Lower Passaic River Restoration Project

Work Plan

August 2005
Version: 2005/08/02

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FOR:
US Environmental Protection Agency
Region 2

US Army Corps of Engineers
Kansas City District
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WORK PLAN

LOWER PASSAIC RIVER RESTORATION PROJECT

Prepared by:

Malcolm Pirnie, Inc., in conjunction with Battelle and HydroQual, Inc.

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1.0 INTRODUCTION

1.1 OVERVIEW

This Work Plan (WP) presents the technical approach for conducting sampling and investigation activities for the Lower Passaic River Restoration Project (LPRRP), which includes a Remedial Investigation/Feasibility Study (RI/FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and a Water Resources Development Act (WRDA) FS. This WP is a dynamic document that will be amended as the project evolves and additional work phases are initiated.

The LPRRP Study Area (hereafter referred to as the Study Area) encompasses the 17-mile tidal reach of the Passaic River below the Dundee Dam, its tributaries (e.g., Saddle River, Second River, and Third River), and the surrounding watershed that hydrologically drains below the Dundee Dam (116.2 square miles). Refer to Figure 1-1 for a Site Location Map. Investigations may also be conducted in major physically connected water bodies, including the Hackensack River, Newark Bay, the Arthur Kill, and the Kill van Kull.

Figure 1-1: Site Location Map

1.2 SITE BACKGROUND AND HISTORY

The U.S. Environmental Protection Agency (USEPA), the U.S. Army Corps of Engineers (USACE), the New Jersey Department of Transportation (NJDOT) and the New Jersey Department of Environmental Protection (NJDEP) have partnered to conduct a comprehensive study of the Lower Passaic River and its tributaries. The LPRRP is an integrated, joint effort among state and federal agencies that will take a comprehensive look at the problems within the Lower Passaic River Basin and identify remediation and restoration options to address those problems. This multi-year study will provide opportunities for input from the public at all phases of development.

The project's goals are to provide a plan to:

- Remediate contamination found in the river to reduce human health and ecological risks.
- Improve the water quality of the river.
- Improve and/or create aquatic habitat.
- Reduce the contaminant loading in the Passaic and the New York/New Jersey Harbor Estuary.

1.2.1 A Brief History

The Passaic River derives its name from the Algonquin word meaning "peaceful valley". The river spans over 80 miles of suburban and urban areas from its headwaters in Morristown, NJ to its confluence with the tidal waters of Newark Bay. The Passaic River Basin drains an area of approximately 935 square miles with 787 square miles in New Jersey and 148 square miles in New York. Seven major tributaries bring water into the river's main stem, which is used for water supply, recreation, navigation and wastewater assimilation.

During the 1800s, the area surrounding the Lower Passaic River became a focal point for the nation's industrial revolution. By the 20th century, Newark had established itself as the largest industrial-based city in the country. The urban and industrial development surrounding the Lower Passaic River, combined with associated population growth, have resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitat. Figure 1-2 illustrates sites on the National Priorities List (NPL) in the vicinity of the Lower Passaic River. Figure 1-3 indicates facilities in the vicinity of the Study Area regulated pursuant to the Resource Conservation and Recovery Act (RCRA). Figure 1-4 shows locations of New Jersey Known Contaminated Sites in the vicinity of the Study Area.

Point and non-point discharges to the Lower Passaic River, including, but not limited to, Combined Sewer Overflows (CSOs) and Storm Water Overflows (SWOs), have contributed to its contamination. Figure 1-5 illustrates CSOs and SWOs in and near the northern portion of the Study Area (*i.e.*, Paterson area), and Figure 1-6 illustrates CSOs and SWOs in and near the southern portion of the Study Area (*i.e.*, Newark area). CSOs and SWOs are discussed further in Section 2.2 and identified with numbering on Table 2-2.

Historically, the Lower Passaic River has been divided into five reaches:

- Point-No-Point [River Mile (RM) 0.0-2.2];
- Harrison (RM 2.2-4.4);
- Newark (RM 4.4-5.8);
- Kearny (RM 5.8-6.8);
- Upstream (RM 6.8-17.4).

These river reaches are described in more detail in Section 2.5 – River Miles and Reaches.

Figure 1-2: Superfund Sites in and near the Study Area

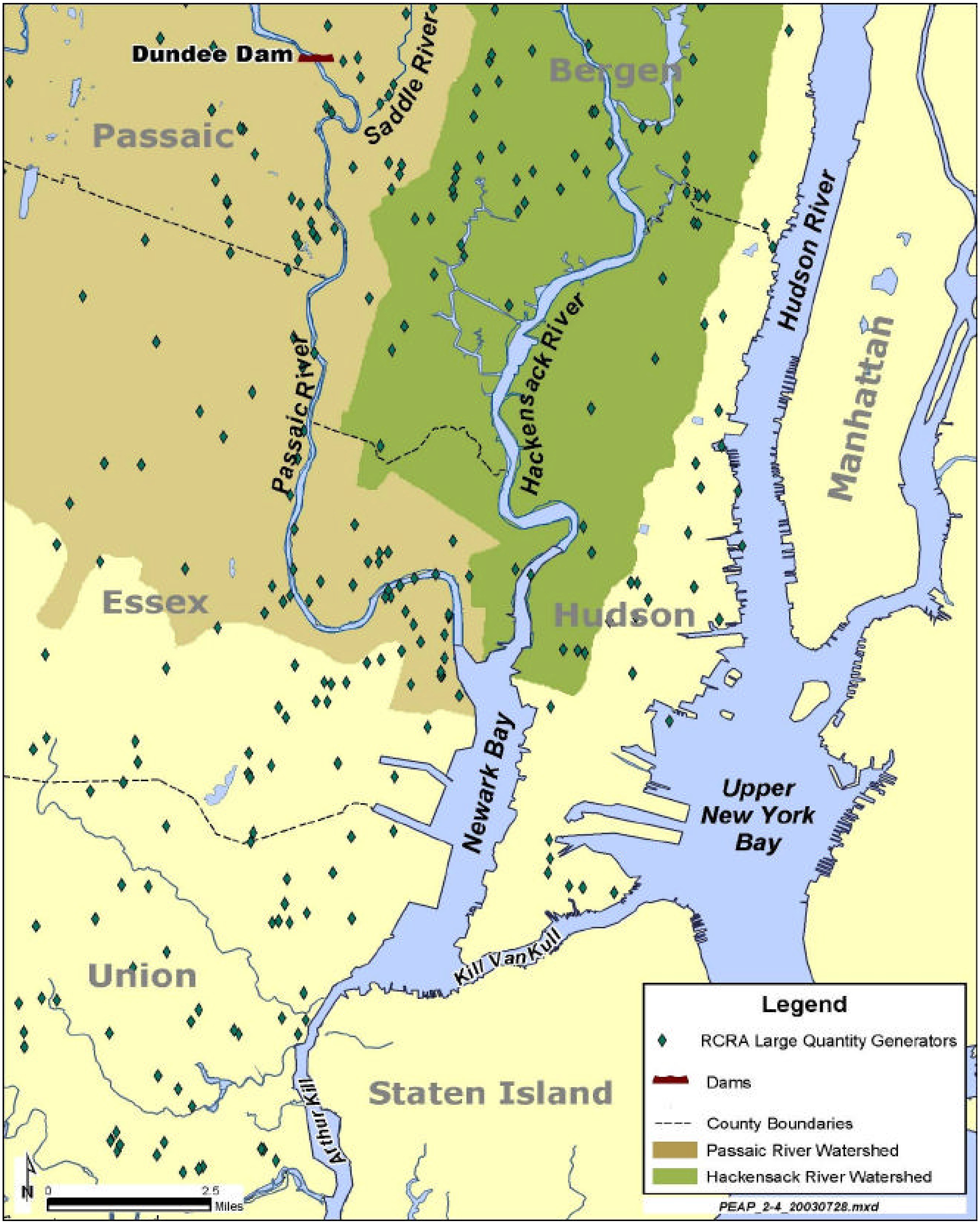


Figure 1-3: Regulated RCRA Facilities in and near the Study Area

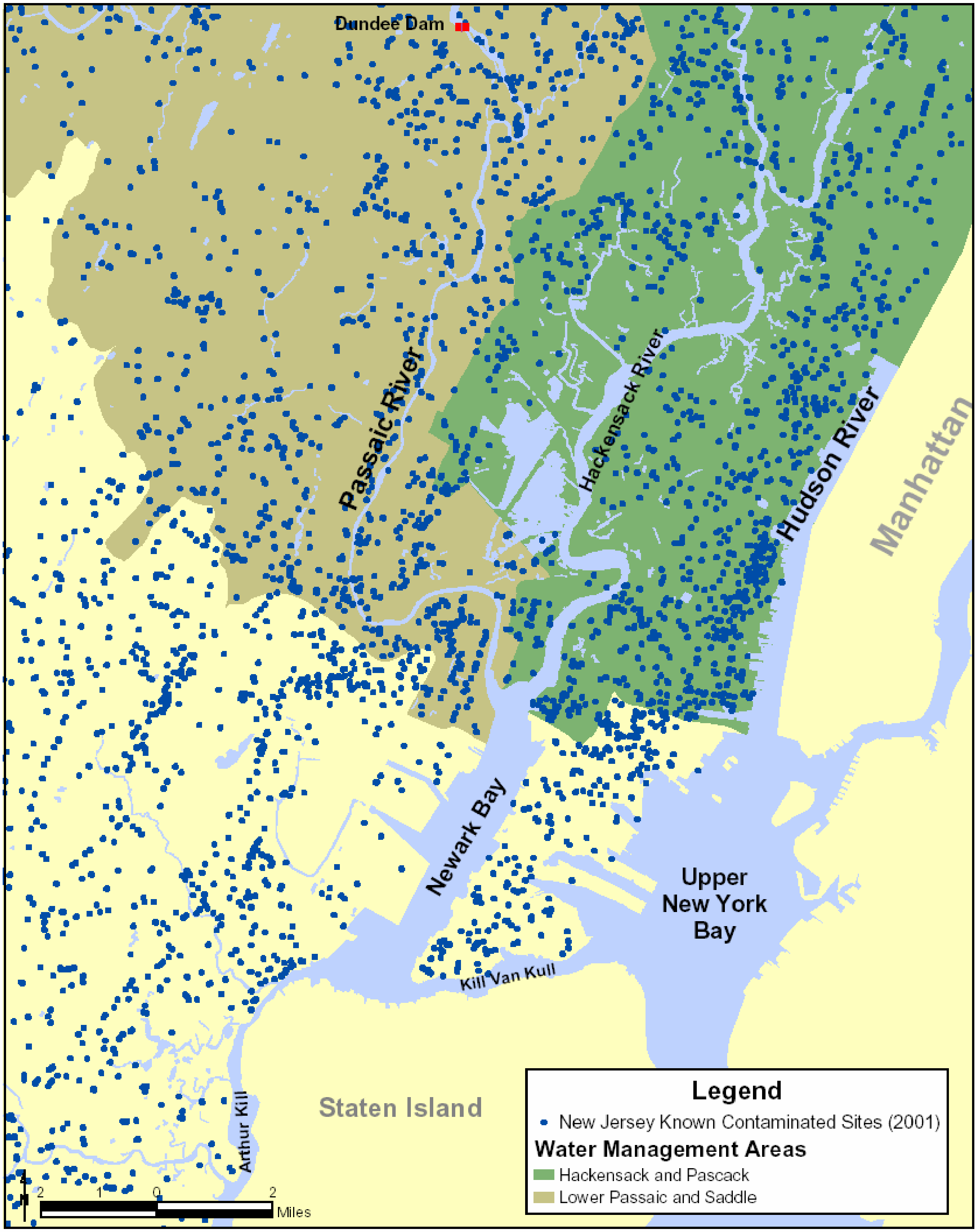


Figure 1-4: New Jersey Known Contaminated Sites in and near the Study Area

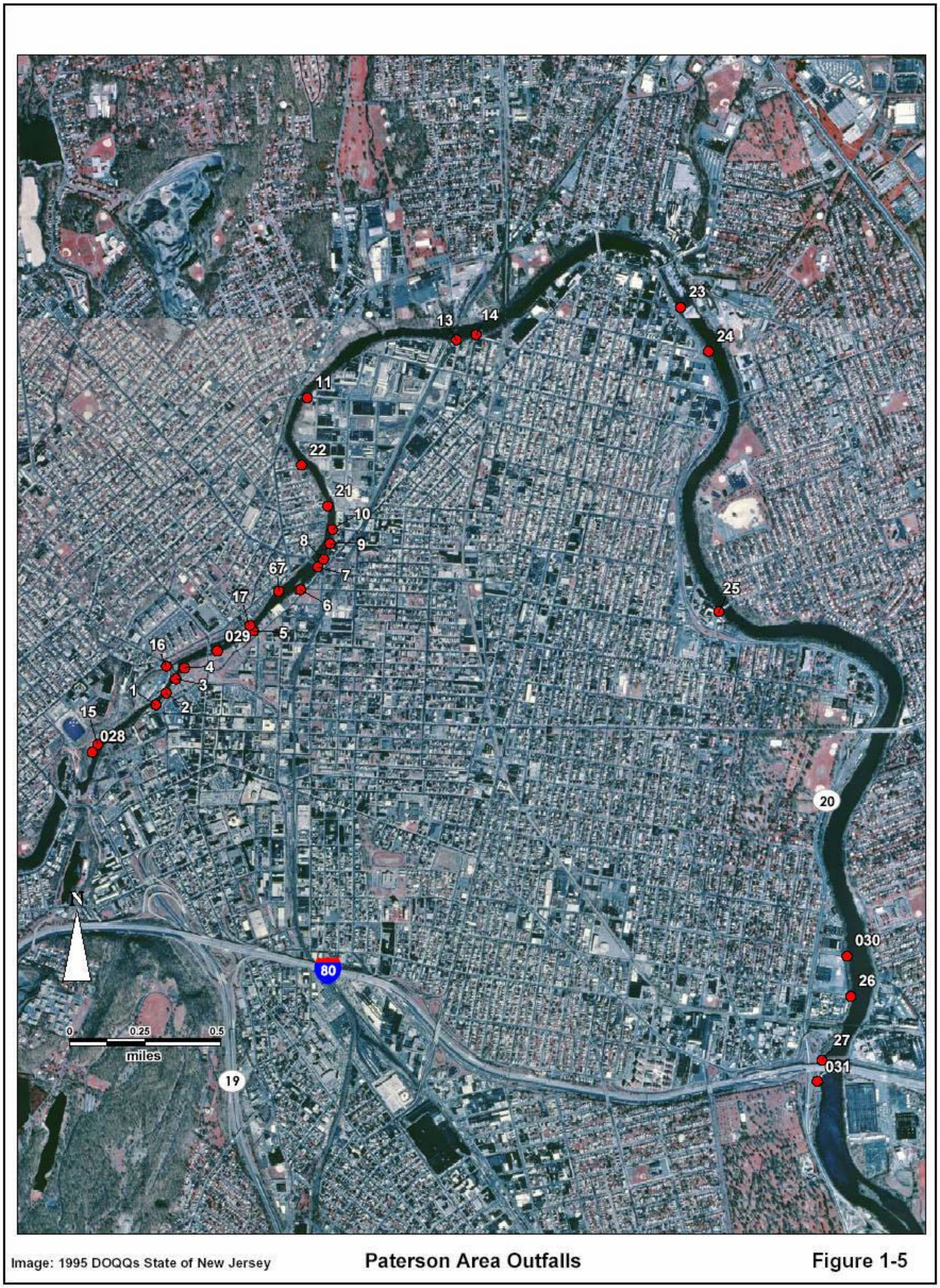


Figure 1-5: CSOs and SWOs in and near the Northern Portion of the Study Area

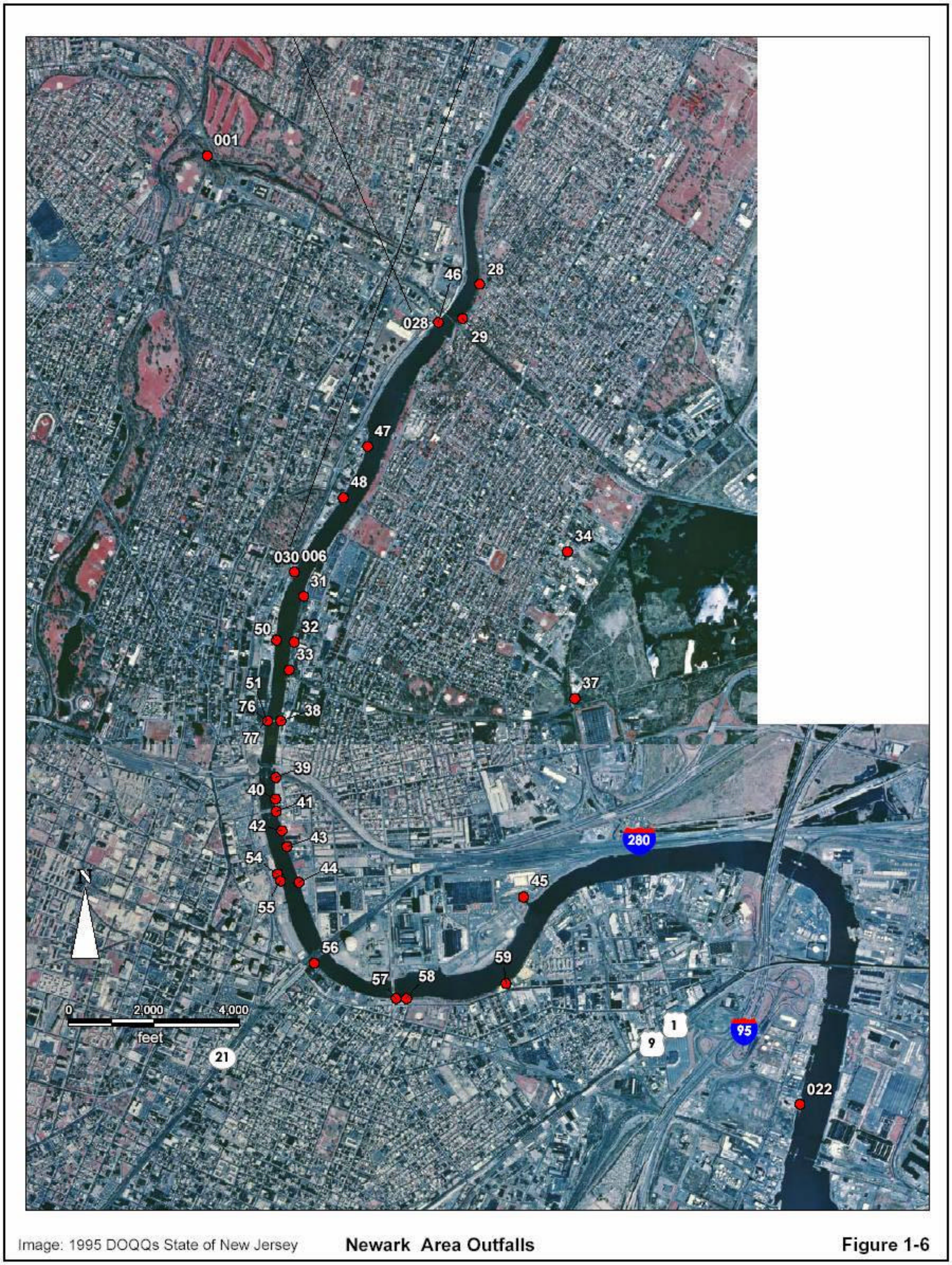


Figure 1-6: CSOs and SWOs in and near the Southern Portion of the Study Area

1.2.2 Federal and State Agencies' Involvement

In the early 1980s, USEPA found soil contaminated with dioxin at the Diamond Alkali manufacturing plant in Newark, NJ, adjacent to the Passaic River. Cleanup work was initiated and the USEPA added the site to the NPL in 1984, making it eligible for cleanup funds under the federal Superfund Program. Contaminants such as metals, persistent organic chemicals, pesticides, and dioxins were also found in the sediments of the lower six miles of the Lower Passaic River. The contaminated sediments were analyzed and the results showed that some areas of the Passaic River contained contaminants at concentrations exceeding federal and state standards. Some locations had concentrations several times higher than these standards.

Several more studies by USEPA, USACE, and others showed that contaminated sediments and other hazardous chemical sources exist along the 17-mile tidal stretch of the Lower Passaic River. Therefore, USEPA, USACE, and NJDOT formed a partnership to expand the study to include the entire Lower Passaic River watershed through joint signature of a Project Management Plan (PMP; USACE, *et al*., 2003). The partners are also coordinating with the natural resources trustees [National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), and NJDEP] to provide information useful to them for their assessment of injuries and related damages to natural resources associated with hazardous substances releases.

USACE's authority to conduct this study is from a U.S. Congress (House of Representatives) Resolution. Using funds from the annual Energy and Water Resources Appropriations Act, NY/NJ Joint Dredging Plan, and the Transportation Trust Fund, a nine million-dollar cost-sharing agreement to study Lower Passaic River restoration was signed in June 2003 between USACE and NJDOT. The remediation portion of the study will be funded under USEPA's Superfund Program, through an Administrative Order on Consent (AOC) among USEPA and over 31 potentially responsible parties. Since the restoration and remediation studies have many overlapping information needs, the USACE, USEPA, and NJDOT have agreed to combine their authorities and funds to carry out a single, integrated study of the Lower Passaic River.

1.2.3 Project Delivery Team and Workgroup Structure (PMP Task ZAB)

The partner agencies have established the coordination structure shown in Figure 1-7. Project Delivery Team (PDT) meetings are held once a month among the six partner agencies and stakeholder groups (including representatives from cooperating parties, local environmental groups, and universities) to keep everyone informed of project progress. While the PDT meetings seemed to be a good forum for providing general overviews of progress, participants also saw the need for another venue to allow smaller groups of experts to discuss the technical details of particular tasks in the Work Plan. Therefore, topic-specific Work Groups were formed, as shown in Figure 1-7. These Work Groups meet more or less frequently, depending on the need to discuss deliverables within each task or topic. This coordination structure has evolved from the initial establishment of an agency-only PDT to the structure shown in the figure, and may continue evolving according to the needs of the project or participants (agencies and stakeholders).

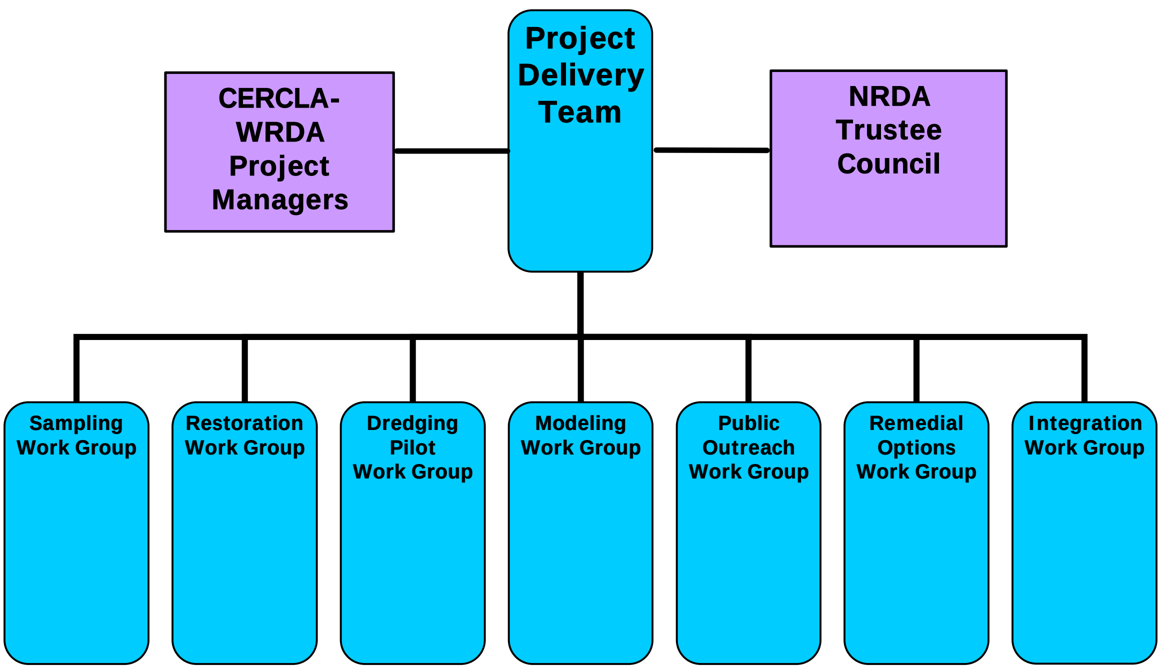


Figure 1-7: Coordination Structure

1.3 COMMUNITY INVOLVEMENT AND PUBLIC OUTREACH (PMP TASK JI)

Community involvement is a key LPRRP component. A Community Involvement Plan is being developed to guide public outreach activities for the project. Plan development started with a series of stakeholder interviews to identify community concerns and to ask how people would prefer to receive information about the project as it proceeds. While some stakeholders were more focused on either Passaic River or Newark Bay, most had interest and concern about both. Between December 2004 and February 2005, over 50 individuals were interviewed across a diversity of interests and geographies at several different locations from Keyport to Clifton, New Jersey. Many of the stakeholders are members of organizations with an interest in the environment, local economy, environmental justice, fishing and recreation, and land preservation and sustainable development. The "common threads" heard among the stakeholders' concerns and interests were captured in the "Community Interview Report: Summary of Comments Heard During Community Interviews" (Malcolm Pirnie, 2005a), which serves as a basis for development of the Community Involvement Plan. This report and other pertinent information on the LPRRP can be found on the project website www.ourPassaic.org.

2.0 ENVIRONMENTAL SETTING

2.1 GEOLOGIC SETTING

The Lower Passaic River is situated within the Newark Basin portion of the Piedmont physiographic province, located between the Atlantic Coastal Plain Province and the Appalachian Plateau (Fenneman, 1938). The Newark Basin is underlain primarily by sedimentary rocks (sandstone, shale, calcareous shale, and conglomerate), to a lesser extent by igneous rocks (basalt and diabase), and may locally be underlain by metamorphic rocks (slate and schist). The Newark Basin rocks are from the mid-Triassic to early Jurassic periods. Bedrock underlying the Lower Passaic River is the Passaic Formation (Olsen, *et al.*, 1984; Nichols, 1968), consisting of interbedded red-brown sandstone and shale.

Almost the entire Passaic River Basin, including the Lower Passaic River, was subjected to glacial erosion and deposition as a result of the last Wisconsin glaciation stage. Considerable quantities of stratified sand, silt, gravel, and clay were deposited throughout the area. These glaciofluvial deposits, in the form of glacial lake sediments, overlie bedrock and underlie the Meadowlands section of the Newark Basin.

2.2 SURFACE WATER HYDROLOGY

Most of the freshwater inflow to the Lower Passaic River [approximately 1,200 cubic feet per second (cfs) on average] comes from the Passaic River above Dundee Dam at the up-estuary end of the Study Area (USACE, 1987; USGS, 1989). Tributaries contributing to the river’s flow include U.S. Geological Survey (USGS)-gauged rivers (Saddle River, Second River, and Third River) and rivers not gauged by the USGS (Frank’s Creek, Lawyer’s Creek, Harrison’s Creek, and Plum Creek). Table 2-1 provides the confluence points with these tributaries, drainage area and the contributing stream flow for those rivers that are USGS-gauged (USGS, 2005).

Table 2-1: Tributary RM Confluence with the Lower Passaic River and Mean Stream Flow Contributions

Tributary	RM Confluence Point	Contributing Stream Flow (ft^3/s)	Drainage Area (square miles)
Dundee Dam	17.4	Not applicable	805
Saddle River	15.6	99.4	54.6
Second River	8.1	18.3	11.6
Third River	11.3	20.7	11.8
Frank's Creek *	3.2	Not applicable	Not applicable
Lawyer's Creek *	1.8	Not applicable	Not applicable
Harrison Creek *	1.6	Not applicable	Not applicable
Plum Creek *	0.7	Not applicable	Not applicable
Total River Miles in the Lower Passaic River = 17.4			
*Note: These tributaries are not USGS gauged. Creek RMs are approximations based on NOAA charts.			

Additional in-flow sources include urban runoff, storm sewers, CSOs, and SWOs (Figures 1-5 and 1-6). Details of the CSOs down-estuary of the Dundee Dam, including each CSO's name, location, and receiving water body are provided in Table 2-2 and Figures 1-5 and 1-6. According to Suszkowski (1978), the ungauged flows between the Dundee Dam and Newark Bay contribute less than 10% of the total flow at the mouth of the Passaic River. Water quality in the Lower Passaic River is rated very poor in the freshwater regime above the Dundee Dam and in the saline tidal reaches below the dam (USACE, 1987).

Table 2-2: Summary of CSOs and SWOs in the Passaic River

CSO #	Name	Location		LATITUDE	LONGITUDE	RECEIVING WATERBODY
ABOVE DUNDEE DAM						
1	Curtis Place	Paterson	Active	40.91955744	-74.17605623	Passaic River
2	Mulberry Street	Paterson	Active	40.92011366	-74.17540063	Passaic River
3	West Broadway	Paterson	Active	40.92078742	-74.17480113	Passaic River
4	Bank Street	Paterson	Active	40.92131086	-74.17425219	Passaic River
5	Bridge Street	Paterson	Active	40.92307858	-74.16987565	Passaic River
6	Montgomery Street	Paterson	Active	40.92504566	-74.1668825	Passaic River
7	Straight Street	Paterson	Active	40.92612198	-74.16577762	Passaic River
8	Franklin Street	Paterson	Active	40.92649528	-74.16542827	Passaic River
9	Keen Street	Paterson	Active	40.92724333	-74.16501875	Passaic River
10	Warren Street	Paterson	Active	40.9279176	-74.16486462	Passaic River
11	Sixth Avenue	Paterson	Active	40.93424146	-74.16642248	Passaic River
13	E. 11th Street	Paterson	Active	40.93698444	-74.1569832	Passaic River
14	Fourth Avenue	Paterson	Active	40.93723503	-74.15574227	Passaic River
15	S.U.M. Park	Paterson	Active	40.91766503	-74.1797415	Passaic River

CSO #	Name	Location		LATITUDE	LONGITUDE	RECEIVING WATERBODY
16	Northwest Street	Paterson	Active	40.92139141	-74.17539027	Passaic River
17	Arch Street	Paterson	Active	40.92334229	-74.17012051	Passaic River
21	Bergen Street	Paterson	Active	40.92904461	-74.16514483	Passaic River
22	Short Street	Paterson	Active	40.93101362	-74.16680416	Passaic River
23	Second Avenue	Paterson	Active	40.93849243	-74.14280616	Passaic River
24	Third Avenue	Paterson	Active	40.93637785	-74.14104983	Passaic River
25	33rd Street & 10th Avenue	Paterson	Active	40.9239142	-74.14047266	Passaic River
26	20th Avenue	Paterson	Active	40.90545931	-74.13224861	Passaic River
27	Market Street	Paterson	Active	40.90239889	-74.13407241	Passaic River
67	Hudson Street	Paterson	Active	40.92497747	-74.16826962	Passaic River
028	Sum Park 2	Paterson	Active	40.91729174	-74.18009014	Passaic River
029	Loop Road	Paterson	Active	40.92212059	-74.17215995	Passaic River
030	19th Avenue	Paterson	Active	40.90737302	-74.13247222	Passaic River
031	Route 20 Bypass	Paterson	Active	40.90138723	-74.13438519	Passaic River
BELOW DUNDEE DAM						
28	Stewart Avenue	Kearny	Active	40.77896986	-74.14772199	Passaic River
29	Washington Avenue	Kearny	Active	40.77677024	-74.14918854	Passaic River
31	Nairn Avenue	Kearny	Active	40.75896229	-74.16269243	Passaic River
32	Marshall Street	Kearny	Active	40.75603734	-74.16351313	Passaic River
33	Johnston Avenue	Kearny	Active	40.75423926	-74.16393242	Passaic River
34	Ivy Street	Kearny	Active	40.76176767	-74.14039016	Frank's Creek
37	Duke Street	Kearny	Active	40.75233594	-74.13981581	Frank's Creek
38	Central Avenue	East Newark	Active	40.75097986	-74.16466396	Passaic River
39	New Street	Harrison	Active	40.74734431	-74.16510358	Passaic River
40	Cleveland Street	Harrison	Active	40.74595681	-74.16512276	Passaic River
41	Harrison Avenue	Harrison	Active	40.74516906	-74.16508007	Passaic River
42	Dey Street	Harrison	Active	40.74392541	-74.16460475	Passaic River
43	Bergen Street	Harrison	Active	40.74290808	-74.16417641	Passaic River
44	Middlesex Street	Harrison	Active	40.74060601	-74.16316868	Passaic River
45	Worthington Avenue	Harrison	Active	40.73960351	-74.14422336	Passaic River
46	Verona Avenue	Newark	Active	40.77651771	-74.15121519	Passaic River
47	Delavan Avenue	Newark	Active	40.76856688	-74.15723593	Passaic River
48	Herbert Place	Newark	Active	40.76528267	-74.15930066	Passaic River
50	Fourth Avenue	Newark	Active	40.75616158	-74.16499307	Passaic River
51	Clay Street	Newark	Active	40.75098545	-74.16579839	Passaic River
76	Passaic Street	Newark	Active	40.75098545	-74.16579839	Passaic River
77	Ogden Street	Newark	Active	40.75098545	-74.16579839	Passaic River
54	Rector Street	Newark	Active	40.74114583	-74.16498813	Passaic River
55	Saybrook Place	Newark	Active	40.74069462	-74.16474564	Passaic River
56	City Dock	Newark	Active	40.73542444	-74.16189875	Passaic River
57	Jackson Street	Newark	Active	40.73312292	-74.15501819	Passaic River
58	Polk Street	Newark	Active	40.73311271	-74.15413036	Passaic River
59	Freeman Street	Newark	Active	40.73406639	-74.14573431	Passaic River
60	Peddie Street	Newark	Active	40.71070986	-74.18648354	Peddie Ditch

CSO #	Name	Location		LATITUDE	LONGITUDE	RECEIVING WATERBODY
61	Queens District	Newark	Active	40.70635743	-74.18603914	Queen Ditch
62	Waverly District	Newark	Active	40.69047792	-74.19106382	Waverly Ditch
63	Yantacaw Pump Station	Clifton	Relief Point	40.82137	-74.13047928	Third River
64	Yantacaw Street	Clifton	Relief Point	40.82159556	-74.13057626	Third River
65	Wallington Pump Station	Wallington	Relief Point	40.85754361	-74.11967586	Passaic River
66	N. Arlington Branch	North Arlington	Relief Point	40.78732424	-74.14613403	Passaic River
69	Lodi Force Main	Passaic	Relief Point	40.85698944	-74.11997697	Passaic River
70	Passaic Tail Race	Passaic	Relief Point	40.85762611	-74.11982333	Passaic River
75	2nd River Joint Meeting	Newark	Relief Point	40.77692778	-74.15071787	Passaic River
001	Meadowbrook	Newark	Active	40.7872817	-74.17067965	Second River
006	Oriental	Newark	Active	40.76054118	-74.11888586	Passaic River
022	Roanoke	Newark	Active	40.72621861	-74.12096986	Newark Bay
023	Adams	Newark	Active	40.71198924	-74.16860515	Adams Ditch
024 & 030	Wheeler / Ave. A	Newark	Active	40.71295792	-74.18023238	Wheeler Ditch
	Newark Airport Peripheral Ditch	Newark		40.68818813	-74.15972907	Flows Into Elizabeth Channel

The Lower Passaic River is tidally influenced for approximately 17 miles extending from just below Dundee Dam down-estuary to the confluence with Newark Bay. The mean tidal range [difference in height between mean high water (MHW) and mean low water (MLW)] at the New Jersey Turnpike Bridge (approximately RM 2.4) is 5.1 feet (NOAA, 1972) with a mean tide level (midway between MLW and MHW) at elevation 2.5 feet (NOAA, 1972). The mean spring tide range (average semi-diurnal range occurring during the full and new moon periods) is 6.1 feet. Depending on tidal cycles and flow conditions, the salt front may be found as far north as the Newark Reach and as far south as Newark Bay (Rutgers, 2005). The cross-sectional average river velocity due to freshwater flow in the Lower Passaic River is approximately 1 foot per second with a typical maximum tidal velocity of approximately 3 feet per second (USACE, 1987). The velocities resulting from up-estuary flow conditions will not normally control the resuspension of bottom sediments (USACE, 1987).

A logical subdivision of the river is into freshwater, transitional, and brackish sections. Habitats, physical processes, and geochemical processes will differ in each of these river sections. This subdivision scheme will be used throughout this document and in the Conceptual Site Model (CSM).

2.3 CLIMATE

The information provided by USACE (1987) indicates that the climate for the Lower Passaic River and surrounding area is characteristic of the Middle Atlantic Seaboard, where marked changes in weather are frequent, particularly in the spring and fall. Precipitation is moderate and distributed fairly uniformly throughout the year, averaging approximately 47 inches annually with an average of 121 precipitation days per year, although the region may be influenced by seasonal tropical storms and hurricanes between June and November. Thunderstorm activity is most likely to occur in the summer. Winters are moderate with snowfall averaging approximately 34 inches annually from October through mid-April. Northeasters usually occur from November to April; these events usually bring strong northeast winds as they move northward along the Atlantic Coast, leading to heavy rain, snow, and coastal flooding. The average annual temperature in Newark is 54 degrees Fahrenheit (^{o}F) with extremes from -26^{o}F to +108^{o}F. Mean relative humidity varies from 67% to 73%. Prevailing winds in the Newark area are from the southwest with only small seasonal variations in direction. The mean wind direction for the winter months is west-northwest (13% of the time) while southwest winds (12% of the time) predominate during the summer. Mean wind speeds are generally highest during the winter and spring months [10 to 12 miles per hour (mph)], and lower (8 to 9 mph) during the summer months, with an average annual velocity of approximately 10 mph.

2.4 SHORELINE FEATURES

Both shorelines of the Lower Passaic River are almost completely developed, consisting of commercial and industrial properties as well as man-made recreational areas. For the purposes of this document, the shorelines of the Lower Passaic River will be defined as left and right shorelines from the perspective of looking up the river from RM 0.0 toward the Dundee Dam. The thalweg (deepest part of the river channel) of the river is generally in the center of the channel in straight sections and is observed to favor the outside bends of the meanders.

2.5 RIVER MILES AND REACHES

The Lower Passaic River encompasses four complete navigational reaches (Point No Point, Harrison, Newark, and Kearny Reaches) and one partial USACE-defined navigational reach (Upstream Reach). The map provided in Plate 1 illustrates the reach locations.

There have been many studies conducted to date on and along the Lower Passaic River by various entities with different goals. Along with the large amount of data produced came differing, and sometimes conflicting, coordinate systems and references to RMs. In the Work Plan produced by Tierra Solutions, Inc. (USEPA, 1995), RM 0.0 was located at the abandoned ConRail Railroad Bridge approximately 4,000 feet up-estuary from the red channel junction marker at the Passaic River and Newark Bay confluence. The TSI RM 0.0 is approximately 4,000 feet up-estuary of the RM 0.0 established for this project. The RM 0.0 established for the LPRRP uses two lighthouses, one located in Essex County, NJ (lat = 40.707725; long = 74.118945) and the other located at Kearny Point in Kearny, NJ (lat = 40.712119; long = 74.115551), as markers. An imaginary line drawn between these lighthouses is assigned as RM 0.0 for the LPRRP.

Point No Point Reach

The Point No Point Reach extends from the down-estuary river boundary RM 0.0 to approximately RM 2.2. The reach follows a north-south trend and is the deepest portion of the Lower Passaic River. Natural inflows to the reach include three small tributaries (Lawyer’s Creek, Harrison Creek, and Plum Creek), which enter the reach at RMs 1.8, 1.6, and 0.7, respectively. The reach contains three bridges including the abandoned ConRail Bridge, the Lincoln Highway, and the General Pulaski Skyway Bridges (U.S. Routes l & 9).

The USACE is responsible for delineating and maintaining navigation channels in the Lower Passaic River. The Federal Project Limit to maintain a channel that is 30 feet deep (relative to MLW) and 300 feet wide in the Point No Point Reach was originally adopted in 1907 and modified in 1911, 1912, and 1930 (USEPA, 1995).

The latest available USACE hydrographic survey was performed in 2004 to assess the conditions of the river. The deepest water in the Point No Point Reach is 21.1 feet at MLW [or an elevation of -23.5 feet NGVD29 (where NGVD29 indicates reference to the National Geodetic Vertical Datum of 1929)]. The channel in the Point No Point Reach was last dredged in 1983 to the Project Depth of 30 feet. Previous dredging events are reported by IT (1986) in 1940, 1946, 1957, 1965, and 1971; Ianuzzi, *et al.* (2002) reported that dredging occurred in 1884, 1917, 1921, 1922, 1932, 1933, 1941, 1946, 1951, 1953, 1957, 1962, 1965, 1971, 1972, 1977, and 1983.

The shorelines of the reach consist primarily of wooden and stone bulkheads and are bordered by several industrial facilities. The right shoreline contains several large industrial facilities including Western Electric, Badische Anilin- & Soda-Fabrik AG (BASF), SpectraServe, and a former Monsanto manufacturing plant. The left shoreline consists of mostly wooden bulkheads and contains ship piers, several current and former chemical and petrochemical manufacturing facilities (including Reichhold Chemical, Sun Oil, and Hoechst-Celanese), and the former Public Service Electric and Gas Company (PSE&G) Essex Generating Station.

Harrison Reach

The Harrison Reach extends from approximately RM 2.2 to RM 4.4. Based on the hydrographic survey conducted by USACE in 2004, the deepest water in the Harrison Reach is 19.5 feet at MLW (or an elevation of -21.9 feet, NGVD29). In general, areas of higher deposition are observed on the inside bend of the meanders rather than the outside bends.

Two bridges are located in the Harrison Reach and are positioned close together near the down-estuary end of the reach. Looking up-estuary, the first bridge is a ConRail (Penn Central) Freight Bridge and the second is the bridge for Interstate 95 (New Jersey Turnpike).

The USACE has delineated the Federal Project Limits for the Reach as a 300-foot wide channel with a Project Depth of 20 feet MLW. Dredging in the Harrison Reach was performed in 1949 with a Project Depth of 20 feet. Ianuzzi, *et al.* (2002) reported that dredging occurred in 1884, 1916, 1921, and 1937.

The right shoreline consists primarily of gravel rip-rap and wooden, or stone, bulkheads bordered by a passenger train yard, a train servicing depot, and the Kearny landfill with a leachate discharge outfall. The left shoreline consists of wooden bulkheads bordered by several chemical facilities (*e.g.*, Benjamin Moore, Chemical Waste Management, Hilton-Davis, and inactive industrial properties including Sherwin-Williams, Commercial Solvents, and the former Diamond Alkali site). A disused marina is located at Blanchard Street between the abandoned Commercial Solvents site and the Benjamin Moore facility.

Newark Reach

The Newark Reach extends from approximately RM 4.4 to RM 5.8 and runs through the downtown section of the City of Newark. This reach begins in an east-west direction and slowly curves in a northerly direction.

The Newark Reach contains numerous bridges. Looking up-estuary, the bridges include: Jackson Street Bridge, Amtrak Railroad Bridge, Harrison Avenue Bridge, ConRail Freight Railroad Bridge, William Stickel Memorial Bridge, and Clay Street Bridge, which delineates the up-estuary extent of the Newark Reach. The former Center Street Bridge was located between the Amtrak and Harrison Avenue Bridges; however, this bridge has been abandoned and the bridge piers have been removed.

The USACE has designated the Federal Project Limits as 300 feet wide in the Newark Reach with a Project Depth of 20 feet MLW. Dredging in this reach was performed in 1949 to a Project Depth of 16 feet MLW. The last hydrographic survey was performed in 2004 and showed that the deepest water in the Newark Reach is 19.6 feet at MLW (or an elevation of -22.0 feet, NGVD29).

The right shoreline consists of wooden, metal, and stone bulkheads bordered by oil storage tanks, numerous small manufacturing facilities, and a former coal burning power generator near the Jackson Street Bridge. The left shoreline consists of parking lots and wooden, or stone, bulkheads bordered by a small park alongside Route 21 (fenced on the river side).

Kearny Reach

The Kearny Reach extends from approximately RM 5.8 to RM 6.8. The reach begins in a general north-south direction and then curves to the northeast. The reach contains two bridges: the aforementioned Clay Street Bridge that delineates the boundary between the Newark and Kearny Reaches and a former Erie & Lackawanna Railroad Bridge. The railroad bridge is abandoned in the open position.

The USACE has designated the Federal Project Limits for the Kearny Reach as 300 feet wide with a Project Depth of 20 feet MLW. Dredging in this reach was performed in 1950 to a Project Depth of 16 feet MWL. Ianuzzi, *et al.* (2002) reported that dredging took place in 1913, 1919, 1933, and 1950. Based on the 2004 hydrographic survey, the deepest water in the Kearny Reach is 16.8 feet at MLW (or an elevation of -19.2 feet, NGVD29).

The left shoreline consists primarily of stone bulkheads and is bordered by train tracks serviced by ConRail and Route 21 (McCarter Highway), leading northward from downtown Newark. The ConRail train tracks end at the site of the former PPG manufacturing plant located along the left shore of Kearny Reach. The right shore of the Kearny Reach consists of wooden and stone bulkheads bordered by several small manufacturing facilities.

Upstream Reach

The Upstream Reach extends from approximately RM 6.8 to the Dundee Dam. The river direction does not change appreciably in the Upstream Reach. The USACE has delineated the Federal Project Limits as 200 feet wide in the Upstream Reach with a project depth of 16 feet MLW. Dredging in the navigable portion of this reach was performed in 1950 to a Project Depth of 16 feet MLW (USEPA, 1995). Ianuzzi, *et al.* (2002) reported that dredging activities occurred in 1874, 1876, 1878, 1879, 1883, 1899, 1906, 1915, 1916, 1927, 1929, 1930, 1931, 1932, 1934, 1938, 1939, 1940, 1945, 1949, and 1956. Based on the 2004 hydrographic survey, the deepest water in the Upstream Reach is 9.2 feet at MLW (or an elevation of -11.5 feet, NGVD29).

There are 13 bridge crossings over this reach. These are listed along with type, RM, and clearance for each in Table 2-3. To be noted are the low clearance heights of the northernmost fixed bridges; these will pose obstacles to river accessibility for the field team.

Table 2-3: Upstream Reach Bridges

RM	Bridge Name	Bridge Type	Vertical Clearance (See Note)
7.8	Conrail Railroad	Swing Bridge	36 ft
8.5	Belleville Turnpike/Route 7	Bascule Bridge	8 ft
10.4	Kingsland Avenue	Swing Bridge	7 ft
11.45	Conrail Railroad	Swing Bridge	26 ft
11.65	Route 3	Bascule Bridge	35 ft
13	Union Avenue	Swing Bridge	13 ft
13.9	Main Street	Fixed Bridge	12 ft
14.45	2nd Street	Fixed Bridge	5 ft
15	8th Street	Fixed Bridge	5 ft
15.75	Passaic Street	Fixed Bridge	5 ft
16	Conrail Railroad	Fixed Bridge	5 ft - 7 ft
16.1	Monroe Street	Fixed Bridge	5 ft - 7 ft
16.35	Van Winkle Avenue	Fixed Bridge	5 ft - 7 ft
17	Outwater Lane	Fixed Bridge	5 ft - 7 ft

Note: All vertical clearance figures are given at high tide. The low tide figures would be approximately 5-6 ft more clearance.
Source: According to NOAA Nautical Charts 12337, 22^{nd} Edition, November 15, 1997.

The right shoreline of the Upstream Reach consists of wooden and stone bulkheads bordered by several small manufacturing facilities and some private homes at the northern end of the Lower Passaic River. The left shore of the Upstream Reach consists primarily of manufacturing facilities, roadways, and parking lots.

3.0 WORK PLAN RATIONALE

This Section describes the inputs and basis for the scoping of the data evaluations and field investigations presented in the Quality Assurance Project Plan (QAPP) (Malcolm Pirnie, Inc., 2005b), Field Sampling Plan (FSP) Volume 1 (Malcolm Pirnie, Inc., 2005c), Volume 2 (to be published in 2006), and Volume 3 (Malcolm Pirnie, Inc., 2005d), consisting of:

- A summary of the output of the Data Quality Objective (DQO) process for the LPRRP.
- A description of the primary "tools" or exhibits included in this Work Plan, FSP Volumes 1 (Malcolm Pirnie, Inc., 2005c), 2 (in 2006), and 3 (Malcolm Pirnie, Inc., 2005d), and the QAPP (Malcolm Pirnie, Inc., 2005b) that are used jointly to design and describe the field investigations and data collection.
- A brief summary of each field investigations' role in the data collection necessary to address the decision statements in the DQOs (Attachment 1.1, QAPP, Malcolm Pirnie, Inc., 2005b).

3.1 DATA QUALITY OBJECTIVES AND FUNDAMENTAL QUESTIONS

The objectives of the LPRRP investigation activities ("the Study") are as follows:

- To characterize the nature and extent of contamination in the Lower Passaic River.
- To characterize the mechanisms governing long-term fate and transport of site contaminants.
- To assess the human health and ecological risks posed by the contamination in the Lower Passaic River.
- To characterize the function and structure of candidate restoration sites in the Lower Passaic River watershed.
- To evaluate remedial alternatives that meet both CERCLA and WRDA selection criteria to address unacceptable human health/ecological risks and provide for restoration within the Lower Passaic River watershed; as well as to evaluate options for reducing costs associated with dredging contaminated harbor sediments originating from the Passaic River.
- To support development of a natural resource damage assessment (NRDA) under CERCLA.

The following Fundamental Questions need to be answered during the investigation to meet these objectives:

1. If we take no action on the River, when will the COPCs and COPECs recover to acceptable concentrations?
2. What actions can we take on the River to significantly shorten the time required to achieve acceptable or interim risk-based concentrations for human and ecological receptors?
3. Are there contaminated sediments now buried that are likely to become exposed following a major flood, possibly resulting in an increase in contaminants within the fish/crab populations?
4. What actions can we take on the River to significantly improve the functionality of the Lower Passaic River watershed?
5. If the risk assessments for Newark Bay demonstrate unacceptable risks due to contaminant export from the Passaic River, will the plan proposed to achieve acceptable risks for Passaic River receptors significantly shorten the time required to achieve acceptable or interim risk-based concentrations for receptors in Newark Bay, or will additional actions be required on the Passaic River?[1]
6. What actions can we take on the River to significantly reduce the cost of dredged material management for the navigational dredging program?
7. What actions can we take to restore injured resources and compensate the public for their lost use?

The development of these objectives and Fundamental Questions is discussed in more detail in the DQOs presented in the QAPP (Malcolm Pirnie, Inc., 2005b). Note that the development of DQOs is on-going and subject to further revisions by the Integration Work Group described in Section 1.2.3 – Project Delivery Team and Workgroup Structure.

3.2 TOOLS TO BE DEVELOPED TO ADDRESS THE OBJECTIVES AND ANSWER THE FUNDAMENTAL QUESTIONS

Various lines of evidence will be pursued to provide robust answers to the Fundamental Questions. Following are the tools that will be used to pursue those lines of evidence during the study:

1 This question is shared with the RI/FS for the Newark Bay Study, since the actual benefits of such reduction will need to be jointly determined. A similar question to address the adequacy of any future Newark Bay Plan toward achieving Passaic River goals may be included in the Newark Bay Study.

- CSM;
- Predictive Fate and Transport/Bioaccumulation Model;
- Treatability Pilot Studies.

3.2.1 Conceptual Site Model

A CSM is being developed to represent the processes in the Lower Passaic River watershed that determine the fate and transport of contaminants, to evaluate exposure pathways, and to identify receptors. Essential elements of the CSM include the following:

- Information about sediment stability, contaminant sources, contaminated media, and geochemical data to characterize the nature and extent of contamination,
- Information about hydrodynamic, sediment transport and stability, and biotic processes to assess the fate and transport of contaminants in sediments, water, and biota.
- Description of exposure pathways and receptors to evaluate human health/ecological risks and support the NRDA.

A CSM expresses a site-specific contamination problem through a series of diagrams, figures, and text consistent with USEPA Office of Solid Waste and Emergency Response (OSWER) RI/FS guidance (USEPA, 1988). These diagrams, figures and narrative illustrate the potential physical, chemical, and biological processes that transport contaminants from sources to receptors. Overall, a CSM provides a tool for site managers and planning teams to examine the contamination problem and to provide the basis for identifying and evaluating the potential risks to human health and the ecosystem.

A CSM is developed during the first step of the data quality objective process (DQO; USEPA, 2000) and continues to evolve throughout the project as historical and recently collected data are evaluated, DQOs are updated, and the human health and ecological risk assessments are refined. Typical components of a CSM include:

- Potential sources of contamination.
- Potentially contaminated media and types of contaminants expected.
- Contaminant fate and transport mechanisms/migration pathways.
- Potential exposure pathways and routes of exposure.

- Potential human and ecological receptors.

Together, these CSM components and the DQOs present a current understanding of the contamination problem; outline existing data gaps and the sampling necessary to address these gaps; identify potential exposures that may result in existing human and ecological risks; and provide guidance for future project decision-making. It must be understood by all audiences that a CSM is a multidisciplinary tool that serves a critical role in risk assessment, numerical model development, project and sample planning, decision making, and ultimately in choosing a remedial strategy. For this reason, a series of diagrams, figures, and text that describe various aspects and uses of the CSM may be appropriate for a complex project. These diagrams, figures, and text link together to represent the entire CSM, but individually, each diagram or figure may highlight a different aspect of the project.

Attachment A is a technical document presenting a basis for the iterative CSM development process and a preliminary CSM. The attached document describes the presentation of the CSM, likely processes and data that will be included in the comprehensive CSM, and methods for updating the CSM as studies are completed and new information and understanding becomes available. The document is framed with the understanding that the CSM development process will be on-going throughout the project. The developed CSM will be used by modelers, geochemists, risk assessors, decision makers, and stakeholders.

To accomplish these objectives in a clear fashion, broad geochemical processes are presented. Neither data nor exposure pathways are presented in the attached CSM; hence the CSM is currently incomplete. A compact disk containing preliminary geochemical evaluations of historical data is also provided as Attachment B to this Work Plan. Future iterations of the CSM will integrate the plethora of existing data, data collected during future field investigations, and the exposure pathways and receptors noted in the Pathways Analysis Report (PAR) (Battelle, 2005) to construct a comprehensive CSM that addresses pertinent aspects of the LPRRP. Examples presented in the attached CSM document are intentionally generalized and serve as the foundation for future iterations. It is likely and planned that from this initial CSM a variety of tools will evolve to suit the needs of the project.

3.2.2 Predictive Fate and Transport and Bioaccumulation Model

A Passaic River-Newark Bay model is being developed to provide information about the fate and transport and bioaccumulation of contaminants in the Study Area where the field sampling program is unable to provide it and to predict future conditions where required to answer the Fundamental Questions. The model development is based on the scientific approaches and computational framework of a NY/NJ Harbor-wide model developed by the Harbor Estuary Program's Contaminant Assessment and Reduction Program (CARP). Model development is summarized in Section 7.0 – Hydrodynamic, Sediment Transport, Chemical Fate and Transport, and Bioaccumulation Modeling and is described in detail in the Lower Passaic River Restoration Project Modeling Work Plan (HydroQual, 2005).

3.2.3 Treatability Pilot Studies

Treatability pilot studies are planned to evaluate performance and estimate costs to support evaluation of remedial alternatives and options to address the needs of the navigational dredging program and potential future remedial dredging program. While various pilots might be proposed throughout the multi-year study, a pilot of environmental dredging and sediment decontamination technologies is being planned at this time. Development of the dredging and decontamination pilot is summarized in Section 5.11 – Environmental Dredging and Sediment Decontamination Technologies Pilot (PMP Task JAE) and is described in detail in the Dredging Pilot Work Plan (TAMS, 2005a).

3.3 HISTORICAL DATA EVALUATIONS AND FIELD INVESTIGATIONS

The CSM and eventual project recommendation are based on the evaluation of existing (or historical) data as well as new data collection. Numerical modeling will build on the CSM to supply more quantitative estimates of future river conditions for use in remedial decisions. Just as the CSM is being developed in manageable working stages, the historical data evaluation and field investigation are also proceeding in stages.

The historical data evaluation presented in Section 4.1 – Preliminary Historical Data Evaluation focuses on the nature and extent objective described previously. The FSP Volumes are plans that outline the collection of new data to supplement the CSM and risk assessment. FSP Volume 1 is designed to fill in the sediment and water chemistry data gaps identified for this objective. FSP Volume 3 is designed to fill in the physical data gaps identified for this objective.

The historical data evaluation related to the human health and ecological risk assessment is summarized in Section 8.2.1 – Data Review and Evaluation and is described in more detailed in the PAR (Battelle 2005). While the investigation described in FSP Volume 1 will provide supporting data for the risk assessment, the biological community and chemistry data necessary to complete the risk assessment will be described in FSP Volume 2. Additional historical data evaluations related to biological information will be presented in the introduction to FSP Volume 2.

The historical data evaluation completed to develop the predictive model is described in the Lower Passaic River Restoration Project Modeling Work Plan (HydroQual 2005). The predictive model will be used to forecast future conditions based the field investigation. As part of the development of the model, the results of the model output will be compared with field data to verify that the model simulates the environmental system closely enough that it can be used in decision-making. FSP Volumes 1, 2, and 3 are also designed to gather the data necessary to perform this model calibration and validation.

3.4 FIELD SAMPLING PLAN VOLUMES

A field investigation is being designed to provide the additional data needed to fully develop each line of evidence. A full description of the components of the field investigation is provided in the three-volume FSP:

- Volume 1: FSP 1 (Malcolm Pirnie, Inc., 2005c) includes investigations to characterize sediment and surface water quality in the Passaic River and in major tributaries. These investigations are being done to gain chemical and physical data necessary to evaluate the spatial extent of contamination, to prepare human and ecological health risk assessments, and to develop the Hydrodynamic, Sediment Transport, and Fate and Transport Models. The investigations will include measurements of hydrodynamic and sediment transport characteristics of the Lower Passaic River and major tributaries.

- Volume 2: FSP Volume 2 includes investigations that relate to the biota and biological aspects of the Lower Passaic River and the surrounding watershed. Investigations are to include taking inventory and cataloging the species found within and around the Lower Passaic River and obtaining tissue samples to determine potential contaminant concentrations. FSP Volume 2 is scheduled to be developed from Fall 2005 to Spring 2006.
- Volume 3: FSP 3 (Malcolm Pirnie, Inc., 2005d) includes additional investigations on candidate restoration sites, upland areas, and wetland areas in the Study Area but outside the main stem of the Passaic River. FSP Volume 3 also includes the 17-mile bathymetric survey of the Lower Passaic River conducted in 2004 (USACE, 2004). Data obtained from candidate restoration site screening will also be used to support the FS where appropriate.

4.0 PRELIMINARY EVALUATION

This section provides a summary of historic data evaluations conducted to date. A preliminary CSM, presented in Attachment A, was developed based on these evaluations, as well as known and potential routes of migration, and known or potential human and environmental receptors. The CSM will be updated as additional evaluations of historical data are performed and new field data collected under this program.

4.1 PRELIMINARY HISTORICAL DATA EVALUATION

An initial evaluation of available historical data has been completed to identify benchmark chemicals for subsequent analyses and understanding of the site. This evaluation focused on surface sediment results; subsurface sediment concentrations were only evaluated within the area where the highest surface concentrations were found. The objectives of the evaluation were to:

- Provide a preliminary quality review of the available data using an established data quality scheme.
- Provide a preliminary review of the available Passaic River sediment data to characterize the nature and extent of sediment contamination and identify a preliminary list of benchmark chemicals. The benchmark chemicals are a subset of the chemicals of potential concern (COPCs) and chemicals of potential ecological concern (COPECs) identified for the project within the PAR (Battelle, 2005); discussion of COPC and COPEC selection is provided below.

The purpose of identifying benchmark chemicals is to produce a focused list to aid in subsequent geochemical analyses and determining sampling locations for the field investigation. While the benchmark chemicals will be used to establish sampling locations, the list of COPCs and COPECs has been used to establish the initial list of analytical parameters. This initial list may be reduced as experience is gained in the sampling program and preliminary risk evaluations continue.

The available chemistry data for sediment and fish tissue were evaluated to assess the COPCs for human health and COPECs for ecological receptors as an initial step in the risk assessment process. This screening process and the results are described in detail in the PAR (Battelle, 2005). It is recognized that the historical sediment data may no longer represent current surface conditions. In summary, to identify COPCs for initial evaluation in the human health risk assessment (HHRA), the process took into consideration the following factors:

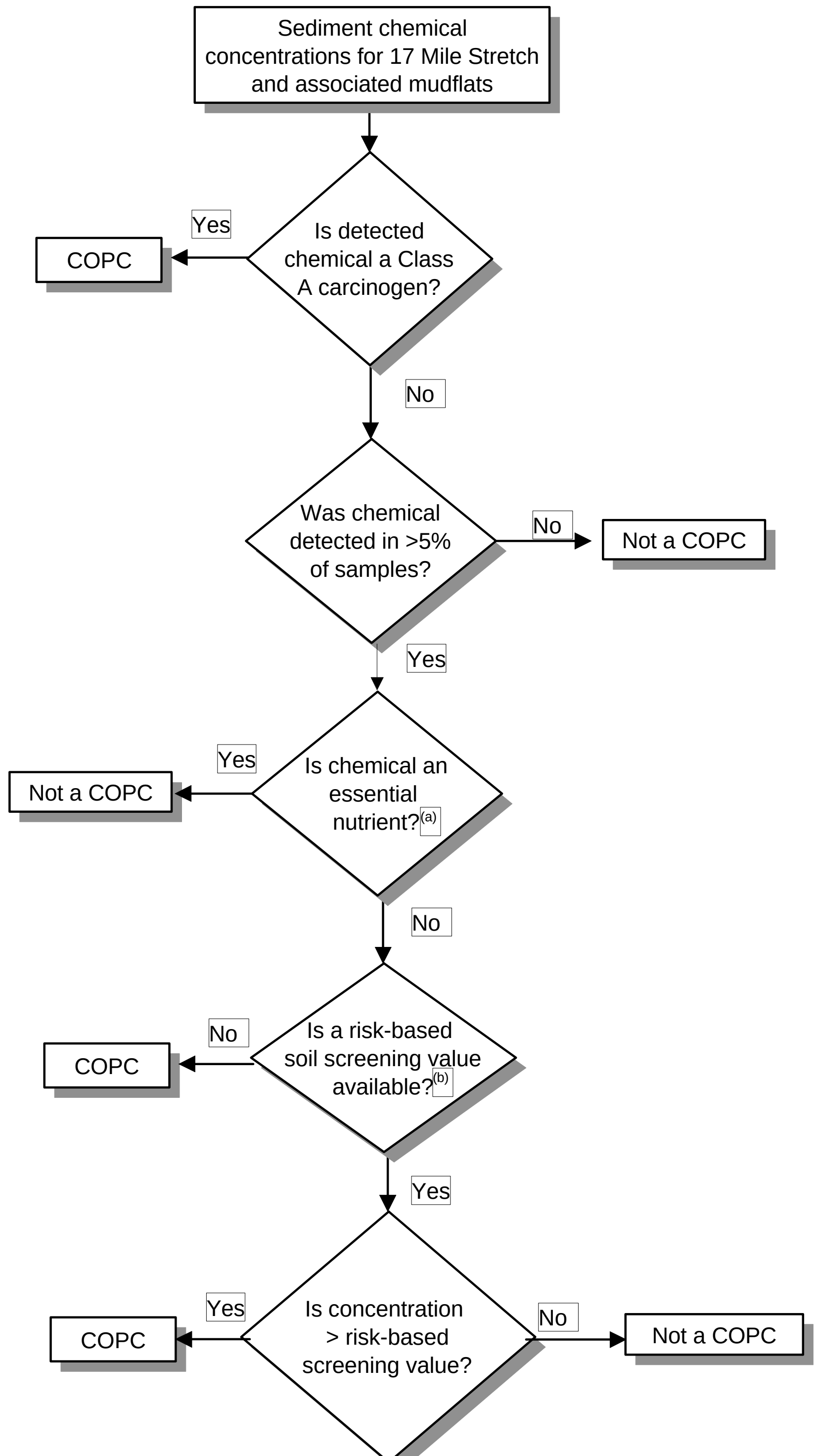
- Is the compound a Class A carcinogen?
- How frequently is the chemical detected?
- Is the chemical an essential nutrient?
- Does the maximum chemical concentration exceed USEPA Region 9 Preliminary Remediation Goals (PRGs) for soil or USEPA Region 3 Risk-Based Concentrations for fish tissue?

Figure 4-1 provides a decision framework for selecting COPCs on the basis of sediment concentrations for consideration in the HHRA. Figure 4-2 provides a decision framework for selecting COPCs on the basis of tissue concentrations for consideration in the HHRA.

For identification of COPECs for ecological receptors in the ecological risk assessment, the process took into consideration the following factors:

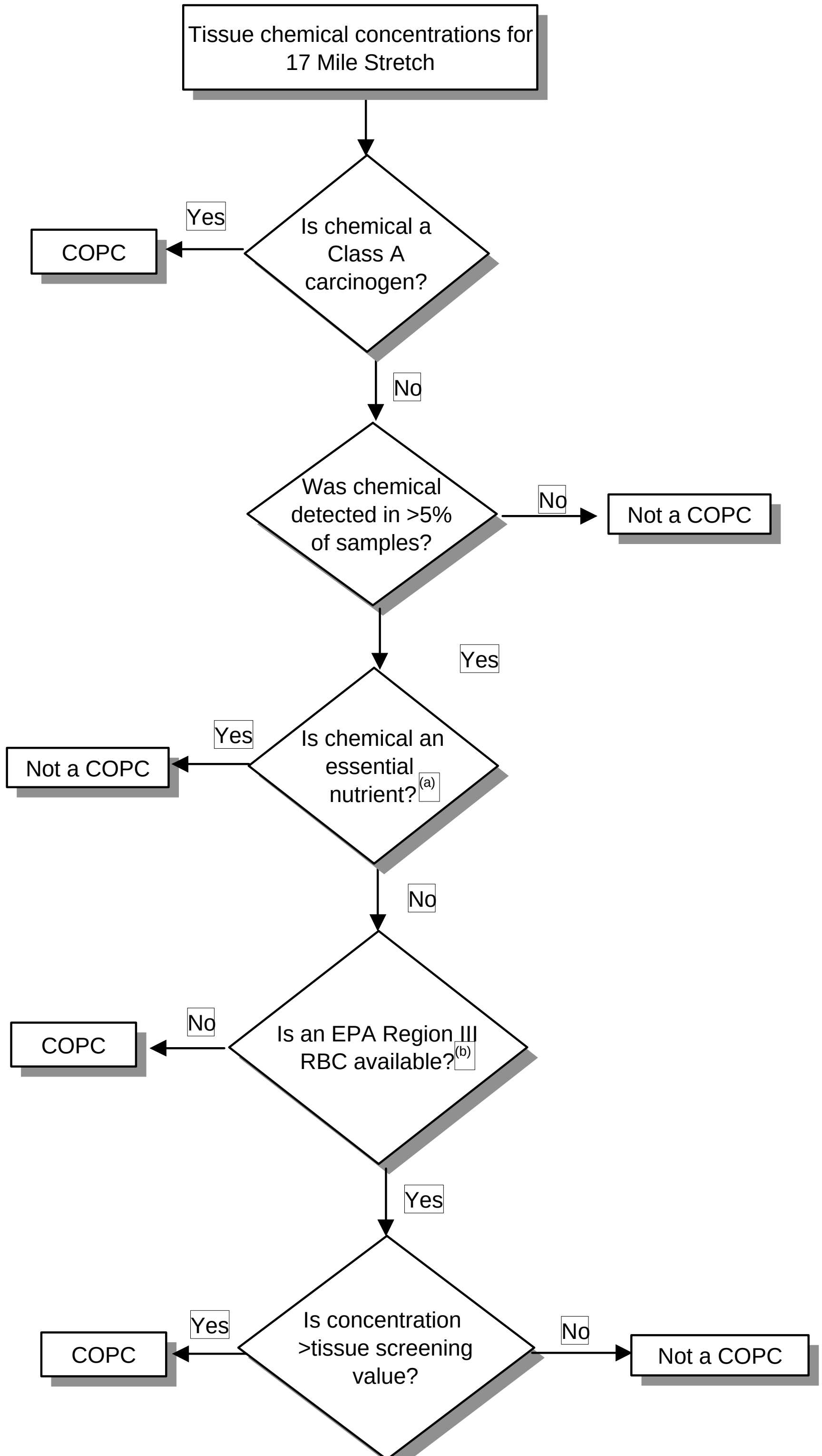
- Is the compound bioaccumulative?
- How frequently is the chemical detected?
- Is the chemical an essential nutrient?
- Does the maximum chemical concentration exceed toxicological benchmarks, such as the Effects Range Low (ER-L), the Effects Range Median (ER-M), or Oak Ridge National Laboratory (ORNL) benchmarks?

Figure 4-3 provides a decision framework for selecting COPECs on the basis of sediment concentrations for consideration in the ecological risk assessment. The COPCs and COPECs selected through this process are summarized in Table 4-1.



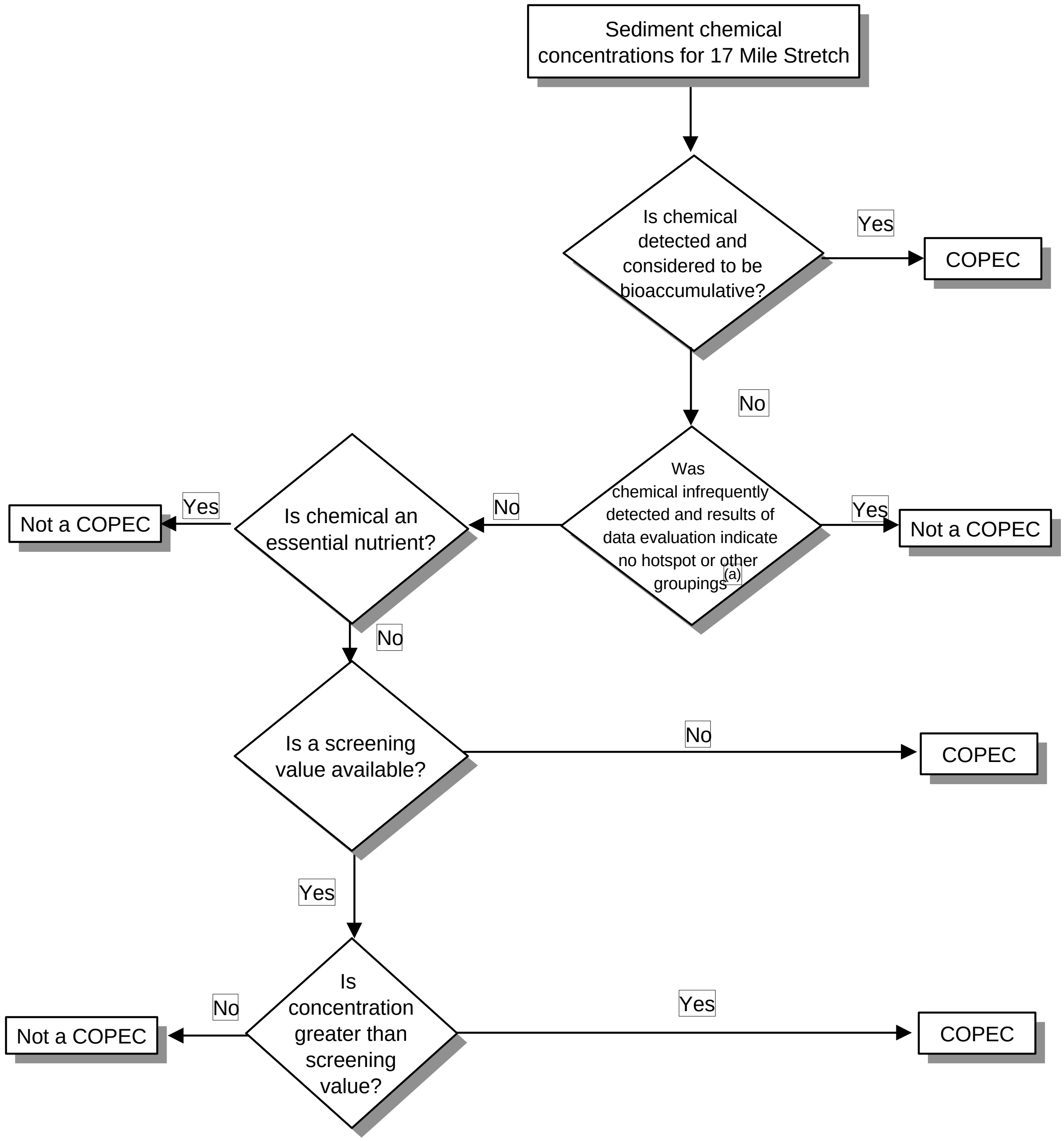
(a) Essential nutrients with toxicity data will be compared to PRGs.
(b) Screening values will be based on the more conservative of EPA Region IX PRGs and NJDEP values.

Figure 4-1: Sediment COPC Decision Diagram for LPRRP HHRA



(a) Essential nutrients with toxicity data will be evaluated based on comparison to RBCs.
(b) Use of EPA Region III RBC based on most current, up-to-date versions.

Figure 4-2: Tissue COPC Decision Diagram for LPRRP HHRA



(a) Initally based on frequency of detection of 5% and will be professionally evaluated with respect to magnitude, hotspots, or other groups.

Figure 4-3: Sediment COPEC Decision Diagram for the LPRRP Ecological Risk Assessment

Table 4-1: List of COPCs and COPECs Identified in PAR

Analyte	Human Health COPC (sediment)	Human Health COPC (fish tissue)	Ecological COPEC
INORGANICS			
Aluminum	✔	✔	
Antimony	✔	✔	✔
Arsenic	✔	✔	✔
Barium	✔		✔
Beryllium	✔		✔
Cadmium	✔	✔	✔
Chromium	✔	✔	✔
Cobalt			✔
Copper	✔	✔	✔
Cyanide			✔
Iron	✔	✔	✔
Lead	✔	✔	✔
Manganese	✔	✔	✔
Mercury	✔	✔	✔
Methylmercury		✔	
Nickel	✔	✔	✔
Selenium		✔	✔
Silver	✔	✔	✔
Thallium	✔	✔	✔
Titanium			✔
Vanadium	✔	✔	✔
Zinc		✔	✔
VOCs			
Benzene	✔		
Chlorobenzene			✔
Ethylbenzene			✔
Methyl chloride			✔
Toluene			✔
Xylenes, Total			✔
Petroleum Hydrocarbons	✔	✔	✔
TPH - DRO	✔		✔
1,2-Dichlorobenzene			✔
1,3-Dichlorobenzene			✔
1,4-Dichlorobenzene	✔	✔	✔
1,2,4-Trichlorobenzene			✔
2,4-Dichlorophenol		✔	
2,4-Dinitrotoluene		✔	
4-Methylphenol		✔	
bis(2-Ethylhexyl)phthalate	✔		✔
Butyl benzyl phthalate	✔		✔
Carbazole			✔

Analyte	Human Health COPC (sediment)	Human Health COPC (fish tissue)	Ecological COPEC
Dibenzofuran	✔		✔
Dibenzothiophene	✔	✔	✔
Dibutyltin	✔	✔	✔
di-n-butyl Phthalate			
di-n-octyl Phthalate			✔
Isophorone		✔	
Monobutyltin	✔	✔	✔
N-nitroso-di-phenylamine			✔
Tetrabutyltin	✔		✔
Tributyltin		✔	✔
PAHs			
1-Methylnaphthalene	✔	✔	✔
1-Methylphenanthrene	✔	✔	✔
2-Methylnaphthalene	✔		✔
2,3,5-Trimethylnaphthalene	✔	✔	✔
2,6-Dimethylnaphthalene	✔	✔	✔
Acenaphthene	✔		✔
Acenaphthylene	✔	✔	✔
Anthracene			✔
Benz[a]anthracene	✔	✔	✔
Benzo[a]pyrene	✔	✔	✔
Benzo[b]fluoranthene	✔	✔	✔
Benzo[e]pyrene	✔	✔	✔
Benzo[g,h,i]perylene	✔	✔	✔
Benzo[k]fluoranthene	✔	✔	✔
Chrysene	✔		✔
Dibenz[a,h]anthracene	✔	✔	✔
Fluoranthene	✔		✔
Fluorene			✔
Indeno[1,2,3-c,d]-pyrene	✔	✔	✔
Naphthalene	✔		✔
PAHs, High Molecular Weight (HMW)	✔		✔
PAHs, Low Molecular Weight (LMW)	✔		✔
PAHs, Total	✔		✔
Perylene	✔	✔	✔
Phenanthrene	✔	✔	✔
Pyrene	✔		✔
PCBs			
Total PCBs (Aroclors)	✔	✔	✔
Total PCBs (Congeners)	✔	✔	✔
PESTICIDES/HERBICIDES			
4,4'-DDD	✔	✔	✔
4,4'-DDE		✔	✔
4,4'-DDT	✔	✔	✔
DDTs, Total	✔	✔	✔
BHC- alpha			✔

Analyte	Human Health COPC (sediment)	Human Health COPC (fish tissue)	Ecological COPEC
BHC – beta			✔
BHC - gamma			✔
Aldrin	✔		✔
Dieldrin	✔		✔
Chlordane (total)	✔	✔	✔
Endrin (total)	✔		✔
Endosulfan (total)			✔
Heptachlor			✔
Hexachlorobenzene			✔
Methoxychlor			✔
2,4,5-TP			✔
2,4-DB			✔
DIOXINS			
2,3,7,8-Tetrachloro-dibenzo-dioxin (TCDD)	✔	✔	✔

In the initial historical data evaluation, chemical data from 58 relevant studies were examined using the following evaluation methodology:

- Sediment data were divided into surface sediment (less than 0.5 feet depth) and subsurface sediment (below 0.5 feet depth).
- Statistical description of chemicals in surface and subsurface sediments, including the frequency of detection, the frequency of exceedance above applicable screening values, minimum, maximum, and mean concentrations, was performed.
- Sediment concentrations in surface and, if applicable, subsurface sediment were screened against established sediment quality guidelines (SQGs) to determine the exceedance frequency of chemicals. Information on the frequency of exceedance and the frequency of detection were used to determine a preliminary list of benchmark chemicals. In general, the Long, *et al.* (1995) marine/estuarine ER-M screens, which represent a greater than 50% incidence of adverse effects to sensitive species and/or life stages, were selected for screening chemical data. General guidelines of 50% detection frequency where no SQG was given or 25% exceedance frequency when an SQG was available, were used to determine benchmark chemicals. Note that if a chemical group as defined by the SQG is classified as a benchmark chemical, then the individual chemical constituents of the chemical group were assumed to be benchmark chemicals [*e.g.*, total Polychlorinated Biphenyls (PCBs)]. For chemicals for which SQGs were not available, the determination of whether they are benchmark chemicals was based on the overall frequency of sample detection. These guidelines were established to serve as general rules; however, in some instances class-specific criteria were also used where applicable (*e.g.*, since metals are naturally occurring and ubiquitous in the environment, additional information, such as spatial distribution, was also used in the screening).

- In a case where a SQG is available for an entire chemical group (*e.g.*, Total PCBs), the total concentration of the SQG chemical group was determined by summing the individual constituent concentration with the assumption of zero concentration for non-detected values.

All of the data used in this evaluation were collected at least 4 years ago; the majority of the data were collected prior to 1999. Therefore, these data may not be representative of current surface conditions. To determine how the bottom of the Lower Passaic River has changed with time, a comparison of bathymetric data collected in Fall 2004 by USACE-NY district and bathymetric data collected by USACE-NY district in 1989 was conducted. See Section 4.3.1 Analysis of Bathymetric Change for a summary of the findings. The following subsections provide a summary of geochemical analyses of the historical data and the conclusions derived from this effort.

4.1.1 Data Sources

Electronic historical data have been obtained from the following sources and uploaded to the project database:

- National Oceanic and Atmospheric Administration (NOAA).
- New York State Department of Environmental Conservation (NYSDEC).
- New York State Department of Health (NYSDOH).
- TAMS/EarthTech, Inc (TAMS).
- TSI.
- USACE.
- USEPA.
- USFWS.

Based on the records of these studies the project database contained 5,857 unique samples collected from 994 locations. These samples, collected from sediment, surface water, and biota, were analyzed for a variety of parameters, which are summarized in Table 4-2. It should be noted that radionuclides were analyzed for purposes of sediment dating, not for the purposes of assessing radiological contamination. The samples were collected during 58 relevant studies; these studies are summarized in Table 4-3.

Table 4-2: Parameters Evaluated in the Initial Historical Data Evaluation

GEOTECHNICAL		
% Clay	% Sand	Dry density
% Coarse sand	% Silt	Liquid limit
% Fine sand	% Solids	Plastic index
% Gravel	% Fines	Phi angle
% Medium sand	Wet density	Staged unconsolidated undrained triaxial
METALS / INORGANICS		
Aluminum	Cyanide	Silicon
Antimony	Iron	Silver
Arsenic	Lead	Sodium
Barium	Magnesium	Thallium
Beryllium	Manganese	Tin
Cadmium	Mercury	Titanium
Calcium	Nickel	Vanadium
Chromium	Potassium	Zinc
Cobalt	Selenium	Simultaneously extracted metals
Copper		
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)		
Acenaphthene	Chrysene	Naphthalene
Acenaphthylene	Dibenz[a,h]anthracene	PAHs, Low Molecular Weight
Anthracene	2,6-Dimethylnaphthalene	PAHs, High Molecular Weight
Benz[a]anthracene	Fluoranthene	PAHs, Total
Benzo[a]pyrene	Fluorene	Perylene
Benzo[b]fluoranthene	Indeno[1,2,3-c,d]-pyrene	Phenanthrene
Benzo[e]pyrene	1-Methylnaphthalene	Pyrene
Benzo[g,h,i]perylene	1-Methylphenanthrene	1,6,7-Trimethylnaphthalene
Benzo[k]fluoranthene	2-Methylnaphthalene	2,3,5-Trimethylnaphthalene
Benzoflouranthenes, total		
PESTICIDES		
Aldrin	2,4'-DDT	Endrin ketone
BHC, alpha	4,4'-DDD	Heptachlor
BHC, beta	4,4'-DDE	Heptachlor epoxide
BHC, delta	4,4'-DDT	Isopropalin
BHC, gamma	Total DDT	Kelthane
BHCs, total	Dieldrin	Methoxychlor
Chlordane	Diphenyl disulfide	Mirex
Chlordane, alpha (cis)	Endosulfan sulfate	Nonachlor, cis-
Chlordane, gamma (trans)	Endosulfan, alpha	Nonachlor, trans-
Chlordane, oxy-	Endosulfan, beta	Octachlorostyrene
2,4'-DDD	Endrin	Perthane
2,4'-DDE	Endrin aldehyde	Toxaphene
HERBICIDES		
2,4,5-T	Dalapon	Dinoseb
2,4,5-TP	Dicamba	MCPA
2,4-D	Dichloroprop	MCPP
2,4-DB		
DIOXINS/FURANS		
1,2,3,4,6,7,8-HpCDD	1,2,3,7,8-PeCDF	Total HxCDD
1,2,3,4,6,7,8-HpCDF	2,3,4,6,7,8-HxCDF	Total HxCDF
1,2,3,4,7,8,9-HpCDF	2,3,4,6,7-PeCDF	Total PCDDs
1,2,3,4,7,8-HxCDD	2,3,4,7,8-PeCDF	Total PCDFs
1,2,3,4,7,8-HxCDF	2,3,6,7-TeCDF	Total PeCDD
1,2,3,6,7,8-HxCDD	2,3,7,8-TCDD	Total PeCDF
1,2,3,6,7,8-HxCDF	2,3,7,8-TCDF	Total TCDD
1,2,3,7,8,9-HxCDD	3,4,6,7-TeCDF	Total TCDF
1,2,3,7,8,9-HxCDF	Total HpCDD	Total OCDD
1,2,3,7,8-PeCDD	Total HpCDF	Total OCDF
POLYCHLORINATED BIPHENYLS (PCBs)		
2-Chlorobiphenyl	2,3',5,5'-Tetrachlorobiphenyl	2,3,3',4,4',6-Hexachlorobiphenyl
3-Chlorobiphenyl	2,4,4',5-Tetrachlorobiphenyl	2,3,3',4,5,6-Hexachlorobiphenyl

4-Chlorobiphenyl	2,4,4',6-Tetrachlorobiphenyl	2,3,3',5,5',6-Hexachlorobiphenyl
2,2'-Dichlorobiphenyl	3,3',4,4'-Tetrachlorobiphenyl	2,3',4,4',5,5'-Hexachlorobiphenyl
2,3'-Dichlorobiphenyl	3,4,4',5-Tetrachlorobiphenyl	2,3',4,4',5',6-Hexachlorobiphenyl
2,3-Dichlorobiphenyl	2,2',3,3',4-Pentachlorobiphenyl	3,3',4,4',5,5'-Hexachlorobiphenyl
2,4'-Dichlorobiphenyl	2,2',3,3',5-Pentachlorobiphenyl	2,2',3,3',4,4',5-Heptachlorobiphenyl
2,4-Dichlorobiphenyl	2,2',3,3',6-Pentachlorobiphenyl	2,2',3,3',4,4',6-Heptachlorobiphenyl
2,5-Dichlorobiphenyl	2,2',3,4,4'-Pentachlorobiphenyl	2,2',3,3',4,5,5'-Heptachlorobiphenyl
2,6-Dichlorobiphenyl	2,2',3',4,5-Pentachlorobiphenyl	2,2',3,3',4',5,6-Heptachlorobiphenyl
3,4-Dichlorobiphenyl	2,2',3,4,5'-Pentachlorobiphenyl	2,2',3,3',4,5',6-Heptachlorobiphenyl
4,4'-Dichlorobiphenyl	2,2',3,4,6-Pentachlorobiphenyl	2,2',3,3',4,5,6'-Heptachlorobiphenyl
2,2',3-Trichlorobiphenyl	2,2',3,4',6-Pentachlorobiphenyl	2,2',3,3',4,6,6'-Heptachlorobiphenyl
2,2',4-Trichlorobiphenyl	2,2',3,5,5'-Pentachlorobiphenyl	2,2',3,3',5,5',6-Heptachlorobiphenyl
2,2',5-Trichlorobiphenyl	2,2',3,5',6-Pentachlorobiphenyl	2,2',3,3',5,6,6'-Heptachlorobiphenyl
2,2',6-Trichlorobiphenyl	2,2',3,6,6'-Pentachlorobiphenyl	2,2',3,4,4',5,5'-Heptachlorobiphenyl
2,3,3'-Trichlorobiphenyl	2,2',4,4',5-Pentachlorobiphenyl	2,2',3,4,4',5',6-Heptachlorobiphenyl
2,3,4'-Trichlorobiphenyl	2,2',4,5,5'-Pentachlorobiphenyl	2,2',3,4,4',5,6'-Heptachlorobiphenyl
2,3,4-Trichlorobiphenyl	2,3,3',4,4'-Pentachlorobiphenyl	2,2',3,4,4',6,6'-Heptachlorobiphenyl
2',3,4-Trichlorobiphenyl	2',3,3',4,5-Pentachlorobiphenyl	2,2',3,4,5,5',6-Heptachlorobiphenyl
2,3',4-Trichlorobiphenyl	2,3,3',4',5-Pentachlorobiphenyl	2,2',3,4',5,5',6-Heptachlorobiphenyl
2,3,5-Trichlorobiphenyl	2,3,3',4,6-Pentachlorobiphenyl	2,3,3',4,4',5,5'-Heptachlorobiphenyl
2',3,5-Trichlorobiphenyl	2,3,3',4',6-Pentachlorobiphenyl	2,3,3',4,4',5,6-Heptachlorobiphenyl
2,3',5-Trichlorobiphenyl	2,3,3',5,6-Pentachlorobiphenyl	2,3,3',4,4',5',6-Heptachlorobiphenyl
2,3',6-Trichlorobiphenyl	2,3,4,4',5-Pentachlorobiphenyl	2,3,3',4,5,5',6-Heptachlorobiphenyl
2,4,4'-Trichlorobiphenyl	2',3,4,4',5-Pentachlorobiphenyl	2,3,3',4',5,5',6-Heptachlorobiphenyl
2,4,5-Trichlorobiphenyl	2,3',4,4',5-Pentachlorobiphenyl	2,2',3,3',4,4',5,5'-Octachlorobiphenyl
2,4',5-Trichlorobiphenyl	2,3,4,4',6-Pentachlorobiphenyl	2,2',3,3',4,4',5,6-Octachlorobiphenyl
2,4',6-Trichlorobiphenyl	2,3',4,4',6-Pentachlorobiphenyl	2,2',3,3',4,4',5',6-Octachlorobiphenyl
3,4,4'-Trichlorobiphenyl	3,3',4,4',5-Pentachlorobiphenyl	2,2',3,3',4,4',6,6'-Octachlorobiphenyl
2,2',3,3'-Tetrachlorobiphenyl	2,3,4,5,6-Pentachlorobiphenyl	2,2',3,3',4,5,5',6'-Octachlorobiphenyl
2,2',3,4'-Tetrachlorobiphenyl	2,2',3,3',4,4'-Hexachlorobiphenyl	2,2',3,3',4,5,5',6-Octachlorobiphenyl
2,2',3,4-Tetrachlorobiphenyl	2,2',3,3',4,5'-Hexachlorobiphenyl	2,2',3,3',4,5,6,6'-Octachlorobiphenyl
2,2',3,5'-Tetrachlorobiphenyl	2,2',3,3',4,5-Hexachlorobiphenyl	2,2',3,3',4,5',6,6'-Octachlorobiphenyl
2,2',3,6'-Tetrachlorobiphenyl	2,2',3,3',4,6'-Hexachlorobiphenyl	2,2',3,3',5,5',6,6'-Octachlorobiphenyl
2,2',3,6-Tetrachlorobiphenyl	2,2',3,3',5,6'-Hexachlorobiphenyl	2,2',3,4,4',5,5',6-Octachlorobiphenyl
2,2',4,4'-Tetrachlorobiphenyl	2,2',3,3',5,6-Hexachlorobiphenyl	2,3,3',4,4',5,5',6-Octachlorobiphenyl
2,2',4,5'-Tetrachlorobiphenyl	2,2',3,3',6,6'-Hexachlorobiphenyl	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
2,2',4,5-Tetrachlorobiphenyl	2,2',3,4,4',5'-Hexachlorobiphenyl	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl
2,2',5,5'-Tetrachlorobiphenyl	2,2',3,4,4',5-Hexachlorobiphenyl	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl
2,2',5,6'-Tetrachlorobiphenyl	2,2',3,4,4',6'-Hexachlorobiphenyl	Decachlorobiphenyl
2,2',6,6'-Tetrachlorobiphenyl	2,2',3,4,5,5'-Hexachlorobiphenyl	Aroclor 1016
2,3,3',4'-Tetrachlorobiphenyl	2,2',3,4',5,5'-Hexachlorobiphenyl	Aroclor 1221
2,3,3',5'-Tetrachlorobiphenyl	2,2',3,4,5',6-Hexachlorobiphenyl	Aroclor 1232
2,3,4,4'-Tetrachlorobiphenyl	2,2',3,4',5',6-Hexachlorobiphenyl	Aroclor 1242
2,3',4,4'-Tetrachlorobiphenyl	2,2',3,4,5,6'-Hexachlorobiphenyl	Aroclor 1248
2,3',4,5-Tetrachlorobiphenyl	2,2',3,5,5',6-Hexachlorobiphenyl	Aroclor 1254
2,3',4',5-Tetrachlorobiphenyl	2,2',4,4',5,5'-Hexachlorobiphenyl	Aroclor 1260
2,3',4,6-Tetrachlorobiphenyl	2,3,3',4,4',5'-Hexachlorobiphenyl	Total PCBs
2,3,4',6-Tetrachlorobiphenyl	2,3,3',4,4',5-Hexachlorobiphenyl	
RADIONUCLIDES		
Be-7	Pb-210	Po-210
Cs-137		
SEMIVOLATILE ORGANICS		
Aniline	Dibenzothiophene	Monobutyltin
Azobenzene	Dibutyltin	2-Nitroaniline
Benzidine	1,2-Dichlorobenzene	3-Nitroaniline
Benzo(b)thiophene	1,3-Dichlorobenzene	4-Nitroaniline
Benzoic acid	1,4-Dichlorobenzene	Nitrobenzene
Benzyl alcohol	3,3'-Dichlorobenzidine	2-Nitrophenol
Biphenyl	2,4-Dichlorophenol	4-Nitrophenol
bis(2-Chloroethoxy)methane	Diethyl phthalate	N-nitrosodimethylamine
bis(2-Chloroethyl)ether	Dimethylphthalate	N-nitroso-di-phenylamine
bis(2-Chloroisopropyl)ether	2,4-Dimethylphenol	N-nitroso-di-propylamine
bis(2-Ethylhexyl)phthalate	2,6-/2,7-Dimethylnaphthalene	Pentachloroanisole
4-Bromophenyl phenyl ether	Di-n-butyl phthalate	Pentachlorobenzene
Butylbenzylphthalate	Di-n-octyl phthalate	Pentachloronitrobenzene
Carbazole	4,6-Dinitro-o-cresol	Phenol
4-Chloroaniline	2,4-Dinitrophenol	Pyridine

Chlorobenzilate	2,4-Dinitrotoluene	1,2,3,4-Tetrachlorobenzene
2-Chloronaphthalene	2,6-Dinitrotoluene	1,2,4,5-Tetrachlorobenzene
2-Chlorophenol	Hexachlorobenzene	Tetrabutyltin
4-Chloro-3-methylphenol	Hexachlorobutadiene	Tributyltin
4-Chlorophenyl phenyl ether	Hexachlorocyclopentadiene	1,2,4-Trichlorobenzene
Chlorpyrifos	Hexachloroethane	2,4,5-Trichlorophenol
o-Cresol	Isophorone	2,4,6-Trichlorophenol
Dacthal	4-Methylphenol	Trifluralin
Dibenzofuran	3-Methylphenol/4-methylphenol	TPH
VOLATILE ORGANICS		
Acetone	1,4-Dichloro-2-butene, trans-	Methyl-tert-butyl ether
Acid volatile sulfides	Dichlorodifluoromethane	Methyl ethyl ketone
Acrolein	1,1-Dichloroethane	Methyl iodide
Acrylonitrile	1,2-Dichloroethane	Methyl methacrylate
Allyl chloride	1,1-Dichloroethene	4-Methyl-2-pentanone
Benzene	1,2-Dichloroethylene, cis-	Propionitrile
Bromobenzene	1,2-Dichloroethylene, trans-	N-Propylbenzene
Bromochloromethane	1,2-Dichloroethylene, total	Styrene
Bromoform	1,2-Dichloropropane	1,1,1,2-Tetrachloroethane
BTEX, Total	1,3-Dichloropropane	1,1,2,2-Tetrachloroethane
n-Butylbenzene	1,3-Dichloropropane	Tetrachloroethylene
sec-Butylbenzene	2,2-Dichloropropane	Tetrahydrofuran
tert-Butylbenzene	1,1-Dichloropropene	Toluene
Carbon disulfide	1,3-Dichloropropene, cis-	1,2,3-Trichlorobenzene
Carbon tetrachloride	1,3-Dichloropropene, trans-	1,1,1-Trichloroethane
Chlorobenzene	1,4-Dioxane	1,1,2-Trichloroethane
Chlorodibromomethane	Ethyl methacrylate	Trichloroethylene
Chloroethane	Ethylbenzene	Trichlorofluoromethane
2-Chloroethylvinylether	2-Hexanone	1,2,3-Trichloropropane
Chloroform	Isobutyl alcohol	1,2,4-Trimethylbenzene
Chloroprene	Isopropylbenzene	1,3,5-Trimethylbenzene
2-Chlorotoluene	p-Isopropyltoluene	Vinyl acetate
4-Chlorotoluene	Methacrylonitrile	Vinyl chloride
1,2-Dibromo-3-chloropropane	Methyl bromide	Xylene, m&p
1,2-Dibromoethane	Methyl chloride	Xylene, o-
Dichlorobromomethane	Methylene bromide	Xylenes, total
1,4-Dichloro-2-butene, cis-	Methylene chloride	

Table 4-3: Studies Relevant to the Initial Historical Data Evaluation

PREMIS STUDY ID	ORGANIZATION/ PROGRAM	STUDY NAME
465	NOAA	NOAA NS&T Hudson-Raritan Phase I, 1991
466	NOAA	NOAA NS&T Hudson-Raritan Phase II, 1993
471	NYSDEC	NYSDEC 1975
472	NYSDEC	NYSDEC 1980
473	NYSDEC	NYSDEC 1983
474	NYSDEC	NYSDEC 1984
475	NYSDEC	NYSDEC 1985
476	NYSDEC	NYSDEC 1987
477	NYSDEC	NYSDEC 1990
478	NYSDEC	NYSDEC 1993
479	NYSDEC	NYSDEC 1994
480	NYSDEC	NYSDEC 1995
481	NYSDEC	NYSDEC 1997
482	NYSDEC	NYSDEC 1998
483	TAMS	TAMS Hudson River Database, HR-002 (1992)
484	TAMS	TAMS Hudson River Database, HR-003 (1992)
485	TAMS	TAMS Hudson River Database, HR-004 (1992)
486	TAMS	TAMS Hudson River Database, HR-006 (1992)

PREMIS STUDY ID	ORGANIZATION/ PROGRAM	STUDY NAME
462	USEPA	EPA EMAP 90-92
463	USEPA	REMAP, 1993
464	USEPA	REMAP, 1994
564	USEPA	REMAP, 1998
97	USEPA	PASSAIC 1990 Surficial Sediment Investigation
98	USEPA	PASSAIC 1991 Core Sediment Investigation
99	USEPA	PASSAIC 1992 Core Sediment Investigation
100	USEPA	PASSAIC 1993 Core Sediment Investigation - 01 (March)
104	USEPA	PASSAIC 1993 Core Sediment Investigation - 02 (July)
106	USEPA	PASSAIC 1993 USEPA Surficial Sediment Program
107	USEPA	PASSAIC 1994 USEPA Surficial Sediment Program
119	USEPA	PASSAIC 1995 Biological Sampling Program
120	USEPA	PASSAIC 1995 RI Sampling Program
121	USEPA	PASSAIC 1995 Sediment Grab Sampling Program
122	USEPA	PASSAIC 1995 USACE Minish Park Investigation
144	USEPA	PASSAIC 1996 Newark Bay Reach A Sediment Sampling Program
146	USEPA	PASSAIC 1997 Newark Bay Reach B, C, D Sampling Program
147	USEPA	PASSAIC 1997 Outfall Sampling Program
148	USEPA	PASSAIC 1998 Newark Bay Elizabeth Channel Sampling Program
149	USEPA	PASSAIC 1999/2000 Minish Park Monitoring Program
530	USEPA	PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program
531	USEPA	PASSAIC 1999 Newark Bay Reach ABCD Baseline Sampling Program
532	USEPA	PASSAIC 1999 Sediment Sampling Program
533	USEPA	PASSAIC 2000 Spring ESP Sampling Program
534	USEPA	PASSAIC 2001 Supplemental ESP Biota Sampling Program
535	USACE	93F62MT: MOTBY (MILITARY OCEAN TERMINAL AT BAYONNE)
536	USACE	93F64CL: CLAREMONT 93 REACH III (93FCLMT)
537	USACE	93F64HR: HACKENSACK RIVER
538	USACE	93F64PE: PORT ELIZABETH 93
539	USACE	94F36BU: BUTTERMILK
540	USACE	94F41HU: HUDSON_RIVER
541	USACE	94F62LI: LIBERTY_ISLAND
542	USACE	95F34BR: BAY_RIDGE
543	USACE	95F34RH: RED_HOOK
544	USACE	95F64CL: CLAREMONT_RETEST
545	USACE	95F64PJ: PORT_JERSEY
546	USACE	96PEXXON: EXXON
547	USACE	96PNBCDF: NEWARK BAY CONFINED DISPOSAL FACILITY
548	USACE	96PPANYNJ: PORT AUTHORITY NEW YORK NEW JERSEY
550	USACE	97F62RH: ACOE_RED_HOOK_FLATS
551	USACE	97F62RH_RE: COE_RED_HOOK_FLATS_RETEST

4.1.2 Data Quality

Prior to conducting the preliminary historical data evaluation, a data quality screening process was devised and used to determine whether or not available historical data contained sufficient information for inclusion in the project database. A list of 45 attributes that are the most useful in establishing data quality and in assessing data usefulness was compiled into a checklist and is presented as Table 4-4.

Further details regarding the data quality screening process are discussed in the Technical Memorandum: Preliminary Data Quality Scheme – Passaic River Restoration Project Superfund Site (Battelle, 2004). In summary, the data screening resulted in all 58 relevant studies being assessed as acceptable for this evaluation.

Table 4-4: Comprehensive List of All Screening Items

General Information		Field Data		Analytical Data		Other Information	
Item No.	**Screening Item**	**Item No.**	**Screening Item**	**Item No.**	**Screening Item**	**Item No.**	**Screening Item**
1	Study Number	15	Reference or Area Lat/Lon Location Data	28	Units	44	Login(s)
2	Data Quality Level	16	Sample Lat/Lon Location Data	29	Lab Qualifiers	45	Record Count
3	Program	17	Sample Northings/ Eastings	30	Final Qualifiers		
4	Study ID	18	Collection Start Date	31	Detect limit		
5	Study Name	19	Collection End Date	32	Analytical QC Samples		
6	Organization	20	Field QC samples	33	Analysis Methods		
7	Study Year	21	Collection depth top	34	Lab Name		
8	File name	22	Collection depth bottom	35	Extraction Method		
9	Study Start Date or Min sample collection date	23	Collection depth units	36	Extraction Dates		
10	Study End Date or Max sample collection date	24	Field sample size	37	Sample wt/volume		
11	Test type	25	Field sample size units	38	Sample wt/ volume units		
12	List distinct media reported	26	Media	39	Percent Moisture		
13	List distinct chemical class reported	27	Species	40	Percent lipids		
14	Is Program CLP Level Program?			41	Analysis Dates		
				42	Validation level		
				43	Dilution		

4.1.3 Summary of Results

This section summarizes the major findings of the preliminary historical data evaluation for the following classes of chemicals. A list of the parameters selected as benchmark chemicals is included in Table 4-5. Evaluations have not yet been conducted for conventional parameters [such as total suspended solids (TSS), dissolved organic carbon (DOC), particulate organic carbon (POC), grain size, hardness, and pH] or total petroleum hydrocarbons (TPH). Benchmark chemicals were chosen based on professional judgment with regard to:

- Preponderance in the system;
- Magnitude of detection;
- Representativeness of chemical class;
- Toxicity and potential risk to human and ecological receptors.

The primary categories of selected benchmark chemicals include:

- Metals.
- Pesticides/Herbicides.
- Volatile Organic Compounds (VOCs).
- Semi-Volatile Organic Compounds (SVOCs).
- PCBs.
- Dioxins/Furans.

For each chemical class, Table 4-6 summarizes the number of surface and subsurface sediment samples included in the historical data evaluation, the SQGs used, and the benchmark chemicals selected. Refer to Plates 2 through 34, which illustrate the spatial distribution of benchmark chemicals in the sediment. Refer to Tables 4-7 and 4-8 for summaries of the benchmark chemicals.

Table 4-5: Chemicals Identified as Benchmark Chemicals

Benchmark Chemical	Areas of Generalized Surface Contamination	Location of Maximum Detected Surface Concentration
METALS		
Lead	RMs 2.0-4.0 (Harrison Reach) and 6.0-7.0 (Kearny Reach)	RM 17 (Upstream Reach)
Mercury	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 8.7 (Upstream Reach)
Silver	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 6.86 (Upstream Reach)
Cobalt	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 3.55 (Harrison Reach)
Zinc	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 7.0 (Upstream Reach)
PESTICIDES/HERBICIDES		
DDT	RMs 2.0-4.0 (Harrison Reach) and 6.0-7.0 (Newark and Kearny Reaches)	RM 2.21 (Harrison Reach)
Chlordane	RMs 2.0-4.0 (Harrison Reach)	RM 6.49 (Kearny Reach)
Dieldrin	RMs 2.0-4.5 (Harrison Reach)	RM 1.1 (Point No Point Reach)
Mirex	RMs 2.0-4.0 (Harrison Reach)	RM 2.13 (Point No Point Reach)
VOCs		
Xylenes	RMs 0.0-6.5 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 1.2 (Point No Point Reach)
Methyl ethyl ketone	RMs 1.0-6.5 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 1.46 (Point No Point Reach) (Not above sediment screening quality guideline for surficial sediment)
SVOCs		
HMW PAHs	Between RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 4.5 (Newark Reach)
LMW PAHs	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 4.5 (Newark Reach)
PCBs		
PCBs	RMs 1.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 5.95 (Kearny Reach)
DIOXINS/FURANS		
2,3,7,8 TCDD and Dioxin/Furan TEQ	RMs 2.5-4.5 (Harrison Reach)	RM 2.64 (Harrison Reach)

Table 4-6: Summary of Samples, Sediment Quality Guidelines, and Benchmark Chemicals Selected

Chemical Class	**Number of Samples**			**Sediment Quality Guidelines Used**	**Benchmark Chemicals Selected**
	Surficial (1)	**Subsurface**	**Total Discrete Cores (2)**		
Metals	378	643	147	1998 NJDEP Marine/ Estuarine Sediment Screening Guidelines (Long, *et al.*, 1995) ER-M.	Lead; mercury; silver; cobalt; zinc.
Pesticides/ Herbicides	261	626	135	1998 NJDEP Marine/ Estuarine Sediment Screening Guidelines (Long, *et al.*, 1995) ER-M, ER-L.	Total DDT; total chlordane; dieldrin; mirex.
VOCs	142	537	110	1998 NJDEP Marine/ Estuarine Sediment Screening Guidelines (Long, *et al.*, 1995) ER-M, ER-L were not available. Therefore, the most conservative screening values from other screening guidelines were used (3).	Total xylenes; methyl ethyl ketone.
SVOCs	244 (330 for PAHs)	622 (611 for PAHs)	134 (133 for PAHs)	1998 NJDEP Marine/ Estuarine Sediment Screening Guidelines (Long, *et al.*, 1995) ER-M, ER-L were not available for SVOCs. For PAHs, the 1997 NOAA Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments, ER-M values, were used. The most conservative screening values from all other screening guidelines were used for all other SVOCs (3).	High Molecular Weight PAHs; Low Molecular Weight PAHs.
PCBs	255	580	127	1998 NJDEP Marine/ Estuarine Sediment Screening Guidelines (Long, *et al.*, 1995) ER-M.	Total PCBs.
Dioxins/ Furans	267	598	126	1998 NJDEP Marine/ Estuarine Sediment Screening Guidelines (Long *et al.*, 1995) ER-M and ER-L were not available. Therefore, a 1 ng TEQ/g (TEQ = Toxic Equivalency Quotient) screening value was used as published by the WHO (Van den Berg, *et al.*, 1998).	2,3,7,8-TCDD; dioxin TEQ.

(1) Surficial samples include discrete samples and surface grabs.
(2) Number of cores was determined assuming that the “location_ID” field in the database represents the location of a sediment core.
(3) These screening criteria include:

- National Ambient Water Quality Criteria (NAWQC): 1997 Sediment Quality Benchmarks, Marine/Estuarine - NAWQC Chronic Values.
- NAWQC: 1997 Sediment Quality Benchmarks, Marine/Estuarine - NAWQC Secondary Chronic Values.
- USEPA Office of Solid Waste and Emergency Response Ecotox Thresholds. As cited in Jones, *et al.*, 1997.
- USEPA Region 5, RCRA Ecological Screening Levels, 2003.
- NOAA: Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments, ER-M Values, 1997.
- WHO TEQs (Van den Berg, *et al.*, 1998).

Table 4-7: Statistical Report for Benchmark Chemicals in Surface Sediment

Chemical	Min. Conc.	Max. Conc.	Average Conc. (Arithmetic Mean)	Detection Frequency	SQG Conc.	Exceedance Frequency	Units
Lead	< 0.01	2200	252	337 / 344	218	225/344	ppm
Mercury	< 0.01	12.4	3.0	261 / 344	0.71	242/344	ppm
Silver	< 0.01	39.5	4.5	227 / 341	3.7	127/341	ppm
Cobalt	< 0.01	41.1	8.9	299 / 321	NA[1]	NA	ppm
Zinc	< 0.01	1900	425	332 / 344	410	213/344	ppm
Total DDT	6.0	5980	231	238 / 261	46	216/261	ppb
Total Chlordane	3.0	210	49	130 / 232	6.0	126/232	ppb
Dieldrin	3.0	270	27	119 / 261	8.0	110/261	ppb
Mirex	8.0	135	26	12 / 13	7.0	12/13	ppb
Total Xylenes	2.0	440	108	13 / 142	25	9/142	ppb
Methyl ethyl ketone	9.0	83	36	29 / 142	43	9/142	ppb
HMW PAHs (total)	1,500	1,400,000	30,062	326 / 330	9,600	288/330	ppb
LMW PAHs (total)	210	1,410,000	10,603	299 / 330	3,160	158/330	ppb
Total PCBs	230	2,482	1,219	16/16	Not calculated	Not calculated	ppb
2,3,7,8-TCDD	2	13,500	518	260 / 266	NA	NA	ppt

(1): "NA" = None Available

Table 4-8: Statistical Report for Benchmark Chemicals in Subsurface Sediment

Chemical	Min. Conc.	Max. Conc.	Average Conc. (Arithmetic Mean)	Detection Frequency	SQG Conc.	Exceedance Frequency	Units
Lead	1.0	22,000	527	573/619	218	443/619	ppm
Mercury	0.01	29.6	7.7	511/618	0.71	472/618	ppm
Silver	0.63	26.7	9.1	413/616	3.7	363/616	ppm
Cobalt	2.6	42.9	12.8	570/616	NA[1]	NA	ppm
Zinc	10.8	3,110	789	592/619	410	432/619	ppm
Total DDT	4.1	18,600,000[2]	61,250[2]	471/606	46	417/606	ppb
Total Chlordane	3.0	791	72	328/578	6.0	311/578	ppb
Dieldrin	1.3	580	63	313/615	2.0	312/615	ppb
Mirex	No subsurface samples						
Total Xylenes	3.0	150,000	1,130	233/526	25	216/526	ppb

Chemical	Min. Conc.	Max. Conc.	Average Conc. (Arithmetic Mean)	Detection Frequency	SQG Conc.	Exceedance Frequency	Units
Methyl ethyl ketone	10.0	7,200	109	315/526	43	196/526	ppb
HMW PAHs (total)	220	2,290,000	43,500	517/611	9,600	451/611	ppb
LMW PAHs (total)	280	5,460,000	39,700	474/610	3,160	322/610	ppb
Total PCBs	180	27,560	2,774	351/580	Not calculated	Not calculated	ppb
2,3,7,8-TCDD	0.072	5,300,000	22,000	524/598	NA	NA	ppt

1 – None Available

2 – It should be noted that this sample concentration is anomalous when compared to all of the other Total DDT sample results. Therefore, it is possible that this value is unreliable.

4.1.4 Data Gaps Identified from Preliminary Historical Data Evaluation

During the surface sediment data evaluation process, the following data gaps were identified:

- Data are needed regarding loads coming in from tributaries, point sources, and the Passaic River above the Dundee Dam. These represent external loads to the system that must be compared to the internal loads generated by river sediments. Understanding internal versus external loadings is essential for forecast simulations (*e.g.*, sediment loading, bioaccumulation, cumulative risks).
- Data are needed to describe the extent of contamination in the upper reaches of the Lower Passaic River. The majority of historical samples were collected from the sediments of the lower six miles of the Lower Passaic River. Tidal displacement may serve to disperse contaminants and contaminate sediments upstream and downstream of sources.
- Data are needed to describe the extent of contamination down estuary of the Conrail Bridge to RM 0.
- Data are needed to better describe the vertical extent of contamination. Knowledge of the vertical extent of contamination is essential to assess impacts of erosion, depth of biological exposure, and potential for groundwater migration of contaminants, as well as engineering parameters related to evaluation of remedial scenarios or restoration opportunities.
- Data are needed to describe mercury geochemistry and in particular, methylmercury formation. This is important since mercury bioaccumulation is generally driven by methylmercury concentrations.

- Surface water samples are needed to fully describe conditions in the estuary. Very few historical surface water samples are available for the Lower Passaic River. Surface water samples provide a measure of biological exposure, as well as important geochemical information on contaminant fate and transport and external loads.
- PCB congener data are needed to help identify internal and external loads of PCBs.

These data gaps were considered in the development of DQOs [refer to Section 1.5 of the QAPP – Quality Objectives and Criteria (Malcolm Pirnie, Inc., 2005b) for further information]. Aquatic organism tissue data gaps will be considered in the development of Field Sampling Plan Volume 2.

4.2 GEOCHEMICAL EVALUATION OF EXISTING DATA

Attachment B contains a compact disk containing analyses of existing geochemical data. These analyses include:

- Bathymetric change analysis – the bathymetric data sets from 1989 and 2004 were compared to determine the changes in the river bottom over time.
- Sediment geochemistry analysis for the following chemicals: 2,3,7,8-TCDD, DDT and its derivatives, PAHs, mercury, Cesium-137 (Cs-137), and Lead-210 (Pb-210).

These analyses were used in the preparation of this document, the CSM, and sampling design detailed in the FSP.

5.0 FIELD INVESTIGATION TASKS

5.1 OVERVIEW

This section summarizes field investigation tasks required to support the data needs of the CERCLA and WRDA programs. Figure 5-1 provides an example overall decision strategy identifying major components of the field sampling program, sources of input, and the interactive nature of these components.

More detailed information regarding the field tasks can be found in the Field Sampling Plan Volume 1 (Malcolm Pirnie, Inc., 2005c), Volume 2 (to be published in 2006), and Volume 3 (Malcolm Pirnie, Inc., 2005d) for the LPRRP, as described in Section 3.4. Additional information regarding quality assurance/quality control (QA/QC) procedures for these sampling events can be found in the QAPP (Malcolm Pirnie, Inc., 2005b). Each task is linked to the appropriate section of the PMP (USACE, *et al.*, 2003), which is the initial planning document for the LPRRP.

5.2 BATHYMETRIC AND GEOPHYSICAL SURVEYS (PMP TASKS JAA, JDE)

The following subsections outline the bathymetric and geophysical surveys. Standard Operating Procedures for conducting these surveys are fully detailed in FSP Volume 3 (Malcolm Pirnie, Inc., 2005d).

5.2.1 Base Maps and Bathymetric, Aerial, and Supplemental Land Surveys

Bathymetric and aerial surveys will be conducted to describe local topography, assess sediment stability and characterize restoration sites in the Lower Passaic River watershed. The following data needs will be met:

- Evaluate the river's configuration and geomorphology and compare these characteristics to historical data.
- Identify areas of high shear and low shear stress which, in conjunction with the geophysical surveys, will identify potential sediment scour/deposition areas in the Passaic River.
- Delineate in-river habitats, including in-channel, near-shore, mudflat, and submerged aquatic vegetation beds.
- Support feasibility analyses and evaluation of remedial and restoration alternatives.

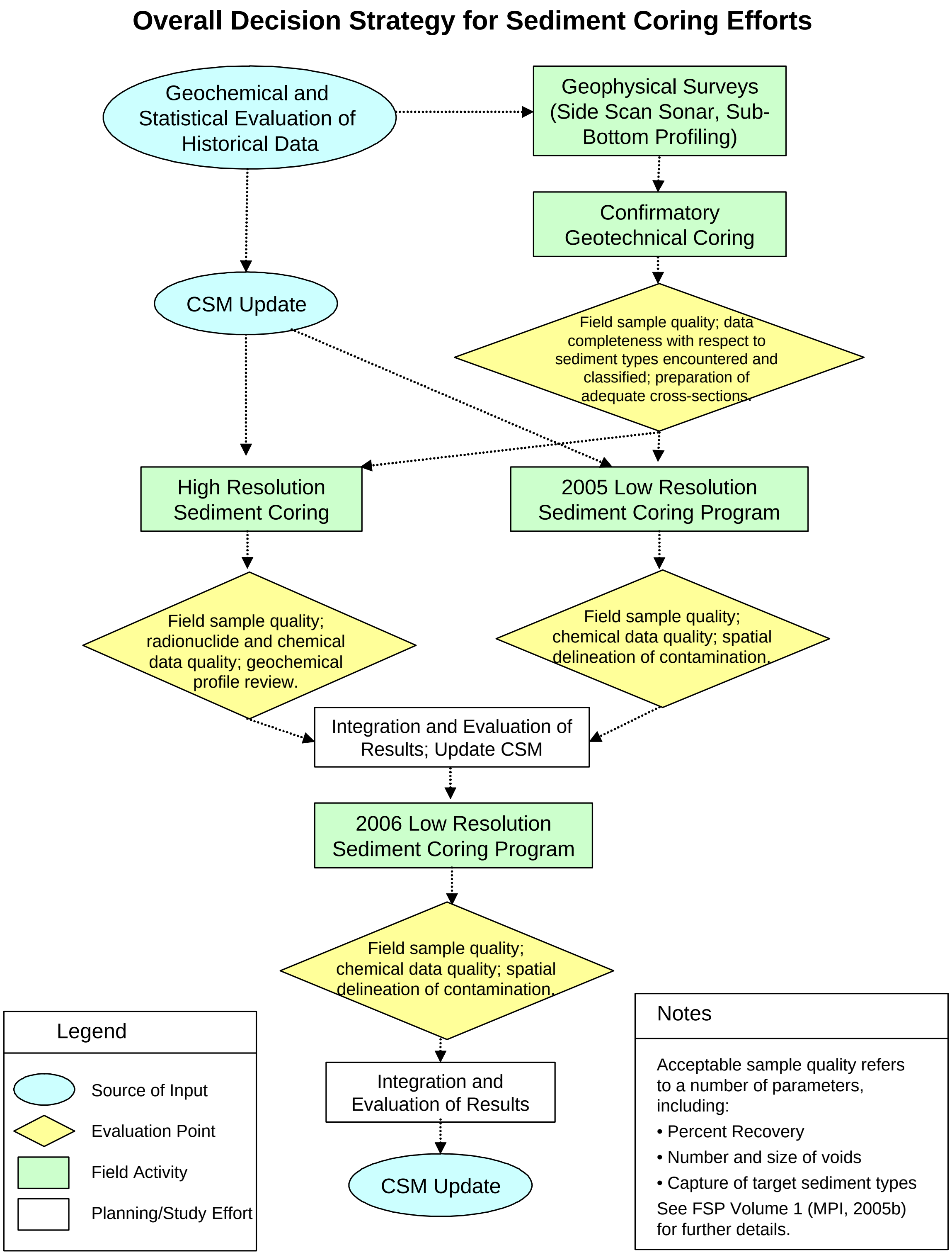


Figure 5-1: Example Overall Decision Strategy

- Determine the elevation and topography of candidate sites to support restoration design.
- Determine the grades of the side slopes of the Passaic River and tributaries to support design of bank stabilization/re-grading measures that may be necessary during restoration.
- Develop hydraulic analyses, which will aid in the design of the re-grading plan.
- Determine site access and locations of utilities and other underwater objects.

5.2.1.1 Bathymetric Surveys

In 2004, the USACE conducted a bathymetric survey for the Study Area. These bathymetric and shoreline data cover much of the 17-mile stretch of the Lower Passaic River, extending to RM 15.8. Based on the data collected, mapping of the Passaic River bathymetry and shoreline will be developed in support of the data collection goals as presented above.

5.2.1.2 Aerial Surveys

To survey outside the channel of the Passaic River and upland adjacent areas, Digital Ortho Photography (aerials) will be obtained. The aerial photographs will be sufficiently accurate to produce 0.5-foot contours on one inch equals thirty feet (1? = 30') scaled maps. The actual contour intervals will be specified in the QAPP (Malcolm Pirnie, Inc., 2005b) contingent on expected local data use and any modeling requirements. Data collected will be integrated with data collected from bathymetric surveys to create bathymetric and shoreline maps of the 17-mile stretch of the Lower Passaic River.

5.2.1.3 Land Surveys

Land surveys will be conducted in order to obtain data, develop mapping, and understand constraints for portions of candidate restoration sites not already addressed by existing data and the bathymetry/aerial surveys.

5.2.2 Geophysical Surveying

The geophysical survey will be conducted to support characterization of the nature of the river bottom sediment type, the associated nature and extent of contamination and the function and structure of potential restoration sites. The following data needs will be met:

- Assess the texture of the surficial sediment to understand the characteristics of the Passaic River bottom, characterize existing benthic habitat and invertebrate communities, and provide input to evaluating the feasibility of restoration activities (*e.g.*, wetland rehabilitation or benthic habitat restoration) and remedial actions (*e.g.*, capping, dredging) at various locations along the river.
- Estimate the amount/extent of debris and other targets (*e.g.*, utilities, wrecks) in the Lower Passaic River to evaluate the feasibility of remedial activities (*e.g.*, dredging, capping) and achieving restoration objectives at a particular site.
- Identify the sediment types and depths of stratigraphic layers to evaluate the locations and lengths of sediment cores that will be collected for chemical and physical analysis to support field investigation design and remedial engineering analyses.
- Develop interpretive diagrams of chronological sediment layering in the river bed. This will be a critical input in estimating whether highly contaminated sediments in the Lower Passaic River are stable or may be transported into Newark Bay. Identify the significant stratigraphic/depositional layers of the sediment to support investigations and engineering analyses.

The geophysical survey will consist primarily of a side-scan sonar (SSS) survey to characterize and map sediment texture in the Passaic River. Sub-bottom profiling will be implemented as a supplement to the SSS survey. The extent of the sub-bottom profiling effort will depend on its success in penetrating the river bottom as demonstrated in a geophysical prove-out survey (*e.g.*, if methane gas is present in high quantities, the acoustic signal may not penetrate the sediments and additional sub-bottom profiling efforts may not prove to be worthwhile).

SSS provides mosaic images of the investigation area while sub-bottom profiling investigates sediment stratigraphy and refines the geologic framework between coring locations. Resolution is expected to be approximately one square foot/pixel or finer. Acoustical techniques will be used to derive interpretive diagrams of the river bed, and to identify sediment characteristics of the river bed and active sedimentation processes; ground penetrating radar, supplemented by sampling, may be used as well. Confirmatory shallow sediment core and deep sediment core sampling of river bottom sediments will be conducted to calibrate and verify the results of the geophysical investigation and provide geotechnical information for the sediments.

These data will be used to delineate areas of fine- and coarse-grained sediments, areas of sedimentary bedforms indicative of potential sediment erosion and deposition, and benthic habitat. These data will also be used as a guide for placement of additional sediment cores to delineate the extent of contamination, and in characterizing aquatic habitats.

5.3 SEDIMENT INVESTIGATIONS (PMP TASKS JAC, JFB)

Several different types of sediment studies will be conducted during the LPRRP investigation. Each of the sediment studies is described below.

5.3.1 Confirmatory Coring for Geophysical Surveys

The initial 2005 sediment sample collection efforts are expected to consist of the collection of confirmatory "ground truth" samples to calibrate and verify the SSS and sub-bottom profiling geophysical surveys described in FSP Volume 3 (Malcolm Pirnie, Inc., 2005d) and summarized in Section 5.2.2 – Geophysical Surveying of this WP. Finely segmented, near-surface (approximately 1-2 feet in depth) push cores will be collected during the SSS confirmatory sampling effort. While shallow cores/grab samples will be collected to calibrate the side scan sonar imagery, the ground truth sampling required for the sub-bottom profiling will consist of the collection of deep cores. The data obtained from the geophysical ground truth program is expected to address the following project data needs:

- Identify physical features (*e.g.*, sediment type and stratigraphy) of the Lower Passaic River [refer to Data Quality Objective (DQO) Subtopic No. 4 in QAPP Attachment 1.1 (Malcolm Pirnie, Inc., 2005b)].
- Support of Geophysical Survey activities [refer to DQO Input No. 4e in QAPP Attachment 1.1 (Malcolm Pirnie, Inc., 2005b)].
- Characterize sediment transport in the Lower Passaic River to support model development [refer to DQO Subtopic No. 3 in QAPP Attachment 1.1 (Malcolm Pirnie, Inc., 2005b)].

- Select locations for high resolution sediment cores, low resolution sediment cores, and sediment erodibility experiments [refer to DQO Input No. 8h in QAPP Attachment 1.1 (Malcolm Pirnie, Inc., 2005b)].
- Identify physical properties of sediments for evaluation of remedial and restoration alternatives [refer to DQO Subtopic No. 22 in QAPP Attachment 1.1 (Malcolm Pirnie, Inc., 2005b)].
- Determine sediment characteristics to support evaluation of benthic habitat and restoration opportunities [refer to DQO Subtopic No. 28 in QAPP Attachment 1.1 (Malcolm Pirnie, Inc., 2005b)]. It is important to note that much of this data will be collected under FSP Volume 3 (Malcolm Pirnie, Inc., 2005d).

The cores will be advanced using vibracoring to expedite collection and maximize sediment core penetration. The cores will be advanced until refusal or pre-industrial sediments are encountered, so that each potentially contaminated stratum can be visually classified, (*i.e.*, using ASTM and unified soil classification system soil descriptions), and tested in the field using identification techniques.

The cores will not be segmented, but will simply be split open longitudinally and described in continuous, two-foot intervals. Record samples will be retained at the discretion of the field engineer. Selected sediment samples will be submitted to an off-site laboratory for physical properties analysis (*e.g.*, grain size) and TOC.

5.3.2 High Resolution Sediment Coring

The high resolution sediment coring program will provide data on long term contaminant stability and persistence in the sediments. The main goal of this study is to provide data on current and historical COPC/COPEC transport and fate via an examination of the sediment record in areas of continuous sediment deposition. The specific issues to be addressed in this study include:

- Recent trends in COPC/COPEC concentrations in sediments and, by implication, recent trends in mean annual water column COPC/COPEC concentrations.
- Nature and general location (river mile resolution) of current sources of COPCs/COPECs to the Lower Passaic River.
- Nature and general location of historical input of COPCs/COPECs to the Lower Passaic River.
- Rate of in-situ chemical degradation in the Lower Passaic River sediments.
- Anticipated residence time for COPCs/COPECs in the sediments.

- Geochemical processes affecting sediment COPC/COPEC levels, as well as fate and transport and bioavailability of COPCs/COPECs.
- Burial rate and age progression with depth of sediment using long-lived radionuclides.
- Presence of recent deposition (less than 6 months old) using short-lived radionuclides.

In the 2005 field sampling season, eight high resolution cores will be collected and analyzed for both radionuclide and chemical analysis. These cores will be collected from areas of relatively continuous fine-grained sediment deposition in the Lower Passaic River. Cores will vary from 2 to as much as 40 feet in length. Cores will be approximately evenly distributed along the lower Passaic, with one core every three miles (three cores in the lower six miles, four cores in the upper 11 miles, and one core upstream of the Dundee Dam). The location of high resolution sediment core samples and the core segmentation will be determined based on: geochemical evaluation of historical data, bathymetric change analysis, side scan sonar, sub-bottom profiling, and geotechnical prove-out surveys. In order to obtain eight datable cores, it may be necessary to collect cores from as many as 15 sites along the river, with subsequent radionuclide analysis to identify the best cores for further analysis.

As part of the preliminary geochemical evaluation of historical data (described on the attached CD), changes in bathymetry over time were analyzed to estimate both sediment deposition and erosion rates in the Study Area. Those rates varied from –5 (erosion) to +5 inches per year (deposition). High resolution cores will be obtained from a depositional setting.

Each high resolution core will be segmented into slices representing from one to 5 years of deposition, as estimated by the bathymetric change analysis and based on changes in sediment color or texture observed visually in the field. For planning purposes, local deposition rates will be used to identify sediment slicing intervals prior to core collection. An additional two or more high resolution cores may be required during the 2006 field sampling season to complete the investigation of the sediment contaminant depositional chronology.

The cores collected for this program will be interpreted as records of water-borne COPC/COPEC transport. Core X-radiographs will be obtained to examine the variation in sediment density along the length of the core.

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Based on the fine resolution of sediment cores (*i.e.*, 2 cm, 3, cm, 5 cm, and 20 cm) required for hydrodynamic/risk assessment modeling needs, samples collected from a single core for analysis are likely to be of insufficient size (*e.g.*, volume, mass) to meet analytical laboratory requirements for minimum sample size, possibly affecting reporting limits. Possible solutions can include reducing the number of analytes requested, co-locating cores to obtain sufficient sample volume, modification of equipment to obtain larger sample volume, or reaching agreement with USEPA and analytical laboratories to accept smaller sample volumes than specified in standard methods. None of these approaches is without problems or will satisfy every situation; it will be necessary to establish a decision framework collaboratively among USEPA Contract Laboratory Program (CLP) chemists and project team members.

5.3.3 Low Resolution Sediment Coring

A low resolution sediment coring investigation will be conducted within the Lower Passaic River. The objectives for the low resolution sediment coring program include:

- Delineation of the horizontal and vertical extent of sediment COPC/COPEC concentrations within the Lower Passaic River; gain of chemical data for risk assessment preparation.
- Confirmation of COPC/COPEC profiles in the lower six miles of the river, considering the age of available historical data and the potential for changes to the sediment surface due to seasonally and annually varying river flow and tidal fluctuations, movement of the salt front, as well as various major storm events and episodes of flooding.
- Investigation of previously unknown or poorly documented areas of sediment COPC/COPEC contamination, especially in the upper 11 miles of the Lower Passaic River and tributaries where little or no historical sampling has occurred.
- Estimation of the physical properties of the sediments within the Lower Passaic River.
- Modeling of bioturbation and support of calibration and validation of the hydrodynamic, sediment transport, and fate and transport models.

In the lower six miles of the Lower Passaic River [*i.e.*, the original Passaic River Study Area (or PRSA)], 15 to 25 co-located cores will be collected to confirm the utility of the 1995 and other historical TSI data sets. Co-located cores will be positioned to:

- Target varying contaminant concentrations in the historic data set (from the lower to the upper limits of the detected ranges),
- Explore various spatial characteristics of the known contaminant nature and extent (centers of known "hotspot" areas and fringes of contaminated areas), and
- Investigate both incomplete (depth extent of contamination not documented) and complete historic coring locations.

In the upper 11 miles of the Lower Passaic River, 25 to 35 low resolution cores will be installed along river cross sections, with each cross section located roughly 1 mile apart, with 3 cores on each cross section. This initial cross section spacing was chosen due to the reduced amount of historical subsurface sediment data available for this area.

Low resolution sediment coring samples will be collected via vibracoring, push coring, or piston coring, as necessary to obtain adequate recovery and retrieve representative sediment samples. The type of coring technique used will initially be selected based on the physical characteristics of the sediments. This may be field-corrected based on actual conditions encountered.

Each low resolution core will be segmented into approximately five core segments with each segment analyzed for a variety of chemical and physical parameters. The actual segment lengths will be dependent on the length of core obtained and the local historical information on the rate of deposition. It is expected that most core intervals will be approximately two feet in length, although the current segmentation scheme calls for finer segmentation of every third core to include 0-2 cm, 2-5 cm, 5-10 cm, and 10-30 cm (centimeters used for precision) near-surface aliquots to better characterize surface sediment conditions. Further information regarding core locations, spacing, target depth, and the final segmentation scheme is provided in FSP Volume 1 (Malcolm Pirnie, Inc., 2005c); these factors will be determined and modified accordingly based on geochemical data analysis of existing core data, geophysical surveys, results of the high resolution coring program, and field conditions observed during the low resolution coring program itself.

Based on the fine resolution planned for a subset of the sediment cores [*i.e.*, 2 cm, 3, cm, 5 cm, and 20 cm (centimeters used for precision)] to satisfy the data needs for geochemical characterization and hydrodynamic/risk assessment modeling, samples collected for analysis are likely to be of insufficient size (*e.g.*, volume and mass) to meet analytical laboratory requirements for minimum sample size, possibly affecting reporting limits. Possible solutions can include reducing the number of analytes requested, co-locating cores to obtain sufficient sample volume, modification of equipment to obtain larger sample volume, or reaching agreement with USEPA and analytical laboratories to accept smaller sample volumes than specified in standard methods. None of these approaches is without problems or will satisfy every situation; it will be necessary to establish a decision framework collaboratively among USEPA CLP chemists and project team members.

5.3.4 Vertical Mixing/Bioturbation

Vertical mixing of the sediments can be achieved by tidal flows, storms, wave action, boat traffic, scouring by ice or debris, dredging, and other physical processes, as well as by biological processes (bioturbation). The effects of physical processes cannot often be easily discerned from those due to biota. However, the net effect of the various processes is essentially the same – to mix the uppermost layers of the sediment.

Within stable sediment deposits, the most important natural process that brings contaminants to the sediment surface is bioturbation. In general, bioturbation is the active mixing of sediments by aquatic organisms. Bioturbation occurs in the uppermost layers of sediment in which the animals reside, with the most intensive activity in surficial sediments (generally on the order of centimeters), and a decrease in activity with increasing depth (Clarke, *et al*., 2001). In addition, the depth of mixing is also greater for marine/estuarine environments compared to freshwater environments. The extent and magnitude of the alteration caused by bioturbation depends on site location, sediment type, and the types of organisms and contaminants present.

The effects of vertical mixing can include:

- Alteration of sedimentary structures, thereby affecting analysis of the depositional history of sediments.

- Alteration of chemical forms of contaminants.
- Bioaccumulation in the tissues of benthic organisms resulting from exposure to deeper, more contaminated sediment.
- Transport of contaminants from the sediment to interstitial/pore water or the water column.
- Decrease in cohesion and bulk density due to burrowing (Boudreau, 1998).
- An increase or decrease in the ability of the sediment bed to resist erosion.
- Binding sediment particles and increased cohesion, due to secretions associated with tube building activities.

Because the effects of bioturbation are site-specific and can exhibit substantial spatial and seasonal variation, site-specific data will be required to scale the depths of the mixing zones in the freshwater, transitional, and brackish sections of the Passaic River. The scale of mixing and the sediment properties of surficial Passaic River sediments will be determined through the following:

- Measurements of short-lived (Be-7 and Th-234) radioisotopes in the top segments of sediment cores (including high resolution, and low resolution cores).
- High resolution X-radiograph and/or bulk density profiling of sediment cores (including high resolution cores, low resolution cores and mudflat cores).
- Sediment Profile Imagery (SPI) using a camera inserted into the sediments to photograph cross-section of sediment and biotic activity. The SPI will be used in conjunction with sediment cores collected during geophysical surveys to evaluate benthic populations residing in the Lower Passaic River. This device provides a snapshot of organisms residing in the shallow sediments, thus aiding in delineating the biologically active zone (BAZ) and identifying benthos present. Procedures for conducting SPI can be found in FSP Volume 3 (Malcolm Pirnie, 2005d).
- Oxidation-Reduction profile measurements to provide in-situ determination of reducing-oxidizing discontinuity, during high resolution, low resolution and mudflat sediment coring.

5.3.5 Sediment Transport Investigation

The sediment transport model that will be developed (refer to Section 7 – Hydrodynamic, Sediment Transport, Chemical Fate and Transport, and Bioaccumulation Modeling) will include sediment erosion, sediment transport, and deposition of both cohesive and non-cohesive sediments. Calibration of these processes requires that data be collected to determine site-specific values of parameters in the formulations describing these processes. The primary site characteristics that affect sediment stability are the shear stress at the river bottom under varying conditions and the physical properties of the upper sediment layers which can be affected by bioturbation. Bioturbation is discussed in Section 5.3.4 – Vertical Mixing/Bioturbation.

Sediment deposits can change significantly in spatial extent (both horizontal and vertical) and can be resuspended and redeposited by storms and other events (*e.g.*, dredging) that alter the river's hydraulic behavior. For the long-term prediction of both sediment and contaminant transport, one of the most significant processes to understand and quantify is sediment erosion. These rates can change by orders of magnitude, not only as a function of the applied shear stress due to waves and currents, but also as a function of horizontal location and depth in the sediment. To model the Lower Passaic River tidal system, the sediment transport investigation will consider erosion, settling/flocculation and water column transport processes by conducting special sediment studies. These studies will include:

- <u>Sediment Erosion</u> – Cohesive sediment erosion is highly site-specific, requiring site-specific measurements to define parameters during model formulation for erosion. Erosion rates depend on the relative magnitude of the shear strength of the sediment and the shear stress exerted on the sediment surface. The shear strength can be affected by the following parameters: bulk density, particle size, mineralogy, organic content, pore water salinity, amount of gas, oxidation or other chemical reactions, and consolidation time. Erosion measurements involve specialized devices to characterize the erodibility of sediments in the Passaic River: (1) Gust Microcosm will be used to understand erosion at the surface; (2) SedFlume will be used to understand erosion at depth. The erodibility experiments will be conducted in the field on cores collected from at least 15 locations in the river. Sediment cores will be collected using box/piston corers for these experiments During the Sedflume erosion test (Roberts, *et al*., 1998), small amounts of sediment will be removed at different depths in the core and used to determine the other bulk properties of the sediment sample including water content, grain size (using the Coulter Counter), bulk density (using ASTM Method D4531), and organic content.
  - For the surface sediments, Gust Microcosm field experiments will be conducted to test for changes in surficial sediment erodibility over the range of 0-0.4 Pa (Pascals) applied shear stress. These erosion tests, which involve increasing shear stress through approximately eight levels, with each level of constant stress lasting approximately 20 minutes, will be performed according to protocols described in detail in Sanford and Maa (2001). Further details of these tests are provided in Attachment 4 of FSP Volume 1 (Malcolm Pirnie, Inc., 2005c).
  - SedFlume experiments will be conducted on sediment cores to determine erosion rates as a function of depth and shear stress. This flume can measure erosion rates

of sediments at high shear stresses [up to stresses on the order of 20 N/m^2 (Newtons per square meter)] and with depth (down to a meter or more). Therefore, SedFlume measures in-situ sediment erosion at shear stresses ranging from normal flow to flood conditions and with depth below the sediment/water interface. Protocols for conducting SedFlume experiments are described in McNeil, *et al*. (1996).

- Sediment Settling/Flocculation – Settling is the downward movement of sediments through the water column due to gravity. In the case of cohesive sediments, flocs are formed by the process of flocculation, which is the result of simultaneously occurring aggregation and floc break-up processes. A combination of in-situ techniques is being considered to determine settling velocities of particles in the Passaic River. The first method is to conduct Modified Valeport Settling Tube experiments (Owen-type bottom withdrawal settling tube) on water column samples to determine suspended solids settling velocities. This instrument consists of a long, slender tube which is lowered in the water in the horizontal position to collect a water column sample. The protocols for determining the settling velocity using this tube are described in Sanford, *et al*. (2001). The second in-situ method includes the use of a laser in-situ scattering and transmissometry (LISST) instrument system in combination with an optical backscatter sensor (OBS). These devices have been used to determine concentration and fall velocities of estuarine particle populations in the lower Chesapeake Bay, and the details are described in Fugate and Friedrichs (2002). The third method of in-situ measurement involves the use of a video settling tube that optically monitors the settling flocs in a vertical tube. In this system, suspended flocs are captured in a so-called capture/stilling chamber. Digital image analysis techniques have been developed to establish floc size and settling velocity distribution; protocols and floc structure from video recordings are described in Eisma (1996) and Dyer, *et al.* (1996).

- Water Column Transport – Water column transport consists of the movement of sediments in the water column. Monitoring the concentrations of sediments and the grain size distributions in the water column will be done during the hydrodynamic investigations and during field work associated with water column sampling for contaminants. Studies conducted by Feng, *et al.* (1999 a, b) and Ciffroy, *et al.* (2003) suggest that naturally occurring radionuclides can be used as tracers to understand the processes affecting particle dynamics in estuarine environments since the source terms and the rates of radioactive decay for these radionuclides are well known. Be-7 (half-life of 53 days) and Th-234 (half-life of 24 days), which both have a strong affinity for particle surfaces, were found useful in discerning short-term variations in the Hudson River estuarine system. Using the protocols described in Feng, *et al.* (1999a, b) to determine the processes controlling the short-term fate and transport of particles within the Passaic River, two additional sampling efforts will be conducted. The first involves collecting large-volume water samples for analysis of Be-7 and Th-234 during the hydrodynamic investigations. The second involves obtaining surface sediment samples (0 to 0.5 cm), during the collection of sediment cores for the sediment erosion field experiments for Be-7 and Th-234. The radionuclide activities in the surface sediments will be used to understand the sources for the particles in the water column.

5.3.6 Sediment Sampling in Mudflats

Sediment sampling from semi-diurnally exposed mudflats within the Lower Passaic River will be conducted to determine the potential for adverse human health and ecological effects and further characterize the spatial extent of contamination. Unlike river sediments, mudflats are periodically exposed to varying degrees over the tidal cycle and therefore, could represent a higher potential for receptor exposure (*e.g.*, wading birds, shore birds, water fowl, mammals) to environmental contaminants via dermal contact and inadvertent ingestion.

There are three major objectives for sediment sampling from the mudflat areas:

- Contribute to the characterization of the spatial extent of contaminated sediments in the Lower Passaic River [(refer to DQO Subtopic Nos. 8 and 22 in Attachment 1.1 of the QAPP (Malcolm Pirnie, Inc., 2005b)].
- Characterize the human health risk posed to anglers, transients, or other persons who may walk or wade along the mudflats of the Passaic River [refer to DQO Subtopic No. 15 in Attachment 1.1 of the QAPP (Malcolm Pirnie, Inc., 2005b)].
- Characterize the ecological risks to plants, invertebrates, and fish that may live in or along the tidal mudflats or to animals that may incidentally contact contaminated sediments while foraging [refer to DQO Subtopic No. 20 in Attachment 1.1 of the QAPP (Malcolm Pirnie, Inc., 2005b)].

Sediment samples will be collected to a depth of four feet or to depth of refusal. These samples will be analyzed for a variety of parameters that could include, but are not necessarily limited to: COPCs/COPECs, grain size, biological oxygen demand (BOD), pH, total organic carbon (TOC), Total Kjeldahl Nitrogen (TKN), phosphorus, and nutrients.

Mudflat samples will be collected from flat-bottomed or shallow draft boats (*e.g.*, johnboat, pontoon boat, Zodiac) during high tide. Mudflat sediment samples will be collected using hand coring devices (such as push corers, hand augers, or piston samplers). At each sample location, an attempt will be made to collect up to four feet of core material, or to the depth of refusal. If at any individual sample location the substrate is such that four feet of sample cannot be retrieved, then the core sample will be collected to the deepest depth practicable. If field sampling events indicate that use of hand-coring devices is not practical, then consideration may be given to collection of mudflat sediment samples using direct push technology (if accessible).

For risk assessment data needs, particular care will be taken to collect a sample from each location above the sediment depth where the oxidation-reduction potential shifts from positive to negative (associated with the loss of oxygen with sediment depth). This boundary will be determined using a calibrated field oxidation-reduction potential probe to measure the boundary depth prior to sample collection. Visual cues, such as sediment color or texture that are determined to be useful in identifying this boundary depth, may also be used to expedite the sampling process. It is anticipated that the boundary will fall somewhere between two and four inches below the sediment surface, a depth that should roughly correspond to the bioactive zone.

Samples will be collected from areas identified as possibly being accessible by human receptors, known remnant marsh habitat of potential ecological significance, tributary confluences, and areas where mudflat habitat is evident from either recent study reports or as determined by review of available bathymetry data. The risk assessment needs will be primarily met based on the collection of surficial (as discussed in the following section) sediment samples. The need to evaluate ecological exposures to contaminants in deeper sediments will be determined following review of analytical data derived from sediment cores collected in 2005 jointly from the high resolution, low resolution, and mudflat sediment coring tasks.

Similar to the sample size limitations for high resolution and low resolution cores, the fine resolution of mudflat sediment core segmentation is likely to yield insufficient sample mass to meet analytical laboratory requirements for minimum sample size, possibly affecting reporting limits. Possible solutions can include reducing the number of analytes requested, co-locating cores to obtain sufficient sample volume, modification of equipment to obtain larger sample volume, or reaching agreement with USEPA and analytical laboratories to accept smaller sample volumes than specified in the methods. None of these approaches is without problems or will satisfy every situation; it will be necessary to establish a decision framework collaboratively among USEPA CLP chemists and project team members.

5.4 HYDRODYNAMIC AND WATER QUALITY INVESTIGATIONS (PMP TASKS JAB, JFB)

One of the important elements of the LPRRP is to develop and apply a scientifically-based model that incorporates hydrodynamic transport, sediment transport, contaminant fate and transport, and bioaccumulation processes. This model will be used as a tool for understanding historical and current sources and sinks of organic and inorganic contaminants in the Lower Passaic River and adjacent water bodies through mass balance analyses, as well as to provide the basis for an engineering evaluation of remedial and restoration alternatives. The goals of the hydrodynamic investigation are (1) to provide the baseline data set for calibrating and assessing the skill of the hydrodynamic components of the proposed Lower Passaic River Model, and (2) to characterize the aspects of the circulation and dispersive nature of the Lower Passaic River and describe how these processes change with tidal range and river discharge, as well as their impacts on sediment stability.

The activities that will be undertaken during this investigation include:

- Continuous monitoring using moored instrumentation installed at fixed stations within each section of the Lower Passaic River. This will result in collection of a fixed-point time series of a variety of model calibration and evaluation data, including current velocities, salinity, and temperature. Figure 5-2 illustrates the locations of moorings as installed by Malcolm Pirnie, Inc. and Rutgers University.
- Shipboard CTD (conductivity, temperature and depth) survey under varying tidal and flow conditions. The data collected during the shipboard surveys will supplement the data obtained from the moorings, and will help characterize the strength of the tidal, two-layer flow in the Lower Passaic River by delineating the location of the salt front and stratification as a function of river flow. These surveys will also provide intensive tracking of the salt front and its link to the estuarine turbidity maximum (ETM) zone.
- Cross-section ship-track surveys to provide information on cross-channel circulation, especially along river bends. These surveys will also provide water quality cross-sectional distribution data that will be useful in assessing the model's capability to simulate observed vertical and cross-channel shears in the flow. Assessment of the model's capability to adequately simulate vertical and cross-channel shears in flow is critical since vertical and horizontal shears drive dispersion in a tidal riverine system.
- Total suspended solids (TSS) analysis of water column samples to gain an understanding of the transport of fine-grained sediments in order to predict contaminant fluxes (since most COPCs/COPECs will be adsorbed to particulates). In the Lower Passaic River, there are various processes that cause TSS concentration to vary over time including: turbulence, semi-diurnal tides, diurnal tides, other tidal

harmonics, lower frequency tidal cycles, wind waves, watershed in-?ow, and climatic variability.

- TSS sampling to identify the ETM zone; this is a region where the concentration of TSS may be a hundred times greater than concentrations both seaward and landward.
- Sampling for naturally occurring radionuclides to determine the processes controlling the short-term fate and transport of particles within the estuary, especially at the ETM. In particular, paired measurements of Be-7 and Th-234 can be used to assess the source of suspended solids within the water column. In general, terrestrially derived suspended solids contain a high ratio of Be-7 to Th-234 whereas marine suspended solids contain more Th-234 and thus a lower Be-7 to Th-234 ratio.
- TSS sampling and correlation to turbidity at Dundee Dam to estimate sediment loading at the upstream study area boundary.

Details (*e.g.*, data needs and rationale) of the hydrodynamic and sediment transport investigations are described in the Hydrodynamic Sampling Plan, presented in FSP Volume 1 (Malcolm Pirnie, Inc., 2005c) as Attachment 4.

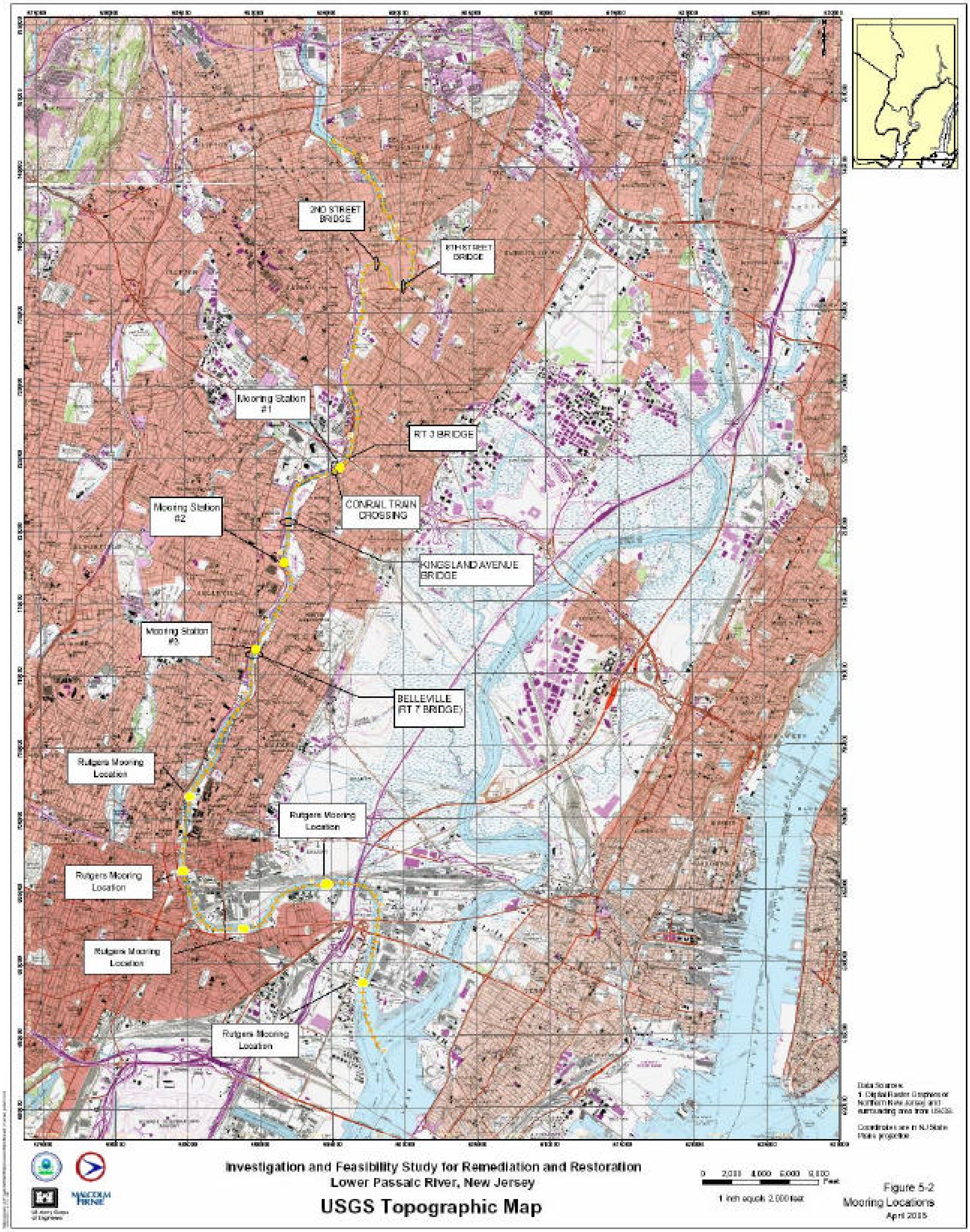

Figure 5-2: Mooring Locations

5.4.1 CSO Sampling

Combined sewers transport treated or untreated sanitary and industrial wastewater during dry weather conditions and combined wastewater and storm water runoff during wet weather conditions. Typically, these waters are sent to municipal treatment facilities, [*i.e.*, publicly owned treatment works (POTW)]. However, when the capacity of a POTW is exceeded, untreated excess wastewater is typically diverted via regulatory chambers directly to the receiving water body(ies). The regulatory chambers are usually located where local sewerage districts join the CSO trunkline. In these cases, CSO effluent can contribute substantially to total chemical loading in a riverine system (USEPA, 1994; USEPA, 1980).

Details of the CSOs and SWOs down-estuary of the Dundee Dam, including name, location, and receiving water body are provided in Table 2-2 and Figures 1-5 and 1-6. The CSO sampling program will involve collection of wastewater and settleable solids samples from CSOs that discharge into the Lower Passaic River. The samples will be analyzed for COPCs/COPECs to provide information regarding the loads of COPCs/COPECs discharged to the Lower Passaic River from CSOs. The estimated COPC/COPEC load contributions from CSOs to the Lower Passaic River will be used for:

- Establishing external source inputs of COPCs/COPECs in the Passaic River modeling framework.
- Analyzing fate and transport of COPCs/COPECs.
- Evaluating the effectiveness of remedial alternatives in the FS.
- Assessing the potential for recontamination subsequent to remedial and restoration activities.

5.4.2 Tributary and Head of Tide Water Column Sampling

There are many neighboring water body and tributary influences to the Lower Passaic River (*i.e.*, Upper Passaic River over the Dundee Dam, Saddle River, Third River, Second River, Franks Creek, Lawyer's Creek, Newark Bay, Arthur Kill, and Kill van Kull). Understanding the influence these water bodies have on the hydraulic properties and contaminant profile of the Lower Passaic River is necessary for determining the fate and transport of contaminants and for assessing the success of selected remedial actions. Continuous measurements of discharge and turbidity and discrete water column samples will be collected from Dundee Dam, just above the head of tide of the Lower Passaic River and from tributaries to the Lower Passaic River (Saddle River, Third River, and Second River), to characterize the COPC and COPEC distribution and external loads to the Lower Passaic River. At the Dundee Dam, discharge data will be used for correlating discharge data with current records from the USGS Little Falls monitoring station; the resulting correlation along with historical discharge information at the Little Falls Station will be used to reconstruct the water discharge history over the Dundee Dam. The water column monitoring program will be done over a period of twelve months and will involve the following:

- Continuous monitoring of discharge at the Dundee Dam and at the USGS gauging stations in Saddle River, Third River and Second River. At the Dundee Dam, a stream flow gauge and associated recording equipment will be installed and calibrated and a stage versus discharge relationship will be established at the dam.
- Continuous monitoring of turbidity across the river cross sections to obtain continuous TSS values and establish the degree of lateral mixing of the rivers prior to their entry into the Lower Passaic River. The goal of this turbidity monitoring is to establish the requirements for chemical monitoring at this location.
- Monitoring for TSS, POC, dissolved organic carbon, grain size, and COPC and COPEC concentrations under varying flow conditions. Composite water column samples will be collected under low flow and storm flow conditions, in a cross sectional transect. During the high flow storm event sampling, flow-weighted cross-sectional composite samples will be collected, one at the rising limb, one at the peak, and one at the falling limb of the storm hydrograph. It is expected that the grain size distribution will vary during the storm events and that COPC and COPEC concentrations may reflect these variations.

The external loads of COPC and COPECs determined by this monitoring program will provide boundary condition inputs to determine the potential for recontamination of proposed remedies and for the development and calibration of the Hydrodynamic and Fate and Transport Models [refer to DQO Subtopics Nos. 9 and 24 and the Data Needs/Data Uses Table in Attachment 1.1 of the QAPP (Malcolm Pirnie, Inc., 2005b)].

Similar sampling programs are currently being planned within adjacent water bodies (*e.g.*, Newark Bay). Activities within this Work Plan and activities underway within adjacent water bodies will be shared across studies and coordinated so that sampling and data overlap is avoided.

5.4.3 Tidal River Water Column Sampling

The COPCs and COPECs in the Passaic River system are numerous, and some are present are very low concentration levels. The behavior of these chemicals in aquatic systems is very complex and influenced by a number of environmental variables including, but not limited to, pH, temperature, reducing-oxidizing conditions, nutrient availability, biological activity, and the presence of inorganic and organic ligands. These factors can impact speciation (*i.e.*, mercury), distribution between sediment and water phases (*e.g.*, hydrophobic organic compounds and mercury), and cycling between inorganic and organic forms (*e.g.*, mercury). In addition, the biogeochemical behavior of hydrophobic organic compounds and organometals can be similar in the environment resulting in strong sorption to solid surfaces, the formation of very stable complexes with organic matter, and bioaccumulation in the food chain.

Water column samples are needed to appropriately characterize the hydrodynamic and hydrologic factors affecting the distribution, to determine source areas, and to understand the fate and transport of COPCs and COPECs in the Passaic River system. Critical to determining the appropriate methods for the collection and associated analyses is understanding if the COPCs and COPECs in the collected samples are at spatial and temporal equilibrium. If they are at equilibrium, then it may be acceptable to collect the samples in the field and then ship the samples to the laboratory for further preparation, extraction, and analysis. However, if the distribution of these chemicals is not at equilibrium, mass transfer of chemicals from one phase to another (*e.g.*, dissolved hydrophobic organic compounds sorbing to solids present in the water sample) can quickly occur. In this case, sample preparation in the field (*i.e.*, filtering of solids) is required.

Based on these questions the water column program will consist of an initial water column sampling program with the objective of providing baseline information that could be used to optimize future water column sampling. This initial program will consist of collecting data over a two month period, using multiple sampling techniques to obtain data on contaminates in the dissolved phase and the suspended solids. Seven transects have been established for initial water column sampling in the Lower Passaic

River. The transect locations and spacing were chosen based on tidal displacement and the location of tributaries and CSOs, and are described below:

- River Mile 17 (approximate): immediately down-estuary of Dundee Dam.
- River Mile 14.5 (approximate): down-estuary of Saddle River.
- River Mile 10.5 (approximate): down-estuary of Third River.
- River Mile 7.5 (approximate): down-estuary of Second River.
- River Mile 4.5 (approximate): down-estuary of CSOs near Newark.
- River Mile 2.5 (approximate): above known contaminated sediment areas in Harrison Reach.
- River Mile 0 (approximate): Newark Bay.

The initial sampling program will consist of:

- Time-Weighted Averaged Samples: These samples will be collected using semi-permeable membrane devices (SPMDs). SPMDs are passive water column sampling units that are deployed for days to months to provide information on dissolved phase hydrophobic organic compound concentrations.
- Small-Volume Grab Samples: Small volume water column transect grab samples will be collected during the ebb tide for metals and organics.
- Large Volume Composite Samples: This will include field-filtrating large volume water column samples for particulate and dissolved hydrophobic organic compounds and also collecting and shipping large volume whole water column samples for laboratory analysis of the dissolved and particulate phases. The results of these sets of samples could provide information on the stability of the different phases during the time period the whole water samples are shipped and filtered in the laboratory.

5.5 SEDIMENT POREWATER AND GROUNDWATER SAMPLING (PMP TASK JFB)

Porewater, defined as the water that occupies the spaces between sediment particles, can be isolated from the sediment matrix to conduct toxicity testing or to measure the concentration of COPCs and COPECs. In general, data from pore water sampling and analysis are used to: (1) determine the relationship between porewater and bulk sediment chemical concentrations, and (2) understand the transport of COPCs/COPECs to the water column through chemical partitioning, diffusion, bioturbation, and/or resuspension processes [refer to DQO Subtopic No. 10 the QAPP

(Malcolm Pirnie, Inc., 2005b)]. The porewater investigation for the LPRRP will be developed in 2006.

Groundwater discharging to the Lower Passaic River can be a source of contamination and can serve as a contaminant transport mechanism to the sediments, porewater and the water column. The volume of groundwater discharge to the Lower Passaic River is un-quantified and its importance as a contaminant source and transport mechanism is unknown. The magnitude of groundwater discharge can be estimated as follows: (1) use base-flow separation of stream flow data from the USGS gauging station on the Passaic River at Little Falls, upstream of the LPRRP to estimate groundwater recharge to the watershed, (2) calculate the recharge to the Lower Passaic River, and then (3) account for known groundwater withdrawals. A decision on the importance of evaluating groundwater further as a potential contaminant source and transport mechanism will be made by combining this information with a review of known information regarding groundwater contamination adjacent to the Lower Passaic River.

5.6 ATMOSPHERIC DEPOSITION MONITORING (PMP TASK JFB)

Atmospheric deposition is the contribution of atmospheric pollutants or chemical constituents to land or water ecosystems. Atmospheric deposition monitoring data will be used to estimate atmospheric loads of chemicals into the open water surfaces of the Study Area. Deposition over land is accounted for via the storm water runoff concentration and deposition over upstream water areas is accounted for via the tributary headwater concentration.

Atmospheric deposition is comprised of the following three components:

- Wet deposition, which accounts for materials transported via precipitation (*e.g.*, rain, fog, snow, dew, frost, hail) (Frick, *et al.*, 1998).
- Dry deposition, which accounts for chemicals deposited directly from the air (*e.g.*, dusts, aerosols, particles).
- Gas absorption, which refers to the process of gases being adsorbed onto the water surface from the atmosphere.

Atmospheric deposition loadings will be applied to the fate and transport model system based on data provided by the New Jersey Atmospheric Deposition Network

(NJADN). The following NJADN stations are contained within the modeling grid developed for the LPRRP: Liberty State Park, Sandy Hook, New Brunswick, and Chester. Some or all of these stations may be used to estimate deposition trends over the open water areas.

Atmospheric deposition loadings to the model for the Lower Passaic River will use the CARP loading generation protocol and available NJADN data for the following chemicals: Total PCBs, PCB homologues, dioxin/furan congeners, PAHs, pesticides, and metals, including mercury. Representative chemicals from these chemical classes will be chosen for inclusion in the model based on physicochemical properties as well as modeling efficiencies.

Using the CARP experience as a guide, historical deposition fluxes for PCB homologues, gases, particles, and precipitation values for each of the four stations are available from NJADN and may be applied directly to the LPRRP model. For mercury and cadmium, historical gas, particle, and precipitation flux data are available from NJADN on a harbor-wide basis; these were applied to the entire CARP model domain. For dioxin/furan congeners, NJADN did not calculate fluxes, but provided historical gas and particle concentration measurements for the Liberty State Park, Sandy Hook, and New Brunswick stations. NJADN protocols were used to develop the concentration measurements into fluxes. New Brunswick data were applied to both urban and northern, less urbanized tributary areas since Chester data were not available for dioxin/furan congeners.

5.7 CULTURAL RESOURCES REVIEW (PMP TASK JG)

This section discusses cultural resources surveys to be conducted in order to satisfy both CERCLA and WRDA requirements. To the extent possible, activities will be coordinated so that surveys can be merged into a single effort.

Section 106 of the National Historic Preservation Act of 1966 (as amended) requires federal agencies, or project sponsors seeking federal funding and/or permits, to take into account the effect of any undertaking on cultural resources included in, or eligible for inclusion in, the National Register of Historic Places (NRHP). As federal agencies, the USACE and USEPA are responsible for the identification, protection and preservation of significant cultural resources within the Area of Potential Effects (APE) of any proposed project. For the LPRRP, the APE may include the riverbed and banks, as well as candidate restoration sites or construction staging areas. Significant cultural resources are any material remains of human activity that are listed on, or eligible for inclusion on the New Jersey State Register of Historic Places and NRHP. Other statutes and regulations specifically addressing these responsibilities include Section 101(b)(4) of the National Environmental Policy Act of 1969 and the Advisory Council Procedures for the Protection of Cultural Properties (36 CFR Part 800).

Project plans will be adjusted as practicable to avoid or minimize impacts to resources determined to be eligible for inclusion on the State and National Registers. An evaluation of the impact of alternative plans on eligible properties will be developed in consultation with the State Historical Preservation Officer (SHPO). If eligible resources cannot be avoided, a Memorandum of Agreement (MOA) will be developed in consultation with the appropriate SHPO(s) to mitigate for unavoidable impacts. Any work stipulated in the MOA will be undertaken prior to initiation of project construction unless otherwise agreed with the SHPO(s).

Further details regarding the methodology for conducting cultural resources surveys are provided in Section 4.7 – Task 7 – Cultural Resources, of FSP Volume 3 (Malcolm Pirnie, Inc., 2005d).

5.8 BIOTA AND ECOLOGICAL RISK SAMPLING (PMP TASKS JDE, JDN, JFB)

Biological surveys conducted as part of the investigation will serve or complement the following tasks identified in the Project Management Plan: Environmental Resource Inventory (or ERI, Task JDE), Ecological Functional Assessment (or EFA, included as part of Task JDN), and HTRW Site Inspection and Sediment Characterization Report (Task JFB).

Based on the data needs identified in the PAR (Battelle, 2005), biota sampling will be conducted as described below. The objectives for this investigation, which will be covered in FSP Volume 2, are to:

- Support the ecological risk assessment by providing quantitative measures of the health and diversity of the aquatic community.

- Support the human health risk assessment by either field verifying bioaccumulation model results or providing actual edible tissue concentrations for selected fish and shellfish species for inclusion in risk models.
- Support the food web modeling for the ecological health risk assessments by either field verifying bioaccumulation model results or providing actual whole body tissue concentrations of relevant prey species for inclusion in risk models. Food web modeling considers contaminant movement from sediment to prey species (*e.g.*, benthic invertebrates and fish) and to piscivorous birds and mammals feeding on contaminated prey; risk to these receptors are then assessed based on this effort.

5.8.1 Benthos Sampling

Surface sediment grabs will be collected from selected locations using one or more of the following techniques: Van Veen grab sampler, ponar grab sampler, Shipek, and/or box corer. Sediment samples will be sieved and macroinvertebrate species will be separated and counted. The objective of this analysis will be to assess potential impacts of contaminants on the diversity and abundance of benthic macroinvertebrate species. Based on the enumeration of species present in each replicate sample, species richness and abundance can be determined for each location using a variety of diversity indices (*e.g.*, dominance, diversity richness, evenness). The results of this evaluation will provide a measure of the health of the benthic community and the potential population-level impacts of sediment-associated contaminants. Risk assessment needs will be fully considered in the identification of reference locations for benthic community analyses based on types of habitats in the study area. To the extent they are co-located, benthic community, bioassay (see Section 5.8.3 – Bioassay Sediment Sampling), and sediment chemistry/physical samples will be collected synoptically.

5.8.2 Fish and Shellfish Sampling

Based on the information presented in the PAR (Battelle, 2005), representative species of forage fish, sport fish, and shellfish will be collected for the purposes of:

- Quantifying tissue concentrations of COPCs/COPECs for use in the human health and ecological risk assessment dose models.
- Determining possible relationships between COPC/COPEC concentrations in tissues and in sediments (*e.g.*, with shellfish or small home-range fish associated with areas with different concentrations of COPCs in the sediments).

- Providing qualitative information regarding the abundance and diversity of fish and shellfish species to evaluate population and community structure.

Fish and shellfish collection techniques will be determined based on the target species and size class desired, but may include gill nets, trawl nets, traps, beach seines, and hook and line techniques.

For the human health risk assessment, edible tissue (*e.g.*, fillet) concentrations of selected sport fish and shellfish will be collected and evaluated for identified chemicals of concern. The specific species evaluated will be determined based on consideration of species most likely to be targeted by recreational anglers. These data will be used to quantify risks associated with consumption of fish, and to verify the results of bioaccumulation modeling.

For the ecological risk assessment, whole body concentrations of forage fish and other relevant fish and shellfish species will be required either to quantify the dose modeling or to validate the results of the bioaccumulation model. The specific species to be targeted for evaluation will be representative of the prey species preferred by the final receptors of concern. In addition, whole body concentrations will be evaluated with respect to body burden concentrations reported to be associated with adverse effects on behavior, growth, reproduction, and survival for those chemicals for which data are available.

5.8.3 Bioassay Sediment Sampling

As discussed in the PAR (Battelle, 2005), laboratory bioassay testing is anticipated as part of the investigation to be conducted for the LPRRP. The objectives for the bioassay testing program may include:

- Supporting the ecological risk assessment outlined in the PAR in assessing effects to benthic invertebrates from exposure to COPECs.
- Establishing a dose-response relationship between sediment COPEC concentrations and observed effects in benthic invertebrate receptors.
- Determining the transfer of sediment contaminants to benthic invertebrates (*i.e.*, bioaccumulation) to support the food-web modeling and dose assessment for higher trophic level organisms identified as receptors of concern.

Bioassay sediment samples will be collected using one or more of the following techniques: Van Veen grab sampler, ponar grab sampler, Shipek, box corer, vibratory core sampler, and/or push corer to obtain adequate recovery and retrieve representative sediment samples. Selection of the sampling technique will be based on the number and type of bioassay tests to be conducted and the complexity of the test design in order to provide an efficient method of sampling so as to achieve the test volumes required. The method will also be influenced by the physical characteristics of the sediments and depth of sample required for the test.

Typically, bioassay tests are conducted on surface sediments representing the BAZ, (generally the top two inches of sediment, although it is recognized that the BAZ may extend to 12-15 inches depending on the organisms being examined). Specific sample handling requirements are necessary to minimize and control the introduction of confounding factors.

5.9 HABITAT DELINEATION AND ASSESSMENT (PMP TASK JDE)

Field investigations will be conducted to characterize ecological communities including submerged aquatic vegetation (SAV), wetlands, channel habitats, mudflats, and vegetated shoreline areas, both to support the ecological risk assessment and to document communities that may be disturbed or removed completely during potential future remedial actions and assessing the feasibility of restoration options. Obtaining adequate documentation to characterize these communities requires data collection regarding the size, location, and composition of the communities, as well as information on the sediment, soil, and hydrologic parameters that support the communities. A reference area may be evaluated to support the selection of receptors for the ecological risk assessment, since receptors may not be present in the study area due to contamination. Identification of reference areas is addressed in FSP Volume 2 (to be published in 2006).

SAV habitat assessment and delineation will consist of several components. SAV beds located in or adjacent to contaminated sediment areas will be documented for species composition, location, and acreage. Sediment samples will be collected to analyze for TOC, grain size, pH, and macro- and micro-nutrients throughout the beds.

Water quality measurements will include temperature, pH, turbidity, and DO. Finally, porewater chemistry samples may be taken to document baseline conditions in the beds.

Wetlands investigation along the Passaic River will focus on areas that are expected to be impacted by site contaminants. Investigations will include wetland delineations, conducted in accordance with the 1987 USACE Wetland Delineation Manual (Environmental Laboratory, 1987), and wetland functional and value assessments, which will be conducted utilizing the Hydrogeomorphic Approach (HGM) and the Evaluation for Planned Wetlands (EPW). The HGM, an assessment method developed by the USACE, typically produces a site wetland profile containing functional site characteristics that are compared with characteristics reference wetlands in the same region that are in the same geomorphic class as the investigated site. The EPW is a rapid assessment technique developed by Environmental Concern, Inc. Soil/sediment samples will be collected and analyzed for physical and chemical parameters, including organic and nutrient content. A survey will be conducted to determine if threatened/endangered species and/or ecologically significant habitats are present in the project area.

Shoreline areas will be evaluated for community characteristics and physical, chemical, and hydrologic conditions. Reference shoreline communities will be described by species composition, age, and density along transects established for the project. Soil samples will be collected and analyzed in a manner similar to that for SAV and wetland samples and will include soil characterization based on USGS Soil Survey data.

5.10 CANDIDATE RESTORATION SITE SAMPLING (PMP TASK JD)

The proposed restoration projects will incorporate a watershed-based approach to effectively restore and protect aquatic resources. Emphasis under the watershed approach is directed at all aspects of surface and ground water quality including physical, chemical, and biological parameters. The watershed approach is action-oriented, driven by broad environmental objectives, and involves key stakeholders. The major cornerstones of the approach are public participation, problem identification, and implementation of restoration projects. This section addresses restoration investigations for in-river sites, riparian sites, tributaries, and other wetlands in the watershed. Additional details of candidate restoration site sampling activities are provided in FSP Volume 3 (Malcolm

Pirnie, Inc., 2005d). It is assumed that the sediment and water quality investigations described in Sections 5.3, 5.4 and 5.5 will cover both CERCLA and WRDA data needs. However, if additional WRDA data needs specific to certain candidate restoration sites emerge, following are descriptions of additional field investigations that might be necessary.

5.10.1 Candidate Restoration Sites Soil and Sediment Investigations

Future data needs for candidate restoration sites will encompass both geotechnical and environmental sampling to satisfy the following objectives:

- Determine whether candidate site soil/sediment contaminant concentrations exceed remediation criteria and/or are likely to have an adverse impact on site restoration (*e.g.*, plantings, biota).
- Determine candidate site soil/sediment geotechnical properties to support restoration feasibility analyses.
- Determine soil geotechnical properties in Passaic River bank areas to evaluate slope stability and whether bank stabilization measures may be required during remedial dredging.
- Provide data necessary for the affected environment section of the National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS).

Based on these data needs, once restoration sites are selected, a detailed sampling program will be developed in consideration of site-specific conditions. Presented below is an overview of studies and sampling methodologies that are likely to be performed at candidate restoration sites.

- <u>Geotechnical Investigation</u> – Specific geotechnical testing will be performed to quantify in-situ soil and sediment properties at areas selected for shoreline softening, public access, and also for areas selected for wetland restoration/rehabilitation. Geotechnical engineering studies will be performed for slope stability analysis of the shoreline, re-contouring of wetlands sediment, construction of bulkheads along the riverbanks, the removal of riprap and contouring of the riverbank. Geotechnical analyses may also be conducted in areas other than candidate restoration sites where information is necessary to assess the potential impacts of contaminated sediment dredging on shoreline slope stability.
- <u>Hazardous/Toxic/Radiological Waste (HTRW) Investigation</u> – In addition to the detailed HTRW sediment investigations described in Section 5.3 – Sediment Investigations, it is anticipated that additional investigations may be necessary outside the riverbed (*e.g.*, in wetlands or tributaries) for establishing baseline characteristics

of candidate restoration sites. Such investigations will be conducted in accordance with guidance provided in "Water Resources Policies and Authorities – Hazardous, Toxic and Radioactive Waste Guidance for Civil Works Projects" (EM 1165-2-132; USACE, 1992), "Engineering and Design - Requirements for the Preparation of SAPs" (EM 200-1-3; USACE, 2001a), and CERCLA RI guidance. A report will be prepared which describes detected HTRW occurrences within, or nearby, the project areas. It will include a preliminary determination of the nature and extent of detected contamination as well as quantitative and qualitative analyses of contamination impacts in the absence of response actions. HTRW site inspections will be conducted for the ecosystem restoration projects in support of alternative plan development. Soil samples may be collected using conventional drilling rigs, direct push technology (DPT), or hand coring and grab sampling for surface or near-surface sampling.

5.10.2 Candidate Restoration Sites Water Quality Investigations

Future data needs for selected restoration sites will encompass both water quality and HTRW sampling to satisfy the following objectives:

- Determine whether groundwater/surface water contaminant concentrations exceed surface and groundwater quality criteria and standards and/or are likely to have an adverse impact on site restoration (*e.g.*, plantings, biota).
- Provide data necessary for the affected environment section of the NEPA-EIS.

5.10.3 Candidate Restoration Sites Socioeconomic Analyses

The objective of socioeconomic analyses is to measure the cost effectiveness, social fairness, and institutional implementability of each remediation and restoration plan proposed for the contaminated environmental media in the Lower Passaic River and the candidate restoration sites. The study period for all evaluations will be 50 years, consistent with the Project Management Plan [PMP (USACE, *et al.*, 2003)].

5.10.4 Candidate Restoration Sites Real Estate Surveys

According to the "Real Estate Handbook" (USACE, 1985), a Real Estate Plan (REP) is the work product that supports project plan formulation. It identifies and describes the lands, easements, and rights-of-way (LER) required for the construction, operation, and maintenance of a proposed project, including those required for relocations, borrow material, transfer facilities for remediation, and dredged or excavated material disposal.

Real estate surveys will be performed for candidate restoration sites. The real estate surveys will be performed to identify ownership, site boundaries, easements, rights-of-way, utilities, etc. Real estate and planning personnel will work on the following elements of the real estate needs as identified in the PMP (USACE, *et al.*, 2003):

- Real Estate Supplement.
- Gross Appraisal.
- Preliminary Real Estate Acquisition Maps.
- Physical Takings Analysis.
- Preliminary Attorney's Opinion of Compensability.
- Rights of Entry.
- Other Real Estate Documents.

5.10.5 Investigations of In-River and Tributary Restoration Sites (PMP Task JDE)

It is anticipated that, in addition to characterizing the contaminant impact to biota, FSP Volume 2 activities will also characterize the diversity and abundance of the aquatic benthic communities. In addition to those described above, techniques may include:

- Fish surveys.
- Avian surveys.
- Benthic community surveys (*e.g.*, SPI).
- Other habitat delineation techniques (*e.g.*, geophysical surveys).
- Analyses to determine sediment health [*e.g.*, pH, redox, dissolved oxygen (DO), TOC, nutrients].

The data collected from these techniques in conjunction with data from the riverbed sediment and other investigations will also be used as a basis for conceptual design for restoration, and will enable consideration of potential restored sites to attract sensitive receptors.

Benthic grab data and SPI data will be taken to document the distribution and occurrence of benthic habitats and invertebrate communities within the Lower Passaic River. Photographic inspections of the top 7 inches of the sediment will be performed at 138 locations using SPI (the SPI camera will be deployed twice per station). The locations include one-half of the shallow core locations sampled in the SSS ground-truthing task (see Section 5.2.2 – Geophysical Surveying). At 25 percent of these locations, a grab sample of the top 6 inches of sediment will be collected for evaluation of the benthic community. Procedures for conducting SPI are detailed in FSP Volume 3 (Malcolm Pirnie, Inc., 2005d).

5.11 ENVIRONMENTAL DREDGING AND SEDIMENT DECONTAMINATION TECHNOLOGIES PILOT (PMP TASK JAE)

A pilot-scale dredging demonstration project coupled with a pilot-scale sediment decontamination technology demonstration project will be conducted in the Lower Passaic River. This project is more fully detailed in the Dredging Pilot Work Plan (TAMS, 2005a). The objectives of the dredging demonstration project are to collect data on equipment performance, dredging productivity, and sediment resuspension as input to the FS evaluation of remedial and restoration alternatives. The objective of the sediment decontamination technologies pilot is to determine whether Passaic River sediments can be treated to produce an economically viable beneficial end use product.

Using environmental dredging techniques, 5,000 cubic yards of sediment will be removed from the Harrison Reach and delivered to two decontamination technology facilities (one for thermal treatment and one for sediment washing). The 1.5-acre dredging location was chosen using data from geophysical, sediment coring, magnetometer, SSS, and sub-bottom profiling surveys focused in the Harrison Reach. A hydrodynamic survey determined that the optimal time for the dredging pilot will be at neap tide to minimize ambient resuspension of sediments so that the signal from the resuspension caused by dredging can best be monitored. As detailed in the "Passaic River Environmental Dredging Pilot Study – Hydrodynamic Modeling" report (TAMS, 2005b), near-field models named Flow3D (by Computational Fluid Dynamics) and DREDGE (Hayes and Je, 2000) are being used to determine the locations of resuspension monitoring equipment.

6.0 DATA PRESENTATION

6.1 PROJECT DATABASE OVERVIEW

The Passaic River Estuary Management Information System (PREmis) is an internal project website designed to collect, store, manage and report historical data, as well as data and information that will be collected during the LPRRP. PREmis also provides effective project communication and coordination among the six partner agencies and associated consultants.

A centralized, web-based portal to the various forms of electronic information collected and stored for the project has been developed. At present, PREmis provides project team members access to information on project contacts, schedules, communications, project management, historical information, planning documents, and GIS mapping and reports. Since PREmis was created in a modular format, it can be upgraded as needed as the project proceeds. Also, the project-related information that is ready for release is made available to the public through the following website interface: http://www.ourPassaic.org.

6.2 OBJECTIVES

The main objectives for PREmis are to:

- Provide a central location for project information including large volumes of electronic field data.
- Provide timely access to data and documents for project team members.
- Deliver a variety of reports in a variety of formats, from on-screen tabular web reports and downloadable data sets for off-line analysis to GIS-based visual reports.
- Maintain defensible information through security safeguards.
- Allow different levels of users to access the site through a multi-tiered security plan.
- Track data and documents through on-line validation, review, and approval processes from remote locations.
- Automate the capture of field data.

6.3 PREMIS DESCRIPTION

The system uses a combination of different technologies, including:

- MapGuide, a web-based GIS interface to display analytical and shape file data.
- ColdFusion as the main programming environment.
- Various Internet technologies to upload, download, and report information.

To facilitate communication among team members on a real-time basis, the system allows members from the consulting team operating in various offices, the six partner agencies, and field crews to enter, manage, and report data. The flowchart of how data presentation will be handled by PREmis is presented in Figure 6-1. The use of Internet technologies such as Web Servers, Web Browsers, Firewalls, and e-mail provides the type of flexibility and security needed for this system.

Users have access to the system via standard Web Browsers and log on to a private web server located in Malcolm Pirnie's White Plains, NY office. All users have separate login identifications and passwords, and have been assigned to different user access levels. All data for the system are stored in ColdFusion and are accessible through both pre-defined reports and ad-hoc query capabilities. Data download capabilities have also been added as part of the reporting area.

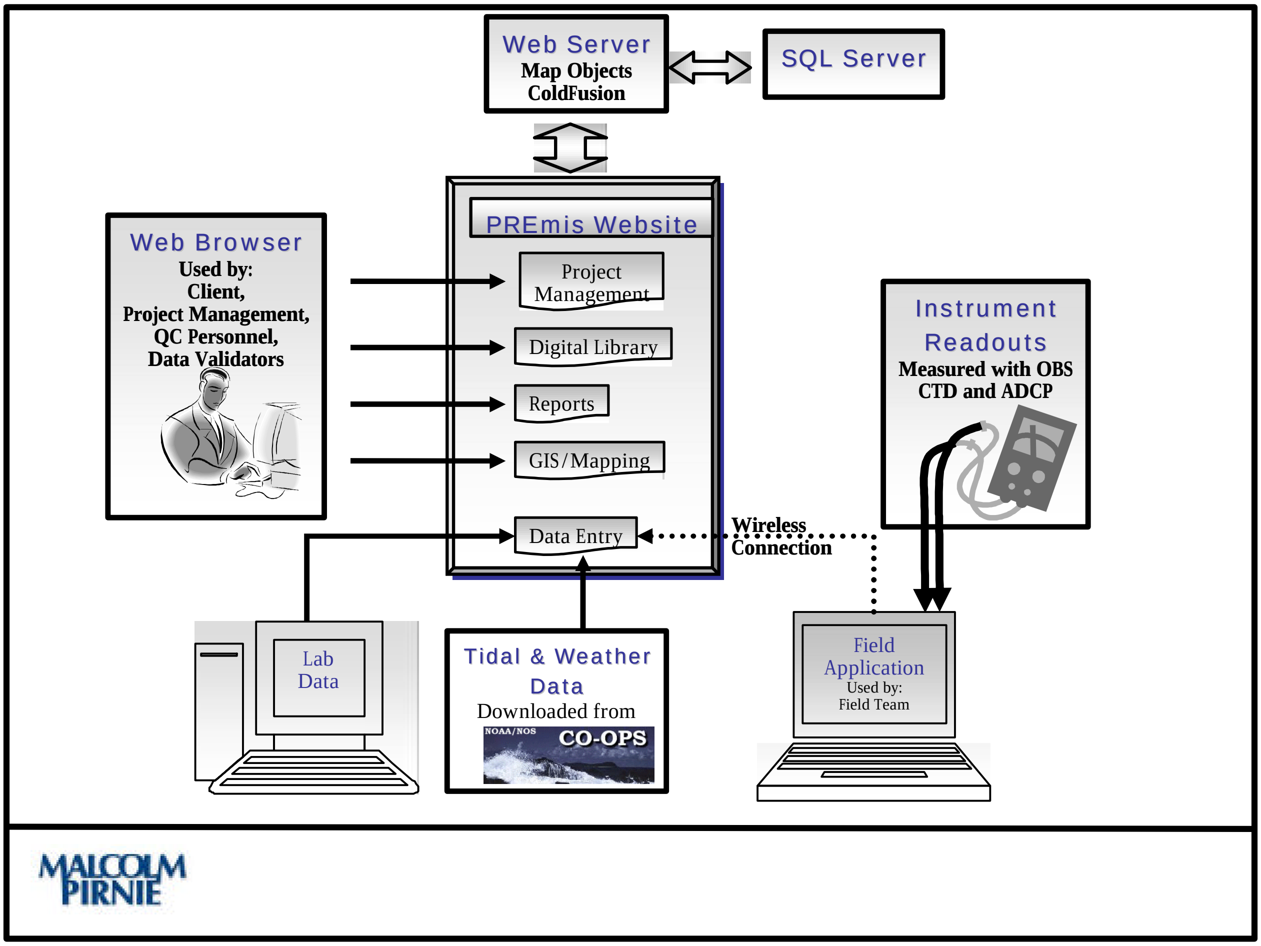

Figure 6-1: Data Presentation Flow Chart

6.4 PREMIS UTILITIES

PREmis uses the following modules for this project:

6.4.1 Management

This module includes budget tracking, scheduling, and project task tracking, as well as a platform for performing task-specific discussions. The reporting function of PREmis also assists in project management by allowing users to generate key management reports.

6.4.2 Data Storage

PREmis provides a platform for the electronic storage of documents and information. The documents are stored in the digital library and are coded with attributes that allow users to query the reports based on key words. The information is contained in a unified database that was developed to be consistent with USEPA's Multimedia Electronics Data Deliverable (MEDD) requirements. This database will be the repository for all historical data as well as data collected during on-going project activities.

The digital library also allows users to save documents and information that need to be available to authorized users in the general public. An option for marking the document as a public document is available in PREmis when storing the documents into the digital library. Once the document is marked public, it is available for viewing and downloading from the ourPassaic.org website.

6.4.3 Data Upload and Validation

The data upload function of PREmis allows users to upload data from various sources such as laboratory electronic data deliverables (EDDs) and field instrument readouts. The interactive module allows users to upload American Standard Code for Information Interchange (ASCII) files containing data directly into the website; the data are then reviewed and approved by the site quality control officer (SQO) or a designee prior to being available to the entire project team.

6.4.3.1 Field Application

The field application allows users (*i.e.*, sampling team members) to collect field information electronically instead of manually into paper-based log books during the project field investigations. The field application is able to support a variety of sampling events (*e.g.*, surface water/water column sampling, sediment sampling, and hydrodynamic monitoring) through the creation of sample-specific modules. The field application will also allow users to periodically download instrument readouts from various sampling instruments and will assist in uploading the information into the PREmis database after the data have been reviewed and approved by the SQO or a designee.

6.4.3.2 Laboratory Data Upload

The laboratory data upload section of PREmis will provide the ability to define and save EDD formats. Access to the laboratory upload section will be limited to laboratory personnel and members of the team involved with laboratory data QA/QC. The user can then select the EDD format, browse his or her computer for the EDD file, identify the file type (*e.g.*, Microsoft Excel or ASCII) and then upload to the website. Appropriate initial checks of the file for format and validation to metadata will be performed. If either of the checks fails, then the upload will be aborted. The user will be alerted as to the reason the process was aborted and resolution suggestions will be displayed.

Following these checks, the file will be copied to the digital library. The EDD will be parsed out and inserted into the PREmis database. Rows of data successfully inserted will be reported back to the user for review. Rows that are rejected will also be reported in an exception report. An e-mail will be sent to the user and the laboratory QA/QC officer with the name of the EDD and a copy of the exception report.

If a laboratory EDD containing errors is corrected and re-uploaded, only results that do not already exist in the PREmis database will be added. Therefore, unchanged results will not be updated.

6.4.3.3 Laboratory Data Validation

Laboratory data will be validated and approved via PREmis. Access to the laboratory validation section will be limited to validators and the SQO. The laboratory validation section will provide validators and the SQO the ability to pick a laboratory EDD and modify results, qualifiers, and add data validator qualifiers to indicate data usability. The validators and SQO will follow the same process. The process will involve:

- Selection of the EDD that is to be validated or approved.
- Download of that data in an Excel file to the validator's or SQO's computer.
- Upload of the modified Excel file to the website.
- Confirmation of changes on the website.
- Marking the status of the EDD.

The validators will only see EDDs that are awaiting validation, while the SQO will see a list of EDDs that have been validated and are awaiting approval, and EDDs that are awaiting validation. The user can select the EDD and download an Excel copy to his or her computer. Once the validation process is complete, the user will navigate back to the validation page and upload the modified file. The uploaded Excel file will go through checks to confirm that samples match for the selected EDD. If the integrity checks pass, then the modified results and qualifiers will be presented to the user for confirmation. Once the user confirms the changes, the information will be written to the database and audit records created to capture the original values and identify who changed the values and when. If the validator is uploading an EDD, it is marked as "Validated." If the SQO is uploading an EDD, s/he will have a choice to select "Approved" or "Rejected." Once the SQO marks an EDD as "Approved" or "Rejected," the final status of the EDD is marked as "Validated & Approved", "Not Validated & Approved," or "Rejected". Validated data that are ready for release are made available through a link to the public website http://www.ourPassaic.org.

6.4.4 Evaluation

The GIS Mapping/Map Guide and report functions of PREmis will assist the project team in assessing problems, formulating and evaluating solutions, and presenting findings. The GIS Mapping/Map Guide portion of PREmis provides a means for all project team members to easily access, display and query map and sample data stored in either ESRI shape files or the PREmis database. The report tool will assist users in querying information based on various attributes. Map Guide is also available on the public website http://www.ourPassaic.org.

With its interactive spatial query tool, GIS Mapping/Map Guide allows users to query information based on a selected area and then view related reports, documents, and data. It also gives users the ability to create custom spatial views of data and allows users to save their custom views of data to a personal library. By saving their MapGuide data views, users can simply pick a saved view from their personal list and MapGuide will automatically retrieve and display the results. In addition, users have the ability to save their personal data views to a public list, enabling other team members to see their MapGuide results rather than re-creating them.

To assist team members in their analysis of sample data, a MapGuide interface displays various GIS data layers and sample data stored in the PREmis database. These data layers, referred to as themes, are stored in the shape files and viewed through MapGuide. Themes that may be included in PREmis include soils, vegetative cover, wetlands, topography, hydrology, tidal reach and elevations, water and sediment quality sample locations, property ownership, land use/cover, zoning, demographic data, regulatory floodplain boundaries, stream bathymetry, HTRW, and cultural sites information. At present, the interface gives users the ability to:

- Turn off and on various map themes incorporated into the shape files.
- Customize the MapGuide display of sample data results.
- Create ad-hoc queries for sample data by date, chemical class, location (*e.g.*, township, river mile, reach), sample type, depth and evaluation criteria such as those reflected in Applicable or Relevant and Appropriate Requirements (ARARs) determined for the project.
- Drill down into sample results for a particular location.
- Create and store custom MapGuide “views” by user.
- Generate tabular reports from selected data.
- Download sample data into either Microsoft Access or Excel.

7.0 HYDRODYNAMIC, SEDIMENT TRANSPORT, CHEMICAL FATE AND TRANSPORT, AND BIOACCUMULATION MODELING

7.1 OVERVIEW

A set of models designed to simulate the physical, chemical, and biological processes occurring within the Study Area is being developed to evaluate the risks posed to human health and the environment from the transport of sediment and associated contaminants and various remedial alternatives developed to address the risks. The choice of processes and specific COPCs/COPECs modeled will be based on the results of data evaluation as guided by the CSM. The integrated modeling framework is needed to determine the fate of contaminants released into the environment under both current conditions and future scenarios, and thus to produce scientifically defensible support for regulatory decision-making. The following section broadly discusses the modeling effort; however, as the CSM is iteratively updated and new information is gathered the methods may change to meet newly defined objectives. A more detailed description of the model is presented in the Lower Passaic River Restoration Study Modeling Work Plan (HydroQual, 2005). The descriptions below may change based on the finalized modeling work plan.

7.2 PURPOSE AND OBJECTIVE OF THE LOWER PASSAIC RIVER MODELING (PMP TASK JAF)

The main purpose of the modeling effort is to spatially and temporally interpolate available information and predict future concentrations of benchmark chemicals under a baseline (or No Action) scenario and under different management scenarios. The model is an essential tool for evaluating the magnitude and relative importance of specific contaminants, transport mechanisms, and sources to the Lower Passaic River, including:

- Upstream loads from above the Dundee Dam.
- Loads from tributaries and other point sources along the 17-mile tidal reach.
- Re-mobilization of contaminants within the 17-mile tidal reach.
- Inputs from water bodies hydraulically connected to the down-estuary end of the 17-mile tidal reach via Newark Bay.

- Surface runoff.
- Non-point sources.
- Sediment and contaminant re-suspension/redistribution during extreme events.

The models will also provide management guidance for the adverse ecological and human health effects of COPC/COPEC transport and ultimate fate within the system. The models will provide data for use in the development of the baseline human health and ecological risk assessments. Additionally, the models will be used to assess the fate of sediment and chemical contaminant re-mobilization due to various remedial action alternatives that may be conducted within the Lower Passaic River during the remediation and recovery periods. Lastly, the models will be used to assess sediment quality and contaminant levels if loadings are reduced or eliminated, and improvement time frames under various remedial action alternatives.

7.3 MODEL FRAMEWORK AND APPROACH

The model domain encompasses the Passaic River, Hackensack River, Newark Bay, their tributaries, and portions of the Arthur Kill and Kill Van Kull. The model must extend to include a portion of New York Harbor to avoid boundary effects that will influence the model in the region of interest. The existing CARP model, developed for the NY/NJ Harbor Estuary Program, will be used to determine the outermost extent of the modeling domain. The model framework used for the Lower Passaic River Modeling Study includes model components describing hydrodynamics, sediment transport and organic carbon cycling, chemical fate and transport, and bioaccumulation as shown in Figure 7-1.

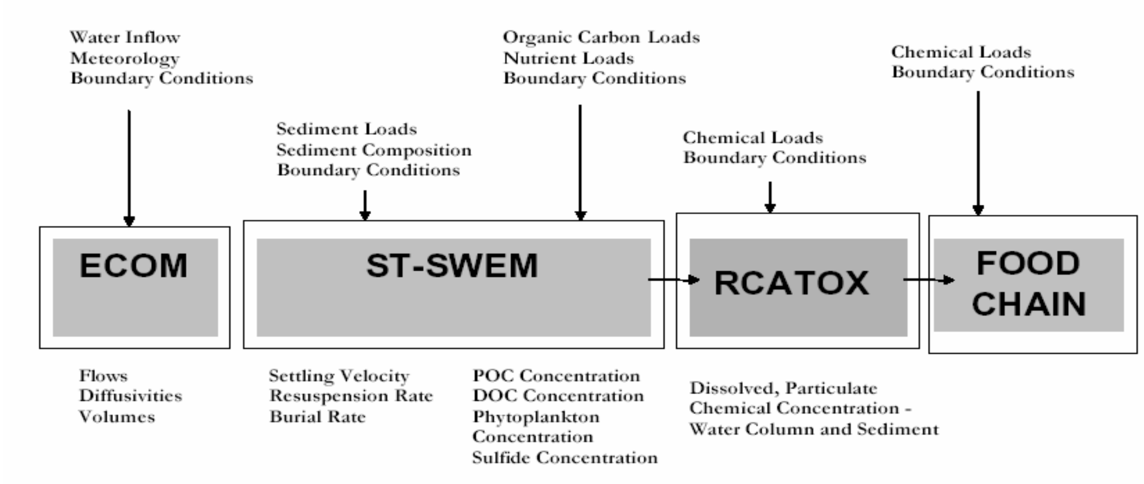

Figure 7-1: Model Framework

The model will be run with a fine spatial and temporal resolution capable of capturing individual storm event dynamics as well as long-term fate and transport and bioaccumulation processes. For computational efficiency, the overall modeling calculations will be decoupled and performed in four successive model calculations as described below.

Hydrodynamic model calculations will first be performed to determine intra-tidal transport, currents, and bottom shear stresses throughout the model domain. This portion of the model suite uses the model inputs of flow upstream and from tributary inputs, downstream tidal action, temperature, salinity, and atmospheric inputs such as wind speed and solar radiation to simulate the flow, dispersion, stratification, and currents within the estuary. In addition to transporting material by advection, the flow imparts a shear stress on the bed, which at a threshold value determined by bed properties such as porosity and grain-size distribution, will re-mobilize the bed sediments and associated contaminants.

This information will be passed forward to a sediment transport/organic carbon cycling model to determine the movement of inorganic particles and organic carbon between the overlying water and the bed. Organic carbon cycling is considered explicitly with sediment transport for three important reasons. The first reason is that POC can be a significant part of the suspended sediment concentrations, particularly in surface waters of the harbor. Secondly, POC can affect the movement of inorganic particles through coagulation, resuspension, and sediment mixing processes. Third, organic carbon and not sediment *per se*, is important in controlling the toxic contaminant distribution between the dissolved and particulate phases in subsequent model calculations.

In turn, information from the hydrodynamic and sediment transport/organic carbon cycling models will be passed forward to a chemical fate and transport model, and will be used along with descriptions of contaminant partitioning to organic carbon and other contaminant processes (*e.g.*, volatilization, degradation) to determine contaminant concentrations in the overlying water and sediment. Finally, contaminant concentrations in the water column and sediment will be used in bioaccumulation and food chain models.

The modeling programs that are planned to be used are shown in Figure 7-1. A summary of processes included in the various models and detailed model descriptions for these processes is described in the Lower Passaic River Restoration Project Modeling Work Plan (HydroQual, 2005). Model calibration for the hydrodynamic and sediment transport/organic carbon cycling models will be performed for select USGS water years (October-September). The most rigorous test of the sediment transport model will be conducted (as part of hindcast simulations for Cs-137) through the evaluation of spatial patterns in sedimentation rates computed over multiple decades. Chemical fate and bioaccumulation model calibration for COPCs/COPECs will be performed for present conditions. These evaluations form the basis for an overall assessment of the model. Further, component load analyses and model projections (scenarios) under various scenarios will be performed and compared with the above described base runs. Details of model calibration, assessment, load analyses and projections are described in the Lower Passaic River Restoration Project Modeling Work Plan (HydroQual, 2005).

8.0 RISK ASSESSMENT (PMP TASK JDE)

8.1 OVERVIEW

A risk assessment will be conducted for the LPRRP to assess the potential threat to human health and the environment, currently and in the future, in the absence of any remedial actions or institutional controls. The risk assessment, which will include both human health and ecological evaluations, will be used to assist in risk management decisions for the site.

The PAR (Battelle, 2005) was prepared as a preliminary planning document for the risk assessment, based on evaluation of available information and historical data. The PAR provides the overall framework and methodology for conducting the risk assessment. The salient features of the PAR include:

- Development and presentation of preliminary CSMs for the human health and ecological risk assessments;
- Summary presentations of the historical sediment and fish/shellfish tissue data, including an assessment of the temporal and spatial data gaps associated with the historical data; and
- Tentative lists of chemicals of potential concern (COPCs) for the human health evaluation and chemicals of potential ecological concern (COPECs) for the ecological evaluation.

Outlines of the planned human health and ecological evaluations, as presented in the PAR, are provided below. Where appropriate in these outlines, reference to the PAR is made to obtain more information regarding site-specific exposure assumptions and others aspects of the evaluations. New data, as well as the results of efforts to refine the various exposure assumptions (*e.g.*, fish and shellfish consumption rates; exposure duration, site use factors), will be incorporated in the risk assessment as the investigation proceeds.

It is anticipated that measured and/or modeled chemical concentrations and other environmental information will be used, as appropriate, to conduct the risk assessment.

8.2 HUMAN HEALTH EVALUATION

The human health evaluation will be focused on potential human health impacts associated with exposure to site-related contamination in the vicinity of the Lower Passaic River. Exposure to the contaminants of potential concern (COPCs) from site-related exposure pathways and receptors identified in the PAR, and those which may subsequently be identified over the course of the project, will be evaluated. The evaluation will be conducted following USEPA guidance, primarily USEPA's Risk Assessment Guidance for Superfund – Parts A, D, and E (USEPA 1989, 2001a, and 2001b, respectively) and other supplemental guidance referenced in the PAR. It will include the four steps that constitute the basic framework for human health evaluations, including:

- Data Review and Evaluation.
- Exposure Assessment.
- Toxicity Assessment.
- Risk Characterization.

8.2.1 Data Review and Evaluation

The first step of the human health evaluation will be to review and evaluate the data gathered during the project for completeness and usability in completing the evaluation, and to statistically summarize the data as necessary. The data review and evaluation will be conducted in accordance with the DQOs provided in the QAPP (Malcolm Pirnie, Inc., 2005b) or the remedial investigation reports. On-going assessment of data will be made to refine the data collection program using a dynamic work plan approach so that the data generated during the field investigation, in conjunction with usable historical data, will be sufficient to complete the evaluation. However, the possibility exists that additional data generation may be required.

In general, the process to select COPCs for the human health evaluation will involve comparing the maximum concentration of each detected chemical against conservative risk-based screening-levels and then applying additional selection or exclusion criteria. The selection processes for sediment and fish/shellfish tissue are outlined in Figures 4-1 and 4-2, respectively. Table 4-1 presents a tentative list of COPCs as selected in the PAR.

8.2.2 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude, frequency, duration, and routes of current and reasonably anticipated future human exposure to site-related constituents. As provided in the PAR, based on available information about current activities, as well as on-going restoration initiatives, it has been assumed that human exposure to COPCs in the river sediments would be associated with recreational activities such as swimming, wading, fishing, crabbing, and boating. Detailed descriptions of the receptors and types of exposures determined for this site to date are provided in the PAR, along with associated exposure parameter assumptions. The CSMs for human and ecological receptors developed based on existing data are provided in the PAR. Human receptors identified for the site include a Recreational User and an Angler/Sportsman. In addition, a transient population has occasionally constructed temporary housing along the banks of the river; thus, a Homeless Resident receptor also has been included in the CSM to address potential exposures to individuals in this type of community. The receptors and exposure scenarios associated with future use are not expected to differ significantly from those being evaluated under the current use scenarios. Consumption of fish and other aquatic organisms is anticipated to be the primary exposure pathway.

A more thorough analysis of the available data and supporting exposure assumptions (*e.g.*, a literature review of consumption of locally-caught fish and shellfish) will be conducted to determine the need for collection of site-specific data in order to minimize the associated uncertainties in the evaluation. Collection of specific data will follow the DQO process as described in the QAPP (Malcolm Pirnie, Inc., 2005b) and will be provided in the FSP Volume 2 (in 2006).

The exposure assessment outlined in the PAR will be utilized in the evaluation in addition to any additional information uncovered as the investigation progresses.

After completing various field activities, the CSM and the selection of COPCs will be updated accordingly.

8.2.3 Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure to a chemical and the nature and magnitude of adverse health effects that may result from each exposure. For purposes of risk assessment, adverse health effects are classified into two broad categories: non-carcinogenic and carcinogenic.

For this evaluation, toxicity criteria will be selected according to the USEPA (2003a) OSWER Directive 9285.7-53 that recommends a hierarchy of human health toxicity values for use in risk assessments at Superfund sites. The hierarchy is as follows: (1) USEPA's Integrated Risk Information System (IRIS); (2) USEPA's Office of Research and Development, National Center for Environmental Assessment, Superfund Health Risk Technical Support Center Provisional Peer Reviewed Toxicity Values, and (3) other sources of information such as the California EPA's toxicity values and the Agency for Toxic Substances Disease Registry (ATSDR) minimal risk levels (MRLs) for non-carcinogenic compounds.

8.2.4 Risk Characterization

Risk characterization involves combining the results of exposure assessment and the toxicity assessment to provide numerical estimates of potential human health risk. Risk characterization also considers the nature and weight of evidence supporting these risk estimates and the magnitude of uncertainty surrounding such estimates. In accordance with USEPA's guidelines for evaluating the potential toxicity of complex mixtures, the evaluation will assume that the effects of all COPCs are additive through a specific pathway within an exposure scenario (USEPA, 1986). Carcinogenic risks and non-carcinogenic hazards will be estimated using the methodology provided in the PAR.

8.3 ECOLOGICAL EVALUATION

The objective of the ecological evaluation process is to evaluate and characterize the potential for adverse effects to ecological receptors associated with exposure to contaminants of potential ecological concern (COPECs) present in environmental media of the Lower Passaic River. To evaluate these potential risks, ecological risk assessment guidance from USEPA (1992, 1997), which specifies a tiered process encompassing eight steps, will be followed.

The first tier, which encompasses Steps 1 and 2 of the USEPA guidance, constitutes a screening-level ecological risk assessment, including preliminary CSM development, COPEC identification, and screening-level dose assessment using conservative assumptions. Preliminary CSM development and COPEC identification based on current understanding of the site and historical data, have been conducted and presented in the PAR. After completing various field activities, the CSM and the selection of COPECs will be updated accordingly.

In general, the process to select COPECs for the ecological evaluation will involve comparing the maximum concentration of each detected chemical to four screening criteria and then applying additional selection or exclusion criteria. The selection processes for sediment are outlined in Figure 4-3. Table 4-1 presents a tentative list of COPECs as selected in the PAR.

While these aspects will be updated and revised as the investigation proceeds, the intent of this effort will be to support development of the Problem Formulation, a step in the second tier. The second tier or baseline ecological risk assessment (BERA) (Steps 3 through 7 of the USEPA process) uses the output from the earlier steps to refine the problem formulation and further evaluate any COPECs that may cause an adverse effect to receptors of concern. Exposure and effects will be assessed for all endpoints defined in the problem formulation step and used to characterize risks to ecological receptors. The risk management decision process (Step 8) is conducted by the USEPA ecological risk manager, who determines what (if any) remedial actions are necessary. The USEPA process also specifies a number of Scientific Management Decision Points where the project team reviews the status of the BERA with the USEPA ecological risk manager and, if necessary, determine appropriate future courses of action (USEPA, 1997).

Based on an evaluation of the likely food web for the Lower Passaic River, complete ecological exposure routes for higher-trophic level organisms are likely to be associated with ingestion of contaminated prey, particularly benthic invertebrates and fish, and direct/incidental ingestion of sediment and (to a lesser extent) surface water. For the purposes of future assessment of risk to ecological receptors, these will be considered the primary routes of exposures for mammals and birds in the Lower Passaic

River. Direct contact with sediments will likely be a primary route of exposure for plants, invertebrates, and fish receptors.

If evaluation of available information indicates a potential for ecological risks in the Lower Passaic River, then the assessment will move toward a BERA. The BERA will expand on particular ecological concerns at the site, following input from stakeholders and other involved parties. In a screening level ecological risk assessment, conservative assumptions may be used where site-specific information was lacking. The BERA, however, will be more specific and encompass new data compiled during subsequent site investigations (*e.g.*, tissue concentrations, community studies, and toxicity data). It will include the following components: Problem Formulation (Step 3), Study Design and Verification of Field Sampling Design (Steps 4 and 5), Site Investigation and Data Analysis (Step 6), and Risk Characterization (Step 7).

8.3.1 Problem Formulation (Step 3)

The PAR presents a preliminary CSM and an initial identification of ecological receptors of concern, potential exposure pathways, and COPECs. Following the review of additional data collected as part of FSP Volume 1 (Malcolm Pirnie, Inc., 2005c) field activities, each of these BERA components will be reassessed based on current understanding of site conditions, and revised if necessary.

The overall goals of the BERA will also be established during the problem formulation phase. Assessment endpoints are expressed in terms of valued social and important ecological attributes; examples of assessment endpoints include reproduction of piscivorous (fish-eating) birds, and survival of benthic invertebrate communities. Following the selection of the BERA assessment endpoints, the risk questions and measurement endpoints presented in the PAR will be revised as necessary. It is likely that measurement endpoints will include community surveys (fish, epibenthic/benthic macroinvertebrate communities), bioassays, and evaluation of tissue residue data.

8.3.2 Study Design and Data Quality Objectives Process and Verification of Field Study Design (Steps 4 & 5)

Following acceptance of the CSM and assessment and measurement endpoints, a statistically-based study design will be developed as part of the overall project DQO process so that information necessary to conduct the BERA is collected. The specification of proposed collection methodologies for ecological data requirements will be provided in FSP Volume 2. As part of Step 4, a Work Plan Addendum may be prepared to document the decisions made in Steps 1 through 3 as well as identifying additional tasks necessary to complete the BERA. The QAPP (Malcolm Pirnie, Inc., 2005b) will be revised as necessary. In accordance with Step 5 of the USEPA process, the practicality of the proposed ecological studies will be confirmed in the field, prior to implementation of the study. In addition, the appropriateness of preliminarily identified reference areas will be confirmed.

8.3.3 Site Investigation and Data Analysis (Step 6)

Following execution of FSP Volume 2 (in 2006) during the site investigation phase, the BERA will proceed with analysis of both ecological exposures and effects in Step 6. The exposure analysis will determine the extent that ecological receptors are exposed to COPECs both spatially and temporally. Analytical data that are determined to be of suitable quality for risk assessment purposes [as specified in the QAPP (Malcolm Pirnie, Inc., 2005b)] will be statistically summarized to estimate ecological exposures. Addition, it is likely that mathematical models will be used to estimate the trophic transfer of COPECs through the food web. For each receptor of concern, the ecological effects analysis will describe the relationship between exposure to the individual COPECs and adverse ecological responses pertinent to the selected assessment endpoints.

8.3.4 Risk Characterization (Step 7)

Risk Characterization is the final step in the risk assessment process. During this step, risks are estimated by combining the results of the exposure and effects analysis, and interpreted relative to the selected assessment endpoints. An evaluation of BERA uncertainties will also be conducted to aid the ecological risk manager during the remedial decision-making process.

9.0 PROJECT SCHEDULE

A summary of the overall project schedule is provided below in Table 9-1. This summary is based on the July 25, 2005 version of the project schedule.

Table 9-1: Project Schedule

PROJECT ACTIVITY	DATE
Bathymetry Survey	October 2004
Historical Geochemical Data Evaluation	February 2005 – June 2005
Geophysical Survey	April 2005 – August 2005
Hydrodynamic Survey	November 2004 – November 2007
Sediment Investigations	September 2005 – November 2006
Water Quality Investigation	May 2005 – November 2006
Biological Investigations	February 2006 – November 2007
Candidate Restoration Site Screening	May 2004 – September 2005
Dredging and Decontamination Pilots	October 2005
Model Calibration	December 2004 – March 2009
Baseline Modeling	October 2008 – January 2010
Risk Assessment PAR	July 2005
Baseline Risk Assessments	March 2006 – September 2010
Draft Feasibility Study	September 2010 – May 2011
Final Feasibility Study	May 2011 – July 2012
Proposed Plan, Public Comment, and Responsiveness Study preparation	July 2012 – May 2014
Select Remedial and Restoration Plan (Record of Decision)	May 2014 – October 2014

10.0 ACRONYMS

2,4-D	2,4-Dichlorophenoxyacetic acid
2,4,5-T	(2,4,5-Trichlorophenoxy)acetic acid
AOC	Administrative Order on Consent
APE	Area of Potential Effect
ARAR	Applicable or Relevant and Appropriate Requirement
ASCII	American Standard Code for Information Interchange
ATSDR	Agency for Toxic Substance Disease Registry
BASF	Badische Anilin- & Soda-Fabrik, AG
BAZ	Biologically Active Zone
Be-7	Beryllium 7
BERA	Baseline Ecological Risk Assessment
BOD	Biochemical Oxygen Demand
CARP	Contaminant Assessment and Reduction Project
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second (ft^3/s)
CLP	USEPA Contract Laboratory Program
cm	centimeter
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CTD	Conductivity, Temperature, and Depth
DDT	4-4'-Dichlorodiphenyltrichloroethane
.DGN	indicates a Bentley MicroStation Design File
DO	Dissolved Oxygen
DPT	Direct Push Technology
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
EIS	Environmental Impact Statement
EPW	Evaluation for Planned Wetlands
ER-L	Effects Range Low
ER-M	Effects Range Median
ETM	Estuarine Turbidity Maximum
^oF	Degrees Fahrenheit
FDEP	Florida Department of Environmental Protection
FS	Feasibility Study
FSP	Field Sampling Plan
ft^3/s	cubic feet per second (cfs)
GIS	Geographic Information System
HGM	Hydrogeomorphic [Approach]
HHRA	Human Health Risk Assessment
HMW	High Molecular Weight
HTRW	Hazardous, Toxic, and Radioactive Waste

IRIS	Integrated Risk Information System
LER	Lands, Easements, and Rights-of-Way
LISST	Laser in-situ Scattering and Transmissometry
LMW	Low Molecular Weight
MEDD	Multi-Media Electronic Data Deliverable
MHW	Mean High Water
MLW	Mean Low Water
MNR	Monitored Natural Recovery
MOA	Memorandum of Agreement
mph	miles per hour
MRL	Minimal Risk Level
MSL	Mean Sea Level
N/m^2	Newtons per square meter
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NJ	New Jersey
NJADN	New Jersey Atmospheric Deposition Network
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJDOT-OMR	New Jersey Department of Transportation – Office of Maritime Resources
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	National Research Council
NRHP	National Register of Historical Places
NRDA	Natural Resource Damage Assessment
NTDE	National Tide Datum Epoch
NY	New York
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OBS	Optical Backscatter
OCC	Occidental Chemical Company
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
Pa	Pascal = 0.01 millibars or 1 Newton/square meter
PAH	Polycyclic Aromatic Hydrocarbon
PAR	Pathways Analysis Report
Pb-210	Lead-210
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated dibenzo-p-dioxins
PES	Particle Entrainment Simulator
PMP	Project Management Plan
POC	Particulate Organic Carbon
POTW	Publicly Owned Treatment Works
ppb	parts per billion

ppm	parts per million
pptr	parts per trillion
PREmis	Passaic River Estuary Management Information System
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PRSA	Passaic River Study Area
PSE&G	Public Service Electric and Gas Company
PVSC	Passaic Valley Sewerage Commissioners
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
REP	Real Estate Plan
RI	Remedial Investigation
RM	River Mile
SAV	Submerged Aquatic Vegetation
SHPO	State Historic Preservation Officer
SPI	Sediment Profile Imagery
SPMD	Semi-Permeable Membrane Device
SQG	Sediment Quality Guideline
SQO	Site Quality Control Officer
SSS	Side-Scan Sonar
SVOC	Semi-Volatile Organic Compound
SWO	Storm Water Overflow
TAMS	TAMS/EarthTech, Inc.
TCDD	Tetrachlorodibenzo-p-dioxin
TEPH	Total Extractable Petroleum Hydrocarbon
Th-234	Thorium-234
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TMDL	Total Maximum Daily Load
TPH	Total Petroleum Hydrocarbon
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
TVGA	Tallamy, Van Kuren, Gertia, and Associates
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WP	Work Plan
WRDA	Water Resources Development Act

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CONCEPTUAL SITE MODEL

LOWER PASSAIC RIVER RESTORATION PROJECT

Prepared by:

Malcolm Pirnie, Inc., in conjunction with Battelle and HydroQual, Inc.

August 2005

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LOWER PASSAIC RIVER RESTORATION PROJECT
CONCEPTUAL SITE MODEL

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1.0 INTRODUCTION

1.1 OBJECTIVE OF A CONCEPTUAL SITE MODEL

A conceptual site model (CSM) expresses a site-specific, contamination problem through a series of diagrams, figures, and narrative consistent with US Environmental Protection Agency (USEPA) Office of Solid Waste and Emergency Response (OSWER) remedial investigation and feasibility study guidance (USEPA, 1988). These diagrams, figures, and narrative are designed to illustrate the potential physical, chemical, and biological processes that transport contaminants from sources to receptors. Overall, a CSM provides a tool for site managers and planning teams to examine the contamination problem and to provide the basis for identifying and evaluating the potential risks to human health and the ecosystem.

A CSM is developed during the first step of the data quality objective process (DQO; USEPA, 2000) and continues to evolve throughout the project as historical and recently collected data are evaluated, DQOs are updated, and the risk assessments are refined. Typical components of a CSM include:

- Potential sources of contamination.
- Potentially contaminated media and types of contaminants expected.
- Contaminant fate and transport mechanisms and migration pathways.
- Potential exposure pathways and routes of exposure
- Potential human and ecological receptors.

Together, these CSM components and the DQOs present a current understanding of the contamination problem; outline existing data gaps and the sampling necessary to address these gaps; identify potential exposures that may result in existing human and ecological risks; and provide guidance for future project decision-making. It must be understood by all audiences that a CSM is a multidisciplinary tool that serves a critical role in risk assessment, numerical model development, project and sample planning, decision making, and ultimately in choosing a remedial strategy. For this reason, a series of diagrams, figures, and narrative may be appropriate for a complex project. These diagrams, figures, and narrative link together to represent the entire CSM, but individually, each diagram or figure may highlight a different aspect of the project.

1.2 CSM FOR THE LOWER PASSAIC RIVER RESTORATION PROJECT

The following document presents, for consideration, an initial CSM for the Lower Passaic River Restoration Project (LPRRP; refer to Section 1.1 of the Work Plan for a description of the study area; Malcolm Pirnie, 2005a). The objectives of this initial CSM are:

- To present the contamination problem of the Lower Passaic River by focusing initially on geochemical and transport processes.

- To lay the foundation and process for future revisions of the CSM.

To accomplish these objectives in a clear fashion, broad geochemical processes are presented. Exposure pathways are not presented in this CSM; hence the CSM is currently incomplete. In-depth data evaluations are also absent from this document; however, those data evaluations that were completed to date, were considered during the development of this initial CSM. These data evaluation include:

- Preliminary historical data evaluation (refer to Section 4.1 of the Work Plan; Malcolm Pirnie, 2005a).
- Preliminary geochemical evaluation (Malcolm Pirnie, 2005b).
- Evaluation of hydrodynamics and sediment transport between the Lower Passaic River, Newark Bay, and the Hackensack River (HydroQual, 2005).

Future iterations of the CSM will, however, integrate the plethora of existing data and the existing body of literature, data collected during future field investigations, and the exposure pathways and receptors noted in the Pathways Analysis Report (Battelle, 2005; and provided in Attachment 1) to construct a comprehensive CSM that addresses all aspects of the LPRRP. Examples presented in this document are intentionally generalized and serve as the foundation for future iterations of the CSM. It is likely and planned that from this initial CSM a variety of tools will evolve to suit the needs of researchers/consultants working on all aspects of the Lower Passaic River.

The Lower Passaic River, as described in the Work Plan (Section 2.0; Malcolm Pirnie, 2005a), is an estuarine system in northern New Jersey, which was heavily developed in the 1800s. By the twentieth century, urban and industrial developments surrounding the Lower Passaic River, combined with associated population growth, had resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitats.

This CSM is being developed as part of the DQO process outlined in the Draft Quality Assurance Project Plan (QAPP; Malcolm Pirnie, 2005c) to address the contamination problem of the Lower Passaic River. The DQOs describe the project objectives, which are:

- Collect information about sediment stability, contaminant sources, contaminated media, and geochemical data to characterize the nature and extent of contamination.
- Collect information about hydrodynamic, sediment transport and stability, and biotic processes to assess the fate and transport of contaminants in sediments, water, and biota.
- Describe the exposure pathways and receptors to evaluate human health/ecological risks and support the Natural Resource Damage Assessment (NRDA).

The CSM is integral in meeting these objectives since the CSM will provide a description of the contamination problem in the Lower Passaic River Study Area, which can be used to guide the necessary data gathering and evaluation.

1.3 DOCUMENT OVERVIEW

This document is divided into the following sections to articulate the CSM development and the process for maintaining, updating, and refining the CSM.

Section 1.0, INTRODUCTION: explains the CSM's objectives, provides a brief description of the LPRRP, and summarizes the contents of the document.

Section 2.0, DEVELOPMENT OF THE CSM: provides the basis for the development of the CSM for the Lower Passaic River and outlines relevant inventories and fluxes in the system as well as potential chemical fate and transport.

Section 3.0, UPDATING THE CSM: outlines the process by which the CSM will be maintained, updated, and refined as the project proceeds.

Section 4.0, SUMMARY: summarizes the ideas and objectives presented in the document.

Section 5.0, ACRONYMS: lists the definitions and acronyms used in this document.

Section 6.0, REFERENCES: lists the references used in this document.

2.0 DEVELOPMENT OF THE CSM

The initial CSM for the LPRRP is described through a series of six figures and Section 2.0 and Section 3.0 of this text. Each figure is intended to build on the previous figure and to provide additional information on the CSM structure. Hence, initial graphics are relatively simple and later graphics are more complex. To articulate the discussion of the CSM, physical, chemical, and biological processes are separated onto different figures even though all processes co-occur. Thus, it is important that the audience view all six figures collectively as the CSM instead of focusing on one particular figure. Furthermore, as the CSM is iteratively developed, more figures will be created to describe newly added components.

2.1 ESTABLISHMENT OF RIVER SECTIONS

The 17-mile, tidal stretch of the Lower Passaic River was divided into three river sections to reflect the main geochemical and ecological settings of the river (Figure 2-1). This division was qualitatively based on available data on water chemistry, sediment characteristics, depositional environments, and habitat. The river sections include the Freshwater Section (beginning immediately downriver of the Dundee Dam), followed by the Transitional Section, and finally the Brackish Section (extending to the river mouth where it empties into Newark Bay). Note that for this document, these river sections are defined only qualitatively and generalized pending further data evaluation; hence, river miles (RM) have not been assigned to denote river section boundaries. A general description of these river sections along with Dundee Dam and Newark Bay is presented below.

2.1.1 DUNDEE DAM

The Dundee Dam (Figure 2-1) represents the upper boundary of the Lower Passaic River. The dam, which is located between Garfield and Clifton, New Jersey, is positioned at RM 17.4 (where RM 0 is defined as the mouth of the Lower Passaic River). The Dundee Dam is the limit of effective tide for the Lower Passaic River, and the water flowing over the dam is made up entirely of freshwater from upriver. Flow at the dam is currently estimated using a US Geological Society (USGS) gauging station located at Little Falls, New Jersey (approximately 12 miles upriver of the Dundee Dam) and watershed-based corrections to account for contributions between Little Falls and the Dundee Dam. Flows measured at this gauging station from 1990 to 2002 ranged from 446 cubic feet per second (cfs) to 1,802 cfs with a long-term, annual average flow of 1,121 cfs (from 1900 to 2002). Note that it is anticipated that river flow estimates at the Dundee Dam will be refined in the future using measurements recorded at a gauging station located at the dam, which is maintained by United Water and the New Jersey District Water Supply Commission.

2.1.2 FRESHWATER SECTION

The Freshwater Section (Figure 2-1) represents approximately the upper third of the Lower Passaic River where the water conditions are defined as “almost always” freshwater, or salinity values are less than 0.5 ‰ (or parts per thousand[1]). At high tide, the salt front rarely penetrates this section (occurring less than 5 percent of the tidal cycles); however, the water elevations in this section may be tidally influenced. Water and solids are preferentially transported from the Freshwater Section to the Transitional Section; additional water and solids exchange occurs with the Saddle River (RM 15.6). Sediments tend to be characterized by coarse-grained material; low sedimentation rates in this river section tend to yield relatively thin sediment beds. The Freshwater Section likely reflects a freshwater ecosystem and likely provides suitable habitat for freshwater aquatic plants (vascular and algae), macroinvertebrates, fish (bass and minnows), and wildlife species that forage on these prey types.

2.1.3 TRANSITIONAL SECTION

The Transitional Section (Figure 2-1) represents the portion of the Lower Passaic River between the Freshwater Section and Brackish Section, where the salt front typically advances under high-tide conditions (occurring greater than 80 percent of the tidal cycles). Hence, water conditions can vary from slightly brackish (*e.g.*, oligohaline with salinity values ranging from 0.5 ‰ to 5.0 ‰) to moderately brackish (*e.g.*, mesohaline with salinity values ranging from 5.0 ‰ to 18 ‰). This river section is continuously influenced by saltwater intrusion and mixing, resulting in changing water chemistry as well as flocculating and settling of dissolved organic matter and particulates. Water and solids are predominantly transported between the Transitional Section and Brackish Section due to tidal exchange. Additional exchanges occur with two major tributaries, Second River (RM 8.1) and Third River (RM 11.3). Sediment characteristics in the Transitional Section are similar to the Freshwater Section, which are dominated by coarse-grained material and relatively thin, fine-grained sediment beds. The habitat in the Transitional Section reflects a mixture of freshwater and salt-tolerant ecosystems, resulting in a high diversity of flora and fauna. This river section likely provides suitable habitat for estuarine aquatic plants (vascular and algae), macroinvertebrates (blue crab), fish (bass, shad, white perch), and wildlife species that forage on these prey types.

2.1.4 BRACKISH SECTION

The Brackish Section (Figure 2-1) represents approximately the lower third of the Lower Passaic River, where the water conditions are defined as "almost always" moderately brackish with salinity values ranging from 5.0 ‰ to 18 ‰. (For reference, ocean water has salinity values greater than 32 ‰.) At high tide, the salt front usually advances past the Brackish Section and rarely stops within this section (occurring less than 15 percent of tidal cycles). Hence, the water elevations are heavily influenced by tides. Water and solids are transported between the Transitional Section, Brackish Section, and Newark Bay due to tidal exchange. Dredging of the Lower Passaic River has created deep channels in this river section. Moreover, the lack of maintenance dredging has resulted in thick sediment beds forming in these channels, which are dominated by fine-grained material. The Brackish Section reflects a salt-tolerant ecosystem and likely provides suitable habitat for estuarine aquatic plants (vascular and algae), macroinvertebrates

[1] Salinity values are typically reported with the units of "per mil," or parts per thousand. The symbol for "per mil" is ‰. This symbolism is analogous to the percent sign (%), which reflects parts per hundred.

(polychaetes, blue mussel, blue crab), fish (white perch), and wildlife species that forage on these prey types.

2.1.5 NEWARK BAY

Newark Bay (Figure 2-1) represents the lower boundary of the Lower Passaic River with average salinity values ranging from 15 ‰ to 24 ‰, depending on the season. The bay, like the Lower Passaic River, is part of the greater Hudson-Raritan Estuary. For this reason, the bay is heavily influenced by tides. Water and solids are transported between the Brackish Section of the Lower Passaic River and Newark Bay due to tidal exchange.

2.2 POTENTIAL SOURCES OF CONTAMINATION IN THE CSM

Development of the CSM involves an examination and representation of potentially contaminated media, sources of contamination, and potential migration pathways. For this CSM, each of the three river sections described above has been further subdivided into three media: sediment, water, and air (Figure 2-1). These media interact through various natural processes and are impacted by various contamination sources. A schematic flow diagram is presented in Figure 2-2 to describe how these media and sources interact. In this figure, the different media are marked with different colors (sediment marked as brown, water marked as dark blue, and air marked as light blue), sources or inventories are denoted in boxes, and release mechanisms or fluxes are marked on the arrows connecting associated inventories. At this point, the arrow length does not reflect the magnitude of the flux, and all relevant inventories were incorporated into the figures; future iteration of the CSM will prioritize these sources and fluxes based on river section. For example, the evaporation and precipitation of water, which are depicted in the figures, may not be significant fluxes, and these fluxes may be excluded in future iterations of the CSM.

2.2.1 WATER COLUMN AND AIR INVENTORIES AND FLUXES

The water column within a given river section is impacted and influenced by several potential sources and physical mechanisms, including:

- Main-stem flow originating above the Dundee Dam.
- Tidal exchange with adjacent river sections.
- Discharge of water from tributaries.
- Discharge and runoff of water from non-point sources.
- Discharge of water from point sources, including combined sewer overflow sites (CSOs), wastewater treatment plants sites, as well as permitted and accidental industrial releases.
- Exchange between porewater and the water column from diffusion and bioturbation.
- Exchange between groundwater and the water column from discharge and seepage.
- Evaporation and precipitation of water between the atmosphere and water column as well as wet and dry atmospheric deposition and volatilizations of contaminants into the water column.

2.2.2 SEDIMENT INVENTORIES AND FLUXES

The sediment within a given river section is impacted and influenced by several potential contaminant migration pathways through the environment, including:

- Transport and deposition of solids originating above the Dundee Dam.
- Resuspension and deposition of solids due to tidal exchange with adjacent river sections.
- Resuspension and deposition of solids due to tidal flow within the section.
- Resuspension and deposition of solids from the tributaries to surface sediment.
- Discharge of solids from non-point sources, including runoff to surface sediment.
- Discharge of solids from point sources, including CSOs, wastewater treatment plant sites, as well as permitted and accidental releases, to the surface sediment.
- Burial of surficial sediment to intermediate sediment beds and deep sediment beds from sedimentation and bioturbation (note that these sediment beds will be assigned vertical boundaries in future iterations of the CSM).
- Resuspension and deposition of solids between mudflats and floodplains and the surface sediment.
- Indirect interactions with groundwater and porewater.
- Remobilization of intermediate and deep sediment beds during floods or storm events.

2.2.3 POTENTIAL SOURCES IN RIVER SECTIONS

While the schematic in Figure 2-2 illustrates how potential sources and media will interact, some sources denoted on this figure will be absent or less significant within a given river section. For this CSM, potential sources are listed for each river section (Figure 2-3). However, during future revisions of the CSM, these lists will be refined and updated to reflect the different ways that the river sections are impacted.

For example, sources that may impact the water quality of the Freshwater Section and the Transitional Section include major tributaries (*e.g.*, Saddle River, Third River, and Second River), non-point sources (*e.g.*, runoff), groundwater, and porewater. Surface sediment quality in the Freshwater Section and Transitional Section may be impacted by solids that were resuspended and transported over the Dundee Dam and from major tributaries (*e.g.*, Saddle River, Third River, and Second River), floodplains, and non-point sources (*e.g.*, transported in runoff). Meanwhile, the Brackish Section's water quality may be impacted by point sources (*e.g.*, CSOs and other industrial discharge points), groundwater, and porewater in addition to tidal exchange with Newark Bay. Sediment quality may be impacted by solids originating from intermediate or deep sediment beds, mudflats, floodplains, point sources, and Newark Bay.

2.3 FATE AND TRANSPORT

To further develop the CSM, the fate and transport of chemicals is overlaid on the schematic diagram of potential sources, which was previously shown in Figure 2-3. Chemicals move between the sediment, water column, and air through a series of reactions and pathways to achieve equilibrium (Figure 2-4). Moreover, certain chemicals have the potential to bioconcentrate in biological media. These chemicals tend to be bioavailable, hydrophobic chemicals that will partition from either the sediment or water column into biological tissue. Depending on the chemical nature of these chemicals, they may bioaccumulate in the food web, resulting in higher tissue concentrations in higher trophic level receptors.

Figure 2-4 and Figure 2-5 present a conceptual representation of the potential reactions and pathways that could affect the fate and transport of chemicals. For simplicity these fate and transport figures are not inclusive and do not include all physical mechanisms shown on Figure 2-2 and Figure 2-3 that can affect fate and transport. The abiotic reactions and pathways are presented in Figure 2-4 as black arrows; additional biological pathways are then added to this graphic and are presented in Figure 2-5 as green arrows. [Note for a complete discussion of all biological pathways refer to the Pathways Analysis Report (Battelle, 2005).] The chemical state (*i.e.*, sorbed chemical, dissolved chemical, or vapor) is denoted in the boxes, which represent inventory while mechanisms are represented by arrows connecting associated boxes as appropriate. Both figures portray general reactions and pathways that may occur in the Transitional Section of the Lower Passaic River. However, some reactions and pathways may be absent or less significant for certain chemicals and for certain river sections. Future iterations will prioritize these reactions and pathways.

In general, potential mechanisms influencing fate and transport of a given chemical in the water and air may be advection, flocculation (aggregation) or disaggregation, sorption or desorption, degradation, volatilization, and/or deposition. In the sediment, the potential mechanisms may be sorption or desorption, resuspension, degradation, and transformations. In biota, the potential mechanisms are bioconcentration and bioaccumulation. To illustrate that chemical reactions and pathways are chemical-specific, a fate and transport model was created for a hydrophobic compound (Figure 2-6). Future iterations of the CSM will develop other chemical-specific, river section-specific fate and transport figures, as appropriate.

Hydrophobic organic chemicals, such as dichlorodiphenyltrichloroethane (DDT), have a greater affinity for the sorbed phase (Figure 2-6). As a result, these hydrophobic chemicals will concentrate in the sediments (specifically the organic matter fraction of the sediment), the organic colloidal-fraction of the water column, and the lipid content of biological tissue. Microbial reactions will cause the transformation of DDT to its metabolites, dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyl-dichloroethylene (DDE); however, complete microbial or chemical degradation is less common. Since DDT, as well as other hydrophobic chemicals, does not concentrate in the dissolved phase in the water column, the transport of solids will tend to have a greater impact on surface sediment concentrations than interactions with the water column. Inventories and fluxes that significantly impact the fate and transport of DDT are shown in Figure 2-6 while less significant inventories and fluxes have been deleted, relative to Figure 2-5.

2.4 UNCERTAINTIES IN THE CSM

The diagrams presented in Figures 2-1 through 2-5 represent a preliminary CSM for the Lower Passaic River. Note that the modeling framework diagram presented in the Section 1.6 of the Draft Modeling Plan (HydroQual, 2005) and the human health and ecological exposure pathways presented in Section 3.0 of the Pathways Analysis Report (Battelle, 2005) also represents components of the CSM. These auxiliary diagrams provide additional project details not included in this discussion of the CSM, such as the interconnection of mathematical models and potential human and ecological exposure pathways, routes of exposure, and receptors. Together, however, all of these diagrams represent a comprehensive CSM that will assist in the development of appropriate study questions and decisions points (step #2 of the DQO process) as well as help to determine the appropriate field sampling needs (step #3 of the DQO process).

The CSM does, however, contain uncertainties due to data gaps that exist regarding the contamination sources on the Lower Passaic River, interactions between sediment, water column, and air, and transportation of chemicals through the system. For example, limited field data exists for river miles up-estuary of RM 7; water column and hydrodynamic data are incomplete for the entire stretch of the Lower Passaic River; and the interactions between Newark Bay and the Lower Passaic River are unresolved. Impacts from time-dependent processes and how the CSM will account for these temporal processes are still uncertain. Examples of temporal processes include: effects of storm events on the Lower Passaic River, changes in sediment deposition over time, reactions that change the bioavailability of contaminants over time, or changes due to remedial action. Additional uncertainties involve the appropriate linkage of the human health and ecological exposure pathways and receptors (Battelle, 2005) to the geochemical CSM presented in this document to construct a comprehensive CSM.

To address current limitations of the CSM, data will be collected and evaluated to resolve uncertainties and associated data gaps. Moreover, as relevant data gaps are identified during the DQO process, a procedure must be established for maintaining, refining, and updating the CSM to understand site-specific conditions.

3.0 UPDATING THE CSM

3.1 MAINTAINING AND REFINING THE CSM

The current CSM is designed to be refined and updated to address uncertainties associated with data gaps. For instance, river sections can be re-defined quantitatively following the collection and evaluation of water column data, geophysical data, and ecological community survey data. A quantitative description of river section characteristics may then lead to the establishment of river mile boundaries (or boundary ranges). An evaluation of historical data may also identify dominant sources in each river section, estimate water flow between river sections, and determine the solid load transported between the Lower Passaic River and Newark Bay. An evaluation of future sediment coring data may determine the magnitude of inventories and fluxes. This information may be reflected together in an updated CSM through a series of weighted boxes and arrows with the degree of uncertainty reflected in visual shading of colors. An updated CSM can then be combined with a refined chemical/biological fate and transport model for each benchmark chemical. These chemical-specific, fate and transport models will then be adjusted for each river section accounting for dominant sources or natural processes. An integration of the information presented in the Pathways Analysis Report (Battelle, 2005) will then complete the exposure pathway from source to receptor.

To accomplish this CSM refinement, appropriate study questions, including risk hypotheses and questions aimed at evaluation of risk-based remediation, have been and will be established. Then, historical data will be evaluated and appropriate field data will be collected to address the study questions and to increase the understanding of the system. Due to the complexity of the LPRRP, future iterations of the CSM may include separate models to highlight different aspects of the project. These individual models may focus on sources, release and media, human health exposure pathways and receptors, and ecological exposure pathways and receptors. Updated versions of the CSM will be posted on the Passaic River Estuary Management Information System (PREmis; an internal database) for review by the partner agencies. Following partner agency review, CSMs may be posted on the public website (www.ourpassaic.org) for review and comment by stakeholders. Previous versions of the CSM will be archived and available via PREmis.

3.2 UPDATING THE CSM WITH HISTORICAL DATA

The CSM can be updated in several fashions using existing literature and historical data, including a geochemical data review to understand contaminant fate and transport, a geophysical data review to build confidence in the feasibility study and restoration effort, or a biological data review to assess expose pathways and receptors. Each of these literature and historical data reviews will involve development of questions to guide the review, an evaluation of historical data, and a presentation of results that leads to an updated version of the CSM.

To update the geochemical component of the CSM, a historical geochemical data evaluation is necessary to address the questions listed below. These geochemical questions build on the work and recommendations developed in the Draft Technical Memorandum: Preliminary Geochemical Evaluation (Malcolm Pirnie, 2005b). Each question below is followed by one or more evaluation tasks that are designed to address the question. Note that some tasks are listed multiple times since they address more than one geochemical question. The listed tasks should not be considered exhaustive, and additional tasks may be warranted based on the evolving findings from the stated analyses. Note that these geochemical questions are not the DQO questions listed in the Draft QAPP (Malcolm Pirnie, 2005c). These geochemical questions were designed explicitly for the evaluation of historical geochemical data. One result of this geochemical evaluation is to prioritize geochemical data gaps and quantify uncertainties.

1) **What more can be known about the fate and transport of solids in the Passaic River?**
   a) What is the long-term net amount of solids eroded / deposited within each section of the Lower Passaic River?
      i) Building on the bathymetric comparisons previously conducted (Malcolm Pirnie, 2005b), determine net gain of solids or net loss of solids over each river section and across the entire river; estimate a solids mass balance for the river.
      ii) Use radionuclide data to establish local deposition rates over the full 17-mile stretch of the Lower Passaic River.
   b) What is the impact of a major flow event on the movement of solids and contaminants downriver?
      i) Using the available lead-210 (Pb-210) data, date the discontinuities that are observed in the sediment cores – match these dates to major flooding events.
      ii) Map the location of these discontinuities.
   c) What are the dynamics of the estuarine mixing processes that can maintain relatively homogeneous concentrations in some benchmark chemicals (*e.g.*, 2,3,7,8 tetrachlorodibenzo-p-dioxin; 2,3,7,8-TCDD) while apparent concentration gradients exist for other benchmark chemicals (*e.g.*, polycyclic aromatic hydrocarbons; PAHs)?
      i) Compare the sources, locations, loadings mechanisms, and transport mechanisms of different benchmark chemicals to determine or estimate conditions that yield homogeneous mixing.

2) **What is the nature and extent of historical contamination in the Lower Passaic River?**
   a) What is the extent of contamination in the sediment beds?
      i) Continue work started in the Draft Technical Memorandum (Malcolm Pirnie, 2005b) to map the concentration of contaminants in the sediments, including polychlorinated biphenyls (PCBs) and heavy metals.
      ii) Use total DDT and Pb-210 data to infer the vertical extent of 2,3,7,8-TCDD contamination in the Lower Passaic River. Pb-210 measurements will be used to identify depositional and non-depositional environments; total DDT data

will be used to identify the depth of contamination since the peak loading of total DDT is expected to occur at greater depths than the 2,3,7,8-TCDD peak loading.

iii) Calculate the mass per unit area (MPA) for each benchmark chemical to estimate an inventory and to identify areas of concern (use of this calculation does not imply that MPA will necessarily be used or recommended as an action criterion in subsequent phases of the project).

b) What are the impacts of contaminated Passaic River surface water on adjacent or connected waterbodies within the broader study area, including Newark Bay, the Hackensack River, and the Kills?

i) If a sufficient amount of data is available, evaluate surface water quality in the Lower Passaic River and adjacent waterbodies.

c) What is the relationship between the contaminant load in the dissolved-phase and the suspended-phase for six benchmark chemicals and one ratio (*i.e.*, Total DDT, 2,3,7,8-TCDD, Total PAHs, Total PCBs, Mercury and Lead, and the ratio of 2,3,7,8-TCDD to Total Tetra-CDD)?

i) Compare the dissolved-phase concentration and corresponding suspended-phase concentration versus river mile; plot the ratio of the dissolved-phase to the sum of the dissolved-phase plus suspended-phase.

ii) Identify the chemical-specific, distribution coefficient for the dissolved-phase and the suspended-phase.

iii) Examine the relationship between the contaminant loads in the suspended-phase and the contaminant loads in surficial sediment.

3) What is the fate and transport of each benchmark chemical in the Passaic River?

a) How is the transport of solids affecting the fate and transport of benchmark chemicals?

i) Identify a chemical fingerprint unique for Newark Bay and trace this fingerprint into the Passaic River. Possible fingerprints include DDT and metabolites, polychlorinated dibenzodioxin/furan (PCDD/F) congener ratios, and heavy metal ratios.

ii) Incorporate findings of task 1)(a)(i).

iii) Estimate mass of benchmark chemicals using the average surface concentrations and net gain or loss of solids.

iv) Map the ratio of benchmark chemicals to cesium-137 (Cs-137) along the Lower Passaic River to identify sources.

v) Examine variations in the ratio of total DDT/2,3,7,8-TCDD in previously determined erosional and depositional environments to evaluate the fate and transport of total DDT and 2,3,7,8-TCDD.

vi) Compare benchmark metal concentrations to one another to identify those that are inversely or directly related – draw inferences regarding the fate and transport of the metals compared.

b) What ratios are characteristic of a given waterbody that can be used to fingerprint contaminant transport?

i) Incorporate findings of task 3)(a)(i).

ii) Use principal component analysis of PAHs and PCBs to attempt to identify source fingerprints; and examine specific ratios across the Lower Passaic River and into adjacent waterbodies to evaluate fate and transport.

c) What is the history of contamination for each benchmark chemical?
   i) Building on the bathymetric and radionuclide analyses previously conducted (Malcolm Pirnie, 2005b), examine cores from depositional areas to determine chronology and loading of additional benchmark chemicals.
   ii) Incorporate findings of task 2)(a)(ii).

4) How closely linked is the contamination in the Lower Passaic River and Newark Bay?

a) Is the Passaic River receiving contamination from Newark Bay?
   i) Incorporate findings of task 3)(a)(i).

b) What is the concentration gradient from the Lower Passaic River to Newark Bay?
   i) Using historical sediment data, solve algebraic equations to estimate the relative magnitude of the loading of benchmark chemicals from the Lower Passaic River to Newark Bay.

5) What are the impacts of contaminants in the Lower Passaic River on its biota?

a) What is the impact of surficial sediment on the biota for six benchmark chemicals and one ratio (*i.e.*, Total DDT, 2,3,7,8-TCDD, Total PAHs, Total PCBs, mercury and lead, and the ratio of 2,3,7,8-TCDD to Total Tetra-CDD)?
   i) Examine the relationships between the concentrations in surficial sediment and in biological tissue.
   ii) Evaluate the bioavailability of contaminants by examining field-collected samples and laboratory-controlled toxicity tests.

3.3 UPDATING THE CSM WITH FIELD DATA

The CSM and DQO questions were established to assist in identifying important data gaps that exist in the historical data set and to guide the future field sampling efforts. [A complete listing of the DQO questions for the LPRRP is provided in Attachment 1.1 of the QAPP (Malcolm Pirnie, 2005c).] The DQOs are the foundation for the Field Sampling Plans (FSPs) Volumes 1 through 3, which are designed to collect appropriate data to satisfy the DQOs and update the CSM. Hence, all future updates of the CSM will be linked to the fundamental DQO questions, which are provided in Attachment 1.1 of the QAPP (Malcolm Pirnie, 2005c).

The CSM will be updated after the collection, validation, and evaluation of appropriate field data. It is anticipated that an update will occur following the geophysical survey, sediment sample classification, and sediment physical properties testing effort (see Figure 3-20 of FSP Volume 1; Malcolm Pirnie, 2005d); sediment coring programs (see Figure 3-21 of FSP Volume 1); and the water column sampling (see Figure 3-24 of FSP Volume 1). It is also anticipated that as data are collected and evaluated, additional investigations will be identified and conducted, resulting in further updates of the CSM.

Additional CSM updates will occur with the refinement of the human health and ecological exposure pathways diagram (Battelle, 2005) following an upcoming Passaic River Ecological Risk Assessment Workshop. As part of this CSM update, it is anticipated that food webs will be constructed for each river section and appropriate receptors will be assigned for each food web. Future iterations of the CSM will also connect the geochemical CSM and the human health and ecological exposure pathways (*e.g.*, ingestion, dermal contact, root sorption) to illustrate a complete pathway from source to receptors (*e.g.*, fisherman and piscivorous bird). Examples of how field information will feed the human health and ecological evaluations include: an examination of geochemical data to identify exposure point concentrations in sediment and surface water as well as to forecast temporal trends for contaminants; and an examination of geophysical data to identify transient areas in sediment beds and to identify where exposure is likely to occur.

4.0 SUMMARY

The CSM provides a tool for site managers and planning teams to examine the contamination problem, to determine an appropriate sampling plan, and to evaluate potential risk to human health and the ecosystem. The CSM will evolve throughout the project as historical data and field data are evaluated and as the DQOs are updated and refined.

For the Lower Passaic River CSM, the river was qualitatively divided into three river sections (Freshwater Section, Transitional Section, and Brackish Section) based on water chemistry, sediment characteristics, depositional environments, and habitat. These river sections interact with each other due to freshwater flow down river and tidal exchange. Moreover, external sources impact each river section by introducing additional water and solids. The CSM was further developed by considering reactions that move chemicals between various media of the Lower Passaic River. Typical reactions include sorption/desorption, resuspension/deposition, degradation, volatilization/deposition, and bioaccumulation.

The CSM does, however, contain uncertainties due to data gaps regarding contamination sources on the Lower Passaic River; interactions between the sediment, water column, and air media; and transportation of chemicals through the system. To address these uncertainties and associated data gaps, historical data will be evaluated and field data will be collected and evaluated. After each data evaluation, the CSM will be updated accordingly and, as is appropriate, reflect a better understanding of the processes controlling the Lower Passaic River.

5.0 ACRONYMS

‰	parts per thousand or “per mil”
cfs	cubic feet per second
Cs-137	Cesium-137
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DQO	Data Quality Objective
FSP	Field Sampling Plan
LPRRP	Lower Passaic River Restoration Project
MPA	Mass per Area
NRDA	Natural Resource Damage Assessment
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbon
Pb-210	Lead-210
PCB	Polychlorinated Biphenyl
PCDD/F	Polychlorinated dibenzodioxin/furan
PREmis	Passaic River Estuary Management Information System
QAPP	Quality Assurance Project Plan
RM	River Mile
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzodioxin
USEPA	US Environmental Protection Agency
USGS	US Geological Society

6.0 REFERENCES

Battelle, 2005. “Pathways Analysis Report.” Prepared by Battelle under contract to Malcolm Pirnie, Inc. (White Plains, NY) for the USEPA Region 2 and USACE-New York District. May 2005.

HydroQual, 2005. “Draft Modeling Plan.” Prepared by HydroQual under contract to Malcolm Pirnie, Inc. (White Plains, NY) for the USEPA Region 2 and USACE-New York District. April 2005.

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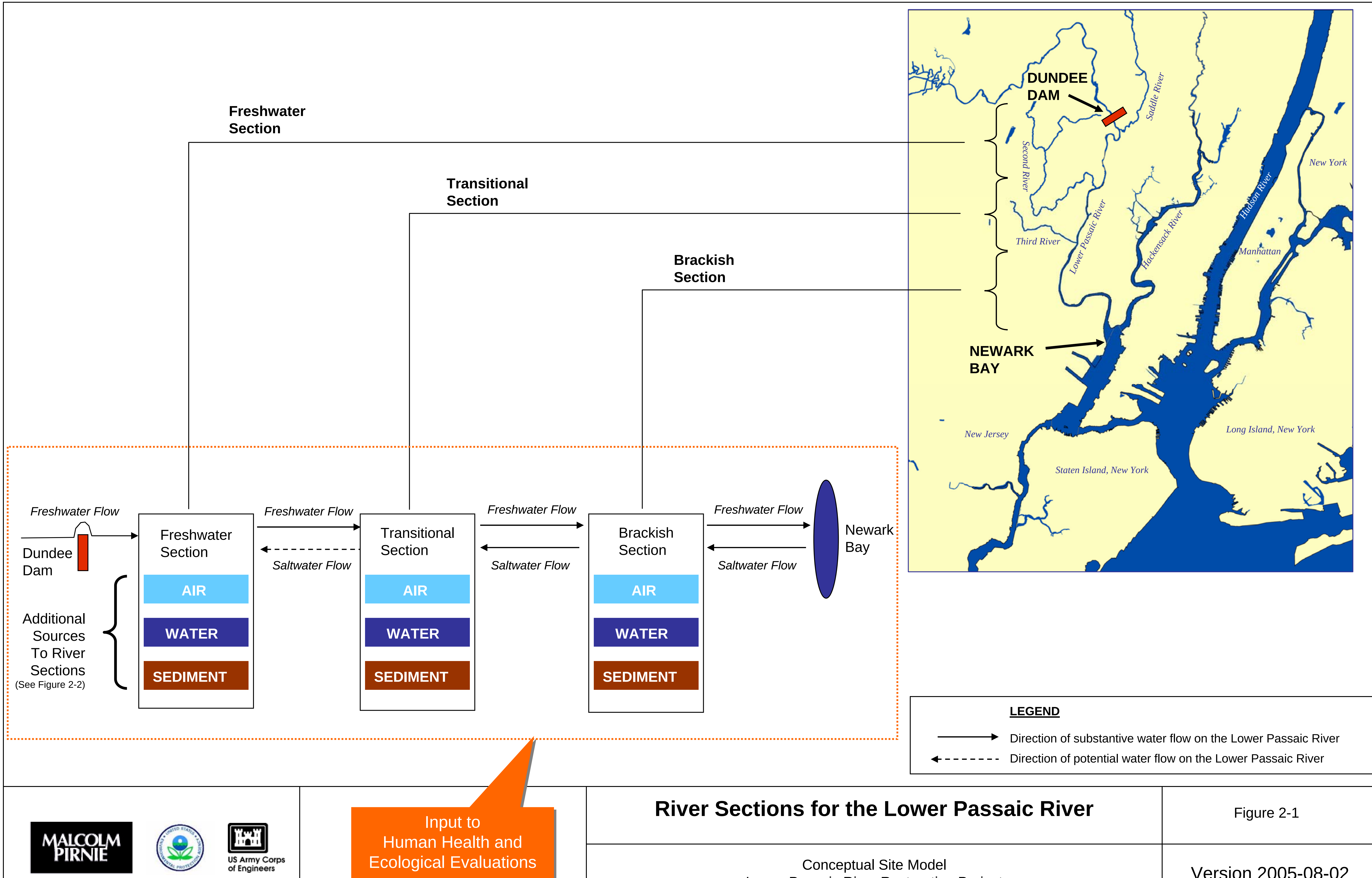
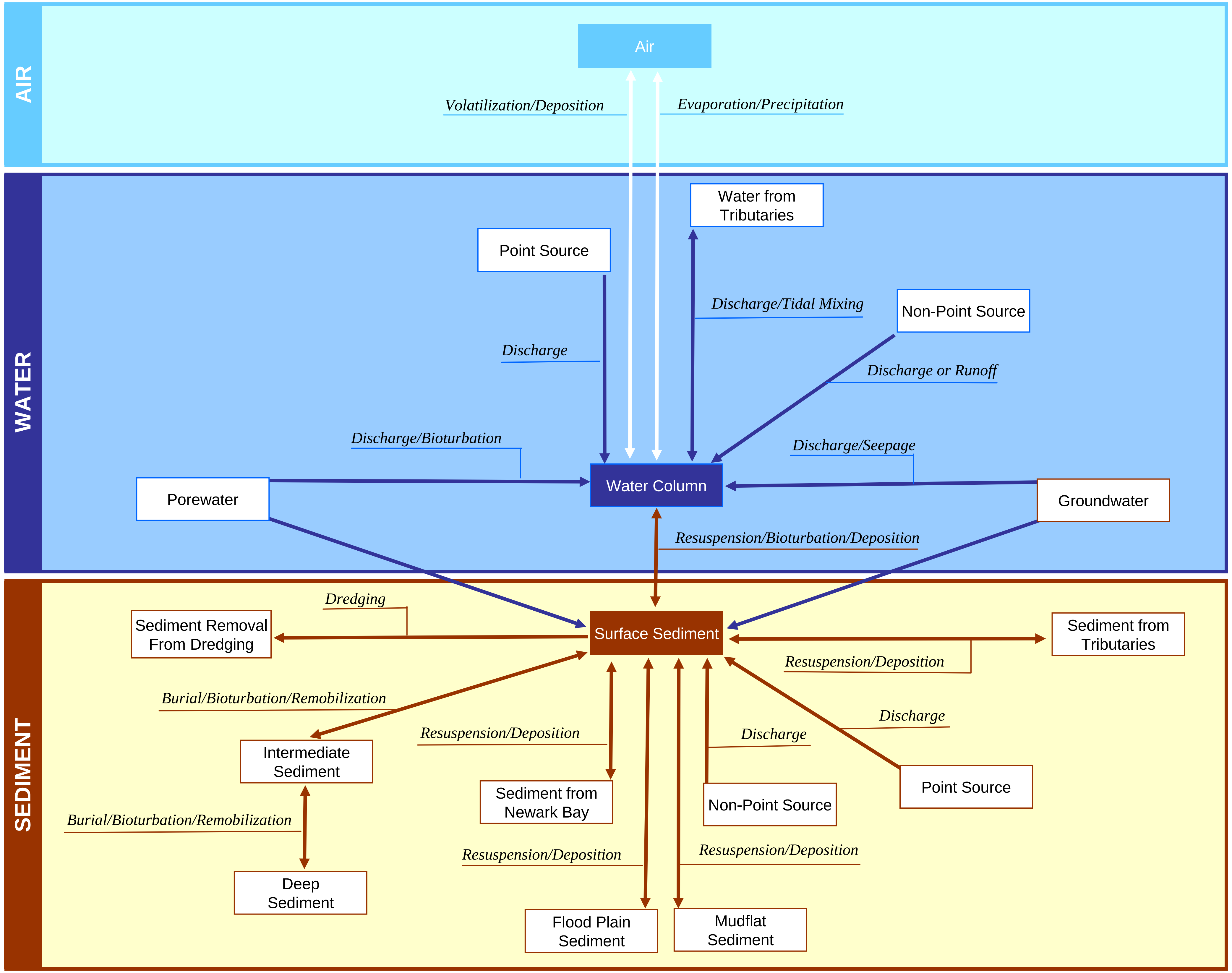


River Sections for the Lower Passaic River

Figure 2-1

Conceptual Site Model
Lower Passaic River Restoration Project

Version 2005-08-02



NOTES

Figure 2-2 is intended to depict substantive physical processes that affect the transport of contaminants between different media. Some physical processes may be less significant or absent in certain river sections. Future iterations of the CSM will prioritize these physical processes. Note that the chemical fate and transport processes are depicted in subsequent figures.

The color scheme used in Figure 2-2 reflects different media, including air (light blue), water (dark blue), and sediment (brown), and it represents the media depicted in Figure 2-1.

LEGEND

Groundwater — Sources of air, water, or sediment to the Lower Passaic River

Release mechanisms connecting associated inventories (bi-directional arrows are marked with two mechanisms separated by a slash mark)

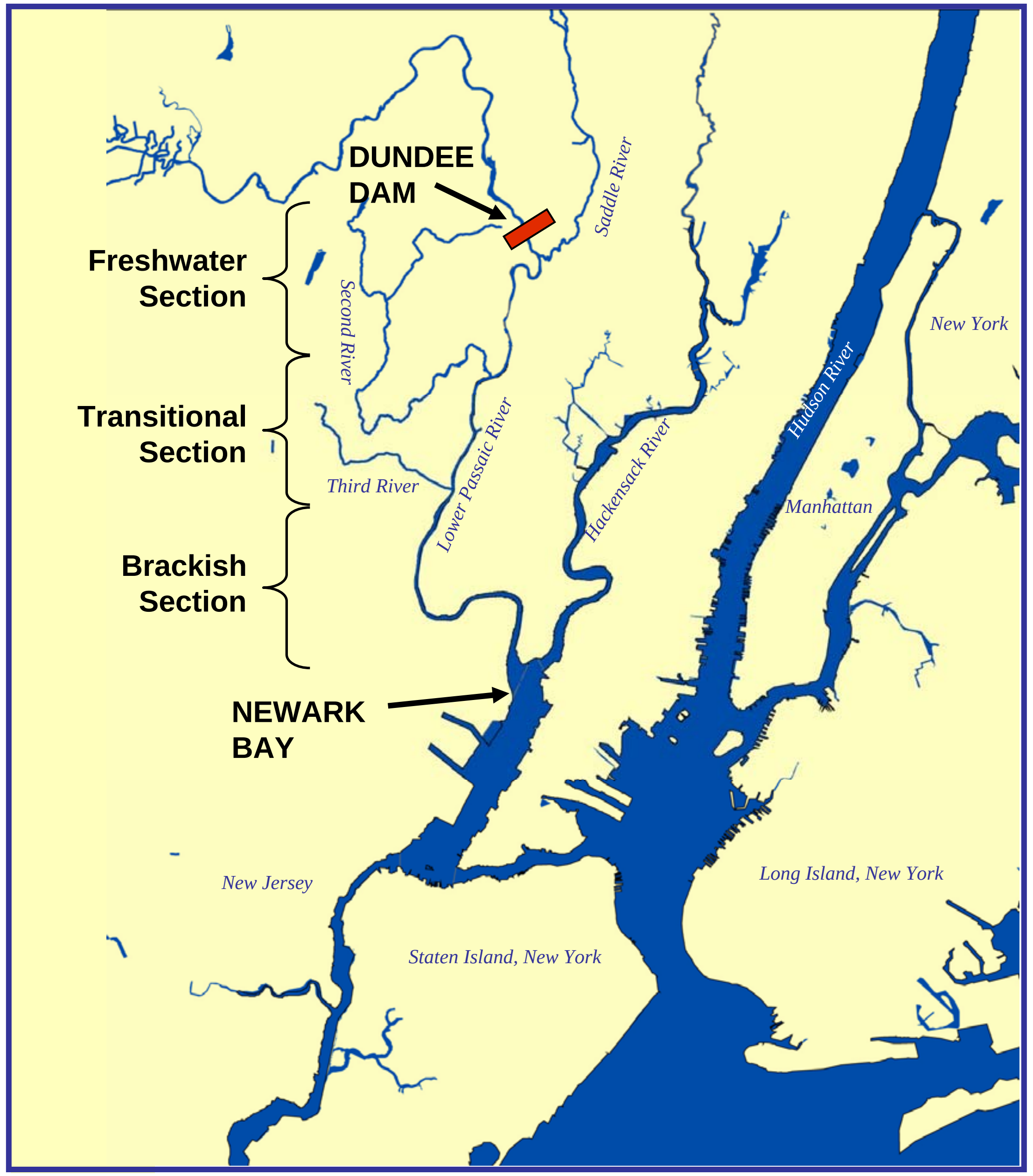
Input to Human Health and Ecological Evaluations

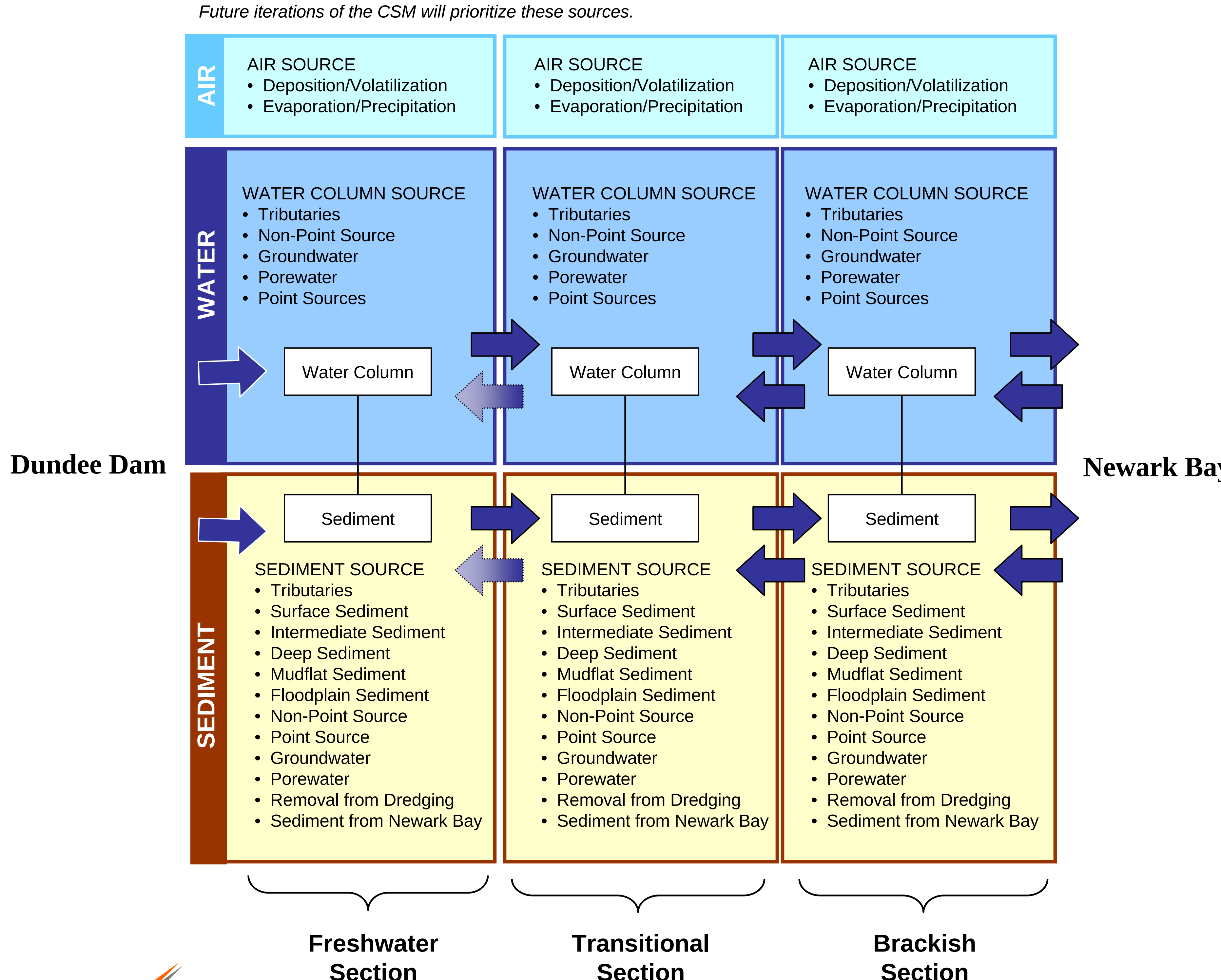
General Sources & Physical Release Mechanisms for Contaminants in Sediment, Water, and Air

Figure 2-2

Conceptual Site Model
Lower Passaic River Restoration Project

Version 2005-08-02





LEGEND

- Direction of substantive water flow and sediment transport on the Lower Passaic River
- Direction of potential water flow and sediment transport on the Lower Passaic River

NOTES

Sources and processes shown in Figure 2-2 are applicable to Figure 2-3; however, for simplicity, arrows presented in Figure 2-2 are not duplicated in Figure 2-3. Note that some sources may be less significant or absent in certain river sections; future iteration of the CSM will prioritize these sources.

The color scheme and boxes used in Figure 2-3 reflect different media, including air (light blue box), water (dark blue box), and sediment (brown box), and they represent the sources, mechanisms, and media depicted in Figure 2-1 and Figure 2-2.

Input to Human Health and Ecological Evaluations

MALCOLM PIRNIE

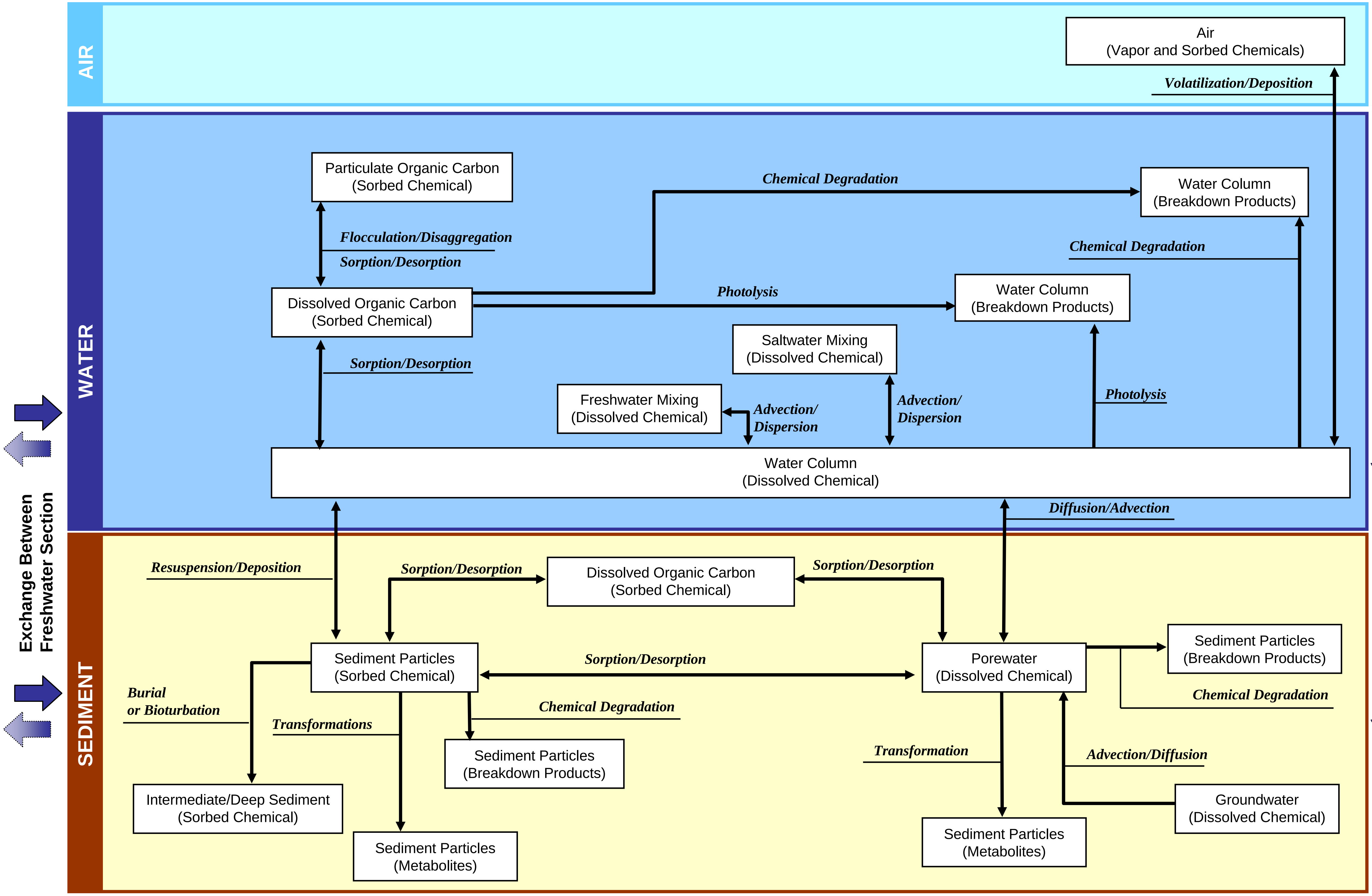
US Army Corps of Engineers

Sources in Each River Section

Figure 2-3

Conceptual Site Model
Lower Passaic River Restoration Project

Version 2005-08-02



NOTES

Figure 2-4 is intended to depict substantive chemical processes that affect the transport of contaminants. Some chemical processes may be less significant or absent in certain river sections. Future iterations of the CSM will prioritize these processes. For simplicity, physical process shown on Figures 2-2 and 2-3 are not duplicated in this figure. Note that the biological processes are depicted in subsequent figures.

The color scheme and boxes used in Figure 2-4 reflect different media, including air (light blue box), water (dark blue box), and sediment (brown box), and they represent the sources, mechanisms, and media depicted in Figure 2-1 through Figure 2-3.

LEGEND for Figures 2-4 and 2-5

Inventory with chemical state marked in parentheses, where appropriate

Abiotic reactions or pathways connecting associated inventories

Biotic reactions or pathways connecting associated inventories (see Fig. 2-5)

Direction of substantive water flow and sediment transport on the Lower Passaic River

Direction of potential water flow and sediment transport on the Lower Passaic River

MALCOLM PIRNIE

US Army Corps of Engineers

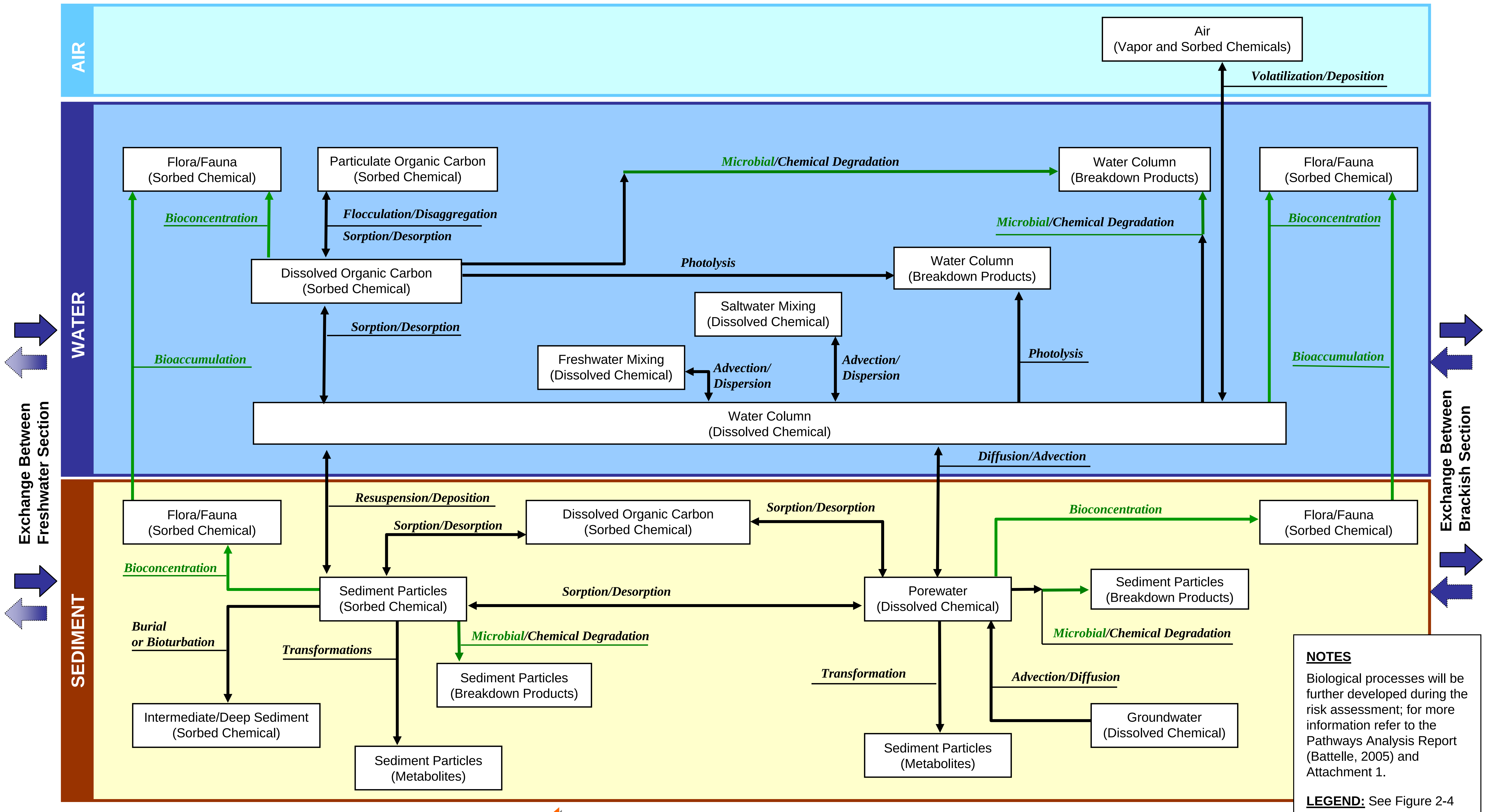
Input to Human Health and Ecological Evaluations

Chemical Fate and Transport Processes in Transitional Section

Figure 2-4

Conceptual Site Model
Lower Passaic River Restoration Project

Version 2005-08-02



US Army Corps of Engineers

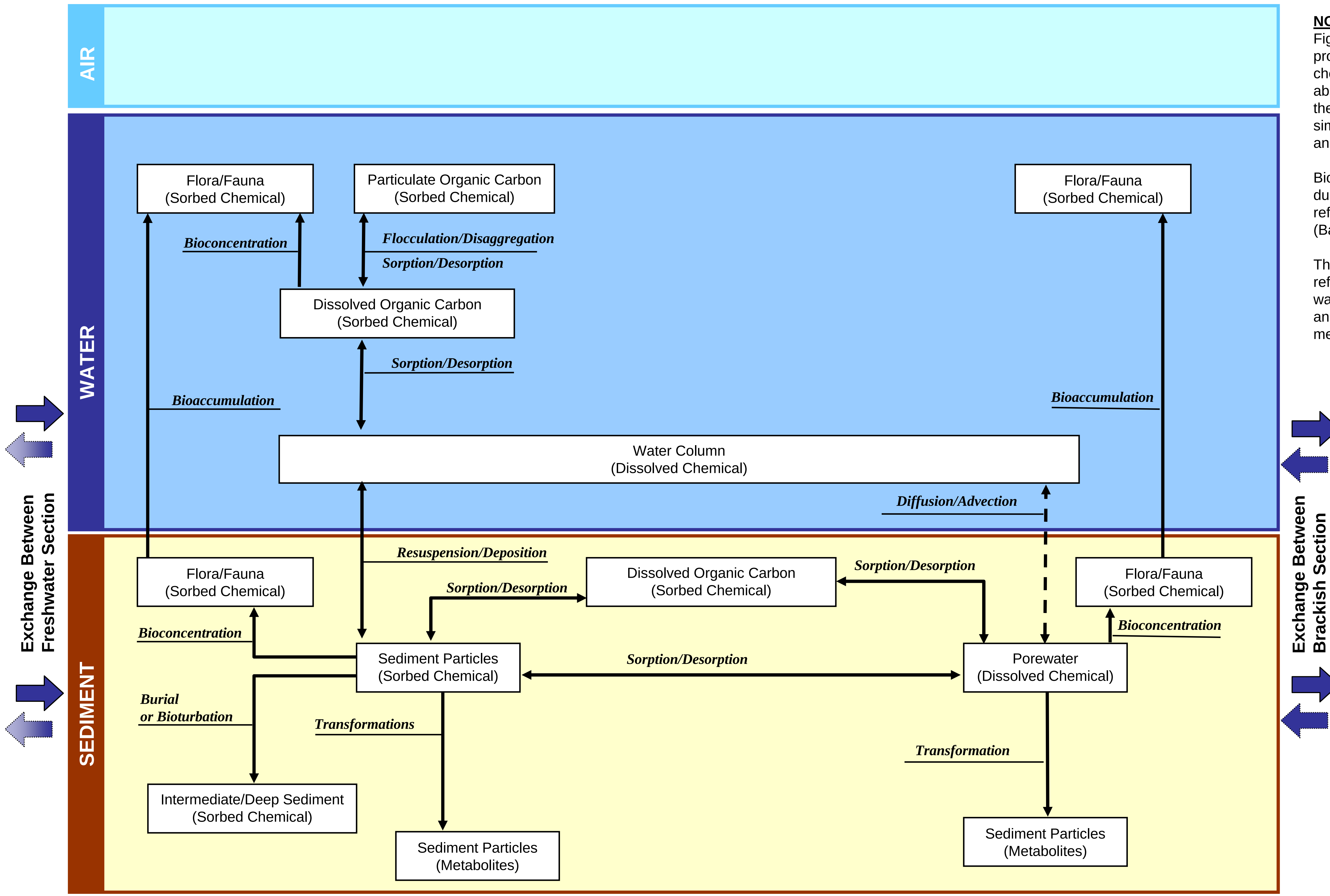
Input to
Human Health and
Ecological Evaluations

Chemical and Biological Fate and Transport Processes in Transitional Section

Figure 2-5

Conceptual Site Model
Lower Passaic River Restoration Project

Version 2005-08-02



NOTES

Figure 2-6 is intended to depict substantive processes that affect the transport of DDT. Some chemical processes may be less significant or absent in certain river sections. Future iterations of the CSM will prioritize these processes. For simplicity, physical process shown on Figures 2-2 and 2-3 are not duplicated in this figure.

Biological processes will be further developed during the risk assessment; for more information refer to the Pathways Analysis Report (Battelle, 2005) and Attachment 1.

The color scheme and boxes used in Figure 2-6 reflect different media, including air (light blue box), water (dark blue box), and sediment (brown box), and they represent the sources, mechanisms, and media depicted in Figure 2-1 through Figure 2-5

LEGEND

Inventory with chemical state marked in parentheses, where appropriate

Reactions or pathways connecting appropriate DDT inventories (bi-directional arrows are marked with two reactions or pathways separated by a slash mark)

Potential reactions or pathways that connect appropriate DDT inventories (bi-directional arrows are marked with two reactions or pathways separated by a slash mark)

Direction of substantive water flow and sediment transport on the Lower Passaic River

Direction of potential water flow and sediment transport on the Lower Passaic River

MALCOLM PIRNIE

US Army Corps of Engineers

Input to Human Health and Ecological Evaluations

Chemical and Biological Fate and Transport Processes for DDT in Transitional Section

Figure 2-6

Conceptual Site Model
Lower Passaic River Restoration Project

Version 2005-08-02

Attachment 1

Battelle, 2005. “Pathways Analysis Report.” Prepared by Battelle under contract to Malcolm Pirnie, Inc. (White Plains, NY) for the USEPA Region 2 and USACE-New York District. May 2005.

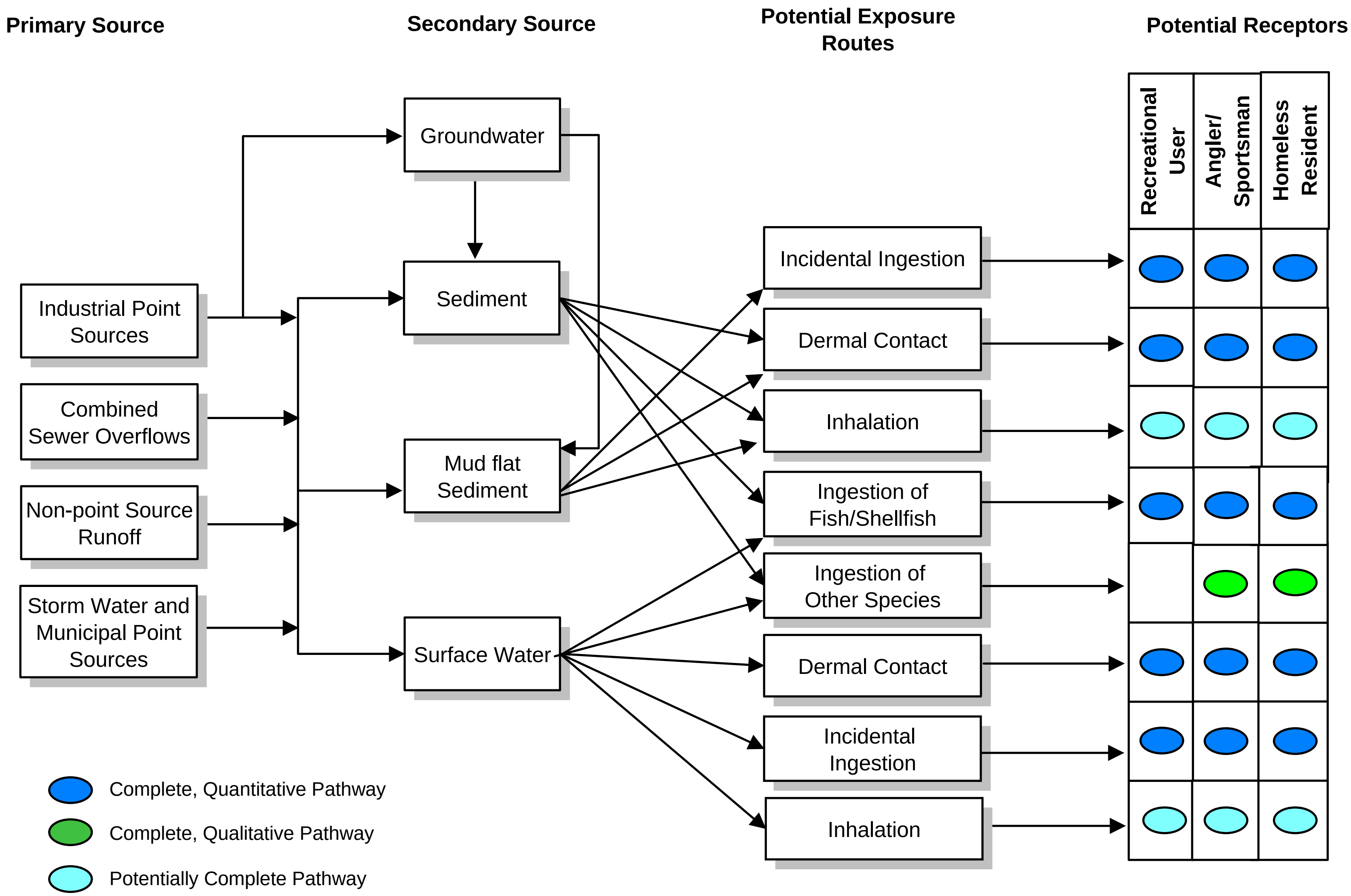


Figure 5. Human Health Conceptual Site Model.

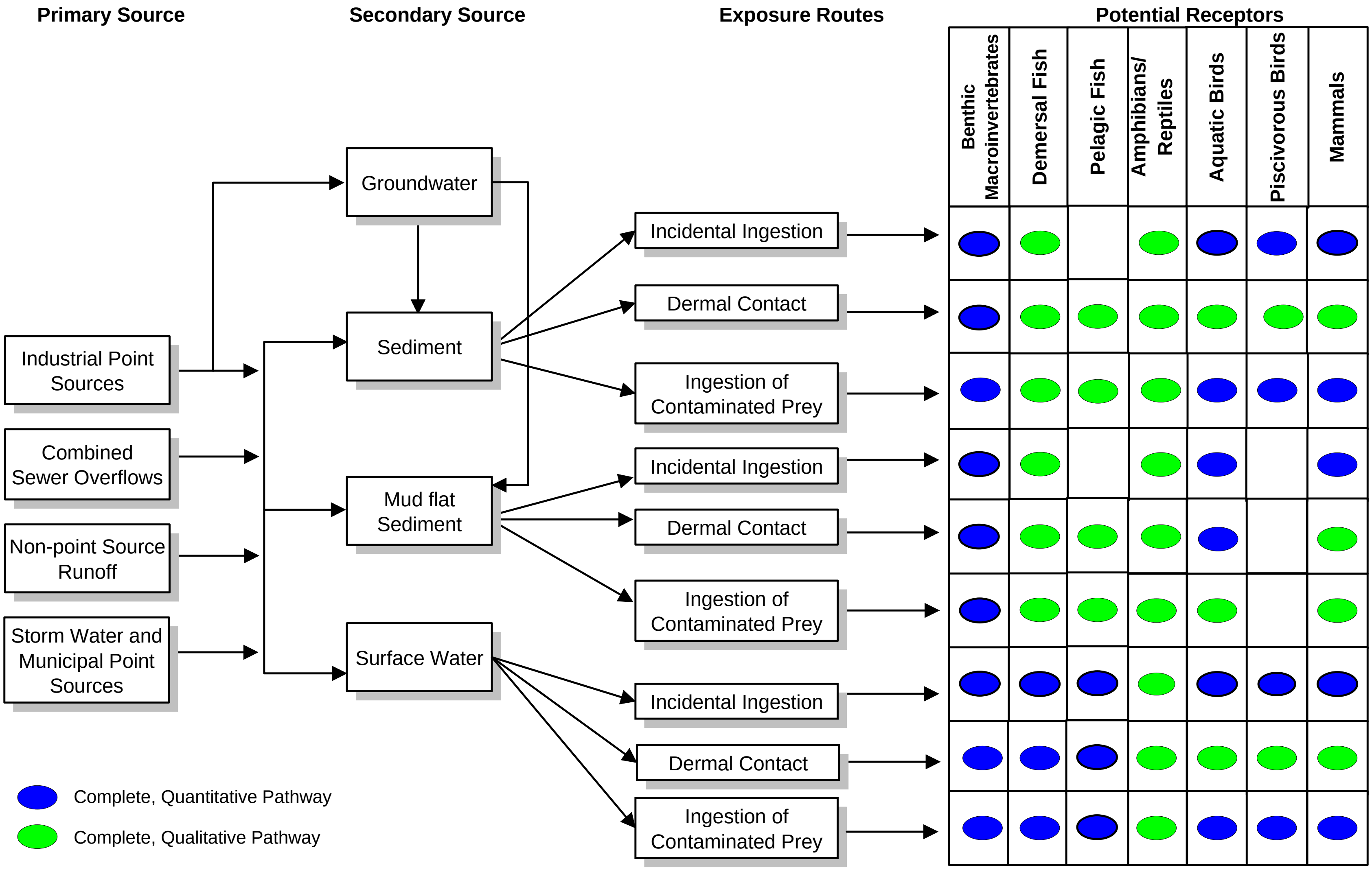


Figure 6. Ecological Conceptual Site Model.