PASSAIC RIVER SEDIMENT STUDY

PREPARED FOR:

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BY:

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EXECUTIVE SUMMARY

In compliance with Administrative Consent Order I (ACO I), issued March 13, 1984 by the New Jersey Department of Environmental Protection (NJDEP), Diamond Shamrock Chemicals Company (Diamond Shamrock) conducted an assessment of its 80 Lister Avenue plant site in Newark, New Jersey. A portion of the 80 Lister Avenue site assessment, submitted to the NJDEP in February 1985, concerned the discovery of 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin or TCDD) in identifiable concentrations in the sediments of the Passaic River. The February 1985 assessment document reported that 26 of the 36 samples taken from the river sediments contained concentrations of dioxin that ranged from 0.53 to 130 micrograms per kilogram (µg/kg or parts per billion, ppb).

As a result of that study, Diamond Shamrock commissioned IT Corporation (IT) in May 1985 to conduct a more detailed assessment of dioxin in the Passaic River sediments. Presented in this report are the findings of that study for a stretch of the Passaic River from its mouth upstream to Dundee Lake.

Project objectives were primarily twofold:

- To assess the occurrence and concentration of dioxin in the river sediments of the lower Passaic River (below Dundee Dam)
- To assess whether or not the occurrence of dioxin in the sediment poses an immediate and substantial risk to public health or the environment.

To accomplish these objectives, a total of 94 sediment cores from 35 locations were taken in the river at variously distributed points along the 16.5-mile study area, comprising 297 sediment samples analyzed for dioxin and 328 archived for future reference. Selected samples were also analyzed for total organic carbon (TOC) and lead. In addition, most samples were also tested for physical properties, including grain-size distribution, water content, and specific gravity.

Results of the chemical analysis of the sediment samples showed the following:

- Dioxin was found in detectable quantities in all reaches of the river up to 9.4 miles upstream of the site.

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- The distribution of dioxin concentrations was highly skewed, in that over 60 percent of the samples had dioxin concentrations less than 1 part per billion (ppb) and 58 percent had no detectable dioxin at the limit of detection (as low or lower than 0.78 ppb).

- Generally, the sediment surface (upper 2 feet) contained much less dioxin than the deeper sediments.

- Fifty percent of the samples taken from the upper 2 feet of sediment had no detectable dioxin/

- The occurrence of detectable quantities of dioxin upstream and downstream of the site showed no obvious trends either with distance from the site or with depth in the sediment.

- The distribution of dioxin is relatively uniform throughout the entire lower Passaic River (below Dundee Dam) and strongly suggests that recent contributions of dioxin to the river have occurred without limitation as to location.

- No correlation between dioxin concentrations and sediment grain size could be established.

The results also showed the following characteristics for each section of the river:

- Site-Area Reach - High concentrations of dioxin, where detected, are bounded both above and below by sediments with low or no detectable concentrations of dioxin. This reach is bounded laterally by sediments with low or no detectable concentrations of dioxin. Forty-nine percent of the samples did not contain dioxin at or above the limits of detection. The median concentration of all samples was 0.88 ppb. The highest concentration measured in this study was 1,804 ppb at 8 to 10 feet deep near the south bank.

- Downstream Reach - Forty-five percent of the samples had no detectable dioxin. The median for all samples was 0.81 ppb, and the highest concentration reported was 15.6 ppb at 4-5 feet.

- Upstream Reach - Sixty-three percent of the samples had no detectable dioxin at or above the limits of detection. The median value for all samples was approximately 0.78 ppb and the highest concentration reported was 32 ppb at 8 to 10 feet.

- Far-Upstream Reach - Eighty percent of the samples had no detectable dioxin. The median concentration for all samples was 0.23 ppb. The highest reported concentration from this reach was 20 ppb at 4-5 feet in Area F01. Sixty-three percent of the samples with detectable dioxin (10 of 16 sections) occurred in the surface sediments, in contrast to other reaches (with the exception of the control reach)

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in which most of the measured dioxin lies below the top 2 feet of sediment.

- Control Reach - Eight samples comprising the entire 6.5- to 6.75-foot lengths of two cores were found to contain no detectable dioxin.

Due to the absence of obvious trends in dioxin distribution, information obtained from the field data collection effort and from other published sources was integrated and assessed to determine:

- The spatial distribution of dioxin in the sediments of the lower Passaic River, using nonparametric geostatistical analyses
- A qualitative evaluation of the potential for dioxin mobility via natural sediment transport mechanisms.

These analyses showed that:

- The occurrence of dioxin at some locations could not be attributed to the site-area reach as a source.
- Where dioxin was found in the sediments, it was relatively confined to pockets rather than distributed over a wide area.
- The distribution of dioxin over depth suggests a correspondence with the pattern of runoff and process sewer discharge into the river during the years of plant operation. New clean sediments have been deposited over the native sediments since the sewer line was closed.
- Dioxin occurs throughout the entire length of the lower Passaic River although strong fresh water discharge conditions tend to limit the extent of site-area reach-associated sediment mobility to approximately 6.5 miles upstream.
- The statistical analyses of the data indicate that dioxin occurs in areas which, based on natural sediment transport processes under normal conditions, are not predicted to contain dioxin originating from the site-area reach.
- Numerous sources exist for the discharge of chemicals to the Passaic River, including permitted industrial and municipal discharges, PVSC combined sewer outfall regulators, direct process discharge sewer lines, and direct storm runoff.

The above considerations indicate that multiple sources contributed to the occurrence of dioxin in the sediments of the lower Passaic River.

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A risk assessment, based on the statistical and sediment transport analyses, was conducted, resulting in the following conclusions:

- There is no immediate and substantial risk to public health or the environment associated with the present distribution of dioxin in the site-area reach-associated sediments in the lower Passaic River below Dundee Dam.
- Limited consumption of fish and crustaceans due to bans, the industrial setting, and the poor water quality mitigates the significance of this exposure pathway.
- The higher concentrations of dioxin below the top 2 feet of sediment may pose an additional risk to humans and the environment if the sediments are disturbed.
- The complexity of the study area, including issues such as intense land development, heavy industrialization, estuarial properties of the river, and difficulty in determining actual exposure potential, precluded this study from assessing the risk of long-term exposure to humans and the environment.

The natural sediment transport processes occurring in the river have resulted in the deposition of a cap of essentially dioxin-free sediment overlaying the deeper dioxin-containing layers. The risk assessment indicated that there is no immediate and substantial risk to human health or the environment from the present distribution of dioxin. No immediate remedial action is warranted, based on present conditions and the normal processes addressed in this study. Therefore, conditions allow time for a more thorough evaluation to define the long-term risk and consider response options on a more informed basis.

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1.0

1.0 INTRODUCTION AND SUMMARY

In compliance with Administrative Consent Order I (ACO I), issued March 13, 1984 by the New Jersey Department of Environmental Protection (NJDEP), Diamond Shamrock Chemicals Company (Diamond Shamrock) conducted an assessment of its 80 Lister Avenue plant site in Newark, New Jersey. A portion of the 80 Lister Avenue site assessment, submitted to the NJDEP in February 1985, concerned the discovery of 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin or TCDD) in identifiable concentrations in the Passaic River. The February 1985 assessment document reported that **26 of the 36 samples taken from the river sediments contained concentrations of dioxin that ranged from 0.53 to 130 ppb.**

As a result of that study, Diamond Shamrock commissioned IT Corporation (IT) in May 1985 to conduct a more detailed assessment of dioxin in the Passaic River sediments. The findings of that study for a stretch of the Passaic River from its mouth upstream to Dundee Lake are presented in this report. Project study objectives were to assess:

- **The occurrence and concentration of dioxin in the river sediments of the lower Passaic River (below Dundee Dam)**
- **Whether or not the occurrence of dioxin in the sediment poses an immediate and substantial risk to public health or the environment.**

The objectives of this study are consistent with U.S. Environmental Protection Agency (USEPA) guidance to initially determine if prompt mitigation is necessary or if conditions allow for a thorough evaluation in the future to determine the long-term risks and consider feasible options, thus responding on an informed basis to the overall situation.

To accomplish these objectives, the segment of the river under study was subdivided into five study reaches (portions of the river):

- The site-area reach - In the immediate vicinity of 80 and 120 Lister Avenue
- The downstream reach - Downstream of the site to the mouth of the river

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- The upstream reach - Upstream of the site-area reach to the William Stickel Memorial Bridge
- The far-upstream reach - Upstream of the William Stickel Memorial Bridge to the Dundee Dam
- A control reach - In Dundee Lake upstream of the dam.

A total of 94 sediment cores were taken in the river at about 35 locations variously distributed among the study reaches. From the 94 cores, 297 sediment samples were analyzed for dioxin and 328 were archived for future reference. At the request of the NJDEP, 234 of the samples analyzed for dioxin were also analyzed for total organic carbon (TOC) and selected samples (19) were analyzed for total lead. In addition to chemical analyses, 243 samples analyzed for dioxin were also tested for physical properties, including grain-size distribution, water content, and specific gravity.

Results of the chemical analysis of the sediment samples show that dioxin was found in detectable quantities in all reaches of the river (except the control reach) up to 9.4 miles upstream of the site. Half of the samples analyzed in the 0 to 2 foot sediment depth had detectable concentrations, with the median concentration of reported analyses being 0.76 ppb and the maximum reported value within that depth being 15.1 ppb at area D65 in the downstream reach. The median concentration of dioxin in the upper 2 feet of sediment was fairly uniform throughout the lower Passaic, and ranged from 0.60 to 0.86 ppb among the four reaches.

The greatest concentrations of dioxin were found to occur below 2 feet into the sediment. **The highest concentration of dioxin reported in this study was 1,804 ppb at 8 to 10 feet sediment depth in the site-area reach at core location S14 near the left bank.** The median of all sample results for this reach was 0.55 ppb and 49 percent of these samples had no detectable dioxin. **The occurrence of detectable quantities of dioxin upstream and downstream of the site showed no obvious trends either with distance from the site or with depth in the sediment.**

The detection limit for any individual sample varies with the conditions of that sample, including sample matrix (soil, liquid, etc.), presence of

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interferring substances, and quantity of sample available for analysis. By agreement with NJDEP, the required detection limit for dioxin was 0.78 ppb. However, the analytical procedures were sensitive enough that in many cases dioxin present at levels below 0.78 ppb were detected, or samples were determined to contain no detectable dioxin at much lower limits of detection. In all cases, samples with no detectable dioxin are reported with the sample-specific limit of detection in parentheses.

Due to the absence of obvious trends in dioxin occurrence, information obtained from the field data collection effort and from other published sources were integrated and assessed to determine:

- The spatial distribution of dioxin in the sediments of the lower Passaic River
- The potential for dioxin mobility via natural sediment transport mechanisms.

A qualitative evaluation of the potential for dioxin mobility was made based on existing data and the processes known to affect sediment transport in an estuarial setting. **In view of the extremely low solubility of dioxin in water and its high affinity for sorption onto soils, dioxin transport in the river was assumed to occur solely as a result of sedimentation processes (erosion resuspension, transport, and deposition).** Conceptual models were employed to bracket the extent of dioxin mobility using worst-case assumptions under normal tidal conditions. Consideration was given to tidal flushing, scour potential, and sediment deposition in addition to the location of the zone of turbidity maximum. The primary goal of this analysis was to determine to what extent dioxin-sorbed sediments could be transported away from the site under natural sediment transport mechanisms.

Strong freshwater discharge conditions and the morphology of the Passaic River combine to limit sediment transport in the river. Considering the site-area reach as a source, sediment transport resulting from resuspension would be primarily limited by the zone of turbidity maximum which enhances flocculation and settling of sediments. During the time it was measured, the turbidity maximum zone was determined to occur between Stations U18 and F02 upstream of

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the site. This zone will migrate depending on the freshwater discharge to the esturary.

A nonparametric geostatistical analysis using Indicator Kriging was applied to the dioxin analytical data on an area-by-area basis to (1) allow the prediction of the probability of detecting a particular target concentration within a given distance from a known point and (2) aid in assessing where target concentrations of dioxin might occur at various levels of probability. This technique is particularly applicable when depositional and distribution processes are not entirely controlled by natural mechanisms.

Analysis of the spatial distribution of dioxin in the sediments, however, did not entirely confirm predictions based upon sediment transport alone. The presence of dioxin in the site-area reach and in the zone of turbidity maximum was expected and confirmed by the analyses. However, the occurrence of dioxin at other locations, particularly in the far-upstream reach, could not be attributed to the site-area reach as a source.

Subsequently, these analyses were used to evaluate if an immediate and substantial risk to public health exists. A qualitative risk assessment was conducted to address this issue. Particular emphasis was given to the very low concentration of dioxin found in the upper 2 feet of the river sediments because this is the critical zone for potential exposure. Furthermore, as newer sediments are deposited, a natural cap of cleaner sediments will continue to settle over dioxin-associated material. These considerations were combined with the complex environmental setting to assess immediate and substantial risks.

The chapters of this report are presented as follows:

- Background and setting of the section of the river under study and its environs
- Potential for sediment transport in the river
- Program of sample collection and analysis
- Results and discussion of the data
- Statistical analyses of the spatial distribution of dioxin in the sediments of the Passaic River in the study area

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- Assessment of the potential for immediate and substantial risk to public health from dioxin in the river sediments
- Conclusions of the study.

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2.0

2.0 SETTING AND BACKGROUND

As discussed in the Introduction (Chapter 1.0), the scope of this study is limited to the investigation and assessment of dioxin in sediments of the Passaic River in the 16.5 mile subject study area. This chapter of the report is presented to provide the context within which the project was conducted. Sampling, analysis, and characterization of the river sediments were a natural consequence of previous investigations undertaken by Diamond Shamrock at its 80 Lister Avenue plant site in Newark, New Jersey and the adjacent 120 Lister Avenue site. Those investigations were undertaken as a result of ACOs I and II issued by NJDEP. Various events pursuant to Diamond Shamrock's compliance with those ACOs eventually led to conducting a more detailed study of dioxin in Passaic River sediments than was originally undertaken in the 80 Lister Avenue site assessment. Table 2-1 summarizes events pertinent to the completion of this study.

2.1 PASSAIC RIVER ENVIRONMENTAL SETTING

The river environment is described to provide the framework for this investigation including on-shore land use along the stretch that was studied, river physiography and hydrology, dredging history and the environmental condition of the water and sediments. An understanding of these factors is necessary to evaluate the presence or absence of an immediate and substantial risk to public health and the environment. Figures 2-1 and 2-2 show the study area, the river, and the site-area reach of the river near 80 Lister Avenue.

2.1.1 River Bank Land Use Patterns

2.1.1.1 Industrial Nature of the Study Area

Most of the land on both banks of the Passaic River in the study area is zoned for commercial or industrial uses. The lower Passaic River Basin and City of Newark, NJ are heavily industrialized. According to a study in 1972 concerning pollution control on the Passaic River, there were a total of 103 dye, paint, and chemical industries in Newark alone (Center for Analysis on

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Public Issues, 1972). The area has been heavily industrialized since the middle to late 1800s with the Passaic serving as a major industrial artery.

2.1.1.2 Plant History

The plant history has been described in detail in the Site Evaluation and Feasibility Study reports (IT, 1985a and IT, 1985b). Diamond Shamrock operated the plant from 1951 to 1969, during which time it was predominantly devoted to pesticide and herbicide production. Dioxin associated with the site originated from 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) production. Two factors that may have had the greatest impact on river sediments are the explosion that occurred in 1960 and the presence of sewer pipes that may have acted as a conduit for chemical waste discharges to the river. Sediment mobilization due to storm water runoff was another potential mechanism for migration of dioxin. An explosion in the trichlorophenol (TCP) unit during February 1960 destroyed the large five-story building in which it and several other plant processes were located. As TCP is associated with the inadvertant formation of dioxin, there may have been some residual materials that entered the river system during the cleanup.

A change in the handling of process effluent occurred in 1956 with the installation of an industrial sewer connecting to the Passaic Valley Sewerage Commission (PVSC) Lister Avenue line. Following installation of that connection, the plant process wastes were discharged to the PVSC system, terminating discharge to the river.

In 1960, during work required to stabilize the river bank at 80 Lister Avenue, several sewer pipe discharge lines to the river were discovered. All of the uncovered conduits were plugged with concrete when the new bulkheads were constructed. Presently available information indicates that there are no conduits open to the river remaining at this installation. Figure 2-3 shows the locations of several lines known to have existed at the 80 and 120 Lister Avenue sites.

2.1.2 River Physiography

A major drainage feature of the Hackensack Meadows, the lower Passaic River

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meanders in a relatively narrow (1000 to 2000 foot wide) flood plain. Industrial development along the river has resulted from filling the original tidal marsh land, permitting access to the Passaic River.

The study reach of the river from Dundee Lake to its mouth at Newark Bay is contained within the **Paterson, Hackensack, Orange, Weehawken, Elizabeth and Jersey City, New Jersey 7.5 minute U.S. Geologic Survey (USGS) topographic quadrangles** (Figure 2-1). From the mouth of the Passaic at Kearny Point, the 80 Lister Avenue plant site lies about 2 miles upstream along the southern shore of the river. Numerous highway and railroad bridges cross the river and generally alter many of the natural depositional and erosional characteristics of the river. Many of the industrial facilities along the river have used a combination of fill materials secured with bulkheads for site development and river access.

Sediments below the river bed consist of till, clays, and glaciofluvial and glaciolacustrine deposits (Salisbury, 1902, Lovegreen, 1974, Averill, 1980, and Agron, 1980). Encountering these deposits would indicate a geologic time prior to natural or man-induced alterations in the river. Recent river deposit sediments tend to be dark clayey silts with only trace amounts of sand and coarser sediments.

2.1.3 Hydrology

The river sediments are of primary interest in this presentation because dioxin is almost totally particle associated in the environmental setting. The climate, meteorology, flooding history, and major storm events all have some impact on the environmental fate of the sediments.

Climate and meteorological conditions in the area are reported in detail in the 80 Lister Avenue Site Evaluation (IT, 1985a). The climate of the area is typified by moist, warm summers and moderately cold winters with winds of moderate velocity. **The average annual precipitation for the area is 41.45 inches, based on data from 1944 to 1983 [National Oceanographic and Atmospheric Administration (NOAA), 1983].** Precipitation falls fairly uniformly throughout the year, although the region is influenced by seasonal

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tropical storms and hurricanes. Monthly precipitation averages range from 2.82 inches (October) to 4.27 inches (August).

Tidal elevations for the Passaic River at Newark are predicted annually by NOAA. The mean tidal range (difference in height between mean high water and mean low water) is reported by NOAA (1984b) as 5.1 feet. The spring range (average semidiurnal range occurring semimonthly as a result of the moon being new or full) is reported by NOAA as 6.1 feet with the mean tide level (midway between mean low water and mean high water) at 2.5 feet.

Data obtained at the Little Falls gaging station and regression techniques developed by the USGS (1984) were utilized to calculate the mean annual freshwater flow at the mouth of the Passaic River to be approximately 1,450 cubic feet per second (cfs). The seven-day ten-year low flow discharge (7-10) is the low flow that may be expected to occur on seven consecutive days on the average of once every ten years. A 7-10 value was estimated for the lower Passaic River to be 60 cfs.

Flooding occurs in the Lower Valley due to a relatively narrow flood channel that is constricted by many bridges, heavy urban development along the river banks, and generally flat slopes that are constrained by rock outcrops. The natural storage in the Central Basin reduces the contributing flood flows into the Lower Valley from the flash-flood susceptible highland tributaries (the Ramapo, Wanaque, Pequannock, Rockaway, and Whippany rivers).

Unlike upstream areas where flooding is controlled by rainfall events, flooding of the lower Passaic River is controlled mainly by tidal influences. The greatest potential for inundation in the Lower Valley comes from the storm surge and tidal flooding associated with a major storm. The cross-sectional area of the channel in the tidal zone of the river is so great in relation to the discharge that any rise in water level as a result of rainfall is minimal when compared to elevation changes due to tides. According to the U.S. Army Corps of Engineers (COE) flood insurance study for the region, flood elevations for the 10-, 50-, 100-, and 500-year tides are 7.5, 9.3, 10.2, and 12.8 feet above mean sea level (MSL), respectively (COE, 1968). Elevations at the site vary between 7 and 10 feet MSL.

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The river is in the path of tropical hurricanes and is consequently subject to occasional rainfalls of great intensity. The types of storms producing damaging floods on the Passaic include late summer storms originating over the ocean to the south (such as 1881, 1903, 1945); fall or hurricane storms (such as 1810, 1919, 1938, and 1955), spring storms originating over the continent to the west and southwest (such as 1896, 1901, 1936, 1951, and 1968); and local thunderstorms (such as 1819, 1843, 1865).

The greatest flood on record was due to the storm of 1903 in which the reach from Dundee Dam to the Newark Bay was inundated over an area of 1520 acres to a maximum depth of 14.5 feet. The most recent severe floods occurred in 1936, 1945, 1955, and 1968 (COE, 1968). Occurrence of an event such as a hurricane is not necessarily predictive of flood conditions. Factors which may mitigate a flood include the tidal level, how much rain was associated with the storm, wind direction, location of the eye, etc.

2.1.4 Passaic River Dredging History

Since the flood of 1903, a number of changes have occurred along the river channel that limit the severity of flooding. These include bulkheading and backfilling, dredging of the channel, and installation of dams on the river.

The shipping channels of the Passaic River, Newark Bay and the nearby Hackensack River are active navigation lanes that are regularly maintained. They are dredged by the COE to permit navigation by barge and boat traffic. The COE (1975) has divided the navigable portion of the Passaic River into four separate sections of different depths, the 10-foot, 16-foot, 20-foot, and 30-foot Projects (Figure 2-4).

The downstream limit of the 10-foot Project (channel dredged to a 10-foot depth) runs approximately 8 miles upstream from the mouth of the Passaic. The 16-foot Project ends approximately 7 miles upstream from the mouth (5 miles upstream of the Lister Avenue site). The 20-foot Project extends to just downstream from the New Jersey Turnpike Bridge, approximately 1 mile downstream of the site. The 30-foot Project includes the rest of the Passaic River to the confluence of the Passaic and Hackensack Rivers. The 80 Lister

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Avenue site is located on that section of the river designated as the 20-foot Project. In 1937 the Passaic River channel was dredged to a depth of 20 feet from the downstream limit of the 20-foot Project to the Jackson Street Bridge (COE, 1984). The site-area reach was last dredged in 1949 to 16 feet (COE, personal communication).

Because commercial traffic on the Passaic River above the 30-foot Project is declining, the COE has indicated that there may not be any reason to maintain the 20-foot Project to full depth. However, the possibility exists that the channel could be dredged to an intermediate depth to maintain the channel for barge traffic. The COE points out that, even though the 20-foot Project has not been dredged since 1949, barge traffic is still using the channel without difficulty.

The 30-foot Project of the Passaic River has been established for container ships travelling to Port Newark. The dredging history for the 30-foot Project since 1956 is shown in Figure 2-4. Identified are the portions of the 30-foot Project that were dredged to a 30-foot depth in 1956, 1961, 1964, 1971, 1977, and 1983.

2.1.5 Discharges to the Passaic

The industrialization of New Jersey has had an effect on the Passaic River for over a hundred years (Brydon, 1974). There are reports dating from 1873 of dyestuffs being discharged into the river at Passaic, and the presence in the river south of Passaic of a black stain that spread for more than a mile and was associated with tar fibers. In 1880 Newark residents complained of a creosote taste emanating from a paper mill.

The 80 Lister Avenue facility is considered to be one of many on-land point discharges (or inputs) to the river sediment environment. The Draft Northeast Water Quality Management Plan (NJDEP, 1979) includes an inventory of permitted discharges and describes water quality in the Passaic River basin. The report identifies, for the Upper Passaic River and its tributaries, 18 major and 95 minor industrial discharges and 20 major and 68 minor municipal institutional discharges. In the lower Passaic River and its tributary, the Saddle River, 12 major and 93 minor industrial discharges and 11 major and 11 minor

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municipal institutional discharges are identified. There is also significant pollutant loading attributed to storm water runoff in this industrialized watershed.

The Passaic Valley Sewerage Commission serves 30 municipalities, most of which are located in the lower Passaic Basin. Industrial dischargers account for 37 percent of the dry weather flow. An estimated 35 percent of the total population in this service area are served by combined sewers. The main PVSC interceptor is located along the western bank of the Passaic River from Prospect Street in Paterson to the Newark Bay Pumping Station. There are 73 overflow stations along this main interceptor. With a 1-inch rainfall, an estimated 125 million gallons of combined storm and sanitary sewage are discharged into the river from these overflow stations.

The PVSC treatment plant has recently been upgraded and expanded from 226 million gallons per day (MGD) to 300 MGD. In 1976 average flow to the plant was 258 MGD. The effluent outfall discharges to New York Bay; however, due to recent reconstruction of this outfall, effluent was being discharged to Newark Bay near the mouth of the Passaic River.

In addition to other parameters, PVSC collects monthly data on coliform bacteria at eight stations in the lower Passaic River. The National Interim Primary Drinking Water Regulation sets the maximum level for coliform bacteria at one to four per 100 ml as the arithmetic mean. The permissible concentration of coliforms for swimming in New Jersey rivers is set at 200 coliforms per 100 ml (NJ Department of Health, personal communication). Of a total of 484 separate measurements taken over the past five years, the average count per 100 ml was about 900. Three samples reported zero, but no other measurement was under the standards.

Since coliform bacteria are present in fecal material and are an indication of sewage contamination, it would appear that there is inadequately treated sewage directly discharged to the river. Further, the levels of coliforms discussed above far exceed drinking water and swimming standards and should severely limit the use of Passaic River water for human activities.

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It is evident from review of existing information that sewage and industrial waste have entered the river over the last hundred years by direct discharge as well as by release through bypass storm sewers during storm events. Thus, the overall quality of the river water has been significantly degraded by a multiplicity of sources.

2.2 DIOXIN AND RIVER SEDIMENTS

2.2.1 Chemical and Physical Nature of Dioxin in the River Environment

Dioxin has an octanol/water partition coefficient (K_{ow}) of 1.4 X 10^6 to 1.9 X 10^7 and a sorption partition coefficient (K_{oc}) of 9.9 X 10^5 to 3.3 X10^6 (USEPA, 1984). Dioxin is not readily biodegraded, consequently it is highly persistent in the water and soil/sediment compartment of the environment. Dioxin is persistent in the freshwater aquatic environment (Ward and Matsumura, 1978). Photodegradation of dioxin in the sediments is not likely to occur 20 feet below the water surface due to turbidity preventing sunlight from reaching the bottom. If there are any suspended or colloidal particles in the water column containing dioxin, there is some opportunity for attenuation by photolysis. The chemical is resistant to oxidation, and hydrolysis is not likely to occur under environmental conditions in the marine environment (USEPA, 1984). Volatilization of dioxin from the water column is possible; however, the process is extremely slow, i.e., 5.5-12 year half-life in freshwater. Sorption on particles (suspended or sediments) appears to be the most important environmental process dictating the fate of dioxin in the aquatic environment. In one study, approximately 85 to 99 percent of dioxin remained adsorbed on sediments in an aquatic system; the balance was accounted for in aquatic biota (Isensee and Jones, 1975).

Dioxin's low water solubility and high affinity for sorption onto soils, particularly soils with a high organic content (Isensee and Jones, 1975; Kearney et al., 1972) indicate that the primary mode of transport is via suspended sediments. Estuaries usually have a large amount of dissolved and particulate organic matter due to biological activity, which further promotes adsorption, making sediment transport the dominant means of dioxin mobility in an estuary such as the Passaic River. Large amounts of dissolved organic carbon in water can have the effect of increasing the amount of chemicals such

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as dioxin in the soluble phase if the organic carbon levels on the sediments are low (Caron et al., 1985). This does not appear to be the situation in the Passaic River.

2.2.2 Risk Considerations

This study is limited to determining whether an immediate and substantial risk is present due to the presence of dioxin as a strongly sorbed compound on river sediments. Therefore, long-term exposure scenarios are not considered in the assessment.

Carcinogenicity is one health effect associated with long-term exposure to chemicals. According to one theory, carcinogenicity caused by some chemicals may be manifested after a 10 to 30 year latency period even after relatively short periods of exposure. Scientific evidence to date suggests that dioxin is not such a chemical (Kimbrough et al., 1984) Chronic exposure of animals to dioxin appears to be required before cancer is expressed. In other words, dioxin behaves like a promoter of the carcinogenic process rather than an initiator. However, for health protective considerations this study was approached by assuming dioxin is an initiator and that short-term exposures could potentially lead to a carcinogenic response. For the purposes of this study, potential health effects from acute exposure to the sediments containing dioxin are considered. This evaluation includes the consideration that short-term exposures to chemicals may potentially lead to long-term adverse health effects such as cancer.

Toxicity, hazard, and risk are not interchangeable terms. Toxicity is an inherent, dose-dependent property of a chemical, while a hazard depends upon the conditions of potential exposure to a chemical. The fundamental concept of a risk stipulates the need for a hazard associated with the chemical and an exposure to that hazard in order for a health risk to be possible. Exposure infers a complete exposure pathway which is conditional on three elements. (1) a source -- the presence of contaminants having known toxicological characteristics, (2) an exposure pathway -- actual or potential pathway that is complete; and (3) receptors -- human and environmental receptors in the exposure paths. The primary mode of exposure may be inhalation, ingestion, or direct contact. Secondary modes include ingestion of dioxin in food fish and

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crustaceans taken from the surface waters in the area and some distance from the site.

A detailed evaluation of the risk assessment is presented in Chapter 7.0.

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TABLES

Table 2-1. Events Pertinent to the Passaic River Sediments Study

1945	Approximate start of manufacture of chlorinated organic compounds.
1/56	Connection to Passaic Valley Sewerage Commission sewer line.
1960	Explosion in trichlorophenol unit, reconstruction of bulkhead.
8/69-3/71	No production on site.
9/74-2/75	No production on site.
2/77-2/85	No production on site.
5/83	Dioxin was found on the Diamond Shamrock site. Cleanup action was initiated as a result of the USEPA (and NJDEP) national effort to identify potential locations where dioxin may be present due to the manufacture of pesticides.
5/83-6/83	Initial Remedial Measures (IRMs) were implemented to prevent access to the site, and migration of TCDD-associated soils to air or the river was prevented by installation of a geofabric cover over the site.
8/84	Initiation of a Remedial Investigation (RI) under the terms of Administrative Consent Order (ACO) No. 1 of March 13, 1984 between the Diamond Shamrock Chemical Corporation (DSCC) and NJDEP. Culminated in the IT Site Investigation Report of February 1985.
2/85	RI Report submitted by IT Corporation to DSCC pertaining to the 80 Lister Avenue site. Sampling program included the collection and chemical analysis of river water column (2) and sediment (36) samples adjacent to the on-shore site.
5/85	River sediment sampling and analysis initiated for the current study.
10/85	Feasibility Study (FS) for the remediation of the on-shore site under the terms of ACO No. 1 and ACO No. 2 of December 20, 1984 between DSCC and NJDEP.

DEP\DA0047550

FIGURES

DRAWING NUMBER 846733-E1

DRAWN BY	J. LOGRECO	1-23-86
CHECKED BY	MP	2-11
APPROVED BY		3/20/86

GARFIELD
WALLINGTON
CLIFTON
PASSAIC
RUTHERFORD
LYNDHURST
NUTLEY
NORTH ARLINGTON
BELLEVILLE
ARLINGTON
KEARNY
KEARNY POINT
HARRISON
NEWARK
JERSEY CITY

CONTROL REACH
FARUP STREAM REACH
DOWNSTREAM REACH
SITE AREA REACH
UPSTREAM REACH

HACKENSACK QUAD
WEEHAWKEN QUAD
PATERSON QUAD
ORANGE QUAD
JERSEY CITY QUAD
ELIZABETH QUAD
CALDWELL QUAD

MILE U-14.0 OUTWATER LANE
MILE U-15.0 GARDEN STATE PARKWAY
MILE U-13.0 CONRAIL
MILE U-12.0 EIGHTH STREET
MILE U-11.0 MAIN STREET
MILE U-10.0 UNION AVENUE
MILE U-9.0
MILE U-8.0
MILE U-7.0 KINGSLAND AVENUE
MILE U-6.0
MILE U-5.0
MILE U-4.0
MILE U-3.0
MILE U-2.0
MILE U-1.0
MILE D-1.0
MILE D-2.0
MILE D-3.0

C01M(A,B)
C01L(A,B)
DUNDEE DAM
DUNDEE LAKE
MONROE STREET
PASSAIC STREET
SECOND STREET
WALLINGTON AVENUE
F09MA
F09RA
F08MA
F08RA
F07MA
F07LA
F65L(A,B,C,D)
F06MA
F06RA
RUTHERFORD AVENUE
RT (3)
CONRAIL
THIRD RIVER
F05MA
F05RA
PASSAIC COUNTY
ESSEX COUNTY
PARK AVENUE
F04MA
F04RA
RUTGERS STREET
BELLEVILLE TURNPIKE
F03MA
F03RA
SECOND RIVER
F02MA
F02RA
F01MA
F01RA
BERGEN COUNTY
HUDSON COUNTY
CLAY STREET
(WM STICKEL MEMORIAL BRIDGE) NASSAU STREET
HARRISON AVENUE
JACKSON STREET
S 4TH STREET
CENTER STREET
U18L (A,B,G,D,E,F)
U18R(A,B,C,D)
U45L (A,B,C,D)
U45R(A,B,C,D)
80 & 120 LISTER AVENUE
D65L(A,B,C,D)
D65R(A,B,C,D)
D06R(A,B,C,D)
D19R(A,B,C,D)
D19M(A,B,C,D)
D22R(A,B,C,D)
D22M(A,B,C,D)
D22L(A,B,C,D)
GENERAL PULASKI SKYWAY
COMMUNIPAW AVENUE
LINCOLN HIGHWAY
NEW JERSEY TURNPIKE
HACKENSACK RIVER
NEWARK BAY BRIDGE
NEW JERSEY TURNPIKE

LEGEND:
- BRIDGE
- F01MA SAMPLE DESIGNATION
- MILE U-7.0 (UPSTREAM) MILE D-2.0 (DOWNSTREAM) MILE MARKER DESIGNATION

REFERENCE
7.5 MINUTE USGS TOPOGRAPHIC MAPS OF PATERSON, N.J., ORANGE, N.J., HACKENSACK, N.J., WEEHAWKEN, N.J.-N.Y., ELIZABETH, N.J.-N.Y., AND JERSEY CITY, N.J.-N.Y. QUADRANGLES, DATED 1955 (PR 1981), 1955 (PR 1970), 1955 (PR 1981), 1967, 1967 (PR 1981), 1967 (PR 1981), SCALE 1"=2000'

SCALE 0 2000 4000 6000 FEET

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FIGURE 2-1

LOWER PASSAIC RIVER STUDY AREA AND SAMPLING LOCATIONS

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DRAWING NUMBER 846733-B15

DRAWN BY	J. LOGRECO 1-22-86
CHECKED BY	MP 3/21/86
APPROVED BY	[illegible] 3/21/86

E.2,146,000 E.2,147,000 E.2,148,000

N 696,000

N.695,000

SITE-AREA REACH

D65R

D65L

SITE "A"

SITE "B"

SITE "C"

RIVER FLOW

TIDAL FLOW

PASSAIC RIVER

MILE 0.0

S42RA S43RA S33MA S32MA S23MA S22MA S13LA S24LA S44LA S34LA S12LA S01LA S14LA S11LA S21LA S31LA S41LA

A B C D

120 LISTER AVENUE

80 LISTER AVENUE

LISTER AVENUE

LEGEND:

S42RA ● SAMPLING LOCATION AND DESIGNATION

NOTE:

FOR LOCATION SITE-AREA REACH, SEE FIGURE 2-1

SCALE

0 200 400 FEET

FIGURE 2-2

SITE-AREA REACH
SAMPLING LOCATIONS

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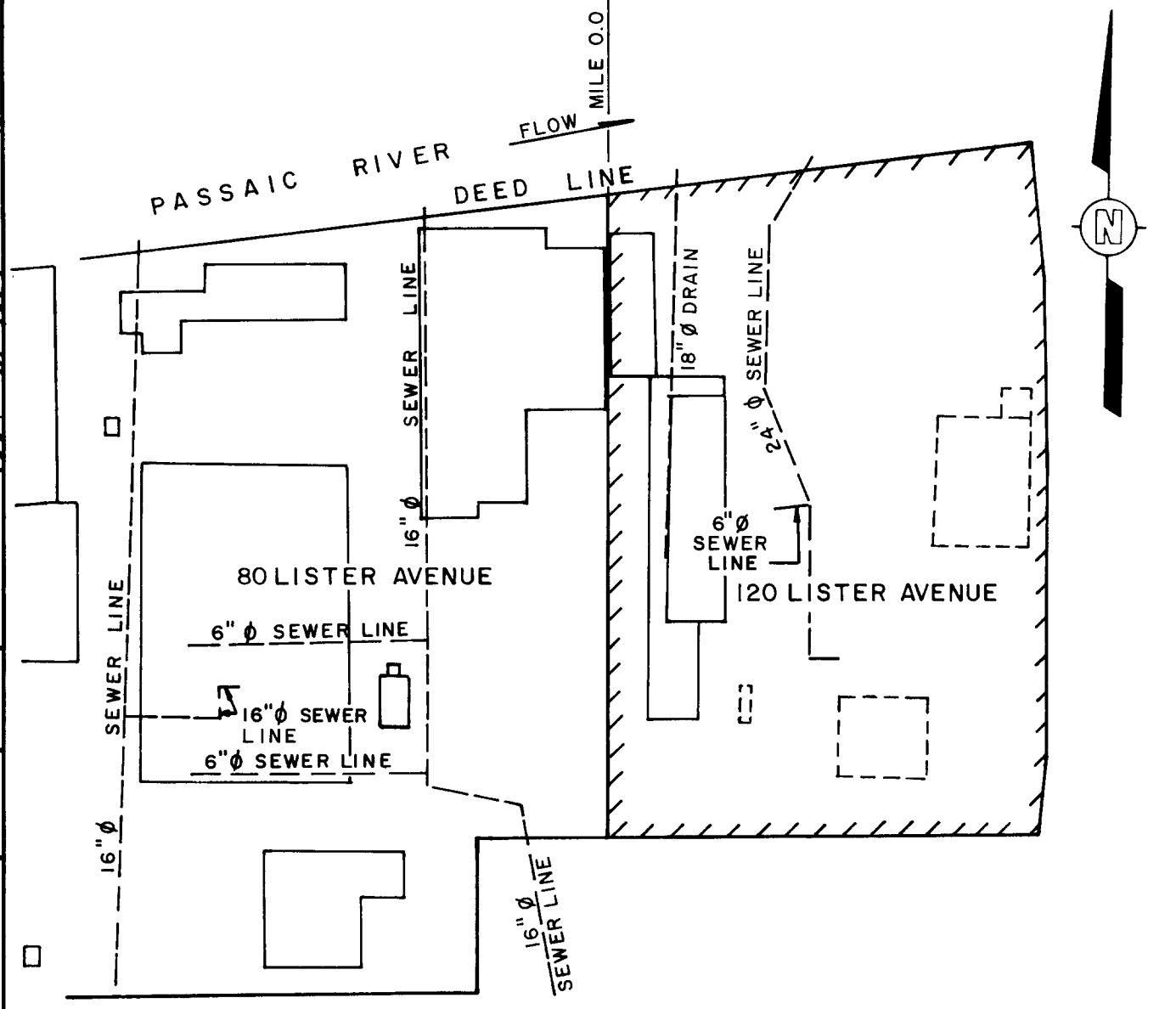

SCALE
0 100 200 FEET

FIGURE 2-3

SEWER LINES AT
80 AND 120 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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cjb/ 01-22-86	APPROVED BY	
	MD	3/20/86
		3/20/86

65360

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DRAWN BY | DATE 01-21-86 | CHECKED BY | APPROVED BY

GARFIELD
WALLINGTON
CLIFTON
PASSAIC
RUTHERFORD
LYNDHURST
NUTLEY
NORTH ARLINGTON
BELLEVILLE
ARLINGTON
KEARNY
KEARNY POINT
JERSEY CITY
HARRISON
NEWARK

CONTROL REACH
FAR UPSTREAM REACH
DOWNSTREAM REACH

MILE U-15.0 GARDEN STATE PARKWAY
COIM(A,B)
COIL(A,B)
DUNDEE DAM
DUNDEE LAKE
MILE U-14.0 OUTWATER LANE
CONRAIL
MILE U-13.0 CONRAIL
F10MA
F10RA
MONROE STREET
PASSAIC STREET
MILE U-12.0 EIGHTH STREET
N LIMIT OF 10-FT PROJECT
SECOND STREET
F09MA
WALLINGTON AVENUE
F09RA
MILE U-11.0 MAIN STREET
F08RA
F08MA
PASSAIC
MILE U-10.0 UNION AVENUE
F07MA
F07LA
MILE U-9.0
F65L(A,B,C,D)
F06RA
F06MA
RUTHERFORD AVENUE
RT (3)
CONRAIL
THIRD RIVER
MILE U-8.0
F05RA
F05MA
PARK AVENUE
KINGSLAND AVENUE
MILE U-7.0
F04RA
F04MA
MILE U-6.0
RUTGERS STREET
BELLEVILLE TURNPIKE
F03RA
F03MA
MILE U-5.0
CONRAIL
SECOND RIVER
F02RA
F02MA
MILE U-4.0
PASSAIC
F01RA
F01MA
MILE U-3.0
CONRAIL
CLAY STREET
(WM STICKEL MEMORIAL BRIDGE) NASSAU STREET
CONRAIL
HARRISON AVENUE
JACKSON STREET
S 4TH STREET
CENTER STREET
MILE U-2.0
U18L (A,B,C,D,E,F)
U18R(A,B,C,D)
CONRAIL
MILE U-1.0
U45R(A,B,C,D)
U45L (A,B,C,D)
80 & 120 LISTER AVENUE
SITE AREA REACH
MILE 0.0
D65R(A,B,C,D)
D65L(A,B,C,D)
CONRAIL
MILE D-1.0
D06R(A,B,C,D)
NEW JERSEY TURNPIKE
GENERAL PULASKI SKYWAY
LINCOLN HIGHWAY
COMMUNIPAW AVENUE
HACKENSACK RIVER
MILE D-2.0
D19R(A,B,C,D)
D19M(A,B,C,D)
CONRAIL
D22R(A,B,C,D)
D22M(A,B,C,D)
D22L(A,B,C,D)
HUDSON COUNTY
ESSEX COUNTY
MILE D-3.0
CONRAIL
NEWARK BAY BRIDGE
NEW JERSEY TURNPIKE
(78)

1976 DREDGED TO 10'
1976 DREDGED TO 10'
1976 DREDGED TO 10'
1976 DREDGED TO 10'
1973 DREDGED TO 10'
1956 DREDGED TO 10'
1964
1983
1956
1961
1977
1971
1949

UPPER LIMIT OF 30-FT PROJECT
LOWER LIMIT OF 20-FT PROJECT
S LIMIT OF 10-FT PROJECT
N LIMIT OF 16-FT PROJECT
S LIMIT OF 16-FT PROJECT
N LIMIT OF 20-FT PROJECT

PASSAIC COUNTY
ESSEX COUNTY
BERGEN COUNTY
HUDSON COUNTY

PATERSON QUAD
ORANGE QUAD
HACKENSACK QUAD
WEEHAWKEN QUAD
BAYONNE QUAD
WEEHAWKEN QUAD
ORANGE QUAD
WEEHAWKEN QUAD
JERSEY CITY QUAD
ORANGE QUAD
ELIZABETH QUAD
ORANGE QUAD
CALDWELL QUAD
JERSEY CITY QUAD
ELIZABETH QUAD

LEGEND:
- BRIDGE
- F0IMA SAMPLE DESIGNATION
- MILE U-7.0 (UPSTREAM) / MILE D-2.0 (DOWNSTREAM) MILE MARKER DESIGNATION
- INDICATES DREDGED AREA

REFERENCE
7.5 MINUTE USGS TOPOGRAPHIC MAPS OF PATERSON, N.J., ORANGE, N.J., HACKENSACK, N.J., WEEHAWKEN, N.J.-N.Y., ELIZABETH, N.J.-N.Y., AND JERSEY CITY, N.J.-N.Y. QUADRANGLES, DATED 1955 (PR 1981), 1955 (PR 1970), 1955 (PR 1981), 1967, 1967 (PR 1981), 1967 (PR 1981), SCALE 1"=2000'

SCALE
0 2000 4000 6000 FEET

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FIGURE 2-4

LOCATIONS AND YEARS OF DREDGING OPERATIONS

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3.0

3.0 SEDIMENT TRANSPORT IN THE PASSAIC RIVER

The purpose of this section is three-fold:

- Identify key processes that affect sediment transport in the Passaic River
- Use the limited data base to qualitatively identify possible trends of sediment transport, which will require validation through a comprehensive, quantitative assessment (not the subject of this report)
- Establish the maximum depth of sediments in the river bed that have the potential to cause immediate and substantial risk to human health and aquatic biota.

Supporting data for this section may be found in Appendices A, B, and C.

Estuaries are the most complex type of water body, due to the myriad of processes that control flow and mixing. Such processes include bi-directional and oscillatory flow and turbulence caused by density gradients and estuary morphology. These processes similarly affect sedimentation phenomena, such as erosion/resuspension, sediment transport, and deposition. **There is sufficient temporal and spatial variability in all of these processes that conclusions on dioxin-associated sediment transport must be validated either with interpretation of an extensive historical data base or with a comprehensive quantitative assessment using deterministic models.** Therefore, the conclusions presented in this section should be viewed in a qualitative light until validation is performed.

Chemicals, such as dioxin, may be transported in water bodies dissolved in and moving with the water column and adsorbed onto sediments and transported as a suspended load. **Given that dioxin sorbs strongly to sediments, as reviewed in Chapter 2.0, a primary assumption was made that dioxin transport in the Passaic River will occur predominantly as a result of sedimentation phenomena such as erosion/resuspension, sediment transport, and deposition.** Dioxin transport in a dissolved phase is not considered to be a critical process, as dioxin concentrations in the sediment bed surfaces are relatively low, and desorption from the bed into the water column should be minimal due to dioxin's low water solubility. Accordingly, the discussions that follow will focus on sediment transport in the Passaic River.

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3.1 KEY PROCESSES AFFECTING SEDIMENT TRANSPORT

Sediment transport in an estuary is governed by a number of physical and chemical processes. These processes can be divided into two primary areas: those associated with tidal flow and mixing phenomena, and those associated with sedimentation phenomena. **Tidal flow processes that can affect transport include tidal variations in water surface elevation, wind stress, fresh water inflow, and internal density differences. Dioxin's strong capacity for sorption onto sediments necessitates the evaluation of sedimentation processes, including scour potential of the sediment bed, sediment transport, and deposition/resuspension of suspended particles.** Key tidal flow and mixing and sedimentation processes are described below.

Estuaries are characterized as having complex, unsteady, spatially-varying flow conditions. Classifying estuaries has been difficult in that the term covers a wide range of flow conditions and a great diversity of sizes and shapes. Bowden (1967) and Pritchard (1967) present classification schemes according to three hydrodynamic categories: sharply stratified estuaries such as fjords and salt wedge estuaries; partially stratified estuaries, where there is a significant vertical density gradient; and well-mixed estuaries, where there is little discernible density gradient. Figure 3-1 provides cross-sections of each type of estuary, showing the vertical salinity distributions. Given the variation in tidal flows and freshwater discharge occurring over the space of a year, an estuary may exhibit different mixing and hence different classifications with time. The Passaic River most likely has temporal-varying mixing and thus could be classified as any one of these categories according to the time of year. For example, during low flow periods when the freshwater discharge is 200 to 500 cubic feet per second, such as during the summer months, and the tidal range at the mouth near Kearny Point is large (4 to 5 feet), the Passaic estuary will most likely be well mixed. During high freshwater discharge periods of approximately 1400 to 5400 cubic feet per second (cfs) and small tidal ranges (such as those from a neap tide), the Passaic estuary can become stratified by the density differences between fresh and saline water. At these times, the freshwater flow can move over the saline tidal wedge and move out to sea. During periods when the freshwater discharge does not exhibit extreme flow conditions, the Passaic

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estuary may be partially stratified. The degree of stratification or mixing, then, is subject to the rate of freshwater discharge and the range of tidal elevation, and can vary on a seasonal, tidal cycle, or tidal stage scale.

The degree of mixing directly affects the transport behavior of dissolved and sediment-sorbed constituents. In particular, the general circulation pattern of sediments in the estuary will be dictated by the degree of vertical mixing. In stratified conditions, very little vertical mixing occurs. In these cases, freshwater flow moves over the saline tidal wedge and is flushed out to sea. During peak flood tide periods or periods of low freshwater discharge, the density gradients between saline and fresh water are not as clearly defined, and more vertical mixing of the water column occurs. During this vertical mixing, sediments can be redistributed in the water column. As stratification becomes more pronounced these sediments become entrained in a predominantly salt water (bottom) or fresh water (surface) flow. Turbulence and eddy effects will promote the suspension and retard the settling of sediments, particularly the finer grained silts and colloidal clays. The net result is that sediments and particles will be internally circulated within the estuarine reach of the river, the extent of which depends on the magnitude of fresh and saline flows, and upon sediment characteristics. This net circulation is termed tidal trapping (Fischer et al., 1979). During high freshwater flows, this net circulation area will move downstream. During low flow periods, the net circulation area may encompass a larger area, due to the extensive vertical mixing and resulting resuspension of particles and sediments. Consequently, the extent of sediment transport and areas of erosion and deposition will be transient over a seasonal time period.

Before sediments can be transported up or downstream, they must be eroded (or resuspended) from the sediment bed. Erosion is a function of many variables, the most important being sediment particle size and density, bed shear stress, and in-stream bottom velocity. The scour or erosion velocity required to resuspend a particle is higher than that required to carry it in suspension.

Once suspended, particles will be transported according to the in-stream flow velocity, their settling velocity, and the degree of turbulence or vertical

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mixing that would cause them to be resuspended in the water column. Sediment deposition, whether it is short-term or long-term, is also dependent upon these variables.

One of the primary objectives in this study is to assess the potential for erosion of dioxin-associated sediments from the sediment bed in the site-area reach and deposition of sediments from other parts of the estuary on top of the native sediments in this reach. The Passaic River estuary, like other estuaries, will exhibit time and space-varying areas of erosion and deposition. As the data in Appendix B show, most of the sediments in the top (0-4 feet depth) of the sediment bed are heterogeneous silts, ranging from 2 to 74 microns in diameter. The sediment in the site-area reach is predominantly silt, with 6 to 8 feet of silts in the center of the channel and 2 to 4 feet along the south and north banks. Silts and clays are characterized as being cohesive, or having the ability to adhere and aggregate. For that portion of silts and collodial clays less than 10 microns in diameter, gravitational settling will be a factor in determining deposition only when aggregation of suspended sediments occurs.

Transport of dioxin-associated silts from the site reach, then, is directly affected by the scour or erosion potential, the degree of vertical mixing, surface and bottom in-stream velocities, size of the silt particles, and salinity gradients.

3.2 QUALITATIVE TRENDS OF SEDIMENT TRANSPORT

The capability of the Passaic River to erode, resuspend, transport, and deposit sediments is the controlling factor of dioxin mobility. The complex and interrelated processes of sedimentation in estuaries and the limited data base available precludes quantitative estimations of sediment movement at this time. However, interpretation of observed data allows us to make qualitative estimates as to the extent of sediment mobility from the site-area reach, under the specific tidal conditions during which data were collected. These qualitative trends are not necessarily indicative of the extent of sediment transport for all possible conditions in the Passaic River. Rather, they represent solely the specific tidal conditions observed.

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The following data were used to identify the tidal condition-specific trends:

- Longitudinal and vertical salinity profiles (November 1985)
- Depth-integrated total suspended sediment concentrations (November 1985)
- Bathymetric survey conducted for the general site area-reach (April 1985) by Woodward-Clyde Consultants.

The salinity and velocity measurement data for both November and April periods are presented in Appendix A. The bathymetric survey is presented in Appendix B.

Using these data, the following tidal and sedimentation phenomena are evaluated: salinity intrusion and mixing, location of the zone of turbidity maximum, and locations of areas of deposition and erosion.

3.2.1 Salinity Intrusion and Mixing

As described in Section 3.1, the Passaic River is subject to a wide variation in freshwater discharge. The rate of freshwater discharge will determine to a large degree the salinity distribution, both longitudinal and vertical, in the river. This distribution provides insight as to the degree of mixing and location of the most inland point of salinity intrusion at a given time. Salinity data and in-stream velocity measurements indicate that the Passaic River was partially stratified during the sampling time in November 1985. Tables 3-1 to 3-4 present in-stream data, including salinity, for four tidal conditions: neap tide/wet weather during low tide; neap tide/wet weather during high tide; spring tide/dry weather during low tide; and spring tide/dry weather during high tide, respectively. Examination of the vertical distribution of salinities reveals significant density gradients through the length of the estuarine portion of the river. However, there were low salinity values for the surface layer, indicating that the estuary is not completely stratified and that limited vertical mixing does occur. It is evident that at this time, some level of tidal trapping did occur, meaning that particles and sediments were internally circulated within the estuarine portion of the river. As shown in Figure 3-1, partially mixed estuaries will have a significant vertical density gradient.

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The circulation pattern demonstrated by the current and salinity data indicate a net upstream flow of the more saline water near the sediment bed. This flow is expected to carry suspended sediment from outside of the river mouth, which includes sediment from the Hackensack River discharge, into the mouth of the Passaic River and upstream a distance of at least one tidal excursion. An average near-bed current of 0.8 feet/second (0.5 knots) would carry Hackensack sediment 3 miles upstream to above the site in one tidal cycle. Such transport can carry sediment polluted in the Hackensack River to the downstream, site-area, and upstream reaches of the Passaic River.

The salinity data are also utilized in defining the extent of upstream transport of constituents by providing the location of the most inland point of salinity intrusion. Salinity intrusion is defined as the maximum inland point of upstream flow associated with the bottom more-saline layer of water. Figure 3-2 illustrates the estimated range of salinity intrusion on the Passaic River during the period of sampling (November 1985). Two different tidal flow and rainfall periods were sampled in order to bracket the range of salinity intrusion that may be observed during this time period. According to salinity data collected in November 1985, for a spring (i.e., high flow) tide and low rainfall period (0.37 inches for the previous 7 days), the maximum extent of salinity intrusion was somewhere below station F04 at high tide, and somewhere below station U18 at low tide. The freshwater discharge at the Little Falls Station for this day (November 14) was 1560 cfs. This value is approximately 25 percent higher than the 87-year average flow of 1168 cfs at the Little Falls station. Observed salinity values were zero at the U18 and F04 stations, indicating that the salinity intrusion point could be farther downstream towards the next station where positive salinity values were reported. Station U18 is approximately 1.9 miles upstream of the site zero mile marker while F04 is approximately 6.5 miles upstream. The distance between these two stations is about 4.6 miles. Given the limited data base from two sampling periods in the fall of 1985, this location is only an approximation, and it may be moved further upstream during the low freshwater flow months of August and September.

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3.2.2 Location of the Zone of Turbidity Maximum

The null zone is defined as that area in the estuary where the upstream bottom transport of constituents is counter balanced by the downstream transport from the fresh water inflow. At this point, there is essentially no net bottom transport. This area is located near the maximum inland point of salinity intrusion. The zone of turbidity maximum is defined as that area in the estuary where high suspended sediment concentrations and deposition rates can be found. This area is also found at the saline-freshwater interface. Although the definitions differ slightly, these two zones are quite often one and the same.

As described earlier, a two-layered circulation pattern (net downstream at surface, net upstream at bottom) in the estuary creates a net circulation area which limits particle and sediment transport up- and downstream. Sediments upstream of the estuary are moved downriver to the estuarine segment of the system due to the net downstream current of the river. If the sediments that pass into the estuarine portion of the river sink to the river bottom, they are moved back upstream, since the net bottom current is in that direction. The zone of turbidity maximum is found near the upstream extent of this net circulation area. The turbidity maximum is a collection zone for particles and sediments. Also, flocculation of particulate matter, including silts and clays less than 10 microns in diameter, is enhanced in the freshwater-saltwater interface zone because negative surface charges of the particles are cancelled by the abundant cations in sea water. These factors combine to account for the relatively high deposition rate in the turbidity maximum area. In most estuaries this area is found where salinities range from 2 to 5 ppth (parts per thousand) (Nichols, 1972).

The existing location of this zone was identified for the sampling period in November 1985. Figures 3-3 and 3-4 show salinities for the slack period prior to ebb tide for the neap and spring tide conditions, respectively. The general location of the turbidity maximum zone is identified for each set of conditions, based on salinity data. Figure 3-5 shows the location of the zone of turbidity maximum in the Passaic River during November 1985. Particles and

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sediments are thus predicted to settle out of the water column at about 5 miles upstream from the mouth of the river (2.5 miles upstream from the site zero mile marker).

Total suspended sediment (TSS) data collected in the Passaic at the same time substantiate these findings (Tables 3-1 to 3-4). The highest concentrations for TSS during low and high tides in neap tide/wet weather conditions were found at station F02 (24 mg/L for each tide). For spring tide/dry weather conditions, the highest concentrations were found slightly downstream from station F02. At low tide, this zone was observed at station U18 (64 mg/L), which had salinity values of zero. At high tide, the maximum TSS value was found at the site area (44 mg/L) with a slightly lower value reported for station F02 (40 mg/L). This variation indicates that for the sampling period in November 1985 station F02 may be the upstream extent of the turbidity maximum zone, and somewhere between station U18 and the site-area reach is the downstream limit of this zone. The location of the zone of turbidity maximum over the course of a year will be variable, according to upstream freshwater discharge and salinities at the mouth.

3.2.3 Location of Areas of Deposition and Erosion

The purpose of this section is to identify these present areas of deposition and erosion. As previously discussed, partially stratified estuaries tend to trap sediments and particles, while allowing freshwater to flow out. This results in a net circulation pattern within the estuary, in which the sediment masses are shifted from one part of the estuary to another. Thus, areas of erosion and deposition may vary according to natural and man-made variations in conditions (e.g., degree of mixing and dredging, respectively) on a yearly, seasonal, or even tidal period scale.

The April 1985 bathymetric survey conducted by Woodward-Clyde Consultants is presented in Appendix B. Figure C-1 in Appendix C shows the location of bathymetric transects in the site-area reach. The area addressed was the Passaic River from the railroad bridge near station F02 downstream to the Pulaski Skyway Bridge. Approximate areas of erosion and deposition have been estimated using bathymetric profile data from earlier Corps surveys and a survey conducted in April 1985 (Figure 3-6). The areas have been identified

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by comparing 1976 bathymetric data with bathymetric data collected in April 1985. It is not clear whether these areas represent long-term sediment transport conditions or short-term phenomena including the effects of combined sewage outfall (CSO) discharges containing high loads of suspended sediments.

Erosion is a result of higher in-stream velocities, which increase the scour potential of the bed. The highest velocities in a straight river channel are near the middle of the channel and near the water surface. As the flow enters a bend, the higher velocity portion of the flow is less easily deflected than the lower velocity portions. A helical component of the flow develops, called a "secondary current," that brings the highest velocity portion of the flow against the outer bank and down to the bed. Friction and mixing slow the velocity of the near-bed current in the inner portion of the bend, with the result that erosion typically occurs at the outer bank and a "thalweg" or deep narrow channel develops in the outer portion of the bed. Deposition commonly occurs along the inside of the bend. This phenomenon is responsible for the propagation and growth of river meanders.

Two erosive areas were identified upstream of the site-area reach. Both were along the outer bank of the river as it bends or meanders. These erosive areas are located between the Jackson Street Bridge and the site-area reach. Small erosive areas of 3 to 4 foot depth (relative to 1976) were observed in transects U-6 to U-9 (Figure B-4). A larger area of erosion was noted along transect U-3 (Figure B-5). It appears that erosion occurred in these areas at an average rate of approximately 0.3 feet per year from 1976 to 1985.

Areas of deposition in the site-area and downstream reaches are the result of lower in-stream velocities in the river. The lower velocities may be a result of the slight physical broadening of the river in the area, which allows the water velocity to slow down as it enters from more constrictive portions of the river. Lower velocities also occur on the inside bends of the river, such as at transect 0-5,(Figure B-5) where some moderate deposition occurred.

Many areas of deposition were identified in the area. An area of sediment deposition was noted along the south (inside bend) shoreline upstream of the site zero mile marker. Its length was approximately 1600 feet, spanning from

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transect 0-1.5 to transect 0-5 (Figure B-5) and extending approximately a third of the width of the river. An average annual accumulation was estimated as 0.5 feet/year (Appendix B). Some moderate deposition was noted on this south shore line of the river at the site also, at a rate of 0.06-0.28 feet/year.

A large area of sediment deposition was noted just downstream of the site zero mile marker, from transects 1-5 to 1-6.5 (Figures B-6 and B-7). The length of this area was approximately 800 feet along the shoreline, and the area extended to more than half the river width. Deposition rates averaged 0.33 feet/year.

It is evident that during the period of 1976 to 1985 the general site-area reach of the river was a primary area of sediment deposition. Sediments from the erosive areas upstream were deposited on top of the native sediments in the bed. It appears that the tendency for sediments to settle in the site area precluded the potential for scour of native sediments. Whether this trend is indicative of long-term conditions is not clear. The primary processes controlling erosion and deposition in the Passaic River include CSO discharge, scour of in-stream sediments, and erosive runoff from the watershed. The continuing requirements for dredging to maintain water depths demonstrate that there is net deposition in the site-area reach. There may be areas of the bed that experience resuspension during flood tide periods, but the net transport results in deposition.

3.3 MAXIMUM DEPTH OF SEDIMENTS FOR POTENTIAL RISK

In order to conduct the risk assessment for immediate and substantial risk of exposure to dioxin in the site-area reach sediment bed (Chapter 7.0), an estimation as to the depth of sediments to which a receptor could potentially be exposed is required. The derived depth is predicated on the basis that the risk is calculated as immediate and substantial, and not a result of long-term conditions where environmental factors, and hence sediment movement, may vary.

The maximum depth of sediments in the bed that could potentially be eroded and suspended in the water column is estimated here. These sediments could be ingested by aquatic biota or come in contact with human receptors.

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Areas of erosion were identified upstream of the site near transects U-3 and U-6 to U-9 (Figures B-4 and B-5). No areas of erosion were identified in the site-area reach according to the bathymetric data. The average rate of erosion for the upstream areas between 1976 to 1985 was 0.3 feet per year. It is not known what the variation in erosion rates was during this time period. However, given that we are concerned with the potential for exposure under existing conditions, a depth of 2 feet is estimated as the maximum potential depth of sediments to which receptors could be exposed. This value is more than 6 times the average yearly erosion rate for the areas upstream (transects U-3 and U-6 to U-9); the actual depth of sediments subject to erosion in the site-area reach will be much less. This estimate is very health-protective in nature, as the site-area reach exhibits net deposition of sediments.

3.4 SUMMARY

Key processes affecting sediment transport in the Passaic River, as well as location of areas of deposition and qualitative trends of the upstream extent of sediment transport during one sampling period in November 1985, have been identified. Specific conclusions concerning sediment transport include:

- Key processes affecting sediment transport include CSO discharges, freshwater discharge, tidal height range, and river morphology.
- Because of the yearly and seasonal variations in environmental conditions, a more extensive empirical data base is required in order to conduct a quantitative assessment covering the entire range of dioxin-associated sediment transport phenomena.
- A comprehensive quantitative assessment of tidal flow and sediment transport, using state-of-the art numerical models, is required in order to validate existing hypotheses of dioxin transport.
- The maximum upstream point that sediment originating from the site-area reach may travel is the point of salinity intrusion. This location varies according to tidal and seasonal changes, but was found between stations U18 and F04, 1.9 to 6.5 miles upstream of the site zero mile marker, during the sampling period.
- Sediments and particles will preferentially settle or be deposited in the zone of turbidity maximum located at stations U18 to F02 during the sampling period.

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- Sediments were deposited in the site-area reach of the river from 1976 to 1985, according to interpretation of bathymetric data. The continuous dredging requirements of the site reach also indicate that this is an area of net deposition.

- Scour of sediments from the site-area reach of the river was low, according to the bathymetric data. There appears to be a greater potential for new sediments from upstream reaches to be deposited in the site-area reach than there is for the native sediments in the bed to be eroded and transported up or downstream from the site area.

- Sediments, including those that might be eroded from the site-area reach, should be trapped by the net circulation patterns of the estuarial portion of the Passaic River, during periods when the estuary is partially stratified.

- There is the potential for polluted sediments from the Hackensack River to be transported into the Passaic River and upstream.

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TABLES

TABLE 3-1. IN-STREAM DATA COLLECTED FOR

NEAP TIDE/WET WEATHER - LOW TIDE

PASSAIC RIVER - NOVEMBER 7, 1985

Station		Diss. Oxygen	Water Temp.	pH	Conduc.	ORP X1000	Sali-nity	TSS (Depth Inte.) mg/l
Mouth	0.5m	6.07	12.01	6.91	16.53	+0.221	8.7	13
	2m	5.88	12.05	6.99	16.53	+0.225	8.8	
	3m	5.62	12.87	7.02	24.53	+0.218	15.7	
	4m	5.57	13.34	7.04	28.98	+0.218	17.3	
	5m	5.56	13.49	7.06	30.93	+0.218	19.2	
	5.8m	5.58	13.50	7.07	31.72	+0.219	19.5	
Total Depth	6.8m							
Site	0.5m	5.75	11.66	7.05	6.080	+0.197	2.9	13
	2m	5.48	11.73	6.99	7.700	+0.208	3.8	
	3m	5.33	12.65	6.90	21.38	+0.212	12.8	
	4m.	5.32	13.32	6.95	29.68	+0.211	11.1	
Total Depth	4.7m							
U18	0.5m	6.36	11.49	7.19	2.443	+0.179	0.8	15
	2m	6.02	11.46	7.12	2.780	+0.190	1.0	
	3m	5.80	11.48	7.06	3.520	+0.198	1.3	
	4m	5.46	11.68	6.94	7.350	+0.207	2.3	
	4.8m	4.96	12.35	6.84	17.14	+0.214	10.0	
Total Depth	5.4m							
F02	0.5m	7.83	11.43	7.36	0.380	+0.182	0.0	24
	2m	7.81	11.39	7.29	0.380	+0.193	0.0	
	3m	7.81	11.38	7.27	0.382	+0.199	0.0	
	4m	7.80	11.38	7.25	0.382	+0.208	0.0	
Total Depth	4.5m							

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TABLE 3-2. IN-STREAM DATA COLLECTED FOR NEAP TIDE/WET WEATHER - HIGH TIDE

PASSAIC RIVER - NOVEMBER 7, 1985

Station		Diss. Oxygen (mg/l)	Water Temp. (°C)	pH (pH Units)	Conduc. (mmhos/cm)	ORP (mV)X1000	Salinity °/oo	TSS (Depth integrated mg/l
Mouth	0.5m	6.53	13.76	7.22	22.78	+0.250	13.6	19
	2m	6.37	14.01	7.23	27.00	+0.249	16.4	
	3m	6.09	14.13	7.25	28.28	+0.249	16.9	
	4m	6.07	13.41	7.26	31.03	+0.249	19.2	
	5m	5.66	13.24	7.29	32.81	+0.241	20.4	
	6m	5.87	13.15	7.30	33.57	+0.241	20.9	
	7.2m	5.94	13.13	7.29	33.80	+0.241	21.1	
Total Depth	8.2m							
Site	0.5m	6.35	12.83	7.16	12.56	+0.218	6.9	15
	2m	6.07	13.26	7.14	24.32	+0.221	14.6	
	3m	5.95	13.39	7.16	27.74	+0.221	17.0	
	4m	5.86	13.42	7.17	29.07	+0.221	17.8	
	5m	5.83	13.42	7.18	30.07	+0.222	18.5	
	6.3m	5.80	13.42	7.18	30.24	+0.222	18.6	
Total Depth	7.1m							
U18	0.5m	6.03	12.59	7.19	9.390	+0.202	5.3	16
	2m	5.45	12.49	7.05	16.39	+0.210	9.3	
	3m	5.38	12.62	7.05	19.12	+0.211	11.2	
	4m	5.37	12.07	7.04	23.52	+0.212	14.1	
	5m	5.40	12.99	7.06	25.36	+0.212	15.3	
	6m	5.41	13.01	7.08	25.64	+0.213	15.5	
	7m	5.36	13.02	7.09	25.76	+0.213	15.5	
Total Depth	7.6m							
F02	0.5m	6.85	12.13	7.33	2.779	+0.184	1.0	24
	2m	6.05	11.81	7.19	4.306	+0.196	1.9	
	3m	5.77	11.95	7.11	6.218	+0.202	3.0	
	4m	5.60	11.95	7.08	7.553	+0.205	3.8	
	5m	5.54	11.98	7.06	8.554	+0.208	4.4	
	5.8m	5.50	12.00	7.07	8.638	+0.208	4.5	
Total Depth	6.4m							
F04	0.5m	8.10	11.74	7.41	0.412	+0.186	0.0	16
	2m	7.73	11.74	7.42	0.413	+0.187	0.0	
	3m	7.55	11.72	7.42	0.412	+0.189	0.0	
	4m	7.59	11.71	7.41	0.413	+0.193	0.0	
	5m	7.53	11.70	7.40	0.413	+0.191	0.0	
	5.5m	7.50	11.70	7.40	0.413	+0.196	0.0	
Total Depth	6.2m							

TABLE 3-3. IN-STREAM DATA COLLECTED FOR SPRING TIDE/DRY WEATHER - LOW TIDE

PASSAIC RIVER - NOVEMBER 14, 1985

Station		Dissolv. Oxygen (mg/l)	pH (pH units)	Water Temp. (C°)	Conduc. (mmhos/cm)	ORP (mV)x1000	Salinity °/oo	TSS (mg/l) Depth Integ
Mouth	0.5m	5.45	7.08	12.32	16.20	+0.269	9.4	27
	2 m	5.39	7.07	12.39	17.03	+0.269	9.7	
	3 m	5.34	7.06	12.49	18.72	+0.269	10.8	
	4 m	5.24	7.06	12.58	20.21	+0.269	12.9	
	5 m	5.15	7.06	12.70	22.52	+0.269	13.5	
	6 m	5.75	7.08	12.85	25.02	+0.268	15.0	
	7 m	5.27	7.10	12.91	28.65	+0.267	17.6	
Total Depth	8.22m							
Site	0.5m	6.19	7.22	11.66	5.125	+0.233	2.4	38
	2 m	5.81	7.16	11.68	5.276	+0.234	2.5	
	3 m	5.66	7.09	11.77	6.830	+0.236	3.3	
	4 m	5.48	7.05	11.90	9.280	+0.239	4.8	
	5 m	4.59	6.95	12.55	20.34	+0.244	12.1	
Total Depth	5.5m							
U18	0.5m	6.85	7.38	11.29	0.834	+0.197	0.0	64
	2 m	6.44	7.30	11.29	0.831	+0.201	0.0	
	3 m	6.31	7.26	11.28	0.772	+0.205	0.0	
	4 m	6.31	7.25	11.27	0.794	+0.207	0.0	
	5 m	6.28	7.24	11.27	0.799	+0.208	0.0	
Total Depth	5.45m							

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TABLE 3-4. IN-STREAM DATA COLLECTED FOR SPRING TIDE/DRY WEATHER - HIGH TIDE

PASSAIC RIVER - NOVEMBER 14, 1985

Station		Dissolv. Oxygen (mg/l)	Water Temp. (C°)	pH (pH units)	Conduc. (mmhos/cm)	ORP (mV)x1000	Salinity °/oo	TSS (mg/l) Depth. Integ.
Mouth	0.5m	5.38	12.87	7.07	25.61	+0.205	15.4	39
	2 m	5.56	12.93	7.09	28.45	+0.205	17.5	
	3 m	5.60	12.94	7.11	29.60	+0.206	18.2	
	4 m	5.62	12.94	7.13	30.40	+0.206	18.7	
	5 m	5.66	12.94	7.15	31.05	+0.207	19.2	
	6 m	5.65	12.93	7.16	31.25	+0.208	19.3	
	7 m	5.65	12.93	7.17	31.33	+0.209	19.4	
	8 m	5.59	12.93	7.17	31.41	+0.210	19.4	
Total Depth	8.8m							
Site	0.5m	5.78	12.76	7.08	23.04	+0.169	13.7	44
	2 m	5.28	12.97	7.06	25.14	+0.173	15.2	
	3 m	5.20	12.99	7.07	25.65	+0.176	15.4	
	4 m	5.16	13.01	7.08	26.27	+0.179	15.9	
	5 m	5.13	13.02	7.08	26.47	+0.180	16.0	
	6 m	5.11	13.02	7.08	26.51	+0.182	16.0	
Total Depth	7 m							
U18	0.5m	5.79	12.27	7.09	17.11	+0.168	9.9	38
	2 m	5.40	12.54	7.06	19.35	+0.174	11.5	
	3 m	5.24	12.57	7.06	21.23	+0.177	12.5	
	4 m	5.20	12.65	7.06	22.30	+0.178	13.2	
	5 m	5.13	12.72	7.06	22.78	+0.183	13.6	
	6 m	5.10	12.72	7.06	23.10	+0.185	13.8	
	7 m	5.07	12.74	7.07	23.15	+0.186	13.8	
Total Depth	7.6m							
F02	0.5m	6.69	11.60	7.28	4.422	+0.166	1.9	40
	2 m	5.88	11.60	7.22	4.911	+0.173	2.2	
	3 m	5.66	11.66	7.14	6.633	+0.180	3.3	
	4 m	5.59	11.68	7.13	6.940	+0.182	3.4	
	5 m	5.55	11.70	7.13	7.250	+0.184	3.6	
	6 m	5.52	11.70	7.12	7.318	+0.186	3.7	
Total Depth	6.7m							
F04	0.5m	7.85	11.17	7.67	0.439	+0.157	0.0	29
	2 m	7.09	11.11	7.48	0.442	+0.172	0.0	
	3 m	6.57	11.21	7.38	0.449	+0.177	0.0	
	4 m	6.50	11.18	7.36	0.447	+0.180	0.0	
	5 m	6.48	11.19	7.34	0.446	+0.183	0.0	
	6 m	6.46	11.17	7.33	0.444	+0.185	0.0	

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FIGURES

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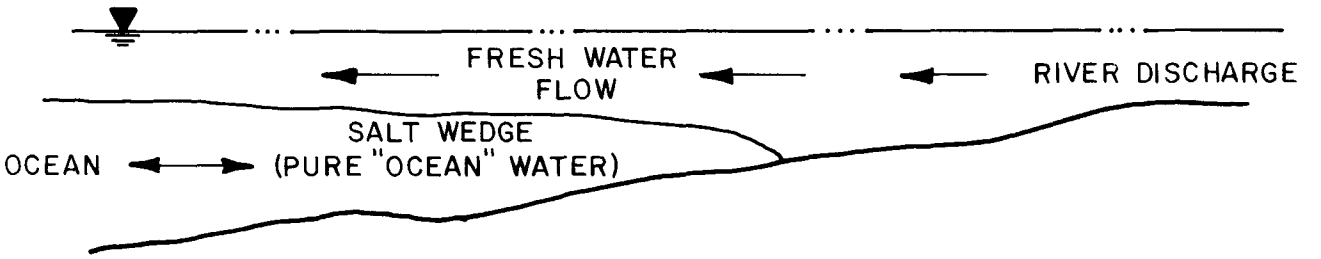
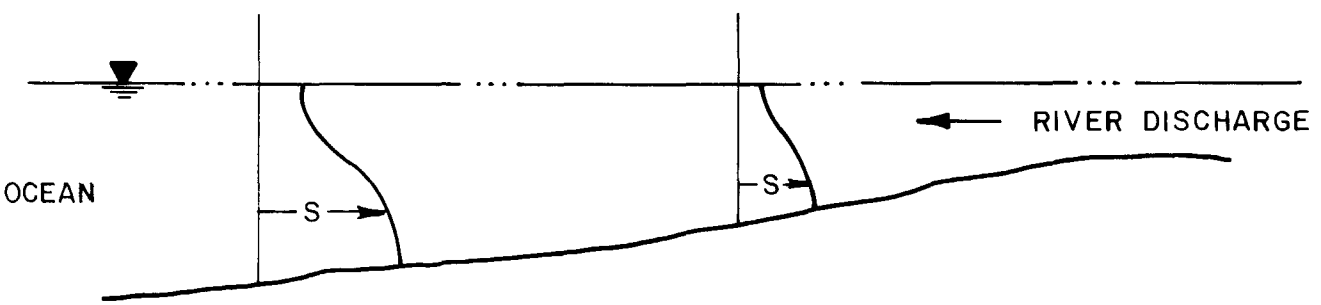


SALT WEDGE ESTUARY



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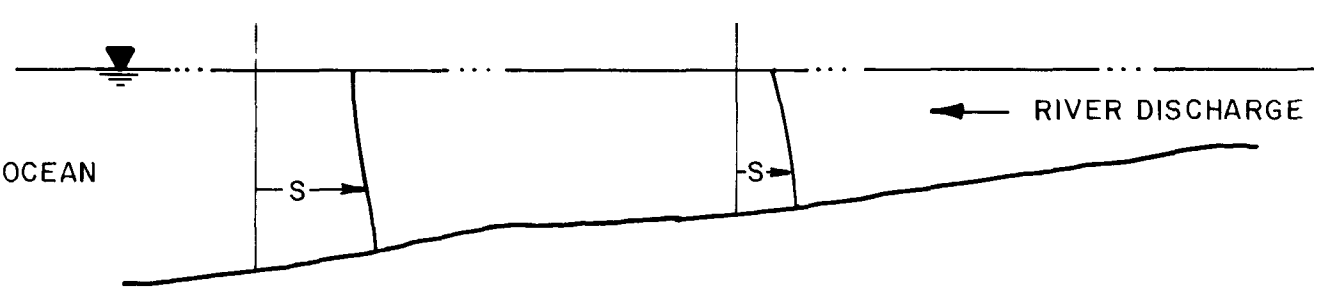

WELL MIXED ESTUARY

FIGURE 3-1

TYPICAL SALINITY DISTRIBUTIONS FOR ESTUARIES

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DIAMOND SHAMROCK
DALLAS, TEXAS

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FISCHER, ET AL , 1979

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GARFIELD
WALLINGTON
CLIFTON
PASSAIC
RUTHERFORD
LYNDHURST
NUTLEY
NORTH ARLINGTON
BELLEVILLE
ARLINGTON
KEARNY
KEARNY POINT
HARRISON
NEWARK
JERSEY CITY

CONTROL REACH
FARUP STREAM REACH
DOWNSTREAM REACH
UPSTREAM REACH
SITE AREA REACH

GARDEN STATE PARKWAY
DUNDEE DAM
DUNDEE LAKE
OUTWATER LANE
CONRAIL
MONROE STREET
PASSAIC STREET
EIGHTH STREET
SECOND STREET
WALLINGTON AVENUE
MAIN STREET
UNION AVENUE
RUTHERFORD AVENUE
PARK AVENUE
KINGSLAND AVENUE
RUTGERS STREET
BELLEVILLE TURNPIKE
CLAY STREET
JACKSON STREET
HARRISON AVENUE
CENTER STREET
WM. STICKEL MEMORIAL BRIDGE (NASSAU STREET)
LISTER AVENUE
80 & 120
GENERAL PULASKI SKYWAY
COMMUNIPAW AVENUE
LINCOLN HIGHWAY
NEW JERSEY TURNPIKE
HACKENSACK RIVER
PASSAIC RIVER
SECONDARY RIVER
S. 4TH. STREET
HUDSON COUNTY
ESSEX COUNTY
BERGEN COUNTY
PASSAIC COUNTY

COIL(A,B)
COIM(A,B)
F09MA
F09RA
F08MA
F08RA
F07MA
F07LA
F65L(T,A,B,C,D)
F06RA
F06MA
F05MA
F05RA
F04MA
F04RA
F03MA
F03RA
F02MA
F02RA
F01MA
F01RA
U18L(A,B,C,D,E,F)
U18R(A,B,C,D)
U45L(A,B,C,D)
U45R(A,B,C,D)
D65L(A,B,C,D)
D65R(A,B,C,D)
D19M(A,B,C,D)
D19R(A,B,C,D)
D22L(A,B,C,D)
D22M(A,B,C,D)
D22R(A,B,C,D)
D06R(A,B,C,D)

LEGEND:
- BRIDGE
- F01MA SAMPLE DESIGNATION
- MILE U-7.0 (UPSTREAM) MILE D-2.0 (DOWNSTREAM) MILE MARKER DESIGNATION
- INDICATES MAXIMUM RANGE OF SALINITY UNDER NORMAL TIDAL CONDITIONS

REFERENCE: 7½ MINUTE USGS TOPOGRAPHIC MAPS OF: PATERSON, N.J.; ORANGE, N.J.; HACKENSACK, N.J.; WEEHAWKEN, N.J.-N.Y.; ELIZABETH, N.J.-N.Y. AND JERSEY CITY, N.J.-N.Y. QUADRANGLES. DATED: 1955 (PR 1981), 1955 (PR 1970), 1956 (PR 1981), 1967, 1967 (PR 1981), 1967 (PR 1981). SCALE 1" = 2000'

SCALE 0 2000 4000 6000 FEET

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FIGURE 3-2

ESTIMATED MAXIMUM RANGE OF SALINITY INTRUSION DURING THE NOVEMBER 1985 SAMPLING PERIOD

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	3/20/86	

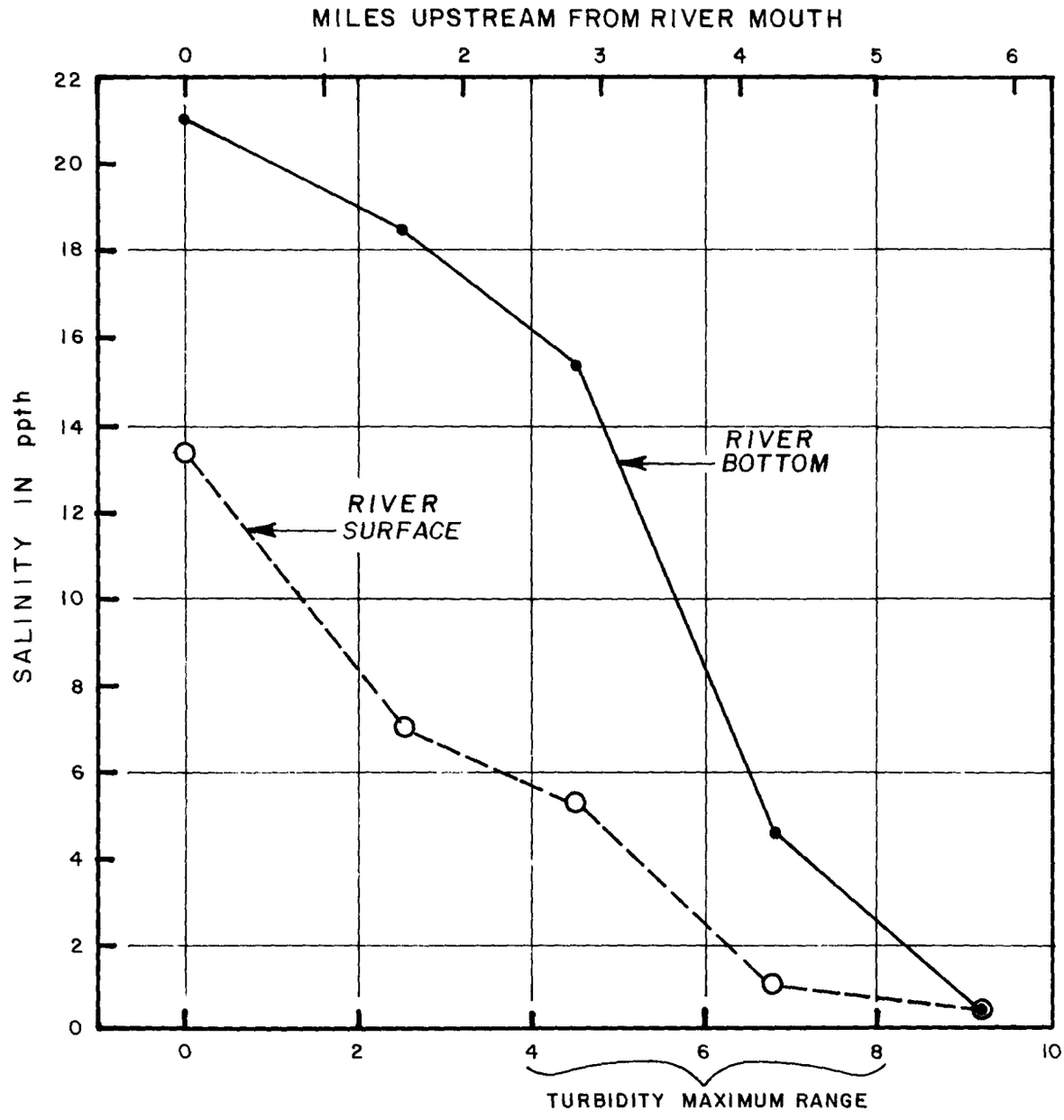

FIGURE 3-3

NOTE

ppth = PARTS PER THOUSAND

ESTIMATED ZONE OF TURBIDITY MAXIMUM
NEAP TIDE/WET WEATHER

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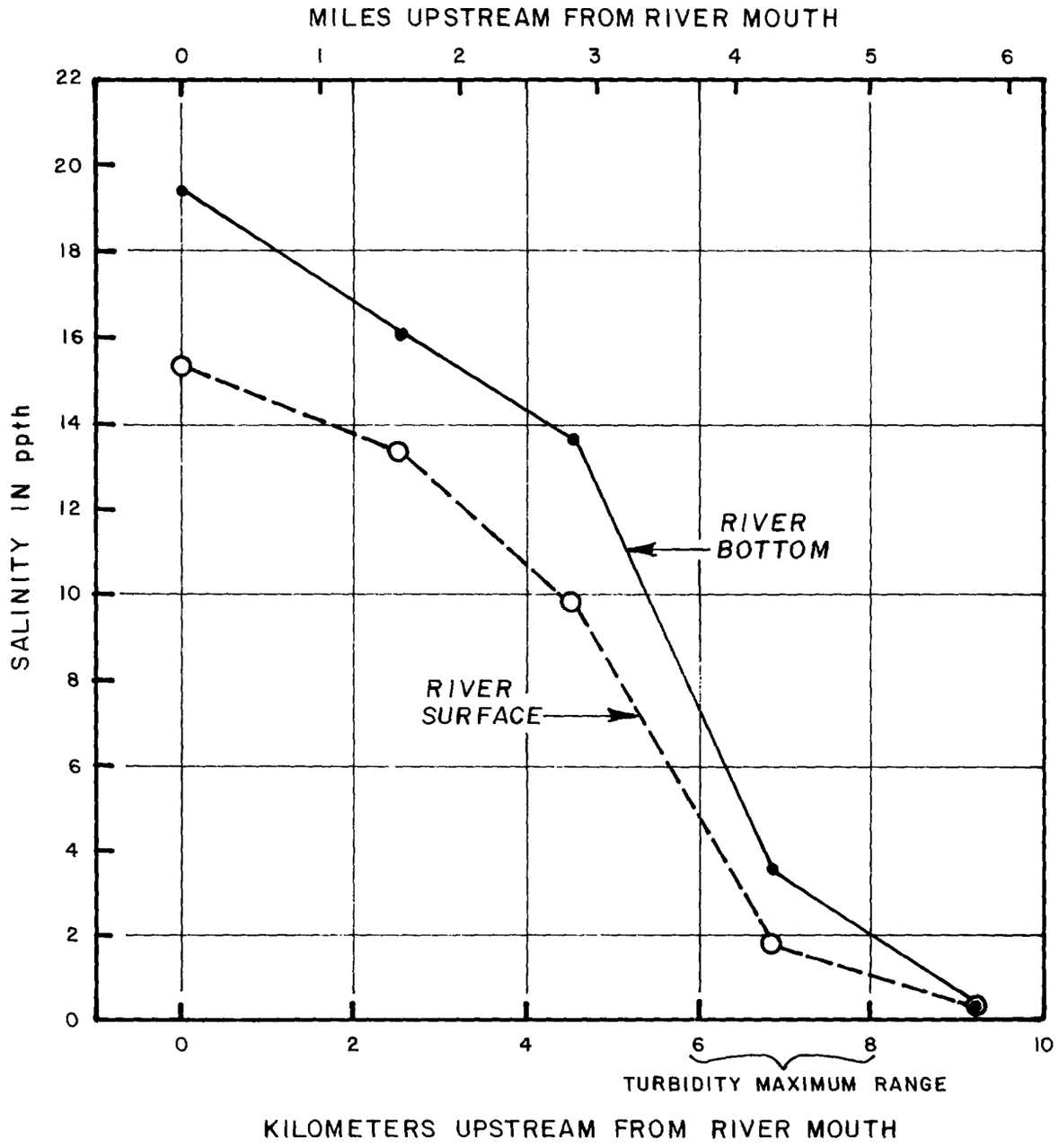

FIGURE 3-4

NOTE:
ppth = PARTS PER THOUSAND

ESTIMATED ZONE OF TURBIDITY MAXIMUM
SPRING TIDE/DRY WEATHER

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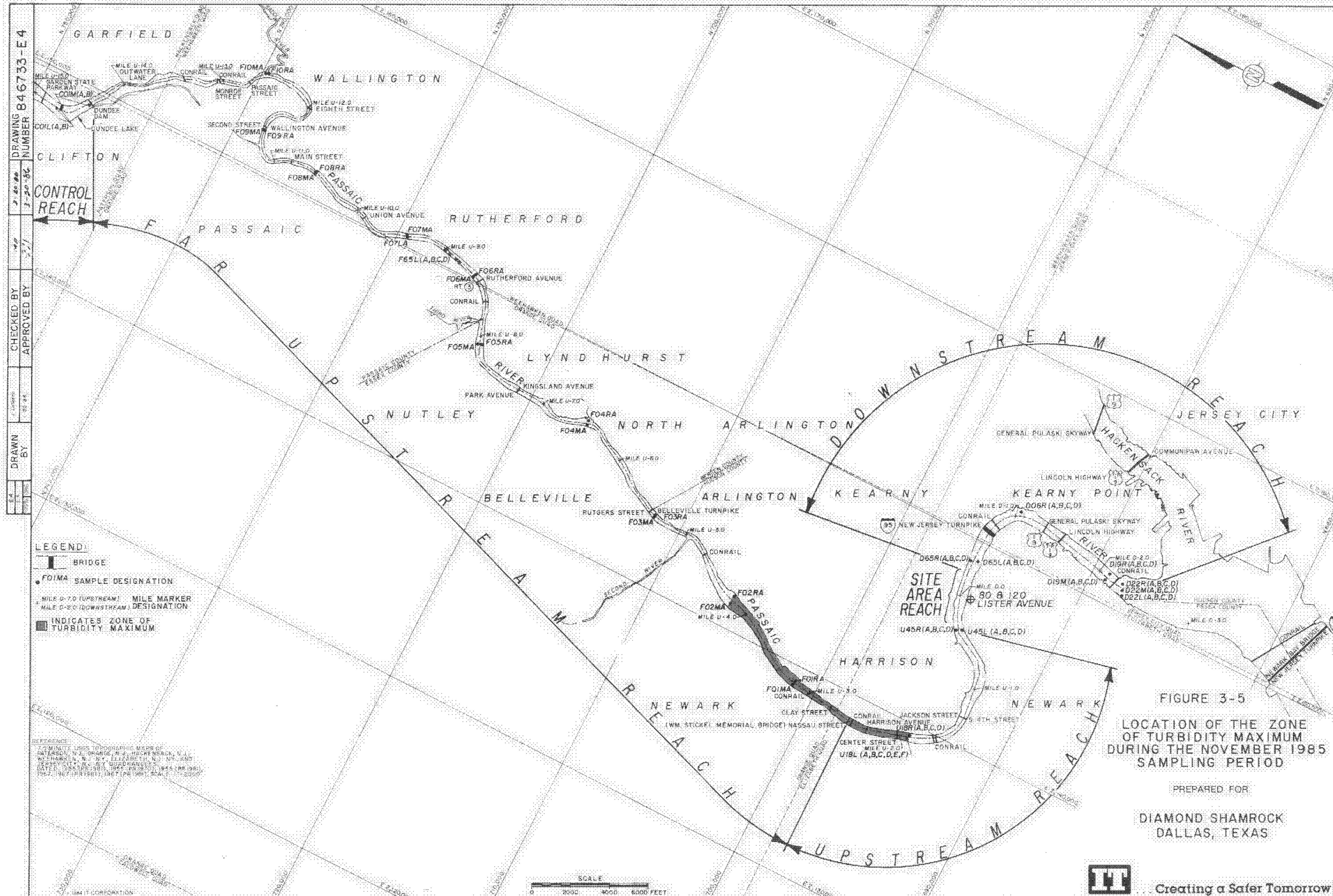

FIGURE 3-5

LOCATION OF THE ZONE OF TURBIDITY MAXIMUM DURING THE NOVEMBER 1985 SAMPLING PERIOD

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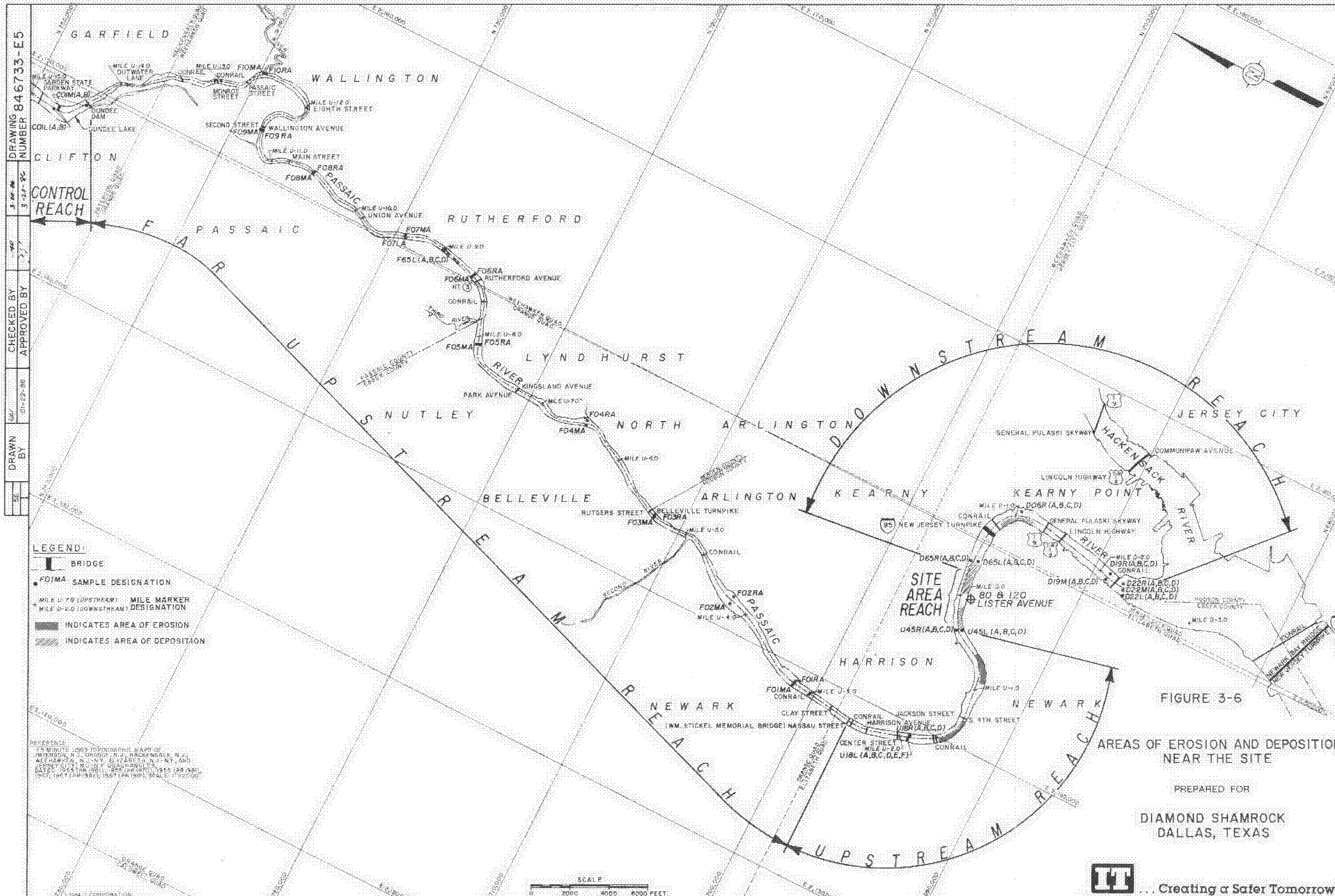

FIGURE 3-6

AREAS OF EROSION AND DEPOSITION NEAR THE SITE

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4.0

4.0 DATA COLLECTION AND ANALYSIS

Samples of Passaic River water and sediment were taken in October 1984, as part of the 80 Lister Avenue Site Evaluation. The sampling locations are shown in Figure 4-1. The sampling methods and results are presented in detail in that report (IT, 1985a). One-liter water samples collected adjacent to the site and upstream at the Jackson Street Bridge each had nondetectable quantities for dioxin at 0.007 ppb and 0.004 ppb detection limits, respectively.

Thirty-six samples of sediment were collected at that time for dioxin analysis, twenty-three at zero to 12 inches depth and thirteen at 12 to 24 inches depth. Twenty-six of these samples had identifiable dioxin concentrations, as listed in Table 4-1. At zero to 12 inches, the dioxin concentrations ranged from 0.53 to 10.8 ppb with six samples having no detectable dioxin at 0.78 ppb detection limit. At 12 to 24 inches, the dioxin concentrations ranged from 0.63 to 130 ppb with four samples having no detectable dioxin at the 0.78 ppb detection limit. A core was taken at station 1-3-0 to a depth of 6 feet. Five samples from that core showed dioxin concentrations ranging from 151 to 450 ppb. These results are shown in Table 4-2.

On the basis of these results, a more comprehensive characterization of dioxin in Passaic River sediments was initiated. The purpose of this section is to describe the sampling strategy and analysis protocol.

4.1 SEDIMENT SAMPLING

A total of 94 cores were taken throughout the 16.5 miles of the river. Of these, 34 were 5-foot-deep cores, taken in areas believed to have low sediment deposition rates, and 60 were 20-foot cores, taken in areas susceptible to high sediment deposition rates. The exact locations of the core samples are described in Appendix C. Each core was assigned a code number consisting in part of the reach and area (within the reach) of the core, the letter L, M, or R to designate location (within the area) as left, middle (channel), or right river bank (looking upstream), and a letter from A to F signifying the particular core from that station. The cores were subdivided into 625

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sediment core section samples. Of these, 297 were analyzed for 2,3,7,8-TCDD, 253 were analyzed for total organic carbon (TOC), and 19 were selected for analysis of inorganic lead. All cores were taken between May 6 and June 5, 1985.

An initial assessment of the Passaic River indicated that it could be divided into five zones or reaches for the purpose of collecting sediment samples, based on distance from the Lister Avenue site, dredging history, and sediment deposition rates. These reaches are described below.

- Site-Area Reach - Includes 2,600 feet in the vicinity of 80 Lister Avenue. The east map coordinate line 2,147,000 is approximately at the eastern boundary of the 80 Lister Avenue property, and is taken as the site zero mile marker for the purpose of measuring distance up- and downstream from the site. Seventeen 20-foot cores were taken in this reach.

- Downstream Reach - This zone extends from the site-area reach to the mouth of the river, a distance of approximately 2.3 miles. The downstream limit of this reach is the ConRail Railroad bridge at Kearny Point. Four sampling areas were identified, and a total of 12 short and 21 long cores were taken in this reach.

- Upstream Reach - The upstream reach extends approximately 2.2 miles from the upstream limit of the site-area reach to the William Stickel Memorial Bridge. There were four sampling areas comprising 8 short and 10 long cores.

- Far-upstream Reach - The far-upstream reach extends from the William Stickel Memorial Bridge to the Dundee Dam, a distance of 11.8 miles. Eleven sampling areas were identified in this reach. One short and one long core were taken in each of ten locations, and four additional long cores were taken north of Rutherford Avenue. There was no sediment recovery from two cores.

- Control Reach - This zone is located in Dundee Lake, above Dundee Dam, which is 14.3 miles upstream of the zero mile marker. This area is far above the point of maximum salinity intrusion in the Passaic River. Four short cores were taken within the lake.

4.2 SAMPLING TECHNIQUES

Sediment samples were collected by driving 3-1/2 inch (I.D.) Lexan tubing into the sediments using a hydraulic vibracoring unit mounted on a barge. Six cores, comprising all four cores from the Control Reach and cores F10MA and F10RA from the Far Upstream Reach, were collected in Lexan tubing using a

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hand-operated coring apparatus operated from a boat. Detailed descriptions of the two techniques are provided in Appendix C.

4.3 SAMPLING ANALYSIS/ARCHIVING STRATEGY

The objective of the sampling program was to collect all the cores which could potentially yield information. Therefore, replicate cores were taken in many locations. An adequate characterization of dioxin distribution could be achieved by analyzing a selected portion of the cores. The remaining core sections were left in the Lexan liners and stored on the 80 Lister Avenue property in an archive room. These core sections were available for dioxin analysis if preliminary results emanating from the initial analysis warranted. In fact, 24 samples from the far-upstream reach were pulled from the archives and analyzed in order to better characterize that stretch of the river.

The total numbers of cores collected per reach, sections comprising each core, and analyzed and archived sections, are summarized in Table 4-3. A total of 297 out of 625 sections collected were analyzed during this investigation. The remaining 328 sections are being held in the archive area, under chain of custody.

The selection of sections to analyze or archive was made upon consideration of the sampling strategy for each reach. These are summarized below.

Site-area Reach. The purpose of sampling the site-area reach was to determine the extent of dioxin occurrence both laterally and vertically. Seventeen 20-foot cores were collected. Each core was divided into 2-foot segments and the top five sections comprising 10 feet were analyzed. In addition, the five cores closest to the south bank, near the Lister Avenue site, were sampled in their entirety.

Downstream Reach. This reach was sampled in order to provide information on dioxin distribution with respect to dredging history, distance from site, and degree of sedimentation. Four replicate cores from each of eight areas were taken in this reach, with the addition of a fifth core near a sunken barge at one location. Each set of four cores was thought to be from locations similar

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with respect to the physical parameters noted above. In areas where shallow cores were taken, all five sections from two short (5-foot) cores per set of four were analyzed (total of 10 sections). Selection was made by coin toss. The remaining two cores were sectioned and archived.

In areas where four deep cores were taken, two cores were analyzed and two were archived. Alternate cores (A and C or B and D) were analyzed while the other pair (B and D or A and C) were archived. Selection was made by coin toss. A total of 7 sections from the upper 10 feet were analyzed from each set of two deep cores: the top (0 to 2 feet) and middle (8 to 10 feet) sections of both cores, plus one section from each depth profile between 2 and 8 feet. All other sections were archived. For example:

Core A		Core C	
	..0 feet ..		
x		x	
x		o	
o		x	
x		o	
x	..10 feet..	x	x - analyzed
o		o	o - archived
o		o	
o		o	
o		o	
o	..20 feet..	o	

This protocol was designed to maximize the information gained relating to dioxin distribution, while maintaining efficiency of river sediment sampling and analysis.

Upstream Reach. The sampling strategy for this reach is similar to that for the downstream reach. Four cores were taken at each of four areas. Two additional cores were taken within a boat slip at one location. These four areas were paired as left and right bank transect locations, with long cores taken at the left bank and short cores at the right bank, according to the expected sediment deposition rates. The cores in this reach were analyzed according to the analysis protocol outlined for the downstream reach.

Far Upstream Reach. The sediment sampling strategy comprised a single long

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and short core at each area in order to characterize dioxin distribution throughout the lower Passaic River. Cores from areas selected for analysis had all five 1-foot sections from the short core and all five 2-foot sections from the top 10 feet of the long cores scheduled for analysis. Cores from two areas furthest upstream were archived.

One set of four long cores was taken in a location north of Rutherford Avenue (Route 3). These cores were sampled and analyzed according to the strategy used in the downstream reach.

Control Reach. The cores collected from the control reach were expected to provide information on dioxin distribution in an area not subject to influence from sediment transport or flow from the lower Passaic River. Of the four cores collected in Dundee Lake, two were archived and two were analyzed in their entirety.

4.4 SAMPLE HANDLING

Treatment of the samples from on-barge storage through shipment of aliquots to the labs is reviewed in this section. Details of these procedures are provided in Appendix C.

Each sediment core section was transported in an upright position to the 80 Lister Avenue site at the end of each day's operations. The cores were kept in either cold storage or a freezer until extrusion in order to permit total organic carbon (TOC) analysis. The freezer was used for cores with a high fluid content, generally surface sediment cores, to preserve the integrity of the core until extrusion. Cores which were scheduled for archive were removed promptly to the archive room.

4.4.1 Sediment Sample Extrusion

The extrusion process consisted of several tasks, including:

- Determination of the unit weight of the sample
- Extrusion of the sample from the Lexan liner
- Removal of the sample periphery
- Photography and description of the sample
- Sampling of the interior of the core sample section for physical analyses and chemical analyses including TCDD and TOC.

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The interior of each core sample section was mixed thoroughly by hand to a homogeneous consistency and aliquots were placed into three bottles. One bottle was shipped for TCDD analysis, one for TOC determination, and one was sent to the on-site sediment laboratory for analysis of physical properties.

4.5 SAMPLE ANALYSIS

4.5.1 Sample Handling and Documentation

A program-specific Standard Operating Procedure (SOP) was developed to define all levels of sample handling and documentation. This SOP is provided in Appendix D, and is based on similar procedures used previously on other phases of the DSCC project, including 80 Lister Avenue, 120 Lister Avenue, and the Off-site Remediations. Briefly, the procedure describes initiation of sampling schedules, sample identification and preparation for collection, transfer of the sediment cores through temporary storage and to the Extrusion Lab, shipment of extruded samples to the laboratories for analysis, all documentation associated with these activities, and initiation of the on-site files for these records.

The only significant modification to the SOP was with respect to the scheduling of cores for extrusion. Due to project requirements and time limitations, all individual core sections from a single boring were rarely, if ever, transferred as a set to the Extrusion Lab. Rather than prepare "intermediate" custody records (per SOP, Section D.1.3.2.1) for every sample, a notation was made on the original core custody record, in the "Comments" column, that the core section had been sent to extrusion on a particular date. After all core sections on a custody record had been sent for extrusion, that record was handled per the SOP (Section D.1.5.6). In cases where no sections of the cores were extruded, the original record remained in the "archived" file.

Once received at the laboratories, the samples were tracked and documented under the routine procedures for each facility. Analytical results were transmitted to the project Analytical Coordinator as soon as they were available.

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All sample information and analytical data are maintained in the central DSCC project files at 9041 Executive Park Drive, Knoxville, Tennessee. They will be made available to NJDEP separately from this report for their review.

4.5.2 Analytical Ouality Assurance/Quality Control

In general, the procedures described in the original Quality Assurance Project Plan developed for the first phase of DSCC work (80 Lister Avenue Work Plan, 1984) remained in effect during the river study. The QA plan reflected appropriate EPA guidelines and presented quality assurance objectives for accuracy, precision, completeness, representativeness, and comparability of the analytical data. The following paragraphs describe specific QA/QC activities instituted during the river sediment study that may differ slightly from that original plan.

4.5.2.1 Field and Trip Blank Requirements

A field and trip blank pair was prepared in association with each day's sediment core collections. In addition, a field blank was prepared daily at the Extrusion Lab.

Field blanks, in general, are intended to verify a lack of cross-contamination among samples due to improper decontamination of sampling equipment between individual collection or extrusion. Trip blanks verify the integrity of individual samples during collection, handling, and shipment.

All of the field blanks were water matrix samples, prepared as rinsates of equipment, for 2,3,7,8-TCDD analysis only. Trip blanks consisted of organic-free water sealed in sample containers and carried along with each day's samples, but not opened prior to laboratory receipt. All blanks were shipped with daily samples to the Knoxville laboratory for analysis or archive, as defined below.

Per NJDEP's request, all of the field blanks associated with sample collection were analyzed; the paired trip blanks were held at the laboratory for possible analysis, pending the field blank results. A few trip blanks were analyzed prior to establishment of this analysis schedule.

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Field blanks from the Extrusion Lab were analyzed on an alternating daily basis; unanalyzed blanks were held for possible analysis pending initial blank results.

4.5.2.2 Field QC Duplicates

Sediment cores were selected randomly for duplicate sample preparation in the Extrusion Lab. The duplicates were given distinct sample numbers, to allow for "blind" receipt and analysis at the laboratory.

A target frequency of 5 percent was established for duplicate samples to be sent for analysis of 2,3,7,8-TCDD. A 1 percent frequency was targeted for duplicates intended for TOC analysis.

4.5.2.3 Laboratory Quality Control

Routine internal quality control procedures were followed by each of the three participating laboratories.

- ITAS - Director's Drive: Dioxin Analysis
- ITAS - Middlebrook Pike: Lead Analysis
- ITAS - Pittsburgh: TOC Analysis

As a minimum, for each set of 20 samples received for analysis, a laboratory method blank, a blind sample split, and a sample or blank spike were analyzed. Where appropriate, internal and surrogate standards were added to each sample to monitor instrument performance and method recovery. For all analyses, reference standards were run at least once during every eight-hour shift.

4.5.3 Analytical Methods

Dioxin (2,3,7,8-TCDD) was analyzed according to USEPA protocols for dioxin in soils. Detailed procedures were provided in the 80 Lister Avenue Work Plan (1984), and significant modifications were not required.

Total Organic Carbon (TOC) was analyzed at the ITAS - Pittsburgh laboratory according to USEPA Method 9060, in "Test Methods for Evaluating Solid Waste," SW-846, USEPA, July 1982.

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Lead analysis was performed at the ITAS - Knoxville laboratory according to USEPA Methods 3050 (preparation) and 7420 (analysis), in "Test Methods for Evaluating Solid Waste," SW-846, USEPA, July 1982.

4.5.4 Analytical Results for Quality Assurance/Quality Control Checks

Quality assurance/quality control checks were performed routinely throughout the course of the river sampling and analysis program, as described above in Section 4.5.2.

Presented in the following paragraphs is a summary of the results of all QA/QC activities performed during the river study.

4.5.4.1 Field and Trip Blanks

A total of 54 field and trip blanks associated with sample collection and sample extrusion were collected during the river study. Of these, 36 were analyzed for 2,3,7,8-TCDD; the remaining 18 blanks were archived at the laboratory.

Appendix E contains a listing of the dioxin results for the analyzed blanks, as well as a list of those blanks held in archive.

No dioxin was detected in any of the field and trip blanks that were analyzed; therefore, additional analysis of archived blank samples was not required.

4.5.4.2 Field Duplicate Samples

Seventeen sediment core sections were prepared in duplicate at the Extrusion Lab for dioxin analysis, representing 6.2 percent of the total number of samples analyzed.

Table 4-4 presents the dioxin results for these duplicate sample pairs. A major difference is noted in comparison of the Relative Percent Difference (RPD) for the 10-gram versus 1-gram aliquots for sample pair Y3323/L3655; the RPD is vastly improved for the 10-gram results. This is considered to be due to the difficulties encountered in obtaining a 1-gram aliquot that is truly representative of the entire sample, regardless of the degree of

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homogenization. Further, no RPD could be calculated for 11 of the 17 duplicate pairs: six of these showed ND results for the original and duplicate, four pairs gave one ND and one positive result, and the original of the last pair could not be calculated due to interferences. Matrix interferences were quite severe for all the sediments analyzed; it is likely that, at the low (near the method detection limits) levels observed in these duplicate pairs, these interferences contributed to the differences noted in the paired results. Excluding the 1-gram result, the average RPD is 38(±27), which is within acceptable QC limits for overall precision.

In addition to the dioxin analyses, one sediment sample was prepared in duplicate for a spot-check of the TOC analysis. Table 4-5 presents the results for this duplicate sample pair. No significant difference between the paired results was observed.

4.5.4.3 Laboratory Quality Control

The following sections summarize the results of the quality control activities performed at each laboratory in association with the river study sample analyses.

4.5.4.3.1 ITAS - Middlebrook: Lead Analysis

Nineteen sediment samples were designated for analysis of lead (Pb) at the Middlebrook Pike laboratory.

These samples were prepared and analyzed as a single set; the instrument calibration standards are on file at the laboratory with the raw sample data. A process blank, sample spike, and sample duplicate were analyzed with the sediments, to provide an 11 percent level of overall QC.

No lead was detected in the blank. The spike recovery was calculated to be 85 percent, and the duplicate analysis showed a relative percent difference of 6.3 percent. All of these results are well within acceptable control limits. Appendix E contains the certificates of analysis for these sample analyses.

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4.5.4.3.2 ITAS - Pittsburgh: TOC Analysis

A total of 253 sediments were analyzed for total organic carbon (TOC) at the ITAS - Pittsburgh facility.

Twenty-two sediment samples were spiked and analyzed to calculate percent recovery, establishing a QC analysis level of 8.7 percent; in addition, seven of these samples were spiked in duplicate or triplicate. Results of these analyses are presented in Table 4-6.

The recoveries are within acceptable limits, with an average of 89(±15) percent.

4.5.4.3.3 ITAS - Director's Drive: Dioxin Analysis

A total of 314 sediment samples were analyzed for 2,3,7,8-TCDD at the ITAS - Director's Drive high hazard laboratory.

Instrument calibrations were performed and documented every eight hours; method blanks were also run every eight hours, or at least once for each batch of up to 20 samples; support data for these routine checks are contained in the complete laboratory batch reports. Dioxin was not detected in any method blanks.

Surrogate standards were added to every sample prior to extraction; comparison of the ^{37}Cl-TCDD recovery to the ^{13}C-TCDD recovery yields a value of "Percent Accuracy," as described by the USEPA method. This percent accuracy result was within the QC acceptable limits of 60 to 140 percent for all but 15 of the 314 samples reported. With one exception, all of those recoveries outside the acceptable range were above the upper limit, owing primarily to the severe matrix interferences observed in most of the sediment samples. The 15 "outliers" account for only 4.8 percent of the sediments analyzed, a completeness level of 95 percent has still, therefore, been achieved.

A sample spike and duplicate pair were analyzed with each batch of up to 20 samples. A total of 16 QC sample pairs were analyzed, representing 5.1 percent of the sediment samples analyzed for dioxin.

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Table 4-7 presents a summary of the duplicate results. Relative percent differences (RPDs) have been calculated, only one of the calculatable values is above 40 percent, which has been determined to be an acceptable level for this analysis based on the percent recovery requirements. This single outlier value is calculated from results that are near the upper limit of the method's calibration range. Nine of the duplicate pairs gave ND results; these have been excluded from calculation of the average RPD, which is 21(±21) percent. This is well within acceptable limits for the analytical method.

Table 4-8 presents the spike recovery data for the QC samples. Two of the 15 samples selected for QC analysis showed dioxin at concentrations greater than or equal to 10 ppb, the spike level of 1.0 ppb becomes negligible for these samples, negating meaningful recovery calculations. Therefore, these values have been excluded from this table. The average percent recovery is calculated to be 123(±42) percent.

Partial scan gas chromatography/mass spectrometry (GC/MS) confirmations were performed on 12 sediment samples with positive dioxin results. Of these, five passed all criteria required for a final confirmation of the presence of 2,3,7,8-TCDD. The majority of the failures were due to dioxin levels too low to be detected by the partial scan method. Back-up documentation of these analyses is contained in the dioxin laboratory batch reports.

4.5.5 Physical Analyses of Sediment

Physical analyses of sediment samples were performed on all 273 samples scheduled for TCDD analysis.

Analysis included determination of sample grain-size distribution (a mechanical analysis using a nest of sieves and a hydrometer), water content, and specific gravity. All analyses followed standard procedures described in the American Society for Testing and Materials Annual Book of Standards (ASTM, 1985). The sample was visually classified using the Burmister System. Details of these procedures are found in Appendix D.

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TABLES

Table 4-1. Passaic River Sediment Samples, 1984 Survey
2,3,7,8-TCDD Analysis Results (ppb)

	Sample Depth (inches)	
Station Number	0-12[a]	12-24[b]
0-1-0	3.9	--[c]
0-2-0	0.96	ND(0.23)[d]
0-3-0	1.1	--
0-4-0	0.53	1.8
0-5-0	ND(0.54)	ND(0.20)
0-6-0	ND(0.72)	3.2
0-7-0	1.8	--
0-8-0	0.6	10.4
0-9-0	10.8	--
1-0-0	2.3	--
1-1-0	0.87	65.6
1-2-0	1.7	--
1-3-0	1.3	130
1-4-0	0.97	--
1-5-0	0.94	--
1-6-0	2.0	--
1-7-0	1.1	--
0-6-1	ND(0.69)	0.63
0-8-1	ND(0.32)	1.3
1-1-1	ND(0.27)	1.5
0-6-2	1.2	ND(0.16)
0-8-2	ND(0.22)	ND(0.54)
1-1-2	3.5	10.3

[a]Corresponds to elevation code 300.

[b]Corresponds to elevation code 299.

[c]-- indicates sample not analyzed.

[d]ND = not detected at the indicated () detection limit.

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Table 4-2. Resampling 2,3,7,8-TCDD
Results of Passaic River Sediment Station 1-3-0, 1984 Survey

Sample Identification Number	Elevation Code	Sample Depth	2,3,7,8-TCDD (ppb)
1-3-0-1785-300	300	0-3'4"	151
1-3-0-1786-299	299	3'4"-3'10"	151
1-3-0-1787-298	298	3'10"-4'4"	176
1-3-0-1788-297	297	5'0-5'6"	238
1-3-0-1789-296	296	5'6"-6'0"	450[a]

[a]Reanalysis result from 1 gram sample aliquot, original (10g) result of 324 ppb was outside the linear calibration range.

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Table 4-3. Summary of Dispensation of Cores and Sections

	Total[a]		Analysis		Archive	
Reach	Cores	Sections	Cores	Sections	Cores	Sections
Control	4	14	2	8	2	6
Far Upstream	22	104	18	79	7	25
Upstream	18	135	9	39	14	96
Site	17	136	17	104	11	32
Downstream	33	236	17	67	27	169
Total	94	625	63	297	61	328

[a]Some cores were partially analyzed and partially archived; therefore, the totals don't add up across the columns.

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Table 4-4. Field Duplicate Sample Results

2,3,7,8-TCDD Analysis

Original/Duplicate Sample Numbers	Original Result* (ppb)	Duplicate Result* (ppb)	RPD (%)
Y3740/L4063	1.3	1.4	7.4
Y3819/L4193	ND(0.27)	ND(0.24)	-
Y3797/L4069	ND(0.34)	ND(0.08)	-
Y3006/L3287	ND(0.08)	1.3	-
Y2964/L3472	ND(0.10)	ND(0.16)	-
Y3264/L3644	ND(0.59)	ND(0.05)	-
Y3311/L3648	65.0	37.9	53.
Y3244/L3653	2.3	ND(0.75)	-
Y3015/L3654	3.3	1.5	75.
Y3323/L3655	747.[1] 1800.[2]	842.[1] 541.[2]	12. 110.
Y3331/L3659	24.5	85.4	72.
Y3359/L3875	1.4	ND(0.68)	-
Y3307/L3878	ND(0.40)	7.7	-
Y3373/L3904	ND(0.47)	ND(0.56)	-
Y3463/L3962	ND(0.18)	ND(0.65)	-
Y3854/L4022	-[3]	ND(0.71)	-
Y3414/L3914	0.72	0.66	8.6

*Detection limits are indicated in parentheses.
[1]Ten gram sample aliquot result.
[2]One gram sample aliquot result.
[3]Sample matrix interferences prevented calculation of a result.

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Table 4-5. Field Duplicate Sample Results
Total Organic Carbon Analysis

Original/Duplicate Sample Numbers	Original Result (ppb)	Duplicate Result (ppb)	RPD (%)
Y3099/W3294	5300.	4800.	9.9

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Table 4-6. TOC Laboratory Spike Recovery Results

Sample Number	% Recovery
D22MA-3224-204-M-Y	89* (92,86)
D22MA-3223-203-M-Y	83* (83,83)
D22MA-3015-201-M-Y	83
D19RB-2976-502-M-Y	81* (93,69)
D65RA-3262-502-M-Y (59,73,68)	67*
S13LA-3403-202-M-Y (70,164,78)	104*
S23MA-3444-203-M-Y (82,111,108)	100*
S24LA-3343-203-M-Y	72
D65LC-3198-200-M-Y	91
D65RC-3270-500-M-Y	88
U45LB-3609-202-M-Y	81
S32MA-3435-204-M-Y	109
S43RA-3464-203-M-Y	124
F01RA-3725-200-M-Y	77
F02RA-3740-200-M-Y	80
F03RA-3755-200-M-Y	79
F06RA-3800-200-M-Y	63
F07MA-3811-501-M-Y	106
F65LD-4006-200-M-Y	104* (96,111)
S11LA-3309-200-M-Y	83
S11LA-3310-201-M-Y	108
Q41LA-3907-201-M-W	77

*Average recovery; individual results for multiple spiked analyses are in parentheses.

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Table 4-7. Laboratory Duplicate Results Summary

2,3,7,8-TCDD

Sediment Sample No.	Lab Batch No.	Original Result (ppb)	Duplicate Result (ppb)	RPD (%)
Y3099	335	ND(0.05)	ND(0.13)	-
Y3200	336	ND(0.05)	ND(0.35)	-
Y3301	340	162.	319.	65.
Y3592	341	0.88	0.59	39.
Y3320	344	55.4	45.3	20.
Y3317	346	ND(0.10)	ND(0.11)	-
Y3124	347	0.91	ND(0.22)	-
Y3270	349	3.3	3.1	6.3
Y3383	350	6.3	6.6	4.7
Y3339	354	1.5	1.5	0
Y3537	355	ND(0.73)	ND(0.39)	-
Y3899	361	5.2	6.0	14.
Y3530	362	ND(0.59)	ND(0.23)	-
Y3750	363	ND(0.12)	ND(0.11)	-
Y3948	371	ND(0.40)	ND(0.29)	-
Y3670	375	ND(0.11)	ND(0.27)	-

Average RPD: 21(±21)%

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Table 4-8. Laboratory Spike Recovery Results Summary
2,3,7,8-TCDD

Sample Number	Original Result (ppb)	+	Amount Spiked (ppb)	=	Theoret. Conc. Sample & Spike (ppb)	Spike Result (ppb)	Recovery %
Y3099	ND		1.0		1.0	1.0	100.
Y3200	ND		1.0		1.0	0.72	72.
Y3592	0.88		1.0		1.9	1.8	96.
Y3124	0.91		1.0		1.9	2.9	150.
Y3270	3.3		1.0		4.3	3.2	74.
Y3383	6.3		1.0		7.3	10.4	140.
Y3339	1.5		1.0		2.5	2.0	80.
Y3537	ND		1.0		1.0	1.5	150.
Y3899	5.2		1.0		6.2	7.0	110.
Y3530	ND		1.0		1.0	1.6	160.
Y3750	ND		1.0		1.0	1.2	120.
Y3948	ND		1.0		1.0	1.2	120.
Y3670	ND		1.0		1.0	2.3	230.

Average Percent Recovery: 123(±42)%

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FIGURES

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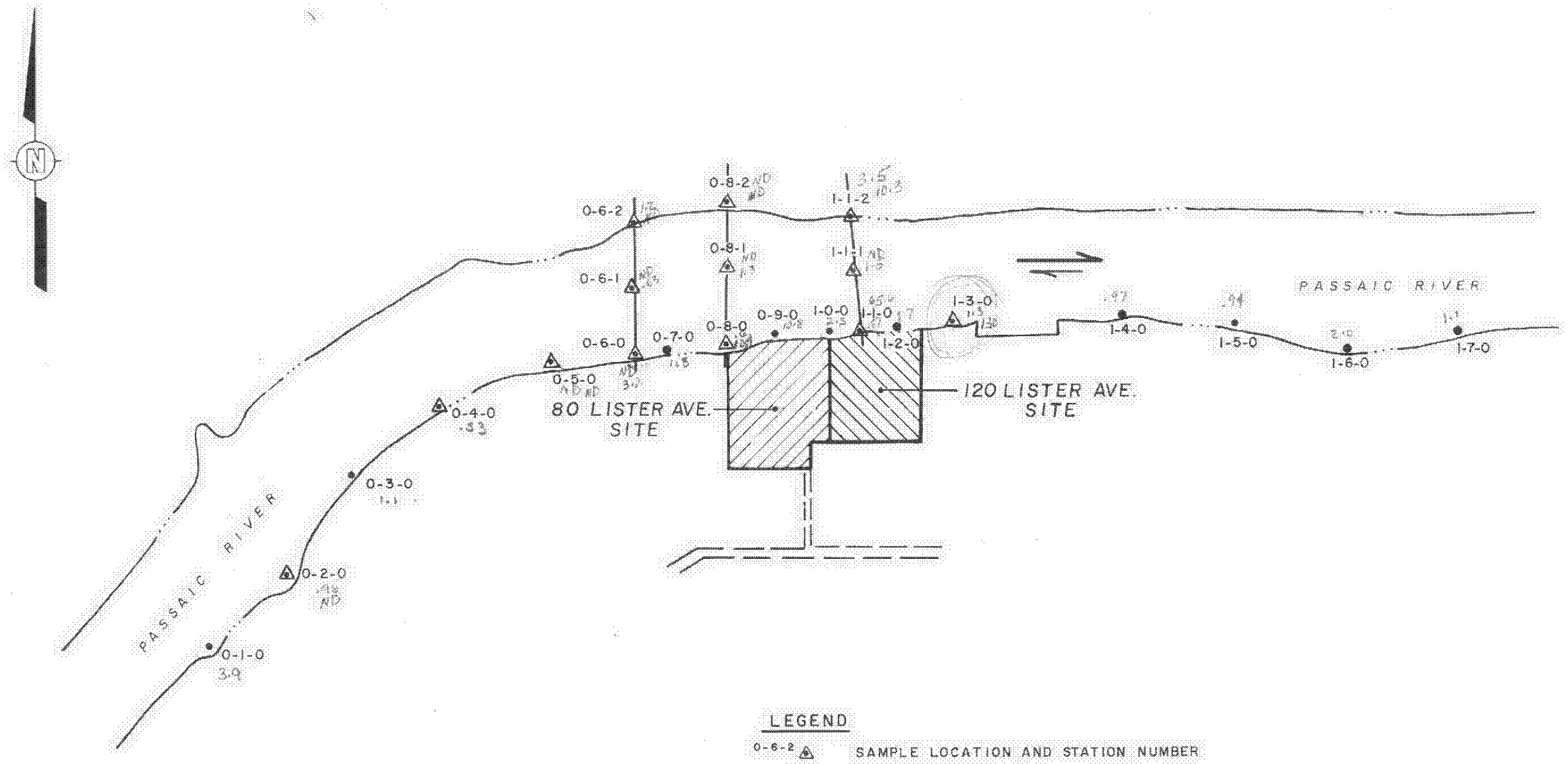
DRAWING NUMBER 846248-B8



LEGEND

0-6-2 ▲ SAMPLE LOCATION AND STATION NUMBER

TCDD ANALYSES

- ● SAMPLE LOCATION, 0"-12" (10 SAMPLES)
- ▲ SAMPLE LOCATION, 0"-12" AND 12"-24" (26 SAMPLES)

RIVER FLOW

TIDAL FLOW

NOTE

ALL REFERENCES TO TCDD ARE SPECIFICALLY 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN.

SCALE

0 400 800 FEET

FIGURE 4-1

SEDIMENT SAMPLING LOCATIONS, TCDD ANALYSIS, 1984 SURVEY

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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5.0 DATA RESULTS AND DISCUSSION

The results of the dioxin, lead, total organic carbon and physical analysis of the sediments and discussion of their occurrence in the study area are presented in this chapter. Details of the physical analyses of the sediments are presented in Appendix F. Complete raw data files as reported from the laboratories are maintained at the IT-Knoxville office, and will be made available to NJDEP separately from this report for their review.

5.1 DIOXIN

A total of 297 sediment samples were analyzed for dioxin. The results are listed in Table 5-1 and are discussed by reach below. For each reach there are separate discussions for the top 2 feet of sediment and the remaining depths. A statistical analysis of the dioxin distribution in sediments is presented in Chapter 6.0.

The distribution of the river sediment dioxin concentration data is highly skewed. Over 60 percent of the concentrations were less than one part per billion (ppb). Less than 15 percent were greater than 7 ppb and most of these were measured in the immediate vicinity of the site. Figure 5-1 presents a graphical representation of this distribution. Note that because the concentration classes are unequal, the areas of the histogram bars are representative of relative frequency of occurrence.

Because the distribution of dioxin concentration data is so highly skewed and there are only a small number of extremes, the median concentration is the appropriate measure of central tendency. The median concentration is defined as that concentration below which 50 percent of the measured concentrations will fall. The median depends only on the rank ordering of the data and, therefore, is not affected by extremes. Use of the median also permits comprehension of the large portion of the measurements reported as below the limit of detection.

Figure 5-2 presents the observed dioxin concentrations as box plots by reach. The lower quartile (25th percentile) and upper quartile (75th percentile) form the ends of the box with the median concentration (50th

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percentile) indicated by a line through the box. The minimum and maximum observations are indicated by vertical lines connected to whiskers extending from the box.

Because of the quantity of data collected from the site-area reach, it has been subdivided into three subreaches in Figure 5-2 (Site A, Site B, and Site C). The east-west boundaries of these subdivisions are the longitudinal map coordinates 2,147,000 and 2,148,000 as shown on the site reach map, Figure 2-2. Site A is the most downstream segment and includes sample area D65.

The box plots of Figure 5-2 clearly show that concentrations as low as those observed in the control reach occur in all reaches. Further, these plots indicate that although the highest concentrations of dioxin are observed in the neighborhood of the site, the median concentrations do not exhibit a pattern directly related to distance from the site. In other words, the concentration of dioxin in the Passaic River cannot be expected to continually decrease as one moves farther upstream or downstream from the site as might be expected in a simple single source discharge situation.

5.1.1 Site-Area Reach

A total of 104 sections were analyzed from 17 cores in the site reach. Of these, 51, or 49 percent, had no detectable dioxin. The median concentration of all samples was 0.88 ppb. The locations of these cores are shown on Figure 2-2.

Surface Sediments. Seventeen sections of sediment from 0-2 feet were analyzed for dioxin. Five of these (29 percent) had no detectable dioxin. The median value for all samples was 0.83 ppb. The highest reported value was 3.1 ppb in the center of the channel parallel to 80 Lister Avenue.

The locations of the samples with no detectable dioxin had no apparent pattern of distribution throughout the sample area. These locations included both the left and right banks across from 80 Lister Avenue, and downstream of the property on both banks and in the center of the channel.

Deep Sediments. The highest concentrations of dioxin identified in this study

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were located in the deep (below 2 feet) sediments of the site-area reach. The highest concentration was 1804 ppb at 8 to 10 feet in core S14 near the left bank downstream of 120 Lister Avenue. Fifty-three percent of these samples (46) had no detectable dioxin. The median concentration of the deep samples was 0.92 ppb. The disparity between the mean and median values highlights the extreme skewness in distribution of dioxin, and indicates that most of the samples contain very low levels of dioxin, while only a few samples contain relatively high levels. This is consistent with exposure of the river sediments to dioxin during the time that a direct process discharge line from the 80 Lister Avenue facility terminated in the river, followed by a longer period of time up to and including the present during which natural movement of sediment has overlain these older sediments. The younger sediments after direct discharge was terminated show much lower (<5 ppb) concentrations of dioxin.

Five cores (S01, S11, S21, S31, S41) were analyzed to their full depths of 20 feet. These cores were located close to the bulkhead adjacent to the 80 Lister Avenue site. Four of these cores had no detectable dioxin below 10 feet.

One core at location S21 was located directly across from the former process discharge line, and revealed detectable dioxin along its full length. However, there was no clear gradient of dioxin concentration along the length of the core. For example, dioxin values in core S21 ranged from 0.74 to 702 ppb, with a median value of 94 ppb. There are two sections, 10-12 feet, and 14-16 feet, where the concentration of dioxin drops one hundred-fold, and ten-fold, respectively, from the adjacent sections. These discontinuities, present in many cores, indicate that even where the sediments were most exposed to dioxin, there was not a strong tendency for the material to migrate vertically through the sediments and equilibrate throughout the environment.

The vertical distribution of dioxin varies among all the cores. Two cores, S42 and S43, located at the extreme right bank across from and downstream from the site, respectively, contained no detectable dioxin at all throughout the analyzed core length.

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Only three of the 17 cores, S14, S21, and S44 contained measurable dioxin throughout their lengths. Cores S14 and S21 were located near the left bank close to the location of the former process sewer discharge lines. S44 was located along the left bank downstream of the 80 Lister Avenue site. A fourth core, S01, contained dioxin below the top 2 feet only. Core S14 dioxin values ranged from 2.7 to 1804 ppb. The concentration of dioxin increased in this core with depth to 10 feet. The median concentration of dioxin in this core was 494 ppb.

5.1.2 Downstream Reach

Sixty-seven sections from 17 cores were analyzed for dioxin in this reach. Thirty of these (45 percent) had no detectable dioxin. The median concentration of the downstream reach samples was 0.81 ppb. The highest concentration reported was 15.6 ppb at 1-2 feet at D65, an area in close proximity to the site-area reach. In the statistical analysis of dioxin distribution (Chapter 6.0), this location is grouped with the site-area reach.

Core D06RB was taken as per NJDEP's request along the right bank next to a pier, in an area of deposition. The top 2 feet contained a dioxin concentration of 0.91 ppb, while the remaining analyzed sections of the core had no detectable dioxin. These results suggest that low levels of dioxin are being deposited in recent sediments, while older sediments were relatively free of dioxin.

Surface Sediments. Eight of 22 samples (36 percent) had no detectable dioxin. The median concentration of the surface samples was 0.86 ppb.

Deep Sediments. There were 45 samples taken from deep (2-10 feet) sediments. Twenty-two (49 percent) were recorded as having no detectable dioxin. The samples had a median value of 0.73 ppb. The distribution of dioxin throughout these cores did not follow a consistent pattern, with samples without detectable dioxin appearing in every core and no single core entirely free of detectable dioxin.

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5.1.3 Upstream Reach

From this reach, 39 sections from 9 cores were analyzed. For the reach as a whole, 20 of 32 sections (63 percent) had no detectable dioxin. The samples had a median value of approximately 0.78 ppb. The highest concentration reported in this reach was 32 ppb at 8-10 feet in area U18 along the left bank. Seven sections from area U45 contained an interfering compound which precluded resolution of dioxin concentration. No results were reported for these seven samples. Of the remaining ten samples from U45, six (60 percent) had no detectable dioxin.

Core U18LE was taken in a small boat slip as per NJDEP's request. The entire top 10 feet of this core was analyzed for dioxin. The top 4 feet had no detectable dioxin. The highest value reported for this core was 5.2 ppb at 8-10 feet.

Surface Sediments. Ten of the 12 reportable surface sediment results (83 percent) had no detectable dioxin. The remaining samples were 0.88 and 1.6 ppb, at one core within area U45 and one core within area U18, respectively. The surface samples had a median value of 0.72 ppb.

Deep Sediments. The median value of the 10 deep (2-10 foot) sections was 1.39 ppb. The vertical distribution of dioxin within each set of cores was not consistent. For example, at location U18L, core A showed 32 ppb dioxin at 8-10 feet while core C, located approximately 200 feet away, had no detectable dioxin at that depth. Both cores had no detectable dioxin at the surface.

Similarly, the results at location U18R revealed dioxin at 2-4 feet in core A and no dioxin at that depth at core C. This discontinuous distribution, which occurred in all the sets of cores throughout the entire river, prevented correlation of the sample results with sedimentation rate, dredging, or distance from 80 Lister Avenue.

5.1.4 Far Upstream Reach

A total of 79 sections from 18 cores were analyzed for dioxin. Sixty-three samples (80 percent) had no detectable dioxin. The 79 samples had a median value of 0.23 ppb. The highest reported concentration from this reach was 20

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ppb at 4-5 feet at F01. Eight cores (44 percent) from six areas had no detectable dioxin throughout their entirety. At four of these areas, however, the companion core had detectable dioxin.

Surface Sediments. Fifteen of 25 sections (60 percent) had no detectable dioxin. The median concentration of the samples was 0.60 ppb.

In this reach, 10 of the 16 samples with detectable dioxin (64 percent) occurred at the surface. This is in contrast to other reaches, including the site-area reach, in which most of the detectable dioxin lies below the top 2 feet of sediment.

Deep Sediments. The median value of all the deep samples was 0.15 ppb. No detectable dioxin was reported for 48 of 54 samples (89 percent). The remaining six samples ranged from 0.08 ppb to 20 ppb. Four of these six samples were located in core F01M.

This core, taken midchannel at station F01, showed dioxin from 2-5 feet, with 20 ppb at the 4-5 foot depth. This location is within 1500 feet of two combined sewer overflow regulators at Clay Street and at Johnston Avenue, Kearny (see Appendix H for list of major overflow regulators). The Clay Street overflow is the major one for Newark. The overflow regulators discharge combined storm water and process discharge from sewer lines hooked into the central PVSC system directly to the river during periods of high rainfall. The companion deep core taken at the right bank had no detectable dioxin throughout its length.

5.1.5 Control Reach

Eight samples comprising the entire 6.5 to 6.75 foot length of two cores were collected from this reach. All samples had no detectable dioxin.

5.1.6 Summary of Dioxin Results

The analyses indicated that 164 of 282 reported samples (58 percent) for the river as a whole, with the exception of the control reach, had no detectable dioxin. For the upper 2 feet of sediment, 38 of 76 samples (50 percent) had no detectable dioxin. No reach was entirely free of dioxin. The percentage

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of samples with measurable dioxin ranged from 20 percent in the far-upstream reach to 55 percent in the downstream reach. Areas with detectable dioxin are shown in Figure 5.3 for the top 2 feet of sediment and Figure 5.4 for sediment from 2 to 10 feet. These figures illustrate the discontinuous distribution of dioxin along the length of the river.

The vertical distribution of dioxin varied from reach to reach. Generally, the surface 2 feet of sediment contained lower levels of dioxin than did the deeper areas. The exception was the far-upstream reach, in which most of the reported dioxin was found in the surface sediments.

This may indicate that the occurrence of dioxin in the different reaches is due to several sources that vary both in space and time. In the site-area reach, the dioxin is found at relatively high levels in sediment sections that are well defined, and generally are bounded both above and below by sediments with low or no detectable dioxin levels. The site-area reach is also bounded laterally by cores with low or no detectable dioxin concentrations.

Dioxin located in the downstream reach is clustered at area D19 along the right bank. The areas both upstream and downstream of D19 show lower or no detectable dioxin. This might indicate a point source in the immediate vicinity of area D19 such as a Passaic Valley Sewerage Commission (PVSC) combined sewer overflow regulator or a process discharge line from a chemical plant.

The upstream reach showed a discontinuous distribution of dioxin both laterally and vertically. Samples from this reach also showed matrix interferences during analysis. This reach is in a heavily industrialized area of Newark and also includes at least two major PVSC combined sewer overflows. This reach, therefore, may be described as subject to heavy industrial discharge from numerous sources.

Most of the dioxin found in the far-upstream reach occurs in the upper 2 feet of sediment, although the distribution was discontinuous and 80 percent of the samples contained no detectable dioxin. Numerous PVSC combined sewer overflows are located along this reach.

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As reported earlier, half of the surface sediment samples contained measurable dioxin. The median concentration of each of the reaches was 0.88, 0.81, 0.78 and 0.23 ppb for the site, downstream, upstream, and far-upstream reaches, respectively. This distribution is fairly uniform throughout the entire lower Passaic River, and strongly suggests that recent contributions of dioxin to the river have occurred without limitation as to location.

The discontinuous occurrence of dioxin throughout the sediments has been subjected to geostatistical analysis in order to better define the spatial distribution of dioxin in the sediments. This analysis is presented in Chapter 6.0.

5.2 LEAD

An investigation was made into the potential for using lead to establish the age of the Passaic River sediments. The purpose of this study was to determine if the occurrence of lead could be related to the age of sediments. Such a relationship could permit the use of simpler lead analyses to identify sediments with potential TCDD association.

Samples from two river sediment cores were analyzed for both lead (Pb) and dioxin. Statistical analysis of the resulting data indicates that lead is not effectively correlated with the age of sediments.

The cores chosen for this analysis are identified as S01LA and S11LA. These cores are located approximately 160 feet apart off the south bank of the Passaic River between Transects 1-2 and 1-3 (Figure C-1, Appendix C). Because of their close proximity, it is reasonable to assume that they reside in the same regime with regard to sedimentation and geology. The data collected on grain-size distribution and lead, dioxin, and TOC concentrations in these cores are presented in Table 5-2.

A scatter diagram of Pb concentrations versus depth is presented in Figure 5-5. Though a drop in Pb concentration below 15 feet of sediment is suggested by this diagram, lack of consistency in Pb concentrations between the two borings at the 15-foot depth makes interpretation difficult, if not

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impossible. No meaningful functional relationship between Pb concentration and sediment depth could be derived from the data. Thus, the use of Pb concentrations for determining sediment age as associated with years of process plant operation is doubtful. Instead, the drop in Pb concentration may best be explained by a correlation with the beginning of industrialization and use of leaded gasoline.

These conclusions are supported by the published literature. In order for a soil (or, by analogy, sediment) to be used in a study of lead soil inventories, it must be in steady state with respect to the input of lead from the atmosphere (or the water column), requiring that the soil or sediment lie undisturbed (Benninger et al., 1976). The Passaic River sediments have been subject to daily tidal influences, unusual events such as hurricanes, barge and other boat traffic, and dredging. Studies of undisturbed sediment in areas with approximately 1 cm/year sedimentation rates indicate that pre-1945 sediments occur at or below 30 cm (Kelley, 1983; Goldberg et al., 1977). Sedimentation rates in the Hudson River have been found to range from less than 1 cm/year to as high as 10-20 cm/year (Williams et al., 1978). One of the cores from that study was analyzed for ^{14}C to provide an age date for the various strata. Sediment from three meters' depth (approximately 10 feet) was found to be representative of preindustrial sediments. The Chesapeake Bay near the Susquehanna River was found to have a sedimentation rate of 8 cm/year (Goldberg et al., 1978). In each of these studies lead analyses were conducted on 0.5 to 5 cm segments of the cores, to permit fine resolution of lead correlation with depth.

In contrast, the present study utilized core segments of 30 - 60 cm (1 - 2 feet). With a calculated deposition rate of 1.8 - 8.5 cm/year (0.06 - 0.28 feet/year), the analysis protocol mixes from 3 to 40 years of sedimented material together. Since no relationship between lead and depth of the core sections could be established, the potential relationship between lead and dioxin was not investigated.

5.3 TOTAL ORGANIC CARBON

All core sections initially slated for dioxin analysis were analyzed for total organic carbon (TOC), according to the standard protocol. The purpose of

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these analyses was to determine if a relationship exists between concentrations of TOC and dioxin in the Passaic River sediments. Figure 5-6 presents a scatter diagram of the rank order correlation of TOC versus dioxin. The overall rank correlation of TOC and dioxin for the far upstream, upstream site-area, and downstream reaches at depths ranging from surface to 10 feet is 0.53561, which is statistically significant at p less than 0.0001. When rank correlation coefficients are computed for TOC and dioxin, stratified by reach and depth, this relationship becomes more enlightening. Consideration of the far upstream reach suggests an additional source of dioxin. The rank correlation of dioxin and TOC is significant only for a depth of 0 to 2 feet (r_s equals 0.69809; p equals 0.0026). The upstream reach shows no significant correlation of dioxin and TOC at any depth sampled, suggesting that this far upstream dioxin is of recent origin. Both the site reach and the downstream reach show significant rank correlations of TOC and dioxin at depths of 4 to 6 feet and 6 to 8 feet. Nonetheless, TOC is not an adequate predictor of dioxin concentration. High TOC concentrations are found, even in areas with little or no dioxin. The distribution of dioxin is very highly skewed, with a coefficient of variation (CV) of 640 percent, while the distribution of TOC is relatively symmetrical with a CV of 52 percent. These differences preclude the utilization of elevated TOC as a sentinel for dioxin.

5.4 SEDIMENT PHYSICAL ANALYSES

All 273 sediment samples originally scheduled for TCDD analysis were also analyzed for various physical properties. The purpose of determining grain-size distribution was to permit a comparison of this sediment feature with dioxin occurrence. The associated physical analyses of the sediment, moisture content, specific gravity, and settling behavior in river water, were performed in order to more completely characterize the sediment in the case of subsequent studies. The results of the sediment physical analyses are presented in Appendix F. A discussion of the distribution of sediment grain size throughout the river sediments, and the association of dioxin with grain size, is presented below.

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5.4.1 Sediment Grain Size Distribution

The various reaches of the river are characterized by different overall grain size distributions. The distribution reflects the erosive and depositional characteristics and the dredging history of the river.

The site-area reach was the most extensively sampled of the reaches. The majority of the samples were composed almost entirely of silt. All of the top 10 feet of all the cores along the south bank (near Lister Avenue) were composed entirely of silt. In the center of the channel, the cores penetrated through 6 to 8 feet of silt to a sand layer. Along the north bank only 2 to 4 feet of silt overlay sand. This pattern is consistent with deposition along the south bank. Sand is representative of older sediments as discussed in Chapter 2.0. Detection of sand overlain by silt in the channel may indicate that the channel is currently receiving silt deposition after being dredged. The sand layer is much closer to the surface sediments along the north bank. The area has probably reached equilibrium with no net change in the depth of the sediment.

Most of the downstream reach consists of silt with some clay, indicating that net deposition may occur. The center of the channel also consists of silt to at least 10 feet. The exception to this pattern of silt deposition is along the left (west) bank, in which predominantly sand is found throughout the top 8 to 10 feet. Beneath this is a silt layer mixed with sand and clay.

The upstream reach is similar to the site-area reach in its distribution of sediment. The left (west) bank is almost entirely silt, indicating net deposition. Sand is found along the right bank throughout the top 5 feet of the short cores. Some sections of the replicate cores in this area show predominantly silt. These findings may indicate an area of equilibrium in which surface material, either sand or silt, if scoured, is replaced by silt to achieve no net change in depth of sediment.

Samples taken in the center of the far-upstream reach channel are predominantly sand, with some gravel recorded at 4 to 5 feet. Samples taken

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along the right or left banks are silt mixed with sand or clay for the top 2 to 8 feet, with sand below. Core F03R, which is close to River Bank Park in North Arlington, is predominantly sand throughout its length.

Dundee Lake, the control reach, appears to have a 1-foot layer of predominantly sand overlaying silt with some clay.

5.4.2 Correlation of Sediment Grain Size with Dioxin

The potential correlation of sediment grain size with dioxin was investigated. As reviewed in Chapter 2.0, previous studies have indicated that dioxin preferentially sorbs to the silt and clay fractions rather than the more coarse sand.

A scatter plot of dioxin vs. grain size is presented in Figure 5.7. To develop the plot, each core section was given a value corresponding to its predominant grain size. The figure shows that most of the core sections are composed primarily of silt. In the site-area reach, which is predominantly silt, the concentration of dioxin ranges from nondetectable to 1804 ppb. However, there was no detectable dioxin in any sample which was predominantly sand. In the downstream reach, the sand samples contained 2 ppb or less dioxin, although there were too few samples containing sand to permit a comprehensive comparison in this reach. In the upstream reach as well, samples that were predominantly sand contained less than 2 ppb dioxin. In the far-upstream reach, the highest concentration of dioxin appeared in a silt layer. In this reach, both the sand and the silt samples were predominantly free of dioxin.

No analyses for dioxin were made on separated fractions of sediment. The data presented here do not permit a determination of the correlation between grain size and dioxin occurrence.

5.5 TIDAL CURRENT MEASUREMENTS

Current velocity and direction, salinity and temperature measurements were made in the vicinity of the 80 Lister Avenue site in the channel and along the margin, at half hour intervals throughout an entire tidal cycle. The results are presented in Appendix A.

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TABLES

TABLE 5-1

ANALYTICAL RESULTS

TABLE 5-1
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

SITE REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
S01LA	0.00 - 2.00	ND<0.83	11000	D0.07*	2147454	695329	200	3299
S01LA	2.00 - 4.00	30.9	13000	D0.07	2147454	695329	201	3300
S01LA	4.00 - 6.00	162.	13000	D0.07	2147454	695329	202	3301
S01LA	6.00 - 8.00	419.	14000	D0.07	2147454	695329	203	3302
S01LA	8.00 - 10.00	184.	13000	D0.07	2147454	695329	204	3303
S01LA	10.00 - 12.00	ND<1.3	.	D0.07	2147454	695329	205	3304
S01LA	12.00 - 14.00	ND<0.17	.	D0.07	2147454	695329	206	3305
S01LA	14.00 - 16.00	ND<0.12	.	D0.07	2147454	695329	207	3306
S01LA	16.00 - 17.20	ND<0.4	.	D0.07	2147454	695329	208	3307
S11LA	0.00 - 2.00	1.8	9500	D0.04	2147293	695312	200	3309
S11LA	2.00 - 4.00	2.7	11000	D0.04	2147293	695312	201	3310
S11LA	4.00 - 6.00	65.0	12000	D0.04	2147293	695312	202	3311
S11LA	6.00 - 8.00	ND<0.45	12000	D0.04	2147293	695312	203	3312
S11LA	8.00 - 10.00	ND<0.38	9100	D0.04	2147293	695312	204	3313
S11LA	10.00 - 12.00	ND<0.16	.	D0.04	2147293	695312	205	3314
S11LA	12.00 - 14.00	ND<0.72	.	D0.04	2147293	695312	206	3315
S11LA	14.00 - 16.00	ND<0.55	.	D0.04	2147293	695312	207	3316
S11LA	16.00 - 18.00	ND<0.1	.	D0.04	2147293	695312	208	3317
S11LA	18.00 - 19.50	ND<0.42	.	D0.04	2147293	695312	209	3318
S12LA	0.00 - 2.00	0.80	13000	D0.05	2147297	695356	200	3391
S12LA	2.00 - 4.00	1.6	12000	D0.05	2147297	695356	201	3392
S12LA	4.00 - 6.00	19.0	12000	D0.05	2147297	695356	202	3393
S12LA	6.00 - 8.00	ND<0.48	7800	D0.05	2147297	695356	203	3394
S12LA	8.00 - 10.00	ND<0.42	4600	D0.05	2147297	695356	204	3395
S13LA	0.00 - 2.00	0.73	13000	D0.09	2147550	695418	200	3401
S13LA	2.00 - 4.00	16.1	14000	D0.09	2147550	695418	201	3402
S13LA	4.00 - 6.00	ND<0.03	8700	D0.09	2147550	695418	202	3403
S13LA	6.00 - 8.00	ND<0.39	7700	D0.09	2147550	695418	203	3404
S13LA	8.00 - 10.00	ND<0.84	15000	D0.09	2147550	695418	204	3405
S14LA	0.00 - 2.00	2.7	16000	D0.11	2147631	695302	200	3319
S14LA	2.00 - 4.00	55.4	19000	D0.11	2147631	695302	201	3320

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

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TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

SITE REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
S14LA	4.00 - 6.00	71.4	16000	D0.11*	2147631	695302	202	3321
S14LA	6.00 - 8.00	916.	13000	D0.11	2147631	695302	203	3322
S14LA	8.00 - 10.00	1804.	22000	D0.11	2147631	695302	204	3323
S21LA	0.00 - 2.00	0.74	14000	U0.03	2146917	695242	200	3329
S21LA	2.00 - 4.00	4.6	13000	U0.03	2146917	695242	201	3330
S21LA	4.00 - 6.00	24.5	9600	U0.03	2146917	695242	202	3331
S21LA	6.00 - 8.00	561.	16000	U0.03	2146917	695242	203	3332
S21LA	8.00 - 10.00	220.	13000	U0.03	2146917	695242	204	3333
S21LA	10.00 - 12.00	7.3	.	U0.03	2146917	695242	205	3334
S21LA	12.00 - 14.00	702.	.	U0.03	2146917	695242	206	3335
S21LA	14.00 - 16.00	28.0	.	U0.03	2146917	695242	207	3336
S21LA	16.00 - 18.00	175.	.	U0.03	2146917	695242	208	3337
S21LA	18.00 - 20.00	161.	.	U0.03	2146917	695242	209	3338
S22MA	0.00 - 2.00	0.54	13000	D0.02	2147161	695502	200	3411
S22MA	2.00 - 4.00	2.5	15000	D0.02	2147161	695502	201	3412
S22MA	4.00 - 6.00	3.6	16000	D0.02	2147161	695502	202	3413
S22MA	6.00 - 8.00	0.72	12000	D0.02	2147161	695502	203	3414
S22MA	8.00 - 10.00	ND<0.31	15000	D0.02	2147161	695502	204	3415
S23MA	0.00 - 2.00	0.67	13000	D0.13	2147729	695617	200	3421
S23MA	2.00 - 4.00	2.4	15000	D0.13	2147729	695617	201	3422
S23MA	4.00 - 6.00	5.3	13000	D0.13	2147729	695617	202	3423
S23MA	6.00 - 8.00	ND<0.84	13000	D0.13	2147729	695617	203	3424
S23MA	8.00 - 10.00	ND<0.2	3400	D0.13	2147729	695617	204	3425
S24LA	0.00 - 2.00	1.5	15000	D0.17	2147926	695389	200	3339
S24LA	2.00 - 4.00	11.6	15000	D0.17	2147926	695389	201	3340
S24LA	4.00 - 6.00	ND<0.26	8900	D0.17	2147926	695389	202	3341
S24LA	6.00 - 8.00	ND<0.26	1000	D0.17	2147926	695389	203	3342
S24LA	8.00 - 10.00	ND<0.48	14000	D0.17	2147926	695389	204	3343
S31LA	0.00 - 2.00	ND<0.58	15000	U0.07	2146713	695197	200	3349
S31LA	2.00 - 4.00	1.5	13000	U0.07	2146713	695197	201	3350
S31LA	4.00 - 6.00	4.6	13000	U0.07	2146713	695197	202	3351

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047621

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

SITE REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
S31LA	6.00 - 8.00	ND<1	9500	U0.07*	2146713	695197	203	3352
S31LA	8.00 - 10.00	ND<0.37	9400	U0.07	2146713	695197	204	3353
S31LA	10.00 - 12.00	ND<0.12	.	U0.07	2146713	695197	205	3354
S31LA	12.00 - 14.00	ND<0.27	.	U0.07	2146713	695197	206	3355
S31LA	14.00 - 16.00	ND<0.21	.	U0.07	2146713	695197	207	3356
S31LA	16.00 - 17.50	ND<0.24	.	U0.07	2146713	695197	208	3357
S32MA	0.00 - 2.00	3.1	21000	U0.03	2146874	695559	200	3431
S32MA	2.00 - 4.00	4.2	17000	U0.03	2146874	695559	201	3432
S32MA	4.00 - 6.00	ND<0.76	12000	U0.03	2146874	695559	202	3433
S32MA	6.00 - 8.00	ND<0.55	9000	U0.03	2146874	695559	203	3434
S32MA	8.00 - 10.00	ND<0.37	20000	U0.03	2146874	695559	204	3435
S33MA	0.00 - 2.00	ND<0.54	20000	D0.16	2147875	695729	200	3441
S33MA	2.00 - 4.00	4.8	21000	D0.16	2147875	695729	201	3442
S33MA	4.00 - 6.00	ND<0.92	6100	D0.16	2147875	695729	202	3443
S33MA	6.00 - 8.00	ND<0.21	5300	D0.16	2147875	695729	203	3444
S33MA	8.00 - 10.00	ND<0.32	15000	D0.16	2147875	695729	204	3445
S34LA	0.00 - 2.00	1.4	12000	D0.22	2148214	695400	200	3359
S34LA	2.00 - 4.00	4.9	12000	D0.22	2148214	695400	201	3360
S34LA	4.00 - 6.00	31.0	14000	D0.22	2148214	695400	202	3361
S34LA	6.00 - 8.00	ND<1.4	12000	D0.22	2148214	695400	203	3362
S34LA	8.00 - 10.00	ND<0.51	13000	D0.22	2148214	695400	204	3363
S41LA	0.00 - 2.00	0.39	14000	U0.14	2146396	695135	200	3369
S41LA	2.00 - 4.00	1.1	6400	U0.14	2146396	695135	201	3370
S41LA	4.00 - 6.00	2.6	11000	U0.14	2146396	695135	202	3371
S41LA	6.00 - 8.00	11.7	12000	U0.14	2146396	695135	203	3372
S41LA	8.00 - 10.00	ND<0.47	7900	U0.14	2146396	695135	204	3373
S41LA	10.00 - 12.00	ND<0.6	.	U0.14	2146396	695135	205	3374
S41LA	12.00 - 14.00	ND<0.7	.	U0.14	2146396	695135	206	3375
S41LA	14.00 - 16.10	ND<0.31	.	U0.14	2146396	695135	207	3376
S42RA	0.00 - 2.00	ND<1	13000	U0.07	2146635	695681	200	3451
S42RA	2.00 - 4.00	ND<0.38	6900	U0.07	2146635	695681	201	3452

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047622

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

SITE REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
S42RA	4.00 - 6.00	ND<0.25	5400	U0.07*	2146635	695681	202	3453
S43RA	0.00 - 2.00	ND<1.1	12000	D0.18	2147907	695881	200	3461
S43RA	2.00 - 4.00	ND<0.32	13000	D0.18	2147907	695881	201	3462
S43RA	4.00 - 6.00	ND<0.18	7500	D0.18	2147907	695881	202	3463
S43RA	6.00 - 8.00	ND<0.51	520	D0.18	2147907	695881	203	3464
S43RA	8.00 - 10.00	ND<0.78	720	D0.18	2147907	695881	204	3465
S44LA	0.00 - 2.00	1.2	8300	D0.27	2148480	695443	200	3379
S44LA	2.00 - 4.00	4.7	8100	D0.27	2148480	695443	201	3380
S44LA	4.00 - 6.00	29.5	9700	D0.27	2148480	695443	202	3381
S44LA	6.00 - 8.00	111.	8800	D0.27	2148480	695443	203	3382
S44LA	8.00 - 10.00	6.3	8200	D0.27	2148480	695443	204	3383

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047623

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

DOWNSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
D06RB	0.00 - 2.00	0.91	10000	D1.05*	2152402	694698	200	3124
D06RB	4.00 - 6.00	ND<0.52	8500	D1.05	2152402	694698	202	3126
D06RB	8.00 - 10.00	ND<0.14	10000	D1.05	2152402	694698	204	3128
D06RD	0.00 - 2.00	0.69	9300	D0.96	2152034	695167	200	3144
D06RD	2.00 - 4.00	2.0	10000	D0.96	2152034	695167	201	3145
D06RD	6.00 - 8.00	ND<0.73	10000	D0.96	2152034	695167	203	3147
D06RD	8.00 - 10.00	ND<0.15	6900	D0.96	2152034	695167	204	3148
D19MB	0.00 - 1.00	ND<0.86	15000	D2.1	2151268	689233	500	2955
D19MB	1.00 - 2.00	ND<0.6	13000	D2.1	2151268	689233	501	2956
D19MB	2.00 - 3.00	0.32	12000	D2.1	2151268	689233	502	2957
D19MB	3.00 - 4.00	ND<0.75	15000	D2.1	2151268	689233	503	2958
D19MB	4.00 - 5.00	0.66	1700	D2.1	2151268	689233	504	2959
D19MD	0.00 - 1.00	ND<0.52	13000	D2.03	2151374	689581	500	2960
D19MD	1.00 - 2.00	ND<0.76	12000	D2.03	2151374	689581	501	2961
D19MD	2.00 - 3.00	6.1	10000	D2.03	2151374	689581	502	2962
D19MD	3.00 - 4.00	3.8	13000	D2.03	2151374	689581	503	2963
D19MD	4.00 - 5.00	ND<0.1	280	D2.03	2151374	689581	504	2964
D19RB	0.00 - 1.00	ND<0.96	16000	D2.09	2151585	689156	500	2974
D19RB	1.00 - 2.00	1.2	12000	D2.09	2151585	689156	501	2975
D19RB	2.00 - 3.00	3.3	14000	D2.09	2151585	689156	502	2976
D19RB	3.00 - 4.00	7.7	10000	D2.09	2151585	689156	503	2977
D19RB	4.00 - 5.00	5.8	15000	D2.09	2151585	689156	504	2978
D19RD	0.00 - 1.00	0.81	9600	D2.03	2151655	689442	500	2979
D19RD	1.00 - 2.00	ND<0.74	14000	D2.03	2151655	689442	501	2980
D19RD	2.00 - 3.00	ND<0.85	11000	D2.03	2151655	689442	502	2981
D19RD	3.00 - 4.00	0.94	8000	D2.03	2151655	689442	503	2982
D19RD	4.00 - 5.00	1.3	13000	D2.03	2151655	689442	504	2983
D22LB	4.00 - 6.00	ND<0.08	150	D2.38	2150651	687649	202	3006
D22LB	8.00 - 9.50	ND<0.2	140	D2.38	2150651	687649	204	3008
D22LD	0.00 - 2.00	0.84	13000	D2.28	2150778	688273	200	3014
D22LD	2.00 - 4.00	3.3	6800	D2.28	2150778	688273	201	3015

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047624

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

DOWNSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
D22LD	6.00 - 8.00	ND<0.05	4600	D2.28*	2150778	688273	203	3017
D22LD	8.00 - 10.00	0.25	4600	D2.28	2150778	688273	204	3018
D22LE	0.00 - 2.00	ND<0.78	12000	D2.38	2150598	687769	200	3097
D22LE	4.00 - 6.00	ND<0.05	5300	D2.38	2150598	687769	202	3099
D22LE	8.00 - 10.00	ND<0.02	3600	D2.38	2150598	687769	204	3101
D22MA	0.00 - 2.00	ND<0.55	14000	D2.41	2150863	687550	200	3220
D22MA	2.00 - 4.00	0.35	15000	D2.41	2150863	687550	201	3221
D22MA	6.00 - 8.00	0.75	11000	D2.41	2150863	687550	203	3223
D22MA	8.00 - 10.00	0.82	8900	D2.41	2150863	687550	204	3224
D22MC	0.00 - 2.00	0.65	11000	D2.34	2150831	687916	200	3240
D22MC	4.00 - 6.00	0.86	12000	D2.34	2150831	687916	202	3242
D22MC	8.00 - 10.00	2.3	9300	D2.34	2150831	687916	204	3244
D22RA	0.00 - 2.00	0.92	9200	D2.36	2151661	687872	200	3055
D22RA	4.00 - 6.00	ND<0.28	14000	D2.36	2151661	687872	202	3057
D22RA	8.00 - 10.00	ND<0.19	14000	D2.36	2151661	687872	204	3058
D22RC	0.00 - 2.00	1.7	10000	D2.3	2151622	688145	200	3075
D22RC	2.00 - 4.00	5.3	10000	D2.3	2151622	688145	201	3076
D22RC	6.00 - 8.00	ND<0.17	10000	D2.3	2151622	688145	203	3078
D22RC	8.00 - 10.00	ND<0.84	14000	D2.3	2151622	688145	204	3079
D65LA	0.00 - 2.00	0.86	14000	D0.4	2149127	695450	200	3178
D65LA	2.00 - 4.00	7.3	7900	D0.4	2149127	695450	201	3179
D65LA	6.00 - 8.00	ND<0.02	9300	D0.4	2149127	695450	203	3181
D65LA	8.00 - 10.00	ND<0.35	6800	D0.4	2149127	695450	204	3182
D65LC	0.00 - 2.00	8.4	14000	D0.35	2148896	695442	200	3198
D65LC	4.00 - 6.00	ND<0.05	11000	D0.35	2148896	695442	202	3200
D65LC	8.00 - 10.00	3.9	7400	D0.35	2148896	695442	204	3202
D65RA	0.00 - 1.00	2.8	11000	D0.41	2149126	695984	500	3260
D65RA	1.00 - 2.00	15.1	11000	D0.41	2149126	695984	501	3261
D65RA	2.00 - 3.00	ND<0.38	8700	D0.41	2149126	695984	502	3262
D65RA	3.00 - 4.00	ND<0.11	11000	D0.41	2149126	695984	503	3263
D65RA	4.00 - 5.00	ND<0.59	12000	D0.41	2149126	695984	504	3264

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047625

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

DOWNSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
* D65RC	0.00 - 1.00	3.3	15500	D0.32*	2148673	695941	500	3270
D65RC	1.00 - 2.00	7.2	13000	D0.32	2148673	695941	501	3271
D65RC	2.00 - 3.00	4.5	12000	D0.32	2148673	695941	502	3272
D65RC	3.00 - 4.00	8.6	13000	D0.32	2148673	695941	503	3273
D65RC	4.00 - 5.00	15.6	15000	D0.32	2148673	695941	504	3274

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047626

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

UPSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
U18LA	0.00 - 2.00	ND<0.73	14000	U1.83*	2139315	694263	200	3537
U18LA	4.00 - 6.00	12.6	17000	U1.83	2139315	694263	202	3539
U18LA	8.00 - 10.00	32.0	12000	U1.83	2139315	694263	204	3541
U18LC	0.00 - 2.00	ND<0.48	14000	U1.88	2139235	694516	200	3557
U18LC	2.00 - 4.00	ND<0.72	9000	U1.88	2139235	694516	201	3558
U18LC	6.00 - 8.00	12.3	14000	U1.88	2139235	694516	203	3560
U18LC	8.00 - 10.00	ND<0.78	13000	U1.88	2139235	694516	204	3561
U18LE	0.00 - 2.00	ND<0.74	17000	U1.91	2139066	694597	200	3895
U18LE	2.00 - 4.00	ND<0.88	15000	U1.91	2139066	694597	201	3896
U18LE	4.00 - 6.00	1.9	16000	U1.91	2139066	694597	202	3897
U18LE	6.00 - 8.00	ND<7	11000	U1.91	2139066	694597	203	3898
U18LE	8.00 - 10.00	5.2	15000	U1.91	2139066	694597	204	3899
U18RA	0.00 - 1.00	ND<1.3	14000	U1.82	2139606	694284	500	3517
U18RA	1.00 - 2.00	ND<0.62	15000	U1.82	2139606	694284	501	3518
U18RA	2.00 - 3.00	4.2	16000	U1.82	2139606	694284	502	3519
U18RA	3.00 - 4.00	8.7	12000	U1.82	2139606	694284	503	3520
U18RA	4.00 - 5.00	ND<0.74	11000	U1.82	2139606	694284	504	3521
U18RC	0.00 - 1.00	ND<0.65	18000	U1.87	2139485	694525	500	3527
U18RC	1.00 - 2.00	1.6	9400	U1.87	2139485	694525	501	3528
U18RC	2.00 - 3.00	ND<0.39	10000	U1.87	2139485	694525	502	3529
U18RC	3.00 - 4.00	ND<0.59	5200	U1.87	2139485	694525	503	3530
U18RC	4.00 - 5.00	ND<0.78	7000	U1.87	2139485	694525	504	3531
U45LB	0.00 - 2.00	.	13000	U0.34	2145506	694703	200	3607
U45LB	4.00 - 6.00	.	16000	U0.34	2145506	694703	202	3609
U45LB	8.00 - 10.00	.	13000	U0.34	2145506	694703	204	3611
U45LD	0.00 - 2.00	.	13000	U0.41	2145260	694459	200	3627
U45LD	2.00 - 4.00	.	14000	U0.41	2145260	694459	201	3628
U45LD	6.00 - 8.00	7.0	13000	U0.41	2145260	694459	203	3630
U45LD	8.00 - 10.00	26.4	13000	U0.41	2145260	694459	204	3631
U45RB	0.00 - 1.00	ND<0.71	11000	U0.29	2145521	695093	500	3582
U45RB	1.00 - 2.00	.	14000	U0.29	2145521	695093	501	3583

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047627

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

UPSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
U45RB	2.00 - 3.00	.	8600	U0.29*	2145521	695093	502	3584
U45RB	3.00 - 4.00	ND<0.42	23000	U0.29	2145521	695093	503	3585
U45RB	4.00 - 5.00	ND<0.63	21000	U0.29	2145521	695093	504	3586
U45RD	0.00 - 1.00	0.88	14000	U0.34	2145275	694940	500	3592
U45RD	1.00 - 2.00	ND<0.56	8300	U0.34	2145275	694940	501	3593
U45RD	2.00 - 3.00	ND<0.44	11000	U0.34	2145275	694940	502	3594
U45RD	3.00 - 4.00	3.8	9300	U0.34	2145275	694940	503	3595
U45RD	4.00 - 5.00	ND<0.1	10000	U0.34	2145275	694940	504	3596

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047628

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

FAR UPSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
F01MA	0.00 - 1.00	ND<0.75	4300	U3.14*	2139099	701146	500	3720
F01MA	1.00 - 2.00	1.1	9200	U3.14	2139099	701146	501	3721
F01MA	2.00 - 3.00	0.37	6400	U3.14	2139099	701146	502	3722
F01MA	3.00 - 4.00	2.2	14000	U3.14	2139099	701146	503	3723
F01MA	4.00 - 5.00	20.0	9700	U3.14	2139099	701146	504	3724
F01RA	0.00 - 2.00	ND<0.87	10000	U3.15	2139320	701145	200	3725
F01RA	2.00 - 4.00	ND<0.6	11000	U3.15	2139320	701145	201	3726
F01RA	4.00 - 6.00	ND<0.65	9700	U3.15	2139320	701145	202	3727
F01RA	6.00 - 8.00	ND<0.23	1600	U3.15	2139320	701145	203	3728
F01RA	8.00 - 10.10	ND<0.46	400	U3.15	2139320	701145	204	3729
F02MA	0.00 - 1.00	ND<0.64	13000	U4.17	2141201	706046	500	3735
F02MA	1.00 - 2.00	0.66	4400	U4.17	2141201	706046	501	3736
F02MA	2.00 - 3.00	ND<0.09	1000	U4.17	2141201	706046	502	3737
F02MA	3.00 - 4.00	ND<0.01	14000	U4.17	2141201	706046	503	3738
F02MA	4.00 - 5.00	ND<0.49	460	U4.17	2141201	706046	504	3739
F02RA	0.00 - 2.00	1.3	7400	U4.18	2141527	706031	200	3740
F02RA	2.00 - 4.00	ND<0.07	6900	U4.18	2141527	706031	201	3741
F02RA	4.00 - 6.00	ND<0.11	4200	U4.18	2141527	706031	202	3742
F02RA	6.00 - 8.00	ND<0.08	510	U4.18	2141527	706031	203	3743
F02RA	8.00 - 8.80	ND<0.12	320	U4.18	2141527	706031	204	3744
F03MA	0.00 - 1.00	ND<0.12	400	U5.27	2143397	711329	500	3750
F03MA	1.00 - 2.00	ND<0.23	24	U5.27	2143397	711329	501	3751
F03MA	2.00 - 3.00	ND<0.04	21	U5.27	2143397	711329	502	3752
F03MA	3.00 - 4.00	ND<0.12	24	U5.27	2143397	711329	503	3753
F03MA	4.00 - 5.00	ND<0.45	58	U5.27	2143397	711329	504	3754
F03RA	0.00 - 2.00	4.8	9200	U5.27	2143603	711261	200	3755
F03RA	2.00 - 4.00	ND<0.08	3200	U5.27	2143603	711261	201	3756
F03RA	4.00 - 6.00	ND<0.08	6500	U5.27	2143603	711261	202	3757
F03RA	6.00 - 8.00	ND<0.06	6700	U5.27	2143603	711261	203	3758
F03RA	8.00 - 10.00	ND<0.11	24	U5.27	2143603	711261	204	3759
F04MA	0.00 - 1.00	1.5	.	U6.47	2146156	716816	500	3765

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047629

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

FAR UPSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
F04MA	1.00 - 2.00	2.0	.	U6.47*	2146156	716816	501	3766
F04MA	2.00 - 3.00	ND<0.08	.	U6.47	2146156	716816	502	3767
F04MA	3.00 - 4.00	ND<0.13	.	U6.47	2146156	716816	503	3768
F04MA	4.00 - 5.00	ND<0.03	.	U6.47	2146156	716816	504	3769
F04RA	0.00 - 2.00	2.6	.	U6.46	2146353	716827	200	3770
F04RA	2.00 - 4.00	ND<0.29	.	U6.46	2146353	716827	201	3771
F05MA	0.00 - 1.00	ND<0.21	.	U7.89	2147258	723751	500	3780
F05MA	1.00 - 2.00	ND<0.15	.	U7.89	2147258	723751	501	3781
F05MA	2.00 - 3.00	ND<0.09	.	U7.89	2147258	723751	502	3782
F05MA	3.00 - 4.00	ND<0.1	.	U7.89	2147258	723751	503	3783
F05MA	4.00 - 5.00	ND<0.06	.	U7.89	2147258	723751	504	3784
F05RA	0.00 - 2.00	9.3	.	U7.87	2147235	723546	200	3785
F05RA	2.00 - 4.00	ND<0.13	.	U7.87	2147235	723546	201	3786
F05RA	4.00 - 6.00	ND<0.06	.	U7.87	2147235	723546	202	3787
F05RA	6.00 - 8.00	ND<0.39	.	U7.87	2147235	723546	203	3788
F05RA	8.00 - 10.00	ND<0.24	.	U7.87	2147235	723546	204	3789
F06MA	0.00 - 1.00	ND<0.2	270	U8.58	2150261	725482	500	3795
F06MA	1.00 - 2.00	ND<0.38	460	U8.58	2150261	725482	501	3796
F06MA	2.00 - 3.00	ND<0.34	300	U8.58	2150261	725482	502	3797
F06MA	3.00 - 4.00	ND<0.29	24	U8.58	2150261	725482	503	3798
F06MA	4.00 - 4.50	ND<0.14	186	U8.58	2150261	725482	504	3799
F06RA	0.00 - 2.00	ND<0.13	5000	U8.59	2150405	725521	200	3800
F06RA	2.00 - 4.00	ND<0.15	5500	U8.59	2150405	725521	201	3801
F06RA	4.00 - 6.00	0.08	2600	U8.59	2150405	725521	202	3802
F06RA	6.00 - 8.00	ND<0.15	2400	U8.59	2150405	725521	203	3803
F06RA	8.00 - 8.50	0.09	530	U8.59	2150405	725521	204	3804
F07LA	0.00 - 2.00	2.2	21000	U9.37	2150416	729382	200	3815
F07LA	2.00 - 4.00	4.0	14000	U9.37	2150416	729382	201	3816
F07LA	4.00 - 6.00	ND<0.62	13000	U9.37	2150416	729382	202	3817
F07LA	6.00 - 8.00	ND<0.38	9200	U9.37	2150416	729382	203	3818
F07LA	8.00 - 10.00	ND<0.27	8700	U9.37	2150416	729382	204	3819

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047630

TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

FAR UPSTREAM REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
F07MA	0.00 - 1.00	0.57	270	U9.39*	2150510	729540	500	3810
F07MA	1.00 - 2.00	ND<0.54	350	U9.39	2150510	729540	501	3811
F07MA	2.00 - 3.00	ND<0.46	50	U9.39	2150510	729540	502	3812
F07MA	3.00 - 4.00	ND<0.59	520	U9.39	2150510	729540	503	3813
F07MA	4.00 - 5.00	ND<0.07	220	U9.39	2150510	729540	504	3814
F08MA	0.00 - 1.00	ND<0.13	.	U10.48	2151159	735038	500	3825
F08MA	1.00 - 2.00	ND<0.00	.	U10.48	2151159	735038	501	3826
F08MA	2.00 - 3.00	ND<0.41	.	U10.48	2151159	735038	502	3827
F08MA	3.00 - 4.00	ND<0.19	.	U10.48	2151159	735038	503	3828
F08MA	4.00 - 5.00	ND<0.4	.	U10.48	2151159	735038	504	3829
F08RA	0.00 - 1.00	ND<0.22	.	U10.48	2151348	735011	200	3830
F08RA	2.00 - 2.20	ND<0.2	.	U10.48	2151348	735011	201	3831
F65LB	0.00 - 2.00	ND<0.71	9600	U8.83	2150546	726749	200	3986
F65LB	2.00 - 2.40	ND<0.14	3700	U8.83	2150546	726749	201	3987
F65LD	0.00 - 2.00	ND<0.37	3800	U8.96	2150716	727459	200	4006
F65LD	2.00 - 4.00	ND<0.19	4700	U8.96	2150716	727459	201	4007
F65LD	4.00 - 4.70	ND<0.03	210	U8.96	2150716	727459	202	4008

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

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TABLE 5-1 (CONT.)
PASSAIC RIVER SEDIMENT SAMPLES
ANALYSES AS OF 15JAN86

CONTROL REACH

LOCATION	DEPTH RANGE IN FEET	DIOXIN PPB	TOC PPM	MILES FROM SITE	MAP EAST	MAP NORTH	DEPTH CODE	SAMPLE
C01LA	0.00 - 2.00	ND<0.1	11000	U14.69*	.	.	200	3680
C01LA	2.00 - 4.00	ND<0.09	11000	U14.69	.	.	201	3681
C01LA	4.00 - 6.00	ND<0.42	26000	U14.69	.	.	202	3682
C01LA	6.00 - 6.50	ND<0.06	18000	U14.69	.	.	203	3683
C01MA	0.00 - 2.00	ND<0.11	10000	U14.36	.	.	200	3670
C01MA	2.00 - 4.00	ND<0.12	19000	U14.36	.	.	201	3671
C01MA	4.00 - 6.00	ND<0.29	21000	U14.36	.	.	202	3672
C01MA	6.00 - 6.75	ND<0.6	15000	U14.36	.	.	203	3673

* D/U REFERENCE DOWNSTREAM/UPSTREAM DIRECTION FROM POINT 0.0

DEP\DA0047632

Table 5-2. Lead, TCDD, TOC, and Sediment Grain-size Distribution for Selected Passaic River Sediments

Location	Sample	Depth Code	Depth Range (feet)	Lead (ppm)	TCDD (ppb)	TOC (ppm)	Sand Percent	Silt Percent	Clay Percent
S01L	3299	200	0 - 2	490.0	ND<0.83	11,000	8 - 15	69 - 80	12 - 16
S01L	3300	201	2 - 4	480.0	30.9	13,000	6	68	26
S01L	3301	202	4 - 6	520.0	162	13,000	8	61	31
S01L	3302	203	6 - 8	450.0	508	14,000	10	78	12
S01L	3303	204	8 - 10	550.0	184	13,000	6	72	22
S01L	3304	205	10 - 12	830.0	ND<1.3	.	.	.	.
S01L	3305	206	12 - 14	460.0	ND<0.17	.	.	.	.
S01L	3306	207	14 - 16	0.1	ND<0.12	.	.	.	.
S01L	3307	208	16 - 18	2.6	ND<0.4	.	.	.	.
S11L	3309	200	0 - 2	410.0	1.8	9,500	13 - 18	67 - 75	12 - 1
S11L	3310	201	2 - 4	340.0	2.7	11,000	7	57	36
S11L	3311	202	4 - 6	390.0	65.0	12,000	4	56	40
S11L	3312	203	6 - 8	580.0	ND<0.45	12,000	11	61	28
S11L	3313	204	8 - 10	440.0	ND<0.38	9,100	9	53	38
S11L	3314	205	10 - 12	320.0	ND<0.16	.	.	.	.
S11L	3315	206	12 - 14	360.0	ND<0.72	.	.	.	.
S11L	3316	207	14 - 16	670.0	ND<0.55	.	.	.	.
S11L	3317	208	16 - 18	50.0	ND<0.1	.	.	.	.
S11L	3318	209	18 - 20	0.1	ND<0.42	.	.	.	.

WPR:ds-5

DEP\DA0047633

FIGURES

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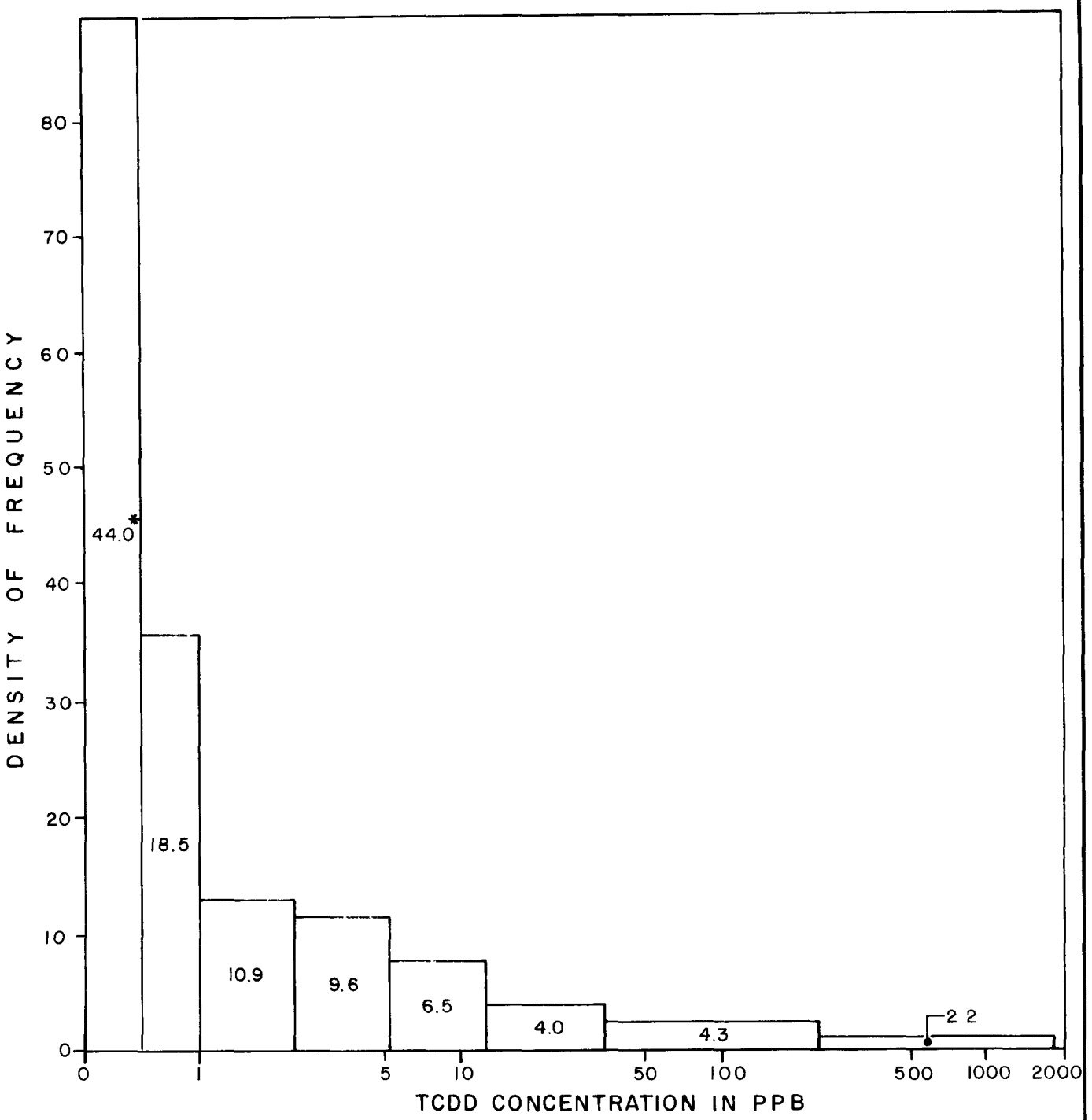

FIGURE 5-1

NOTES:

1. (*) INDICATES RELATIVE FREQUENCY OF OCCURRENCE.
2. ALL REFERENCES TO TCDD ARE SPECIFICALLY 2, 3, 7, 8 – TETRACHLORODIBENZO-P-DIOXIN
3. TCDD CONCENTRATION SCALE IS LOGARITHMIC

DISTRIBUTION OF OBSERVED TCDD CONCENTRATIONS

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DALLAS, TEXAS

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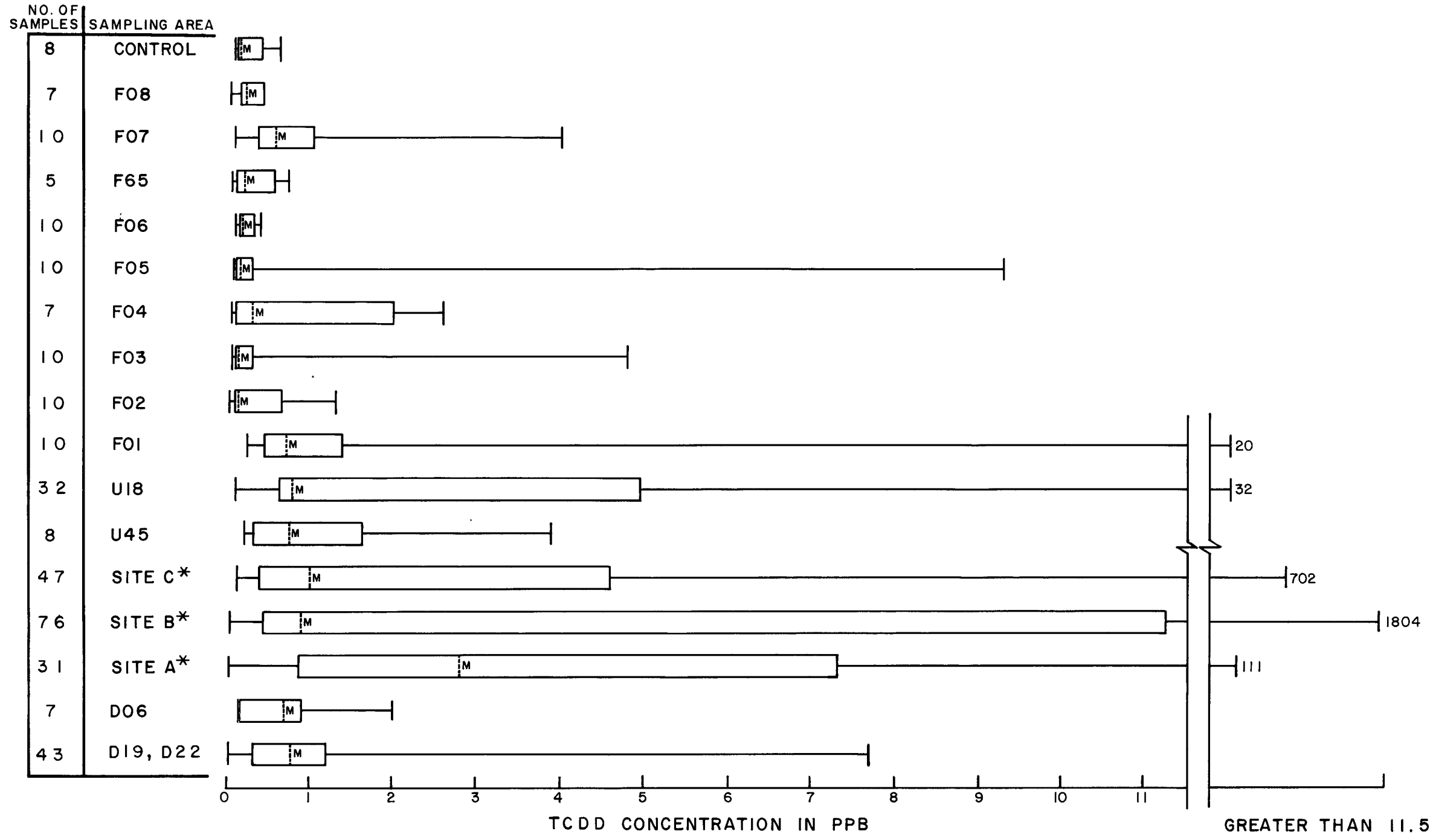

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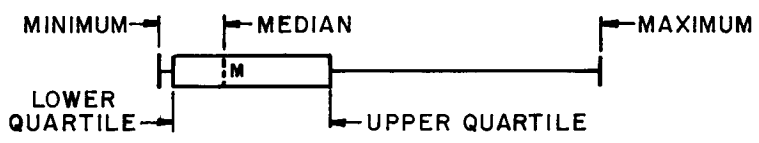

NOTES:

*1. SUBDIVISION OF SITE REACH, (SITE "A" E 2,148,000 TO E 2,149,000, SITE "B" E 2,147,000 TO E 2,148,000, SITE "C" E 2,145,950 TO E 2,147,000) FOR LOCATION, SEE FIGURE 2-2

2. ALL REFERENCES TO TCDD ARE SPECIFICALLY 2,3,7,8 – TETRACHLORODIBENZO – P – DIOXIN

3. FOR LOCATION OF SAMPLING AREAS, SEE FIGURE 2-1

FIGURE 5-2

TCDD CONCENTRATIONS BY SAMPLING AREAS

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DRAWN BY

GARFIELD
WALLINGTON
CLIFTON
PASSAIC
RUTHERFORD
NUTLEY
LYNDHURST
NORTH ARLINGTON
BELLEVILLE
ARLINGTON
KEARNY
KEARNY POINT
HARRISON
NEWARK
JERSEY CITY

CONTROL REACH

FAR UPSTREAM REACH

DOWNSTREAM REACH

SITE AREA REACH

PASSAIC RIVER

HACKENSACK RIVER

GARDEN STATE PARKWAY

OUTWATER LANE

CONRAIL

MONROE STREET

PASSAIC STREET

EIGHTH STREET

SECOND STREET

WALLINGTON AVENUE

MAIN STREET

UNION AVENUE

RUTHERFORD AVENUE

RT 3

KINGSLAND AVENUE

PARK AVENUE

RUTGERS STREET

BELLEVILLE TURNPIKE

CLAY STREET

HARRISON AVENUE

JACKSON STREET

S. 4TH STREET

CENTER STREET

WM. STICKEL MEMORIAL BRIDGE

NASSAU STREET

GENERAL PULASKI SKYWAY

COMMUNIPAW AVENUE

LINCOLN HIGHWAY

NEW JERSEY TURNPIKE

80 & 120 LISTER AVENUE

NEWARK BAY BRIDGE

HUDSON COUNTY / ESSEX COUNTY

ESSEX COUNTY / HUDSON COUNTY

HARRIS COUNTY / ESSEX COUNTY

BERGEN COUNTY / HUDSON COUNTY

BERGEN COUNTY / ESSEX COUNTY

ORANGE COUNTY / ESSEX COUNTY

RED BANK QUAD

WEEHAWKEN QUAD

ORANGE QUAD

ELIZABETH QUAD

MILE U-14.0

MILE U-13.0

MILE U-12.0

MILE U-11.0

MILE U-10.0

MILE U-9.0

MILE U-8.0

MILE U-7.0

MILE U-6.0

MILE U-5.0

MILE U-4.0

MILE U-3.0

MILE U-2.0

MILE U-1.0

MILE 0.0

MILE D-1.0

MILE D-2.0

F01MA

F01RA

F02MA

F02RA

F03MA

F03RA

F04MA

F04RA

F05MA

F05RA

F06MA

F06RA

F07MA

F07RA

F07L

F08M

F08RA

F09MA

F09RA

F10MA

F10RA

F65L(A,B,C,D)

COIM(A,B)

COIL(A,B)

DUNDEE DAM

DUNDEE LAKE

U8L(A,B,C,D,E,F)

U8M(A,B,C,D)

U45L(A,B,C,D)

U45R(A,B,C,D)

D65L(A,B,C,D)

D65R(A,B,C,D)

D6R(A,B,C,D)

D9R(A,B,C,D)

D9M(A,B,C,D)

D22R(A,B,C,D)

D22M(A,B,C,D)

D22L(A,B,C,D)

LEGEND:

BRIDGE

F01MA SAMPLE DESIGNATION

MILE U-7.0 (UPSTREAM) MILE D-2.0 (DOWNSTREAM) MILE MARKER DESIGNATION

F07LA ≥ 1 ppb

F05RA < 1 ppb

REFERENCE:
7.5 MINUTE USGS TOPOGRAPHIC MAPS OF PATERSON, N.J., ORANGE, N.J., HACKENSACK, N.J., WEEHAWKEN, N.J.-N.Y., ELIZABETH, N.J.-N.Y. AND JERSEY CITY, N.J.-N.Y. QUADRANGLES, DATED: 1958 (PR 1981), 1965 (PR 1970), 1935 (PR 1981), 1967, 1967 (PR 1981), 1967 (PR 1981), SCALE: 1"=2000'

SCALE
0 2000 4000 6000 FEET

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FIGURE 5-4

OCCURRENCE OF TCDD GREATER THAN 1 PPB 2-10 FEET DEPTH PASSAIC RIVER SEDIMENTS

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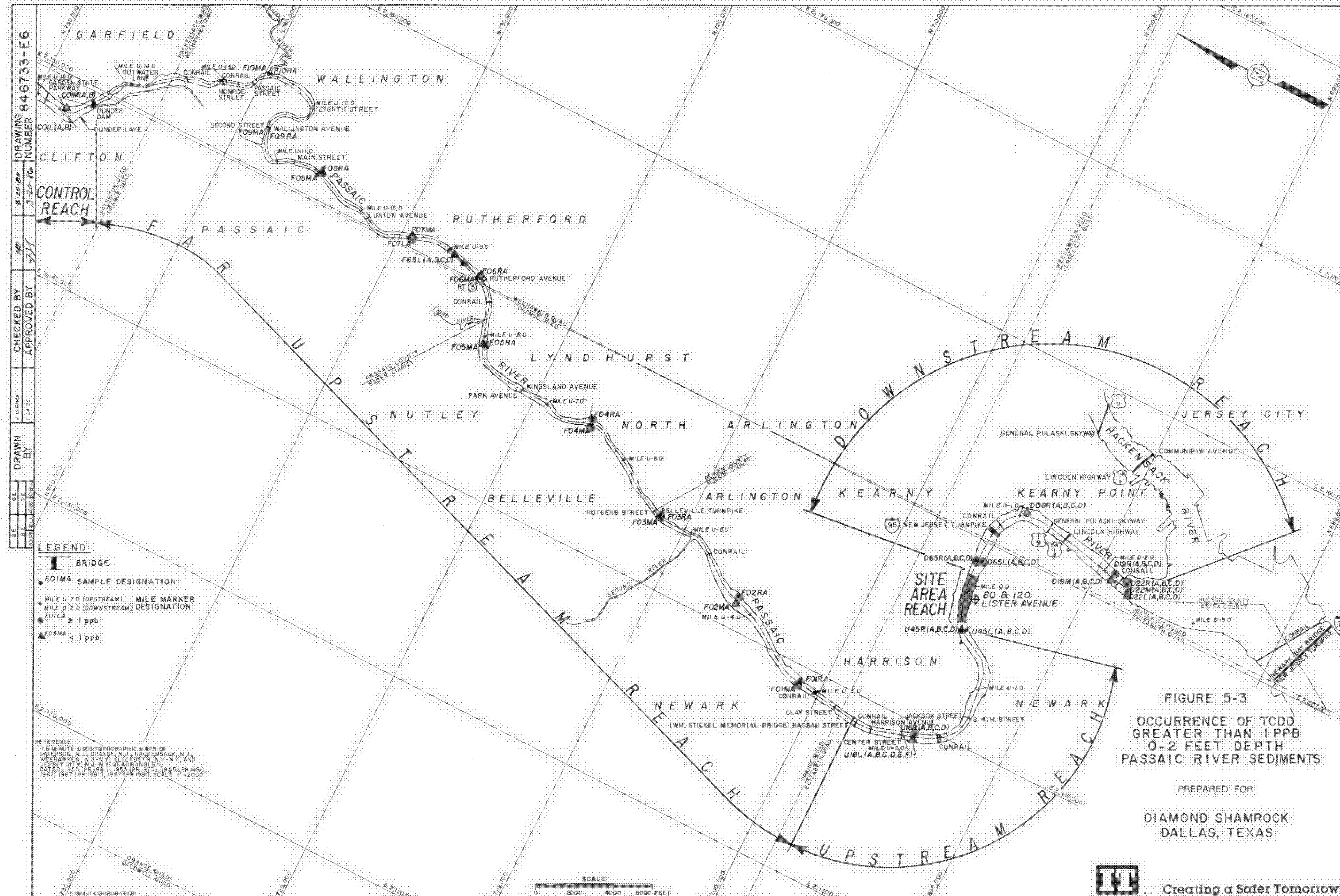

FIGURE 5-3

OCCURRENCE OF TCDD GREATER THAN 1 PPB 0-2 FEET DEPTH PASSAIC RIVER SEDIMENTS

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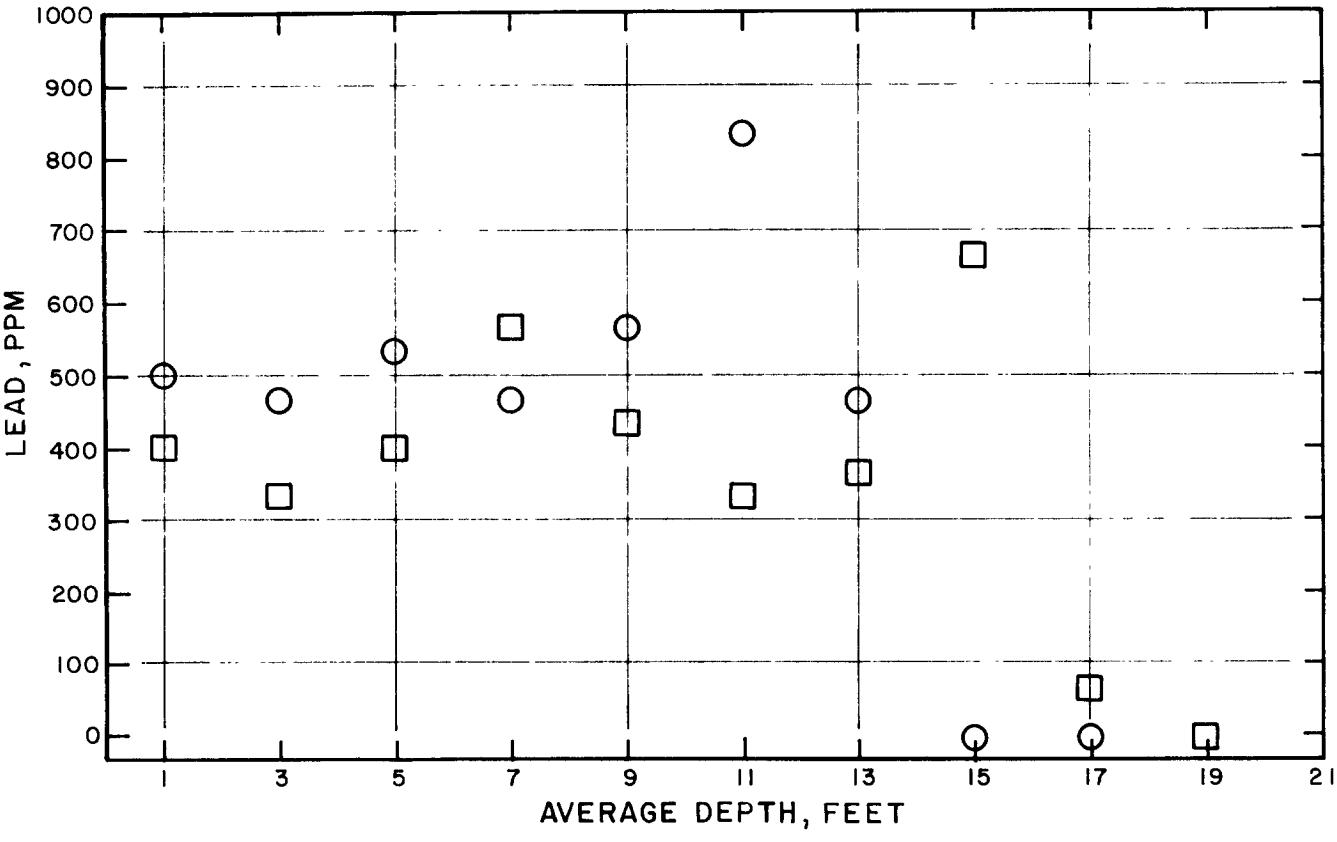

LEGEND:

- ○ BORING S01L
- □ BORING S11L

NOTE:

FOR LOCATION OF BORINGS, SEE FIGURE 2-2

FIGURE 5-5

PASSAIC RIVER SEDIMENT
LEAD TRACER STUDY
LEAD VS. DEPTH BY BORING

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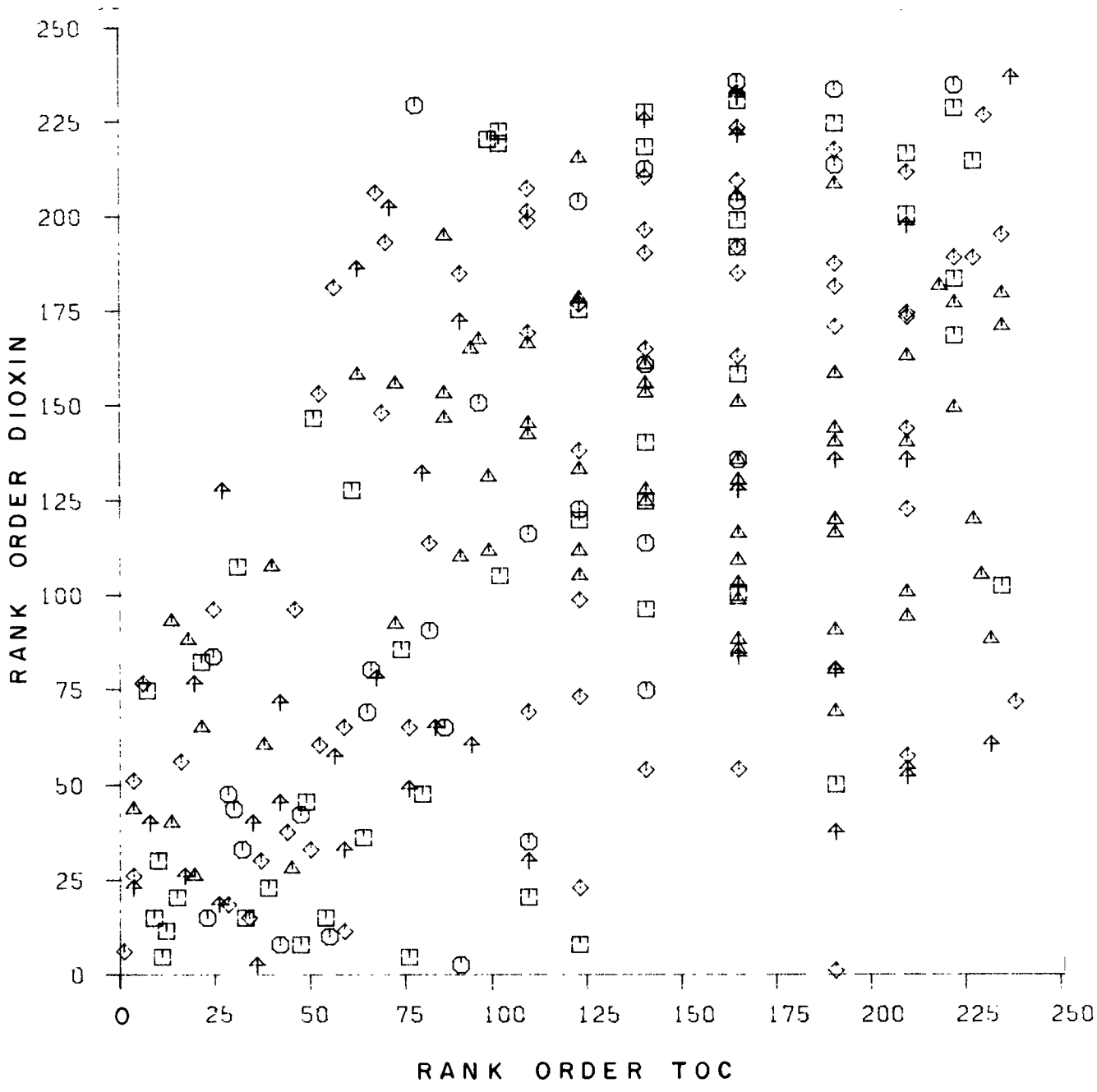

LEGEND:

- 0-2 FEET
- 2-4 FEET
- 4-6 FEET
- 6-8 FEET
- 8-10 FEET

NOTES:
1. ALL REFERENCES TO TCDD ARE SPECIFICALLY 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN.
2. TOC = TOTAL ORGANIC CARBON

FIGURE 5-6

RANK CORRELATION TOC
VS
TCDD BY DEPTH

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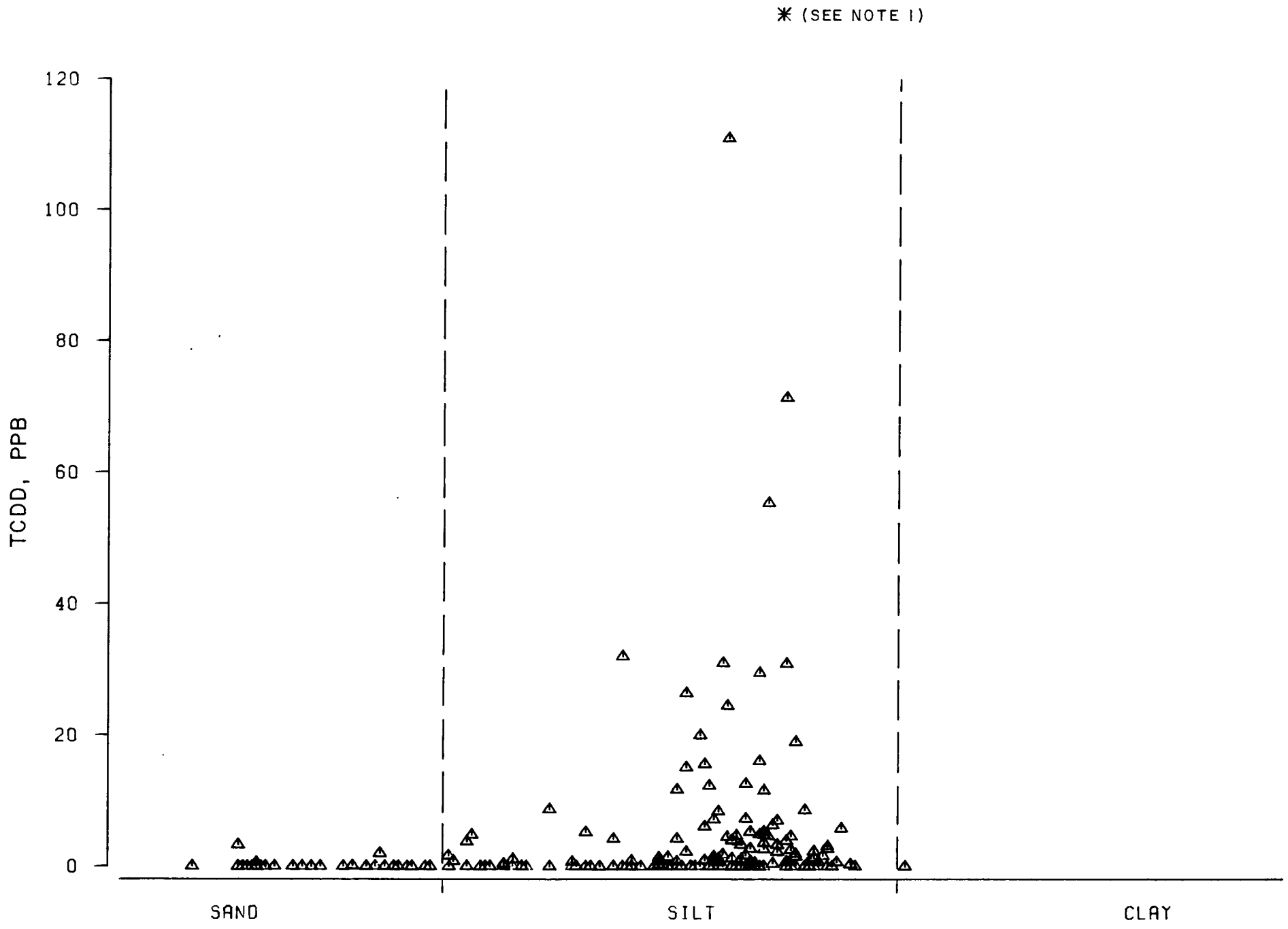

NOTES:

1. THREE OBSERVED TCDD CONCENTRATIONS ARE GREATER THAN 120 PPB. THESE CONCENTRATIONS ARE 561, 916 AND 1804 PPB.
2. ALL REFERENCES TO TCDD ARE SPECIFICALLY 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN.

FIGURE 5-7

SCATTER DIAGRAM
TCDD CONCENTRATION BY
SEDIMENT SIZE CLASSIFICATION

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6.0

6.0 STATISTICAL ANALYSES OF DIOXIN SPATIAL DISTRIBUTION IN SEDIMENTS

An initial statistical analysis of the results of the dioxin sampling program indicated that the distribution of dioxin could not be strictly correlated with the physical characteristics of the river which governed selection of the sampling locations. These characteristics included:

- Position relative to the 80 Lister Avenue site (upstream and downstream)
- Dredging history of the reach
- Local deposition rates.

Nonparametric geostatistical analyses place the data in perspective with regard to the relationship between adjacent sampling points, the characteristics of the river, and the history of chemical production at the 80 Lister Avenue plant. Appendix G contains supporting information for this section.

6.1 METHODS

Because of the large variation in measured dioxin concentrations exhibited in small zones of sediment, it is necessary to use nonparametric geostatistical techniques in making inferences regarding the spatial distribution of dioxin in the sediments of the Passaic River. These techniques, commonly identified as indicator Kriging, not only permit geostatistical estimation of the spatial distribution of concentration in situations with such data variability, but also permit the use of semiquantified data such as measurements reported as below the limit of detection. This approach to the estimation of spatial distributions has been employed in the mineral industry to estimate local recoverable ore reserves. Conceptually, this estimation technique entails the selection of mining units where the average ore grade is above a selected cutoff (Journel, 1983). Since the estimated spatial distribution of mining unit grades does not facilitate reliable selection of mining units, the local distribution of the mining unit grades is estimated. The distribution pattern of dioxin in Passaic River sediments presents an environmental circumstance similar to that of minable ores, making indicator Kriging the analytical method of choice.

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The statistical analyses are described in detail in Appendix G. In brief, all of the dioxin concentrations measured in the Passaic River were rank ordered from low to high and their relative ranks computed to provide the cumulative distribution of dioxin concentrations conditional on the data. This sample distribution was then segmented by the selection of indicator concentrations or cutpoints as illustrated in Figures 6-1 through 6-4. Note from these figures that large changes in dioxin concentrations in the high ranges translate to very small changes in cumulative frequency of occurrence.

The indicator concentrations chosen for the Passaic River sediments are given in Table 6-1. For each of the ten indicator concentrations, an indicator variable was given a value of one if the measured concentration was less than or equal to the indicator and a value of zero otherwise. This permits incorporation of concentrations reported as not detectable into the analysis. Of the 323 measurements available for this analysis, 174, or roughly half, were reported as less than the limit of detection.

The spatial similarity among the indicator data were estimated in three dimensions using the geostatistical tool known as the variogram. The basic concept underlying geostatistical principals is that of spatial correlation. Simply stated, this concept means that a positive correlation exists between the distance separating two samples and their physical/chemical characteristics, i.e., the closer they are, the more alike they tend to be. The variogram is a tool which describes this correlation as a function of distance. The statistical measure used to quantify the correlation is the variance, which calculates the degree of variability within a data set. The variogram usually is presented in the form of graph showing the variance between all pairs of points in the data set that are a given distance apart (see Appendix G). Assuming that spatial correlation exists, the smaller the distance between samples the less variation. The variation grows with increasing distance until a point known as the range is reached. At this distance and beyond, spatial correlation no longer exists; therefore, the variance between samples also stops increasing and becomes constant. The variance value at the range is called "the sill" of the variogram.

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Variogram models are usually directionally dependent as well. In the present case, variogram models of the relationship between observation locations were constructed along the direction of river flow, the cross river direction, and in the vertical direction with depth (Appendix G). The three directional variograms for each indicator variable describe a variogram model for that variable.

Each of the resulting ten variogram models was validated by employing the model to predict the observed data. This was accomplished by using the "jack-knife" technique of removing each datum one at a time and using the model to predict the removed datum. The variogram models which minimized the sum of squared differences between predicted and observed indicator values were used for characterization of the cumulative distribution function of dioxin in each river reach. This characterization was performed by obtaining Kriged estimates of the probability that an indicator concentration would not be exceeded at each node of a 100- by 100- by 2-foot grid system for each of the ten indicators. The grid spacing was chosen based upon the reasoning that all measured concentrations could be characterized as representing composites of 2-foot increments of core samples, and that very few borings were made within 100 feet of each other. The details of the variogram models and subsequent estimation are presented in Appendix G of this report.

The probability estimates for each grid node are estimates of the cumulative distribution function of dioxin concentrations conditioned on the observed data. They are data value dependent, and therefore estimates of concentration may be obtained from this distribution function. In addition, all such estimates are probability qualified.

6.2 DISCUSSION

The spatial distribution of dioxin was estimated for the site-area reach using the variogram models derived as described above. Figure 6-5 presents this spatial distribution for the upper 2 feet of sediments, in terms of isopleths of the probability that a dioxin concentration in excess of 1 ppb will occur. Isopleths corresponding to probabilities of 0.75 and 0.90 are shown in this figure. An area circumscribed by a 0.75 probability isopleth will have at least a 75 percent chance of having dioxin concentrations in excess of

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1 ppb. Similarly, an area circumscribed by a 0.90 probability isopleth will have at least a 90 percent chance of having dioxin concentrations in excess of 1 ppb.

In addition to providing a more complete picture of the spatial distribution of dioxin in the river sediments than that supplied by the analytical data, these evaluations permit several general conclusions to be drawn. Where dioxin is found in the sediments, it is relatively confined. Concentrations in the range of 1 ppb are predicted to be confined to areas 500 feet in the flow direction by 250 feet in the cross-river direction and approximately 6 feet in depth. Higher concentrations are predicted to exist in more confined areas of 200 to 250 feet in the flow and cross-river directions. The highest concentrations are predicted to be confined to areas 250 feet in the flow direction by 50 feet in the cross-river direction and 2 feet in depth. Thus, for the distribution of dioxin concentrations, layering is quite evident.

The distribution of dioxin over depth near the 80 Lister Avenue site suggests a correspondence with the pattern of runoff and process sewer discharge into the river during the years of plant operation. New sediments were deposited over the native sediments after the sewer line was closed. By using known deposition rates in the area as developed in Chapter 3.0, the period of dioxin deposition can be estimated. Assuming a deposition rate of 0.06 to 0.28 foot per year for the area adjacent to the site, it is estimated that this spot was deposited between 11 and 33 years ago. This translates to a time frame between 1952 and 1974, roughly corresponding to the period of plant operation.

There is evidence that suggests a discontinuity in the distribution of dioxin along the length of the lower Passaic River such that dioxin detected in the far-upstream reach may be from a different source or sources than that downstream near 80 Lister Avenue. Figure 6-6 presents the median, 75th percentile, and maximum of the expected concentrations within each sampling area as a function of distance. Note from this figure that though dioxin concentrations are predicted in the sediments of sampling area F07 (9.4 miles upstream of the site), none are predicted in the areas above and below F07. Note also from Figure 6-6 that dioxin concentrations tend to decrease with increasing depth upstream from Area F03 (5.4 miles from the site). The

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opposite is true below Area F02 (4.2 miles from the site). Because sediment deposition is a continuing process, this suggests that dioxin detected in the upper sediments of areas upstream of F02, as with dioxin in the upper sediments in all of the reaches, may be of recent origin.

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TABLES

Table 6-1. Passaic River Indicator Concentrations

Indicator	Dioxin Concentration (ppb)	Probability (in Percent) of Concentration Less Than Indicator
I1	0.40	32.5
I2	0.78	55.1
I3	0.88	60.1
I4	1.0	63.2
I5	1.4	68.1
I6	2.3	74.0
I7	5.3	83.6
I8	12.5	89.5
I9	35.50	93.5
I10	232.0	97.8

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FIGURES

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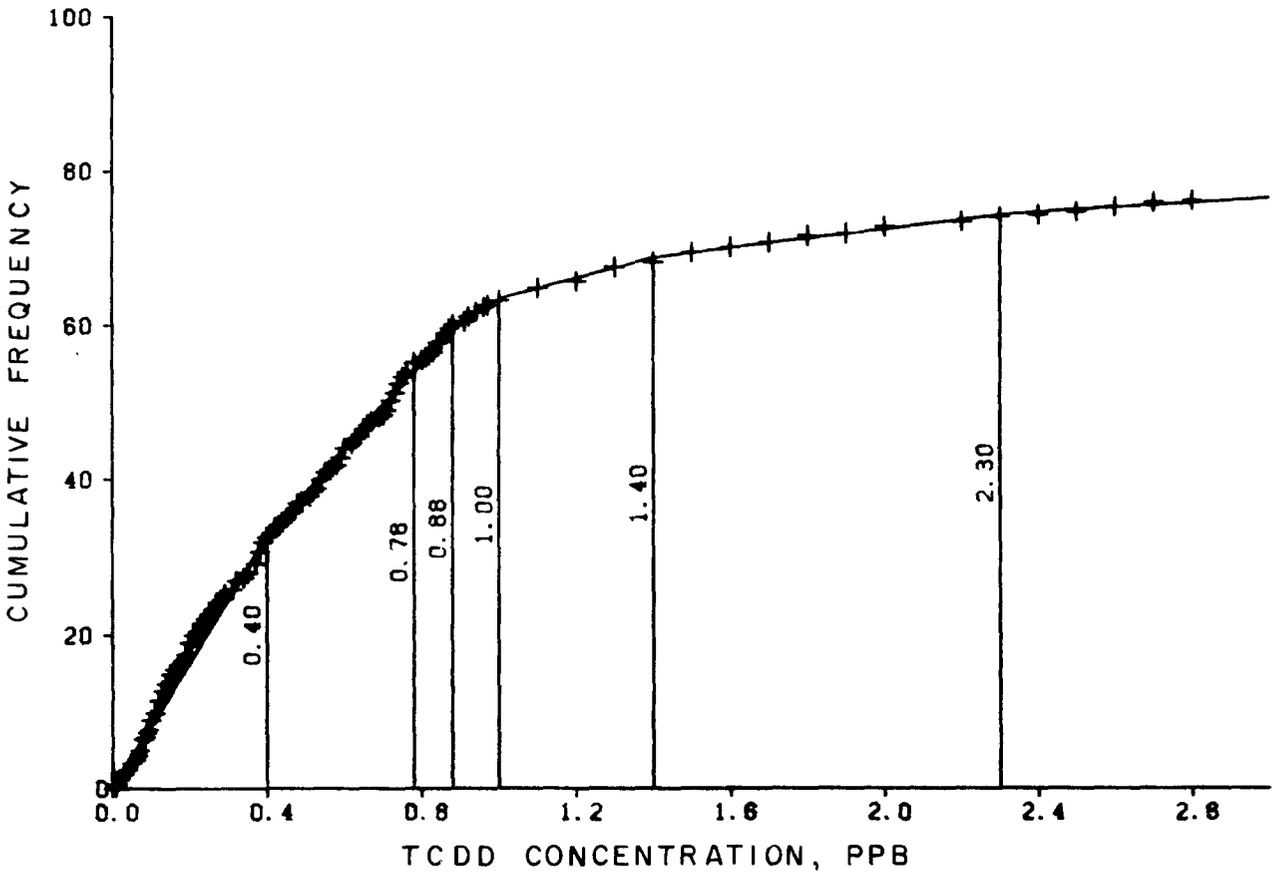

FIGURE 6-1

PASSAIC RIVER SEDIMENTS
CUMULATIVE DISTRIBUTION CUT POINTS
TCDD CONCENTRATION RANGE
0.0-3.0 PPB

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NOTES:

1. ALL REFERENCES TO TCDD ARE SPECIFICALLY 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN.
2. TCDD VALUES INCLUDE ALL SEDIMENT SAMPLES ANALYZED FOR THIS STUDY.

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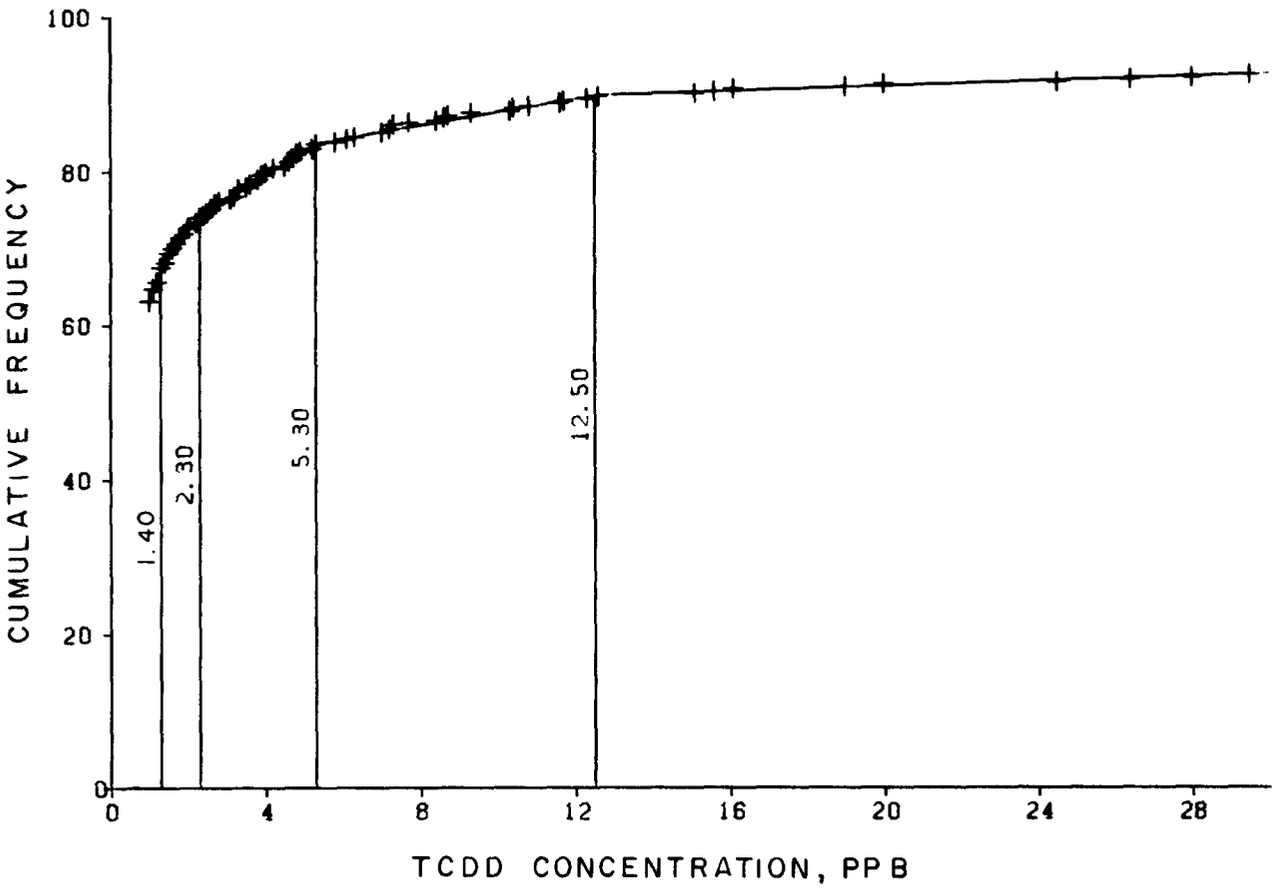

FIGURE 6-2

PASSAIC RIVER SEDIMENTS
CUMULATIVE DISTRIBUTION CUT POINTS
TCDD CONCENTRATION RANGE
1.0-30.0 PPB

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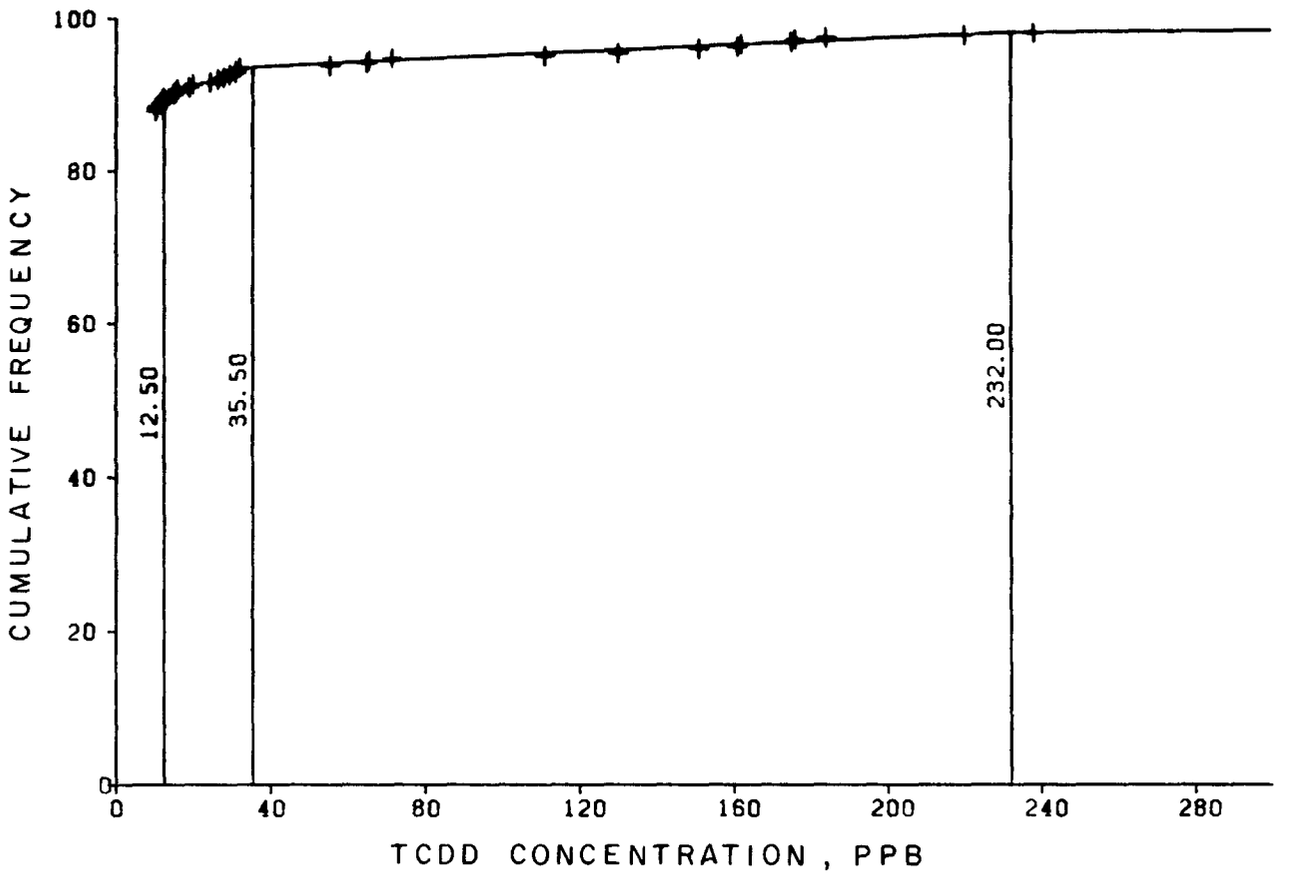

FIGURE 6-3

PASSAIC RIVER SEDIMENTS
CUMULATIVE DISTRIBUTION CUT POINTS
TCDD CONCENTRATION RANGE
10.0-300.0 PPB

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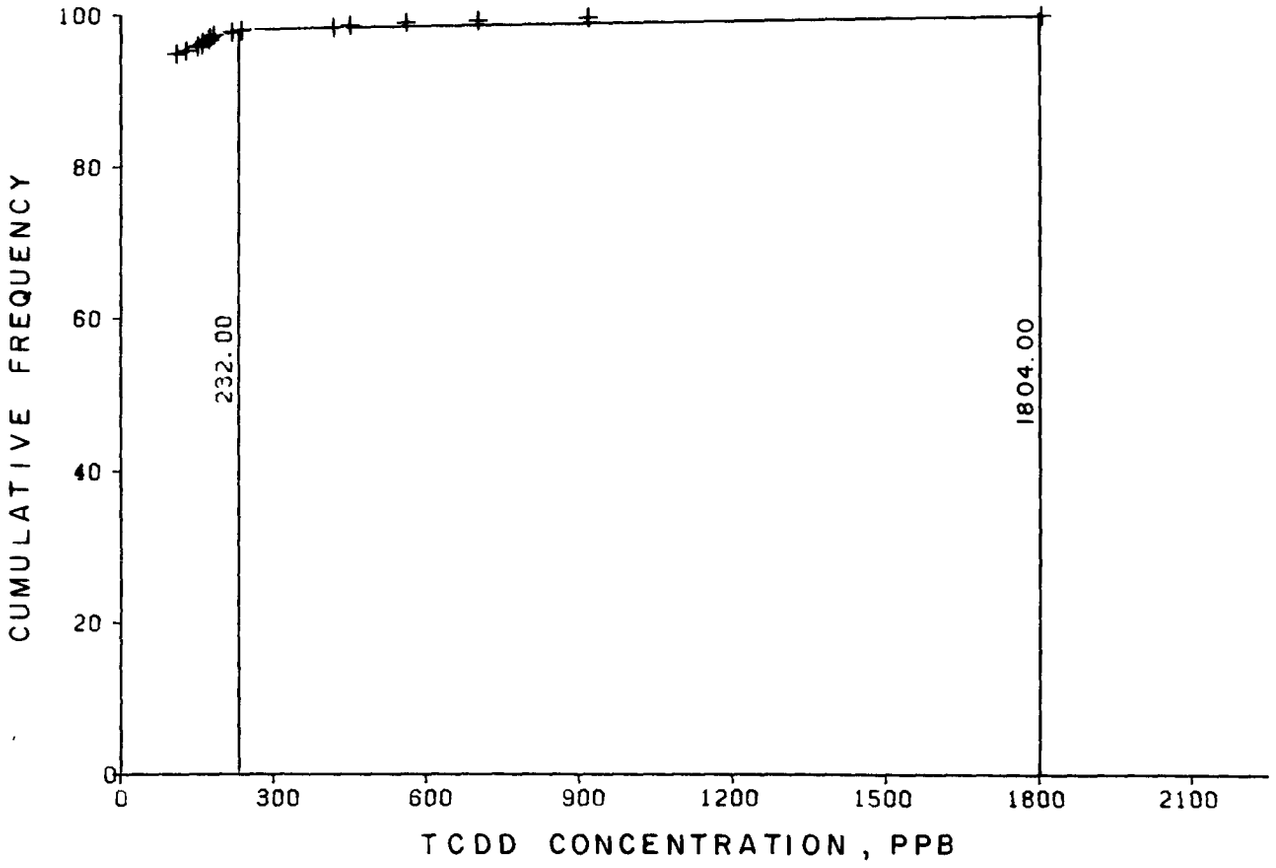

FIGURE 6-4

PASSAIC RIVER SEDIMENTS
CUMULATIVE DISTRIBUTION CUT POINTS
TCDD CONCENTRATION RANGE
100.0-1804.0 PPB

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NOTES:

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E. 2,146,000 | E. 2,147,000 | E. 2,148,000

N 696,000

N. 695,000

SITE-AREA REACH

D65R

D65L

S42RA | S32MA | S43RA | S33MA | S23MA | S22MA | S13LA | S12LA | S11LA | S10LA | S14LA | S24LA | S44LA | S34LA | S31LA | S21LA | S41LA

PASSAIC RIVER

FLOW

MILE 0.0

0.25 | 0.50 | 0.75 | 0.90

B | C | D

LISTER AVENUE

NOTE:
ALL REFERENCES TO TCDD ARE SPECIFICALLY 2, 3, 7, 8- TETRACHLORODIBENZO-P-DIOXIN.

SCALE
0 200 400 FEET

FIGURE 6-5

PROBABILITY ISOPLETHS FOR TCDD CONCENTRATION GREATER THAN 1 PPB, 0-2 FEET DEPTH SITE-AREA REACH
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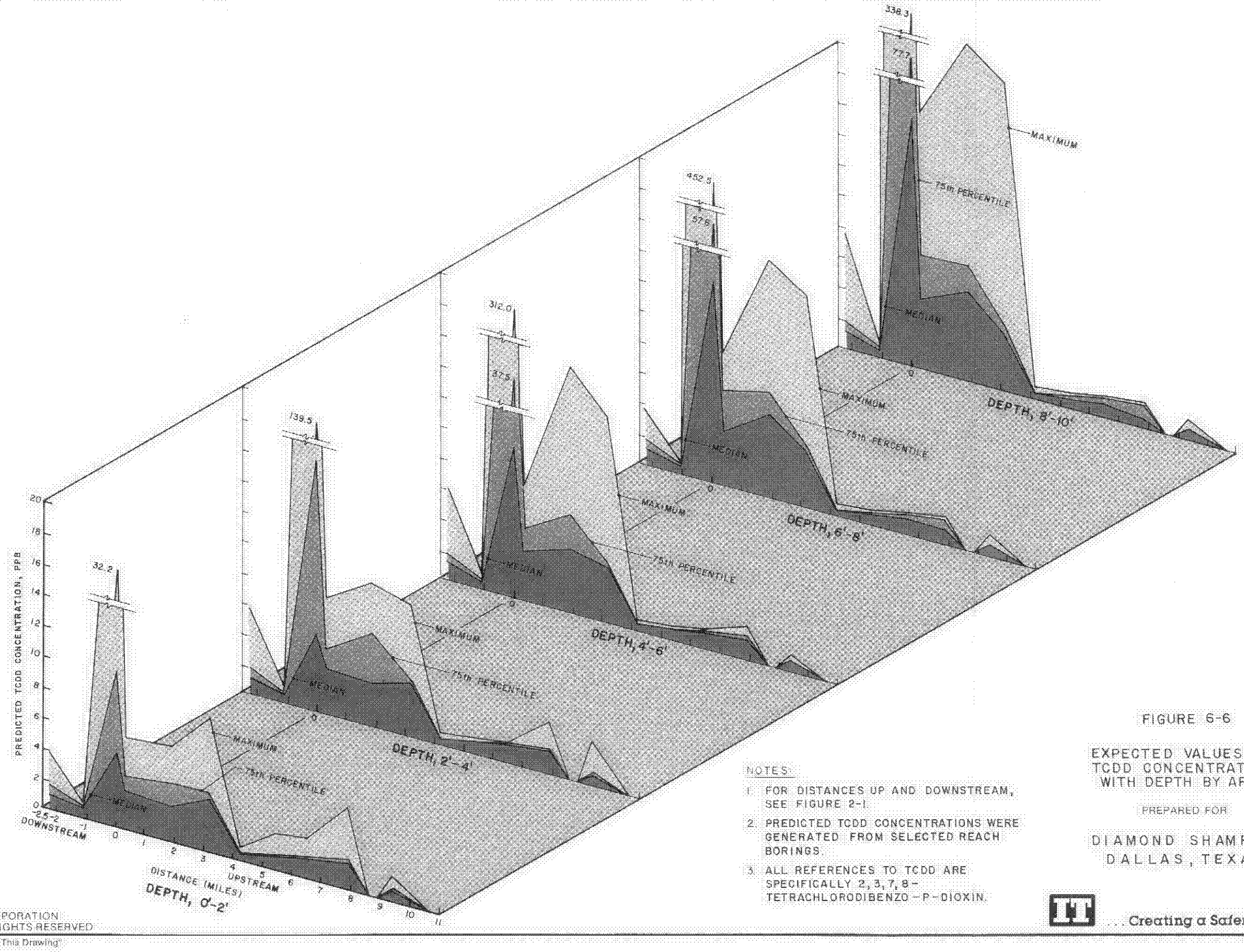

NOTES:

1. FOR DISTANCES UP AND DOWNSTREAM, SEE FIGURE 2-1
2. PREDICTED TCDD CONCENTRATIONS WERE GENERATED FROM SELECTED REACH BORINGS.
3. ALL REFERENCES TO TCDD ARE SPECIFICALLY 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN.

FIGURE 6-6

EXPECTED VALUES OF TCDD CONCENTRATIONS WITH DEPTH BY AREA

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7.0

7.0 RISK ASSESSMENT

The purpose of this assessment is to determine if there exists an immediate and substantial risk to public health or the environment due to presence of 80 Lister Avenue-associated dioxin in sediments of the lower Passaic River. An immediate and substantial risk is defined here as a reasonable likelihood that sufficiently high exposures will occur over the relatively short time frame of several years to cause harm to receptors. For the purposes of this study, potential health effects from acute exposure to the dioxin contaminated sediments are considered. This evaluation includes the consideration that short-term exposures to chemicals may potentially lead to long-term adverse health effects such as cancer.

The scope of the risk assessment is limited to this extent by the existing data base as described in the previous sections of the report. The Passaic River is estuarial, making it a complex ecosystem. The setting is further complicated by intense land development, heavy industrialization, and the fact that dioxin is sediment-associated and has not been detected in the water column. Such complex circumstances limit the objectives of the risk assessment, i.e., that they be kept within the bounds of our current understanding of the Passaic River environment. The stated objectives provide assurance of the appropriate use of present data.

Moreover, characterizing immediate and substantial risks is adequate at the present time and is consistent with the approach given in available USEPA regulatory guidance (Morgan et al., 1984). The objective inherent in that guidance is to determine if prompt mitigation is necessary, or if conditions allow for more thorough evaluation to define the long-term risks and, if necessary, consider options to respond on an informed basis to the overall situation. This risk assessment represents a rational, measured response to the presence of dioxin in an extremely complex environmental setting.

This risk assessment is predominantly qualitative. However, as much as possible and where appropriate, quantitative considerations are discussed to assist in establishing a frame of reference. This assessment is a collective effort with multidisciplinary considerations. Scientific literature on health

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effects is reviewed and integrated with the present understanding of the site-specific conditions to provide an overall perspective. Included is a discussion of the high toxicity of dioxin. However, toxicity does not automatically imply hazard or risk. Hazard depends upon the conditions under which a material is used. Likewise, hazard does not imply risk, for risk is a product of both hazard and the probability of exposure to levels sufficient to elicit adverse health effects. Hence, the exposure factor is crucial.

The basic conclusion is that the presence of 80 Lister Avenue-associated dioxin in the Passaic River does not pose an immediate and substantial risk to the public health and the environment.

7.1 APPROACH

The technical approach to this assessment is made up of three components: a toxicity assessment, an exposure assessment, and a risk evaluation. The toxicity assessment characterizes the nature and severity of dioxin toxicity and quantifies the relationships between the dose of the chemical and the incidence of adverse effects. The exposure assessment identifies actual or potential routes of exposure, characterizes the potentially exposed populations, and estimates the extent of potential exposures. The final component, risk evaluation, is an integration of the first two components into a qualitative characterization of the potential for immediate and substantial adverse health or environmental effects.

7.2 TOXICITY ASSESSMENT

This section does not provide a review of all available toxicology literature on dioxin. Several reviews have been published recently (National Research Council of Canada, 1981; Tucker et al., 1983; Kimbrough et al., 1984). This section offers a brief overview of the highlights of dioxin toxicity in major categories of interest to this risk assessment. An overview of the quantitative dose-response relationships estimated for humans is also provided.

In these discussions, distinction is made between the terms bioconcentration, bioaccumulation, and biomagnification. Bioconcentration refers to uptake of chemical residues through gills or epithelial tissue directly from water.

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Bioaccumulation describes uptake from any dietary source, including but not limited to water. Biomagnification describes the process of an increase in the tissue concentration of bioaccumulated chemical residues as they pass up the food chain through two or more trophic levels.

7.2.1 Dioxin Toxicity to Humans

The only consistently reported toxic effect of dioxin observed among exposed people is chloracne, a serious but reversible skin condition (Esposito et al., 1980; Crow, 1983). Other reported effects include liver function impairment and neurological disorders. Some studies show no observed effects caused by human exposure to dioxin (Royal Commission of Australia, 1985). The existing epidemiologic studies contain a number of significant deficiencies including a lack of dose-response correlations, and may involve multiple chemical exposures (IARC, 1982).

7.2.2 Dioxin Toxicity to Animals

The only dose-response data on dioxin are from animal studies. It is not presently known which animal species most closely approximates human responses, although the closest similarities appear in nonhuman primate studies (Kimbrough et al, 1983). Animal species vary widely in their susceptibility to the toxic effects of dioxin, with lethal dosages ranging from 1 to 5000 µg/kg body weight (Schwatz et al., 1973; Henck et al., 1981). The liver appears to be the primary target organ from repeated sublethal exposure of about 1 µg/kg/week in rats and mice (Kociba et al., 1976; NTP, 1980). Reproductive effects have been observed at about this same dose level. Sufficient evidence exists from long-term studies in rats and mice to classify 2,3,7,8-TCDD as an animal carcinogen (Kociba et al., 1978; NTP, 1982). Doses ranged from about 0.001 µg/kg/day to 0.1 µg/day with significant carcinogenic responses observed in female rats at 0.01 µg/kg/day. The most sensitive animal species and sex is used in making human health risk estimates due to the absence of validated animal models for extrapolation to humans. This is discussed in greater detail in the following section.

7.2.3 Extrapolation from Animals to Man

Due to the regulatory agencies' position on the nonthreshold theory of carcinogenesis, cancer risk estimation for dioxin results in the most

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stringent exposure criteria relative to other health effects. Therefore, by protecting against cancer, protection is afforded for other types of health endpoints.

The Carcinogen Assessment Group (USEPA, 1984) uses a prescribed protocol to evaluate animal data to estimate human cancer potencies. The model utilized is the linearized multistage extrapolation model which provides a mathematical derivation of the dose-response slopes. This model is biased. The scientific community and the USEPA recognize that its use most likely overestimates the actual risk. Deliberate use of this model that is considered biased is a public policy decision of the agency and not a strictly scientific decision. No conclusive evidence exists to validate selection of any of the other models that yield lower estimates of risk. Furthermore, in publishing its slope estimates, the Carcinogen Assessment Group does not base the projections on the line of best fit of the data. Rather, it chooses to use the lower 95 percent confidence interval, which represents the "upper bound" of the risk estimate. This significantly exaggerates the risk related to a given dose or exposure. Also, because the slope estimates are based on animal data, many compounds (e.g., dioxin) which have not been shown to be human carcinogens have higher potency values than those that are known human carcinogens (e.g., vinyl chloride). In other words, the issue of qualitative differences in response between species is completely ignored when deriving potency.

The cancer potency slope for dioxin is reported to be 1.56×10^5 per milligram per kilogram per day $(mg/kg/day)^{-1}$. Kimbrough et al. (1984) utilized the same methodology, the same animal study involving rats, and the same interpretation of the histopathological data to calculate a cancer potency slope that is almost 4.5 times lower (i.e., less potent) at 3.6×10^4 $mg/kg/day^{-1}$. Both of these models were developed using reputable and scientifically valid approaches. The differences reflect the handling of uncertainty factors which govern the extrapolation of animal data to human exposure.

A further consideration in the development of both of these potency slopes was the use of data from female rats only. Although use of all available data could lower the estimated potency values by about 500 times, the current models utilize only the most sensitive animal organ in which the health end

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point is manifested, in this case the female rat liver. This is also a public policy decision. Overall, recommended dioxin exposure limits for people range from 0.03 to about 1 pg/kg body weight per day. This dosage range is 1000 to 30,000 fold lower than the chronic no-observed effect levels observed in the mammalian species tested.

7.2.4 Toxicity to Aquatic Life

Data on various aquatic species suggest that no-effect concentrations in water range from 0.1 to about 200 ppt (Kanaga and Norris, 1983). Significant toxic effects generally occurred at levels of 1 ppt or above. One lifetime study on mosquito fish showed no effect from sediment concentrations ranging from 10-35 ppt. No other study in which sediments were the exposure medium is reported in the literature. Concentrations in various aquatic biota that were estimated to be no-effect levels ranged from 0.1 ppb to 9 ppm for various species including fish, Daphnia, mosquito larvae, and snails. These no-effect level estimates were based on short-term bioconcentration factors from water to organism of 1000 to 7000. Long-term studies that allow estimates of bioconcentration factors have not been conducted to date.

7.3 EXPOSURE ASSESSMENT

The objective of this exposure assessment is to screen the exposure pathways to identify the major potential exposure route to dioxin in the river sediments. Fish and crab exposure followed by human consumption of these edible species is determined to be the major route and is discussed in detail.

7.3.1 Routes of Potential Exposure

The routes of potential exposure to sediment-associated dioxin in the Passaic River are illustrated in Figure 7-1. Analyses of river water samples obtained from the 80 Lister Avenue site area have not shown detectable levels of dioxin at a detection limit of 0.004 ppb (IT, 1985a). Therefore, no quantifiable exposures can be estimated for the water pathways illustrated in the figure. If dioxin were present in the water at concentrations below this detection limit, direct human exposure would be negligible.

The lower Passaic River is not a source of drinking water. Industrial uses exist e.g., cooling water and process water. It is unknown if aerosols of the

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river water containing dioxin are created in the industrial setting, but these types of uses are unlikely for the lower Passaic users due to the high salinity of the water.

Observations made by IT Corporation during river study operations and routine surveillance on weekdays and weekends during the summer months revealed that recreational boating and swimming are extremely limited. Furthermore, fecal coliform measurements on water from the lower Passaic River greatly exceed permissible concentrations for drinking water or swimming (Chapter 2.0). The presence of these bacteria, associated with fecal material, indicates raw sewage contamination; consequently, swimming is banned.

The remaining pathways in Figure 7-1 relate to direct receptor exposure to river sediments. Dioxin associated with 80 Lister Avenue was detected in sediments near that site (Chapters 5.0 and 6.0). However, dioxin was also associated with sediments from areas upstream of the site beyond the zone of tidal influences. As discussed in Chapters 3.0 and 6.0, transport of sediment-associated dioxin is substantially determined by tidal influences. Sediment depths where dioxin was detected also relate to potential transport and exposure. The vast majority of the dioxin detected is below the top 2 feet of sediment in the vicinity of the 80 Lister Avenue site. This area of the river is subject to deposition much more readily than it is to scour. Effectively, the top several feet of sediment serve as a cap that contains the deeper material and precludes it from river transport. In addition, the biologically active zone, as it impacts on aquatic biota, is generally contained within the top 2 feet of sediment. Combined, these factors limit the concern for presence of dioxin to that which is contained in the top 2 feet for the purposes of addressing immediate and substantial risks.

Where dioxin was detected in the top 2 feet of sediment near the 80 Lister Avenue site, the concentrations were in the range of 0.39 to 3.1 ppb. However, not all will be bioavailable for exposure since dioxin tightly adsorbs to organic material in soils and sediments (Kearney et al., 1973; USEPA, 1985). For example, Umbreit et al. (1985) showed that less than 0.05 percent of dioxin contained in 80 Lister Avenue soil was absorbed by rats following oral ingestion. Bioavailability and aquatic biota uptake studies on

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dioxin-containing river sediments have not been conducted. The availability of sediment-associated dioxin for absorption and accumulation by aquatic species will determine if and to what extent the material might bioaccumulate. Estimates for the long-term aquatic bioconcentration factor of dioxin range from about 500 to 100,000 (Neely, 1979; Veith et al., 1980). In other words, certain aquatic species may concentrate dioxin from water into their tissues by the amount of this factor higher than the concentration in water. No data are available for estimates on bioaccumulation of dioxin from sediments. Although the phenomena of bioconcentration and bioaccumulation cannot be quantified for the Passaic River at this time, the potential magnitude of these processes clearly make the human consumption of edible aquatic species the major potential exposure route for consideration in this assessment.

7.3.1.1 Analysis of the Major Potential Exposure Route

Since dioxin was not detected in the river water, the major consideration in the context of short-term exposure is for impacts on those organisms that directly contact sediments and for the consumption of fish and crabs that may have resided for a time in the river reach near 80 Lister Avenue. Historically, the Newark Bay and its drainage basin, including the Passaic River, has supported very little commercial consumables (personal communication from Ruppel, Office of Science and Research, NJDEP, 2 December 1985). All commercial fishing was banned in December 1982 due to presence of polychlorinated biphenyl (PCB) compounds in fish, eels, and crabs (New Jersey Emergency New Rule N.J.A.C. 7:25-18A). The ban resulted from a comprehensive survey begun in 1976 that included the lower Passaic River (Belton et al., 1982, 1983). This rule includes an advisory to limit consumption and prohibits the sale of striped bass and American eels taken from the lower Passaic River and Newark Bay. An advisory to limit consumption was also issued for bluefish, white perch, and white catfish. In 1982, commercial collection of clams and blue crabs was prohibited (personal communication, B. Ruppel, 2 December 1985). In 1983, similar bans on sale and consumption of fish and shellfish from the lower Passaic River, and in 1984, striped bass and blue crabs from Newark Bay and associated areas, were established due to the presence of dioxin in these fish (NJDEP Administrative Orders E040-17 and E040-19).

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The number of people that fish and crab in the lower Passaic River is difficult to estimate. A joint Rutgers University/NJDEP survey of recreational fishermen and crabbers was conducted in the Hudson-Raritan Estuary Project, which lies east of the lower Passaic (NJDEP, 1985). The surveyed area comprised popular urban fishing zones where eleven fishing sites were identified including a fishing pier built by the state. The popular fishing period was for the four months of June through September when, for example, about 10 to 20 people were observed on the fishing pier at specific observation times. In contrast, observations made during the current study activities indicated that the lower Passaic River has no areas specifically developed for fishing and the local land use severely restricts access. **The River Bank Park is 3.3 miles upstream of the site and offers access to the river by the general public.** Although a comprehensive fishing survey was not part of the present scope of work, **very little recreational fishing was observed in the entire Passaic River study area over the summer months. These observations amounted to sighting of one or two anglers at three or four locations predominantly located in the far-upstream reach.** Consumption of the catch is uncertain, but the NJDEP survey (NJDEP, 1985) of the Hudson-Raritan Estuary implies that 20 to 40 percent of the catch may be consumed.

A biocommunities study of the Passaic River from Little Falls to the mouth was conducted for the Passaic Valley Sewerage Commission in 1982 (Appendix H). Results of the surveys showed that fish and other aquatic species are more varied and plentiful in areas above Dundee Dam. It is likely that this more dense aquatic population results in a higher catch for fishermen, making the upper Passaic area more attractive to frequent anglers than the lower portions of the river. Results of the biocommunities survey also leads to the implication that the river reach near the 80 Lister Avenue site supports only sparse populations of hardy organisms resilient to environmental stress.

7.4 RISK EVALUATION

The only immediate health issue is the potential that anglers may consume fish or crabs caught from the lower Passaic River even though a fishing ban was initiated in 1982 due to presence of PCBs. This is expected to be a very limited group of people based on the discussions above. The U.S. Food and

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Drug Administration (FDA) issued a guidance in 1981 that fish with dioxin concentrations of 50 ppt or less were suitable for consumption, but that fish with levels of 25 to 50 ppt should not be consumed more than twice a month (USEPA, 1984). This guidance was based on a daily consumption of fish containing dioxin every day for an entire lifetime.

The NJDEP sponsored a dioxin analytical survey of aquatic species caught in the Passaic River (NJDEP, 1983). Most samples that had detectable dioxin levels above the 50 ppt FDA guidance level were only slightly above this amount, except for carp which showed levels of 100 to 150 ppt. Crab muscle had 16 ppt while the crab hepatopancreas had about 450 ppt. The origin of the dioxin detected in these aquatic species is unknown. Many of the species tested are migratory or their behavior pattern is one of ranging over great distances. Dioxin was detected in many sediment samples throughout the entire 16.5 mile study area of the Passaic River indicating multiple contributory sources (Chapters 5.0 and 6.0). Furthermore, dioxin has been detected in other regional tidal rivers including the nearby Hackensack (Ruppel, 1984). Given the widespread presence of dioxin in the region and the fact that the surface sediment concentrations detected near the 80 Lister Avenue site are similar to those detected elsewhere on the Passaic, the potential appears low for the relatively small surface area of sediments in the lower Passaic River in the vicinity of the 80 Lister Avenue site to contribute significantly to dioxin levels in edible aquatic organisms. Even though there is no immediate and substantial risk to public health by 80 Lister Avenue-associated dioxin in the Passaic, NJDEP should continue to make known its fishing ban in the area, due to the presence of dioxin and numerous other compounds.

Little data are available on dioxin toxicity to marine aquatic species, as discussed in Section 7.2.4. Overall, the data on various freshwater aquatic species suggest that no-effect concentrations of dioxin in water range from 0.1 to about 200 ppt (Kanaga and Norris, 1983). **Effects have been observed in the 1 to 5 ppt concentration range for some species.** The detection limits were 4 to 7 ppt for water samples from the Passaic near 80 Lister Avenue that showed no traces of dioxin. These detection limits are near the lower end of the no-effect range indicating there is no overwhelming reason to suspect immediate and substantial risks to aquatic life.

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FIGURES

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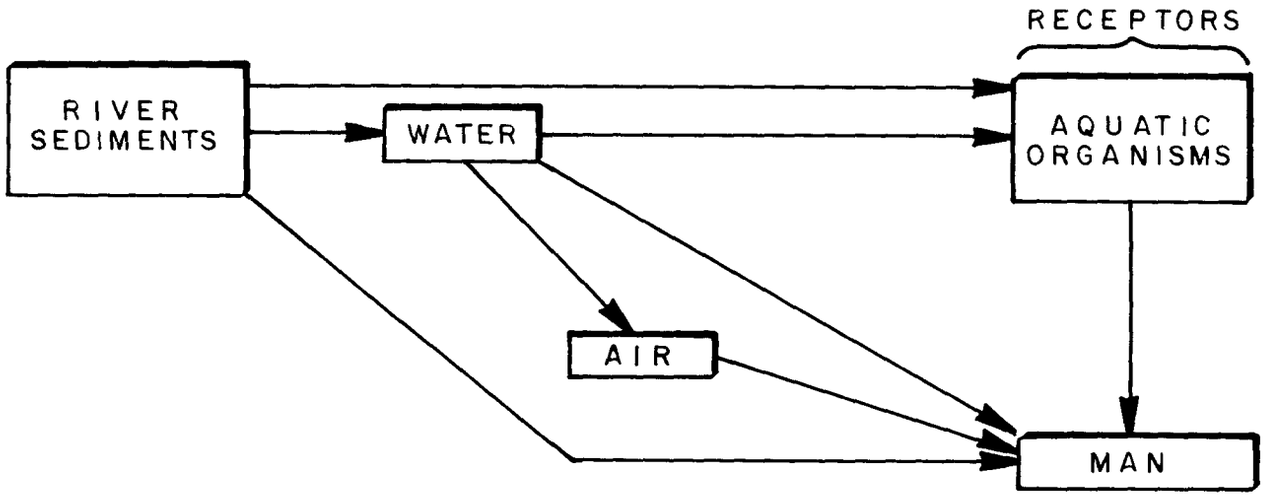

FIGURE 7-1

ROUTES OF POTENTIAL EXPOSURE TO TCDD

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8.0

8.0 SUMMARY AND CONCLUSIONS

The purpose of this section is to present a summary of the evaluations performed for this investigation, and to use that information to support the conclusions of the study. As stated in Chapter 1.0, the project study objectives were to assess:

- The occurrence and concentration of dioxin in the river sediments of the lower Passaic River (below Dundee Dam)
- Whether or not the occurrence of dioxin in the sediment poses an immediate and substantial risk to public health or the environment.

In order to meet these objectives, the following were addressed:

- Background and setting of the section of the river under study and its environs
- Potential for sediment transport in the river
- Results and discussion of the data
- Statistical analyses of the spatial distribution of dioxin in the sediments of the lower Passaic River
- Assessment of the potential for immediate and substantial risk from dioxin in the river sediments.

8.1 SUMMARY OF THE MAJOR FINDINGS OF THE STUDY

8.1.1 Background and Setting

The lower Passaic River has been bounded by industrial properties for over a hundred years. It is used as a receiver for over 100 industrial discharges and 22 municipal discharges. In addition, there are 73 combined sewer overflow stations along the river with the potential for contributing chemical discharges. Prior to installation of the PVSC combined sewer line, many more industries had direct process sewer lines to the river. The river also has elevated bacterial counts, indicative of discharge of primary sewage to the

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river. In general, the Passaic River has extremely low water and sediment quality. This has limited its recreational use and value for commercial and recreational fishing.

8.1.2 Sediment Transport

The upper 2 feet of sediment consists predominantly of organic silt. Transport of this sediment is limited due to the morphology of the river and strong freshwater discharge conditions. The maximum point upstream that sediment originating from the site-area reach would travel under normal flow conditions, as determined for the period in which the data were collected, is between Stations U18 and F04 (1.9 to 6.5 miles upstream of the site-area reach), due to consideration of the point of maximum salinity intrusion and the zone of turbidity maximum. Dioxin is strongly sorbed to sediments of this type, and partitioning into the water phase would be extremely minimal.

Sediments from upstream that are essentially free of dioxin are transported via natural sediment transport processes downstream where they are deposited over older material. The net effect of these processes is the deposition of a cap of relatively dioxin-free sediment. It is expected that this sedimentation pattern will continue, resulting in an even thicker cap of dioxin-free material. These processes will tend to preclude the transport and bioavailability of sediments associated with the highest concentrations of dioxin.

8.1.3 Results and Discussion of the Data

For the lower Passaic River (below Dundee Dam), 164 of 282 samples (58 percent) had no detectable dioxin. Fifty percent of the samples from the upper 2 feet of sediment had no detectable dioxin. Generally, the surface (upper 2 feet) contained much less dioxin than the deeper sediments. However, in the far-upstream reach (11.8 miles of river), dioxin was detected more frequently in the upper 2 feet of sediment than at lower depths.

In the site-area reach, high concentrations of dioxin, where found, are bounded both above and below by sediments with low or no detectable dioxin concentrations. The site-area reach is also bounded laterally by sediments with low or no detectable dioxin levels. Dioxin located in the downstream

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reach is clustered at area D19, which is circumscribed by cores showing low or no detectable dioxin concentrations. The upstream reach showed a random distribution of dioxin both laterally and vertically. The far-upstream reach contained most of its reported dioxin in the top 2 feet of sediment.

The analyses of TOC, lead, and grain-size distribution indicate that no correlation can be made with respect to dioxin occurrence and these parameters.

8.1.4 Statistical Analyses of the Data

The statistical analyses of the data indicated that there are several areas of the river, including the site-area reach, with predicted concentrations of dioxin. These analyses also confirmed that dioxin occurs in areas not predicted to receive sediment originating from the site-area reach, based on normal sediment transport processes under normal tidal conditions as determined at the time these processes were investigated. Where dioxin is found in the sediments, it is relatively confined. The distribution of dioxin with depth reflects this layering process. There is evidence that suggests a discontinuity in the distribution of dioxin along the length of the lower Passaic River, so dioxin detected in the far-upstream reach may be of different origin from that downstream near 80 Lister Avenue.

8.1.5 Risk Assessment

The risk assessment provided a toxicity assessment for dioxin, determined that the major potential human exposure route to dioxin from the river was ingestion of exposed fish and crabs, and characterized the risk associated with presence of 80 Lister Avenue-associated dioxin in the sediments.

8.2 CONCLUSIONS OF THE STUDY

8.2.1 Occurrence of Dioxin in the Lower Passaic River Sediments

The above findings lead to the following major conclusions:

- The site-area reach contains zones of relatively high dioxin concentration well bounded above, below, and laterally by areas with low or no detectable dioxin; the former process sewer discharge line from 80 Lister Avenue is within this reach.

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- Dioxin occurs throughout the entire length of the lower Passaic River, although sediment transport analyses calculated for one set of data limited the extent of site-area reach-associated sediment mobility to approximately 6.5 miles upstream.

- The statistical evaluation of the data indicate that dioxin occurs in areas which, based on natural sediment transport processes under normal conditions, are not predicted to contain dioxin originating from the site-area reach.

- Numerous sources exist for the discharge of chemicals to the Passaic River, including permitted industrial and municipal discharges, PVSC combined sewer outfall regulators, direct process discharge sewer lines, and direct storm runoff.

The above considerations indicate that multiple sources contributed to the occurrence of dioxin in the sediments of the lower Passaic River.

8.2.2 Risk Assessment

The risk assessment resulted in the following conclusions:

- There is no immediate and substantial risk to public health or the environment from the present distribution of dioxin in the site-area reach-associated sediments of the lower Passaic River below Dundee Dam.

- Limited consumption of fish and crustaceans due to bans, the industrial setting, and the poor water quality mitigates the significance of this exposure pathway.

- The higher concentrations of dioxin below the top 2 feet of sediment may pose an additional risk to humans and the environment if the sediments are disturbed.

- The complexity of the study area, including issues such as intense land development, heavy industrialization, estuarial properties of the river, and difficulty in determining actual exposure potential, precluded this study from assessing the risk of long-term exposure to humans and the environment.

8.2.3 Immediate Remediation

The natural sediment transport processes occurring in the river have resulted in the deposition of a cap of essentially dioxin-free sediment overlaying the deeper dioxin-containing layers. The risk assessment has indicated that there is no immediate and substantial risk to human health or the environment from the present distribution of dioxin. No immediate remedial action is warranted, based on present conditions and the normal processes addressed in

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this study. Therefore, conditions allow time for a more thorough evaluation to define the long-term risks and consider response options on a more informed basis.

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