Once the Hackensack enters New Jersey in Bergen County, it flows south towards the Oradell Reservoir, with a capacity of 3507 million gallons. The Oradell Dam marks a dividing line between the tidal and non-tidal portions of the watershed. Approximately 51 square miles of land within New Jersey drain to the Oradell Reservoir.
Pascack Brook, a major tributary to the Hackensack River, enters the Oradell Reservoir along its northwest end. The headwaters for Pascack Brook are also in Rockland County, New York. Shortly after entering New Jersey, Pascack Brook enters Woodcliff Lake. After exiting Woodcliff Lake, Pascack Brook flows southeast towards the Oradell Reservoir. Approximately 18 of the 51 square miles in New Jersey that drain to the Oradell Reservoir are associated with Pascack Brook.

Below the Oradell Dam
Below the Oradell dam, WMA 5 comprises 85 square miles of land. A significant portion of this area consists of the New Jersey Meadowlands. While there is not enough data to accurately determine the total extent of historic wetlands, the Meadowlands are known to have covered a wide expanse of estuarine marsh, freshwater marsh, and Atlantic white cedar swamp. Decades of suburban development, dredging, draining, mosquito control, landfilling, and industrial pollution led to destruction or degradation of much of the wetland habitats. Approximately 7,700 acres of wetlands remain in the 32-square mile Meadowlands District.

1.1.1 Subwatershed Areas (HUCs)

The three WMA 5 watersheds are made up of 18 subwatersheds as defined in the "HUC System," which is the national hydrologic unit code (HUC) system used by the United States Geological Survey and the NJDEP as a way to identify individual watershed areas. This study examines the subwatersheds defined by 14-digit Hydrologic Unit Codes (HUC14). HUC14s in WMA 5 vary in size from 2.7 to 26.4 square miles. **Error! Reference source not found.** shows the HUC14 boundaries in relation to the watersheds of WMA 5.

Kearny Marsh and Hackensack River Subwatershed - Route 3 to Amtrak Bridge (HUC 02030103180090)
The Kearny Marsh and Hackensack River subwatershed area is approximately ten square miles. The dominant land cover is wetlands and streams, totaling more than 3,500 acres. The remaining land uses include mixed urban, commercial, and medium to high-density residential.

Climate patterns affect water quantity and quality both in the short term and in the long term. In the short term, seasonal precipitation variations result in dry months and wet months. Temperature variations affect water quality as the amount of available oxygen and the growth of algae in water are affected by temperature.

1.1.2 Precipitation Patterns

The WMA 5 is located in the northeastern region of New Jersey. This region falls within the Central Climate Zone and Precipitation Division 1 as defined by the Office of the New Jersey State Climatologist (ONJSC). Based on precipitation data compiled by ONJSC over a period of record from 1895 through 2003, the average annual precipitation for this region is 46.13 inches. The

greatest amount of precipitation falls during July, August and September, with the driest month being February. Rainfall occurs during most of the year, while most of the precipitation during the winter months falls as snow. Much of the state was in a drought that began in 1998; however 2003 was the fifth wettest year during the 108-year period of record, prompting a lifting of drought status.

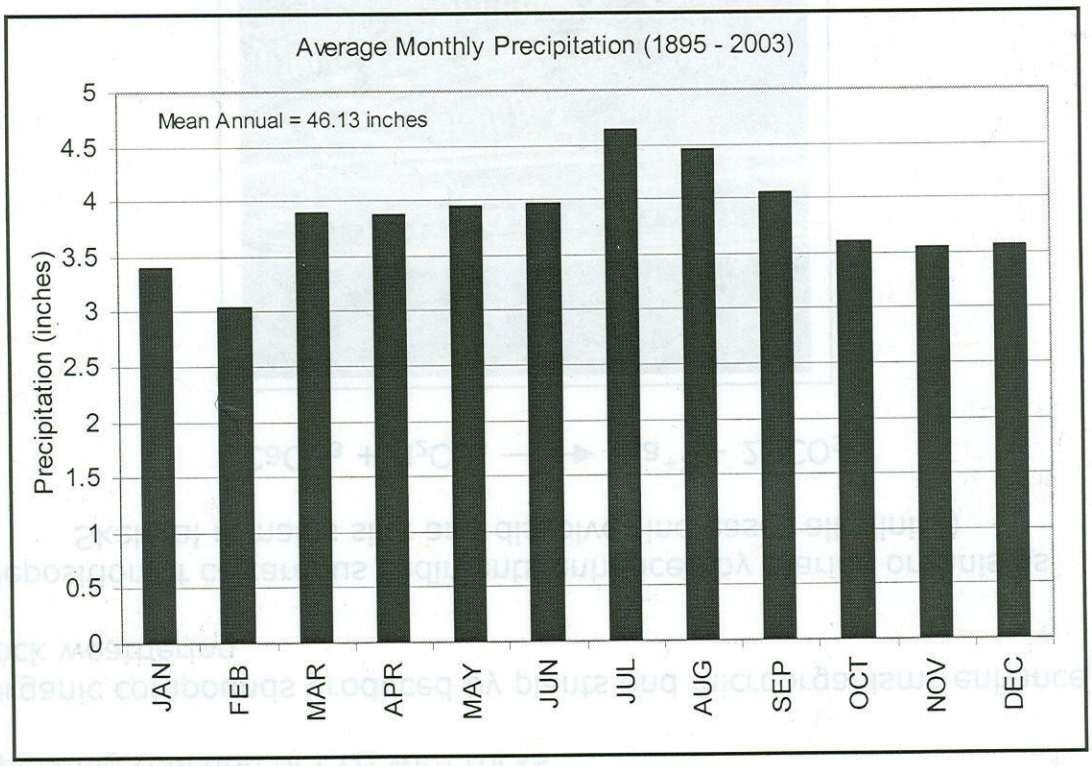


Figure 1: Average Monthly Precipitation

1.1.3 Temperature Variability

The Office of the New Jersey State Climatologist (ONJSC) also collects temperature data for the entire state of New Jersey. As previously discussed in the previous section the historic data is also divided into Divisions. Based on a review of the ONJSC data collected over a period from 1895 through 2003, the average annual temperature for this region is 50.7 °F. The highest temperatures occur during the summer months (June - August) with July being the hottest month with an average monthly temperature of 73.0 °F. The winter months (December - February) do not, on average, exceed 40 °F with January being the coldest month (28.4 °F).

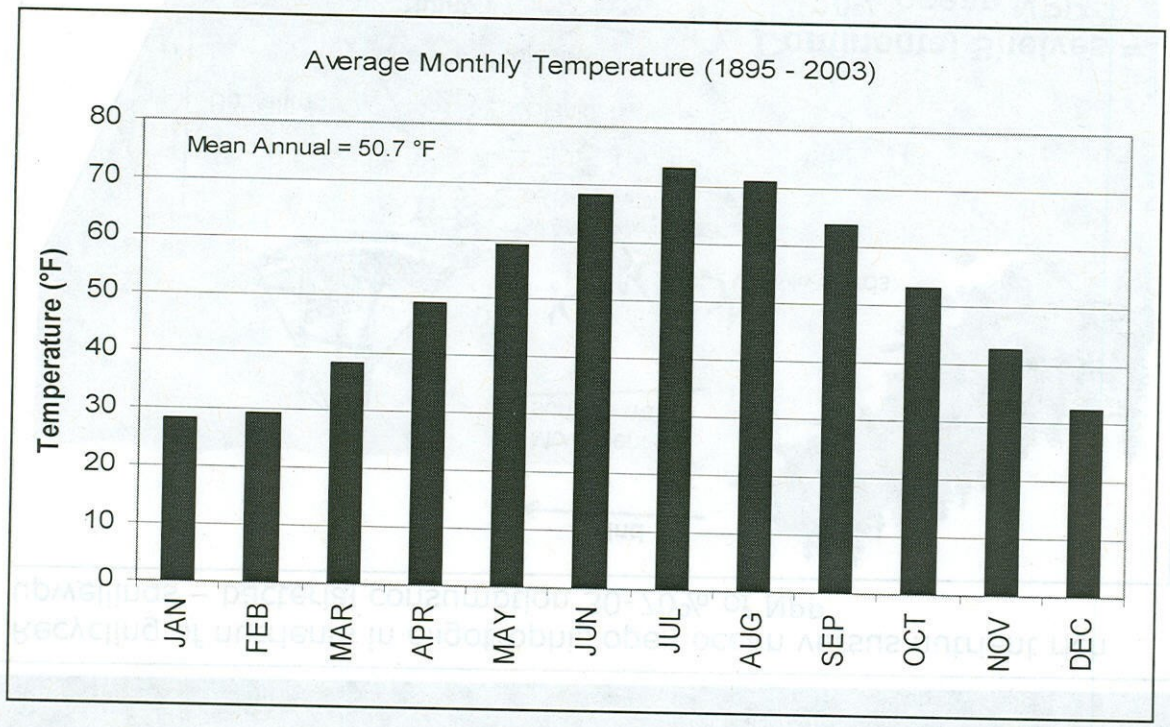


Figure 2: Average Monthly Temperature

1.1.4 Geology

The geology of the Basin influences the movement and storage of groundwater, as well as the rate of erosion. Unconsolidated deposits of the Piedmont include weathered bedrock deposits referred to as Residuum, Lacustrine glacial lake-bottom deposits, Fluvial deposits contributed from rivers and streams, Organic deposits of decomposed vegetation, and Estuarine deposits from water-bodies adjoining the ocean, found along the coastline of New Jersey.

Most of the valleys and lowlands of WMA 5 are underlain by sandstone and shale (see **Error! Reference source not found.**). The uplands, including the Palisades region, consist of Diabase rock that is more resistant to erosion.

Bedrock formations in WMA 5 are primarily sedimentary rocks. The smallest percentage of bedrock within WMA 5 is Diabase. In the WMA 5, groundwater in bedrock flows primarily through the cracks, joints, fractures, and bedding planes of the sedimentary rock formations. Water movement through sedimentary rock formations tends to be limited with relatively poor to moderate yields.

Sedimentary rock aquifers within WMA 5 include the Passaic, a major aquifer formerly known as the Brunswick Group, and the minor Stockton and Lockatong aquifer formations (see **Error! Reference source not found.**). These formations are part of the Newark Group, a group of formations of underlying bedrock created from sedimentary deposits. The sedimentary rocks of the Piedmont province are characteristically capable of yielding larger quantities of water (100 – 250

gallons per minute) than the igneous Diabase formation (less than 25 gallons per minute). No soul-source aquifers are located within WMA 5.

1.1.5 Impervious Surfaces

A high percentage of impervious surfaces in a watershed may indicate areas with water quantity or water quality problems. Generally, areas with a high percent of impervious surfaces are associated with high stormwater runoff flows and with higher nonpoint pollutant loads. **Error! Reference source not found.** summarizes the breakdown of impervious surfaces throughout WMA 5. Nearly 40 % of the area has very low impervious surface percentages (0 – 10 %); a large portion of these areas are forested lands. A significant amount of land falls in the 30 – 45 % impervious range, while nearly a quarter of the watershed is 50% impervious or higher.

The percent imperviousness within each subwatershed in WMA 5 is one factor that affects the runoff potential in each area. Table **Error! No text of specified style in document.**-1 describes the percent imperviousness in each subwatershed.

Table Error! No text of specified style in document.**-1: Subwatershed Percent Impervious**

Subwatershed	HUC 14	Percent Impervious
Hudson River	02030101170010	25%
Sparkill Brook	02030101170020	20%
Pascack Brook (above Westwood gage)	02030103170010	29%
Pascack Brook (below Westwood gage)	02030103170020	25%
Hackensack River (above Old Tappan gage)	02030103170030	18%
Tenakill Brook	02030103170040	25%
Dwars Kill	02030103170050	19%
Hackensack River (Oradell to OldTappan gage)	02030103170060	20%
Coles Brook / Van Saun Mill Brook	02030103180010	37%
Hirshfeld Brook	02030103180020	40%
Hackensack River (Ft Lee Rd to Oradell gage)	02030103180030	40%
Overpeck Creek	02030103180040	34%
Hackensack River (Bellmans Ck to Ft Lee Rd)	02030103180050	44%
Berry's Creek (above Paterson Ave)	02030103180060	53%
Berry's Creek (below Paterson Ave)	02030103180070	36%
Hackensack River (Rt 3 to Bellmans Ck)	02030103180080	38%
Hackensack River (Amtrak bridge to Rt 3)	02030103180090	26%
Hackensack River (below Amtrak bridge)	02030103180100	47%

Comparing **Error! Reference source not found.** and Table **Error! No text of specified style in document.**-1 shows that while 38 percent of the overall watershed is characterized by very low impervious surfaces (less than 10 percent impervious), each watershed has a much higher overall

percent impervious. This may suggest that impervious surfaces are well distributed in WMA 5, with few large contiguous areas of pervious surface in any watershed.

Water Budget – WMA5

Therefore, precipitation was assumed to be uniform over the entire area. United Water's precipitation gage in New Milford indicates that approximately 44 inches of rain falls over the WMA 5 area on average each year.

Based on available data, the groundwater recharge rates in WMA 5 range from 0.9 inches/year (Hackensack River [below Amtrak Bridge]). Based on available data, the runoff rates in WMA 5 range …to 18.22 inches/year (Hackensack River (below Amtrak Bridge).

1.1.6

Error! Reference source not found. summarizes the results of the Water Budget for each subwatershed in the WMA 5 area, along with the areas contributing from New York. **Error! Reference source not found.** also summarizes water movement in WMA 5. The area for the New York contributing areas is included in the area shown in the table.

Seasonal stations (ie., quarterly samples throughout the year) 1 through 14 are water quality monitoring locations specific to the Hackensack Meadowlands District. The stations listed above have been monitored since 1993 to the present. MERI also maintains a database of publications that are available by contacting the MERI library; report titles and reference information can be viewed at http://cimic.rutgers.edu/hmdc/ reports1. Reports can be searched by keyword, author, title, or location in the watershed.
The USGS published a report entitled "Relations of Surface-Water Quality to Streamflow in the Hackensack, Passaic, Elizabeth, and Rahway River Basins" that was also used in this analysis (USGS, 1998).

The NJDEP Environmental Regulation Division, Division of Water Quality, and the Bureau of Point Source Permitting have collaborated on a data source that maintains location information for all surface water discharge pipes with a New Jersey Pollutant Discharge Elimination System (NJPDES) permit. This source of information was published in 2002 by the NJDEP and is available online at www.state.nj.us/dep/gis/digidownload/zips/statewide/njpdesswd.zip. The NJPDES data source maintains categories of the discharge type, which are referred to later in this report. Those categories are as follows:

- ***Industrial Minor (IMI) and Industrial Major (IMJ)*** – based on the amount of pollutants in the effluent; 118 IMI and 21 IMJ discharges in WMA 5;
- ***Municipal Minor (MMI)*** – publicly-owned wastewater treatment plants with a discharge less than 1.0 MGD; 5 MMI discharges in WMA 5;
- ***Municipal Major (MMJ)*** – publicly-owned sewage treatment plants with a discharge greater than 1.0 MGD; 8 MMJ discharges in WMA 5;

- ***Petroleum Hydrocarbon Remediation discharge (B4B)***; 25 B4B in WMA 5;
- ***Non-contact Cooling Water (CG)***; 11 CG discharges in WMA 5;
- ***Combined Sewer Outfall (CSO)***; 74 CSOs in WMA 5.

High mercury concentrations are found in Berry's Creek. High nickel concentrations are found at the Hackensack River (Amtrak Bridge to Route 3)

The Keegan Landfill is believed to be leaching pollutants into the Kearny Marsh.

The NJMC is currently in meetings with local and state officials to purchase the Keegan Landfill. The end goal of the purchase is to re-open the landfill, remediate the location, and properly close the landfill to eliminate ongoing pollution concerns from landfill leachate and runoff. Data on stormwater runoff from this site have been collected on a quarterly basis by the HMDC; however, no real analysis on these data have been conducted. Further evaluation of stormwater runoff from this location could aid in designing pollution prevention and mitigation plans for WMA 5.
Due to the findings in the *Draft Environmental Impact Statement on the Special Area Management Plan for the Hackensack Meadowlands District, NJ* (USEPA, 1995) and the objectives of the HMDC/NJMC, efforts are in the beginning stages to bring old landfills into environmental compliance. In doing so, the abandoned landfills will need state-of-the-art engineering to close off the landfill from generating leachate and begin the remediation of groundwater and soil contamination. Also, the surface water runoff will need to be controlled from abandoned landfill sites. Finally, fugitive emissions released from the landfills need to be collected and processed. From 350 acres of landfill in the District, it has been measured that six million cubic feet of gas are collected daily (USEPA, 1995).
Other efforts by the NJMC include attempts to contain sediment-borne contaminants in the Kearny Marsh with a patented capping material. This work, if approved, will serve as a trial for the capping material and may lay ground to isolate contaminated sediments in the Marsh from being re-suspended in the water column. This work will focus on the sediments of the Kearny Marsh, where contaminants include arsenic, cadmium, chromium, copper, lead, mercury, and zinc leaching from junk yards and landfills adjacent to the Kearny Marsh.

1.1.7 Kearny Marsh and Hackensack River (Route 3 to Amtrak Bridge)

HUC 02030103180090

Water Quality
Monitoring stations do exist in the navigable waterways of this subwatershed. According to data collected by MERI and the USGS, water quality is generally poor in this subwatershed. Copper, zinc, cadmium, lead, nickel, pH, fecal coliform, and dissolved oxygen were found to be pollutants/parameters of concern based on a review of the MERI data for this subwatershed. These parameters frequently exceed water quality standards.

Point Sources

Due to the land uses in this subwatershed, there are relatively fewer discharges than in the nearby subwatershed areas. NJPDES permits do exist for minor industrial and minor municipal utility discharges, as well as for one CSO owned by the Town of Kearny. Industries include metal fabricators and remediation sites.

Other Sources

Known contaminated locations in the watershed indicate the industrial history in this region. In the area of this subwatershed that includes portions of North Arlington Borough and the Town of Kearny, there are numerous KCS listings which involve complex contaminants and several spills and discharges on one site. This includes five Hudson County chromate sites, which have been discussed previously in this document. The portion of the watershed, which can be referred to as the Lyndhurst area, has several clustered KCS. Some of these are landfill locations. There is a variety of remediation complexity in this portion of the watershed, north of Kearny Marsh. East of the Hackensack River, in this subwatershed, there exist landfill and transportation-related KCS, with moderately complex contamination.

Low levels of dissolved oxygen have been reported for the waterways around Kearny Marsh and in Sawmill Creek. When organic matter that has collected on the river bed or in a tidal marsh bed decomposes, oxygen is consumed, resulting in low dissolved oxygen concentrations. This is what is known as sediment oxygen demand (SOD). SOD is a natural phenomenon in tidal and freshwater marshes; it includes both the respiration rate of benthic communities and the chemical oxidation of reduced substances in the sediment, such as iron, manganese, and sulfide. While anthropogenic releases with high BOD and stormwater runoff may also remove oxygen from the water column, the low levels of dissolved oxygen noted for this subwatershed may be due to SOD.

Sediments in this subwatershed are observed as exceeding the effects range-low (ER-L) level for lead, mercury, and organics including PCBs. Note that sample results were sparse and that these results may represent localized conditions and not represent the entire subwatershed.

Nonpoint Source Load Analysis

The NPS Load Analysis conducted for this area (See Appendix **Error! Reference source not found.**) indicates that mixed urban land use contributes the most runoff concentrations of lead, copper, zinc, cadmium, BOD, COD, and nitrate (50-60% of loads). Both mixed urban and industrial land areas contribute the majority of total phosphorus, TSS, and total nitrogen to stormwater loads (55-60% of load).

Potential Watershed Management Strategies

Additional Data Collection – Additional research is needed to determine the cause of the low levels of dissolved oxygen in this subwatershed.

Site Remediation – Additionally, this HUC 14 has a history of industrial activity that has resulted in several contaminated sites. The remediation of these sites is needed including the abandoned landfills and the Hudson County chromate sites. These sites have the potential to severely impact the water quality of this HUC 14.

Kearny Marsh and Hackensack River (Route 3 to Amtrak Bridge), HUC 02030103180090

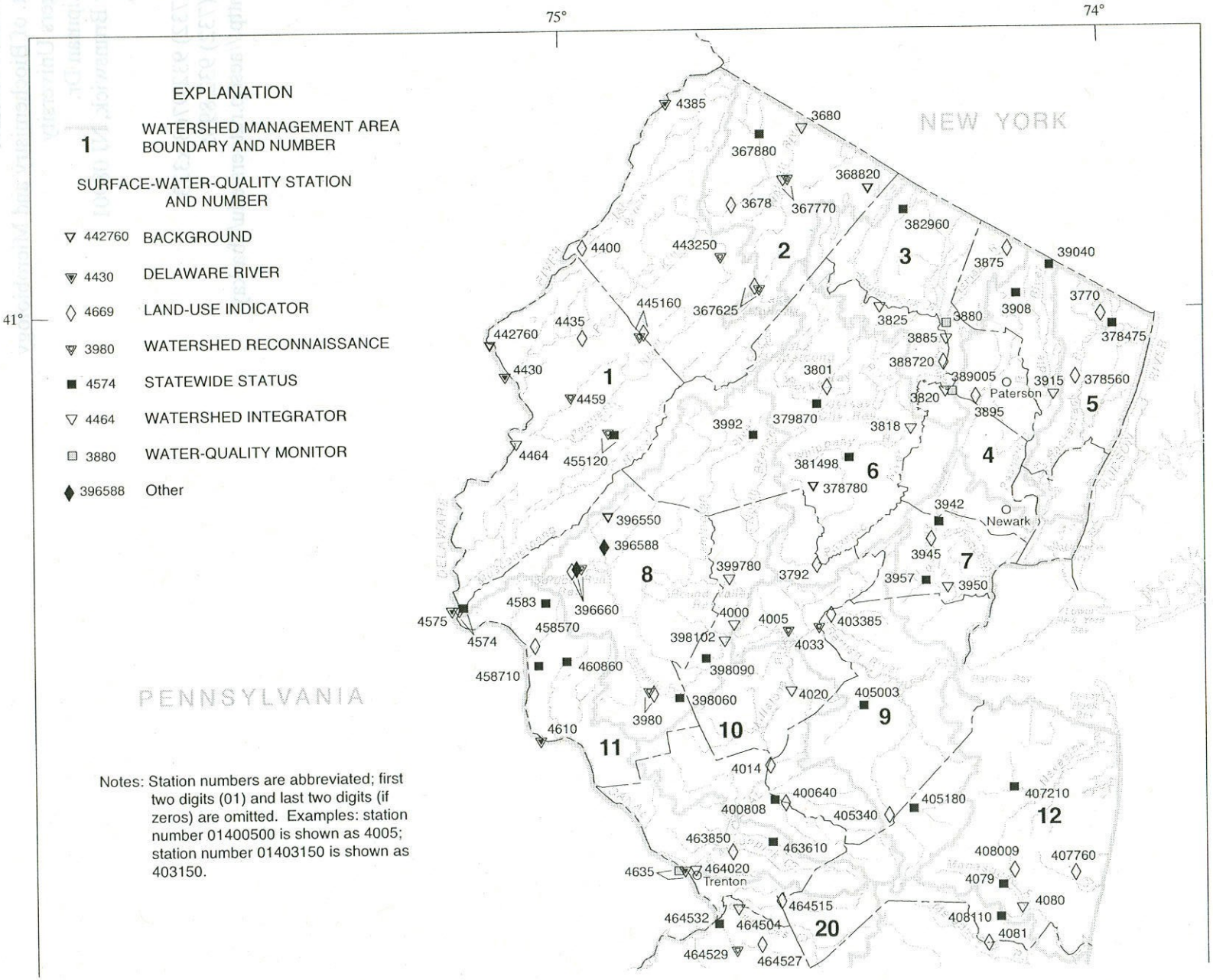
- Perform a study of the dissolved oxygen in the watershed and determine the impact of SOD on instream dissolved oxygen.

- Monitor the clean up activities to keep informed of the progress, and
- Continue to work with local stakeholders to solicit local, state, and federal officials for remediation funds for these activities.
- Collect additional data to confirm if TMDLs are needed for copper, zinc, cadmium, lead, and nickel.

NJDEP 1995/97 Land Use	AREA Acres	TP lbs/yr	TN lbs/yr	TSS lbs/yr	NH3-N lbs/yr	LEAD lbs/yr	ZINC lbs/yr	COPPER lbs/yr	CADMIUM lbs/yr	BOD lbs/yr	COD lbs/yr	NO2+NO3 lbs/yr
High/Med Residential	752.1	1052.9	11281.5	105293.6	488.9	223.0	252.0	340.7	0.0	19253.7	114770.0	1278.6
Low/Rural Residential	1.1	0.7	5.5	109.9	0.0	0.2	0.2	0.2	0.0	9.3	0.0	0.1
Commercial	277.3	582.4	6101.2	55465.8	526.9	264.8	242.1	217.4	0.6	11675.6	183758.2	859.7
Industrial	1078.9	1618.4	17262.8	215785.4	215.8	1520.2	1724.1	1003.4	3.2	33878.3	0.0	1402.6
Mixed Urban	1553.7	1553.7	15537.3	186447.4	2719.0	4995.2	2708.1	2375.7	3.9	104410.5	287128.9	5515.7
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest, Water, Wetlands	3581.3	358.1	10743.8	143251.0	0.0	32.2	64.5	96.7	0.0	32947.7	7162.5	1074.4
Barren Land	713.0	356.5	3565.1	42781.1	0.0	0.0	1.4	0.0	0.0	2210.4	0.0	0.0
Total	7957.5	5522.7	64497.2	749134.1	3950.6	7035.8	4992.4	4034.1	7.7	204385.5	592819.7	10131.1

		Area	Precipitation	Evapo-transpiration*	Groundwater Recharge	Runoff
		Sq. Miles	Inches/yr	Inches/yr	Inches/yr	Inches/yr
WMA 5		226.7	43.7	24.6	6.1	13.0
HUC14	**Subwatershed Name**					
Hackensack River (below Amtrak bridge)	02030103180100	10.6	43.7	24.6	0.9	18.2

*Evapotranspiration number is derived from Raritan River data – may not be accurate for Kearny Marsh system


EXPLANATION
WATERSHED MANAGEMENT AREA BOUNDARY AND NUMBER
1
SURFACE-WATER-QUALITY STATION AND NUMBER
442760 BACKGROUND
4430 DELAWARE RIVER
4669 LAND-USE INDICATOR
3980 WATERSHED RECONNAISSANCE
4574 STATEWIDE STATUS
4464 WATERSHED INTEGRATOR
3880 WATER-QUALITY MONITOR
396588 Other
Notes: Station numbers are abbreviated; first two digits (01) and last two digits (if zeros) are omitted. Examples: station number 01400500 is shown as 4005; station number 01403150 is shown as 403150.
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74°
41°
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PENNSYLVANIA
Paterson
Newark
Trenton
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