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Hackensack Meadowlands District-Wide Water Quality Monitoring

Project Summary

Covering the Period January, 1993 to June, 1994

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Table of Contents

Monitoring Effects of Urban Land Use on Estuarine Water Quality, HackensackMeadowlands District, New Jersey

Executive Summary

Objectives

Responsible environmental policymaking depends on the existence of good, objective scientific research, to provide the balanced, thorough, and credible information needed by policymakers to solve environmental problems. Sen. Tom Daschle (D-SD), introducing a bill to create the National Institute for the Environment (NIE).

The HMDC and United States Geological Survey (USGS) have established a monitoring program to depict the status and trends in water quality of the Hackensack River during the next twenty years. Data measured the ability of this body of water to support the uses designated by state and federal criteria. Throughout subsequent years, problem areas identified will be addressed, control stategies can be devised and implemented, and overall environmental improvement resulting from the Special Area Master Plan will be recorded. A summary report, co-authored with the USGS, has been prepared, describing the initial stages of this program, measuring the impacts from the potential sources of pollution in this urban estuary. The partnership between the HMDC and USGS will provide the increased level of expertise needed to confront the complex challenges associated with basin wide water quality enhancement.

Project Design

Existing water quality information was investigated, influencing the choice of sampling locations and parameters. Integration with the knowledge gained in prior years provided the consistency necessary for the recognition of long term trends. The site selection criteria insured the depiction of spatial variability caused by various sources of pollution and natural estuary characteristics.

The first year encompassed four seasonal sampling events. All samples were taken at low tide, in the center of the channel on the river sites and along the tributaries where possible. Methodology for collection of samples and preparation for analyses followed protocols utilized by the USGS. Quality of the data was assured by the usage of the New Jersey certified environmental operations research laboratory and the USGS National Water Quality Laboratory for analyses.

The cooperative arrangement between the HMDC and the USGS was governed by The Joint Funding Agreement, in which the allocation of tasks between agencies was defined. The HMDC staff performed appraisal of the existing database, sampling, analyses and report writing (a peer reviewed document for presentation at a national conference). The USGS provided technical support throughout all phases, analytical services and co-authorship of the summary document.

A Federal College Workstudy Contract between the HMDC and the New Jersey Institute of Technology (NJIT) provided supplementary labor. The program offered up to 90% of the students' stipend, significantly reducing labor costs incurred by the HMDC.

First Year Results

The scope of this report to a review of the project design, methods, presentation of results of selected parameters, a discussion of trends and a comparison to state and federal criteria which allow for designated uses.

The applicability of criteria is determined by salinity, which differentiate between fresh and saline waters at 3.5 0/00. Four of the sites, indicative of freshwater for regulatory purposes, result from barriers to tidal flow which have created impoundments. Salinity also helped to deliniate the gradient of tidal influence from the mouth of the Hackensack River at Newark Bay to the northern boundary of the Hackensack Meadowlands District.

The presence of high levels of fecal coliform bacteria indicate the extent this estuary is impacted from the surrounding urban areas. Two sources are suggested, combined sewer outfalls, which represent a non point source of pollution, and sewage treatment plant effluent. The combined sewers discharge surface runoff and untreated sanitary sewage during storm events. The sewage treatment plants do not have the excess flow capacity necessary for proper treatment during extraordinary events.

Dissolved oxygen, the most readily applied measure of the ability of a body of water to sustain life, appears to be controlled by a natural phenomenon, seasonal temperature fluctuations. Only during the summer, when elevated temperatures limit the amount of oxygen held in water, are seriously low concentrations encountered.

Two of the metals measured, cadmium and lead, exceed applicable criteria. Rather than indicating a particular, point source for these pollutants, a more general trend is apparent. The metals, associated with suspended particulate matter, are dispersed throughout the estuary by tidal flows. In the case of cadmium, copper and nickel, a gradient which follows diminishing salinity suggests Newark Bay is a possible source of contamination.

Overall, the first year results indicate the Hackensack River in the Meadowlands District has impaired water quality based on seasonal depletion of dissolved oxygen, high bacterial concentrations and metal pollution. Confirmation of the sources of bacteria and application of innovative or Best Management Practices offers the greatest opportunity for marked improvement in water quality. Limiting the extent of sediment transport, perhaps by taking advantage of sediment trapping function of mitigated wetlands, could ameliorate the impact of metal pollution. A continuation of the monitoring program will enable the HMDC to affect policy decisions based upon "...balanced, thorough and credible information."

Evaluation

Administrative

The cooperative arrangement with the USGS, who contributed up to 50% of the project cost as well as expertise, enabled the HMDC to maximize scope and credibility with limited financial resources. Utilizing College Work Study students allowed the HMDC to reduce its labor costs. Providing a direct stipend would broaden the potential labor pool to include recent graduates. This would allow for a stronger commitment and consistency, because the turnover of work study interns made training difficult. Staff involvement in the project was greater than anticipated due to the scale of the project. Until a consistant funding source becomes available, such as outlined in the Environmental Improvement Program, the scope of the program will have to be narrowed.

Technical

The comprehensive monitoring program, with 14 sites sampled during 4 seasonal events, confirmed that the Hackensack River within the Hackensack Meadowlands District is an "impaired" water body. This is a regulatory classification based upon the inability of the water quality to meet certain criteria, thereby limiting the designated functions of the river.

It is unlikely that dissolved oxygen levels will respond to the imposition of a direct management strategy, depletion is most likely a result of natural factors, which are either too complex to address or impossible to reverse by intervention. Metals and other pollutants associated with sediment transport from Newark Bay could be mitigated through the construction of wetlands designed to maximize sediment-trapping potential. The excessive bacterial concentrations call for the application of innovative strategies to address the non-point character of stormwater outfalls.

It is recommended that in the near term monitoring should focus on a clearer depiction of these two problems, with a continuation of systematic monitoring. The choice of analytical parameters present a quandary; while you cannot discern a problem if you do not analyze for it, cost savings can be derived by limiting analyses. The Environmental Chemistry Practicum (Appendix IV), is an attempt to derive information in the most cost effective manner. The Environmental Improvement Program contains specific recommendations in terms of funding and design that, when implemented, would allow for the resumption of a more comprehensive investigation of district wide water quality issues.

APPENDIX I

Monitoring Effects of Urban Land Use on Estuarine Water Quality, Hackensack Meadowlands District, New Jersey.

MONITORING EFFECTS OF URBAN LAND USE ON ESTUARINE WATER QUALITY, HACKENSACK MEADOWLANDS DISTRICT, NEW JERSEY

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ABSTRACT: In 1993, the U.S. Geological Survey, in cooperation with the Hackensack Meadowlands Development Commission, established a network of 14 ambient water monitoring sites to characterize the current status of water quality in the Hackensack Meadowlands District. The network is designed to analyze trends in water quality over the next 20 years. The District, situated less than 6 miles west of New York City in northeastern New Jersey, consists of 20,000 acres of tidal marshes and upland drained by the lower segment of the Hackensack River into Newark Bay. Along this 10 nautical-mile-long reach, industry, power plants, sewage treatment plants, combined and discreet stormwater outfalls, landfills, hazardous-waste sites, and an extensive transportation network are present. Water quality constituents summarized include conventional field parameters, nutrients, trace metals, chlorinated pesticides and polychlorinated biphenyls, chlorophyll a- an b- as phytoplankton, suspended solids, biochemical oxygen demand, chemical oxygen demand, fecal coliform bacteria and turbidity. This program will insure the uninterrupted flow of information needed by decision makers to manage development within the estuary.
Key Terms: Estuarine, water quality, monitoring.

INTRODUCTION

The call for "greater coordination, consistency, and collaboration" among agencies engaged in water quality monitoring activities was issued by the Intergovernmental Task Force on Monitoring Water Quality in 1992 (ITFM, 1993). In 1993, the United States Geological Survey (USGS) and the Hackensack Meadowlands Development Commission (HMDC) joined as part of the USGS Federal-State Cooperative Water Resources Program to monitor the water quality of the lower Hackensack River and some of its tributaries. As stated by Blanchard and Coupe (1982) in describing the USGS Tidal Potomac and Estuary Study, the primary goal is to "gain information forming the foundation for water resources management and planning activities." The HMDC, charged with balancing development with a fragile ecosystem, was given the opportunity to restart a monitoring program, initiated in 1971, after a four year hiatus. This program will depict the present status of the Hackensack River water quality, and provide a benchmark from which future trends can be measured.

Figure 1 depicts the Hackensack Meadowlands District, a thirty-two square mile estuary situated 6 miles west of New York City, where tidal flow from Newark Bay mixes with the lower Hackensack River creating 20,000 acres of tidal marshes. Construction of the Oradell Dam in 1922 established a reservoir

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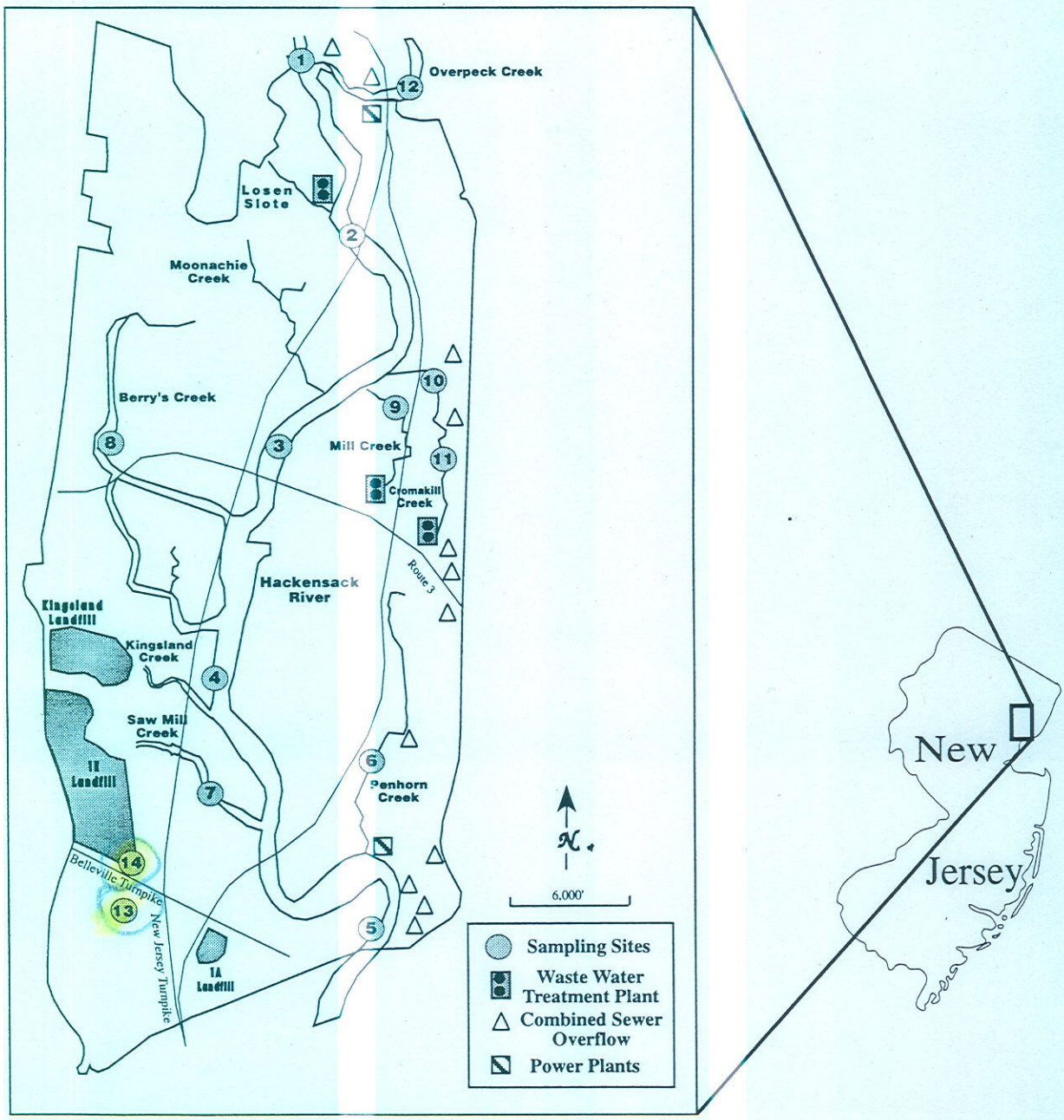
for potable water but severely constricted freshwater flow into the lower reach of the river. Freshwater is principally composed of wastewater discharges from over 50 industrial and municipal permittees and precipitation induced runoff. The vegetation and tidal regime are consistent with a mid-Atlantic saltmarsh, containing mudflats, halophyte dominant marshes, salinity ranging from 0-15 ppt., and semi-diurnal tides in the main watercourse (Cheng and Konsevick, 1988). Three wastewater treatment plants are situated within the watershed, as are the outfalls from combined sewer overflows. Two power generating stations utilize the riverwater for cooling purposes, contributing thermal anomalies. Over 2,000 acres of landfills have left a legacy of leachate and surface runoff from 150 years of dumping. The ongoing closure activity of much of this acreage should yield a measurable improvement in water quality. The other primary impacts on this ecosystem come from the hazardous residue of the industrial facilities and the aging urban infrastructure common both within and beyond the boundaries of the Hackensack Meadowlands District.



Hackensack Meadowlands District - Figure 1

Several of the shortcomings outlined by Hren et. al. (1990), associated with the usefulness of existing data for assessing the status, trends and causes of water quality conditions, were addressed in the design of this study: the focus was on the receiving waters rather than pollution discharges; a balanced spatial and temporal design, rather than transient assessments associated with individual problems was adopted; metal, pesticide and volatile organic constituents were determined as well as traditional properties; sites established for sample collection will be periodically resampled over a twenty year period; standardized field procedures, utilized by the USGS, were applied in this study; and the quality assurance standards of the HMDC Environmental Operations Research Laboratory (EORL), certified by the state of New Jersey, and the USGS National Water Quality Laboratory were maintained during analysis.

Periodic reports summarizing water quality data collected in this basin were reviewed in preparation for the design of this study. Improvement was documented in Water Quality in a Recovering Ecosystem (HMDC, 1976). Spatial and temporal trends were described by Cheng and Konsevick (1988). Other information is available in Inventory of Fisheries Resources (HMDC, 1989), the New Jersey Department of Environmental Protection and Energy (NJDEPE) 304L Toxic Monitoring Survey (NJDEPE, 1989), and Bergen County Utility Authority (BCUA) Impact Analysis of Sewage Treatment Plant Discharges on the Water Quality of the Lower Hackensack River (BCUA, 1990).

The State of New Jersey in implementing the Clean Water Act has established criteria for surface water quality to allow for designated uses (N.J.A.C. 7:9B-1.14, 1993). Waters of the Hackensack River within the Study Area have been classified SE-2, which applies to estuarine surface waters having salinities greater than 3.5 parts per thousand (0/00). The designated uses are:

1. Maintenance, migration and propagation of the natural and established biota;
2. Migration of diadromous fish;
3. Maintenance of wildlife;
4. Secondary contact recreation; and
5. Any other reasonable use.

Tributaries which join the main stem of the Hackensack and have salinities less than 3.5 0/00 are designated FW-2 Nontrout. The designated uses are:

1. Maintenance, migration and propagation of the natural and established biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after such treatment as required by law or regulation; and
5. Any other reasonable uses.

This report will describe the process of designing the monitoring network; summarize the results of selected parameters from the first year's collection; compare the results with water quality criteria established as standards allowing for designated uses of surface water; and depict spatial and seasonal trends where apparent.

STUDY DESIGN

A three-step approach was used to design and implement a water quality monitoring program over an 18-month period. The first step involved investigating existing water quality information and locations of possible point and nonpoint pollution sources in the study area. This information was used to develop a list of primary and secondary site criteria for determining sampling locations, sampling frequency, field properties to be collected, and water quality constituents to be analyzed. The second step was to implement the water quality monitoring at the 14 chosen sites in quarterly sampling over a 12-month period. The third step was to assess and evaluate the first years monitoring results to plan the next phase of study.

Site Selection Criteria

Existing water quality studies and other published literature regarding the District provided site locations of former data collection, municipal wastewater discharge, industrial discharge, landfills, hazardous waste sites, combined sewer overflows, tidegates, and flood control pump stations. These site locations were placed on 1:24000 scale U.S. Geological Survey topographic quadrangle maps that incorporate the Hackensack Meadowlands District.

TABLE 1. Criteria for Selecting Water Quality Monitoring Sites.

PRIMARY:

- Boundaries of the HMDC District - northern and southern sites.
- Major Tributaries - site may be influenced by tide gate locations.
- Point Sources - STP's, CSO's, industrial and hazardous waste sites.
- Non-Point Sources - landfills.
- Existing Sites - historic data.

SECONDARY:

- Estuary Characteristics - flow direction, velocity and salinity
- Point Source - thermal power plants.

Site Description

Field trips were conducted by boat to investigate the study area, visit possible monitoring sites, and conduct a simple channel analysis to test for mixing of the water column, vertically and horizontally. Specific conductance and temperature data collected at six sites showed that the 5.5 to 6.5 foot tide range in the Hackensack Estuary results in a well mixed estuarine system. There were no observed indications of stratification or a salt wedge at any of the selected sampling locations. On the basis of the channel mixing analysis, monitoring sites located at the centroid of flow of the main channel would provide a sufficient characterization of the water chemistry at that point in the estuary. That is providing the site is an adequate distance upstream or downstream of a point source discharge to ensure proper mixing. The criteria listed in Table 1 and Table 2 provide the a description of the monitoring sites. The 14 sites chosen are shown in Figure 1 and include five sites located on the main channel of the Hackensack River (1,2,3,4, and 5), seven sites located on major tributaries (6,7,8,9,10,11, and 12), one site located in the Kearny Marsh area (13) and one site adjacent to a Municipal Solid Waste (MSW) Landfill (14).

Numerous structures associated with the imposition of an urban lifestyle on the estuarine ecosystem impact the water quality. The imprint of the transportation network crisscrossing the meadowlands creates barriers to flow causing impoundments to form. In the Kearny Marsh, saltwater intrusion is restricted by the New Jersey Turnpike, and the Belleville Turnpike serves as a barrier to landfill leachate. This creates a large marsh with unique qualities. Flood control structures, such as the tidegate at the mouth of Penhorn Creek, severely disrupts the flushing function of a tidal creek. And the most important structure, from the standpoint of water quality impact, is the Oradell Reservoir Dam, which has allowed pollution laden tides from Newark Bay to intrude upon the freshwater flow of the Hackensack River.

TABLE 2. List of HMDC Water Quality Monitoring Sites.

SITE #	LOCATION	SITE DESCRIPTION
1	Hackensack River	Upstream boundary
2	Hackensack River	South of BCUA & Bergen Generation Station (GS)
3	Hackensack River	Corresponds with #1 HMDC summer WQ project
4	Hackensack River	Corresponds with #10 HMDC summer WQ project
5	Hackensack River	Downstream boundary, south of Hudson GS
6	Penhorn Creek	Non-tidal and borderline freshwater
7	Sawmill Creek	Inactive landfills and no industry
8	Berrys Creek	Downstream of hazardous waste and industrial sites
9	Mill Creek	Downstream of Secaucus STP
10	Cromakill Creek	Downstream from Combined Sewer Overflows (CSO's)
11	Cromakill Creek	Downstream from North Bergen STP
12	Overpeck Creek	North of tide gate, upstream boundary of HMD district and major tributary
13	Kearny A	South of Belleville Turnpike, west of NJ Turnpike
14	Kearny B	North of Belleville Turnpike, west of NJ Turnpike

Selection of Water Quality Chemical, Physical, and Biological Properties

The properties and constituents selected for collection and analysis were chosen primarily to gain a better understanding of the overall water quality in the Hackensack River estuary and to evaluate the effects of known point and non-point sources of pollution in the District.

The constituents chloride, sulfate, sodium, calcium and magnesium, are associated with salt water and tidal effects within the estuary. Total dissolved and suspended solids, biochemical oxygen demand, chemical oxygen demand, fecal coliforms, oil and grease, surfactants, and turbidity, can originate from wastewater treatment plants.

Chlorinated pesticides and polychlorinated biphenyls have been used in the area and they tend to degrade slowly in the environment. They present serious effects on wildlife because they are easily bioconcentrated. There are strict lifetime health advisory levels on these constituents in fish and other marine life. Volatile organic compounds can come from hazardous waste sites and sewage treatment plants. Trace metals can be present in the environment from hazardous waste sites and landfills. In the past mercury has been detected in Berry's Creek at elevated levels.

Total phenols can originate from two sources. Some phenols are natural environmental products and others come from hazardous waste sites. If the total phenols are elevated, further analysis to determine specific compounds can be conducted by gas chromatograph mass spectrometer. Cyanide can be a product from hazardous waste sites.

Dissolved and suspended organic carbon, dissolved and total nutrients, and chlorophyll data reveal how nutrient rich or eutrophic the system is. Chlorophyll a and b as phytoplankton surrogates show the impact of the nutrients on the algae population in the system.

METHODS

Sample Collection

Field sampling from the Hackensack River and her tributaries was accomplished over a three day

period in each season during low tide using the HMDC's 17' Privateer work-boat. Non-river sites were accessed by vehicle from adjacent roads. The sampling techniques implemented for the study included depth integrated collection where appropriate and subsurface grabs from shallow tributaries and freshwater sites. Once taken, all samples were cooled in ice filled coolers for transport back to HMDC for processing.

Sample bottles were prepared by both the USGS and HMDC in accordance to Federal EPA guidelines as well as those adopted by the USGS. Container types included various size polyethylene bottles, assorted glass bottles and several pre-cleaned vials, each prepped within the guidelines specified for the sample being taken. Sterilized glass bottles, prepared in accordance with NJ DEP regulations for micro biological analysis, were prepared at the HMDC laboratory and used for fecal coliform analysis.

Field analysis incorporated the use of Orion Model #140 field meters for the parameters of temperature, salinity, specific conductance; Orion Model #840 for dissolved oxygen, and the use of Beckman PHI21 for pH. Prior to each day of sampling, the meters were calibrated at the HMDC laboratory to assure proper operation and accurate results. All field parameters were completed within fifteen minutes of sampling in situ to assure accuracy and all data recorded in a sampling log. Quality assurance included development of a monitoring network workplan, proper training on sampling protocols, and systematic handling and cleaning of sampling equipment.

Laboratory Analyses

Filtering and preservation (dependent on individual parameter), and all appropriate documentation for shipment as well as internal analysis were completed in the lab. Shipping samples to the USGS National Water Quality Laboratory was done after all samples for a sampling event were completed. All parameters performed by the HMDC-EORL were done in accordance with EPA and NJ DEP approved methodologies including the appropriate quality assurance as specified by each method. Analytical results were then calculated and entered into the laboratory computer for tabulation and review.

RESULTS

The analytical results of the 4 seasonal sampling events at all 14 sites appear in the summary tables. Criteria listed are based on aquatic life protection.

Along the mainstem of the Hackensack River the salinity decreases with distance from Newark Bay, from 14 0/00 (Site 5) to 5 0/00 (Site 1). Sites 6, 11, 12 and 13 have average salinities indicative of an FW2-NT classification. At Sites 6 and 12, tide gates constrict flow. Site 11 is in the upper reaches of a shallow tributary which acts as a receiver for Combined Sewer Overflows. Site 13 is within a surface impoundment where saltwater intrusion is restricted to shallow, tidally influenced groundwater. Each of these sites result from a modification of the natural tidal regime. (See Table 3.)

Freshwater criteria for total suspended solids were exceeded in the four sites where this level was applicable. At the SE-2 sites, where numerical standards do not apply, the suspended solids do not render the waters unsuitable for designated uses. The highest values were obtained in tidal creeks (Sites 7 and 14) where scouring is likely to occur. In the river, values follow the salinity trend, decreasing upriver. The turbidity standard was not exceeded at any site. (See Table 3.)

The overall average for fecal coliform bactreria is 3,894 counts/100ml, which exceeds the state standard of 770 counts/100ml. Individual site averages, with the exception of Sites 5, 8 and 13, exceed the standard. Sites 1, 6, 10, 11 and 12 are influenced by runoff from combined sewer outfalls. An additional source of bacteria is suggested by the high values associated with sites downstream from sewage treat-

TABLE 3. Average Values of Selected Properties.

Parameter		Salinity	D.O.	Fecal Coliform	pH	TSS	Turbidity
		0/00	mg/l	counts/100 ml	S.U.	mg/l	N.T.U.
Criteria	FW2-NT	<3.5	4.0		6.5-8.5	40.0	50.0
Site	SE2	>3.5	4.0	770/100	6.5-8.5		30.0
1		4.8	4.3	5075	7.5	51.5	6.7
2		5.2	4.4	3205	7.4	56.5	6.6
3		7.5	5.2	1225	7.3	69.3	6.4
4		10.4	6.1	838	7.6	77.5	6.2
5		14.1	6.8	580	7.4	85.2	5.3
6		1.2	6.8	12275	7.3	57.5	28.7
7		11.9	7.3	848	7.4	100.3	10.5
8		7.6	5.8	548	7.3	61.8	8.4
9		4.9	4.4	3125	7.2	61.5	6.6
10		5.6	3.7	7200	7.3	54.4	5.9
11		2.6	7.3	10575	7.4	38.9	15.1
12		2.4	7.7	5425	7.3	43.1	8.0
13		2.5	4.7	70	7.5	63.2	16.7
14		3.8	6.6	3525	7.6	270.2	24.4
Total Avg.		*6.0*	*5.8*	*3894*	*7.4*	*77.9*	*11.1*

ment plant discharges, Sites 2 and 9. Fecal coliform values in the study area tend to be greater during wet weather periods than dry weather; this may indicate that nonpoint sources and CSO's are influencing the bacteria levels. (See Table 3.)

None of the sites reveal an average dissolved oxygen concentration below the 4.0 mg/l criteria except Site 10. However, during summer sampling, nearly 64% of the sites exhibited reduced dissolved oxygen concentrations (See Table 3).

Ammonia displays a strong spatial trend. High concentrations are present at Site 14, adjacent to a large MSW landfill. Site 13, appears to be separated by an effective barrier to leachate transmission, based upon its comparatively low ammonia concentration. Site 7, which is downstream from Site 14, also exhibits relatively low concentrations (See Table 4).

TABLE 4. Site Averages and Seasonal Average of Conventional Parameters.

Parameter	Precip.	D.O.	Total Phosphorus	Ammonia	Sulfate	Chloro-a Phytoplankton	BOD	COD	Temp.
Site	inches	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	oC
1		4.3	0.9	5.2	413.7	36.3	11.2	86.9	17.4
2		4.4	0.9	5.8	383.6	22.6	14.4	98.2	17.9
3		5.2	0.7	3.7	546.2	26.7	7.4	122.6	17
4		6.1	0.5	2.5	663.8	26.8	3.7	116.1	16.1
5		6.8	0.3	1.4	697.7	9.8	3	86	16.5
6		6.8	0.6	2.4	65.4	135.4	4	146.4	18.9
7		7.3	0.5	2.2	696.4	20.5	3.1	286.2	17.2
8		5.8	0.6	2.1	467.1	36.4	8	89.5	15.8
9		4.4	1.4	1.7	277.2	22.8	8.9	234.9	16.6
10		3.7	1.0	4.7	335.5	28.0	10.2	96.5	16.8
11		7.3	1.3	7.4	184.0	54.5	10.5	70.5	20.9
12		7.7	0.4	1.9	149.7	60.4	10.7	115.3	19.3
13		4.7	0.4	0.3	170.4	110.3	10.5	183.2	19.8
14		6.6	1.2	54.8	322.2	99.3	12.7	289.5	17.5
Total Avg.		*5.8*	*0.8*	*6.9*	*383.8*	*49.9*	*8.5*	*144.4*	*17.7*
Spring	0*	7.0	0.5	6.9	314.5	52.6	13.0	130.3	21.4
Summer	0.03*	3.9	1.5	3.9	570.7	106.4	10.7	137.1	26.1
Fall	1.45*	4.2	0.7	4.2	431.6	13.9	6.4	109.6	18.8
Winter	0.54*	8.2	0.4	8.2	218.3	27.0	4.6	200.7	4.4

* *The value indicates the total precipitation for the period of 3 sampling days.*

Table 5 summarizes the results obtained for 5 heavy metals. Criteria are carcinogenic or noncarcinogenic effect-based human health standards. Based on averages obtained over the course of four seasonal sampling events, cadmium and lead exceed standards where the freshwater criteria apply. An interesting spatial trend is apparent for some of the metals: cadmium, copper, and nickel achieve their highest concentrations at the southernmost site in the river, with lower concentrations encountered upriver.

TABLE 5. Site Averages of Heavy Metals.

Parameter		Cd	Cu	Cr	Pb	Ni
		ug/l	ug/l	ug/l	ug/l	ug/l
Criteria*	FW2-NT SE2	10(h)		160(h)	5(h)	516(h) 3,900(h)
Site						
1		45.7	19.8	65.5	519.8	124.8
2		44.9	30.2	19.0	433.0	152.4
3		46.7	24.6	39.0	406.0	196.1
4		57.8	32.0	57.0	440.4	251.5
5		73.8	45.6	30.1	504.0	330.9
6		20.8	2.6	15.3	111.4	25.1
7		48.0	27.9	36.4	387.3	271.2
8		37.9	35.4	40.2	217.7	155.6
9		40.7	16.6	31.4	215.8	81.2
10		38.1	16.3	35.2	210.2	117.0
11		18.6	6.8	21.5	159.0	61.3
12		34.1	7.1	25.3	137.7	55.9
13		27.5	9.6	38.9	191.6	51.2
14		23.9	28.2	20.2	311.5	31.8
Total Avg.		*39.9*	*21.6*	*33.9*	*303.3*	*135.7*

*All criteria for metals are total recoverable. Criteria followed by an (h) are non carcenogenic effect-based human health criteria as a 30-day avg.

DISCUSSION

While serving as an oasis of open space within an intensively developed region of northeastern New Jersey, the results of the first year of water quality sampling suggest that the Hackensack Meadowlands do not remain free of the effects of the urban surrondings. According to Section 304(l) of the 1987 amendments to the Federal Clean Water Act, the Hackensack River and its tributaries are included on the short list of waterbodies impaired due to point source discharges of toxic pollutants. While permitted industrial discharges exist within the study area, the coinciding trends of metal concentrations, suspended solids and salinity may indicate that Newark Bay is also contributing some metal pollution with each tidal cycle.

Dissolved oxygen appears to be reduced during the summer. No other effects of thermal pollution are displayed by the data. While this could easily be an artifact of sampling site placement, the lack of an imprint on the nearest river site indicates that any negative impact from power plants is spatially restricted.

Much of the freshwater flow into the lower Hackensack River is from stormwater runoff and sewage treatment plant effluent. The Fall sampling, which coincided with rain events, yielded the highest levels of fecal coliform bacteria, indicating that possible sources are combined sewer overflows. An apparent spatial trend provides additonal confirmation of this association.

Based upon values obtained at Site 14 during each sampling, the presence of ammonia is associated with a large municipal solid waste landfill. There appears to be a dissipation of this leachate at the downstream Site 7, and no further evidence of this pollutant is apparent.

No indication of a primary source or cluster of metal pollution within the sampling area is apparent. Sediment dynamics control the presence of metals, with scouring and redeposition of particles along with pollutants obliterating any but the most obvious spatial trend.

CONCLUSIONS

A sampling network was established by this program to provide adequate information about the water quality within the HMD. The data that was collected during the first year was compared to surface water criteria, depicting a natural ecosystem impaired by low seasonal dissolved oxygen, high bacterial concentrations and metal pollution. A continuation of the monitoring program will allow for confirmation of apparent spatial trends, and will record changes in the state of water quality with time.

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