuls (see Eluate Composition 10.4.). Perform the first elution with 200 ml of 6% ethyl ether in petroleum ether, and the second elution with 200 ml of 15% ethyl ether in petroleum ether. Perform the third elution with 200 ml of 50% ethyl ether - petroleum ether and the fourth elution with 200 ml of 100% ethyl ether.

10.3.3.1 Eluate Composition - By using an equivalent quantity of any batch of Florisil as determined by its lauric acid value, the pesticides will be separated into the eluates indicated as follows.

<u>6% Eluate</u>

Aldrin	DDT	Pentachloro-nitrobenzene
BHC	Heptachlor	Strobane
Chlordane	Heptachlor Epoxide	Toxaphene
DDD	Lindane	Trifluralin
DDE	Methoxychlor	PCBs
	Mirex	

15% Eluate	50% Eluate
Endosulfan I	Endosulfan II
Endrin	Captan
Dieldrin	
Dichloran	
Phthalate esters	

Certain thiophosphate pesticides will occur in each of the above fractions as well as the 100% fraction. For additional information regarding eluate composition, refer to the FDA Pesticide Analytical Manual (5).

10.3.4 Concentrate the eluates to 6-10 ml in the K-D evaporator in a hot water bath.

10.3.5 Analyze by gas chromatography.

10.4 Silica Gel Micro-Column Separation Procedure (6)

10.4.1 Activation for Silica Gel

10.4.1.1 Place about 20 gm of silica gel in a 100-ml beaker. Activate at 180°C for approximately 16 hours. Transfer the silica gel to a 100-ml glass-stoppered bottle. When cool, cover with about 35 ml of 0.50% diethyl ether in benzene (volume:volume). Keep bottle well sealed. If silica gel collects on the ground glass surfaces, wash off with the above solvent before resealing. Always maintain an excess of the mixed solvent in bottle (aproximately 1/2 in. above silica gel). Silica gel can be effectively stored in this manner for several days.

10.4.2 Preparation of the Chromatographic Column

10.4.2.1 Pack the lower 2 mm ID section of the micro-column with glass wool. Permanently mark the column 120 mm above the glass wool. Using a clean rubber bulb from a disposable pipet seal the lower end of the microcolumn. Fill the microcolumn with 0.50% ether in benzene (v:v) to the bottom of the 10/30 joint (Figure 1). Using a disposable capillary pipet, transfer several aliquots of the silica gel slurry into the microcolumn. After approximately 1 cm of silica gel collects in the bottom of the microcolumn, remove the rubber bulb seal, tap the column to insure that the silica gel reaches the 120 ± 2 mm mark. Be sure that there are no air bubbles in the column. Add about 10 mm of sodium sulfate to the top of the silica gel. Under low humidity conditions, the silica gel may coat the sides of the column and not settle properly. This can be minimized by wiping the outside of the column with an anti-static solution.

10.4.2.2 Deactivation of the Silica Gel

a. Fill the microcolumn to the base of the 10/30 joint with the 0.50% ether-benzene mixture, assemble reservoir (using spring clamps) and fill with approximately 15 ml of the 0.50% ether-benzene mixture. Attach the air pressure device (using spring clamps) and adjust the elution rate to approximately 1 ml/min. with the air pressure control. Release the air pressure and detach reservoir just as the last of the solvent enters the sodium sulfate. Fill the column with n-hexane (not mixed hexanes) to the base of the 10/30 fitting. Evaporate all residual benzene from the reservoir, assemble the reservoir section and fill with 5 ml of n-hexane. Apply air pressure and remove the reservoir just as the n-hexane enters the sodium sulfate. The column is now ready for use.

b. Pipet a 1.0 ml aliquot of the concentrated sample extract (previously reduced to a total volume of 2.0 ml) on to the column. As the last of the sample passes into the sodium sulfate layer, rinse down the internal wall of the column twice with 0.25 ml of n-hexane. Then assemble the upper section of the column. As the last of the n-hexane rinse reaches the surface of the sodium sulfate, add enough n-hexane (volume predetermined, see 10.4.3) to just elute all of the PCBs present in the sample. Apply air pressure and adjust until the flow is 1 ml/min. Collect the desired volume of eluate (predetermined, see 10.4.3) in an accurately calibrated ampul. As the last of the n-hexane reaches the surface of the sodium sulfate, release the air pressure and change the collection ampul.

c. Fill the column with 0.50% diethyl ether in benzene, again apply air pressure and adjust flow to 1 ml/min. Collect the eluate until all of the organochlorine pesticides of interest have been eluted (volume predetermined, see 10.4.3).

d. Analyze the eluates by gas chromatography.

10.4.3 Determination of Elution Volumes

10.4.3.1 The elution volumes for the PCBs and the pesticides depend upon a number of factors which are difficult to control. These include variation in:

a. Mesh size of the silica gel

b. Adsorption properties of the silica gel

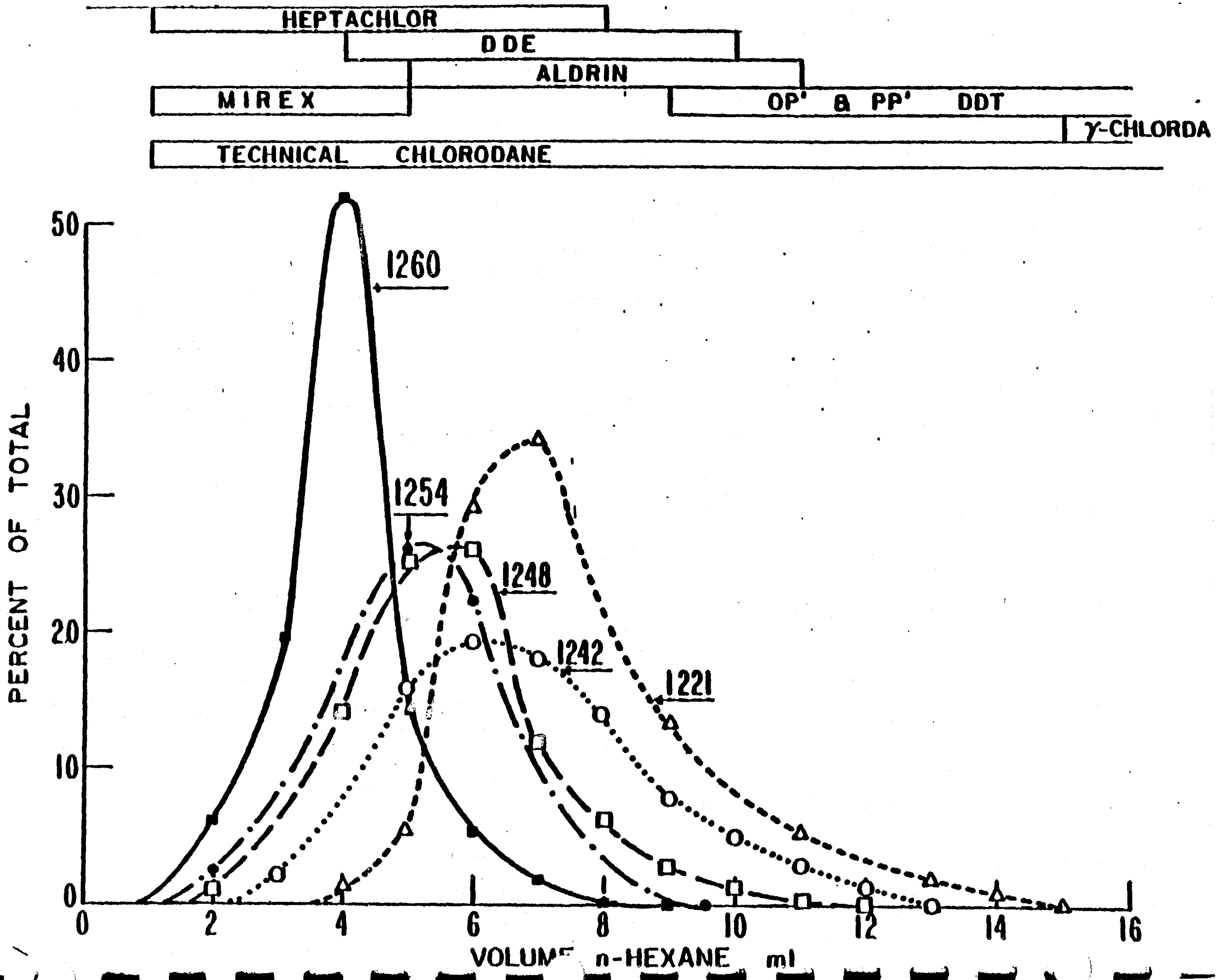
c. Polar contaminants present in the eluting solvent

d. Polar materials present in the sample and sample solvent

e. The dimensions of the microcolumns

Therefore, the optimum elution volume must be experimentally determined each time a factor is changed. To determine the elution volumes, add standard mixtures of Aroclors and pesticides to the column and serially collect 1-ml elution volumes. Analyze the individual eluates by gas chromatography and determine the cut-off volume for n-hexane and for ether-benzene. Figure 2 shows the retention order of the various PCB components and of the pesticides. Using this information, prepare the mixtures required for calibraton of the microcolumn.

10.4.3.2 In determining the volume of hexane required to elute the PCBs the sample volume (1 ml) and the volume of n-hexane used to rinse the column wall must be considered. Thus, if it is determined that a 10.0-ml elution volume is required to elute the PCBs, the volume of hexane to be added in addition to the sample volume but including the rinse volume should be 9.5 ml.


HEPTACHLOR
DDE
ALDRIN
MIREX
OP' & PP' DDT
γ-CHLORDA
TECHNICAL CHLORODANE
PERCENT OF TOTAL
0
10
20
30
40
50
1260
1254
1248
1242
1221
0
2
4
6
8
10
12
14
16
VOLUME n-HEXANE ml

10.4.3.3 Figure 2 shows that as the average chlorine content of a PCB mixture decreases the solvent volume for complete elution increases. Qualitative determination (9.4) indicates which Aroclors are present and provides the basis for selection of the ideal elution volume. This helps to minimize the quantity of organochlorine pesticides which will elute along with the low percent chlorine PCBs and insures the most efficient separations possible for accurate analysis.

10.4.3.4 For critical analysis where the PCBs and pesticides are not separated completely, the column should be accurately calibrated according to (10.4.3.1) to determine the percent of material of interest that elutes in each fraction. Then flush the column with an additional 15 ml of 0.50% ether in benzene followed by 5 ml of n-hexane and use this reconditioned column for the sample separation. Using this technique one can accurately predict the amount (%) of materials in each micro column fraction.

10.5 Micro Column Separation of Sulfur, PCBs, and Pesticides

10.5.1 See procedure for preparation and packing micro column in PCB analysis section (10.4.1 and 10.4.2).

10.5.2 Microcolumn Calibration

10.5.2.1 Calibrate the microcolumn for sulfur and PCB separation by collecting 1.0-ml fractions and analyzing them by gas chromatography to determine the following:

1) The fraction with the first eluting PCBs (those present in 1260),
2) The fraction with the last eluting PCBs (those present in 1221),
3) The elution volume for sulfur,
4) The elution volume for the pesticides of interest in the 0.50% ether-benzene fraction.

From these data determine the following:

1) The eluting volume containing only sulfur (Fraction I),
2) The eluting volume containing the last of the sulfur and the early eluting PCBs (Fraction II),
3) The eluting volume containing the remaining PCBs (Fraction III),
4) The ether-benzene eluting volume containing the pesticides of interest (Fraction IV).

10.5.3 Separation Procedure

10.5.3.1 Carefully concentrate the 6% eluate from the florisil column to 2.0 ml in the graduated ampul on a warm water bath.

10.5.3.2 Place 1.0 ml (50%) of the concentrate into the microcolumn with a 1-ml pipet. Be careful not to get any sulfur crystals into the pipet.

10.5.3.3 Collect Fractions I and II in calibrated centrifuge tubes. Collect Fractions III and IV in calibrated ground glass stoppered ampuls.

10.5.3.4 Sulfur Removal (7) - Add 1 to 2 drops of mercury to Fraction II stopper and place on a wrist-action shaker. A black precipitate indicates the presence of sulfur. After approximately 20 minutes the mercury may become entirely reacted or deactivated by the precipitate. The sample should be quantitatively transferred to a clean centrifuge tube and additional mercury added. When crystals are present in the sample, three treatments may be necessary to remove all the sulfur. After all the sulfur has been removedfrom Fraction II (check using gas chromatography) combine Fractions II and III. Adjust the volume to 10 ml and analyze by gas chromatography. Be sure no mercury is transferred to the combined Fractions II and III, since it can react with certain pesticides.

By combining Fractions II and III, if PCBs are present, it is possible to identify the Aroclor(s) present and a quantitative analysis can be performed accordingly. Fraction I can be discarded since it only contains the bulk of the sulfur. Analyze Fractions III and IV for the PCBs and pesticides. If DDT and its homologs, aldrin, heptachlor, or technical chlordane are present along with the PCBs, an additional microcolumn separation can be performed which may help to further separate the PCBs from the pesticides (See 10.4).

11. Quantitative Determination

11.1 Measure the volume of n-hexane eluate containing the PCBs and inject 1 to 5 μl into the gas chromatograph. If necessary, adjust the volume of the eluate to give linear response to the electron capture detector. The microcoulometric or the electrolytic detector may be employed to improve specificity for samples having higher concentrations of PCBs.

11.2 Calculations

11.2.1 When a single Aroclor is present, compare quantitative Aroclor reference standards (e.g., 1242, 1260) to the unknown. Measure and sum the areas of the unknown and the reference Aroclor and calculate the result as follows:

$$\text{Microgram/liter} = \frac{[A]\,[B]\,[V_t]}{[(V_i)\quad(V_s)]} \times [N]$$

$$A = \frac{\text{ng of Standard Injected}}{} = \frac{ng_2}{mm}$$

B = of Sample Peak Areas - (mm^2)

V_i = Volume of sample injected (µl)

V_t = Volume of Extract (µl) from which sample is injected into gas chromatograph

V_s = Volume of water sample extracted (ml)

N = 2 when micro column used
1 when micro column not used

Peak Area = Peak height (mm x Peak Width at 1/2 height

11.2.2 For complex situatons, use the calibration method described below (8). Small variations in components between different Aroclor batches make it necessary to obtain samples of several specific Aroclors. These reference Aroclors can be obtained from the Southeast Environmental Research Laboratory, EPA, Athens, Georgia, 30601. The procedure is as follows:

11.2.2.1 Using the OV-1 column, chromatograph a known quantity of each Aroclor reference standard. Also chromatograph a sample of p,p'-DDE. Suggested concentration of each standard is 0.1 ng/µl for the Aroclors and 0.02 ng/µl for the p,p'-DDE.

11.2.2.2 Determine the relative retention time (RRT) of each PCB peak in the resulting chromatograms using p,p'-DDE as 100.

$$RRT = \frac{RT \times 100}{RT_{DDE}}$$

RRT = Relative Retention Time

RT = Retention time of peak of interest

RT_{DDE} = Retention time of p,p'-DDE

Retention time is measured as that distance in mm between the first appearance of the solvent peak and the maximum for the compound.

11.2.2.3 To calibrate the instrument for each PCB measure the area of each peak.

Area = Peak height (mm) x Peak width at 1/2 height. Using Tables 1 through 6 obtain the proper mean weight factor, then determine the response factor ng/mm^2.

$$ng/mm^2 = \frac{(ng_i)\quad \frac{(\text{mean weight percent})}{100}}{(\text{Area})}$$

ng_i = ng of Aroclor Standard Injected

Mean weight percent - obtained from Tables 1 through 6.

11.2.2.4 Calculate the RRT value and the area for each PCB peak in the sample chromatogram. Compare the sample chromatogram to those obtained for each reference Aroclor standard. If it is

Table 1

Composition of Aroclor 1221 (8)

RRT[a]	Mean Weight Percent	Relative Std. Dev.[b]	Number of Chlorines[c]	
11	31.8	15.8	1	
14	19.3	9.1	1	
16	10.1	9.7	2	
19	2.8	9.7	2	
21	20.8	9.3	2	
28	5.4	13.9	2	85%
			3	15%
32	1.4	30.1	2	10%
			3	90%
37	1.7	48.8	3	
40				

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent. Overlapping peaks that are quantitated as one peak are bracketed.

[b]Standard deviation of seventeen results as a percentage of the mean of the results.

[c]From GC-MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

100695

Table 2

Composition of Aroclor 1232 (8)

RRT[a]	Mean Weight Percent	Relative Std. Dev.[b]	Number of Chlorines[c]	
11	16.2	3.4	1	
14	9.9	2.5	1	
16	7.1	6.8	2	
20	17.8	2.4	2	
21				
28	9.6	3.4	2	40%
			3	60%
32	3.9	4.7	3	
37	6.8	2.5	3	
40	6.4	2.7	3	
47	4.2	4.1	4	
54	3.4	3.4	3	33%
			4	67%
58	2.6	3.7	4	
70	4.6	3.1	4	90%
			5	10%
78	1.7	7.5	4	
Total	94.2			

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent. Overlapping peaks that are quantitated as one peak are bracketed.

[b]Standard deviation of four results as a mean of the results.

[c]From GC-MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

Table 3

Composition of Aroclor 1242 (8)

RRT[a]	Mean Weight Percent	Relative Std. Dev.[b]	Number of Chlorines[c]	
11	1.1	35.7	1	
16	2.9	4.2	2	
21	11.3	3.0	2	
28	11.0	5.0	2	25%
			3	75%
32	6.1	4.7	3	
37	11.5	5.7	3	
40	11.1	6.2	3	
47	8.8	4.3	4	
54	6.8	2.9	3	33%
			4	67%
58	5.6	3.3	4	
70	10.3	2.8	4	90%
			5	10%
78	3.6	4.2	4	
84	2.7	9.7	5	
98	1.5	9.4	5	
104	2.3	16.4	5	
125	1.6	20.4	5	85%
			6	15%
146	1.0	19.9	5	75%
			6	25%

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent.

[b]Standard deviation of six results as a percentage of the mean of the results.

[c]From GC-MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

Table 4

Composition of Aroclor 1248 (8)

RRT[a]	Mean Weight Percent	Relative Std. Dev.[b]	Number of Chlorines[c]	
21	1.2	23.9	2	
28	5.2	3.3	3	
32	3.2	3.8	3	
47	8.3	3.6	3	
40	8.3	3.9	3	85%
			4	15%
47	15.6	1.1	4	
54	9.7	6.0	3	10%
			4	90%
58	9.3	5.8	4	
70	19.0	1.4	4	80%
			5	20%
78	6.6	2.7	4	
84	4.9	2.6	5	
98	3.2	3.2	5	
104	3.3	3.6	4	10%
			5	90%
112	1.2	6.6	5	
125	2.6	5.9	5	90%
			6	10%
146	1.5	10.0	5	85%
			6	15%
Total	103.1			

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent.

[b]Standard deviation of six results as a percentage of the mean of the results.

[c]From GC-MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

Table 5

Composition of Aroclor 1254 (8)

RRT[a]	Mean Weight Percent	Relative Std. Dev.[b]	Number of Chlorines[c]	
47	6.2	3.7	4	
54	2.9	2.6	4	
58	1.4	2.8	4	
70	13.2	2.7	4	25%
			5	75%
84	17.3	1.9	5	
98	7.5	5.3	5	
104	13.6	3.8	5	
125	15.0	2.4	5	70%
			6	80%
146	10.4	2.7	5	30%
			6	70%
160	1.3	8.4	6	
174	8.4	5.5	6	
203	1.8	18.6	6	
232	1.0	26.1	7	
Total	100.0			

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent.

[b]Standard deviation of six results as a percentage of the mean of the results.

[c]From GC-MS data. Peaks containing mixtures of isomers are bracketed.

Table 6

Composition of Aroclor 1260 (8)

RRT[a]	Mean Weight Percent	Relative Std. Dev.[b]	Number of Chlorines[c]	
70	2.7	6.3	5	
84	4.7	1.6	5	
98	3.8	3.5	[d]	
104			5	60%
			6	40%
117	3.3	6.7	6	
125	12.3	3.3	5	15%
			6	85%
146	14.1	3.6	6	
160	4.9	2.2	6	50%
			7	50%
174	12.4	2.7	6	
203	9.3	4.0	6	10%
			7	90%
232			[e]	
244	9.8	3.4	6	10%
			7	90%
280	11.0	2.4	7	
332	4.2	5.0	7	
372	4.0	8.6	8	
448	.6	25.3	8	
528	1.5	10.2	8	
Total	98.6			

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent. Overlapping peaks that are quantitated as one peak are bracketed.

[b]Standard deviation of six results as a mean of the results.

[c]From GC-MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

[d]Composition determined at the center of peak 104.

[e]Composition determined at the center of peak 232.

apparent that the PCB peaks present are due to only one Aroclor, then calculate the concentration of each PCB using the following formula:

ng PCB = ng/mm^2 x Area

Where Area = Area (mm^2) of sample peak

ng/mm^2 = Response factor for that peak measured.

Then add the nanograms of PCBs present in the injection to get the total number of nanograms of PCBs present. Use the following formula to calculate the concentration of PCBs in the sample:

Micrograms/Liter =

V_s = volume of water extracted (ml)

V_t = volume of extract (µl)

V_i = volume of sample injected (µl)

ng = sum of all the PCBs in nanograms for that Aroclor identified

N = 2 when microcolumn used

N = 1 when microcolumn not used

The value can then be reported as micrograms/liter PCBs or as the Aroclor. For samples containing more than one Aroclor, use Figure 9 chromatogram divisional flow chart to assign a proper response factor to each peak and also identify the "most likely" Aroclors present. Calculate the ng of each PCB isomer present and sum them according to the divisional flow chart. Using the formula above, calculate the concentration of the various Aroclors present in the sample.

12. Reporting Results

12.1 Report results in micrograms per liter without correction for recovery data. When duplicate and spiked samples are analyzed, all data obtained should be reported.

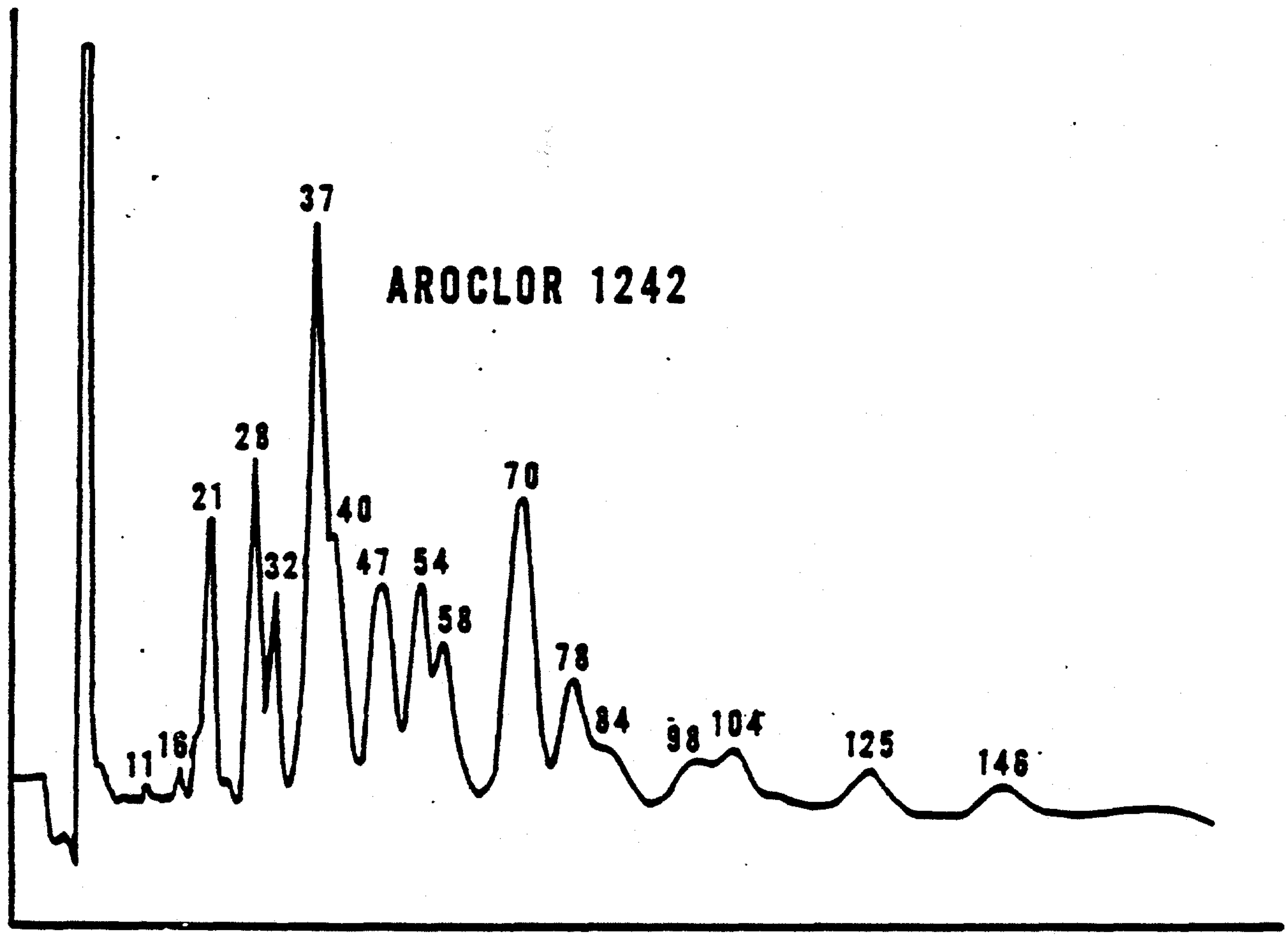


Figure 3. Column: 3% OV-1, Carrier Gas: Nitrogen at 60 ml/min, Column Temperature: 170 C, Detector: Electron Capture

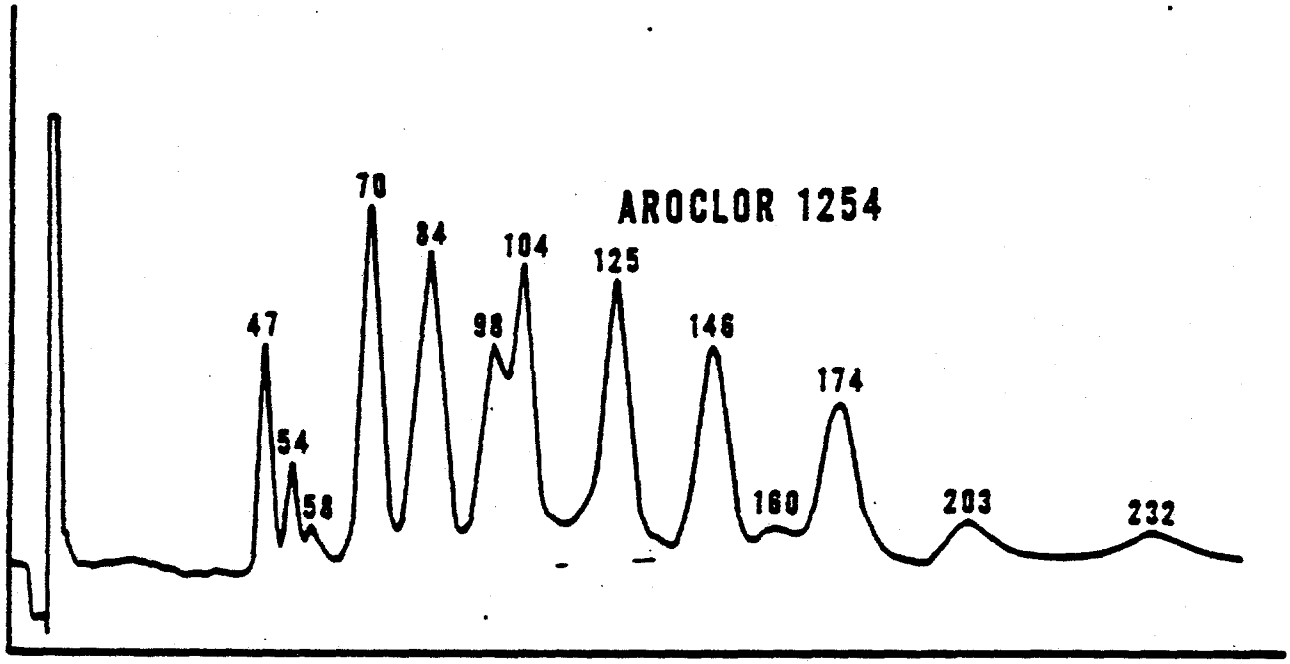


Figure 4. Column: 3% OV-1, Carrier Gas: Nitrogen at 60 ml/min, Column Temperature: 170 C, Detector: Electron Capture.

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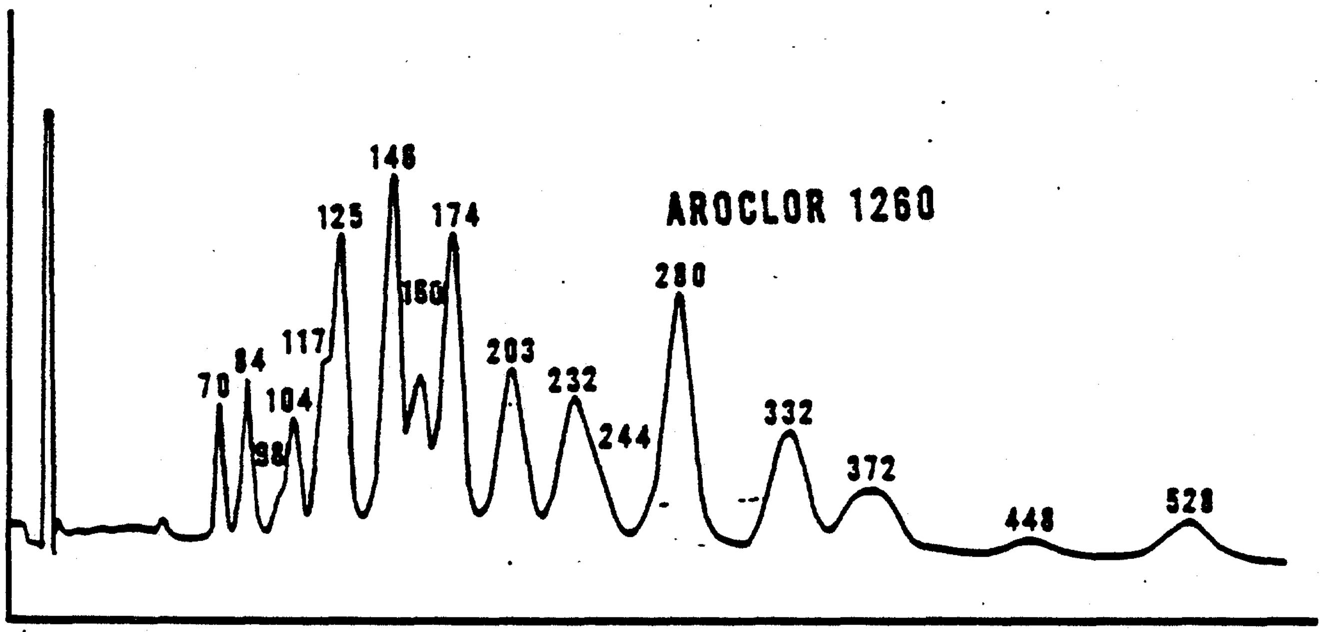

Figure 5. Column: 3% OV-1, Carrier Gas: Nitrogen at 60 ml/min, Column Temperature: 170 C, Detector: Electron Capture.

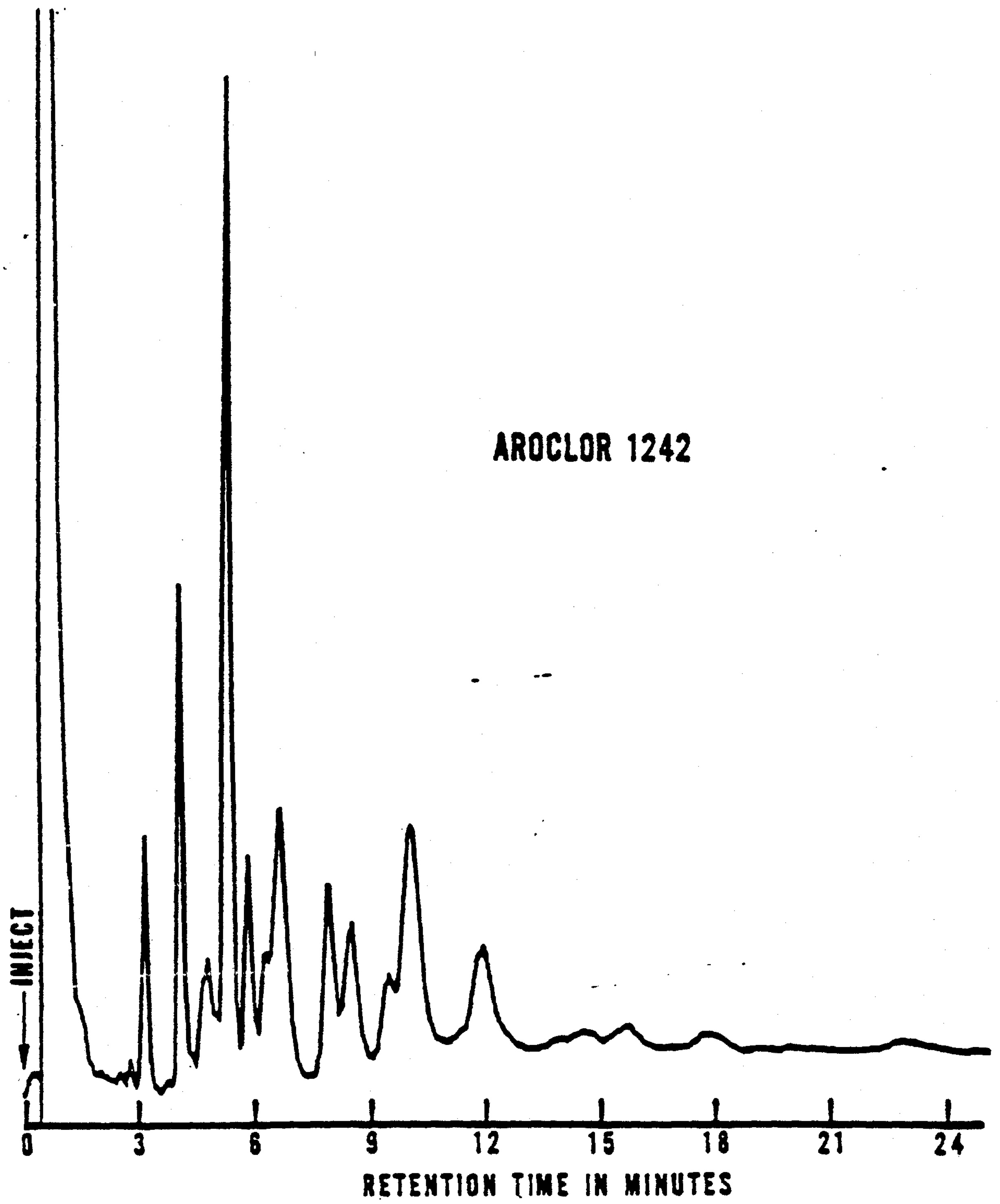

Figure 6. Column: 1.5% OV-17 + 1.95% QF-1, Carrier Gas: Nitrogen at 60 ml/min, Column Temperature: 200 C, Detector: Electron Capture.

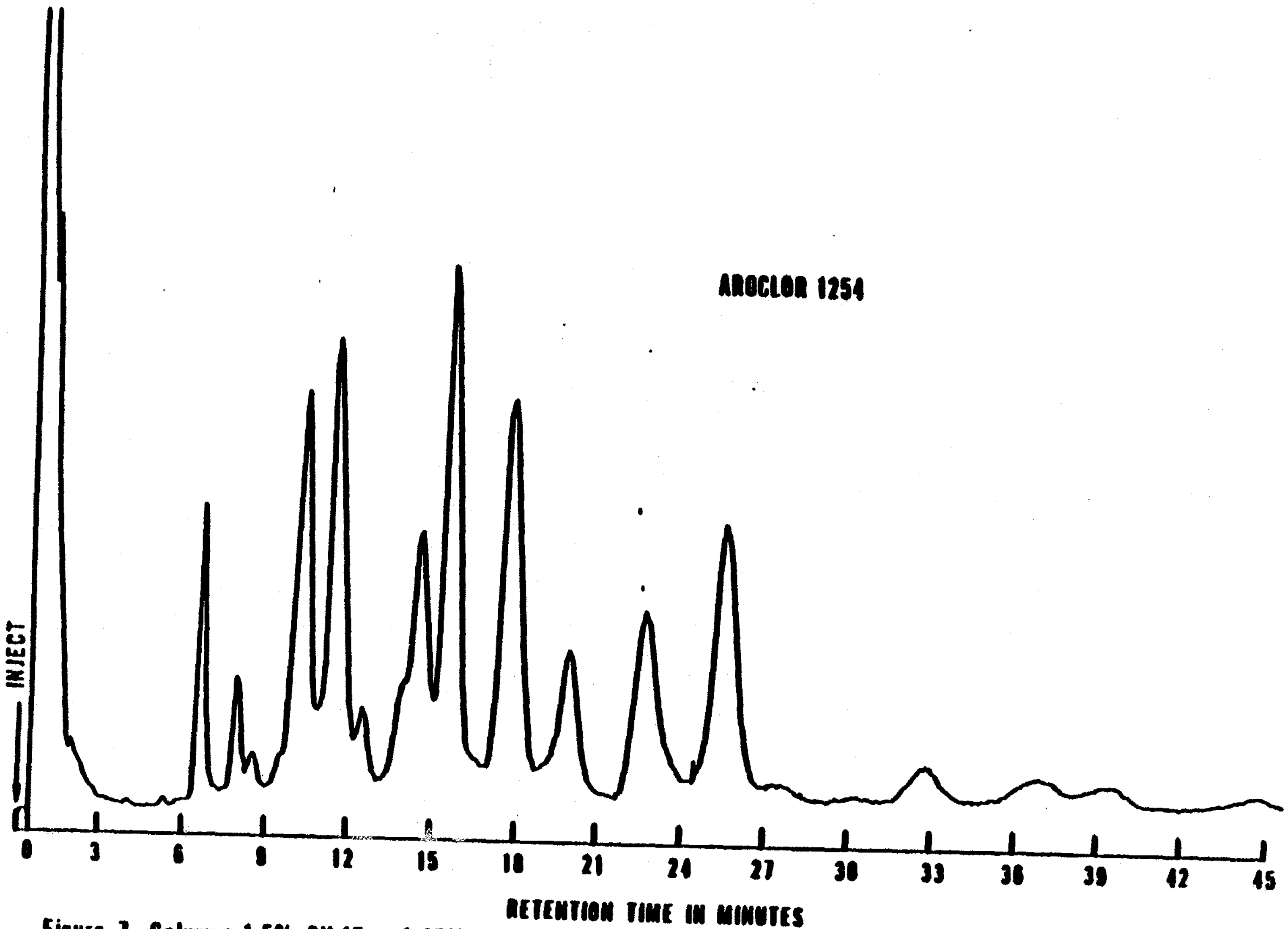

Figure 7. Column: 1.5% OV-17 + 1.95% QF-1, Carrier Gas: Nitrogen at 60 ml/min, Column Temperature: 200 C, Detector: Electron Capture.

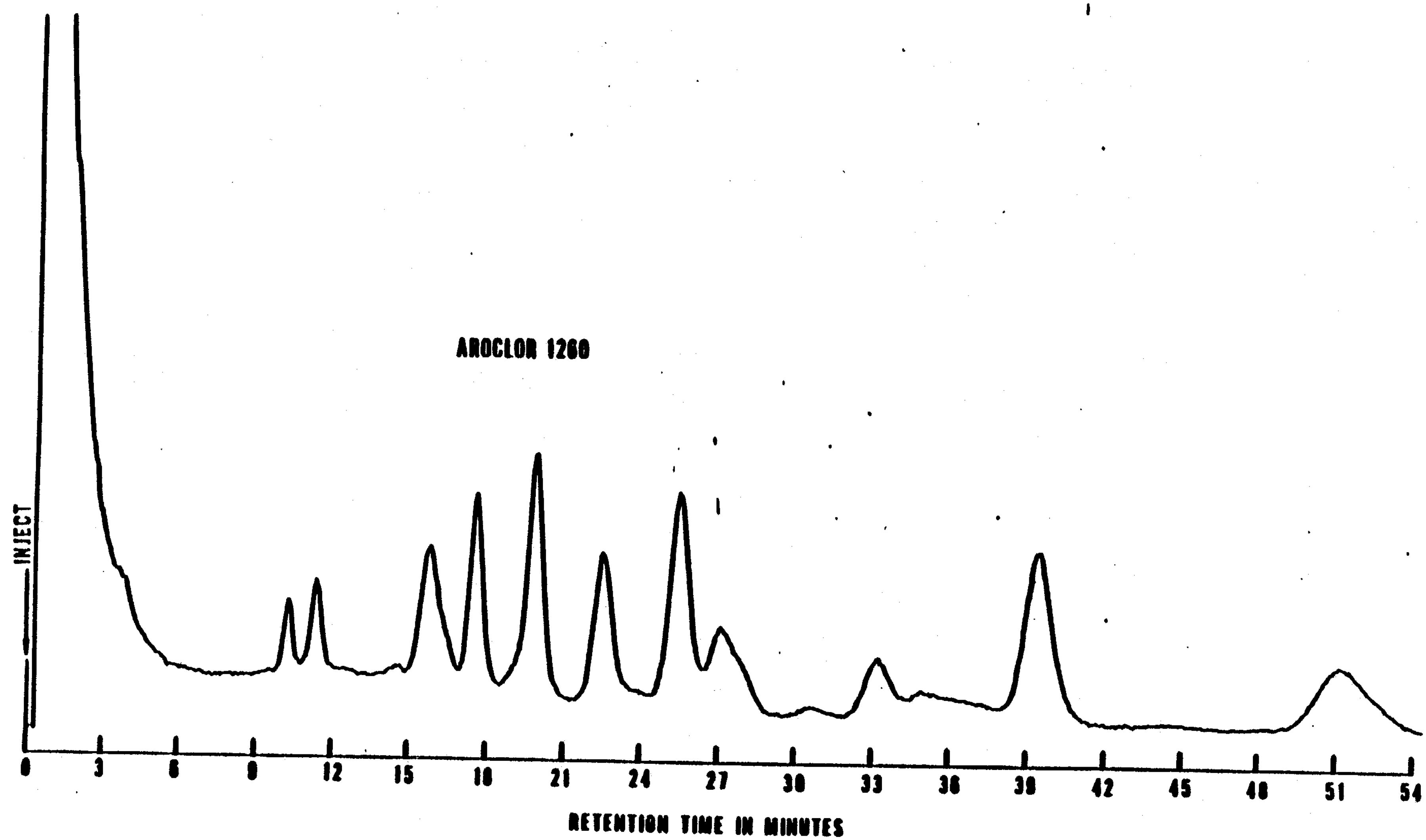

Figure 8. Column: 1.5% OV-17 + 1.95% QF-1, Carrier Gas: Nitrogen at 60 ml/min, Column Temperature: 200C, Detector: Electron Capture.

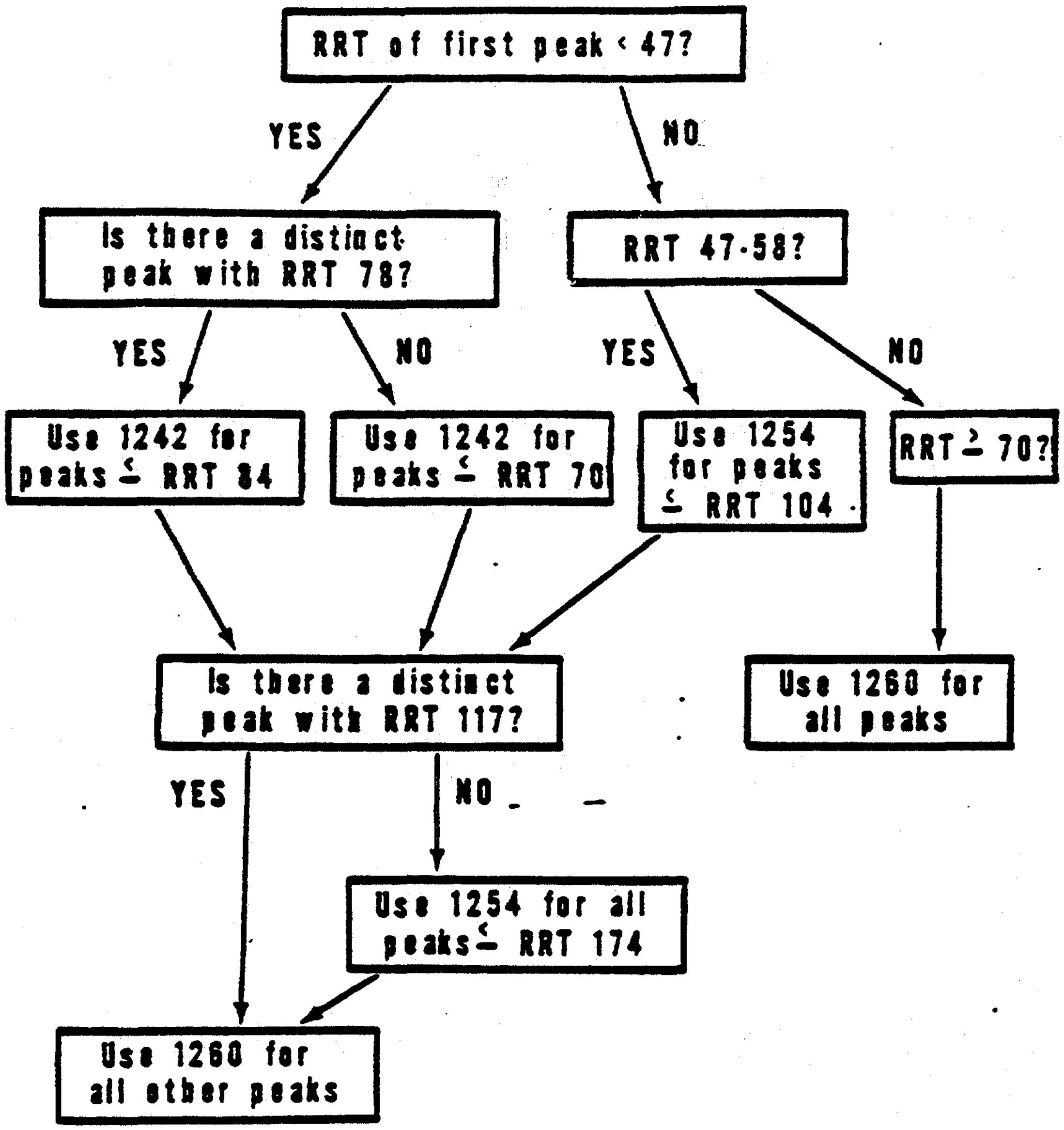

Figure 9. Chromatogram Division Flowchart (8).

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APPENDIX F

REMEDIAL INVESTIGATION COSTS AND SCHEDULES/

REMEDIAL ACTION CONSTRUCTION SCHEDULES

HUDSON RIVER PCBs SITE

NEW YORK

Cost estimates and project schedules for the Remedial Investigation programs proposed in Section 10.0 are presented in Appendix F. Estimated pre-construction and construction schedules are also presented.

Direct cost items and a Cost Summary Table for the Remnant Deposit Remedial Investigation described in Section 10.3 are presented on pages F-2 and F-3. Similar tables for the Phase One Remedial Investigation of the river, described in Section 10.4 are presented on pages F-4 and F-5.

Pages F-6 and F-7 present estimated project schedules for the Remnant Deposit and River Monitoring Remedial Investigations. Pages F-8 and F-9 present preconstruction and construction schedules for the actual remedial activities at the Remnant Sites.

HUDSON RIVER PCBs SITE, NEW YORK
REMEDIAL INVESTIGATION, REMNANT DEPOSITS
DIRECT COST TABLE

(JANUARY 1983 DOLLARS)

	Preliminary Activities	Site Activities
Total Hours	1,360	1,430
Travel & Living	$5,000	$ 2,500
CLP Lab Analysis	0	36,000
Special Equipment	800	300
Subcontracts	0	13,000
Other Direct Costs	5,600	6,300

HUDSON RIVER PCBs SITE, NEW YORK
REMEDIAL INVESTIGATION, REMNANT DEPOSITS
COST SUMMARY

(JANUARY 1983 DOLLARS)

Direct Labor	$ 37,800
Travel & Living	7,500
Special Equipment	1,100
Subcontracts	13,000
Other Direct Costs	11,900
Subtotal	$ 71,300
Overhead & Profit (125% direct labor)	47,200
CLP Lab Analysis	36,000
Subtotal	154,500
G&A + Fees (20%)	30,900
Total Cost	$185,400

HUDSON RIVER PCBs SITE, NEW YORK
REMEDIAL INVESTIGATION, RIVER ACTIVITIES
DIRECT COST TABLE

(JANUARY 1983 DOLLARS)

	Preliminary Activities	Site Activities
Total Hours	1,370	4,140
Travel & Living	$4,600	$17,000
CLP Lab Analysis	0	88,900
Special Equipment	300	13,900
Subcontracts	0	19,000
Other Direct Costs	5,800	22,800

HUDSON RIVER PCBs SITE, NEW YORK
REMEDIAL INVESTIGATION, RIVER ACTIVITIES
COST SUMMARY

(JANUARY 1983 DOLLARS)

Direct Labor	$ 70,000
Travel & Living	21,600
Special Equipment	14,200
Subcontracts	19,000
Other Direct Costs	28,700
Subtotal	$153,300
Overhead & Profit (125% direct labor)	87,500
CLP Lab Analysis	88,900
Subtotal	$329,700
G & A fees (20%)	65,900
Total Cost	$395,600

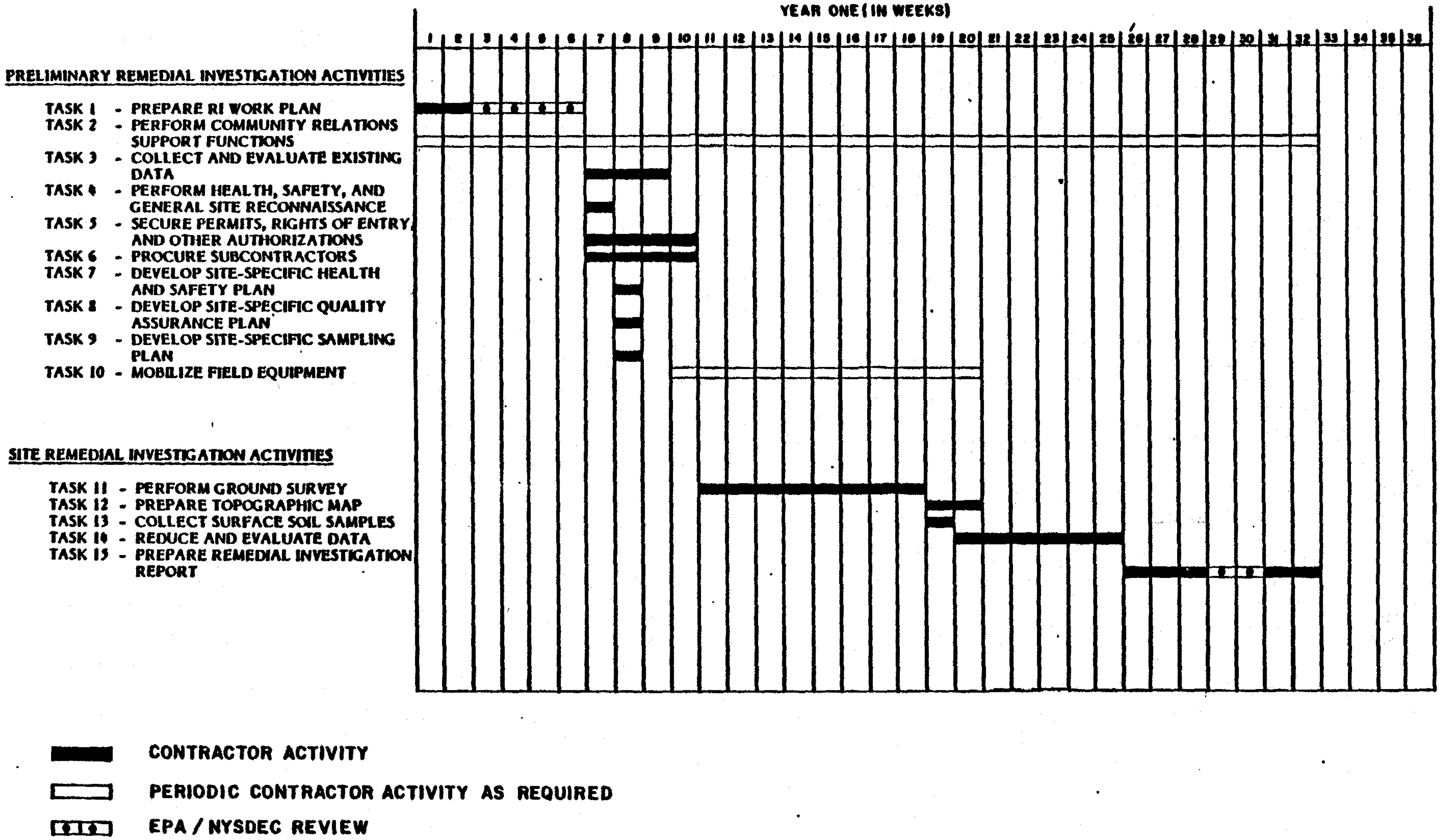


FIGURE F-1

REMEDIAL INVESTIGATION PROJECT SCHEDULE, REMNANT DEPOSITS
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

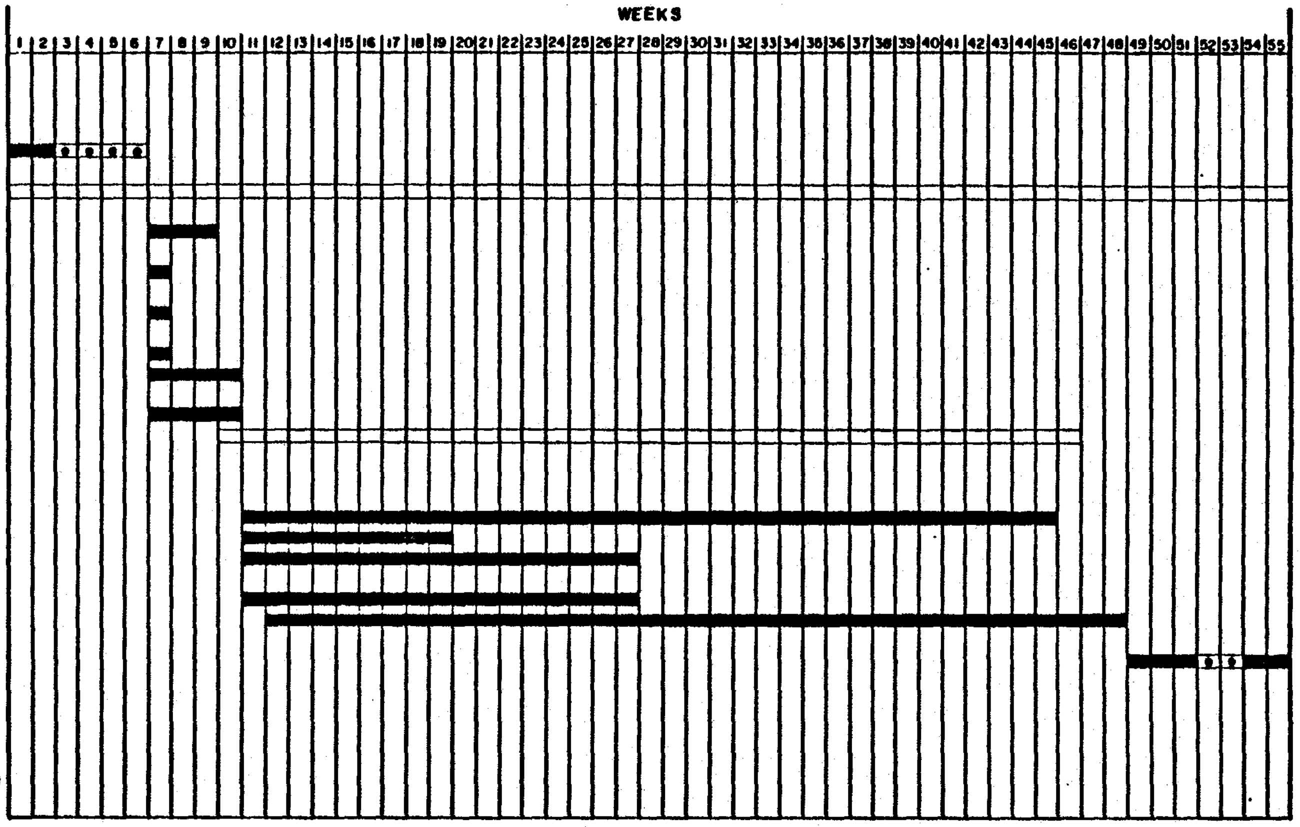
100719

PRELIMINARY REMEDIAL INVESTIGATION ACTIVITIES

TASK 1 - PREPARE RI WORK PLAN
TASK 2 - PERFORM COMMUNITY RELATIONS SUPPORT FUNCTIONS
TASK 3 - COLLECT AND EVALUATE EXISTING DATA
TASK 4 - DEVELOP SITE-SPECIFIC HEALTH AND SAFETY PLAN
TASK 5 - DEVELOP SITE-SPECIFIC QUALITY ASSURANCE PLAN
TASK 6 - DEVELOP SITE-SPECIFIC SAMPLING AND ANALYSIS PLAN
TASK 7 - PROCURE SUBCONTRACTORS
TASK 8 - SECURE PERMITS, RIGHTS OF ENTRY, AND OTHER AUTHORIZATIONS
TASK 9 - MOBILIZE FIELD EQUIPMENT

SITE REMEDIAL INVESTIGATION ACTIVITIES

TASK 10 - COLLECT DRINKING WATER SAMPLES
TASK 11 - COLLECT AIR MONITORING SAMPLES
TASK 12 - PERFORM WETLAND STUDY
TASK 13 - COLLECT TERRESTRIAL VEGETATION SAMPLES
TASK 14 - REDUCE AND EVALUATE DATA
TASK 15 - PREPARE REMEDIAL INVESTIGATION REPORT



LEGEND

■ CONTRACTOR ACTIVITY
□ PERIODIC CONTRACTOR ACTIVITY AS REQUIRED
⊡ EPA/NYSDEC REVIEW

F-7

FIGURE F-2

REMEDIAL INVESTIGATION PROJECT SCHEDULE, RIVER ACTIVITIES
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

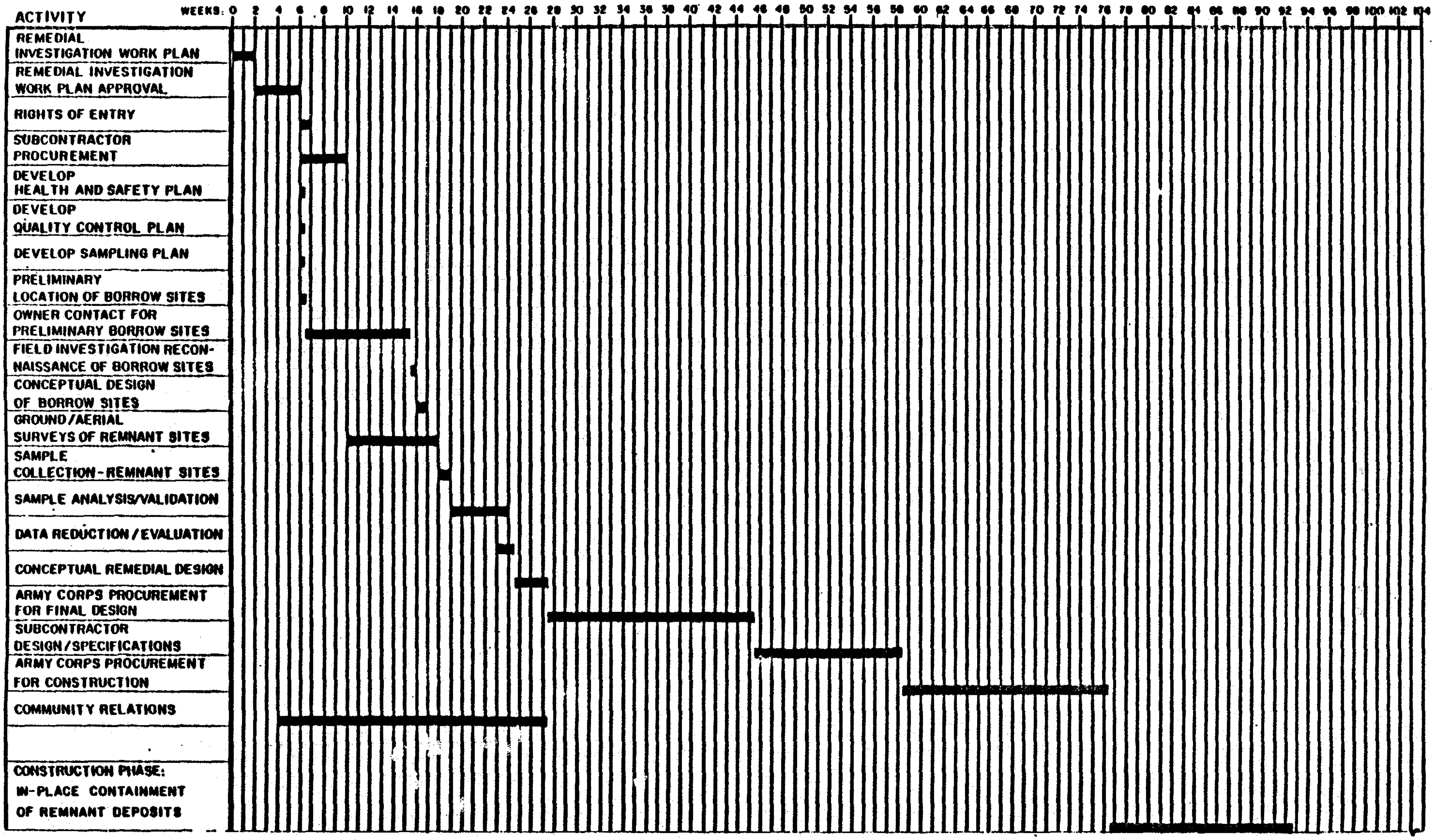
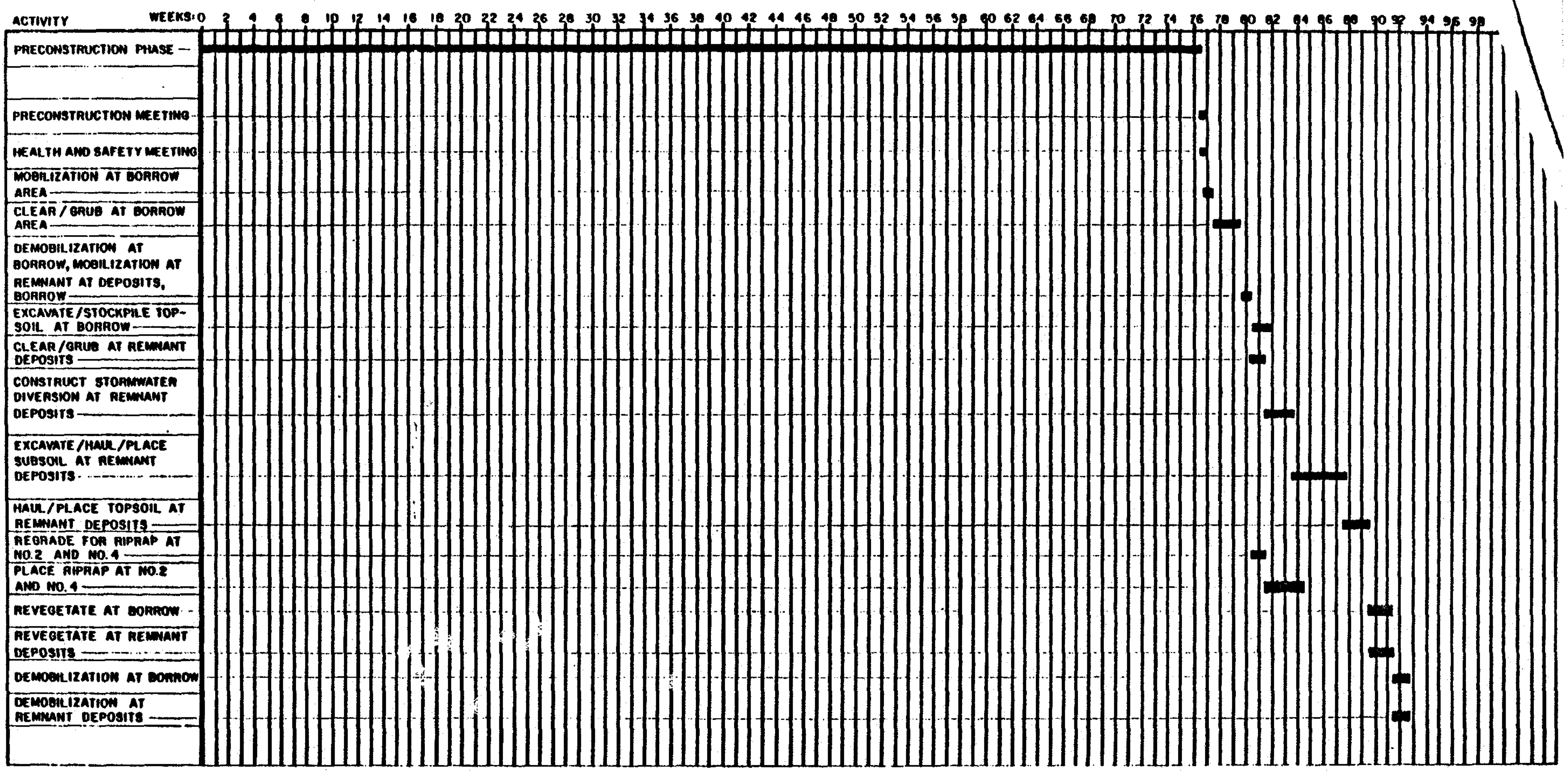


FIGURE F-3

PRECONSTRUCTION PHASE
HUDSON RIVER PCB SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

100721



F-9

CONSTRUCTION PHASE:

IN-PLACE CONTAINMENT OF REMNANT DEPOSITS

HUDSON RIVER PCB SITE, HUDSON RIVER, NY

FIGURE F-4

NUS CORPORATION

A Hallibu[illegible] Company

NUS CORPORATION

Park West Two
Cliff Mine Road
Pittsburgh, PA 15275
412-788-1080

VOLUME II

RESPONSE TO COMMENTS

HUDSON RIVER PCBs SITE
NEW YORK

EPA WORK ASSIGNMENT
NUMBER 01-2V84.0
CONTRACT NUMBER 68-01-6699

NUS PROJECT NUMBER 0723.01

APRIL 1984

REVISED BY EPA

September 1984

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SUMMARY

The Draft Feasibility Study (DFS) on the Hudson River PCBs Site was issued for public comment and review on October 5, 1983. The public review period was closed on November 30, 1983. During this time, many comments were received by EPA from numerous public, governmental, and other organizations. Volume II of the final Feasibility Study was devoted exclusively to responding directly to more than 150 comments on the Draft Feasibility Study. That response has been further revised to more clearly explain EPA's basis for the remedial action decisions.

Although many comments were received, there are about five major issues that essentially summarize the concerns of citizens interested in the DFS. These issues are discussed below.

The first issue of concern to many commenters was a discrepancy between the PCB quantities reported in the DFS and the PCB quantities reported elsewhere. The DFS stated that there were approximately 500,000 pounds of PCB distributed among remnant deposits, hot spots, Upper Hudson River cold areas, and Lower Hudson River sediments. Many readers thought that this was an underestimation of the PCB mass. However, a review of four widely quoted reports revealed that the 500,000 pounds is an appropriate figure; the estimates of in-situ PCB mass ranged in the reports from 497,520 to 653,000 pounds.

The confusion stemmed from statements in the DFS which linked the General Electric plant discharges to the 500,000-pound figure. This is probably inaccurate because the evidence indicates that there may actually be 1.4 to 1.8 million pounds of PCB in the Hudson Basin traceable to General Electric. The other 900,000 to 1.3 million pounds of PCBs are distributed among dredge spoils, upland dumps, and extra-system transport. These PCBs, however, were not of direct concern in the evaluation of remedial alternatives--the primary objective of the DFS. The 500,000-pound figure, then, was justified by the literature, as were the figures for hot-spot PCBs. The DFS did not over- or underestimate the amount of PCB in the river relative to other studies. Therefore conclusions in the DFS relating to these numbers were reliable.

The second major issue dealt with public health concerns. Many commenters did not agree that the health impact associated with the PCB problem was limited, because previous reports had indicated that the presence of PCB-contaminated sediment created a potential for chronic exposures. The DFS attempted to assess the actual health impacts, rather than the potential impacts, by comparing environmental concentration data to Federal and State Health Standards criteria.

It was found that the PCB concentrations in Waterford, New York, drinking water did not exceed the State water quality standard of 1 µg/l (1 ppb) in more than 50 NYSDOH samples, nor did PCB concentrations approach the 0.80 µg/l concentration that is the EPA Ambient Water Quality Criteria. The evidence indicates that the incremental health risk to those consuming Waterford water may be very low, a conclusion which was also reached in recent reports by NYSDOH and the USGS.

It was also determined that concentrated terrestrial sources of PCB, such as remnant deposits and dumps, were sometimes associated with significant local concentrations of airborne PCBs. The health impact of these sources on receptors, however, is hard to delineate because the air samples were not taken near homes. It was determined that submerged sediments do not substantially affect air quality because only barely detectable levels of PCB were found near sources such as riffles and dams. It was recommended that additional air monitoring be done near home sites to confirm these conclusions.

It was also concluded that the only major health risk was posed by the potential consumption of PCB-contaminated fish. Although PCB concentrations have decreased significantly in all species that were studied, many individuals still contained in excess of the 5 ppm PCB limit set by the Food and Drug Administration. A continuation of State fishing restrictions and State advisories, however, will substantially lower the potential for contacting PCBs from this route. Similar restrictions would likely be required after any major remedial action.

From a health impact point-of-view, the data that were analyzed did not cover every possible pathway of exposure at every point on the river; however, the information that was examined was felt to represent the worst-case conditions that could occur any time in the future. However, the DFS suggested that further environmental testing, including drinking water, vegetation, air, and biota sampling, should be conducted to confirm these conclusions.

A third issue dealt with PCB transport. Many commenters felt that the draft study ignored the significance of the 20-year flow cycle which was included in the Lawler, Matusky, and Skelly (LMS) PCB *Transport Model*. The "20-year flow cycle" projected a period of increased PCB loads in the 1990's and has therefore led to the widespread notion that remedial actions should be expedited. For several reasons, however, the importance of the 20-year flow cycle may be overstated.

Because hydrologic systems are probabilistic, LMS used statistical means to verify the existence of the 20-year flow cycle, and the limitations of the statistical model should be recognized. First, because flow is probabilistic, high flows of concern to PCB transport can occur in any year. Secondly, the statistical regression model utilized monthly average data, whereas daily data would be more significant to PCB transport. Thirdly, only 48 years of data went into the model; therefore, only two "samples" of the 20-year flow cycle were available. Fourthly, the statistical regression model had a final r^2 value of 0.508, which is not particularly high and indicates that only 50.8 percent of the variation in monthly data was accounted for by the 20-year flow cycle. Finally, it should be recognized that the actual input to the PCB transport model was the flow record for the past 20 years. Although in some instances this is an acceptable technique, it introduces a degree of misrepresentation since past flows will never be exactly duplicated in the future. The degree of uncertainty which this introduced was never stated.

It should be recalled that the model evaluation demonstrated that the PCB transport model greatly overestimated the transport of PCB during high-flow periods. This pattern seems to be corroborated by recent estimates of annual PCB transport rates which are, on the average, nearly 2,000 pounds per year less than the model estimates for similar average annual flows. This means that PCB transport (and presumably PCB concentrations) will not be as high as the model projects if high flows do occur at the end of the 20-year cycle.

It should also be noted that many conclusions drawn from the LMS model were based on the projected average 20-year transport rate of 7,200 pounds per year. This projection may be too high since recent transport rates, estimated from measured data, are on the order of 1,500 to 2,500 pounds per year.

A fourth issue also concerned the PCB transport model evaluation. Many reviewers felt that certain conclusions of the model evaluation presented the most convincing arguments to date for the reduced-scale (Thompson Island pool) dredging program. This sentiment is linked to speculations in the model evaluation which suggested that most of the PCB-contaminated sediment passing into the lower Hudson River originated in the Thompson Island pool.

The authors agree that this hypothesis has merit. However, it should be noted that although the hypothesis appears to be consistent with the historical disturbances which have affected the Thompson Island pool (i.e., dam removal and subsequent deposition of large unstable sediment deposits), there is very little field data to confirm the hypothesis. Secondly, if the hypothesis is true, the recent historical trends in PCB transport would seem to indicate that the Thompson Island pool deposits are gradually returning to a stable, more natural state, and that the pool is progressively contributing lower amounts of PCB-contaminated sediment.

This thinking also appears to ignore the origin and transport of dissolved PCBs, and their possible contributions to the overall PCB problem. Dissolved PCBs will not be completely filtered from drinking water by normal treatment, and some authors have speculated that it is the dissolved PCB component which plays the most important role in the contamination of the fishery. Dissolved PCBs are also an important prerequisite for volatilization and atmospheric transport. PCB desorption and subsequent transport is not under the control of river flows. Thus it may be a mistake to conclude that removal of the most unstable deposits would correct even a substantial portion of the overall PCB problem. Even after a large-scale dredging project, large areas of the river would remain contaminated and capable of releasing dissolved PCBs.

As a final issue, the largest number of comments expressed the concern that the matrix analysis, as it originally appeared in the Draft Feasibility Study, gave an undue weight to costs; thus it was believed that the method did not conform to the cost-effectiveness directive of CERCLA. After consideration of the comments and careful evaluation of the cost-effectiveness methodology, the matrix analysis was redesigned to give roughly equal weights to cost and effectiveness ratings. This was done by giving the costs a relative numerical ranking to be used in the matrix analysis rather than the actual dollar value. Cost ratings were expressed on a scale of 1.0 to 2.0; a 1.0 corresponded to zero cost while a 2.0 corresponded to the highest single cost in the analysis. This change brought the range in cost variation more in line with the range of effectiveness rating variations.

However, despite these changes certain inherent flaws remained in the matrix that did not fully conform to the cost effectiveness requirements of CERCLA. Therefore, EPA based its decision-making process on the subjective analysis of the effectiveness factors required by CERCLA. The results of the revised matrix were used as one of several inputs to this decision making process. This process is described at length in the Record of Decision (ROD).

INTRODUCTION

The purpose of this Document is to respond to comments received from public, governmental, and other organizations on the Hudson River PCBs Site Draft Feasibility Study (DFS) issued on October 5, 1983. Initially, the public review deadline was October 31, 1983. Two public meetings were held on November 3, 1983, and the public review deadline was then extended to November 30, 1983.

Comments have either been addressed in the Response to Comments Report (Volume II) or through changes incorporated directly into the Final Feasibility Study Report (Volume I). Any major revisions have been incorporated into the Feasibility Study Report. Most minor additions and revisions have been discussed in the Response to Comments Report.

Although the responsiveness summary is predominately a collection of comments on the Draft Feasibility Study and corresponding responses, a number of revisions to this document, have been made by EPA in order to ensure its consistency with the final Record of Decision.

Revisions made in the Feasibility Study included changes in the cost-effectiveness methodology. Corresponding results were included in Section 9. Revisions in the recommended remedial actions were incorporated into Section 10. Comments addressed by the Response to Comments Report are presented in the following sections. Section G.0 contains responses to general comments that were not referenced to a specific passage in the text or related to one specific issue. Section ES.0 contains responses to specific comments on passages in the Executive Summary. Sections 1.0 to 10.0 contain responses to comments on specific issues related to the topics covered by the corresponding sections in the Draft Feasibility Study. Sections A.0 through E.0 are responses to comments on the references and appendix A, B, C, D, and E of the Draft Feasibility Study.

In the Response to Comments Report, the comments were addressed on a section-by-section basis; general comments were addressed first, followed by comments that pertained to particular paragraphs or sentences. The exception to this was the comments for Section 4, which were organized on a topic-by-topic basis. When a comment was addressing a specific passage in the Draft Report, the appropriate passage was noted next to the comment in the following format:

(page no.; paragraph no.; line no.).

G.0 GENERAL COMMENTS

G.1 COMMENT:

With respect to the Port of New York issue, it is totally inaccurate and misleading to imply that the failure to implement the PCB Dredging Project will in any way threaten the New York harbor or impede the recovery of a national waterway. According to a 1982 report by the National Oceanic and Atmospheric Administration (NOAA) PCBs from the hotspots in the upper river are a relatively minor contribution to the harbor sediment compared to PCBs from other sources. The NOAA report concluded that, given the restraints under section 116 of the Clean Water Act, the project will not demonstrate a recovery of a national waterway or alter the concentrations of PCBs in the New York harbor sediments.

Gerald B. Solomon, Congressman, New York State

RESPONSE:

The authors agree with the basis of the comment. However, the cited report does not appear to indicate that the PCB contribution of the Hudson River to the estuary is minor. The report referred to is believed to be "Contaminant Inputs to the Hudson-Raritan Estuary" by James A. Mueller and others. The report concludes that nearly 40 percent of the PCB input to the estuary is from the Hudson River. Other major sources included municipal wastewater and atmospheric inputs. However, this report was based on data from 1977-78 during which time PCB transport was much higher than it is today.

G.2 COMMENT:

On April 21, 1982, the Greene County Legislature approved a resolution expressing their concern that the PCB proposal to expend over $25 million for dredging less than 25 percent of the PCBs deposited in the river will result in the stirring up of otherwise dormant chemicals into the water column of the river. Their resolution, approved 12 to 0, states that the dredging may jeopardize the drinking water in localities along the Hudson River.

Gerald B. Solomon, Congressman, New York State.

RESPONSE:

The comment is supportive of the conclusions of the DFS and the authors agree to some extent with the comment.

G.3 COMMENT:

My primary concern with respect to the project has always been the health of the people I represent in the Hudson Valley. I believe that all necessary steps should be taken to limit the contact of PCBs to the public. I am pleased that the Feasibility Study has recommended the monitoring of PCB concentrations in fish and river water, and in drinking water supplied from the Hudson River. I have said for several years that the construction of activated carbon filtration systems designed to filter all forms of hydrocarbons such as PCBs and heavy metals from drinking water would be a much wiser expenditure of federal funds from a health perspective. If the monitoring of drinking water indicates a threat from PCBs, I will take action in Congress to approve funding for the construction of these systems.

Gerald B. Solomon, Congressman, New York State.

RESPONSE:

The final report recommends that a treatability study be conducted at Waterford. The treatability study will access the need for protective measures and the level of protection that could be achieved by various alternative measures.

G.4 COMMENT:

On April 28, 1982, the Saratogian newspaper stated, "Not only would the huge PCB dump pose a potential hazard to farmers and residents but it would likely lead to prolonged and costly lawsuits down the road if farmers seek restitution of damaged crops or milking cows contaminated by the toxic waste. The plan to dump the PCBs in this area is extremely ill-advised and goes directly against the wishes of the people who will have to live with it."

Gerald B. Solomon, Congressman, New York State.

RESPONSE:

No response is needed.

G.5 COMMENT:

We are pleased that critical questions about many aspects of the PCB problem finally are being asked. Prior to release of the Draft Feasibility Study, these questions, or issues, received only cursory attention, particularly at the state level. New York Farm Bureau supports the contention of the Draft Feasibility Study that a number of these important issues would have to be resolved before further consideration can be given to a remedial dredging alternative.

Jack Hughes, Senior Associate Director of Governmental Relations, New York Farm Bureau.

RESPONSE:

No response is needed.

G.6 COMMENT:

I would also like to comment briefly on the public concern which has been raised with respect to Section 113 [sic] of the Clean Water Act. In a letter to EPA, the President of the New York State Farm Bureau expressed a strong opposition of the Farm Bureau to the PCB Demonstration Project. His letter states, "The recommendations, which were not supported by all members of the PCB study committee, have met violent local opposition. All local legislative bodies, town, municipal and county, have publicly opposed the project as well as citizen groups and the farm community through their Farm Bureau organizations."

Gerald B. Solomon, Congressman, New York State.

RESPONSE:

No response is needed.

G.7 COMMENT:

In light of the conclusion reached by the feasibility study, that the PCB dredging project not be carried out, I have requested that the Administrator of the U. S. Environmental Protection Agency to justify his decision to possibly consider the dredging project.

I expect the Administrator will base his decision on the law and legal opinion of the Environmental Protection Agency. Concerning the existing law I would like to emphasize that the Administrator should carefully review my amendment to Section 116 of the Clean Water Act. This amendment states that no pollutants shall be placed in any landfill unless the Administrator first determines that disposal of the pollutants in such landfill would provide a higher standard of protection of the public health, safety and welfare than disposal of such pollutants by any other method including but not limited to, incineration or a chemical destruction process. My amendment should be considered in relationship to the findings on page ES-10, of the Feasibility Study which states, "...the limited threat to the public health does not justify the large expenditure of money required to remove a portion of the contaminated sediment." As an author of Section 116 I believe that approval of the project would clearly violate the Congressional intent of the Act.

Gerald B. Solomon, Congressman, New York State.

RESPONSE:

On May 10, 1984, EPA entered into a settlement agreement with New York State and other plaintiffs. Under the terms of the agreement, EPA will make a grant to New York State of approximately $18 million for dredging and disposal of PCBs, if the State obtains an acceptable disposal site with all necessary State and Federal permits within three years.

G.8 COMMENT:

We need to clarify the period of time for which money from CERCLA will be made available for sampling.

Division of Solid and Hazardous Waste, NYSDEC.

RESPONSE:

CERCLA funding will be available for evaluating the Waterford water supply and for pre-design studies at the remnant sites.

CERCLA funding will not be available for monitoring fish and air contamination or for river sediment sampling. However, Section 116 funds will be made available for this work.

G.9 COMMENT:

Significant conclusions, such as the amounts of PCBs in the river from past G.E. discharges being much greater than previously estimated, are made in one section of the RAMP and then ignored throughout the rest of the document.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

This was not a conclusion of the DFS. There is no reliable way to determine the over or underestimation of PCB mass. It was speculated that because of the sampling methodology, some hotspots may have been missed while others may have contained large amounts of sediment with less than 50 ppb PCB.

G.10 COMMENT:

Underscored also in this example is the RAMP's pattern of turning arguments and data upside down so that assumptions made earlier in the text are contradicted later on. Certainly the understatement of total pounds in the river is a good example of this kind of confusion. Similarly, if sediment-pass-through is a correct interpretation of PCB transport, then dredging the hot spots farthest north would be the most-effective way to remove the contaminated spoil. Yet that was not a conclusion reached in the RAMP.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The amount of PCBs in the river is not understated. There is approximately 497,520 to 653,000 pounds of PCB in remnant deposits and in Upper and Lower Hudson River sediments. What was understated was the amount of PCB associated with the General Electric Plants. There may well be from 1.5 to 1.8 million pounds of PCBs throughout the basin in dredge spoils and dumps as well as in the river. See the Response to Comment 2.1 for a further discussion.

The pass-through model suggests that most of the suspended, PCB-laden sediment getting into the water column comes from the bed sediments north of Thompson Island Dam. However the model evaluation also concluded that there was insufficient information on suspended sediment and PCB transport south of Thompson Island Dam to confirm this conclusion. See Comment 4.5.2 for further discussion on this point.

G.11 COMMENT:

There also appears to be several erroneous assumptions used throughout the RAMP which are not justified by the facts:

— Not enough is known about the PCB contamination problem to do anything. (Careful studies, data collection and review, have been ongoing since 1977, and all indicate a serious problem and the need for immediate remedial action.)

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

There is a wealth of information on the Hudson River PCB problem. Earlier studies found a large amount of PCB in the sediments of the Hudson River and cited the potential for chronic exposures as the cause for immediate remedial actions. Six years after the initiation of studies, the existing information indicates that the resulting health impacts are lower and that the terrestrial and aquitic ecosystems are recovering on their own. A level of risk continues to exist, however, it should be realized that some level of risk will continue to exist with or without a partial dredging option.

G.12 COMMENT:

There also appears to be several erroneous assumptions used throughout the RAMP which are not justified by the facts:

— Only the upper Hudson River is a site of concern for PCB contamination. (The river dynamics are moving and dispersing PCBs throughout the estuary into New York Harbor. The dispersal and its continued impacts on down river drinking water supplies, the fishery and dredge spoil disposal options is ignored.)

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

It is recognized that the Hudson River PCB problem affects the environment all along the river from Fort Edward to the New York Bight and beyond. However, the DFS was limited to addressing the most pressing issues connected with PCBs in the Upper Hudson River. These issues included the health impacts of PCBs in air, water, and biota, and the transport of PCB to the estuary. Because of time constraints, issues such as those concerning other pollutants, the effects of PCB on downstream water supplies, harbor maintenance, and power generation were addressed but not at the level of discussion that the DFS authors would have liked. However, because the present potential level of impact on the Upper Hudson River would not likely be exceeded elsewhere on the river, it is believed that more discussion would not change the basic conclusions reached.

G.13 COMMENT:

Ignores its own conclusions regarding the seriousness of PCB exposure and human health effects.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Refer to the responses to comments in Section 5 for discussion on the health effects of PCB in the Hudson River.

G.14 COMMENT:

Ignores long-term PCB pollution and the effects on the Hudson River water supplies, aquatic environment, commercial shipping interests, mandated dredging programs and waterfront revitalization projects.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The DFS concluded that the impact on the Waterford water supply system, which is most susceptible to PCB problems because of its proximity to the source of PCB, is minimal (see responses in Section 5).

The damage to the aquatic environment, as indicated by PCB contamination in fish, was found to be decreasing with time (see responses in Section 4).

Commercial shipping and dredging interests are not at risk because the rate of migration of PCB is decreasing with time and maintenance dredging will not often involve sediments greater than 1 ppm in PCB concentration (see responses to comments in Section 4).

G.15 COMMENT:

The recommended alternative of "no action except water treatment," is chosen when the costs of doing almost nothing are compared to those of removing the 40 hot spots in the upper Hudson. We contend that the limited ability of the recommended alternative for river sediments does not meet the overall goals of CERCLA to protect public health, welfare and the environment.

- *Most importantly, in the preamble to the CERCLA regulations, EPA requires;*

"...comparative assessment of alternatives in terms of their effectiveness in minimizing and mitigating the health or environmental problem. This assessment is essential, along with consideration of cost and engineering reliability, in making the decision required by Sec. 300.88(j). The final decision on the appropriate alternative is based on cost-effectiveness; it selects the lowest cost alternative which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare and the environment (Sec. 300.88(j)). EPA notes that this series of analyses and check points explicitly requires remedies that provide the requisite protection of public health while still meeting statutory requirements for analysis of costs and cost-effectiveness. Cost alone may not control these decisions."

In general, however, the RAMP demonstrates the absurdity of the Superfund cost-effectiveness matrix analysis process in comparison with a common-sense approach to solving a serious, urgent contamination problem.

We contend that the recommended alternative for river sediments does not meet the goals of CERCLA, and, therefore, should not be considered a viable alternative under Superfund.

A cost-effectiveness alternative is defined in the regulations as one that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment" (40 CFR 300.68(j), emphasis added).

Only alternatives which meet the criteria are to be evaluated for cost-effectiveness. Although a no-action alternative may be included, it is appropriate "when a response action may cause a greater environmental or health danger than no action." Clearly not the case here.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

These statements, taken from the document submitted by the commentor, essentially present the major arguments opposing the conclusions reached by the DFS. In many ways, all other responses to comments address this argument directly or indirectly.

The major objective of this study was to evaluate remedial alternatives using a cost-effectiveness approach consistent with the goals and objectives of CERCLA. A cost-effective remedial alternative is defined in the National Contingency Plan (NCP) (40 CFR 300.68J) as "...the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or environment." The NCP outlines procedures and criteria to be used in selecting the most cost-effective alternative.

The first step is to evaluate public health and environmental effects and welfare concerns connected with the problem. Criteria to be considered are outlined in Section 300.68(e) of the NCP and include such factors as actual or potential direct contact with hazardous material, degree of contamination of drinking water, and extent of isolation and/or migration of the contaminant and so on.

The next step is to develop a limited list of possible remedial actions that could be used. The no-remedial-action alternative may be included on the list.

The third step in the process is to provide an initial screening of remaining alternatives. The costs, possible adverse effects, relative effectiveness in minimizing threats, and reliability of the methods are reviewed here. The no-action alternative may be included for further evaluation when response actions may cause greater environmental or health damage than no-action responses. No-action alternatives may also be included if they are appropriate relative to the extent of the existing threat or if response actions provide no greater protection.

The next step is a detailed analysis of alternatives. This analysis requires a more detailed estimation of costs and engineering implementation and a closer assessment of the ability of alternatives to minimize or mitigate threats. In this study, the detailed analysis was aided by a cost effectiveness-matrix that was developed by independent consultants under the direction of EPA.

The final step requires that the lead agency evaluate the cost-effectiveness of the selected response actions against the need to respond to problems with hazardous materials at other sites. Thus, the fund-balancing theme of the NCP generally allows only for the implementation of proven technologies which can be shown to demonstrate a level of protection that is greater than under existing conditions.

The results of the aforementioned steps were used to arrive at the recommended alternative. The results of the cost effectiveness matrix were used solely as an aid to this decision making process. As is explained in the ROD, EPA's final decision to select the no-action alternative was based not on the fact that it was the cost effective option; rather EPA determined that none of the options evaluated were considered to present a reliable and effective means of removing highly-contaminated PCB sediment from the river bed.

G.16 COMMENT:

The concentration of this study solely on PCBs is, to say the least, myopic in light of the almost 2,000 chemicals now found in the River. The study must take into account a broader perspective or the results will be worthless because of the artificially limited parameters of the task.

Paul A. Rickard, Spokesman, Citizens for Safe Water

RESPONSE:

The primary objective of this study was to reevaluate the Hudson River PCB problem under the criteria and goals of CERCLA as set forth in the National Contingency Plan. Time constraints did not permit the accumulation and evaluation of information pertaining to the various other chemicals reported to be in the river.

The extent and impact of these contaminants is unknown and a health risk assessment needs to be done. These issues may be more appropriately addressed under another project or perhaps under the statutes of The Clean Water Act.

G.17 COMMENT:

This plan is not adequate to the tasks. It is based upon minimizing costs, not maximizing benefits or protecting the well being of citizens now using the river as a drinking water source. Only a complete removal program and wide spectrum chemical testing will actually affect the deposits and provide the information needed to measure the impact of river water on our health.

At a minimum, EPA should use its funding to construct the pipeline necessary for Waterford to obtain water from the City of Troy. At least then it will have obviated part of the problem.

Paul A. Rickard, Spokesman, Citizens for Safe Water.

RESPONSE:

It has been shown by this and other studies that complete bank-to-bank removal of contaminated sediments is not feasible because of the sheer volume of material that would have to be dealt with, and the amount of environmental damage that would result.

Existing information, limited as it is, indicates a minimal health risk associated with PCBs in Waterford drinking water. Additional monitoring at Waterford and at other water supplies should be conducted to confirm this conclusion. Task 10 of the proposed Remedial Investigation was recommended to provide information on the ability of existing water supplies to meet public health standards. Expanding the task to monitor for other toxics is a worthwhile proposal which will likely be incorporated into the final sampling plan. In the final report, it will be recommended that a treatability study be conducted at Waterford to determine whether or not the water supply will have to be replaced if it is found that the existing system cannot meet public health standards.

G.18 **COMMENT: (General)**

For several years, I have asserted that dredging and landfilling PCB contaminated material is the wrong solution and I am pleased that the Feasibility Study on the PCB Hudson River Site supports my position.

...My primary concern with respect to the project has always been the health of the people I represent in the Hudson Valley. I believe that all necessary steps should be taken to limit the contact of PCBs to the public. I am pleased that the Feasibility Study has recommended the monitoring of PCB concentrations in fish and river water, and in drinking water supplied from the Hudson River. I have said for several years that the construction of activated carbon filtration systems designed to filter all forms of hydrocarbons such as PCBs and heavy metals from drinking water would be a much wiser expenditure of federal funds from a health perspective. If the monitoring of drinking water indicates a threat from PCBs I will take action in Congress to approve funding for the construction of these systems.

...The beauty and purity of the Hudson River, one of our greatest river systems, must be restored. I favor efforts to renew the river but not at the expense of the agricultural base of the region or at the expense of the health of the people I represent.

The Feasibility Study, intended to provide EPA with a scientific basis to decide future actions on the Hudson River, has recommended the dredging and landfilling scheme not be carried out. It is the responsibility of the Environmental Protection Agency to base their final determination on the Feasibility Study on the Hudson River PCBs Site in accordance with the laws of the United States.

Gerald B. Solomon, Congressman, New York.

RESPONSE:

No response is needed.

G.19 **COMMENT:**

The conclusion of the Executive Summary of the NUS Project Number 0723.01, dated September 1983, is well founded on the previous documentation and the lack of current data availability of hot spot migration. As a river resident of Hot Spot #8, I feel the conclusion of this document to be most viable. Certainly the remnant deposits must be covered and stabilized as soon as possible. Additionally, consideration must be given to activated carbon filtration systems for communities which draw their drinking water from the Hudson.
Karen Scelzi, Secretary, CEASE.

RESPONSE:

No response is needed.

G.20 COMMENT:

We believe the Report is a comprehensive and relatively well-conducted analysis of the alternatives available for PCB clean-up in the Hudson River. We concur with many of its criticisms of earlier attempts to understand the extent of PCB contamination of the Hudson River and the mode of movement of sediments and PCB load. However, the final conclusion of the Report for a preferred "no-action" alternative is entirely unjustified by the earlier conclusions of the Report. We strongly urge that EPA take the inconsistencies of the technical conclusions with the summary recommendations and the fundamental methodological flaws of the matrix analysis into account in the preparation of the final report.

A. Karim Ahmed, Senior Staff
Senior Staff Scientist, National Resources Defense Council, Inc.

RESPONSE:

The DFS authors believe the final conclusions of the report are justified by the findings in earlier sections. The authors also recognize the inconsistencies and problems associated with the matrix approach in the DFS. The matrix has been modified. In addition, the Agency has determined that the selection of remedial alternatives should not be based primarily on a matrix analysis, although where matrixes are developed the results may be considered in remedial selection.

G.21 COMMENT:

The New York Farm Bureau has been involved actively in the review process of the proposed Hudson River PCB Reclamation Demonstration Project from the beginning. It remains our contention that the risks to the environment, including agricultural resources, as a result of dredging and encapsulation are greater than the very limited environmental and public health benefits. Any dredging plan, in our view, must include immediate detoxification of dredged sediments.

We are pleased that critical questions about many aspects of the PCB problem finally are being asked. Prior to release of the Draft Feasibility Study, these questions, or issues, received only cursory attention, particularly at the state level. New York Farm Bureau supports the contention of the Draft Feasibility Study that a number of these important issues would have to be resolved before further consideration can be given to a remedial dredging alternative.

New York Farm Bureau holds that the most reasonable conclusion to draw in considering the Hudson River PCB problem, is that the very limited public health benefits associated with remedial dredging do not warrant the expenditure of a minimum of 34 million dollars. Further, there are immediate and long term risks associated with dredging and little or no evidence of any adverse public health impact if dredging is not done.

Jack Hughes, Senior Associate Director of Governmental Relations, New York Farm Bureau.

RESPONSE:

No response is needed.

G.22 COMMENT:

We found that the document adequately consolidates the available information on the PCB problem in the Hudson River. We cannot say that it draws consistent or entirely useful conclusions from the scientific data. It is most important, in our view, that remedial action control the hot spots of the upper Hudson before the high flow cycle of the river returns. The low-flow years have bought us the time to consider our actions. Now we must act promptly.

Scenic Hudson.

RESPONSE:

The question of the 20-year flow cycle raises a crucial issue. The importance of the 20-year flow cycle may have been overstated, however. In the first place, the flow cycle was incorporated into the model on statistical evidence, and there are limitations to the statistical model that must be realized. In the second place, the model appears to greatly exaggerate the importance of high flows in sediment transport. Hence PCB-contaminated sediment transport in the high flow years may not be as significant as the model projects. These issues are addressed in detail in Section 4 under Comments 4.5.1 and 4.5.2.

G.23 COMMENT:

I have read this document carefully and find that it is in general a remarkably good synthesis of all the information that has been assembled about the PCB-pollution problem of the Hudson River.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

No response is needed.

G.24 COMMENT:

My biggest suggestion is that no final conclusions about the status of the river with respect to CERCLA should be made until the many important unknown issues raised by NUS in the RAMP have been settled, particularly the one dealing with the nature of the suspensions and the LMS model study. If NUS is correct, as they may be, then the whole basis for evaluating the impact of the proposed hot-spot program needs to be revised; the answer may be 100 percent instead of 30 percent or whatever. This point is so fundamental that I do not comprehend how any matrix games could have been played without having the correct information.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The "pass-through" model is addressed at length in the response to comment 4.5.3. In this discussion, it is pointed out that it cannot be concluded that the deposits in Thompson Island pool contribute 100 percent of the PCB problem. It is also suggested that it would be a mistake to base decisions on the suspended sediment issue alone because from a health impact point of view, it is the dissolved PCB, not the transport of PCB by sediments, that potentially presents the most problems. The DFS finds that the low health risk involved with the problem, and the limited benefit of dredging in combination with the large costs are sufficient reason to formulate a decision under CERCLA.

ES.0 COMMENTS ON EXECUTIVE SUMMARY

ES.1 COMMENT: (ES-2;2;1)

The use of only G.E. company records as estimates of PCBs discharged into the Hudson over a 30 year period is a poor basis for evaluating the problem. Instead of 500,000 pounds given here, conservative estimates of the discharges are over 1 million pounds. RAMP tables in Sections 2 & 4 also show much higher figures for total pounds.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

Similar comments made by: John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Many commentors questioned the PCB mass estimates given by the DFS. Because of the variation in the PCB tabulations in the existing literature, the DFS utilized very generalized estimates that were in some cases inaccurate. Estimates given by various authors were reexamined and a new mass balance table was prepared to replace Table 2-1. The new table may be found on page 2-2. This table is much more precise in its statement of PCB mass estimates than the one it replaced. However, it should be noted that the most crucial estimates, namely, the tabulations giving total pounds of PCB for the Upper Hudson River and the pounds of PCB in hot spots, are comparable within ± 5,000 pounds. This difference is insignificant in relation to the total PCB mass. Therefore the conclusions reached in the DFS are consistent with the numbers. What was mistated in the DFS was the implication that General Electric discharged about 500,000 pounds of PCB. When all estimates of PCB associated with GE are tallied, the PCB mass is well over 1.4 million pounds. What was of most concern to the DFS was the approximately 500,000 pounds (497,520 to 653,000) of PCB that was directly in contact with the river. This issue is discussed at length in comment 2.1.

ES.2 COMMENT: (ES-5;2;3)

The statement "little additional data on PCB distribution in sediments has been accumulated since 1978" is inaccurate. Much study of downstream transport has been conducted by Richard Bopp, the Corps of Engineers, and USGS, and is cited in the RAMP's reference section.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

Remedial activities would be directed towards sediments in the Upper Hudson River. Practically everything that is known about the distribution and transport of PCB in the Upper Hudson River stems from studies initiated by the DEC Hudson River PCB Settlement Agreement. The majority of these studies were concluded in 1978. Little additional data on the distribution of PCB in Upper Hudson River sediments, to which remedial activities would be directed, has been accumulated since then.

ES.3 COMMENT: (ES-7;1)

1,200 samples may not be as many as everyone would want but re-evaluate this paragraph in light of the money and facilities available for this work at the time it was done. How many would be enough - 2,000, 5,000?

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

Similar comment made by: John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Given the variability of the medium and the size and complexity of the contaminated system, 1200 sediment samples and 700 PCB analyses may be insufficient. The statistical properties of PCB distributions in sediment are not developed enough to allow the determination of how many and where samples should be taken. The present data base is, however, an excellent starting point. Appendix D of the DFS outlines a preliminary sampling program that suggests ways in which samples could be collected to facilitate the answering of these questions.

ES.4 COMMENT: (ES-7;2)

What are the questions regarding '77 analysis in 1983?

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The present understanding of PCB distributions in submerged sediment comes from a single comprehensive analytical survey completed in 1977 and 1978. This survey consisted of approximately 700 PCB analyses from 1200 core and grab samples taken along cross-river transects which were spaced a minimum of 700 feet apart in the Thompson Island pool and further apart south of the Thompson Island Dam.

This data base has several serious problems. One problem concerns the variability of PCB contamination on the river bottom and the accuracy of hot-spot delineation. Measured PCB concentrations varied widely within short distances, exhibiting almost no regionalized trends. Very high PCB concentrations were found adjacent to and in the same hot spot with concentrations less than 50 ppm. This may indicate that hot spots are actually very localized phenomena consisting of contaminated sediments which have settled in small depressions and pockets in the river bottom. In some cases, hot-spot delineations have been based on one or two high concentration samples, and intuitive assumptions on sediment deposits, particle size distribution, and river hydrology. There is a distinct possibility that delineated hot spots contain extensive areas of sediments containing less than 50 ppm of PCB. If this is the case, then PCB mass estimates based on hot-spot area and average concentrations may be low and extremely misleading.

A more serious implication of this problem is that many small, localized hot spots may have been missed by the survey. In looking at the original survey data, about a dozen PCB concentration values that could have been included in hot spots were not. The sampling density for the 5-mile stretch of the river above the Thompson Island Dam is low and it decreases as the distance downstream from the Fort Edward Dam increases. A 1983 aerial survey revealed many shallow areas, which could contain hot spots, that had not been heavily sampled. The possibility is great that a substantial amount of high-concentration sediments was missed while high volumes of low-concentration sediments were included in hot spots. If such areas exist they may never be found, and dredging known hot spots would not reduce the problem as much as expected.

Another problem with the survey concerns the dynamic nature of the river system and the age of the survey. A certain amount of sediment reworking is expected over the 5 years since the survey was completed, especially with the occurrence of an 80-year return period flood in May 1983. The amount of sediment reworking and shifting in individual pools is completely unknown. Many of the more extensive contaminated deposits, especially those in the Thompson Island pool, appear to be located in unprotected high-velocity areas where flow velocities may be sufficient to cause scouring.

A third problem concerns the quality of PCB analyses performed on the sediments. Even today, PCB quantification is a difficult process subject to a high degree of error. Some of the analytical methods used by the original contractors may have been faulty since information in some NYSDEC publications shows that ratios of the results of some duplicate samples were at least 1 to 3. The analytical error is a source of variation that adds to the uncertainty about the amount and concentration of PCBs in delineated hot spots.

Many of these problems were recognized by State officials, which is why they had proposed an extensive sampling survey prior to the implementation of a dredging program. However, it must be pointed out that PCB mass estimates, cleanup operations, and most other conclusions are based on hot-spot delineations and sediment PCB data, that had a significant amount of uncertainty associated with it in 1977. These data are even more uncertain in 1983.

E.5 COMMENT: (ES-1;1;2) (ES-8;1;3-5) (ES-10;2)

...you write: "Before any action is taken on this project, it is essential that a new and more complete series of PCB analyses in the river be taken so that an accurate knowledge of quantities and locations can be obtained." A very admirable sentiment, but one full of contradictions. What do you mean by "action"? Making decisions? You already made a decision without following your own advice (p. ES-9, par. 2, 1-5). What is going on? In the step-one grant that EPA pulled back funds from, funds were available to carry out much more sampling and analyses. Who is going to pay for what you decree must be done? Is this sampling to be done before the CERCLA decision is to be finalized? Surely you can do your readers more justice than write sentences such as this one. Does your recommendation imply that EPA through CERCLA will tend to all this sampling before they decide the river's standing under CERCLA?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

Similar comments made by: Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The possibility of implementing a demonstration project under Section 116 of CWA still exists. However, any type of remedial design work would require more information than is now available. This was as evident in 1978, when the State proposed extensive pre-dredging sampling, as it is today. In addition the DFS has raised questions as to the underlying assumptions, objectives, and effectiveness of a dredging option. It is strongly urged that if an appropriate agency is to pursue this option, that the pre-design studies be directed towards answering these questions and assessing whether or not dredging is the best alternative.

CERCLA will not fund additional sediment sampling. Funds for this purpose were made available through Section 116 of the Clean Water Act.

ES.6 COMMENT: (ES-10;1;6-8)

There is no evidence in the RAMP or elsewhere which documents, even partially, the theory that cold spots are the present cause of PCB levels in the water column. The theory does not, as implied here, detract from the need to remove heavily contaminated spoils subject to erosion from the river bed.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

There is no evidence to document the theory that hot spots are the present cause of PCB levels in the water column. If the relationships of earlier studies are to be believed, hot spots are the areas least susceptible to scouring. Such thinking also ignores the origin of dissolved PCBs and their possible contribution to the overall PCB problem. At the low and average flows, the majority of environmental PCB is dissolved and remains unassociated with the suspended-sediment load. Dissolved PCBs cannot be completely filtered out of drinking water by normal treatment. Some authors have speculated that dissolved PCB, being the most prevalent form of PCB during the most frequent flows, plays the most important role in the contamination of the fishery. Dissolved PCBs are also a prerequisite for volatilization and atmospheric transport. Since dissolved PCB could be released from lesser contaminated cold areas as well as hot spots, the origin of the desorbed component is not really known. Thus, it may be a mistake to conclude that the removal of a relatively small area of the river bottom (i.e., hot spots) would correct even a substantial portion of the overall PCB problem. After such an action, large areas of the river would remain contaminated and the dissolved PCB concentration of the water column may not change. It is suggested that such questions be answered satisfactorily before any further action is decided upon.

ES.7 COMMENT: (ES-4;3;1) (ES-6;2;5-9) (ES-7;5;2)

Your comments about the LMS model: first of all, you have evidently failed to comprehend the clear story about the 20-year flow cycle that is in the model. Secondly, if your analysis is correct that the sediments scoured above Thompson Island dam pass through, then you have made the most-telling argument yet in favor of doing this project, because it would then make a total cleanup and ought to be recorded accordingly in your "cost-effectiveness" matrix hocus pocus. More on this later.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

Similar comments made by: Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The 20-year flow cycle was apparently incorporated into the model as a convenient time period for projecting model results. The 20-year flow pattern was idantified on the basis of statistical evidence, and its validity must be considered in relation to the limitations of the statistical analysis. For example, based on the analysis of only 48 years of data, the LMS model indicates a tendency for high flows to occur at 20-year intervals. However, since runoff events are associated with a component of random variation, high flows can occur at any time. More importantly, the inherent inadequacies of the model (e.g., overestimation of PCB transport during high flows) largely overstate the importance of the 20-year flow cycle.

The "pass-through" model of the DFS suggests that most of the suspended, PCB-laden sediment comes from bed sediments north of the Thompson Island Dam. However, the model evaluation also concluded that there was insufficient information on suspended sediment and PCB transport south of the dam to confirm this conclusion. In any event, the origin of suspended sediment alone may be a poor basis for making decisions since it is the dissolved PCB, which is not controlled by river flows, that could present the most serious problems. This is because dissolved PCB cannot be filtered out and it is the most prevalent form of PCB on most days.

These issues are addressed at length in the responses to comments 4.5.1 and 4.5.2.

ES.8 COMMENT: (ES-5;2;5)

"Desorbed" form is probably misleading; they are by definition "dissolved," and probably have been desorbed out of sediments, but that is only an inference not yet fully substantiated.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The form of, and the mechanisms involved with "dissolved" PCB are only speculation at this point. A recent study by the USGS (Schroeder and Barnes, 1983B) states that laboratory studies suggest that simple molecular diffusion of PCB across the sediment-water interface does not occur. Instead dissolved PCB transport is accomplished by gas bubbles generated by microorganisms in anaerobic sediments and by bioturbation caused by macroorganisms in aerobic sediments.

ES.9 COMMENT: (ES-6;6;5-9)

The LMS sediment-transport model, critiqued by the RAMP, was used to predict the change in PCB-transport rate of various remedial actions. The new model concepts suggested in the RAMP are not used for new predictions of remedial action effectiveness. This is a gross oversight.

Hudson River Sloop, Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

New predictions, based on currently estimated PCB transport rates determined by Brown and Werner (1983) and Tofflemire (April 1983), were presented in Section 8 of the DFS on Pages 8-2 and 8-3. A discussion of these transport rates may be found under comments 2.2 and 4.5.1.

ES.10 COMMENT: (ES-6;1;7-8)

"It is not known whether PCB levels increase during and after periods of scour during large floods."

What are you trying to say here? All the data clearly show the connection between high discharge, high suspended sediment and high PCBs. Not known about where or in what?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

Similar Comment made by: Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

It is true that on an event-specific basis, total PCB concentrations increase with river flows. However recent studies show that the PCB loading rate expected at any given flow has been decreasing from year to year (Schroeder and Barnes, 1983). The question the DFS authors pose by stating "It is not known whether PCB levels increase after periods of scour..." is whether or not disturbances created by periods of abnormally high flows will reverse that decreasing trend. The existing information does not answer this question. The LMS PCB transport model suggested that such a scenario would occur in the future. Further discussion of this problem is presented in the response to comment 4.5.2.

ES.11 COMMENT: (ES-10;1;1-3)

The RAMP itself estimates up to 117 years (not 64 as stated here) for PCBs to be purged from the system without dredging.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The 117 years was projected under the "No Remedial Action-Discontinued Maintenance Dredging" Alternative. This alternative was considered to be infeasible in preliminary evaluations. The 64 years reported in the Executive Summary is for the "No Remedial Action-Continued Maintenance Dredging" Alternative.

ES.12 COMMENT: (ES-10;1;1) (ES-10;1;9-11)

Consistency problem again; you first destroy the LMS model and here you are using its projected time figures. You can't have it both ways! All these depletion figures are based on the notion that the river will totally erode by scour all the contaminated sediments. In contrast, you make a case for just the opposite, namely, that what's below Thompson Island Dam is going to stay where it is right now.

"The limited improvement which would result from the hot-spot dredging does not appear to justify the large expenditures of money required to accomplish it." Did some EPA reviewer insert this sentence? It is straight EPA "party-line dogma." You make such a fuss over wanting more data than are provided (notice use of data as a plural here--you could emulate such usage to your benefit by policing throughout for this) by 1200 cores, yet you parrot the LMS story after first showing that you do not really accept it. What is needed before such mighty pronouncements are made is a thorough understanding of how the upper Hudson River sediments respond to various flow situations.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Reference to Table 8-1, page 8-2 of the DFS reveals that the "46-year" and the "64-year" periods stated on page ES-10, represent the clean-up times developed in the DFS from currently estimated transport rates for the "No Remedial Action-Continued Maintenance Dredging" and the "Full-Scale Dredging" alternatives, respectively. These are not quotes from LMS model results. However, the commentor is correct in his assertion that these projections assume that all of the in-river PCB deposits will erode and that the assumption does not conform to the conceptual basis of the model evaluation. The model evaluation suggests that only a portion of the contaminated sediment may be susceptable to scour. Similar projections, assuming a constant PCB source equal to the total mass of PCB, were made by Lawler, Matusky, and Skelly (1979) and in the Draft Environmental Impact Statement. Projections such as these, however, imply a degree of predictability and understanding that does not really exist, and it is highly unlikely that PCB will be purged from the Upper Hudson in any of the time periods specified either in the DFS or in other studies. Table 8-1 was included to compare previous projections with projections based on recently accumulated data.

The DFS authors would not argue the need for a thorough understanding of how Upper Hudson River sediments react to environmental influences. However, previously proposed alternatives such as dredging do not meet the goals and criteria of CERCLA because it cannot be demonstrated, based on present understanding, that such actions will result in a higher level of public and environmental protection than that which now exists. In particular, the technology for dredging in this particular situation is of uncertain feasibility and effectiveness.

ES.13 COMMENT: (ES-8;3;8)

Many fish levels...found to exceed...5ppm. In fact, fish levels in the upper Hudson are very high. Similarly, marshland snapping turtles, for example, contain very high levels of PCBs and have been regular diet additions for many "river people" who look for such animals on a regular basis. [Kiviat-Studies at Tivoli Bays].

Hudson River Sloop Clearwater Inc., Poughkeepsie, New York.

RESPONSE:

It is obvious that PCB contamination exists throughout the food chains associated with the Hudson River. The PCB levels and trends in plants, aquatic macroinvertebrates, and fish were addressed at length in Section 4 of the DFS. Numerous sources reporting PCB levels in other segments of the food chain can be found. Published information on PCB content of some terrestrial and aquatic wildlife of the Hudson River can be found in the NYSDEC "Toxic Substances in Fish and Wildlife" publications series. NYSDEC Department of Hazardous Waste has accumulated some limited information on the PCB levels in mammals, birds, and amphibians residing in Moreau Marsh (Tofflemire, 1984). Other information is available according to the comment. It is recognized that not all available information was presented. It is believed that what was presented was adequate to describe the level of contamination and health risk that now exists.

At the present time, consumption of aquatic organisms potentially presents the greatest threat to the public health. However, it is believed that the present State-enforced restrictions on fishing as well as the advisories issued by the State, are the most cost-effective responses because such actions would likely be required regardless of the choice of clean-up options.

ES.14 COMMENT: (ES-9;1;11)

The statement "that some risk continues to exist at the current time" does not impart the serious health risk due to chronic exposure to PCBs which is a conclusion of the RAMP's Section 5.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Please see the response to the following comment.

ES.15 COMMENT: (ES-9;1;6)

"Some limited, more recent information which is available relative to the receptors, does indicate that the risks associated with the site have decreased." How limited? Which receptors? Where? Who determined the decrease in risk by using what formula? Statements such as the one quoted above are purposely vague, we suspect, in order to continue dragging out the whole remedial action review process.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Potential health impacts arise from PCBs that find their way into water, air, and biota of the Hudson River Basin. Data on PCB concentrations in ambient water, air, and biota were presented in Section 4 of the DFS. Tabulations of PCB data in drinking-water supplies were used in the evaluation but not presented in the DFS. These tabulations are now given in comment 4.3.1. To assess the health risk associated with the Hudson

River PCB problem, this information was compared to all available Federal and State recommended or legislated health standards criteria.

The most comprehensive information on PCBs that are known to actually reach the public-at-large is the PCB concentration data for the Waterford water supply. Data on PCBs in air were evaluated even though this information is source-oriented and not representative of what may be reaching receptors. It is known that PCB concentrations of fish flesh from the Hudson commonly exceed Federally-regulated health-limits; however it was assumed that the State-imposed bans and recommendations are an effective barrier to public contact while further study is conducted. Data on PCB in food stuffs produced in the region were not used because such information was inconclusive and not easy to assess.

The authors recognize that not every possible point-of-contact was considered and that present regulatory or recommended standards are based on information that is not yet completely comprehensive or conclusive. However, a complete and conclusive health-risk assessment of every possible pathway at every location along the affected area represents a research effort that is far beyond the scope of work for this project nor does it appear that such a study is warranted. It was believed that assessment of environmental contamination data for the Upper Hudson and examination of information on the Waterford water supply was sufficient to reach a conclusion under CERCLA because this material represents a worst-case risk that would not be exceeded elsewhere in the study area. The authors recommend that further monitoring be done to confirm such conclusions and to complete the health-risk assessment. The responses to comments in Section 5 will address concentrations and health standard factors in depth.

ES.16 COMMENT: (ES-9;2;20-0)

The statement that there is a limited threat to the public health is contradicted by the RAMP's own conclusions in Section 5. In addition, this statement assumes partial PCB-sediment removal based on low amounts of PCB's estimated as being in the river. If this figure changes, the effectiveness of dredging also changes. Most importantly, removal of the hot spots, although not the total problem, would mitigate exposure and...(written comment was not completed).

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Section 5 of the DFS concludes that there is a potential risk of chronic exposure to PCB but finds that the level of contamination described by existing data is low from a health-risk standpoint. This should not be confused with a situation of no-risk, for no matter what course of action is followed for the Hudson River, there will be a potential health risk. No course of action short of removing and destroying all PCB will eliminate the potential of chronic exposures.

In the responses to comments in Section 2, it will be shown that the DFS did not underestimate the PCBs in the River. The amount of PCBs in the river and potentially susceptible to movement is estimated to be from 497,520 to 653,000 pounds. What was mistated was the amount of PCB in the entire Hudson Basin that is associated with the GE plants, which is more than 1.4 million pounds.

ES.17 COMMENT: (ES-9;2;22-25)

The upper Hudson originally became eligible for Superfund money because of the potential for drinking water contamination, not just of local residents wells, but the approximately 80,000 people in six municipalities who are dependent on Hudson River drinking water. The PCB-contaminated river sediments and remnant deposits are the source of the health risk.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The Hudson River PCB problem became eligible, in part, for Superfund money because of its potential impact on public water supplies. It will be shown in section 5 that the actual health impact associated with the drinking water is low.

ES.18 COMMENT: (ES-11;1)

The Superfund remedial action proposed for the remnant deposits does not appear to address the major health concern - contamination of drinking water - which initially prompted EPA to include the Hudson on the National Priorities List. Ground cover and bank stabilization cannot "prevent" scour. Such an action only delays or discourages possible scour from normal weather events and does not guard against unusual weather events, heavy ice action or 100 year floods, which the Hudson is subject to. As this paragraph itself states, erosion can only be "minimized" not stopped. The danger to drinking water supplies will continue to exist while high concentrations of PCBs can potentially enter the river due to events - such as the river's high flow cycles, and weather - which are not under the control of engineering solutions. EPA considers containment of the remnant deposits an interim measure, and other options for dealing with this material in the future may be evaluated.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

At the present time, the water supply closest to the highly contaminated reaches (Village of Waterford) does not appear to be severely affected by the Hudson River PCB problem. Raw-water PCB concentrations rarely reach or exceed State Health Department or Federally-recommended standards. Treated water has never exceeded these standards in any sample. These issues will be discussed at length in Section 5.

Remedial actions at the remnant deposits were proposed to prevent direct contact with the most highly contaminated sediments and to reduce air transport of PCBs and PCB-contaminated dust to populated areas. Additional bank stabilization and revegetation will reduce further additions of PCB to the bed sediments.

ES.19 COMMENT: (ES-9;1;11)

The consideration of increased risk due to the remedial actions themselves is valid. However, these risks can also be drastically reduced, and must also be compared to the risk of continued potential exposure.

The consideration of some risk due to remedial actions which do not remove all PCB's is absurd. Surely extensive removal is less risky than doing half the job or nothing at all.

Again, the expense of remedial action is expected to ensure against migration of an exposure to PCBs not only for local residents, but for the estuary population as well. The removal of 30-48 percent of total PCB's removes the greatest part of the river contaminated sediments.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

On a river-wide basis (including the estuary), dredging the Thompson Island pool will remove only about 19-22 percent of the PCB, and dredging all hot spots will remove only 31-35 percent. If scour losses and dredge losses are considered, the PCB recovery is reduced to 14-15 percent for the 20 hot-spot alternative and 25-27 percent for the 40 hot-spot alternative (Table R2.2).

In either case, PCBs will continue to migrate to the estuary, some health risk will continue to exist, and environmental monitoring will still be required. Exposure of more concentrated sediments during dredging could result in the release of more dissolved PCB, which in turn could result in short term increases in atmospheric, water supply, and fish contamination. Also, important benthic communities would have been destroyed. In addition, another concentrated source of PCB will have been created, and environmental contamination could be potentially worse than before dredging.

All of these adverse conditions could be created based on an unproven and as yet unverifiable assumption that removal of a certain percentage of PCB-contaminated sediment will reduce the problem by an equal proportion.

ES.20 COMMENT:

Information on page ES-7 and ES-8 appears to be largely in conflict with ES-9; i.e., "comprehensive records of PCB concentrations in drinking water supplies...are not available" and "surface water contamination...is a potential problem." ES-9 then says that "the information...available appears to show very little, if any, public health impact."

Based upon incomplete information EPA has drawn an unwarranted conclusion. We submit that it is misleading to present such a statement based upon the premises presented.

EPA's contention that it will overcome this lack of data by conducting two (2) water samples for PCB's <u>only</u> strains our credulity.

Paul A. Rickard, Spokesperson, Citizens for Safe Water

RESPONSE:

The contamination of river water is a potential problem because the river serves as a source of drinking water for a number of communities. However the concentrations of PCB in drinking water do not appear to present a high health hazard. The DFS authors urge that a more comprehensive analysis be performed on drinking water supplies to confirm this conclusion. The sampling protocol of the DFS is not finalized, and all suggestions by interested parties will be seriously considered.

ES.21 COMMENT: (ES-1;3;6-7)

Remedial alternatives were evaluated using <u>a cost effective approach</u> consistent with the goals and objectives of (the Comprehensive Environmental Response, Compensation and Liability Act) CERCLA but what does this mean in real terms, what objective criteria were plugged in?

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The methodology, effectiveness measures, and weighting factors were based on two guidance documents prepared for the EPA:

- JRB Associates, July 11, 1983. <u>Superfund Feasibility Study Guidance Document, First Draft.</u> JRB Associates, McLean, Virginia.
- Radian Corporation, January 10, 1983. <u>Evaluating Cost-Effectiveness of Remedial Actions at Uncontrolled Hazardous Waste Sites, Draft Methodology Manual.</u> Radian Corporation, Austin, Texas.

The criteria used in the evaluation process are discussed in detail in Section 9 of the Feasibility Study report.

ES.22 COMMENT: (ES-2;1;1-3) (ES-3) (ES-9)

While we only have the "Executive Summary" of the EPA's draft <u>Feasibility Study for the Hudson River PCB Problem</u> of October 1983, we are concerned with page ES-9 which concludes that the removal of 30-48 per cent of the total PCB's is not cost effective. While the study considers only public health, it is an ultimate concern for public health that prohibits the ocean disposal of dredged material that contains unacceptable levels of PCB's at the Port of New York and New Jersey. Without disposal there can be no dredging, and without dredging, the port will shoal and thereby jeopardize 154,000 jobs and $3.6 billion in personal income, $1.6 billion in business income, $9.0 billion in sales, and $390 million in State and local taxes annually which depend upon the port. In other words, the regional economic impact of the Port is strongly influenced by basic public health concerns over PCB's that are no less real here than those concerning mid and upper Hudson River fisheries and drinking water, and yet these considerations are not reflected in the "Executive Summary". Were they, the study could not deem PCB removal as not being cost effective, a conclusion that would appear to be based largely on project costs....

...In short, we question the conclusion that PCB "hot spot" dredging is not cost effective, due to failure of the study to consider the full range of conditions at the Port of New York and New Jersey; and indeed, we remain distressed that so important an aspect of the problem continues to get such scant attention by the EPA.

Linda O'Leary, Save Our Port, New York, New York.

Similar comment made by: Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

Past conclusions about ocean disposal of PCB-contaminated sediment may be misleading. Acting on information from Save Our Port, Inc., the Draft Environmental Impact Statement on the PCB problem, lead one to believe that if the PCB concentration of Harbor Sediment were to rise above 4 ppm (currently Harbor sediments average 2-3 ppm, Bopp, et al, 1982) then ocean disposal would be precluded. This is not so. According to sponsors of the ocean disposal program, the 4 ppm limit has no legal or scientific basis. The decision to allow or prohibit ocean dumping is based on an Interim Guidance Matrix procedure developed exclusively for the New York Harbor by the EPA and the Army Corps of Engineers.

Essentially the Guidance Matrix is a laboratory bioassay procedure which examines PCB bioaccumulation by exposing sets of test organisms to samples of contaminated sediments that are proposed for ocean disposal. Whether or not the sediments are suitable for ocean disposal depends on the results of the bioassay matrix. If, after exposure, test organisms contain significantly more PCB than the concentrations specified by the matrix for the same organisms in New York Bight, then ocean disposal of the sediments would not be allowed.

The bioassay matrix scientifically accounts for the many factors influencing desorption and bioaccumulation. The bioassay matrix does not catagorically prohibit ocean disposal of all sediments having a certain PCB concentration. Contaminated sediments with a high bulk PCB concentration may be suitable for ocean disposal if the nature of the sediment is such the PCB is tightly bound to the particles and not available for biouptake. Conversely, other sediments may be unsuitable for ocean disposal even if the bulk PCB concentration is less than 4 ppm.

The DEIS also suggested that PCB migration from the Upper Hudson River could substantially raise the average concentration of Harbor sediments and thereby increase the potential for placement of a ban on ocean disposal. This projection involved the unlikely assumption that all of the PCB-contaminated sediment above Albany would be washed into the Harbor in 64 years and be distributed uniformly throughout the harbor. This assumption ignores the natural PCB containment and attenuation proceses which appear to be ongoing in the Hudson River System. Recent trends in environmental data show that PCB concentrations and PCB transport have been significantly decreasing since the initial studies in the mid 1970s. Some authors (Shroeder and Barnes, 1983) speculate that the decreases are caused by a layer of recently deposited clean sediment that restricts the transfer of dissolved PCB and protects the contaminated sediment from scour during moderate floods. In addition, the constant shifting and mixing of bottom sediments caused by bed load movement and seasonal deposition and scour may be diluting the contaminated deposits and effectively reducing the availability of PCB to transports. Many other factors may be responsible for the decrease. The attenuation potential of the 150 miles of river between Troy, New York and the harbor must also be considered. Therefore, the natural containment of hot spots, in combination with dilution and attenuation processes, would seem to indicate that scenarios such as that depicted by the commenter are not likely.

It is now recognized that the sediments accumulating in the Harbor are decreasing in PCB concentration (Bopp, et al, 1982). This trend is probably related to the overall decreasing trends in PCB contamination which have been evident. Since dredging generally removes only the most recently deposited material, the future ocean disposal of dredged sediment may not be endangered. If present conditions continue, the amount of PCB passing into the estuary will continue to decrease with time and what may occur is that previously deposited sediments will remain at a concentration of 3 ppm, and that the level of PCBs in fresh dredged material will decrease.

With respect to maintenance dredging in the Hudson River, it has been shown by the Final Environmental Impact Statement on Federal Channel Maintenance Dredging, that dredging plans over the next 10 years will not involve large quantities of sediment exceeding 1 ppm in PCB concentration and that subsequent disposal plans are not expected to create significant environmental impacts.

ES.23 COMMENT: (ES-7;6;1-5)

The evaluation contained in this report could have included a broader perspective but was, perhaps, limited by the EPA's guidelines for this contract.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The commenter addresses the following lines in the DFS:

"It is important that the reader understands that the results of the evaluation contained in this report are only as good as the original data provided. Given the lack of knowledge regarding the total quantity of contaminated sediments and their location in 1983, the authors of this RAMP based their derivation of alternatives on the 1977 data, assuming no movement."

It is recognized that the Hudson River PCB problem affects the environment all along the River from Fort Edward to the New York Bight and beyond. However, the DFS was limited to addressing in detail only the most pressing issues connected with PCBs in the Upper Hudson River. These issues included the health impacts of PCBs in air, water, and biota, and the transport of PCB to the estuary. Issues such as those concerning other pollutants, the effects of PCB on downstream water supplies, harbor maintenance, and power generation were addressed but not at the same level of discussion. However, because the present potential level of impact on the Upper Hudson River would not likely be exceeded elsewhere on the river, it is believed that more discussion would not change the basic conclusions reached.

ES.24 COMMENT: (ES-8;2;3)

Remnant deposits. Why not give credit where credit is due? NYDEC (urged on by the Settlement Advisory Committee) expended that last major part of its resources to make a significant impact on the remnant deposits. In area 3A, values to 10,000 ppm were found and removed to the new Moreau encapsulation site. In addition, the haul road was built down the steep E bank of the valley, and much rock was brought in to build a flood-resistant riprap along the bank of Area 3, where deposits were otherwise prone to erosion by bank scour. DEC would have done more with the remnant deposits with the 40 hot-spot project. When the crunch came and only 2/3 the funds requested were potentially available, something had to go and the basis was erodibility by the river.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

Comments were referenced by: Hudson River Sloop Clearwater, Inc., November 29, 1983.

RESPONSE:

NYSDEC-authorized remediation at the remnant deposits greatly reduced the potential for scour. Superfund remedial actions are directed toward improving the resistance to scour, preventing direct contact, and reducing air transport of PCBs and PCB-contaminated dust. Proposed remediation will also reduce infiltration of rain water and provide for adequate vegetative cover.

ES.25 COMMENT: (ES-9;2)

"The limited threat to the public health does not justify the large expenditure of money required to remove a portion of the contaminated sediments." Here you go again with the EPA "party line" from which your own analysis in fact diverges. If your "pass-through" model is correct (as it might be), then cleaning up the upper river gets 100 percent of the movable sediments and should get a high enough score to justify the $55 million or $34 million you project it will cost. Instead, you do not explain how this "limited" public-health situation was arrived at, much less deal with how much it costs for a cancer victim or two or more. Your own analysis puts a lie to your statement, that "only approximately 30-48 percent of the total PCBs in the sediments" will be removed. If scour is coming from only above Thompson Island, then everything else can be considered as "safe" as far as going into the estuary is concerned, and the proposed dredging operation will produce about a 100-percent effect.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The issue of the "Pass Through Model" is discussed at length in the response to comment 4.5.2. This discussion concludes that the origin of PCB-contaminated sediment is unconfirmed. It also concludes that it would be a mistake to base an evaluation only on the origin of suspended sediment because "dissolved" PCBs are also present in the river. These "dissolved" PCBs potentially present the most serious problem because they cannot be filtered from drinking water and they can be transferred to the atmosphere. The evolution of dissolved PCB is not under the control of river flows, and dissolved PCB can come from any contaminated sediment.
It is worth repeating that EPA's decision not to undertake remedial action with respect to the sediments was not based on the results of the matrix, but rather on the finding that none of the alternatives available can be considered sufficiently feasible and effective.

ES.26 COMMENT: (ES-9;2;16-17)

The matrix evaluation process used in Section 9 to determine a cost-effective solution does not in our opinion, conform to the CERCLA statute or to the pursuant regulations. The effective measures and weighting factors developed do not appear to have any relation to the criteria detailed in the regulations. Our comments in Section 9 describe in detail the deficiencies of the matrix evaluation process.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The matrix analysis was redesigned in the Final Report. These concerns are addressed in Section 9 in the responses to the detailed comments. In addition, EPA's remedial action decision was not primarily based on the results of the matrix analysis.

ES.27 COMMENT: (ES-9; 2; 18-20)

Any remedial solution as defined by the regulations (40 CFR 300.68j) must be one which is "technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment." No remedial action is to be considered only when a "response action may cause a greater environmental or health danger than no action." This is clearly not the case with the PCB problem in the Hudson.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The "no action" alternative is considered appropriate when alternatives are developed for evaluation. There is no provision which requires the selection of the No-Action Alternative ONLY when a "...response action may cause a greater environmental or health danger than no action."

The National Contingency Plan (40 CFR 300.68g) states:

"One alternative may be a no-action alternative. No-action alternatives are appropriate, for example, when response action may cause a greater environmental or health danger than no action."

ES.28 COMMENT: (ES-10;1;9-11)

The "limited improvement" statement made here simply does not reflect either the conclusions of numerous studies on sediment transport, bioaccumulation, and fisheries data done to date, or the conclusions on aspects of the data drawn by NUS itself in specific sections of the RAMP.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The hot-spot-dredging scheme was predicated on the assumption that the removal of the most highly contaminated sediments would reduce the problem in proportion to the amount of PCBs removed. This solution is intuitively appealing; however, it obscures the idea that it is a limited response. PCBs are ubiquitous in the Hudson River environment, and the PCB problem would continue to exist with or without dredging.

Past studies have merely defined the possible consequences and cite hot-spot dredging as the only alternative available.. Few studies have attempted to measure the actual impact of the problem or tried to quantify the actual effectiveness of dredging. Six years after the initiation of PCB studies, the DFS found that the actual health impacts are lower than previously expected, and that environmental contamination is decreasing much more rapidly than had been anticipated. A review of studies into PCB-environmental interactions and PCB transport has left many questions unanswered but it has indicated that the mechanisms are much too complex to conclude that hot-spot dredging would lead to a measurable amount of improvement.

ES.29 COMMENT:

2. Reduced vs. Full-Scale Hot Spot Dredging. The Report concludes that compared with the full-scale dredging program (40 hot spots), the reduced-scale dredging in the Thompson Island pool (20 hot spots) "will clean up a relatively larger area for the money expended." (pp. 9-35) It is clear that Reduced-Scale hot spot dredging is an attractive alternative. Unfortunately, this conclusion is not reflected in the Executive Summary, which compares the "no-remedial" action option only with the Full-Scale dredging program. This is, indeed, a very misleading way of presenting the Report's actual findings.

Karim Ahmed, National Resource Defense Council, Inc.

RESPONSE:

While the no-action alternative cannot be considered to provide fully adequate protection to human health and the environment both the modeling and sampling data collected to date indicate a decreasing threat to public health and the environment. The lack of sufficient data to establish the fate and transport of PCBs in the Hudson River prevents the Agency from making a final determination of no-action. Additional environmental data collection will continue during the interim evaluation period on feasible and reliable alternatives. The most feasible and reliable alternatives assessed by EPA (limited and full scale hot spot dredging) would be likely to decrease the level of risk somewhat. However, as is mentioned above, the actual reliability and effectiveness of current dredging technologies in this particular situation is subject to considerable uncertainty. For this reason the no-action alternative is recommended at this time. This decision may be reassessed in the future if, during the interim evaluation period, the reliability and applicability of in-situ or other treatment methods is demonstrated, or if techniques for dredging of contaminated sediment from an environment such as this one are further developed.

ES.30 COMMENT: (ES-11;1)

The world will rejoice that you have concluded it is appropriate to deal with the remnant deposits, but consistency problems haunt you here, too.

First of all, what about that detailed "remedial investigation?" By the time all that has been done and paid for, one could have hauled all of the remnant deposits away. Your suggestion of capping them is curious: that is just the treatment DOT has done with some dredge spoils and EPA is carrying on about "noncompliance." But more important, you assume it will be easy to locate a source for this capping (I think it will not be so easy), and then you are going to dump all that sediment into a place where it might be eroded, and thus add to the DOT future dredging burden at Fort Edward! Fencing and signs are fine, but they invite vandalism. If trucks are going down there full of capping material, it would be a crime for them to come out empty, when they could be carrying away highly contaminated sediments.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

There are significant problems associated with complete removal of remnant deposits. In the first place, estimates in Section 9 have shown the costs to be prohibitively high. But more importantly, removal and transportation of such large amounts of contaminated material may pose a health hazard to residents along haul routes. Air transport of PCB and PCB-contaminated dust during excavation and transportation of sediment could be a problem. The lack of a suitable disposal site, although not considered a critical flaw in the evaluation, is also a significant problem.

Typical cross sections of remnant deposits in Section 4 show that those deposits that were subject to bank stabilization are adequately protected from floods up to the 100-year return period. Additional bank stabilization work and adequate revegetation should reduce--not add to--DOT sediment problems.

Full consistency with TSCA standards is not being achieved because in-place containment is intended as an interim remedy to address only the direct contact and volatilization threats to public health from the remnant sites, and not the lesser environmental threats.

ES.31 COMMENT: (ES-11; 2; 4)

What do you mean by the last sentence? Does someone get that $1.1 million now, or dribbles of $50K per year for 20 years? Whose pocket pays?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

CERCLA funding will be available for monitoring the water supplies and for pre-design studies at the remnant sites. CERCLA funding will not be available for monitoring fish contamination or for river sediment sampling. Expenditures of funds will depend on the final sampling scheme.

ES.32 COMMENT: (ES-3; 3: 7-9)

It is unclear just where the Hudson River PCB problem ranks on the National Priorities List (NPL) and whether or not funds are, in fact, available for the purpose of remedial action.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

Similar comment made by: James R. Donnalley, General Electric Company.

RESPONSE:

The Hudson River PCB Site was included on the August 1983 Proposed Update to the National Priorities List. This list is subject to public comment and will be finalized this year. Funds have been allocated under the Superfund Remedial Accomplishments Plan for the purpose of capping the remnant areas and fencing the area.

1.0 COMMENTS ON SECTION 1 (INTRODUCTION)

1.1 COMMENT: (1-2)

This chronologic summary does not mention all the remedial work that has been done in the upper river by DEC and DOT. DEC forced GE to cease polluting the river (done by July 1977) and made two massive cleanups around Fort Edward (involving possibly 175,000 lb. or more of PCBs in contaminated sediments removed).

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

A chronological list of major occurrences, including physical remedial and legal response actions, is found in Section 2, pages 2-6 and 2-7, of the DFS. A more extensive site chronology is found in Appendix A. To the list in Section 2 of the final report, the following corrections and additions were appropriate:

April-Dec. 1974	Dredging of 175,000 yd^3 of debris and sediments from main river channel downstream of Lock 7 by DOT maintenance forces.
	Dredging of 85,000 yd^3 of debris and sediments from Fort Edward Terminal Channel between Lock 7 and D&H Railroad bridge by DOT maintenance forces.
July 1974-June 1975	Removal of 180,000 yd^3 of debris and sediment from Fort Edward Terminal Channel upstream of D&H Railroad bridge and northerly tip of Rogers Island and excavation of sediment trap of 70,000 yd^3 capacity by State contractors.
Oct. 1974-July 1975	Placement of rock from cribs on banks of remnant deposits 3 and 4 by State contractors.
	Placement of dumped rock at remnant deposit 5.
May-Nov. 1975	Removal of 130,000 yd^3 of debris and sediments from west channel near Rogers Island.
1976	Dredging of 35,000 yd^3 of sediment near buoy 212 by DOT maintenance forces.
Fall 1977-Spring 1978	Dredging of 170,000 yd^3 of sediment from channel near Rogers Island and containment of these sediments in New Moreau Site.
	Additional bank stabilization measures at Site 3.

Source (Malcolm Pirnie, August 1977)

- Although these activities probably involved contaminated sediments, they were made in response to sedimentation problems caused by the removal of the Fort Edward Dam rather than in response to the PCB problem.

1.2 COMMENT: (1-3; 2)

Why not get the story straight? NYDEC applied to every possible EPA program and was repeatedly denied any funds. Finally, it became a matter of who was to interpret the will of Congress--EPA acting under their view of how programs should work, or the Congress itself? Congress removed this ambiguity.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

It is true that New York State petitioned EPA for funds under the Construction Grants Program for several years during the late 1970's. However, a project of this kind was found ineligible for funding under this program since these monies were designated for the construction of sewage treatment facilities.

In 1980, Congress passed the Section 116 Amendment to the Clean Water Act (CWA), which authorized the use of Section 205(a) Construction Grants monies specifically for the Hudson River. At that time several other funding sources were identified as potentially available, including Section 311 and 115 (CWA), as well as the Superfund, which was in its infancy. In the Amendment, Congress specifically stated that Section 116 monies were only available to the extent that funds were not available from these other sources. On December 30, 1982, the Administrator determined that the project was most appropriately addressed under CERCLA and the project was subsequently placed on the NPL.

However, further analysis indicated that Superfund action would not be appropriate with respect to the sediments, although action is appropriate for the remnant deposits. Also see response to G-7 and G-8.

1.3 COMMENT: (1-3; 4)

Neglects to state that this laudable rating did not become a reality until July 1983 after several lawsuits had been filed.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

In the December 30, 1982 Record of Division, the Administrator determined that the Hudson River PCBs Site ranked sufficiently high to be included on the National Priorities List. The site was subsequently included on the August 1983 proposed update.

Lawsuits filed against EPA in July 1983 had no bearing on the accomplishment or value of this rating.

2.0 COMMENTS ON SECTION 2 (THE SITE)

2.1 COMMENT: (2-7)

It was not made clear how balance on page 2-7 was arrived at.

John E. Sanders, Chairman, DEC, Hudson River PCB Settlement Advisory Committee.

Comments also made by:
Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.
Scenic Hudson, Poughkeepsie, New York

RESPONSE:

A large number of commentors questioned the PCB-mass estimates reported by the DFS and also the conclusions that may have been based on those estimates.

The following discussion will show that although in some cases the PCB tabulations lacked consistency, important conclusions were reached using acceptable PCB-mass estimates.

Mass balances and tabulations of total pounds of PCB for various locations in the Hudson River Basin are found in many reports. It was difficult to assemble and verify the PCB information in these documents because the numbers varied greatly from one report to the next and sometimes particular values differed within a single report. The most widely quoted PCB-mass estimates for the Upper Hudson River Basin are those found in Hetling et al. (April 1978), Tofflemire and Quinn (April 1979), and Malcolm Pirnie (1980). Bopp et al.'s (1978) PCB mass balance is probably the most widely accepted estimate for the Lower Hudson River.

Because of the wide variation in PCB tabulations found in the existing literature, the DFS used very general ranges of PCB-mass estimates that were rounded to the nearest 10,000 pounds. These were presented in Table 2-1, page 2-7. Because of the number of comments on these estimates, the four reports mentioned above were consulted and a new and much more precise table was prepared. This tabulation now appears in Table R2-1 and also in the final report.

The values in Table R2-1 are comparable with the values in the old table except for two major errors. The DFS Table 2-1 gave a range of 110,000 to 120,000 pounds of PCB for Thompson Island pool cold-areas, whereas 22,000 to 30,900 pounds is probably a more accurate estimate. Also there are only from 103,455 to 160,000 pounds of PCB in dredge spoils; not the 580,000 to 590,000 pounds reported by the old table. The first error was a typographical mistake. The second error was the result of copying the wrong value from a table. However, the tabulations most crucial to the conclusions of the DFS, namely the total mass of PCB in hot spots and the total mass of PCB in the Upper Hudson River, are comparable. For example, in the DFS, the proportions of PCB removed by dredging hot spots

TABLE R2-1

Estimated Mass of PCB in the Hudson River Basin
Associated with General Electric Plants
Near Fort Edward, New York

UPPER HUDSON RIVER BASIN

Remnant Deposits	46,820 - 108,600 pounds[1]
Thompson Island Pool Sediments[2]	
Hot Spots	97,700 - 105,800
Cold Areas	22,000 - 30,900
Remaining Upper Hudson Pools	
Hot Spots	60,600 - 64,100
Cold Areas	101,400 - 146,400
Subtotal, Upper Hudson River Sediments Only	
Hot Spots	158,300 - 169,900
Cold Areas	123,400 - 177,300
	281,700 - 347,200
Dredge Spoils	103,455 - 160,000
Dumps	528,000 - 745,000
Subtotal, Upper Hudson Basin Only	959,975 - 1,360,800

LOWER HUDSON RIVER BASIN

Sediments	169,000 - 200,000
Dredged	86,000
Washed out to sea	200,000
TOTAL PCB	1,414,975 - 1,846,800

1 Remnant deposit totals do not include estimates for area 3A.
2 Thompson Island Pool totals include estimates for sediments above Lock 7.

Sources: Bopp et al, 1978
Hetling et al, April 1978
Tofflemire and Quinn, 1979
Malcolm Pirnie, 1980

were based on a total of 290,000 pounds of PCB in the Upper Hudson River, and 110,000 pounds and 170,000 pounds of PCB for Thompson Island and Upper Hudson River hot spots, respectively. When PCB transport projections were made, a source of 350,000 pounds of PCB was used.

Therefore, conclusions as to proportions of PCB removed by dredging and also conclusions as to the length of time over which PCB would be transported to the estuary are valid. These conclusions, adjusted for the more precise estimates, are restated in Table R2-2.

Another point of confusion stems from statements in the DFS that cite the mass of PCB in the river at about 500,000 pounds and which relate this number to the 500,000 pounds of PCB reportedly discharged by GE. Earlier reports had indicated that according to company records, GE had discharged about 500,000 pounds of PCB to the river. In fact, the evidence clearly indicates that GE generated much more PCB pollution. Considering every known source, including PCBs in dredge spoils, upland dumps, remnant deposits, and those PCBs washed out to sea, the final total of PCB associated with GE is well over 1.4 million pounds (Table R2-1). However the amount of PCB actually found in the river and the amount of most concern to the evaluation of remedial alternatives is about 500,000 pounds; the estimates given by various reports ranged from 497,520 to 653,000 pounds according to Table R2-1.

2.2 COMMENT: (2-4; 2)

Didn't any of you people think it is a bit curious that nearly 3 years elapsed between the time GE applied for the permit to pollute the river and date when EPA issued said permit?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The National Pollution Discharge Elimination System (NPDES) was established under Section 402 of the 1972 Clean Water Act. The first permit issued to General Electric under this system was issued on January 31, 1975 to their Fort Edward plant. This time lapse is not unreasonable and is typical of the program. During the permit process, information must be exchanged between EPA and the company in order to complete the permit. A public notice and comment period is necessary before the permit is finalized. This process can take from several months to more than a year. In this particular case, GE was issued one of the first group of permits under the new NPDES program.

2.3 COMMENT: (2-6; 4; 2)

On p. 4-14, par. 2, last line, a possible PCB source at Mechanicville is mentioned. Why not get that situation sorted out instead of repeating no other source?

TABLE R2-2

Major Conclusions Relying on Estimates of PCB Mass in the Hudson River

Assuming 1978 Data (Table R2-1)

Dredging Thompson Island Pool Hot Spots will remove:
30-35% of Upper Hudson River PCBs;
19-22% of all in-river PCBs.

Dredging all Hot Spots will remove:
48-56% of Upper Hudson River PCBs;
31-35% of all in-river PCBs.

Assuming 25,000 pounds of PCB were scoured from Hot Spots and Assuming 6 percent loss of PCB during dredging.

Dredging Thompson Island Pool Hot Spots will remove:
22-24% of Upper Hudson River PCBs;
14-15% of all in-river PCBs.

Dredging all Hot Spots will remove:
39-49% of Upper Hudson River PCBs;
25-27% of all in-river PCBs.

PCB Transport Projections (Section 8.1.1.1 of the DFS)

...used currently estimated annual transport rates (1500 pounds/year) and were based on 350,000 pounds of PCB stored in the Upper Hudson River. This value was used by Lawler, Matusky, and Skelly (1979) and the DEIS, and represents the worst-case assumption because it is the largest estimate of source PCB. Using the lower estimate of Upper Hudson River PCB (290,000 pounds) would shorten the projected period as shown below:

- No Remedial Action - Discontinued Maintenance Dredging:
  - Period projected using 350,000 pounds: 117 years;
  - Period projected using 290,000 pounds: 97 years.
- No Remedial Action - Continued Maintenance Dredging:
  - Period projected using 350,000 pounds: 64 years;
  - Period projected using 290,000 pounds: 53 years.
- Reduced - Scale Dredging Alternative:
  - Period projected using 350,000 pounds: 55 years;
  - Period projected using 290,000 pounds: 41 years.
- Full - Scale Dredging Alternative:
  - Period projected using 350,000 pounds: 46 years;
  - Period projected using 290,000 pounds: 30 years.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

In most reports, the General Electric plants are cited as the ultimate source of the PCBs that now exist in river sediments, remnant deposits, dredge spoils, and dumps. The Mechanicville source, mentioned in the DFS on page 4-14, paragraph 2, was hypothesized by Tofflemire and Quinn (1979) to explain why the estimated mass of PCB in the river pool between Lock 4 and Lock 5 was greater than upstream pools. The DFS authors are not aware of investigations of PCB inputs to the Upper Hudson River other than the GE Plant discharges, and the various secondary sources associated with GE.

2.4 COMMENT: (2-4; 4; 1-2)

Why do you make such definite statements when you scream for more data than 1200 cores for knowing how much is where in the river? Nobody really knows this. How much is "Much of this waste"?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

In this passage, the DFS made a statement to the effect that much of the PCB problem was caused after the removal of the Fort Edward Dam. The authors feel the DFS made a valid statement. It is widely reported that between 1974 and 1977, approximately 1.1 million yd^3 of debris and sediment was scoured from the former dam pool after the removal of the Fort Edward Dam (Malcolm Pirnie, February 1975; August 1977; March 1978; September 1980). It is evident that a large portion of this material was highly contaminated, considering the present PCB concentrations in the remnant deposits. Only 615,000 to 775,000 yd^3 of this material was recovered by maintenance dredging. The remaining 300,000 to 400,000 yd^3 of material undoubtedly has made a significant contribution to the wide-spread contamination that now exists. It is probably true, however, that down-stream migration of PCB-contaminated sediments occurred before the dam was removed. General Electric discharges between 1973 and 1976 were also an important factor in the present problem.

2.5 COMMENT: (2-4; 5; 1)

Is navigational dredging yearly? Yearly averages have been computed, but does the same locality get dredged every year? What about citing a source for your figures? In last sentence, here you go with the EPA dogma again. It is wrong to state: "At this time no actions have been made to secure these sites." Be specific or silent.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The average annual dredging rate of 23,000 yd^3/yr reported in the DFS at page 2-4, paragraph 5, line 1 is the average maintenance dredging rate in the Fort Edward area between 1950-1970, as computed by Malcolm Pirnie (September 1980). This value was used to compare normal maintenance dredging to the remedial dredging work done by the NYSDOT in response to sedimentation problems after the Fort Edward Dam removal. It was mistakenly represented by the DFS as the dredging rate during the 1974-76 period when sedimentation problems were at their height. NYSDOT dredged approximately 615,000 yd^3 during this period.

In 1978, Weston (November 1978) investigated 7 PCB-contaminated dredge-spoil sites and made recommendations for appropriate remedial work. Special Area 13, which is located on the west bank south of Moreau, and the Buoy 212 dredge spoil were subsequently capped with soil, revegetated, and supposedly equipped with monitoring well systems.

In 1977-78, approximately 170,000 yd^3 of contaminated river-bottom sediments and 14,000 yd^3 of contaminated sediment from remnant area 3A were placed in the New Moreau facility. This facility was designed as a secure upland containment and is equipped with an impermeable clay liner; a vegetated, impermeable clay cap; and leachate monitoring and treatment features.

2.6 COMMENT: (2-5; 2; 6)

Last sentence: "little or no vegetative cover on them." You've muffed a significant point here: plants grow nearly everywhere (even out of cracks in pavement), but on these highly contaminated sediments, no plants grow! Plants began to grow in Area 3A after the clean-up operation. The message is, in case you need help with the translation, that if no plants are growing, something terrible is wrong, and it is the high content of PCBs. If that is not a serious environmental hazard, what is?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The statements made in the DFS, at page 2-5, paragraph 2, line 6 and page 4-2, paragraph 4, are purely descriptive in nature and were not made to insinuate the phytotoxicity of PCBs in any way. In fact, vegetation does grow to some extent on all remnant deposits. This is evidenced by the photos of remnant deposits 2, 3, and 4 and in the descriptions of vegetative cover on remnant sites 4 and 5 made in the NYSDEC comments in Section 10.

There are a large number of factors that might contribute to the lack of adequate vegetative cover on certain remnant deposits. The nature of the sediments alone may present problems for plants. The texture of remnant deposit sediment is generally coarse, and it often contains large amounts of gravel, wood debris, and slag. The water- and nutrient-holding capacities of this type of material are often insufficient to sustain adequate plant growth (Buckley 1980).

Remnant deposit soils contain large volumes of sawdust and wood chips. Rapid decomposition of this material may result in poor plant growth because nutrients, particularly nitrogen, are bound up by soil microorganisms and made unavailable to higher plants (Hartmann and Kester, 1975). Sawdust may also contain natural phytotoxins, which can be released by decomposition. (Hartmann and Kester, 1975).

Moreover, there does not appear to be any correlation between the PCB content of the deposit and the character of the vegetative cover. Remnant deposits 1, 2, and 3 have the least cover, which consists mostly of a few, sparse patches of low vegetation. These deposits have average PCB concentrations of 20, 5, and 65 ppm, respectively. Remnant sites 4 and 5 support denser vegetation and small trees. Yet these sites contain PCB at concentrations of 40 to 250 ppm respectively. In addition, Buckley (1980) has found that terrestrial plants can withstand extremely high levels of PCB without showing an adverse impact.

It should not be concluded that the sparse vegetation on certain remnant deposits is related to the presence of PCBs.

2.7 COMMENT: (2-8; A-1)

Start of tabulation of response actions should include a statement of DOT dredging 1950 to 1974; it amounted to more than 10^6 yd^3 of sediment, much from Ft. Edward and thus doubtless full of PCB (but no measurements then).

John E. Sanders, Chairman, Hudson River PCB Settlement Advisory Committee.

RESPONSE:

See the response to comment 1.1 in Section 1 and also the revised list of response actions in Section 2 of the final report.

2.8 COMMENT: (2-9)

December 30, 1982. As your report indicates, EPA is not going to make any CERCLA funds "available" for dredging the upper Hudson River. This beguiling play on words using "available" turns out to be the EPA shell game correctly diagnosed by many in early 1983. But for the lawsuits, it would have worked. You turn in your report on 28 September 1983 saying no CERCLA funds for the dredging; the normal statuatory expiration date of Sec. 116 CWA funds was 30 September 30, 1983. Presto! No money, no EPA problem with the river.

John E. Sanders, Chairman, Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The September 1983 draft Feasibility Study published pursuant to CERCLA found that dredging the Upper Hudson River was not a cost-effective remedial alternative according to criteria established under the National Oil and Hazardous Substances Contingency Plan. However, a dredging project has not been precluded by this decision. The statutory expiration date for authorization of funds has been extended. The Administrator will consider funding of the dredging project with Section 116, CWA monies if a site has been approved for disposal and once sampling redefines the hot-spot contaminated areas.

3.0 COMMENTS ON SECTION 3 (ENVIRONMENTAL SETTING)

There were no comments on Section 3 of the DFS.

4.0 COMMENTS ON SECTION 4 (ENVIRONMENTAL CONCENTRATIONS)

4.1 COMMENTS CONCERNING REMNANT DEPOSITS

4.1.1 COMMENT:

The five remnant deposit areas were left high and dry in 1973 when the Fort Edward Dam was removed. Areas 3 and 5 have been riprapped with rock along the river's edge. Area 3A was removed, capped, and seeded.

1. The extent of sediment sampling is noted in DEC Technical Paper No. 56 and pages 82 and 106.

2. Water PCB values at the Rogers Island 197 Bridge, just downstream of the remnant deposits are noted in Table 1 [table not included]. The values decrease with time. Two river water cross section sampling studies were done by USGS (September 1980 and July 1981.) A Rhodamine dye was fed on the east bank in the 1981 study. Although PCB values were slightly higher on the east side of the river, the total mass load of PCB from the east bank is small relative to the total PCB load. The dispersion from east bank sources is not rapid, as evidenced by dye staying in only the east side at cross section 2, a mile downstream.

3. The remnant deposits, other than area 1 are fairly stable. Area 1 has eroded considerably over the years. The 1/100 yr. flood is about 40,000 cfs at Fort Edward. A flow of 27,000 cfs was monitored in April 1982 by USGS. There was no need for follow up downstream dredging by DOT after this flood.

4. The remnant deposits are owned either by New York State or by Niagara Mohawk depending on whether they are considered part of the river or not. The banks along the east side by the tree line are very steep and drop 20 ft. or more. Access is very difficult to areas 1, 2 and 3. Area 2 is isolated by woods and a steep bank. Boat access is also very difficult. Moving upstream over the dam removal area is very difficult due to shallow rapids. The propeller of a motor boat often hits. Canoeing upstream is difficult against the current. Area 4 is accessible by four wheel drive vehicle down 2 roads. Area 5 is easily accessible by walking or by four wheel drive vehicle. The greatest public exposure potential is on Area 5. Several years ago, Niagara Mohawk proposed reinstalling the Fort Edward dam and flooding the area again for increased power generation. This proposal was withdrawn and the alternate calling for upgrading the power generation at the Bakers Falls Dam, upstream, is currently pending.

5. Air and plant PCB data over the remnant deposits from 1979 to 1981 is available from Dr. Buckley. The 1981 data was sent to EPA recently. Dr. Buckley also has 1982 air and plant PCB data, which he will release if paid for. In general the air in the summer of 1981 was in the .1 - .9 $\mu g/m^3$ range. The only area where homes are within 700 meters is - Area 5; however, the homes are 30 ft. or so higher than Area 5.

Mean Air PCB Values Based on Plant Data 1981 -- $\mu g/m^3$

Area 3	Area 4	Area 5	NIOSH std
447	309 (90)#	298	1000

#(90) with one unusual value omitted.

6. The metals levels, especially lead, are elevated in the remnant deposits and river sediments. This was due to past discharges of CIBA Geigy plant (formerly Hercules, Inc.). See the November 20, 1980 memo enclosed and note page 31 of DEC Technical Paper No. 56.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York

RESPONSE:

The above comment includes general information on remnant deposits, some of which did not appear in the DFS. It will be considered in the Final Report.

4.1.2 COMMENT: (4-2; 4)

The feasibility study does not adequately take into account the environmental impacts of PCBs in the Hudson River eco-systems. While data is discussed in Section 4, showing contamination of the biota, that fact is not shown to be a major consideration in the development of remedial actions alternatives. In addition, vegetation has not grown in remnant deposit areas, verified by aerial inspections. The PCB concentrations in those soils are preventing vegetation growth. Even though it is mentioned, briefly in Section 4.1.1.1, it is not given due consideration in Section 10 of the study.

Scenic Hudson

Similar comments made by: John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

As was indicated in the response to comment 2.6, it is not at all certain that the sparse vegetation on remnant deposits 2 and 3 is in any way related to PCBs. Regardless of this fact, some or all of the remaining remnant deposits will be capped with an impermeable material, covered with top soil, and revegetated, as was recommended in Sections 9 and 10 of the DFS. The primary purpose behind this action is to protect humans and wildlife from direct contact with PCB-contaminated materials, and to prevent airborne transport of PCBs and PCB-contaminated dust. The various other minor benefits are described in detail elsewhere in this report.

4.1.3 COMMENT: (4-2; 2; 4-6)

- Discuss and settle the different estimates Tofflemire vs. MPI. I think the lower figure is correct (so do you in Table 4-1, p. 4-9).

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The comment refers to a discrepancy between the remnant deposit PCB-mass estimates published by NYSDEC (Tofflemire and Quinn, April 1979) and Malcolm Pirnie (March 1978). The Malcolm Pirnie estmate was not included in the DFS. The two estimates, as presented by Tofflemire and Quinn, are now shown in Table R4-1.

Based on 20 pre-1978 and January 1978 samples, Malcolm Pirnie estimated 139,700 pounds of PCB for the remnant deposits. Later samples from March and April 1978 raised questions as to the accuracy of the previous estimate. The spring sample concentrations were doubled by NYSDEC because a quality control check revealed that the analytical results were one half of their true value. But even then, the March and April data showed a much lower PCB concentration for area 3A than previously estimated. Thus DEC revised the PCB-mass estimates as indicated in Table 4-1. The new estimates were based on somewhat different values for contaminated area and depth of contamination, as well as on average concentration differences. The discrepancy in the estimates "illustrates the difficulty entailed in delineating the areal extent and concentration of PCB contamination based on unavoidably variable and limited sampling data" (Malcolm Pirnie, September 1980). The NYSDEC estimates are generally accepted as being more accurate.

4.1.4 COMMENT: (4-9)

Table 4-1. Get this story straight, esp. for area 3A. In Tofflemire and Quinn, 1979, Table 30, p. 80, are contained the Tofflemire vs. MPI estimates and the correct figures determined after the work had been done. Removed were 14,000 yd^3 containing 24,500 lb. of PCB. I make the total contaminated volume 355,205 yd^3 and the amount of PCB, 46,820 lb.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The comment relates to the PCB-mass estimates for the remnant deposits illustrated in Table 4-1 in the DFS and the Table R4-1 in this report.

TABLE R4-1

PCB CONTAMINATION IN REMNANT DEPOSITS
HUDSON RIVER PCBs SITE, NEW YORK

Malcolm Pirnie, March 1978

Area	Acres	Depth ft	Volume cu. yd.	Volume $ft^3 \times 10^6$	PCB@ ug/g	PCB@ lb
1	5	5	40,300	1.09	1	70
2	8	6	77,400	2.09	5	680
3	12	10	193,600	5.23	200	67,950
3A	11	1	17,700	.48	1000	31,100
4	20	3	96,800	2.61	10	1,700
5	6	10	98,800	2.61	225	38,200
Total						139,700

Tofflemire and Quinn, April 1979

Area	Acres	Depth ft	Volume cu. yd.	Volume $ft^3 \times 10^6$	PCB@ ug/g	PCB@ lb
1	4.0	2	12,900	.348	20	450
2	8.0	5	64,530	1.742	5	570
3	13.3	7.5	160,925	4.345	65.3	18,550
3A	6.0	1	9,680	.261	1000	17,000
4	12.0	2	38,720	1.045	25	1,700
4A	8.5	3	41,140	1.111	40	2,900
5	4.0	8	51,630	1.394	250	22,650
Total						63,820

@ 65 lb/ft^3 dry bulk density used

Tofflemire and Quinn's (April 1979) estimates show a contaminated volume of 9680 yd^3 and a PCB mass of 17,000 pounds for remnant area 3A. In the Fall of 1978, area 3A was excavated and removed to the New Moreau secure containment facility. The actual volume removed was 14,000 yd^3, not 9680 yd^3. The commentor insists that, based on the larger volume, an average PCB concentration of 1000 ppm, and a bulk density of 65 lb/ft^3, the actual PCB mass in this deposit was 24,500 pounds--not 17,000 pounds as shown in the table. The calculation is as follows:

$$(14{,}000\ yd^3)\ (27\ ft^3/yd^3)\ (65\ lb/ft^3)\ (1000\ lb\ PCB/1{,}000{,}000\ lb\ sediment)$$

$$= 24{,}570\ lbs\ PCB.$$

Regardless of the amount of PCB in area 3A, however, the estimate of PCB in the remaining deposits stays at 46,820 pounds. Appropriate notation is included in the revised Table 4-1.

4.1.5 COMMENT: (4-10; 3;7-11)

Last sentence. There are data to support this position. See U.S. Geological Survey measurements for the river and MPI reports on the areas that have not been protected by riprap.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

It is believed by some NYSDEC officials that most of the dissolved PCBs and PCB-contaminated sediments which move downriver away from the remnant deposits come from the river bottom. See the statements made by NYSDEC, Division of Solid and Hazardous Waste, on the remnant deposits in comment 4.1.1.

4.1.6 COMMENT: (4-68;2)

This whole paragraph is peculiar. Why not resolve the estimates? Actually, more samples than you suggest were collected--only the second round involved pits and cores. "Most of the sampling at these areas was done before the sites were regraded" is totally wrong. All of the areas were sampled; only area 3A, so highly contaminated, was altered (14,000 yd^3 picked up and trucked to new Moreau site for long-term encapsulation).

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The paragraph in the DFS addressed by the commentor attempts to evaluate the existing information on the remnant deposits. The statement at line 3 - "most of the sampling at these areas was done before the sites were regraded." – is incorrect. The regrading and stabilization work at the remnant sites was completed in July 1975. At least 40 sediment samples from the remnant deposits were obtained between 1976 and 1978. The only work occurring after the sampling was the removal of area 3A and some additional bank work done at area 2.

This correction does not change the authors' opinion that some additional investigation will be needed before remedial work can begin.

The available PCB data for the remnant sites is not well presented in the existing literature. Apparently 43 sediment samples, including pits and cores, have been taken from the remnant deposits; yet only 29 PCB-analyses results can be found in the literature. The sample distribution from individual remnant deposits is summarized below:

Remnant Area	No. of Samples A	B	Total	PCB Analysis
1	1	6	7	7
2	4	1	5	4
3	3	9	12	10
4	4	10	14	4
5	5	0	5	4
			43	29

A: Malcolm Pirnie, 1978
B: NYSDEC, 1978
Source: Tofflemire and Quinn, April 1979
Malcolm Pirnie, March 1978

It is suggested that the original data be located, if possible, and be re-evaluated. It is anticipated, however, that additional sampling will be required at sites 2 and 5 and perhaps at site 4.

4.1.7 COMMENT: (4-68;3)

Area 1 is an island within the river; its PCB content is considered (on basis of perhaps 1 sample) to be low, so DEC cares not if it scours. The point is: as far as available samples show, the hottest remnant deposits (Areas 3 and 5) have been made unavailable to the river.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

This comment pertains to page 4-68, paragraph 3, lines 3 to 5 of the DFS which indicate that, based on a comparison of aerial photos between 1978 and 1983, substantial erosion losses may have occurred at remnant area 1.

The authors agree with the comment. It is not clear what the official position of NYSDEC is with respect to the remnant deposits. See the comments of the Division of Solid and Hazardous Waste on the remnant deposits (4.1.1).

4.2 COMMENTS CONCERNING RIVER SEDIMENTS

4.2.1 COMMENT: (4-14;2;12)

Mechanic/(not Mechanicsville) PCB source; why ignore this question?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

In most reports, the General Electric plants are cited as the ultimate source of the PCBs that now exist in the river sediments, remnant deposits, dredge spoils, and dumps. The Mechanicville source, mentioned in the DFS on page 4-14, paragraph 2, was hypothesized by Tofflemire and Quinn (April 1979) to explain why the estimated mass of PCB in the river pool between Lock 4 and Lock 5 was greater than upstream pools. Other authors (Lawler, Matusky, and Skelly, 1979) have also suggested that additional PCB sources might exist.

This question was not intentionally ignored by the DFS authors. The work assignment limited the DFS almost entirely to existing information. To the authors' knowledge this information did not include follow-up investigations to confirm the existence of additional PCB sources.

4.2.2 COMMENT: (4-16;1;6)

Last sentence. What does this really mean? In all the MPI documents, the point was made repeatedly that no matter how shallow the depth of PCB less than 36 inches (3 ft), the dredge cut would be 36 inches because they can't do less. This is something of a problem for the channel areas, for out there, sediments rarely are thicker than 18 inches. With all the volumes figured at 36 inches, one wonders if they will blast out 18 inches of bedrock to meet the specified 36 inches. (The 36-inch figure appears in Table 4-3, note 5, on page 4-29.)

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The statement on page 4-16, paragraph 1, line 6, indicates that because of the depth of PCB contamination, an optimal removal depth of 15 to 24 inches would be desired. However because of wall sloughing and the inherent inaccuracies of dredging, a 12-inch overcut would be specified to ensure that all target sediment was obtained. Obviously if the sediment is not this thick, 36 inches of sediment could not be removed. However, although hydraulic and clamshell dredgas are less efficient at depths less than 36 inches, a shallower removal depth is possible with an experienced operator (Malcolm Pirnie, September 1980). It should be noted, however, that poorer dredging success in thinner sediment may give dredging a lower effectiveness.

4.2.4 COMMENT: (4-17;9)

"Dynamic equilibrium" is a commonly used, but incorrect term; dynamic balance is satisfactory, but "equilibrium" implies a static condition, achieved after interaction among dynamic variables.

John E. Sanders, Chairman, Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Equilbrium: "a state of balance between opposing forces or actions that is either static or dynamic (as in a reversible chemical reaction when the velocities in both directions are equal)" (Webster's New Collegiate Dictionary).

Most physical chemists would argue in a similar vein. The same argument could be made for the balance between sediment inputs and stream carrying capacities.

4.2.5 COMMENT: (4-29;2)

This whole paragraph reeks of vagueness, behind which might be some important ideas. Why not pose these possibilities as questions to be determined by the studies you keep screaming have to be done? I hope EPA is able to deal positively with your pleas for more understanding.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Paragraphs 1 and 2 on page 4-29 make an attempt to illustrate the differences between the past depositional regimes of the Thompson Island pool and the depositional regimes of downstream pools. In the Thompson Island pool, the most highly contaminated deposits are buried under less contaminated sediments and are concentrated at a depth of 6 to 8 inches below the surface. In lower reaches, PCB is found rather uniformly throughout the sediment profile and the contamination is of a lesser magnitude. This seems to indicate rapid and massive deposition of contaminated sediments in the Thompson Island pool but a more gradual deposition of PCB-laden sediments farther downstream. It is possible that the deposits in the Thompson Island pool were brought about by the massive release of sediments after the removal of the Fort Edward Dam. The more uniform distribution of contamination in lower pools might be reflecting a more uniform migration of sediment from the old dam pool and from the Thompson Island pool, that is decreasing as these disturbed areas gradually return to a more normal condition. Such a situation may partially explain why hot spots are distributed haphazardly in the Thompson Island pool but are found more often in low-velocity areas in downstream reaches.

This interesting concept was first discussed by Tofflemire and Quinn (April 1979). It may provide a clue as to what mode of sediment transport (i.e., graded or pass-through) is dominant in the Upper Hudson River. Further study to confirm and better define the mechanisms involved would go a long way in enabling a better assessment of the future movements of contaminated sediments. These questions were posed in Appendix D of the DFS along with a conceptual study design directed toward answering these and other questions.

4.2.6 COMMENT: (4-29;3)

Same problem with this paragraph and the barge traffic. You seem to put as much credence in your offhand, nondocumented remarks as in the solid data based on thousands of samples.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

An assessment of barge traffic in connection with the suspension of PCB-laden sediment was made by Tofflemire (December 1980). The assessment concluded that propeller jets and wave fronts from river traffic did, indeed, increase the local suspended solid and PCB load. These increases, however, were judged to be minor in comparison with the existing load. The authors were aware of these conclusions when the paragraph was written.

4.2.7 COMMENT: (4-45;2;15-16)

Obviously the scour during floods is going to alter "the distribution of PCB contaminated [sic] sediments". What seems to be on your mind here is that a hot spot or two might have disappeared or shifted. At the end of this paragraph, what are all the weasel words about "three times more than usually picked up" etc. if you don't say how many $ft^3\ sec^{-1}$ are involved in the "normal" annual high flows.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Contaminated sediments are distributed on the bottom in such a way as to create what is perceived to be isolated pockets of highly contaminated sediment. A flood would not suspend and move a complete hot spot from one point to another as if it were a solid object. Some sediments would be moved while others would be deposited, changing the spatial distribution of contamination.

In May 1983, flow rates above 50,000 cfs were observed and in news releases, the USGS reported that PCB transport during this flood was about three times more than what was usually seen during mean annual floods.

The mean annual flood at Fort Edward is 20,800 cfs (Malcolm Pirnie, 1975). Adjusting this flow for 63 percent more drainage area gives 33,600 cfs as a rough estimate for the mean annual flood flow at Waterford.

4.2.8 COMMENT: (4-71;3)

Here you go again about where the sediment is coming from, hot vs. cold. Of course, it would be important to understand this. But, if the reader is to believe your analysis of the LMS model, then all the eroded sediment comes from north of Thompson Island Dam and everything else is tucked away where it is not being bothered by the river. With this terribly important point up in the air, how could you have the temerity to make the ratings you did in your vast state of ignorance? This point should be settled by geologic and chemical research before any final RAMP decision about the dredging status is made re: CERCLA funds; meanwhile let Sec. 116 get moving again.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Humans do not commonly come in contact with PCBs that reside in river-bottom sediments. The potential health risk is presented by PCBs that find their way into air, water, and biota. The existing information, limited as it is, indicates that the present PCB levels in air and water do not exceed State and Federal limits, and that the risk of consuming contaminated fish is controllable (i.e., fishing restrictions). Of course, the sediments are the primary source of this contamination; but it may not be effective to remove and contain a few hot spots if vast expanses of the river bottom remain contaminated and capable of releasing PCBs. Without knowing the relative contribution of hot spots versus cold spots, it cannot be demonstrated that a major action alternative, such as hot-spot dredging, will result in a measurably lower level of public health and environmental risk than currently exists.

The question relating to the LMS PCB Transport model evaluation raises an interesting and crucial point. A major conclusion of the model evaluation contends that the PCB load of the water column is relatively conserved once it passes Thompson Island Dam and that there is little net loss or gain of PCB between Thompson Island Dam and Troy Dam. The commentor suggests that if this is true, then a cleanup of the Thompson Island pool would result in the elimination of practically all of the PCB in the water column.

Water-column PCB, however is two-phased, with both dissolved and adsorbed forms of PCB occurring, and it is the dissolved form which potentially presents the most serious problems. Dissolved PCB can be evolved at any time and from any source including suspended sediments, bed-sediments in the Thompson Island pool, or from hot- and cold-spot sediments located farther down river. Neither the LMS model nor the model evaluation adequately addressed this problem. The authors, however, urge that these aspects be investigated in depth by an appropriate agency.

In summary, the DFS authors maintain that the existing information is sufficient to formulate a decision under CERCLA. The great uncertainty associated with any major action alternative, the enormous costs of such actions, and the absence of information indicating high health and environmental hazards justifies the ratings assigned in the matrix evaluation.

4.3 COMMENTS CONCERNING PCB IN WATER

4.3.1 COMMENT:

You should have the following relevant information:

1. Mean PCB concentration in µg/l by USGS 1977-1982 - shows significant decreases with time.

2. Table 1 - mean low flow water statistics by Tofflemire - shows significant decreases. Also Figure on Log-Log Regression Lines for Waterford shows decreases with time. Also, peak PCB occurs at high flow on particulates.

3. May 28, 1982 USGS data on April 1982 flood. The maximum PCB, at Waterford, was .73 µg/l at 51,000 cfs flow.

4. Data list by USGS on Waterford Water supply 1976-1978 Treated PCB <.1 µg/1.

5. Data list by O'Brien and Gere, Waterford Water Supply 1978-79, treated PCB <.1 µg/l.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York.

RESPONSE:

Mean PCB concentrations and low-flow statistics showing significant decreases in PCB are found in Tables 4-8 and 4-9 of the DFS. These tables were discussed in the DFS and will not be discussed here.

Log-log regression lines showing the trend over time of PCB concentration in relation to discharge are given for Waterford in Figure R4-1. This figure illustrates that, although water-column PCB does vary with flow (increasing with both decreasing flow and increasing flow from a low value at average flows), the actual relationship with discharge has been decreasing. That is, the expected high value during floods is decreasing over time, the expected low value during average flows is decreasing over time, and the expected high value during low flows is decreasing over time.

Maximum observed PCB concentrations (USGS data) at Stillwater and Waterford and PCB concentrations during maximum observed discharges are given in Table R4-2. This table illustrates the extreme variability of PCB during high flows and also that, on an annual basis, the highest PCB concentrations are not always observed at the highest discharges. High PCB values can occur immediately before or after the high flow and, in some years, they can occur during low flows. These tables show no discernible trends.

PCB concentrations observed in Waterford drinking water and the data list by O'Brien and Gere (April 1981), showing PCB concentrations in untreated and finished water, are shown in Tables R4-3 and R4-4. These data reiterate the statements of DFS Section 5, which conclude that even with existing treatment, drinking water contains quantities of PCB that are less than the NYSDOH-recommended limit. The data enforce the notion that public health problems associated with the Hudson River PCBs may be minimal.

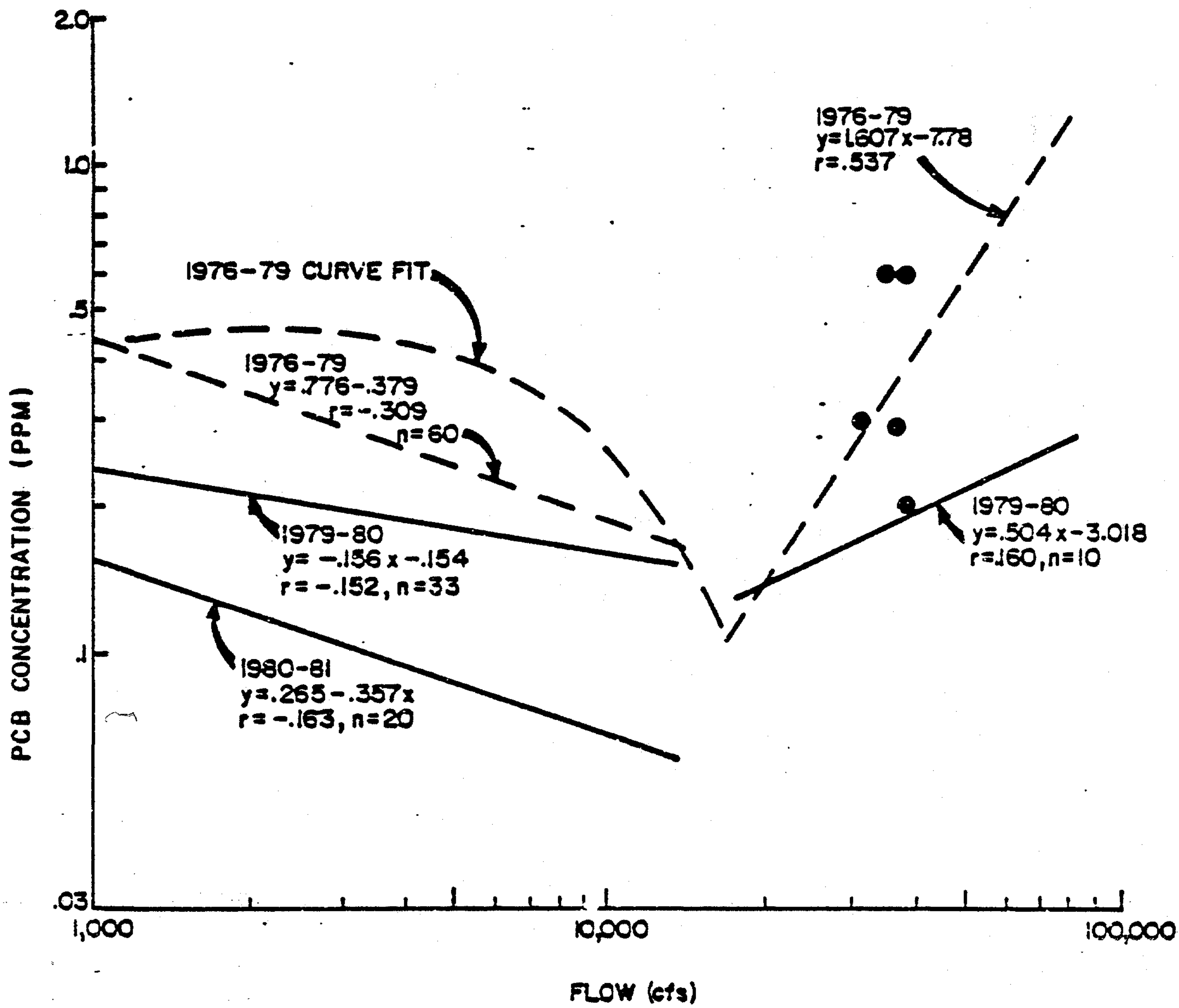
4.3.2 COMMENT: (4-39;2;2)

Where do you get this "emulsified" state? Is it an alternative to being in the dissolved state? Or are you using it as a synonym for dissolved? Not careful usage at all. Also in the less-than-precise category is "transfer state." What you seem to be dealing with here is mechanism of transport in a river. Nowhere have you included the basis for any of these categories. As far as the U.S. Geological Survey is concerned, the world is divided into two parts by a 0.45-micron filter. What passes is "dissolved"; what does not is "suspended." Emulsified?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

When something is dissolved in water, individual molecules become free and unassociated with each other. It is likely that a highly insoluble and nonpolar compound such as PCB may be present as tiny, oil-like droplets suspended in the water column. Such a dispersion of one liquid in another is called an emulsion. Emulsified PCB would pass a 0.45-micron filter and be classified as dissolved according to USGS standards. Emulsified was dropped from the text since the actual form of desorbed PCB is only speculation.



● 1980-81 INSUFFICIENT FOR REGRESSION

SOURCE: TOFFLEMIRE & WERNER 1980 UNPUBLISHED INFORMATION

FIGURE R4-1

WATERFORD LOG-LOG REGRESSION LINES
HUDSON RIVER SITE, HUDSON RIVER, NY

NUS CORPORATION
A Halliburton Company

TABLE R4-2

MAXIMUM OBSERVED PCB CONCENTRATION AND PCB CONCENTRATIONS DURING ANNUAL HIGH FLOW IN THE UPPER HUDSON RIVER AT WATERFORD AND STILLWATER, NEW YORK

MAXIMUM OBSERVED PCB CONCENTRATION			MAXIMUM OBSERVED FLOW RATE		
Date	Discharge (cfs)	PCB (ppb)	Date	Discharge (cfs)	PCB (ppb)
		WATERFORD			
3/15/77	70,500	1.40	3/15/77	70,500	1.40
6/1/78	7,180	0.80	3/28/77	23,600	0.43
4/29/79	39,800	2.58	3/7/79	47,400	0.27
7/24/80	3,220	1.60	3/22/80	42,400	0.09
2/22/81	38,700	0.57	2/22/81	39,000	0.55
4/19/82	51,600	0.73	4/19/82	51,600	0.73
5/2/83	51,700	1.02	5/3/83	52,000	0.41
		STILLWATER			
10/18/77	23,100	2.36	3/14/77	38,000	>.10
8/31/78	3,350	0.87	4/14/78	17,600	0.42
3/26/79	30,700	5.11	4/29/79	39,300	1.92
4/11/80	27,300	0.57	4/11/80	27,300	0.57
2/21/81	29,400	1.33	2/21/81	30,900	0.93
4/20/82	27,900	1.47	4/19/82	35,100	0.45
3/4/83	45,000	3.29	5/4/83	45,000	3.29

Source: U.S.G.S. Data

TABLE R4-3

PCB LEVELS IN THE VILLAGE OF WATERFORD DRINKING WATER

Organic Chemical	Samples Analyzed	Sampling Period	High Value ug/l	Low Value ug/l	Average Value ug/l
Arochlor 1221	3	9/29/77 6/1/83	<0.05	<0.05	0
Arochlor 1016/1242	3	9/29/77 6/1/83	0.3	<0.05	0.10
Arochlor 1254	3	9/29/77 6/1/83	0.5	<0.05	0.16
Arochlor 1260	2	10/22/81 6/1/83	<0.05	<0.05	0
Arochlor 1248	1	6/1/83	<0.05	<0.05	0
PCB Total	23	11/15/76 9/27/77	0.01	0	0.02

No value was above the 1 ug/l guideline for PCBs, set by NYSDOH.

Source: NY State Department of Health. September 1983.

TABLE R4-4

PCB CONCENTRATION OF UNTREATED AND FINISHED DRINKING WATER

Poughkeepsie

Date	Untreated (ug/l)	Finished (ug/l)
7/19/78	0.10	-
8/2/78	0.07	-
8/29/78	< 0.01	-
9/28/78	< 0.01	-
10/13/78	0.30	< 0.01
10/25/78	0.10	< 0.01
11/2/78	0.14	0.02
12/6/78	< 0.01	-
1/15/79	0.06	-
2/16/79	0.07	-

Waterford

Date	Untreated (ug/l)	Finished (ug/l)
8/29/78	0.20	< 0.01
9/13/78	0.70	< 0.01
10/3/78	0.30	< 0.01
10/12/78	0.40	0.10
11/15/78	0.02	-
12/8/78	0.02	-
1/4/78	0.06	-
2/16/79	0.20	-
5/11/79	0.05	-
5/17/79	0.03	-
5/24/79	0.03	-
5/31/79	0.10	-
6/7/79	0.01	-
6/12/79	0.11	-
6/21/79	0.01	-
6/28/79	0.14	-
7/5/79	0.08	-
7/17/79	< 0.01	-
8/2/79	0.07	-
8/15/79	0.06	-
8/30/79	0.08	-
10/10/79	0.03	-
10/22/79	0.01	-

Source: O'Brien and Gere, April 1981.

4.3.3 COMMENT: (4-39;2;7)

Your words "transition from one PCB transfer mechanism to the other..." imply a totally wrong conception. What is dissolved is always dissolved, no matter what else is going on. At higher flow stages, this dissolved load becomes overwhelmed by the great increase in the suspended load. There is no transition from one to the other, only a varying proportion of each, depending on what the river is doing. The predominance or relative proportion of the total belonging to each category is what changes.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The concept was understood by the authors as evidenced by the two preceeding paragraphs in the DFS. The inaccurate phrasing was corrected.

4.3.4 COMMENT: (4-43;3)

End of this par.: the Brown and Werner basis for saying reduction in PCB releases from bed sediments might also be a function of less water coming down the river. The fact that these releases increased again in 1983 suggests the control by water discharge.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Environmental PCB concentrations have decreased much more rapidly than had been anticipated (Schroeder and Barnes, 1983). Few studies have tried to explain this phenomenon. Brown and Werner (1983) suggested a number of mechanisms that could have been responsible. They noted that the elimination of industrial PCB discharges, the stabilization of contaminated river banks at Fort Edward, and a reduction in the releases of PCB from bed sediments have all contributed to the declines in fish [as well as in air and water] contamination that have been observed. Schroeder and Barnes (1983) have suggested that since the initial monitoring efforts, contaminated deposits have been covered with a thin layer of relatively clean sediment, which prevents the transfer of dissolved PCB to the water column and which armors the contaminated beds against scour during moderately high flows.

The commentor suggests that because water column PCB increases with the suspension of sediment during increasing flows, that the recent observed contamination trends are due to low annual flow patterns. Extension of this hypothesis suggests that a return of higher flow patterns will increase the environmental concentration of PCB. This is the type of scenario projected by the Lawler, Matusky, and Skelly PCB model.

A number of indicators seem to show that such a scenario will not occur, at least at the magnitude indicated by the model. In the first place, when flow data are converted by drainage-area scaling to equivalent values at Spier Falls, the recent average annual flows observed at Stillwater (about 5000 to 6000 cfs) are very close to the mean annual flows at Spier Falls for the 47-year period of record.

On the average, scouring flows occur above 12,000 cfs at Waterford and decrease in proportion to drainage area for areas above Waterford, (Schroeder and Barnes, 1983). According to the annual flow frequency histogram in the LMS report (1978), such flows will occur between 7 to 20 days per year. According to data presented by Schroeder and Barnes (1983), scouring flows have occurred with a near-normal frequency in the last 5 years.

Therefore given that 1) annual flows have been normal, 2) scouring flows have occurred with a near-normal frequency, and 3) the LMS model overestimates PCB transport, it is believed that recently observed PCB transport (and concentrations) represents the average conditions that may be expected to occur any time in the future. If high flow patterns do return as projected by the LMS model, PCB transport and environmental concentrations will not be nearly as high as expected because, according to analysis in the DFS, the model highly overestimates PCB transport at high flows.

Also, no consideration has been given to the idea that PCB availability will decrease as time goes on. It is speculated that the most unstable deposits are gradually being eroded away and that annual deposition and scour patterns are progressively mixing up contaminated and clean sediments in more stable areas. As this process continues, the most heavily contaminated deposits will slowly become diluted and the availability of PCB will decrease.

4.3.5 COMMENT: (4-70;2)

This whole paragraph could be vastly improved with a few numbers added in. How about a figure to show what these U.S. Geologic Survey measurements were?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The comment refers to page 4-70, paragraph 2, lines 4 through 7, which state that PCB transport from the Upper Hudson River has been relatively small between 1977 and 1982. Yearly PCB transport estimates for these years, as given by Tofflemire (April 1981) and Brown and Werner (1983), were shown in Figure 4-5 of the DFS. Summing these values gives from 22,038 to 25,527 pounds of PCB transferred from the Upper Hudson to the

Lower Hudson. This is a small percentage of the total mass estimated to be in the river.

4.4 COMMENTS CONCERNING PCB IN BIOTA

4.4.1 COMMENT:

The RAMP study revises and extends the previously projected natural recovery period of the Hudson River. RAMP at 8-1 to 8-8. However, the RAMP does not note that recovery of the river, in terms of decreases in PCB levels in fish to below FDA's 5 ppm level, can be expected to occur well before then.

James R. Donnalley, Vice President, Corporate Environmental Programs, General Electric Company.

RESPONSE:

The situation, with respect to contamination of the Hudson River fishery, is discussed in the response to comment 4.4.3.

4.4.2 COMMENT: (4-45;2;3)

Only Sloan and Armstrong could get involved in "observation of misleading relationships." I haven't the faintest idea of what they were getting at, but possibly they meant that what goes on at low-water flows is not the same as what happens when water discharge is high (or higher). (Especially when high flows are absent; how can their relationships then be observed?)

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The comment addresses the conclusions arrived at by Sloan and Armstrong (1980) and Armstrong and Sloan (1980) in their studies on PCB trends in Hudson River fish. This situation is discussed in the response to comment 4.4.3.

4.4.3 COMMENT:

The RAMP suggests that declining PCB levels in fish "could be artificial" since the background studies were done during a period of "exceptionally stable river flows." RAMP at 4-64. However, this is contradicted at p. 4-45. There, the RAMP notes that the same source has "suggested that an absence of excessively high flows in recent years has resulted in the observance of misleading relationships (Sloan and Armstrong, 1980)," but responds that "with the exception of 1980, mean annual flows have been slightly above normal indicating that the recent annual flow regimes have not been unusually low." Id. Furthermore, although the RAMP study refers to, it does not include, the latest data (1981-82) on PCB concentrations in

Hudson River fish. RAMP at 4-60. These data are also inconsistent with and refute the speculation, based on earlier data, that "PCB concentrations in fish should not continue to decline substantially under present conditions...." RAMP at 4-64.

James R. Donnalley, Vice President, Corporate Environmental Programs, General Electric Company.

RESPONSE

The future trend in PCB content of Hudson River fish is an important issue. The bulk of the work on PCB trends in fish was done for NYSDEC by Sloan and Armstrong (1980) and Armstrong and Sloan (1980). Based on fisheries data from the period between 1977 and 1980, Armstrong and Sloan identified an unquestionable decreasing trend in the PCB content of all freshwater and migrant-marine species they had studied, a trend that has continued through 1983 (NYSDEC November, 1983). Armstrong and Sloan speculated that these decreases could be related to the cessation of PCB discharges from the GE plants and to the elimination of lesser chlorinated PCB isomers by way of volatilization and metabolic processes. Armstrong and Sloan, however, did not conclude that this trend would continue indefinitely. They noted that a high PCB content could be associated with the resuspension of more highly contaminated sediments during exceptionally high flood flows. Furthermore, they stated, that because such high flows had not occurred since 1977, the decreasing trend could be "misleading" and not representative of the possible course that PCB trends could take under less stable flow patterns.

The DFS authors do not strongly agree with the contention that the trends of PCB in fish will change after a flood. Flow statistics for the Hudson River at Stillwater, as presented by Brown and Werner (1983) and the DFS (Table 4-10), show that maximum flow rates (daily averages) varied from 17,000 to 40,000 cfs between 1976 and 1982. Apparently then, "exceptional" flows are flows greater than 40,000 cfs, because this is the highest daily flow during 1977 which is the year of the highest observed PCB concentration in fish. Similarly a "stable flow pattern" would be a string of flows which fluctuated below 40,000 cfs. A flow of 40,000 cfs will roughly have a 10 percent chance of occurring in any year. Such an infrequent event may affect the PCB content of a localized population for a short period of time; however, large infrequent floods would not likely have a strong impact on the overall trend. Secondly, the large flows and the high PCB content of fish in 1977 and 1978 roughly correspond to a period of dredging and excavation around Rodgers Island. Therefore it would be difficult to isolate the flood flows as the cause of high PCB contamination.

The question remains as to what the future trend in fish contamination will be. Before this question can be answered, a number of important mechanisms must be considered. PCB accumulation in fish could be related to the dissolved PCB concentration, to the concentration of resuspended PCB-laden sediments, to the PCB concentration of food, or to a combination of the three mechanisms. Brown and Werner (1983) have speculated that the

100796

PCB content of fish is most strongly related to the dissolved PCB content during the more frequent low-flow periods. But they point out that because of the long residence times of flood waves in the estuary, flood-suspended sediment has a significant impact on Lower Hudson River fish populations. It has been shown by Tofflemire (1980) and the DFS that low-flow PCB concentrations have decreased dramatically since 1977; yet the mechanisms responsible for the decrease in dissolved PCB are unknown. Schroeder and Barnes (1983) have suggested that the release of PCB from the contaminated deposits is being limited by a recently deposited layer of clean sediment.

Armstrong and Sloan (1980) have warned that the return of exceptionally high flows could bring about an increase in the PCB content of fish, but it appears unlikely that contaminated sediment stirred-up by a single flood will affect the decreasing trend appreciably. There is, however, the question of whether a long-term, gradual increase in the flow pattern would result in corresponding increase in environmental PCB. This question is related to the hypothesized 20-year flow cycle which is discussed elsewhere in this report. There is insufficient information to address this problem with respect to fish at the present time.

The mechanisms of bioaccumulation of PCB in the Hudson are complex and its significance in the present trends are not well understood. It is known that the PCB concentration of certain benthic organisms and other aquatic life has decreased along with the PCB content of fish (NYSDEC, 1981). But again, the underlying mechanism responsible is not known. It could be speculated that the deposition of cleaner sediments has provided cleaner substrates for the organisms.

Another process which could influence future trends is the elimination of the more volatile PCB isomers. Armstrong and Sloan (1980) indicated that most of the decreases in PCB content of fish were related to losses of Aroclor 1016. They remarked that as this mixture was depleted, the decreases in PCB content of fish would become less and less.

In summary, the issue of PCB contamination in fish is a complex one, uniquely related to basic questions which are as yet unanswered. The striking decrease in PCB content observed from year to year may represent a natural recovery mechanism that will continue, and perhaps should not be tampered with. Moreover, it is difficult to adequately demonstrate that removal of a certain percentage of PCB-contaminated sediment will result in a corresponding decrease in fish contamination or in an accelerated recovery rate.

A recent news release by NYSDEC has indicated that studies show a continued decline in the PCB contamination of fish. The average PCB content of striped bass has reached 4.8 ppm, which is about the same as the FDA recommended limit of 5 ppm. Therefore, the authors contend that in light of the continued decline in fish contamination, further monitoring, in combination with a continuance of the restrictions on fishing, is sufficient to protect the health of residents.

4.4.4 COMMENT: (4-60;1;2)

Please delete this "half-life" usage. It is completely wrong and has nothing whatever to do with the half lives of radioactive isotopes that served as the supposed "model" of this kind of biologic-environmental usage.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The half-life terminology was taken from Armstrong and Sloan (1980) and was used in the DFS only in conjunction with Armstrong and Sloan's reported results.

The half-life values were based on the first-order rate-law. In many cases, absorption or elimination of a compound by an organism are assumed to follow exponential, or first-order kinetics (i.e; a constant fraction of a drug or compound will be eliminated per unit of time) (Goodman and Gilman, 1980).

The rate of an exponential process can be described by its rate constant, which expresses the fractional change per unit of time or by its half time - the time required for 50 percent completion of the process. Both terms are independent of drug or chemical concentration. Therefore one can speak of half-life, although half-time might be a better term used in association with the presence of drugs or chemicals in the body.

Sloan and Armstrong used the first-order rate law in an attempt to predict the average time required for a 50 percent decline in lipid-based PCB to occur in a comparable population of fish. The appropriateness of half-life as applied to a population rather than to an individual is unknown.

Although no particular significance was attached to Sloan and Armstrong's half-life values, they will be retained in the DFS in the event that a reader may accept the mathematical model and wish to use them.

4.4.5 COMMENT: (4-67;3;7)

Are you not aware that the Boyce Thompson results indicate that PCB contamination of plants comes via the atmosphere and not via the plant roots? This is a hugely important point, and the way you present it, you give a wrong impression.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

PCB uptake by plants can occur at the roots (root uptake) or at the leaves (foliar uptake) (Buckley, 1981). The rate and mode of PCB uptake is highly species-dependent. "Root uptake of PCBs in soil can be as great as the PCB level in the soil if it is sandy, or it may be substantially less than the PCB concentration in the soil where organic matter and clays are also present" (Buckley, 1981). However, translocation of PCBs from roots to above-ground plant parts is negligible in many species and therefore the PCB concentration of leaves is probably the result of foliar uptake.

4.5 COMMENTS CONCERNING PCB TRANSPORT

4.5.1 COMMENT: (4-43;2)

What good is the 20-year average PCB transport rate from the LMS model, when they went out of their way to present predictions based on a 20-yr flow cycle? You've not taken advantage of an opportunity to compare their cyclic predictions with reality in the 5 years since they worked up the model.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Lawler, Matusky, and Skelly (1979) incorporated a 20-year flow cycle into their PCB transport model. This cycle is based on the apparent historical repetition of a certain 20-year flow pattern which is assumed to continue to repeat in the future. Practically speaking, the 20-year flow pattern used in the model results in the prediction of a decreasing flow and PCB transport up to the early 1980's, low and relatively constant flows and PCB transport through the 80's, and increasing flows and PCB transport for the early 1990's to the end of the flow cycle at about the turn of the century. However, to reach conclusions on the time period for a natural clean-up and on the magnitude of contamination inputs to the estuary, LMS relied mostly on average transport values for the 20-year cycle. For the 20-year period, their model shows an average PCB transport rate of about 7200 pounds per year for existing conditions. It will be shown below that this rate may be much too high and that the significance of the 20-year cycle may have been largely overstated.

In Figure R4-2, the LMS predictions for the first six years of the model are compared with PCB transport estimates developed from USGS monitoring data from the Stillwater gaging station (Brown & Werner, 1983).

The flow values used in the LMS model to simulate flows for 1977 to 1982 are actually the average annual flows that occurred at Spier Falls from 1956 to 1962. The Brown and Werner flows are calendar-year flow averages for Stillwater corrected for drainage area to make them more comparable with Spier Falls data.

Comparing the flows for various years shows that the hydrologic model has performed relatively well up to 1982. Not only do the annual average flows compare well--all differences in the average annual flows are less than 2000 cfs--but the monitoring data from Stillwater show a decreasing trend that is consistent with the initial falling period in the 20-year flow cycle. However, the differences do tend to increase with time and the 1977 and 1978 flow values match so well that there is a question as to whether LMS used actual measured flows for this period.

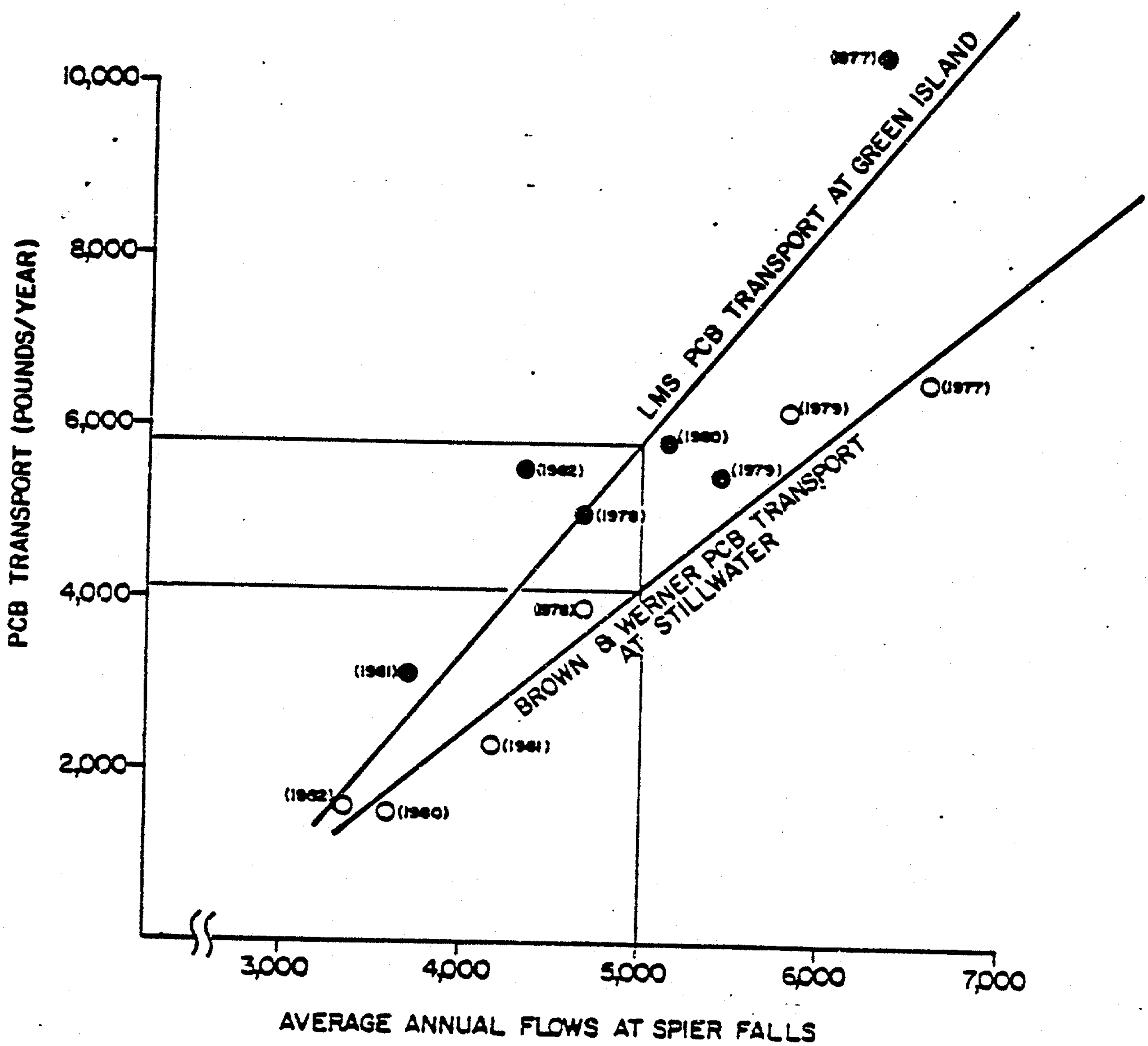
The value of comparing the model results at Green Island with estimated PCB loads of Stillwater is uncertain. Figures IV-17 and IV-26 of the LMS report show that for a given flow frequency, the PCB transport rate at Stillwater is slightly larger than the PCB transport rate at Green Island/Waterford. Thus, on an average annual basis, PCB transport at Stillwater should be greater than that at Green Island. On the other hand, the DFS model evaluation suggested that the PCB load was relatively conserved once it passed the Thompson Island Dam. Therefore, the PCB transport rates at Stillwater and Green Island should be similar because increases in discharge between the stations should be offset by the dilution of PCB by tributary flows. In short, because the normal relationship between PCB transport at Stillwater and PCB transport at Green Island is not clear, the comparison in Figure R4-2 can be questioned.

Nevertheless, the LMS predictions of PCB transport at Green Island are consistently larger than estimates of PCB transport at Stillwater. From the hand-fitted curves in Figure R4-2, it is seen that for average flows at Spier Falls (about 5000 cfs), the model overestimates the average annual PCB transport rate by nearly 2000 pounds. This difference is less at lower flows and greater at higher flows. If actual PCB transport at Stillwater is normally larger than that at Green Island, then the amount of overestimation would be much greater.

A higher transport rate at Green Island is in disagreement with the hypotheses of both the LMS model and the DFS model evaluation. Transport rates at Stillwater should be roughly equal to or greater than transport rates at Green Island unless massive scour is occurring in all reaches between the two stations. If this comparison is valid, it tends to support a major conclusion of the model evaluation which contends that the LMS model highly overestimates PCB transport, especially at high flows. This is significant, for if it is true, it indicates that scour during the predicted high flow period of the 1990's will not be nearly as severe as was supposed. It also suggests that the 20-year average transport rate of 7200 pound per year is much too high and that the currently estimated transport rate--1500 to 2200 pounds per year--which has occurred during average flow conditions--is much more typical.

4.5.2 COMMENT:

The study's critique of the LMS model does not incorporate the twenty year flow cycle of the Hudson River. This component of the LMS model is the main reason for expeditious remedial action pertaining to the high contaminated PCB sediments in the upper Hudson. However, the study uses its projected time figure in Section 10, without the flow cycle incorporated.



LEGEND

- ● LMS MODEL RESULTS FOR WATERFORD
- O BROWN & WERNER ESTIMATED PCB TRANSPORT AT STILLWATER

FLOW AND PCB TRANSPORT COMPARISON
HUDSON RIVER SITE, HUDSON RIVER, NY

FIGURE R4-2

NUS CORPORATION
A Halliburton Company

Thus the feasibility study does not comprehensively review the LMS model, but only uses portions of it when convenient to the support of a predetermined position of the agency not to dredge the PCB hot spots in the upper Hudson.

Scenic Hudson, Poughkeepsie, New York.

Similar comments made by:

- John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.
- Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.
- A. Karim Ahmed, Senior Staff Scientist, National Resource Defense Council, Inc.

RESPONSE:

In response to this criticism of the draft Feasibility Study, three principal questions must be addressed:

- What is the reliability of the 20-year flow cycle?
- How do the flow conditions of the last several years compare to the distribution of flow in the 20-year cycle?
- What is the expected relationship between river flows and the rate of PCB transport?

According to the 20-year flow cycle developed by LMS, unusually high flow conditions (which were concluded by LMS to account for a large percentage of the PCB loads) are not expected until the early 1990's. This apparently has led to the notion that remedial action should be expedited" while we still have time". For several reasons, however, it is not prudent to so include the 20-year cycle in the remedial action decision-making process. First, because the hydrologic cycle is stochastic, the high flows of concern to PCB transport can occur in any given year. Second, the regression analysis used to develop the 20-year cycle was based on mean monthly flows, whereas individual storm events would be more critical to sediment scour and PCB transport. Third, because the 20-year cycle was developed from only 48 years of data, in essence only two cycles were available for the statistical analysis. Finally, an r^2 value of 0.508 (i.e., 50.8 percent of the variance in the monthly data was removed by the flow model) is not particularly high. Note also that the final flow model also had 10-, 5-, 4-, 2-, and 1-year harmonic components, and that the 20-year periodic term accounted for only 21 percent of the variance removed. In summary, the 20-year flow cycle provided a convenient mechanism for projecting future conditions using the LMS model, but its limitations must be recognized.

The second and third questions are also related to the 20-year cycle due to a concern that any projections based on recent data will be misleading since the critical highflow values expected in the future are not accounted for. In addressing the second question, it can be concluded that the flow data from the last several years at Stillwater represent typical conditions for the Hudson River. For example, if the flow data are converted by drainage area scaling to equivalent values at Spier Falls, the average flow for the period 1977-1982 (approximately 5000 cfs) is very close to both the mean annual flow of 4937 cfs for the 47-year period of record, and the median flow value in the 20-year cycle developed by LMS (Figure V-4).

Given that the recent data reflect average conditions as per river flow, the final issue is whether the corresponding PCB data can be considered representative of average PCB loading conditions. A widespread belief, based on the results of the LMS, model is that high flows dominate PCB transport, and thus that river flows and PCB loads are not linearly related. This belief has been reinforced by statements such as the following, which addresses Figures V-4 and V-5 (LMS, 1978):

"The annual sediment loading pattern resembles the hydrologic pattern; however, there is a range of practically three orders of magnitude on the model's minimum to maximum sediment transport through the river at Lock 7."

The actual range is less than two orders of magnitude. What is also misleading is that the range of daily flows over the same period (which is not shown) probably approaches the same 100-fold value. For comparison purposes, the ratio of the maximum and minimum monthly flows is 2.8, whereas the corresponding value for PCB loads is 4.0. This would indicate that high flows are relatively of more importance to PCB transport, but one must recall the following conclusion of the critique of the LMS model (DFS page 4-91):

"...the (LMS) model overestimates PCB loads by almost an order of magnitude at high flows, with an even more serious underestimation of loads at low flows."

Each of these shortcomings would tend to significantly reduce the maximum to minimum ratio of 4.0 for PCB loads, and to conclude that the ratios of flows and PCB loads behave similarly is not unreasonable. This is not to say that high flows do not scour additional PCB-laden sediments, but rather that the level of continual PCB release under low and intermediate flow conditions is sufficient to balance the high flow values on an average basis.

In conclusion, even if the 20-year flow cycle is representative of future conditions, the fact that the draft Feasibility Study ignored the cycle is not a critical shortcoming. The annual PCB loads developed from recent data and extrapolated to future conditions are based on flows representative of average conditions for the Hudson River, and in our opinion are also representative of long-term average PCB loading conditions. This extrapolation of recent conditions may even be an overestimate based on the observed decreasing trend of PCB loads in recent years under average flow conditions. Also see the response to comment 4.5.1.

4.5.3 COMMENT: (4-99;3)

This is the most-important point in your report. Yet, you have probably ignored it in making up your ratings. What I take this to mean is the high probability that a cleanup at Thompson Island pool would in fact clean up the river, period. If that's where all the PCBs are now coming from and the contaminated sediments are taken out of the river, then the problem is solved, and all the benefits will be felt immediately downriver. This point is so important that I do not see how you can defend making any conclusions until this is resolved.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

Similar comments made by:

- Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.
- A. Karim Ahmed, Senior Staff Scientist, National Resource Defense Council, Inc.

RESPONSE:

The "no deposition-no scour" or "pass-through suspension" model introduced by the DFS PCB transport model evaluation was proposed to explain the inconsistencies in the LMS model calibration scheme. In essance, the pass-through model contends that most of the material in transport, including PCBs, originated between Fort Edward and Stillwater and that this material continued down the Hudson River and into the estuary with little loss or gain of suspended load.

This concept was verified in the model evaluation by correcting suspended sediment and PCB loads at various stations for drainage area increases, and plotting these data together on one figure. The suspended sediment-flow and PCB concentration-flow relationships for each station were found to be indistinguishable on the plots, indicating that whatever material was in transport at Stillwater remained so until it reached the estuary.

The underlying problem was to explain where most of the suspended sediment and PCB originated because it was found that what passed into the Thompson Island pool at the Fort Edward gaging station amounted to only 10 percent of the load at Stillwater. The DFS speculated that the Thompson Island pool would be the most logical source because, from a historical perspective, this pool would have been most susceptible to the destabilizing influences of the Fort Edward Dam removal and the subsequent deposition and dredging of large amounts of contaminated sediment. Unfortunately, there were very few field data from gauging stations between Fort Edward and Stillwater to confirm this hypothesis.

Thus it can be concluded with certainty only that most of the suspended material and PCBs originated from somewhere between Fort Edward and Stillwater.

Within this reach are found 36 of the 40 so called hot spots and four major tributaries. Thus it is not a strong conclusion that the Thompson Island pool is the major source of PCB contamination and it would be a mistake to conclude that this pool contributes 100 percent of the PCB problem.

Dredging in this pool suffers from the same uncertainties and problems as the full-scale dredging alternative. If it were verified that the Thompson Island pool contributed most of the suspended PCB-laden sediment, the "level of cleanup" effectiveness measure might be increased to equal that of the full-scale dredging option. Under the new matrix scheme this would increase the cost-effectiveness of Thompson Island pool dredging to 6.2. This is still significantly less than the cost-effectiveness of the chosen alternative.

Moreover, neither the LMS model nor the model evaluation adequately address the origin of dissolved PCBs. Dissolved PCB transfer is now thought to be a function of biological activities (Schroeder and Barnes, 1983) and is not under the control of the river flow. The transfer of dissolved PCB to the water column is constant regardless of the flow and this type of transfer will occur anywhere PCB-contaminated sediments exist. Since the dissolved component potentially presents the most serious problem, addressing the dredging question in terms of sediment resuspension only may not be the best approach.

4.6 OTHER COMMENTS

4.6.1 COMMENT: (General)

Existing data on wetlands, private wells, and plant PCB values appear not to have been used by the consultant.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York.

RESPONSE:

All existing data that could be located were used in preparation of the DFS.

The data on private wells and on PCB values in the Moreau Marsh have recently been sent to the DFS authors. A brief review of this information indicates that it would not have a large impact on the final conclusions of the Feasibility Study.

4.6.2 COMMENT:

On the issue of landfilling I would also care to point out that environmental scientists agree that the Hudson Valley region of the Northeastern United States is totally unsuitable for landfilling, due to the high watertable. In fact, the watertable at the proposed landfill in Ft. Edward would be less than five feet from the bottom of the landfill.

Gerald B. Solomon, Congressman

RESPONSE:

An analysis of the proposed landfill design by the DFS authors concluded that with the exception of the depth to groundwater criteria, the proposed containment facility would generally meet all State and Federal regulations and that the design incorporated acceptable engineering practices. A commentor also notes:

"... a high difference exists in the groundwater piezometric situation. At Site 10, the piezometric flow is from the surrounding hills deep downward and then upward beneath the site. As such, it is guaranteed against groundwater contamination.'

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

4.6.3 COMMENT: (4-17;3;5)

In 1.6, where did you find a meander in the upper Hudson River?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The passage in general refers to hot spots that have formed on the outside banks or the concave side of bends in the river. More specifically it was referring to two hot spots that had formed on the outside banks of a pronounced "S" shaped curve near Lock 6. These were referred to as meanders because of their general appearance. A good definition of a meander is: "one of a series of somewhat regular and looplike bends in the course of a stream, developed when the stream is flowing at grade, through internal shifting of its course toward the convex sides of the original curve" (American Geological Institute Dictionary).

Because the exact fluvial processes involved at the bend in question are unknown, "meander" is probably not an appropriate word. This word has been eliminated from the Feasibility Study Report.

4.6.4 COMMENT: (4-29;1;5)

"Decrease in PCB use" is a vacuous remark; GE has stopped dumping the stuff altogether and has built a wastewater-treatment plant so that their floor-washing water, etc., is cleansed before being returned to the river.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The passage was changed to "virtual elimination".

4.6.5 COMMENT (4-77;1;7-9)

Where did you pick up this idea of modifying the geometric configuration (not geometry, surely) of the river in order to "reduce scour velocity?" The scour velocity is not going to change; you may change how the river behaves, but it is going to be expensive, because such changes involve making deep holes in the channel, and the upper Hudson flows on a thin (ca. 18 inches) carpet of sediment which in turn rests on bedrock.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The idea of modifying channel geometry as a potential mitigating measure was put forth in the "No Action Alternative Study." On page I-4 of Section I (Summary of Findings, Conclusions, and Recommendations), it is stated that the findings of the modeling study suggest that the following mitigating measure is feasible:

"Geometric Changes in River Profile - Dredging the river bed as well as widening the river to reduce stream velocity in areas prone to scour".

On page I-6, it is further stated that:

"The LMS model should also be used to investigate possible stream modifications, such as expansion of the river cross-sectional area to reduce flow velocities within the lower reaches when scouring of the river bed can be significant."

The statement made by the DFS authors on page 4-77 of the draft Feasibility Study Report was not intended to imply concurrence with the LMS conclusions and recommendations, but rather to indicate that a deficiency in the hydraulic calibration of the LMS model would reduce the perceived feasibility of modifying the channel geometry. We agree that the this alternative would be very costly, and that any resultant reductions in stream velocity would not be significant enough to warrant its implementation.

The use of the words "to reduce scour velocity" on page 4-77 was admittedly an oversight that could result in a misinterpretation of the statement. An alternative wording would be: to reduce stream velocity, and thus to reduce the scour potential of the flow".

5.0 COMMENTS ON SECTION 5 (PUBLIC HEALTH CONCERNS)

5.1 COMMENT:

You write some rather specific things here about human-health effects of PCBs that totally lack documentation. The Advisory Committee has been trying to pin down these effects for more than 5 years; what are your sources?

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

The following references concerning the general health effects of PCBs were used:

- Clayton, G.D. and F.E. Clayton, 1981. Patty's Industrial Hygiene and Toxicology, Vol. 2B, Toxicology. John-Wiley & Sons, New York, New York, pp. 3645-3669.
- Finkel, A.J., 1983. Hamilton and Hardy's Industrial Toxicology, Fourth Edition. John-Wright, PSG, Inc., Boston, Massachusetts, pp. 238-240.
- Sax, N. I., 1979. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Company, New York, New York, pp. 484-485.
- Menyer, R.E., and J.O. Nelson, 1980. "Water and Soil Pollutants." Casarett and Doull's Toxicology, The Basic Science of Poison, Eds., J. Doull, C.D. Klaassen, and M.O. Amdor. Second Edition, Macmillan Publishing Co., Inc., New York, p. 647.

Discussions on PCB-related tumor formation in mammals may be found in:

- International Agency for Research on Cancer, 1978. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 18, pp. 43-103.
- International Agency for Cancer Research, 1979. IARC Monographs on the Carcinogenic Risk of Chemicals to Humans, Chemicals and Industrial Processes Associated With Cancer in Humans. Monographs Supplement No. 1, p. 41.

5.2 COMMENT: (5-6; 4; 2)

The statement made here (that volatilization is generally almost non-existent) is contradicted by levels of PCBs in air at PCB contamination sites listed in Section 4, and the figures listed within the same paragraph.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The vapor pressure of PCB is extremely low, ranging from 0.9 X 10^{-4} mm Hg for Aroclor 1260 to 9.0 X 10^{-4} mm Hg for Aroclor 1242 (National Academy of Sciences, 1979). Therefore, relative to other types of organic contaminants, PCBs are not considered to be very volatile, and exposures from the atmospheric pathway are not usually regarded as a serious threat.

However, where concentrated sources of PCB exist, it is possible to get measurable and sometimes significant quantities of airborne PCBs in the atmosphere. As illustrated in Section 4 of the DFS, high concentrations of PCBs have been found in the air near the GE plants in Fort Edward, near dredge spoils and dump sites, and over remnant deposits. Concentrations over the river and near riffles and dams are usually much less than the NYSDOH-recommended limit of 1 $\mu g \cdot m^{-3}$.

Atmospheric contamination has probably been greatly reduced following the elimination of PCB use at GE and the remedial activities at the dump sites. At this time, there is no evidence to establish that volatilization from the river has ever presented a significant threat; however, it was recommended by the DFS authors that additional air sampling be done at remnant sites, dredge spoil sites, and near riffles and dams to confirm this conclusion.

5.3 COMMENT:

There is now a substantial body of scientific data and studies that demonstrates that significant adverse health effects do not occur even from long-term, high-level occupational exposures to PCBs. See Attachment A at pp. 5-8. The RAMP is deficient in failing to mention or take into account these studies, which are critical to a proper evaluation of the need for remedial alternatives.

James R. Donnalley, Vice President, Corporate Environmental Programs, General Electric Company.

RESPONSE:

EPA's position with regard to health effects associated with PCBs is set forth in OTS PCBs Program, Response to Comments on Health Effects of PCBs Submitted by the Chemical Manufacturer's Association and the Edison Electric Institute (August 19, 1982); issued by the Health and Environmental Review Division.

Two studies, cited by General Electric, suggest that health effects due to exposure to PCBs may be less likely to occur than reported elsewhere. These studies are:

- Drill, V.A., S.L. Friess, H.W. Hays, T.A. Loomis, and C.B. Shaffer, February 12, 1982. Potential Health Effects in the Human From Exposure to Polychlorinated Biphenyls (PCBs) and Related Impurities. Drill, Friess, Hays, Loomis & Shaffer, Inc., Arlington, Virginia.

- Lawton, R.W., B.T. Sack, M.R. Ross, and J. Feingold, September 1981. Studies of Employees Occupationally Exposed to PCBs.

5.4 COMMENT:

There also appear to be several erroneous assumptions used throughout the RAMP which are not justified by the facts:

Of the Hudson Valley area residents, only the Village of Waterford should worry about possible PCB exposure through drinking water. (This ignores potential long-term chronic exposures to those living in the estuary.)

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The Village of Waterford is the first community downstream of the highly PCB-contaminated reaches that draws its water directly from the Hudson River. Since PCB concentrations have been shown to decrease with distance from the source, it is likely that this water supply would be most severely affected by the PCB problem.

A recent study (Schroeder and Barnes, 1983) confirms that the incremental health risk associated with Waterford drinking water may be undetectably small. The concentration of PCB in drinking water after normal treatment and addition of powdered carbon rarely approaches 0.16 µg/l and has not exceeded the NYSDOH-recommended guideline of 1 ug/l in any samples. A value derived from EPA Ambient Water Quality Criteria suggests 0.8 µg/l as a suggested limit in drinking water.

Due to the dilution of contaminants with distance from the source, it can probably be said that other downstream water supplies are even safer than the Waterford supply. The DFS recommends additional monitoring at public water supplies to confirm this conclusion.

5.5 COMMENT: (5-10; 2; 4)

The data for USGS Hudson River water samples are mentioned but not given. They should be included.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

USGS and NYSDOH analysis results for samples of the Waterford Water Supply were not published by the time the DFS was released. This information was known, however, through personal communication and written correspondence. Shortly after the DFS was released, this material was made public. It has now been included in Section 5 of the Final Report.

River water PCB concentrations and PCB concentrations for Waterford drinking water are given in Tables R4-2 to R4-4 under comment 4.3.1.

5.6 COMMENT:

...PCB-contaminated fish are also found in large numbers in the lower Hudson. The commercial ban on the sale of some species does not preclude sport fishing and human consumption.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

PCB concentrations in fish have continued to decline through 1983. The average PCB content of striped bass in the Lower Hudson River has reached 4.8 ppm, which is approximately equal to the FDA-imposed tolerance limit of 5 ppm (NYSDEC, November 1983).

Obviously some highly contaminated individual fish still exist and NYSDEC expects that one in four legal-sized fish will contain PCB levels in excess of 5 ppm. For this reason, the ban on commercial fishing will continue in 1984.

Since 1980, the average PCB contents of both migrant/marine and freshwater species in the river below Albany have been lower than 5 ppm. American eel and striped bass have been the exception. For this reason, it has not been necessary to regulate recreational fishing in the Lower Hudson.

Consumption of fish flesh with PCB contamination level similar to those of Lower Hudson River fish has a certain low but significant health risk associated with it. According to EPA Water Quality Criteria, consumption of approximately 1.6 ug of PCB per day results in an estimated 1 in 100,000 additional cancer risk (see comment 5.7). However, it may not be advisable to frequently consume large quantities of Hudson River fish flesh. NYSDEC has issued a standing advisory against eating more than one-half pound of fish per week from any State waters. It would be advisable to continue to publicize this in the Lower Hudson River area.

5.7 COMMENT:

This section specifically concludes that, given the properties of PCBs, there is a danger from chronic exposure to PCBs due to potential routes of exposure, including air, water, fish consumption, and recreational activities. This conclusion is restated and misconstrued on page 9-68, line 13, where it reads that, based on current data, the hot spots do not pose undue risk to local residents. The actual conclusion in Section 5 should be applied throughout the rest of the RAMP.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Section 5 of the DFS concluded that there was a potential for chronic exposure to PCBs in air, water, and fish. However, the existing data indicated that the actual health risk for both Upper and Lower Hudson River residents is low.

To arrive at these conclusions the DFS authors compared existing monitoring data with available Federal and State recommended or legislated health standards criteria. The monitoring data used in the evaluation were summarized in Section 4 of the DFS. This information included ambient water and ambient air PCB concentration data for the Upper Hudson River area and PCB concentrations of fish from both the Upper and Lower Hudson River.

In addition, the health standards were compared to the PCB concentration of Waterford drinking water. This data was not tabulated in the DFS but is included in Table R4-3.

Permissible and/or recommended maximum levels of PCB exposure are listed in Table R5-1. To illustrate the significance of these standards, the EPA Ambient Water Quality Criteria for PCB (45 Federal Register 231) can be used to derive a daily PCB dose associated with a certain level of risk. This derivation is presented below:

The concentration of PCBs in ambient water and aquatic organisms which may result in one additional cancer-related death per every 100,000 individuals (10^{-5}) is 0.79 ng/l. This value assumes that 99 percent of the PCB intake is from the consumption of fish and a bioconcentration factor (BCF) of 31,200. The BCF is the number of times an organism is capable of bioconcentrating a chemical over the ambient concentration of the chemical in the environmental pathway to which it was exposed.

Therefore at this level of health risk, the unit PCB concentration of fish is:

> (0.79 ng /l) (31,200) = 24.648 μg /l or 24.648 μg/kg, assuming 1 liter of water has a mass equivalent to 1 kilogram.

If fish or seafood is consumed at a rate of 6.5 g /day, the daily PCB dosage at this level of risk is:

> (24.648 μg/kg) (0.065 kg/day) = 1.602 μg/day

This is the daily dose at the 10^{-5} risk level regardless of the route of exposure.

TABLE R5-1

PCB STANDARDS AND RECOMMENDATIONS

Source of Intake	Standard Not to be Exceeded
Food (FDS standards)	
Milk fat and dairy products	1.5 µg/g (ppm)
Poultry	3.0 µg/g (ppm)
Eggs	0.3 µg/g (ppm)
Fish and shellfish[1]	5.0 µg/g (ppm)
Finished animal feed (including hay)	0.2 µg/g (ppm)
Drinking Water (NYSDOH recommendation)	1.0 µg/l (ppb)
Ambient Air	
Occupied residences and other sensitive receptors (NYSDOH recommendation)[2]	1.0 µg/cu m
Workside (OSHA standard)[3]	500 µg/cu m
Workside (NIOSH recommendation)[3]	1.0 µg/cu m

NOTE:
1. Proposed FDA revision to 2.0 µg/g (ppm)
2. 24-hour average; applicable to Hudson River reclamation project only
3. 24-hour average; if exceeded, respirators are required

RESPONSE:

A receptor is an individual or group of individuals who could be potentially exposed to a contaminant occurring in water, air, soil, or food.

The most recent information available regarding PCB concentrations at receptors is the NYSDOH data showing the PCB concentration of Waterford drinking water. This information is shown in Section 4 under Comment 4.3.1.

5.10 COMMENT:

Information Missing from Health Assessment

No differentiation is made between the various categories of potential affected public which include: residents in the remnant deposit and hot spot areas; residents near areas of potentially higher volitization, [sic] such as dams; communities using the Hudson for drinking water; people who eat Hudson River fish or fowl; those who drink milk produced near the river (where air deposition and plant uptake can add to levels in milk), and those who pursue recreational activities on the upper Hudson.

Additional chronic exposure from all the sources listed above also occurs for the communities in the estuary. Continued migration into the estuary adds to the potential exposure levels of literally millions of people. Quantifying the increased level of risk for various exposure routes should be taken into consideration the additional burden added by the river contamination problem to populations already exposed to unavoidable levels of PCBs.

There is no mention of the need to test for dibenzofurans (for which PCBs are precursors) at potential sites of public exposure to PCBs and in the PCB-contaminated areas. (This is mentioned in the RAMP in Section 6, p. 6-3, line 1, in relation to remedial work safety precautions.) Some assessment of the associated levels, if any, for the more toxic dibenzofurans should be included in additional health-related monitoring.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The health assessment was conducted according to the procedures outlined in the previous comment. The authors recognize that not every possible point-of-contact was considered and that present regulatory or recommended standards are based on information that is not yet completely comprehensive or conclusive. However, a complete and conclusive health risk assessment of every possible pathway at every location along the affected area represents a research effort that is far beyond the scope of work for this project. It was believed that assessment of environmental contamination data for the Upper Hudson and examination of information on the Waterford water supply was sufficient to reach a conclusion under

CERCLA because this material represents a worst-case risk that would not be exceeded elsewhere in the study area.

The authors recommend that further monitoring be done to confirm such conclusions and to complete the health risk assessment. The remedial investigation sampling protocol suggested in Section 10 of the DFS has not yet been finalized. The appropriate agencies in charge of sampling should consider monitoring for toxic substances that might be associated with PCBs (e.g., dibenzofurans).

5.11 COMMENT:

January 1982 O'Brien and Gere Report on Waterford Water Supply - concludes that filtration and chemical addition (present practice at Waterford) removes 75 percent of influent PCB. With granular activated carbon columns the total PCB removal would average over 94 percent and would add a cost of at least 15¢/1,000 gal. The water PCB is under 1.0 µg/l, 95 percent of the time (1976-78 data) 1.0 µg/l PCB is the NYSDOH action level. This study was funded by DEC and EPA at a cost of $117,000.

A water intake of 2 liters/day, at a PCB of 0.16 µg/l gives a "lifetime cancer risk of about 10^{-6} [one in one million]. Reference NYSDOH Organic Chemicals in Drinking Water, 1980.

November 23, 1982, memo from Dr. Hetling to Mr. Mt. Pleasant and December 6, 1982 reply. These memos recommend that the State and EPA fund the $1500/day charge to shift to Troy water during a flood 2-3 days/yr. A discussion with Dr. Hetling of NYSDOH on November 1983 revealed that this is still their current recommendation.

Recent data on various toxics in the Waterford Water supply was requested from Waterford but has not yet been received.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York.

RESPONSE:

The information in the Comment was taken under advisement.

5.12 COMMENT:

Also said that at times PCB levels at Waterford went above NYSDEC health Department standards.

Russ Mt. Pleasant, Director, NYSDEC Division of Water Resources.

RESPONSE:

Some commentors reported that the PCB concentration in Waterford drinking water has at times exceeded the NYSDOH 1.0 µg/l action level. According to NYSDOH results under comment 4.3.1 and a recent report by the USGS (Schroeder and Barnes, 1983), the PCB concentration of drinking water at Waterford rarely goes above 0.1 µg/l and approaches and exceeds 0.2 µg/l on a few days per year.

6.0 COMMENTS ON SECTION 6 (HEALTH AND SAFETY PROCEDURES)

No comments were made on Section 6.

7.0 COMMENTS ON SECTION 7 (REVIEW OF NEW TECHNOLOGY)

7.1 COMMENT:

You have totally ignored the Wright-Malta process for a combined approach to couple the destruction of PCBs from the sediments with destruction of municipal wastes and/or paper-mill wastes to generate electricity. They have tried it on a bench scale and are gearing up to bigger sizes; the process works in a steam environment so the river sediments do not have to be desiccated first.

John E. Sanders, Chairman, DEC, Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The Wright-Malta process destroys PCBs through incineration while it converts organic debris such as garbage and sewage sludge into useful energy. Proponents of the process contend that by mixing Hudson River sediments with wood chips and injecting the mixture into the reaction chamber, not only will PCBs be destroyed but useful energy will be produced as well.

The process is experimental, and bench-scale studies with newspaper have shown that 99 percent destruction of PCB can be achieved. Larger scale experiments have not been successful. The NYSDEC Division of Solid and Hazardous Waste studied the applicability of this process in the Hudson River PCB problem and concluded: "Insufficient technological and economic information exists to prove the reliability of the system" (Mark Brown, NYSDEC personal communication). For these reasons, the Wright-Malta process would not have passed initial screening.

8.0 COMMENTS ON SECTION 8 (INVESTIGATION OF REMEDIAL ALTERNATIVES)

8.1 COMMENT:

At least you have perceived that "doing nothing" really does not mean "no action," but as you correctly state, "no remedial action." The channel-maintenance dredging to Fort Edward is mandated by the N. Y. State Constitution, so as far as the river goes, it will be "dredge me now or dredge me later." You have ignored your own good insights into the LMS model business by using all their values. By the way, the first official action taken by the Settlement Advisory Committee was to pass a motion exempting from any dredging ban we might later endorse the channel-maintenance dredging mandated by the N. Y. State Constitution. This motion was moved by Dr. Richard Dewling, EPA Region II representative to the Committee.

There will be a few unhappy and cold folks if you manage to bring off the discontinuance of channel-maintenance dredging (as on p. 8-5). Ft. Edward would cease to be a port of unloading for oil barges.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The DFS authors agree that the "No Remedial Action with Discontinued Routine Dredging" alternative is not feasible. This is why it did not appear in the final evaluation.

8.2 COMMENT: (8-1)

Section 8.0 Investigation of Remedial Alternatives

This section divides remedial action alternatives into three categories (river sediments, remnant deposits, and disposal alternatives) which are kept separate throughout the evaluation process. It makes some sense to do this because each problem requires different considerations and possible solutions. However, the separation works against common sense when it becomes apparent that remedial actions for both remnant deposits and river sediments are not considered in combination with the containment site disposal alternative. Although dozens of other combinations appear as alternatives, this practical combination is ignored.

It also makes no sense to consider an action like removal of a hazard without also considering disposal as a part of the action. In the preliminary screening process, and in Section 9, disposal is usually considered separately from the remedial action which, when taken, would generate the material requiring a disposal technique.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

The primary reason behind dividing alternatives into three groups representing detoxification/destruction/disposal, in-river sediment, and remnant deposit options was to limit the number of combinations that would have to be analyzed in the matrix.

Initially, detoxification/destruction/disposal alternatives were evaluated independently of the river sediment options; costs were based on the volumes projected for the maximum recommended hot-spot-dredging program. It was reasoned that the selection of a certain detoxification/destruction/disposal alternative would have a minimal influence on the effectiveness ratings of the river sediment and remnant deposit alternatives. Therefore, the river sediment alternatives were evaluated independently of the detoxification/destruction/disposal methods under the assumption that some method of disposal would be available. The lack of a detoxification/destruction/disposal option did not count against removal alternatives in the effectiveness ratings. Costs for the river-sediment and remnant-deposit alternatives included disposal costs that were in proportion to the ratio of total landfill storage volume to the volume of material generated by a particular removal option. This ensured that all alternatives had the lowest capital costs possible.

8.3 COMMENT: (8-17; 2&3)

I do not know why you have been so polite to this "dump-sand-in-the-river" alternative. The suggestion is absolutely preposterous as far as the upper Hudson River is concerned.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The authors agree with the contention that "in-place-containment" of submerged deposits is not a feasible remedial action. However, it has been used with relative success in quiescent waters of the New York Bight, and the method warranted at least some consideration in the alternative selection process.

8.4 COMMENT: (8-19; 2)

Although the stated purpose of combining remedial alternatives is "the maximization of an effective solution," this section includes no consideration of a secure containment site combined with removal of river sediments <u>and</u> remnant deposits.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Although this combination was not specifically proposed by the DFS, it was indirectly considered because each option, secure containment, hot-spot dredging, and remnant-deposit removal was considered separately. Thus it was possible for the matrix analyses to show that "hot spot dredging and total remnant deposit removal in combination with secure containment" was a potential alternative.

8.5 COMMENT: (8-25; 1; 7)

The initial screening process is designed to remove alternatives which do not offer substantial benefits from further consideration. The pertinent CERCLA regulations specifically require elimination of ineffective alternatives that do not "effectively contribute to protection of public health, welfare, or the environment" (40 CFR 300.68 (h)(2)), at this stage, before detailed analysis begins. In our opinion, some of the remedial alternatives which passed the preliminary analysis in the RAMP do not contribute substantially to the protection of public health and the environment, as required. Such an analysis of the alternatives considered does not appear to have been made in this chapter or elsewhere.

Hudson River Sloop, Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

We assume that the commentor believes that the no-remedial-action alternatives that passed initial screening would not contribute to the protection of public health and the environment.

In the initial evaluation, it was the concensus of the project team that there was sufficient reason to believe that the removal of a proportion of the PCBs in the river via a hot-spot dredging program might not provide more than a limited improvement over existing conditions. This was apparent for a number of reasons that were discussed in the DFS and in the Responses to Comments. Therefore, the DFS authors found justification for including the no-remedial-action alternatives in the final analysis.

8.6 COMMENT: (8-25; 2)

There is some confusion with regard to remedial actions for disposal. This section describes only detoxification and destruction techniques and omits discussion of a secure containment site.

The description of "full-scale dredging of 40 hot spots" remedial action includes a secure containment site here. The site is not included in the dredging action analyzed in Section 9.

Hudson River Sloop, Clearwater, Inc., Poughkeepsie, New York.

RESPONSE:

Secure containment of contaminated sediment was a previously developed alternative but it was also an integral part of remedial activities that had been proposed in the past. Thus the secure containment option was first presented in the DFS in Section 8.1 "Review of Previously Developed Alternatives", under the "Full-Scale Dredging of 40 Hot Spots" option on pages 8-6 and 8-7.

One of the reasons it was separated from the dredging options and evaluated separately in Section 9 was to limit the number of permutations or combinations that would have to be evaluated. However, another reason was that the DFS authors did not initially agree with the conclusion of previous authors that landfilling was the most cost-effective disposal technology for contaminated sediments. Consequently it was separated from the dredging options to afford a comparison of landfilling against newly developed detoxification/destruction technologies.

A more detailed discussion of secure containment is presented in Section 9 pages 9-17 to 9-27 of the DFS.

9.0 COMMENTS ON SECTION 9 (EVALUATION OF ALTERNATIVES)

Based on its experience to date under Superfund, EPA has concluded that it is inappropriate to base a cost effectiveness decision on remedial action primarily upon a matrix analysis such as that developed in the FS for this site. Where matrix analyses have been performed, EPA views them as a confirmatory analysis, rather than as the primary means for making decision.

9.1 RESPONSE TO GENERAL COMMENTS ON MATRIX ANALYSIS

After consideration of the comments received and careful evaluation of the cost-effectiveness methodology, it has been concluded that the methodology, as utilized, tends to give undue weight to the cost measures with respect to the effectiveness measures. In order to eliminate this bias, the cost-effectiveness methodology has been modified and the alternatives re-evaluated. The modifications are discussed in the subsequent paragraphs.

During the Feasibility Study, the cost-effectiveness evaluation procedure was conducted in the following manner:

1) The appropriate remedial alternatives were entered into the matrix.

2) Each alternative was then rated relative to the measures of effectiveness, on a 1 to 5 scale; a 5 was used as a maximum rating, and a 1 was used as a minimum rating.

3) Construction costs and operation and maintenance costs were calculated for each alternative. The cost ratings were then expressed as the cost estimates in millions of dollars (i.e., a cost estimate of $1,530,000 had a corresponding rating of 1.53).

4) The final ratings for each effectiveness measure and cost measure were computed by multiplying the rating by the corresponding weighting factor.

5) The final ratings of the cost measures were summed for each alternative. Likewise, the final ratings of the effectiveness measures were summed.

6) The overall cost-effectiveness score was obtained by dividing the final effectiveness rating sum by the final cost-rating sum. The cost-effective alternative was thereby determined as the alternative with the highest score.

Analysis of the results indicated that there was considerably more variation of cost ratings among alternatives than of effectiveness ratings among alternatives. When considering the remnant deposit alternatives, for example, the highest effectiveness rating is 113 percent greater than the lowest effectiveness rating, while the highest cost rating is 1020 percent greater than the lowest cost rating. It is desired that the influence of effectiveness and cost on the overall rating should be roughly equal; therefore, the variation of each of the ratings should also be roughly equal. Accordingly, it was decided that a change in methodology was required in order to equalize the magnitude of variation of effectiveness and cost ratings.

Since the variation in the cost ratings was much greater than the variation in the effectiveness ratings, a new method of obtaining the cost ratings was developed. The largest variation of effectiveness ratings was approximately 100 percent. Therefore, cost ratings were expressed on a scale of 1.0 to 2.0; a 1.0 corresponded to zero cost, while a 2.0 corresponded to the highest single capital or operation-and-maintenance cost encountered during each cost-effectiveness analysis, intermediate cost ranges were determined for rating increments of 0.1, and the intermediate alternative costs were then rated using the increments to correspond to the relative position of the cost with respect to the overall cost range. Upon completion of the cost ratings, the weighting factors were applied, the total cost ratings were computed, and the overall cost-effectiveness ratings were obtained as before.

The alternatives listed below are the conclusions resulting from the modified matrix analysis for the Hudson River PCB site. These are also included in the Final Report.

- Disposal of Contaminated Material: Secure Landfill. If, as a result of the other two evaluations, contaminated material was removed and had to be disposed of, landfilling and incineration would be found to be approximately equal in terms of cost-effectiveness. However, since incineration is an order of magnitude more expensive than landfilling, the secure landfill disposal alternative would score higher on the matrix analysis.

- River Sediments: No Immediate Corrective Action with Further Study. The existing data appears to indicate that the contamination in its current location does not pose undue risk to local inhabitants and therefore does not justify the large sums of money needed to accomplish removal. However, available data is sparse and/or outdated. A two-phase Remedial Investigation should be performed to further characterize the locations, pathways, and quantities of PCBs present. During the initial phase, drinking water, air, wetlands, terrestrial vegetation, and fish samples should be taken to define the impact of PCBs on potential receptors. If analysis of Phase I data shows a major health impact, the second phase of the Remedial Investigation may be implemented, which would consist of sediment sampling and bed-load movement analysis. An environmental monitoring program should be implemented to monitor concentrations of PCBs in drinking water, fish flesh, and dredge spoils. A treatability assessment of the Waterford water supply will be conducted on the basis of historical information and data obtained from the recommended sampling program.

- Remnant Deposits: In-Place Containment. In-situ capping of the contaminated deposits was determined to be the appropriate interim remedy for the remnant areas. The capping would include the placement of 18 inches of subsoil, followed by 6 inches of topsoil and revegetation. Capping would serve to minimize erosion, leaching and air transport of PCB's. In addition, all appropriate river banks would be "riprapped," in order to eliminate remnant-deposit scour during high river flows. Bi-annual inspection of the cover is also recommended, in order to identify any erosion/damage of the cover material.
  As indicated in the ROD, EPA considers containment to be an interim solution and no decision has been made as to whether further remedial action will be appropriate.

9.2 RESPONSE TO SPECIFIC COMMENTS ON SECTION 9

9.2.1 COMMENT:

The Feasibility Study states that the PCB hot spots have moved and additional samples are needed. Under the Step 1 Grant of the PCB Hudson River Dredging Project under Section 116 of the Clean Water Act, this analysis would take place. We believe that the Feasibility Study makes it only more important that the EPA release the Step 1 Grant monies to fulfill this task.

Scenic Hudson, Poughkeepsie, New York

RESPONSE:

A new application for 116 funds to address this issue, has been submitted by New York State to EPA, and is currently under review. Also see response to G-7 and G-8.

9.2.2 COMMENT:

An assessment of the comparative ability of each remedial action considered to protect public health, welfare, and the environment must be made before detailed cost-effectiveness analysis. This does not appear to have been done.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The assessment was conducted during the initial screening phase, as described in Section 8 of the Feasibility Study.

9.2.3 COMMENT:

Certain remedial technologies were removed from further consideration in Section 8.4. Scenic Hudson does support removal of the in-river containment technique. This is not a final solution for the PCB problem in the Hudson River, and the technique is still viewed as experimental in Long Island Sound - a lower energy environment. Particularly because it would not provide the option for complete destruction in the near future, Scenic Hudson applauds its removal from consideration.

However, Scenic Hudson believes some technologies should not have been removed, and could be incorporated with another technological alternative. For example, Biological Destruction. Once the PCB hot spots are isolated from the river systems, a demonstration program could be administered on a specific section of the contaminant site. Biological destruction has only worked in some laboratory situations, but extensive monitoring of an experimental incorporation of this technique along with a temporary landfill alternative might provide a potential final solution. Other technologies removed from consideration could be applied on an experimental basis after sediments have been removed from the river, such as Hydrothermal, Plasma Arc and Pyro-magnetics incinerator.

Scenic Hudson, Poughkeepsie, New York

RESPONSE:

CERCLA requires that any technologies/alternatives that pass the initial screening phase must be feasible, and represent a reliable means of addressing the problem. Unproven or experimental technologies do not meet this criterion. In considering possible future actions to address PCB contamination in the Hudson, EPA will continue to monitor technological developments.

9.2.4 COMMENT:

All of the alternatives involve some degree of risk, since none of the alternatives involve removing all, or possibly even a significant portion of the PCBs from the river.

New York State Department of Environmental Conservation, Division of Solid and Hazardous Waste

RESPONSE:

EPA agrees with this comment.

9.2.5 COMMENT:

General Electric's comments on the proposed listing are equally applicable to the RAMP study, since the issues raised are essentially the same. However, the RAMP study does raise several new points that warrant brief comment.

1. As the RAMP makes clear, "the result of a matrix evaluation with respect to the contaminated sediments in the Hudson River is 'no remedial action.'" RAMP at ES-9, 9-68. That is the remedial alternative determined to be the most cost-effective solution. Id. Nevertheless, EPA has, "by consensus," chosen an "action alternative" with a considerably lower matrix ranking score, stating that "this solution would more closely agree with the National Contingency Plan goals of selecting the cost-effective remedial action." Id. at 9-68 to

9-69. General Electric submits that the NCP does not require an action alternative to be chosen where, as here, there is essentially no health hazard to be remedied. To the extent that the NCP can be read to authorize or require such a result, it is fundamentally inconsistent with the language and goals of CERCLA.

2. Even if the site were listed on the NPL and some remedial action were taken, the RAMP study confirms that in no event would action be justified that is more extensive or more costly than partial remnant in-place containment, in combination with partial restricted access to certain remnant deposits.

James R. Donnalley, Jr., Vice President, Corporate Environmental Programs, General Electric Company

RESPONSE:

EPA believes that the continued presence of contaminated PCB sediments in the Hudson River continues to pose some degree of risks to health and the environment. This is indicated by, among other things, the continued presence of PCB-levels in many fish at levels which exceed FDA standards for consumption. EPA's selection of the no-action option for river sediments at this time is not based on a finding that those sediments do not present a hazard to health and the environment. While the no-action alternative cannot be considered to provide fully adequate protection to human health and the environment both the modeling and sampling data collected to date indicate a decreasing threat to public health and the environment. The lack of sufficient data to establish the fate and transport of PCBs in the Hudson River prevents the Agency from making a final determination of no-action. Additional environmental data collection will continue during the interim evaluation period on feasible and reliable alternatives. The most feasible and reliable alternatives assessed by EPA (limited and full scale hot spot dredging) would be likely to decrease the level of risk somewhat. However, as is mentioned above, the actual reliability and effectiveness of current dredging technologies in this particular situation is subject to considerable uncertainty. For this reason the no-action alternative is recommended at this time. This decision may be reassessed in the future if, during the interim evaluation period, the reliability and applicability of in-situ or other treatment methods is demonstrated, or if techniques for dredging of contaminated sediment from an environment such as this one are further developed. EPA has selected inplace containment of the remnant deposits as an interim remedy to address the primary threats posed by those site. However, EPA has not made a final determination that this action provides adequate long-term protection of health and the environment.

9.2.6 COMMENT:

Matrix Analysis. We have serious reservations about this method of arriving at a cost-effective strategy for PCB cleanup of the Hudson River. In Appendix B, where the various remedial options are tabulated, the net effectiveness rating for Full-Scale dredging, Reduced-Scale dredging and no-action are essentially the same, i.e., 17.4, 17.0 and 17.4, respectively. However, when the actual cost of each option is used in the final analysis, the "no-action" alternative, since it is at least ten times less costly (not surprisingly, because only limited routine dredging is factored in), the net ratings are clearly in favor of a "no-action" alternative. We question this method of analysis for a number of reasons:

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Dividing net effectiveness by net costs is, at best, misleading in the extreme. For example, even if the effectiveness rating for the two dredging options were ten times the present values, the net ratings of these options could either barely match or be hopelessly behind the "no-action" alternative:

($\frac{170}{40.4}$ = 4.2 for Reduced-Scale dredging; $\frac{174}{61.4}$ = 2.8 for Full-Scale Dredging; compared with 4.3 for the "no-action" alternative). It is clear that in almost all cases, not doing anything at all will essentially come out ahead. Unless the Report makes clear how crude the matrix analysis is, it should not be used as a decision-making tool. In fact, we believe that the Report should discard the matrix-analysis approach altogether.

A. Karim Ahmed, Senior Staff Scientist, Natural Resources Defense Council, Inc.

RESPONSE:

EPA agrees with this comment and has recognized the inherent flaws in this quantitative matrix analysis. Therefore, EPA has based its decision on a subjective evaluation of the various effectiveness factors. EPA attempted to eliminate the bias in the matrix and has used it as a confirmatory tool only.

9.2.7 COMMENT:

Section 9 of the Feasibility Study rates the different remedial alternatives, and the methodology is described in Appendix B. This rating system appears extremely subjective. There is not a detailed rationale on how the numbers found in each box of the cost effectiveness matrices were generated. A complete review of this analysis is warranted, but impossible without more information.

Scenic Hudson

Similar Comments By:

- John E. Sanders, Chairman, UEC
  Hudson River PCB Settlement Advisory Committee
- Hudson River Sloop Clearwater, Inc.
  Poughkeepsie, New York

RESPONSE:

The rating system was developed in conjunction with EPA staff. EPA decision not to rely upon the results of the matrix analysis is based, in part, on concerns over the utility of the matrix approach in selection of CERCLA remedial action.

9.2.8 COMMENT:

This section develops the rationale behind numbers (on a scale of 1 to 5) used in the cost-effectiveness matrix in a very limited narrative form. The numbers are in Appendix B, making reading and understanding difficult. The numbers assigned to each "effectiveness measure" should be included as part of the narrative.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

A summary of modified numerical ratings has been added to Section 9. The matrices have been included in Appendix B because they would encumber the text in Section 9.

9.2.9 **COMMENT:**

RAMP matrix, effectiveness measures, and weighting factors were apparently formulated with no public input.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The RAMP/Feasibility Study utilized the matrix format based on guidance provided by EPA. While the RAMP process did not include public involvement during its development, the draft document was made available for public scrutiny. Constructive comments were received and subsequently changes to the matrix were performed.

9.2.10 **COMMENT:**

The specific effectiveness measures in the RAMP are not based on any specific regulatory requirements, or on any EPA guidance documents which are cited in the Feasibility Study.

The source and rationale for these criteria must be made available to justify their use in the decision-making process.

The definitions for 'effectiveness measures' are both broad and vague, so much so that a wide range of ranks can be assigned depending on emphasis placed on one aspect of an alternative or another.

There is no explanation for why the definitions of 'effectiveness measures' are drawn from a document written by the Radian Corporation, rather than pertinent regulations or EPA guidance documents.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The document prepared by Radian Corporation was a guidance document prepared for the EPA, as was the document by JRB Associates discussed previously. Both were developed specifically for Feasibility Studies under the CERCLA program. However, in the period since the issuance of the RAMP, the recommended use of numerical matrix analyses has been eliminated from the EPA feasibility study guidance document.

9.2.11 COMMENT:

The weighting factors used to screen alternatives and rate the public concerns on page 9.9 are rather subjective. Commercial impacts including the commercial fishery, the maintenance of the river canal system, and the effect of hydroelectric power plants should be given a higher rating. DEC has proposals for hydropower expansion at six of the dams on the upper Hudson. If DOT is not allowed to dredge and maintain the canals, then the locks will be shut. The locks and dams may deteriorate. The locks are useful in aiding fish passage and in providing tourist value. If the dams were removed, severe scour of the PCB deposits would probably occur.

New York State Department of Environmental Conservation, Division of Solid and Hazardous Waste

RESPONSE:

From the initial evaluation of the data, it was concluded that although known and potential commercial impacts existed, the commercial impacts were not of the same importance as public health impacts nor were they as important in the evaluation as technology status, effectiveness, or community and environmental impact.

In the first place, it was a premise of the report that maintenance dredging would continue regardless of which alternative was selected. Maintenance dredging would generally take place in less contaminated main channel areas and thus would not involve large amounts of highly contaminated sediment. Therefore, the chances that river navigation would be hindered were slight and the associated commercial impacts were relatively small.

Secondly, it was known that commercial hardships had already been incurred by the fishing industry due to the State ban on commercial fishing. However, it was realized that some type of ban would be required for an indefinite time period regardless of the choice of alternatives. This was evident because:

- If improvement did occur after a remedial activity, some time would be required to verify that improvement.
- Removal operations such as dredging could potentially elevate fish PCB concentrations and a long time span might be required before a subsequent decrease were noticed.
- It might not be desirable to remove the ban due to presence of other chemicals in fish.

Also, it was not possible to give a very high rating to commercial impacts relating to the fishery because it has not been possible to quantify the effect different remedial measures would have on the trends in PCB content.

9.2.12 COMMENT: (9-3;4;16-23)

The eight criteria or 'effectiveness measures' used in the detailed cost-effectiveness analysis do not adequately reflect CERCLA regulations, which emphasize the choice of remedial alternatives which "effectively mitigate and minimize damage to and provide adequate protection of public health, welfare, and the environment." (40 CFR 300.69(i)(D)&(J)). The specific effectiveness measures used in the RAMP are not based on any specific regulatory requirements, or on any EPA guidance documents which are cited in the RAMP. The source and rationale for these criteria must be made available to justify their use in the decision-making process.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The eight effectiveness measures used in the cost-effectiveness analysis were derived from the following sources:

Six of the criteria--technology status, risk and effect of failure, level of cleanup/isolation achievable, ability to minimize community impacts, ability to meet relevant public health and environmental criteria, time required to achieve cleanup/isolation--were extracted from the following EPA guidance documents. The criteria which were selected for the cost-effectiveness analysis were contained in and common to both documents. These sources are:

JRB Associates, July 11, 1983. Superfund Feasibility Study Guidance Document, First Draft. JRB Associates, McLean, Virginia.

Radian Corporation, January 10, 1983. Evaluating Cost-Effectiveness of Remedial Actions at Uncontrolled Hazardous Waste Sites, Draft Methodology Manual. Radian Corporation, Austin, Texas.

The other two criteria, ability to meet legal and institutional requirements and commercial impacts, were developed during discussion between NUS technical staff and EPA officials. These criteria were selected to represent site-specific effectiveness measures that were not addressed in the previously selected criteria. The procedures and effectiveness measures in the guidance documents were specifically formulated for choosing remedial alternatives under CERCLA.

In any case, EPA's remedial decision was not based primarily on the results of the matrix analysis.

9.2.13 COMMENT: (9-4;3)

Food and Drug Administration standards for PCB levels in fish and milk should be included in this definition. OSHA, NIOSH, and New York State Department of Health criteria for PCB exposure should also be included.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The table below is from the Draft EIS. It contains FDA standards for food, New York State Department of Health recommendation for drinking water and for ambient air at occupied residences and other sensitive receptors, OSHA standard for the work place, and NIOSH recommendation for the work place.

PCB STANDARDS AND RECOMMENDATIONS

Source of Intake	Standard Not To Be Exceeded
Food (FDA Standards)	
Milk fat and dairy products	1.5 µg/g (ppm)
Poultry	3.0 µg/g (ppm)
Eggs	0.3 µg/g (ppm)
Fish and shellfish[1]	5.0 µg/g (ppm)
Finished animal feed (including hay)	0.2 µg/g (ppm)
Drinking Water (NYSDOH recommendation)	1.0 µg/l (ppb)
Ambient Air	
Occupied residences and other sensitive receptors (NYSDOH recommendation)[2]	1.0 µg/cu m
Worksite (OSHA standard)[3]	500 µg/cu m
Worksite (NIOSH recommendation)[3]	1.0 µg/cu m

Note: 1. Proposed FDA revision to 2.0 µg/g (ppm).
2. 24-hour average; applicable to Hudson River reclamation project only.
3. 24-hour average; if exceeded, respirators are required.

9.2.14 COMMENT: (9-8;1;6)

'Weighting factors' for each 'effectiveness measure' were apparently developed using EPA guidance documents. However, the documents are not cited. An "internal technical group" developed the actual weighting factors. No discussion or documentation of this process is included in Section 9.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

Similar Comment By:

A. Karim Ahmed, Senior Staff Scientist, Natural Resources Defense Council, Inc.

RESPONSE:

See responses for comments 9.2.10 and 9.2.12.

9.2.15 COMMENT: (9-21;4)

Although the secure landfill "meets or exceeds" current regulatory requirements, it is assigned a rank of 3. Why rank this a 3, when it appears to score high in the narrative?

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

Although the alternative would, upon completion, meet all appropriate public health and environmental requirements, permanent elimination of PCB-contaminated materials is not provided. Eventual failure of the secure landfill may release contaminants and produce adverse public health and environmental effects. Since the incineration alternative was rated a 4, the secure landfill alternative was rated a 3 on relative merit.

9.2.16 COMMENT: (9-22)

According to the cost-effectiveness matrix scores, the four remedial alternatives considered for the in-river PCB-contaminated hot spots vary little in effectiveness and a great deal in cost. It is an excellent example of how the effectiveness measures used for this matrix analysis completely fail to gauge the comparative effectiveness of remedial actions. (All received effectiveness ratings of 17.0 to 17.5).

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

See response to comment 9.2.6.

9.2.17 COMMENT: (9-68;3)(9-69)

The evaluation team disregards the rigid ranking of matrix scores in making their recommendation to do something instead of nothing regarding the remnant deposits. The explanation of choice of the more costly alternative is that it better conform to the goals of remedial action selection described in CERCLA regulations.

We agree in principle that the recommended action is better than taking no action, however, when considering goals of CERCLA, this alternative does not "effectively mitigate and minimize damage to and provide adequate protection of the public and the environment" as do alternatives where removal is considered. For the remnant deposits, removal provides the only real protection for the environment. The recommended alternative includes a continual threat to public health and the environment due to potential for erosion. The threat of migration has not been addressed anywhere in the document, although its consideration is specifically required by CERCLA regulations (40 CFR 300.68(e)(3)(ii)).

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

Potential for erosion of the caps does exist, but the proposed inspection program would identify such erosion in its initial stages, and appropriate repairs would then be made. This alternative also minimizes the threat of migration. Riprap installation will reduce scouring of the remnant deposits during high river flows and capping will reduce infiltration of rainwater and subsequent leacning of PCBs into the river. In addition, atmospheric transport of PCB will be reduced by the cap and vegetation. While TSCA PCB regulations are not directly applicable to this site, these regulations do indicate EPA's general policy that PCB's should be totally isolated from the environment, and should be contained in secure locations. However, full consistency with TSCA policy is not being achieved at this time because in-place containment is intended as an interim remedy to address only the direct contact and volatilization threats to public health from the remnant sites, and not the lesser environmental threats.

10.0 COMMENTS ON SECTION 10 (REMEDIAL ACTION PLANNING ACTIVITIES)

10.1 COMMENT:

Our position is summarized as follows:

1. There appears to be sufficient data and studies of the Waterford Water Supply to draw conclusions, relative to our involvement and aid under CERCLA. However, two months additional time is requested to evaluate and study this data, since some of it has not yet been received.

2. The only time the raw water will approach 1.0 µg/l PCB is during a major flood. This PCB is largely particulate and can be filtered out. Typically 75 percent of the PCB in the raw water is removed by the treatment plant. During a major flood, Waterford presently switches and gets its supply from Troy via 14" pipeline across the river. This incurs extra cost for Waterford of about $1,500/day. A new pipeline to Troy that would allow for future expansion could cost $.7 to 2.2 million. It appears reasonable to set up a fund to pay Waterford $1,500/day whenever the river flow at Waterford exceeds 50,000 cfs.

3. USGS has monitored PCB at the Rt. 4 Bridge station at Waterford for us routinely and has also monitored the water supply in the past. It appears responsible to ask USGS to do some Waterford water supply sampling along with their river monitoring for a number of years into the future.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York

RESPONSE:

Since the only circumstances for which the PCB concentration in the raw water reaches unacceptable limits is under particulate conditions, and the PCB particulate can be effectively filtered out, a public health threat may not exist. However, the Waterford treatability study, which will be funded under CERCLA, will enable a more definitive statement as to the health risks.

10.2 COMMENT:

Public Health & Drinking Water Supplies

While it is admirable that the feasibility study recommends the monitoring and treatment of the Waterford drinking water system, what about the other municipalities that draw their drinking water from the Hudson? The EPA has determined that the PCB are migrating down-river, but only feel it is necessary to protect the citizens of Waterford. The recommendation should include Poughkeepsie, Rhinebeck, Highland, Port Ewen and any other municipalities that may draw their water from the Hudson River in the future.

Scenic Hudson

RESPONSE:

Baseline sampling of all public water supplies on a quarterly basis is proposed. Refer to page 10-3 of the Feasibility Study.

COMMENT:

Additionally, consideration must be given to activated carbon filtration systems for communities which draw their drinking water from the Hudson.

Karen Scelzi, Secretary, CEASE

RESPONSE:

The proposed monitoring program will identify any requirements for public water supply treatment.

COMMENT:

The possible human intake of PCB via the drinking water route is small relative to eating fish or breathing PCB contaminated air. The private wells along the Hudson River were sampled by the New York State Department of

Health in 1978 and found to be below the detection limits for PCB except for one well which should be resampled. The data was sent previously. The soil along the river banks would tend to adsorb PCB from the river water as it travels underground to well points. Thus, the private well sampling should involve only a few spot checks.

Division of Solid and Hazardous Waste, NYSDEC

RESPONSE:

This information is acknowledged and will be considered in the preparation of the Final Report.

10.5 COMMENT:

We suggest water sampling to correlate the Rt. 4 Bridge samples with the Waterford raw water samples, so that data trends in both could be predicted statistically. As NUS suggested, both high flow and low flow periods should be sampled. We suggest 10 years of fish monitoring and water monitoring as a responsible program. We would like to meet with EPA to discuss such sampling. If you decide that there are funds for an extensive wetlands monitoring program to be pursued, then we would suggest a meeting with our biologists and yours to work out the details. There is some data on PCB levels in wetlands taken by Dr. Buckley and by Dr. Horn for which NUS was apparently unaware.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York

RESPONSE:

A coordinated effort will be made between NYSDEC and EPA prior to the sampling.

10.6 COMMENT:

Did not mention when or who will do the additional investigations.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

This is currently being negotiated between the EPA and the State of New York.

10.7 **COMMENT:**

Detailed air monitoring along the river banks and dams would be costly and inappropriate in view of the present data which indicates:

Air PCB levels over the Hudson River and adjacent land areas are decreasing with time and becoming less of a problem, according to data taken by Dr. Buckley. Also see the paper titled "Uptake of Airborne PCB's by Terrestrial Plants Near the Tail Water of a Dam" enclosed. This paper noted air PCB concentrations of .05-.10 mg/m^3 near the Lock 6 dam. This was 10-20 times as high as values over quiet river areas.

Plant monitoring for PCB along the River areas is more cost-effective than air sampling in monitoring air trends. Air PCB data is extremely variable with wind speed, direction, dispersion and temperature. A relationship between air and plant PCB levels has been established by Dr. Buckley. Thus, a reduced scale plant monitoring program is suggested.

Division of Solid and Hazardous Waste, NYSDEC

RESPONSE:

An air monitoring program will be performed as part of the Section 116. Investigation. All suggestions concerning sampling methodologies will be considered before the Remedial Investigation Work Plan is finalized.

10.8 COMMENT:

The rather limited number of sites to be treated and the superficial treatment including covering the wetland area with 18" of soil and seeding it afterwards is ludicrous. The river sediments have also shifted since the data upon which the proposal is based was developed, making the proposal's methodology somewhat questionable.

Paul A. Rickard, Spokesperson, Citizens for Safe Water

RESPONSE:

It is not proposed to cover wetland areas or sediments. The remnant deposits, which are to be covered, have not been shifted or moved, with the exception of deposit number 1.

10.9 COMMENT:

The following options for the remnant deposits appear reasonable:

Fencing and signs
Grading and capping
Fertilizing and seeding and promoting biodegradation

Fencing limits public assess. However, it will catch debris and become an eye sore and require maintenance. Some residents may not want the fence, and cut it or dig under it. Signs warn the public of the PCB, which most residents are aware of. Fencing on Area 1 island would pose a flood hazard and make little sense. Fencing along the rivers edge of areas 2,3,4, and 5 could also catch debris and is not recommended. Malcolm Pirnie estimated for Area 3, 2,500 ft. of fencing to be repaired and 1,200 ft. of new fencing at a cost of $30,000. For Area 5 complete fencing of 2,700 ft. would cost about $30,000. Engineering and administration would add an additional cost. The only area we recommend fencing is the landward side of Area 5.

Grading and capping would limit PCB volatilization by 93% and prevent direct contact. Malcolm Pirnie and DEC, estimate grading, capping and seeding costs as follows:

	Area 5	Area 3
Area for capping-acres	4	7-10
18" clay cap and topsoil	$180,000	$251,000-400,000
12" topsoil cap	$ 50,000	$90,000

The clay cap would limit infiltration, in addition to volatilization. These estimates do not include engineering and administrative costs.

Fertilizing and seeding with grass will build up an organic layer which will absorb and biodegrade some PCB's. This would also lessen runoff and reduce soil surface temperatures. It is likely that after the grass cover is established the volatilization would be cut in half. Trees on Area 5 also reduce surface temperatures. Technical Paper 59 notes the variation of PCB volatilization with temperatures and wind speed. From figure 11, PCB air values of about .89 ug/m^3 occur over sediment with 100 ug/g of PCB in the summer. Biodegradation of the remnant deposit sites has some potential. G. E. has isolated bacteria from our upland PCB sites that biodegrades up to 80% of arochlor 1248. The lower chlorinated arochlors of PCB can also be biodegraded under aerobic conditions. Fertilizing and seeding the remnant deposits would probably aid the biodegration. Several companies are in the business of biodegradation and have had some success on full scale field sites for chlorinated hydrocarbons. It was only discussed briefly on page 7-3, 4 of the NUS report.

In summary, we question the wisdom of grading and capping areas 4 and 5, because the areas already have considerable vegetation and a number of trees, which would be destroyed by grading and capping. Area 3 is quite bare and it is recommended that grass cover be established on it. This may require some topsoil addition. We also recommend fencing of the landward side of area 5. The comments of the New York State Department of Health on this issue are in the November 25, 1983 letter from Dr. Hetling. It is also recommended that we secure Dr. Buckley's 1982 air data and advice (cost $9,600). Unless extensive capping is desired, we do not recommend additional remnant sediment sampling.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York

RESPONSE:

It is expected that grading and capping would significantly reduce PCB volatilization and migration, and should be implemented in spite of existing vegetation at some sites. Once all sites are capped and revegetated, partial fencing of the landward sides will be included to reduce physical contact with the contaminated deposits.

10.10 COMMENT:

Certainly the remnant deposits must be covered and stabilized as soon as possible.

Karen Scelzi, Secretary, CEASE

RESPONSE:

No response is needed.

10.11 COMMENT:

Under present conditions, we would rate the health priorities of general river monitoring as follows:

Fish sampling (people can get the largest exposure to PCB by this route).

River water sampling including Waterford.

Plant and air sampling.

Macroinvertebrates--and animals that feed on them.

Wetlands and wildlife.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York.

RESPONSE:

This ranking will be taken under advisement in the design of the Remedial investigation.

10.12 COMMENT:

Please translate the following sentence for me as it applies to the expenditure of CERCLA funds: "It includes no remedial action on the contaminated river sediment. However, a remedial investigation is needed to determine the health impacts of those sediments."

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

A no-action alternative is being recommended at this time for the contaminated sediment. However, numerous studies to determine the health impacts of those sediments will be performed using Section 116 funding. The results of these studies may necessitate the reevaluation of the recommended alternative in the future.

10.13 COMMENT: (9-68; 2:13)

Not until this most recent study has EPA concluded (in the form of the NUS feasibility study) that in-river contaminants pose little threat to human health. This conclusion, it states, is based on a lack of data which has not been compiled, in part, due to the lack of EPA funding.

The monitoring recommended should be commenced immediately, not to determine if a public health and environmental hazard exists, but to quantify the risks and direct remedial actions more precisely. A more detailed and extensive monitoring program for drinking water, air, terrestrial vegetation as it effects [sic] the agriculture industry in the area should be added to the plan outlined in Section 10, pages 10-17 to 10-18.

Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York

RESPONSE:

The existing data on PCB in air and drinking water when compared with State or Federal Standards indicates that public health risks are low. The DFS urges additional monitoring to further quantify these risks. The DFS also concludes, however, that under CERCLA, the previously proposed alternatives are not cost-effective.

R.0 COMMENTS ON REFERENCES

COMMENT: (R-5;1)

"Gagahan" should read "Gahagan".

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

Correction incorporated into document, page R-5.

A.0 COMMENTS ON APPENDIX A (SITE CHRONOLOGY)

A.1 COMMENT: (A-3)

1977-78; the quantity of sediments carted to new Moreau from Remnant-deposit Area 3A is 14,000 yd^3.

June-August 1978 "restabilization" of banks; what was done was to add a solid riprap to area 3; area 5 had not been altered much and was not treated.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The draft EIS has been used as the predominant source for the chronology. Differences between the above information and the data presented in the feasibility study are not considered to be significant.

A.2 COMMENT: (A-5)

December 1982. "switched project funding" is a rich choice of words and probably less than accurate.

July 1983 (or was it August?) EPA finally adds upper Hudson River to CERCLA list for New York State.

Should add for September 1983 about the court order "stopping the clock" on the 30 September 1983 deadline for commitment or loss of CWA funds assigned to New York.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

EPA added the upper Hudson River to the CERCLA list on September 8, 1983. This comment was added to the chronology. The September 1983 court order was also added to the chronology.

B.0 COMMENTS ON APPENDIX B (COST-EFFECTIVENESS MATRICES)

The new cost-effectiveness matrices are presented in Section 9.0 Figures R9-1 through R9-8.

C.0 COMMENTS ON APPENDIX C (ALTERNATIVE COST ESTIMATES)

C.1 COMMENT:

No costs of handling contaminated material during maintenance dredging was included.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

These costs are not covered by CERCLA funds.

C.2 COMMENT:

The river monitoring effort is welcomed and essential to protect public health. Our past routine monitoring program for the Hudson River has allocated funds as follows:

USGS - water sampling and analysis, flows	$60,000
NYSDEC - fish sampling and analysis (Lab contracts)	80,000
NYSDOH - Macroinvertebrate sampling and analysis	20,000
	$160,000/yr.

Present worth factors give the present value of an annual payment of $160,000 of:

Time	PWF @ 10%	PW
5 years	3.79	$ 606,400
10 years	6.14	$ 982,400
20 years	8.51	$1,361,000

The continuation of this sampling alone for twenty years exceeds the amount suggested in the NUS report.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York

RESPONSE:

The recommended monitoring program associated with the no-action alternative (C-27) is more extensive than the above program, and would cost on the order of $330,000 annually. In addition, the river monitoring program associated with the remnant deposit containment alternative (C-32) would cost approximately $110,000 annually. Total annual monitoring costs would be on the order of $440,000. It should be noted that these costs are not the same as the Remedial Investigation costs. The Remedial Investigation of air, plant, drinking water, and wetland PCBs would last one year and cost about $396,000.

C.3 COMMENT:

Daily cost of our alternate water source is about $2,100.00 or about $760,000 annually. The cost of the alternate source should be included in the cost of dredging. We do not believe that the citizens of our community should be subject to either the threat of increased PCB levels or the financial burden of purchasing water from Troy as the result of dredging.

Water Commissioners of Waterford, Waterford, New York.

RESPONSE:

Page A-23 of the August 1981 Supplemental Report Environmental Impact Statement outlines contingency measures that would be implemented in the event that the dredging plume carries contaminated sediments beyond one mile downstream of the dredge (which has previously been observed and documented by the U. S. Army Corps of Engineers). If a dredging project is implemented with the Clean Water Act monies, any contingency measure implemented, including purchasing water from Troy, would be funded through the contingency fund for the project.

D.0 COMMENTS ON APPENDIX D (PHASE II REMEDIAL INVESTIGATION)

D.1 COMMENT: (D-4;4)

The point that has come through from all the previous work is that this work should be part of a research project, so that the individuals involved have a personal and professional stake in the results, rather than treating it as just something required by their jobs. Getting DEC/EPA officials to understand that this means spending money under the heading of "research" may not be easy; one gets the idea that they would rather see the whole system collapse than be involved in spending money for "research".

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

CERCLA will not cover costs incurred for "research."

D.2 COMMENT:

Have you figured out how many cores are involved in carrying out your 100-ft grid for the hot spots? You specify 3-foot cores, but that may not be possible in most channel areas where only 18 inches of coarse sediment overlies the bedrock. You should include a recommendation about making relief peels from the cut faces of the split (longitudinally) core faces. Such peels enable the internal structures of bed-load sediments to be displayed and such structures convey information about the bed-load transport.

Another important suggestion about the recommended sampling: installation and subsequent checking of vertical scour chains or scour cords buried in the sediments. After a flood, the length of the bent-over part measured down from the free end indicates the depth of scour during the flood. This is about the only way by which depth of scour can be determined because after the flood has passed, a layer may be deposited that is the same thickness as the layer that was scoured. Without the cords (chains), one may come to the erroneous conclusion that nothing happened.

Another sampling suggestion: Supplement the U. S. Geological Survey's depth-integrating samplers of suspended load with whole samples collected at the surface, at mid depth, and near the bottom, to see if the suspensions are uniform or graded. This vital point is not addressed in any of the programs recommended in the draft.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee.

RESPONSE:

The five hot spots tentatively selected for the Stage I sediment study cover 3.3 million square feet of surface area. A 100-foot sampling grid would required about 330 sample stations. This number could probably be reduced but it is recommended that no less than 200 samples be collected. The DFS suggests about 275 sample stations.

The longest core possible, up to 3 feet in length, should be collected at all stations.

The sampling strategy should not be finalized without input from involved agencies. The foregoing suggestions and all other recommendations should be evaluated by the appropriate agency in light of the study objectives.

E.0 COMMENTS ON APPENDIX E (ANALYSIS OF 1983 SAMPLING DATA)

E.1 COMMENT: (E-1;3;1)

Change "are" to "is"--the subject is "summary" not "results".

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

Correction made.

E.2 COMMENT: (E-1;3;5)

Change "were" to "was" -- same story, subject is "total" not "spots".

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

Correction made.

E.3 COMMENT:

We do not agree with the report interpretation that the hot spots have shifted based on recent sediment data.

Division of Solid and Hazardous Waste, NYSDEC, Albany, New York

RESPONSE:

Appendix E did not suggest that the hot spots <u>have shifted</u>, but rather that the <u>possibility</u> exists. Hot spot #6 is an appropriate example. See comment E.5 for further discussions.

E.4 COMMENT: (E-8;4;7)

What do you mean "qualitatively"? Aren't your analytical numbers good enough to be referred to as "quantitative"? If all analyses exceed 50 ppm, that scores as "hot" by definition.

John E. Sanders, Chairman, DEC Hudson River PCB Settlement Advisory Committee

RESPONSE:

We concur, and the correction has been made.

E.5 COMMENT:

The urgency of some short term action is underscored by the data in Appendix E of the RAMP which is not very supportive of the claims of those who felt the PCBs would just sit there and be covered with sediment. In fact Appendix E gives at least 6 examples where it is postulated that contaminated sediments may have been scoured from the river bottom. Thus it is of critical importance that we go in and get out remaining PCBs from the river while Hot Spots continue to exist and before they get dispersed down river.

Robert Joseph, Sierra Club.

RESPONSE:

Appendix E of the DFS summarizes the results of a recent sampling effort conducted by EPA and the DFS authors. The results appeared to indicate that at four locations where highly contaminated hot-spot sediments were found previously, an apparent reduction in PCB contamination had occurred. However, the results did confirm that in nine other areas, highly contaminated sediments were still present.

The DFS authors have continually stressed the problems associated with drawing conclusions from data drawn from such a variable medium as river sediments. The reduction in contamination noticed at the four areas in question could have been brought about by any number of mechanisms. Hot sediments could have been covered with cleaner sediments at some locations; at other locations, sediments may have been scoured away. The mixing of cleaner sediments with contaminated sediments may have diluted the deposit resulting in the lower PCB concentrations.

It is very likely that the reduction in contamination was observed because the sample stations missed the areas of contamination that had been observed before. With the possible exception of hot spot 14, the authors feel there is sufficient reason to avoid drawing too strongly the conclusion that massive scouring has occurred.

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