WORK PLAN

PASSAIC RIVER SEDIMENT SAMPLING
NEAR 80 LISTER AVENUE

SUPPLEMENTAL ADDITION
TO
ORIGINAL WORK PLAN

Submitted by

Diamond Shamrock Chemical Corporation

3 May 1985
85C7782-47

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3 May 1985
85C7782-47

Mr. David Kindig, P.E.
New Jersey Department of
Environmental Protection
Bureau of Sites Management
Carroll Building
248 East State Street
Trenton, NJ 08625

Re: 80 Lister Avenue-Passaic River Sediment Sampling Plan (Revised)

Dear Mr. Kindig:

Enclosed please find three (3) copies of the revised Passaic River Sediment Sampling Work Plan which was originally submitted by Diamond Shamrock Chemical Corporation on 10 April 1985.

The original work plan has been changed to reflect the comments received on 16 April 1985 at a meeting with the NJDEP and confirmed in the letter dated 24 April 1985 from Dr. J. H. Berkowitz to Mr. Ed Noble. Please note that details of the TCDD and heavy metal analyses are not included in the revised work plan but will be submitted for your review as soon as they are determined.

If you have any questions, please feel free to call us at 201-785-0700.

Very truly yours,

Richard L. Moberly

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SECTION 1.0
BACKGROUND

1.1 EXISTING DATA

Sediment samples were collected in August 1984 from the Passaic River in the vicinity of 80 Lister Avenue and analyzed for 2,3,7,8 TCDD. Twenty-nine samples for TCDD analysis were collected from 22 locations within roughly 2,400 feet upstream and downstream of the site. Of the 29 samples, 20 were from 0 to 1 foot, and 9 were from 1 to 2 feet. One deep (6 feet) core was taken near Station 1-3-0, 400 feet downstream of the site.

Results of the shallow sediment sampling indicated TCDD contamination from below detection levels up to a maximum concentration of 130 ppb. Within the deep core, the concentration of TCDD increased from 151 ppb at the top to 324 ppb at the bottom.

In February 1985, a hydrographic survey of the Passaic River near 80 Lister Avenue was conducted which included bathymetric, current velocity, and salinity profiling. Bathymetric profiles of the Passaic River were recorded at 75 transects spaced over a 5-mile length of river centered at 80 Lister Avenue. The bathymetric data were compared to bathymetric data recorded by the U.S. Army Corps of Engineers in 1974, 1978, 1976, and 1983. Current velocity, salinity, and temperatures during ebb and flood tidal cycles were also measured.

The results of the hydrographic survey indicate that during base flow conditions, the Passaic River estuary is partially mixed. Suspended sediment from the area of 80 Lister Avenue is expected to be transported both upstream and downstream. Net

current velocities near the bottom of the water column are upstream, while those at the middle and upper portions of the water column are downstream. The hydrographic survey also delineated areas of sediment accumulation which are most pronounced along the channel flanks.

1.2 NEED AND PURPOSE

Results of the earlier sediment sampling program and hydrographic survey indicate the need for a comprehensive work plan to delineate the longitudinal and vertical extent of TCDD contamination and to evaluate the potential for movement of contaminated sediment.

The purpose of the proposed work plan is to provide information as follows:

- o delineate areas of TCDD contamination adjacent to the site and upstsream and downstream of the site;
- o evaluate TCDD contamination of suspended sediment and water samples;
- o describe the pattern and process of sediment transport and deposition;
- o determine the movement of sediment under varying freshwater discharge and tide conditions;
- o identify areas of fine grained sedimentation; and
- o evaluate the fate of TCDD contaminated sediment.

This information will be used to formulate remediation alternatives for the Passaic River.

1.3 GENERAL SCOPE

The work plan is designed to identify TCDD contamination and evaluate the potential for its migration. The plan involves a comprehensive field, laboratory, and data analysis program. The field program will involve shallow and deep coring, current velocity and salinity profiling, and suspended sediment sampling. The laboratory program will determine the concentration of total TCDD, the grain size, and the total organic content in bed sediment. Water column samples will be analyzed for concentration of suspended sediment. Data analyses will include statistical analysis (including geostatistics), sediment transport modeling, and Geographical Information Systems (GIS) data manipulation and presentation.

The schedule for Passaic River sediment sampling and analysis is as follows:

15-25 April 1985	Mobilization
29 April to 15 June 1985	Sediment, water column sampling
6 May to 6 July 1985	Chemical, physical analysis
27 May to 15 August 1985	Data analysis, Report preparation

The Health and Safety Plan as per the original 80 Lister Avenue Work Plan, will be used for the sediment and water column sampling as described in Sections 2.0 and 3.0.

SECTION 2.0
SEDIMENT SAMPLING

2.1 APPROACH

For the purpose of developing a sediment sampling work plan for the Passaic River, the river was divided into four (4) reaches as shown in Figure 1:

- Approximately 12 miles from Dundee Dam downstream to the William Stickle Memorial Bridge, which is the upstream extent of the bathymetric survey.

- Approximately 2 miles from the William Stickle Memorial Bridge downstream to the 80 Lister Avenue Site area (including Transects U-26 through O-4.5).

- The 80 Lister Avenue Site area from Transects O-5 through I-5 (roughly 2,000 feet).

- Approximately 1.75 miles below the site area to the mouth of the Passaic River (Transects I-5 through D-24).

The river was split into these four reaches since each reach has a unique combination of physical and chemical characteristics that is expected to correlate with the distribution of TCDD contamination. The characteristics considered include:

- o distance from the 80 Lister Avenue site,
- o position relative to the site (upstream and downstream),
- o dredging history of the reach,
- o documentation of TCDD contamination of the sediments, and
- o local sedimentation rates (either calculated or expected).

For the sake of clarity, the four reaches will be referred to as the far-upstream reach, the upstream reach, the site-area reach, and the downstream reach.

Within each reach, a sampling strategy was developed based on the unique characteristics of the reach and the specific objectives of the sampling/analysis for the reach. The objective common to all plans is to provide data in a cost-effective manner that is appropriate for statistical analysis.

Following is a description of the locations where sediment cores will be collected in each of the four Passaic River reaches listed above. Sampling locations within the upstream, site-area, and downstream reaches are shown in Figure 1. Included in the text are explanations of the rationale for the selection of each sampling location.

2.2 SITE-AREA REACH

In the site-area reach, TCDD contamination was found in surface and near-surface sediment samples collected in 1984. The highest levels were found at Station 1-3-0 below a depth of 12 inches. Station 1-3-0 is located along the south shoreline approximately 400 feet downstream of the site. Other elevated TCDD levels were found adjacent to the site and opposite the site. The sampling objective within the site-area reach is to determine the horizontal and vertical pattern of sediment TCDD contamination radiating from the area of Station 1-3-0 and the 80 Lister Avenue Site.

Deep (20 feet) sediment cores will be collected at the intersections of 4 radii and 4 elliptic arcs having Station 1-3-0 and the site as foci. The 4 arcs will be spaced 200 feet, 500 feet, 800 feet, and 1,100 feet upstream and downstream of Station 1-3-0 along the south shoreline. The sampling pattern will cover the approximately 500-foot width of the river with a total of 17 cores (including one core at 1-3-0). Sampling locations of some cores will be shifted slightly from the arc and radii intersections to coincide with previously-sampled locations (e.g., 0-6-1, 0-8-1, 1-1-1, 1-1-2, 1-5-0).

Two foot sections of the first 10 feet of each core will be analyzed initially. Lower sections will be analyzed only if total TCDD contamination above 1 part per billion (ppb) is found in the 8 to 10 feet section and the pattern of TCDD contamination in upper sections indicate the probablity of elevated levels below 10 feet. A minimum of 85 core sections will be analyzed from the 17 sampling locations within the site-area reach.

2.3 DOWNSTREAM REACH

The downstream reach includes the area from Transect 1-5 (immediately below the site-area reach) to Transect D-24 (the downstream end of the bathymetric survey). Moderate-to-low levels of TCDD contamination were found in surface sediments at Stations 1-5-0, 1-6-0, and 1-7-0 in 1984. No deeper samples were analyzed from those locations, and no sampling for TCDD contamination was conducted further downstream. The sampling objectives within the downstream reach are to determine what level, if any, of TCDD contamination are found downstream of the site area and how various physical factors may affect the distribution of TCDD in the sediment.

Within the downstream reach, three physical factors including dredging history, sedimentation rate, and distance from the site are thought to possibly affect the distribution of TCDD in the sediments. The main channel in the lower half to third of the reach has been dredged several times by the U.S. Army Corps (see WCC,

1985, p. 6 for details). Sedimentation rates of 0 to 0.5 feet per year were calculated for various areas of the downstream reach based on comparisons between the current bathymetric survey and earlier (1976 and 1983) surveys by the Corps. A third physical factor, distance, is also included given the fact that there is approximately 1.75 miles of river within the downstream reach.

In order to select which areas within the downstream reach should be sampled, each of the three physical factors is considered to have two values - high and low. Areas were either dredged (D_1), or not dredged (D_0). Areas experienced either high sedimentation rates (S_1), or low-to-zero rates (S_0). Thirdly, areas are thought of as being either near (L_0) or far (L_1) from the 80 Lister Avenue Site. The resultant matrix of physical factors includes eight (8) combinations:

D_0 S_0 L_0
D_0 S_0 L_1
D_0 S_1 L_0
D_0 S_1 L_1
D_1 S_1 L_0
D_1 S_0 L_1
D_1 S_0 L_0
D_1 S_1 L_1

Areas for sediment sampling in the downstream reach were selected for each combination. Two physical factor combinations - D_1 S_0 L_0 and D_1 S_1 L_0 - failed to be found. This is due to the fact that no dredging was performed upstream of Lincoln Highway near the site. Table 2-1 lists the physical factors and the corresponding areas selected for sediment sampling. By sampling in the areas listed, the resultant data will be appropriate for statistical analysis.

In most cases, deep (20-foot) cores with 2-foot sections will be taken in areas with high sedimentation rates (S_1), and short (5-foot) cores with 1-foot sections will be taken in areas with low rates (S_0) (Table 1). Cores will be taken in sets of four

(4) in order to adequately characterize the sediment contamination pattern in each area. Sampling points will be spaced roughly 100 feet apart along the longitudinal centerline of each area. This sampling geometry is thought to minimize the (Kringing) variance within an area.

All four cores will not be analyzed, however. In areas where shallow cores are taken, all five sections from two cores will be analyzed (total of 10 sections). The remaining two cores will be sectioned and archived for possible later analysis. In areas where deep cores are taken, two cores will be analyzed and two will be archived. In order to further reduce the variance within an area, alternate cores (1 and 3 or 2 and 4) will be analyzed while the other pair (2 and 4 or 1 and 3) will be archived. A total of 7 sections from the upper 10 feet will be analyzed from the two deep cores: the top (0-2 foot) and middle (8-10 foot) sections of both cores, plus one section from each depth profile between 2 and 8 feet. All other sections will be archived. For example:

Core A		Core B
	.. 0 FEET ..	
X		X
X		O
O		X
X		O
X	.. 10 FEET ..	X
O		O
O		O
O		O
O		O
O	.. 20 FEET ..	O

X - Analyzed
O - Archived

By analyzing sections from two deep cores instead of from one core, the area, rather than an isolated location, is characterized. Analyses of the archived core sections may be necessary if anomalous or random patterns are found in the data, if sample prep/analysis problems cause the loss of a core section, or if total TCDD levels of 1 ppb or greater are found in the 8 to 10-foot sections of the 20-foot cores.

A total of three areas will receive short cores, and five areas will receive long cores. This will result in 12 short cores and 20 long cores. Initially, half of all cores collected will be analyzed following the scheme described above. This will result in a minimum of 65 sections being analyzed (30 from short cores and 35 from long cores).

2.4 UPSTREAM REACH

The upstream reach includes a 2-mile stretch of river from Transect 0-4.5 (immediately upstream of the site-area reach) to Transect U-26 (just below the William Stickle Memorial Bridge). Low levels of TCDD contamination were found in the sediments at Stations 0-2-0, 0-3-0, and 0-4-0 in 1984. The sampling objectives within the upstream reach are to determine what levels, if any, of total TCDD are found upstream of the site area and how the two physical factors of distance away from the site and sedimentation rate affect the distribution of TCDD. No sections of the Passaic River above the site have been dredged since 1950.

In order to determine which areas within the upstream reach should be sampled, the two physical factors, sedimentation rate (S) and distance (L) were each assigned two values—high and low. A matrix of the physical factors analogous to that created for the downstream reach is created. Since dredging (D) is not a factor in the upstream reach, the matrix has only four cells: S_o L_o, S_o L_l, S_l L_o, and S_l L_l. Areas having the four combinations of physical factors were selected and are presented in Table 2-2.

As in the downstream reach, it is recommended that four cores be taken in each area listed for each combination of physical factors. Four short cores will be taken in each area of low sedimentation rate, and four long cores will be taken in each area of high sedimentation rate. Two cores out of four will be analyzed initially following the core section selection scheme described for cores taken in the downstream reach. Analysis of the archived core sections may be necessary if anomolous or random patterns are found in the data, if sample prep/analysis problems

arise, or if total TCDD levels of 1 ppb or greater are found in the 8 to 10-foot sections of the 20-foot cores.

Two upstream areas will be sampled with short cores, while two areas will be sampled with long cores. A total of 8 short cores and 8 long cores will be collected, but only half will be analyzed initially. Also, only the upper half of the long cores being analyzed will be analyzed initially. This will result in a minimum of 34 sections being analyzed (20 from short cores and 14 from long cores).

2.5 FAR-UPSTREAM REACH

The far-upstream reach extends approximately 12 miles from the William Stickle Memorial Bridge upstream to Dundee Dam. No data on sediment concentrations of TCDD are known for the far-upstream reach, but sediment could theoretically move upstream from the site to near the upper end of the reach. Sedimentation rates are unknown in this reach since, unlike the three lower reaches no bottom profiles were recorded during the 1985 bathymetric survey. No portion of the far-upstream reach has been dredged since 1950. Given the location of this reach far-upstream of the site and its extreme length, the objective of the sampling program for the reach is quite different from those in the lower reaches. The objective for the far-upstream reach is to reveal any trends in TCDD contamination along the reach in areas of expected high and low sedimentation rates.

In order to see any trends present in the pattern of TCDD sediment contamination, it is recommended that a set of one short and one long core from adjacent areas of anticipated low and high sedimentation rates, respectively, be collected at intervals throughout the reach. Based on the number of sampling locations needed to detect any trends in the TCDD distribution, it is suggested that cores be taken at approximately one-mile intervals. This spacing will result in the collection of cores in 10 areas. Listed in Table 2-3 are 10 areas having a shallow, mud-flat area with an expected higher-than-average sedimentation rate located adjacent to the deeper channel with its lower sedimentation rate.

Sampling at these 10 areas will result in the collection of 10 short (5-foot) cores and 10 long (20-foot) cores. Although a total of 20 cores will be collected, because of anticipated low levels of TCDD, only 10 cores from five sampling locations will be analyzed initially. The cores will be from sampling areas located 0.8, 1.8, 3.0, 6.1, and 7.0 miles upstream of Transect U-26. By analyzing the first three areas, the reach of Passaic River immediately above U-26 can be characterized as to the potential movement of the TCDD nearly six miles upstream of the site. Analyses of sediment from areas 6.1 and 7.0 miles above Transect U-26 are expected to show if another potential source of TCDD contamination located near Route 3 has contributed to the TCDD contamination problem in the river. Initially, all five sections from the five short cores will be analyzed, while only the upper 10 feet (five sections) of the five long cores will be analyzed. Thus, out of a total of 20 cores and 150 sections collected in the far-upstream reach, only 10 cores and 50 sections wil be analyzed initially.

2.6 UPSTREAM CONTROL AREA

Sediment samples collected above Dundee Dam will serve as upstream controls (i.e. - not affected by TCDD contamination coming from 80 Lister Avenue). Four deep cores will be collected in shallow, sediment-accumulating areas above the dam. Of the four cores collected, two will be archived while the other two will be analyzed. Analyses of the two cores will proceed as previously described for long cores in the downstream reach (see p. 2-5), wherein seven of the 20 available sections are analyzed initially.

Based on the sediment plan presented above, the total number of cores and core sections collected in the Passaic river and the total number of core sections to be analyzed initially are presented in Table 2-4.

2.7 SEDIMENT SAMPLING, HANDLING AND ANALYSIS

Prior to sediment collection, the bottom profile of the area to be sampled will be surveyed using a recording fathometer. In those reaches surveyed in February 1985, the bathymetric profiling prior to sampling will serve to confirm the sampling location relative to the bottom and the local estimated sedimentation rate. In other areas (e.g., the far-upstream reach), bottom profiling prior to sampling will help locate the cores in deep areas of anticipated low sedimentation rates and shallow areas of higher sedimentation rates. The bottom profile recorded will be adjusted to depths relative to mean low water (MLW) by referring to a recording tide gauge at the New Jersey Turnpike Bridge or to a tide staff that indicates the tide elevation relative to MLW.

Sediment samples will be collected at each sampling location using the vibracoring technique. This technique is widely used for sediment sampling within estuaries and has several advantages over the techniques evaluated for use in the Passaic River. Briefly, advantages of the vibracoring technique are:

- It collects a core with minimal disturbance or deformation of the stratigraphy,
- It is a faster sampling technique than traditional drilling techniques,
- The equipment is relatively small and can be handled from a small barge and work boat, and
- It can be used for both deep and shallow cores.

Cores will be either short (5 feet) or long (20 feet) depending on the estimated sedimentation rate in the area being sampled. Net sedimentation rates were calculated as part of the bathymetric survey of the river conducted in February 1985. A 20-foot core is long enough to penetrate sediments that could have been deposited as early as 1950 in areas having the highest sediment accumulation rates found. A 5-foot core will be used in areas that were found to have minimal sedimentation

rates. The 5-foot core is recommended over a surface grab or shallower (e.g., 2-foot) core because it is deep enough to provide data at several levels.

The core tube material will be 3.5-inch diameter (I.D.) Lexan plastic. The use of Lexan core tubing will permit the logging of visual changes within the sediment while on the river and will provide guidance as to the proper spacing of the core sectioning. If a distinct stratigraphic change is noted within the proposed section, the core will be split at this transition zone. The objective is to not include a transition zone within a core section. The 20-foot cores will be cut into 2-foot sections for analysis of varying depths, while the 5-foot cores will be cut into 1-foot sections.

Each core section will be securely capped and labeled with a pre-printed sample label, depth interval, and top/bottom orientation. Each section will then be placed in a clean, opaque, plastic bag that is sealed and labeled with a duplicate pre-printed lable. The core segments will be stored vertically prior to, and during, transfer to an onsite sediment laboratory. A core section field sheet will be completed for each core collected and transferred to the sediment laboratory. To minimize transcription errors, duplicates of the pre-printed sample labels will be applied to the field sheet.

All sample handling and documentation will be as stated in the 80 Lister Avenue Work Plan. All core sections will be extruded or longitudinally cut, their visual characteristics logged, and photographed. Their outside, upper surfaces will then be scraped off to minimize cross-contamination among samples. Each labeled core section will be checked against a master list of core sections in order to determine which sections will be analyzed for TCDD and physical characteristics and which will be archived (for possible later analysis). Those core sections which are to be archived will be prepared, described, and stored in a wide-mouth jar and a 250-ml amber bottle. For those core sections being analyzed intially, a 250-ml amber bottle will be filled for use in the TCDD analysis, a 40-ml bottle will be filled for use in the TOC analysis, and the remainder will be put into a wide mouth

jar for use in the physical examination. Physical examination will include grain size analysis, density, specific gravity, and percent moisture.

Each sediment sample will be analyzed for TCDD, total organic carbon (TOC), and a heavy metal (copper or lead). Specific analytical techniques will be provided to the New Jersey Department of Environmental Protection as soon as they are determined.

Table 2-1. DOWNSTREAM REACH SAMPLING AREAS BASED ON DREDGING HISTORY (D), SEDIMENTATION RATES (S), AND DISTANCE DOWNSTREAM OF THE SITE (L).

Physical Factors	Transects	Descriptions	Core Length
D_o S_o L_o	1-5 to 1-6.5	North shoreline; appx. 150 ft. wide, 700 ft. long.	Short
D_o S_o L_1	D-19	East shoreline; appx. 150 ft. wide, 600 ft. long.	Short
D_o S_1 L_o	1-5 to 1-6.5	South shoreline immed. upstream of barges; appx. 300 ft. wide, 700 ft. long.	Long
D_o S_1 L_1	D-6	East shoreline among pier-heads; appx. 100 ft. wide, 400 ft. long.	Long
D_o S_1 L_1	D-22	East flank of channel; appx. 200 ft. wide, 600 ft. long.	Long
D_o S_1 L_1	D-22 to D-23	West shoreline among pier-heads; appx. 100 ft. wide, 700 ft. long.	Long
D_1 S_o L_o	No area available		
D_1 S_o L_1	D-19	Mid-channel; appx. 200 ft. wide, 400 ft. long.	Short
D_1 S_1 L_o	No area available		
D_1 S_1 L_1	D-22 to D-23	Mid-channel; appx. 200 ft. wide, 600 ft. long.	Long

Table 2-2. UPSTREAM REACH SAMPLING AREAS BASED ON SEDIMENTATION RATES (S) AND DISTANCE UPSTREAM OF THE SITE (L).

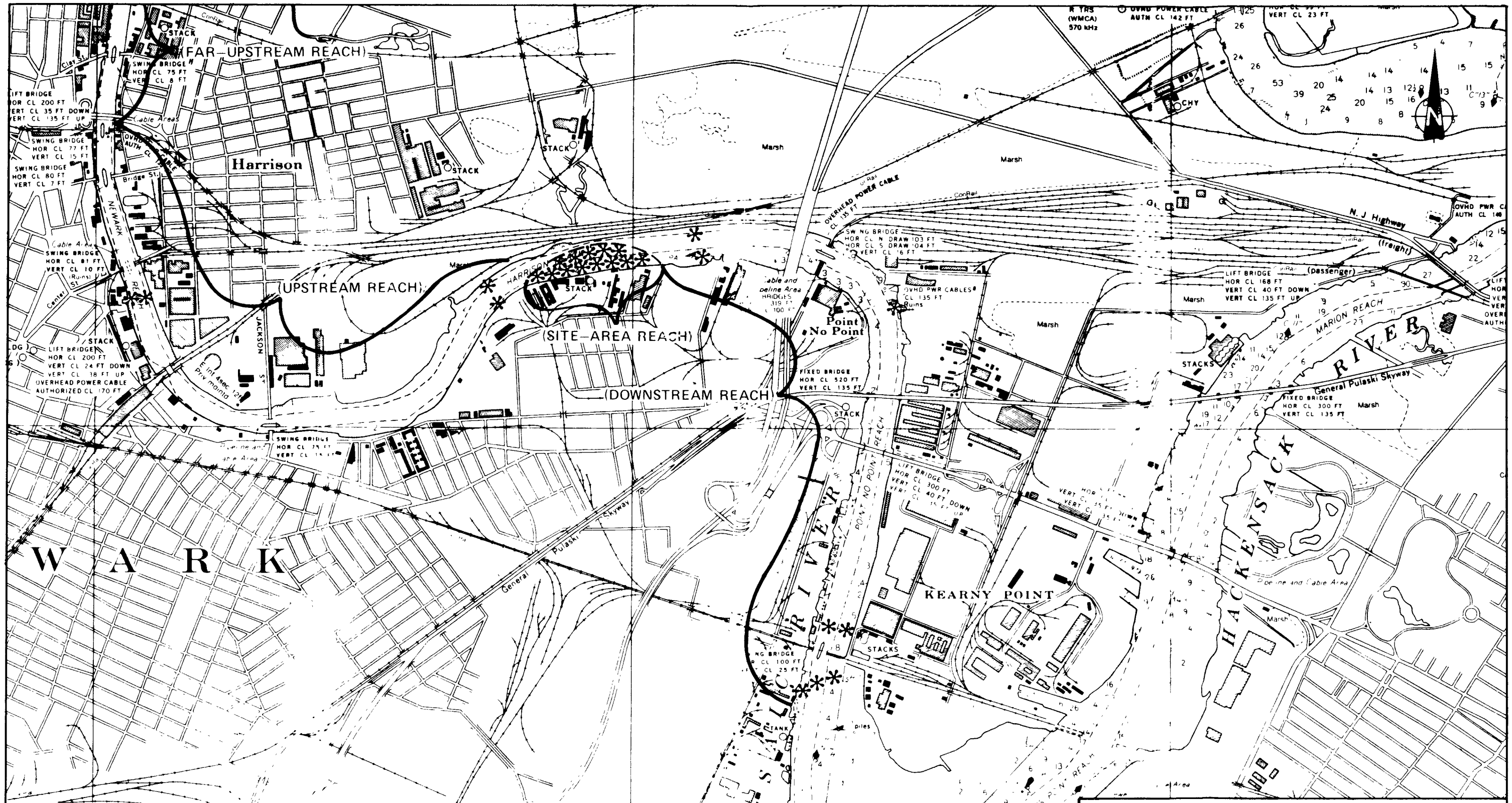
Physical Factors	Transects	Descriptions	Core Length
S_o L_o	0-3 to 0-4.5	North shoreline; appx. 100 ft. wide, 800 ft. long.	Short
S_o L_1	U-18 to U-19	East shoreline; appx. 150 ft. wide, 700 ft. long.	Short
S_1 L_o	0-1.5 to 0-4.5	South shoreline; appx. 150 ft wide, 1,200 ft. long.	Long
S_1 L_1	U-18 to U-19	West shoreline; appx. 150 ft. wide, 700 ft. long. Two cores w/in slip.	Long

TABLE 2-3. FAR-UPSTREAM REACH SEDIMENT SAMPLING LOCATIONS AND ANALYSIS SCHEME.

Distance Above U-26 (miles)	Description	Initial Analysis	Archive
0.8	Kearny Reach	X	
1.8	Arlington Reach	X	
3.0	Belleville Reach (Rutgers Str.)	X	
4.0	Vicinity of Riverside Co. Park		X
5.4	Below Third River		X
6.2	Above Rt. 3 Bridge	X	
7.0	Rutherford Reach	X	
8.0	Below Gregory Str. Bridge		X
9.0	Wallington Reach, near Market Str.		X
10.0	Below Saddle River		X

TABLE 2-4. TOTAL NUMBER OF CORES AND CORE SECTIONS COLLECTED AND THE TOTAL NUMBER OF CORE SECTIONS TO BE ANALYZED INITIALLY.

Location	Cores		Sections	
	Short	Long	Total	Initial Analysis
Site-Area Reach	0	17	170	85
Downstream Reach	12	20	260	65
Upstream Reach	8	8	120	34
Far-Upstream Reach	10	10	150	50
Above Dundee Dam	0	4	40	7
TOTAL:	30	59	740	241



BASE MAP OBTAINED FROM NOAA CHART 12337
PASSAIC AND HACKENSACK RIVERS, DATED
OCT 13, 1984

* SEDIMENT SAMPLING LOCATIONS

SOUNDINGS IN FEET

PASSAIC RIVER SEDIMENT SAMPLING LOCATIONS

WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY: DRS	SCALE: 1 IN = 1650 FT	PROJ. NO. 85C7782 02
CK'D. BY:	DATE: 8 APR 1985	FIG. NO.: 1

DEP\DA0050111

SECTION 3.0
WATER COLUMN SAMPLING

The water column sampling program is designed to further understand the hydrologic character of the Passaic River estuary and to evaluate the potential for, and extent of, bidirectional sediment transport. In addition, the program will provide input data for sediment transport modeling.

Current velocity, salinity and temperature measurements will be recorded over a complete tidal cycle (12-13 hours) during non-storm conditions at Stations 0-9-2 (thalweg) and 0-9-0 (channel margin). These measurements will be recorded simultaneously at both stations every half-hour at vertical intervals within the water column. Current velocity will be measured with Endeco 110 current meters; salinity and temperature will be measured with YSI Model 33 salinometers.

The bathymetric sounding along Transect 0-9 from the hydrographic survey conducted in February 1985, will be used to determine cross-sectional area. Instantaneous water discharge across Transect 0-9 will be computed for each half-hour by multiplying the cross-sectional area by the mean velocity. The mean velocity for ebb flows will be determined using the two-point method, which averages the velocities recorded at 0.2 depth and 0.8 depth. The mean velocity for flood flows will be determined using the three-point method, which averages the velocities recorded at 0.2 depth, 0.4 depth, and 0.8 depth. The two different techniques are recommended because the ebb tide velocity profile was wedge-shaped, while the flood tide velocity profile was bow-shaped. As mean velocity and cross-sectional area will change during rising and falling tide, they will be recalculated for each half-hour period.

Water samples will be collected in conjunction with each current velocity measurement in the thalweg using a depth-integrating sampler. These samples will be analyzed for concentration of suspended sediment (mg/l).

A complete tidal cycle will also be monitored during storm conditions (if available) for current velocity and direction, salinity, temperature, and suspended sediment as outlined above for non-storm conditions.

SECTION 4.0
DATA ANALYSIS

4.1 STATISTICAL ANALYSES

The TCDD data from chemical analysis of sediment samples collected by the sampling plan described in Section 3.0 will be statistically analyzed. These analyses will be performed separately for the following four reaches:

- o the far-upstream reach;
- o the upstream reach;
- o the site area reach; and
- o the downstream reach.

All reaches are fully described in Section 2.0. After a comparison of the TCDD concentrations in these four reaches and the samples collected above Dundee Dam, the results will be combined to estimate the extent of contamination along the river (i.e., where TCDD contamination is currently found).

The statistical analyses to delineate the extent of the longitudinal and vertical contamination will consider two important factors--the effect of sedimentation and dredging in the river. Sedimentation will be considered at two levels: high sedimentation (S_1); and no or low sedimentation (S_0). Dredging on the river will also be at two levels: the areas where dredging has occurred (D_1); and where dredging has not been done since 1950 (D_0). Along with these factors, every sediment sample (besides main variable TCDD concentration) will have four covariables: the location and distance coordinates, the grain size of the sediments, the levels of heavy metal, and finally, the total organic carbon (TOC) levels of the sediments.

These covariables wil be considered in all the statistical analyses. Distance covariable is important because the preliminary Kriging analysis indicated that the range of TCDD is approximately 500 feet. Grain size and TOC data is important because there is a physical evidence that dioxin is preferentially adsorbed onto fine-grained organic-rich sediments. Heavy metal concentrations will be used to estimate sedimentation accumulation rates in the river.

The objectives of the statistical analyses will be to: a) find if the contaminations are significantly different in the four regions; b) find the extent of contamination up and down the river; c) delineate the extent of contamination around the 80 Lister Avenue Site; d) find if sedimentation rates have significant effect on contamination; e) find if dredging has any significant effect on contamination; f) find if sedimentation and dredging interact in anyway to affect the contamination; and g) delineate the location and volumes of significant dioxin contamination and no contamination. The objective of the statistical analysis and the overall work plan is to quantify TCDD and its movement within the Passaic River for the remedial action alternatives.

The statistical methods to be used in the above analyses will include: a) unbiased minimum variance estimation including Kriging; b) minimum error estimation; c) analysis of variance with covariates; d) regression analysis; and e) significance testing of hypotheses. These methods will provide estimates of contamination as well as some measure of level of confidence in these estimates.

4.2 SEDIMENT TRANSPORT MODELING

The primary objective of computer modeling will be to evaluate the pattern and process of sediment transport and deposition, and to evaluate the fate of TCDD-contaminated sediment under varying river and tidal conditions. Modeling will predict where TCDD-contaminated sediments delineated through sediment and statistical analyses are apt to move under a variety of conditions.

Sediment transport modeling will include both conceptual and computer transport models. The conceptual model will be based on an understanding of existing hydrographic and physical data. These data include geomorphic and bathymetric data, current and salinity measurements, and grain size estimates. Conceptual modeling will help delineate the upstream extent of flow reversal, the net movement of sediment, and areas of fine-grained sedimentation. This modeling will be useful in evaluating sedimentation rates, the impact of dredging, and the impact of storm events, and will be applied in the initial interpretation of results.

Computer models will require a relatively comprehensive array of data inputs. Included in this array will be tidal prism and fresh water discharge data, and flood recurrence interval data. In addition, site-specific field and laboratory data on river dynamics and sediment characteristics (grain-size distribution, specific gravity, density, TOC) will be used to construct the model. Results of the computer modeling will be evaluated, compared with known hydrologic characteristics of the Passaic River estuary, and adjustments made to improve the accuracy and applicability of the model. It is anticipated that the computer modeling will be capable of simulating a range of hydologic conditions, particularly changes in fresh water discharge and tidal prism and will predict the resulting sediment transport.

4.3 GEOGRAPHIC INFORMATION SYSTEM

Results of the sediment analyses, water column sampling, plus the subsequent statisitical analyses and the sediment transport modeling, will be presented in text, tables, and figures. High quality figures prepared through the use of a Geographical Information System (GIS) will present the results of the Passaic River sediment analysis program, thus facilitating both the understanding and interpretation of the complex spatially-oriented results.

The following GIS presentations are expected to be included:

- o TCDD data from the four reaches,

- o bathymetric profiles in critical sections of the river,
- o contour maps of TCDD concentrations,
- o contour maps of critical TCDD concentrations (e.g., 1, 10, and 20 ppb),
- o volumes of sediment containing TCDD at critical concentrations, and
- o results of the sediment transport modeling.

Data presented using the GIS will be used in both the Passaic River Report and in the Remediation Plan.