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LIMNOLOGICAL INVESTIGATION OF STAFFORD POND TIVERTON, RHODE ISLAND

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Submitted to:
The Rhode Island Department of Environmental Management
235 Promenade Street
Providence, RI 02908

Ken Wagner
3-2002
Ct. 860
429-5323
ext 222
MA 978
589-3000

Submitted by:
Fugro East, Inc.
6 Maple Street
Northborough, MA 01532

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TABLE OF CONTENTS

Appendices

FIGURES

TABLES

EXECUTIVE SUMMARY

INTRODUCTION

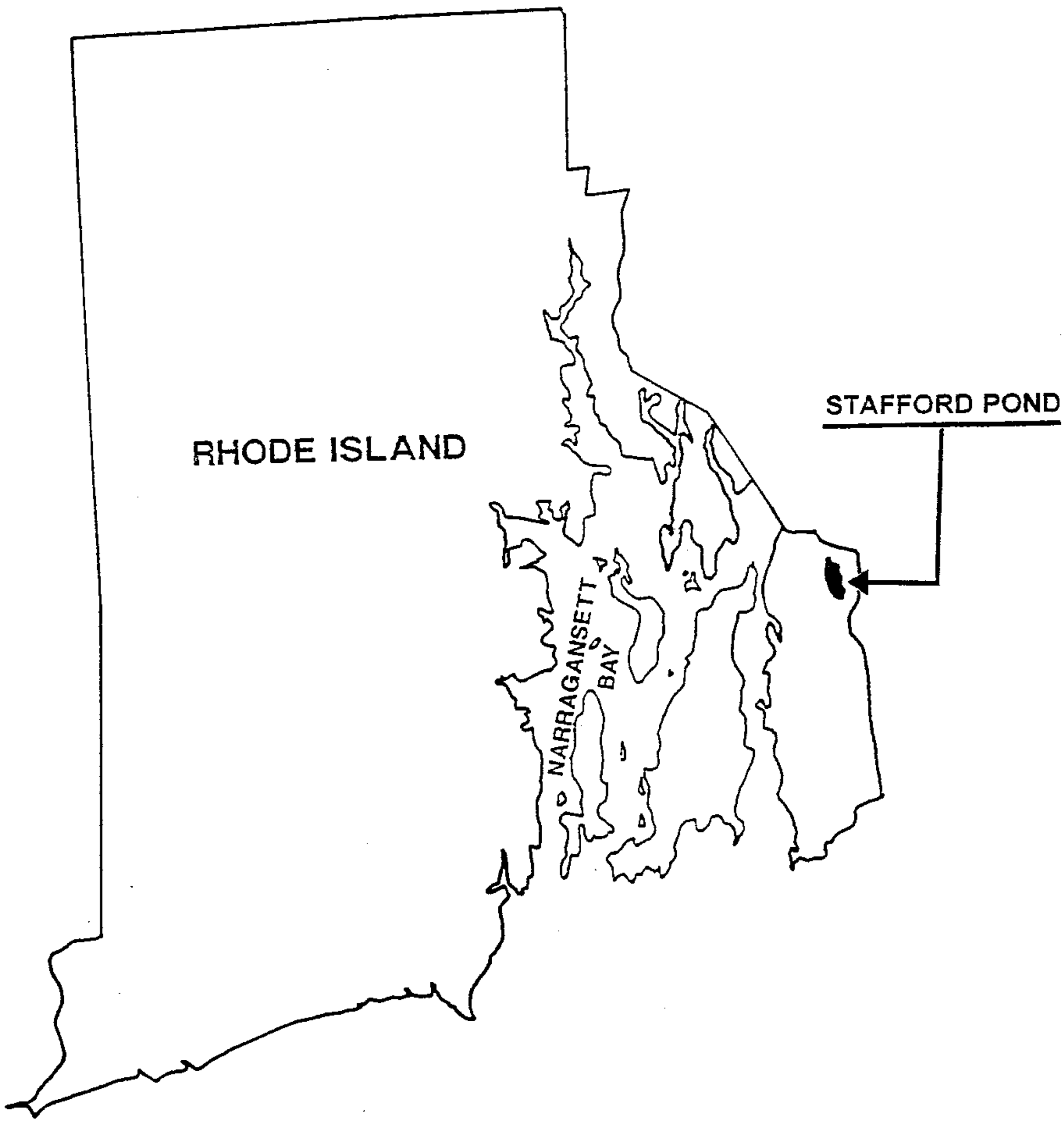
Stafford Pond is located in the northeast corner of Tiverton, Rhode Island and lies within the Narragansett Bay drainage basin (Figure 1). The pond is approximately 487 acres in size. Stafford Pond is categorized as a Class B waterbody by the State of Rhode Island (RIDEM 1988). Designated uses for Class B waterbodies include public water supply with appropriate treatment, agricultural uses, primary contact recreation, and fish/wildlife habitat. The Stone Bridge Fire District of Tiverton, Rhode Island, maintains a water treatment facility on the southwest shore of the pond, and supplies drinking water to nearly 1000 customers. Potable water from the Stone Bridge Fire District treatment facility is supplied to the Town of Portsmouth, the Stone Bridge section of Tiverton, the Tiverton Water Authority, and the North Tiverton Water Authority. The pond supports a viable put and take trout fishery and a self sustaining warmwater fishery, including one of the state's few remaining populations of smallmouth bass. A public boat launch is located on the eastern shoreline.

Concerned over a perceived decline in water quality, the Rhode Island Department of Environmental Management (DEM) initiated a year long study of Stafford Pond beginning in January of 1996. A grant provided by the Rhode Island DEM was used to hire Fugro East, Inc. (now ENSR) for the purpose of conducting a limnological investigation of the pond. This investigation included an evaluation of Stafford Pond and its drainage basin. Water quality is important to the uses of Stafford Pond, which include public drinking water supply, recreational fishing, boating (motorized and non-motorized), limited swimming and other contact recreation, and as an occasional runway area for seaplanes. The goal of this study was not to prioritize pond uses, but to provide scientific information that should facilitate informed decision making.

HISTORICAL DATA REVIEW

Several investigations of Stafford Pond and its drainage basin have been conducted over the past few decades. The earliest reported water quality investigation was conducted in July of 1966 (Guthrie and Stolgitis 1990). Only a few parameters were analyzed. Temperature and dissolved oxygen profiles revealed isothermal conditions and sufficient levels of dissolved oxygen throughout the entire water column. Total alkalinity and pH were approximately 1.0 mg/L and 7.0 SU, respectively.

In May of 1967, a preliminary engineering report on water supply and distribution was presented to the Town of Tiverton (Fenton G. Keyes 1967). Results of this investigation revealed that Stafford Pond was an excellent source of drinking water, both from an engineering and economic standpoint. It was estimated that the dependable yield of the pond ranged from 1.5 to 2.0 million gallons per day. A follow-up report presented to the Town of Tiverton in April of 1977 indicated that Stafford Pond was still the logical choice as a future water supply for a "Town-Wide Water System".



Rhode Island

Locus Map
Stafford Pond

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Figure 1

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The earliest reported instance of poor water quality at Stafford Pond was in 1972, when algal blooms in the pond decreased output capacity at the water filtration plant (LEA 1974). Results of sampling conducted in 1989 indicated that the pond was eutrophic (RIDEM 1989). This classification was based upon chlorophyll a and Secchi transparency values of 15.8 ug/L and 1.7 m, respectively.

As a result of concern for the future of the pond, a Water Quality Protection Plan was generated during the early 1990's (Whitman and Howard 1992). The plan revealed six primary sources of potential contamination. These sources included: 1) a large number of substandard cesspools/septic systems in close proximity to the pond, 2) a dairy farm located northeast of the pond, 3) above ground fuel and oil tanks located within 100 feet of the pond, 4) storage of vehicles and construction equipment within the watershed, 5) storm water runoff, and 6) recreational boating and use by seaplanes.

Volunteer monitoring conducted during 1992, 1993, and 1994 revealed that the pond was in the mesotrophic range (Green and Herron 1995). However, results indicated a general decline in water quality over the three year period; Secchi depths decreased and concentrations of chlorophyll a and total phosphorus increased.

A general decline in water quality has also been noted by employees of the Stone Bridge Fire District water treatment facility. Prior to 1991, algal blooms were rather sporadic. During the past five years, the frequency and intensity of algal blooms has increased. Three algal taxa have been responsible for most of the bloom conditions. These taxa include *Anabaena, Aphanizomenon, and Asterionella* (Sumner 1996). The first two are Cyanophytes (bluegreen algae), while the last is a Bacillariophyte (diatom).

GENERAL APPROACH AND METHODS

WATERSHED FEATURES

Field investigations and a United States Geological Survey (USGS) 7.5 minute topographic map were used to delineate the watershed draining to Stafford Pond. Drainage patterns were used to further divide the watershed into sub-basins. Information regarding watershed geology was obtained from Fenton G. Keyes (1967). Major soil types in the Stafford Pond watershed were determined from the Soil Survey of Rhode Island (Rector 1981). Major land use categories within the watershed were identified from field investigations, USGS 7.5 minute topographic maps, and information provided by the Rhode Island Geographic Information System.

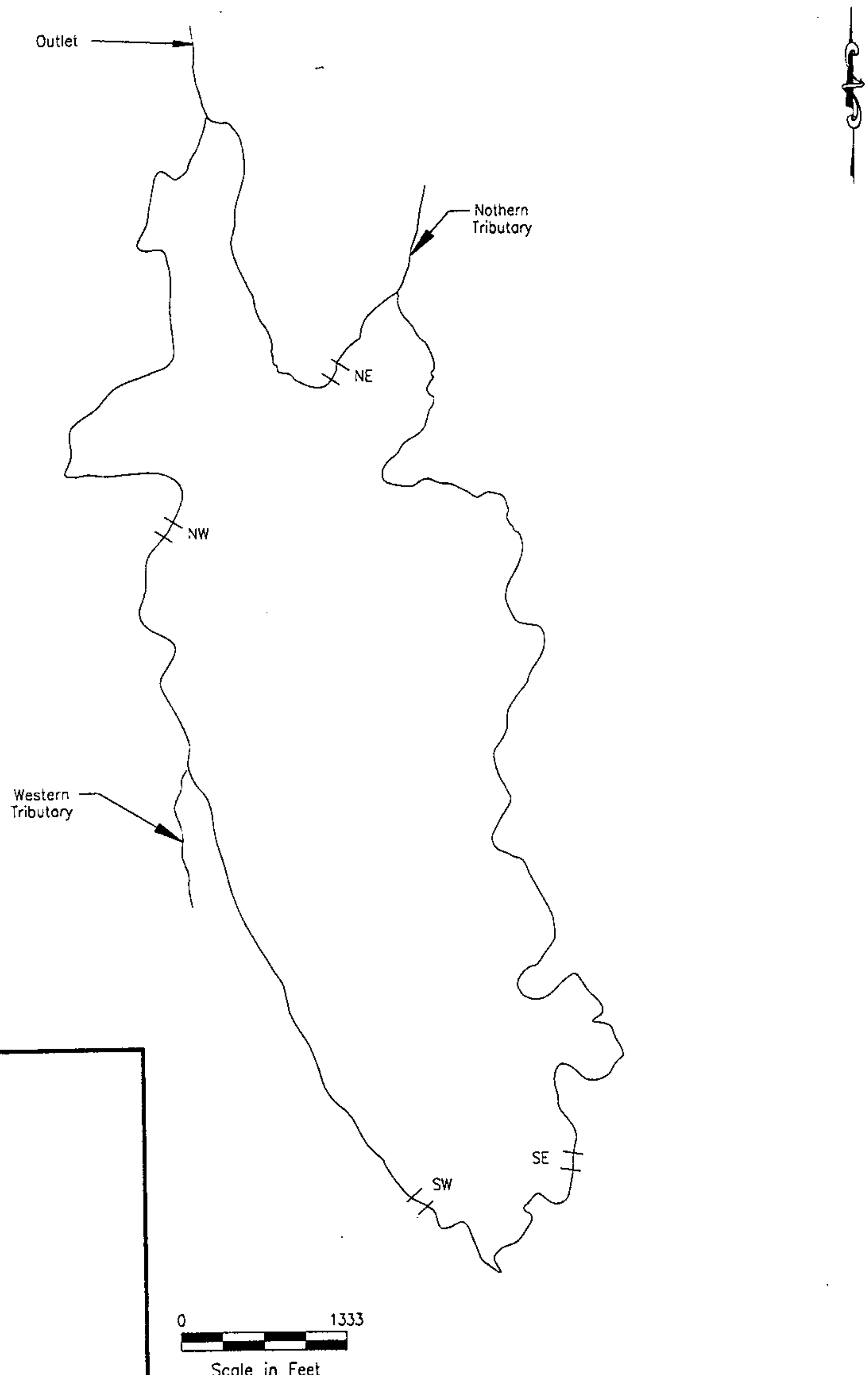
POND FEATURES

PHYSICAL CHARACTERISTICS

A USGS 7.5 minute topographic map was used to calculate total pond area. A bathymetric map obtained from Guthrie and Stolgitis (1990) was verified in the field and used to calculate average water depth, maximum water depth, and total pond volume. Benthic substrate composition was qualitatively evaluated in shallow areas of the pond (<15 ft water depth) by probing the pond bottom with a metal rod. The approximate volume of soft sediment in deep water areas of the pond was estimated by assuming that an average of one foot of soft sediment was present in water depths greater than 15 feet. Tributaries, storm water pipes, and outlets were identified from field investigations and review of USGS 7.5 minute topographic maps. Measurements of base-flow were recorded on most sampling visits to the pond by utilizing the float method as described by Dunne and Leopold (1978).

A seepage survey was conducted in June along four shoreline segments to document the role of ground water on pond hydrology (Figure 2). Shoreline segments were selected to be representative of the pond as a whole. Seepage quantity was estimated by installing two seepage meters per defined shoreline segment and measuring the volumetric change in the attached bag (Mitchell et al. 1988).

Additionally, two shallow ground water wells were installed at each of the aforementioned shoreline segments to further document the role of ground water on pond hydrology. Groundwater wells were monitored from April through October. For each shoreline segment, one well was established on-shore and one well was established in the shallow littoral zone of the pond. Ground water flow was estimated by utilizing the Darcy equation: $Q = CIA$, where Q= discharge, C= hydraulic conductivity, I= hydraulic gradient, and A= seepage area. Hydraulic conductivity was estimated by reviewing infiltration rates for soil types present in the Stafford Pond watershed. The hydraulic gradient or slope of the ground water table was estimated by comparing on-shore and in-pond ground water elevations. Seepage area was estimated by dividing the pond into four equi-distant quadrants and assuming that seepage was minimal or non-existent beyond a known water depth (15 ft.), as mucky bottom sediments in deep water areas of the pond reduce or even eliminate ground water movement.



NOTE:
- All locations and dimensions are approximate.

SOURCE:
- Fugro field reconnaissance.

Legend:

NE=Northeast
NW=Northwest
SE=Southeast
SW=Southwest

Client: Rhode Island Department Of Environmental Management	Shoreline Segments For The Seepage Survey, Well Survey And Ground Water Quality Monitoring Investigation At Stafford Pond (1996)	Figure 2
	Job No. 16-16-9144	

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Hydrologic loading was determined using actual and estimated values based upon watershed and pond features. Hydrologic inputs were divided into four categories: direct precipitation, ground water inseepage, surface water-base flow, and surface water-storm flow. Annual precipitation was estimated by averaging 30-year normal precipitation values for Providence and Newport, Rhode Island. Direct precipitation input was estimated by multiplying annual precipitation by the total pond area. Ground water inseepage was estimated by time weighting and averaging all positive monthly well measurements. Surface water base-flow was estimated by reviewing actual flow measurements and adjusting values to fit average precipitation data and expected watershed water yield (Sopper and Lull 1970). Surface water storm-flow was estimated per sub-basin by multiplying average annual precipitation by selected runoff coefficients relating to land use.

Hydrologic outputs were also divided into four categories: evaporation, ground water outseepage, withdrawal (water treatment facility), and surface outflow. Evaporation was estimated by multiplying direct annual precipitation by 2/3. Ground water outseepage was estimated by time weighting and averaging all negative monthly well measurements. Average annual withdrawal from the drinking water treatment facility was estimated by reviewing pumping records from January through November of 1996. Surface outflow was assumed to make up the remainder, as corroborated by field measurements. Total inflow and morphometric features of the pond were used to estimate flushing rate, detention time, and response time.

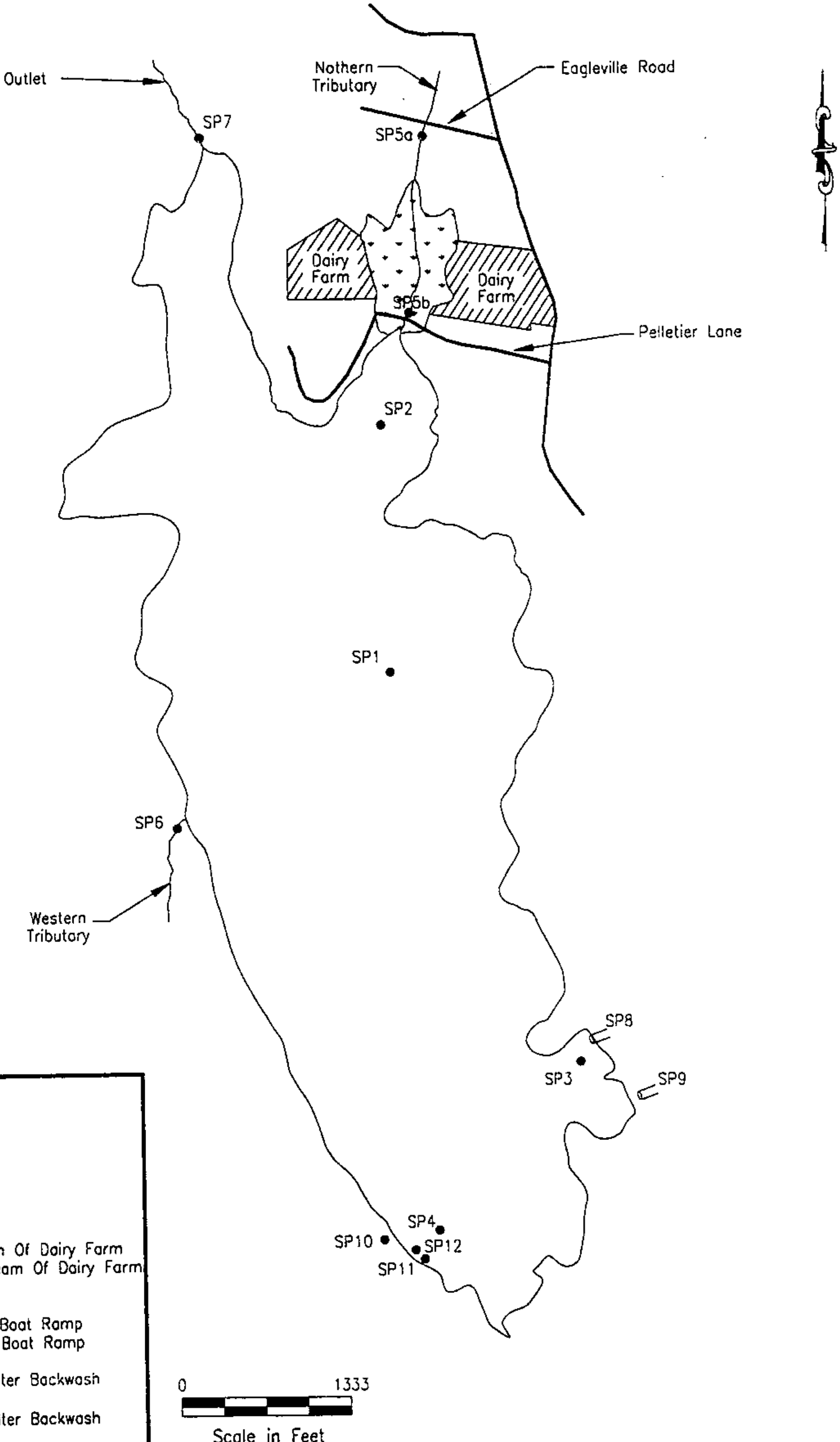
A seasonal hydrologic budget was constructed based on the relationships established by Sopper and Lull (1970) for southern New England and the total inputs and outputs as derived above.

CHEMICAL CHARACTERISTICS

Water quality monitoring locations are presented in Figure 3. Routine monitoring was conducted from February through October and included sampling at stations SP1-7 and SP11-12. The following parameters were analyzed: dissolved oxygen, temperature, pH, total alkalinity, total hardness, conductivity, turbidity, Secchi disk transparency, chlorophyll a, nitrite+nitrate nitrogen, ammonium nitrogen, inorganic nitrogen, total Kjeldahl nitrogen, total nitrogen, total phosphorus, and dissolved phosphorus.

Supplemental monitoring was conducted at four locations (SP1a, SP1e, SP3, SP4) during July and September. The following parameters were analyzed: cadmium, lead, copper, aluminum, calcium, magnesium, sodium, chloride, iron, manganese, total petroleum hydrocarbons, DDT, PCB's, and polynuclear aromatic hydrocarbons. Additionally, a single round of sampling was conducted in October at SP1a to determine concentrations of cadmium, lead, and mercury using very low detection limits.

Three rounds of storm water monitoring were conducted at up to five locations over the course of the study. Storm water monitoring locations included SP5b, SP6, SP8, SP9, and SP10. Routine monitoring parameters were evaluated during each round of sampling and supplemental monitoring parameters were evaluated during a single sampling conducted in September.



NOTE:
- All locations and dimensions are approximate.

SOURCE:
- Fugro field reconnaissance.

SP1a	Deep Hole - Surface
SP1b	Deep Hole - 2m
SP1c	Deep Hole - 4m
SP1d	Deep Hole - 6m
SP1e	Deep Hole - 7.5m
SP2	Northeast Bay - Surface
SP3	Boat Ramp - Surface
SP4	Water Supply Intake
SP5a	Northern Tributary - Upstream Of Dairy Farm
SP5b	Northern Tributary - Downstream Of Dairy Farm
SP6	Western Tributary
SP7	Outlet
SP8	Stormwater Pipe - North Of Boat Ramp
SP9	Stormwater Pipe - South Of Boat Ramp
SP10	Precipitation
SP11	Water Treatment Facility - Filter Backwash at 4" Pipe
SP12	Water Treatment Facility - Filter Backwash at 12" Pipe

Client: Rhode Island Department Of Environmental Management

Water Quality Monitoring Locations At Stafford Pond (1996)

Job No. 16-16-9144

Figure 3

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A ground water quality monitoring investigation was conducted during June and September along four shoreline segments (Figure 2). Shoreline segments were consistent with those selected for the seepage and well surveys. A littoral interstitial porewater (LIP) sampler was used to collect three samples from each shoreline segment which were later composited into a single sample per segment. Parameters evaluated included nitrite+nitrate nitrogen, ammonium nitrogen, dissolved phosphorus, dissolved iron, and dissolved manganese.

Benthic sediments were collected at three in-pond locations with the aid of an Ekman dredge (Figure 4). Parameters evaluated included grain size analysis, total organic carbon, solids content, total phosphorus, total Kjeldahl nitrogen, total metals (Cd, Cu, Pb, Al, Fe, Mn, Ca), total petroleum hydrocarbons, DDT, PCB's, and polynuclear aromatic hydrocarbons.

Edible portions from three white perch *(Morone americana)* were composited and analyzed for cadmium, lead, mercury, PCB's, and polynuclear aromatic hydrocarbons. Fish ranged in size from 11 to 12 inches total length.

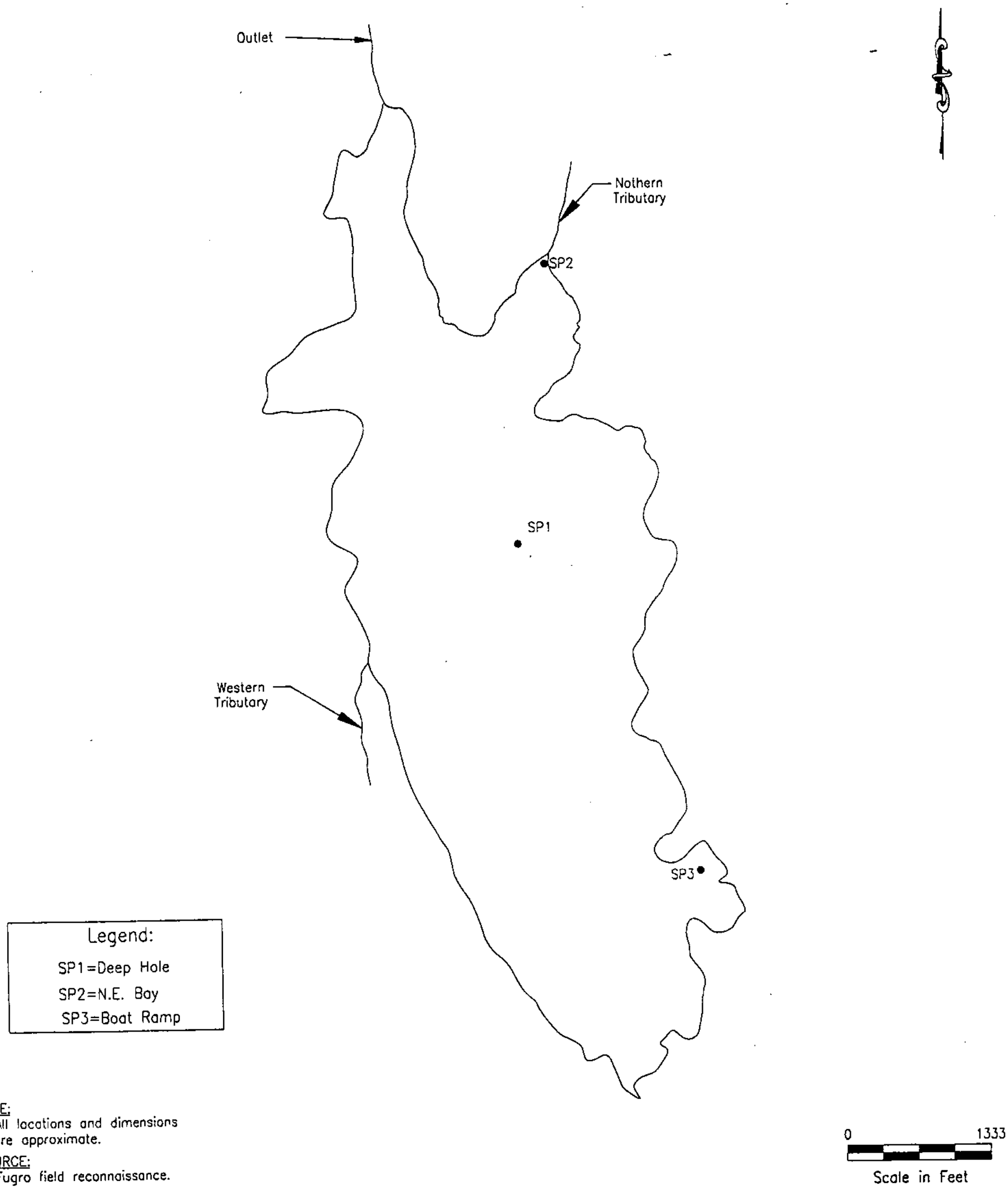
Duplicate water quality samples from one station were analyzed for selected parameters on multiple sampling dates. The purpose of this project component was to quantify variability as a function of sampling and/or lab error. Additionally, phosphorus analysis was conducted at two separate labs on several dates to provide cross-lab comparisons.

Three separate approaches were used to estimate nitrogen and phosphorus loading to Stafford Pond. In the first approach, existing data for water flows and nutrient concentrations were used to calculate approximate inputs from sources for which data were available, and to derive rough estimates for unsampled sources through comparison. The second approach involved empirical models utilizing hydrologic lake features and known in-lake concentrations to calculate the load necessary to generate those concentrations. The third approach employed export coefficients for pollutant loading from land use types, tempered by known attenuation mechanisms, specific watershed features, and existing data. This third approach also results in a model which can be used to predict the impact of various management actions on in-lake water quality.

Internal load, a potentially important feature of any nutrient budget, was evaluated as a function of the average difference between surficial and bottom concentrations for phosphorus and nitrogen, and as the change in concentration over the summer period of lowest external inputs and maximum likely internal loading. Inputs from other sources, such as birds, were quantified as a function of literature values and field observation.

BIOLOGICAL CHARACTERISTICS

Water samples collected during routine and storm water monitoring were analyzed for fecal coliform and fecal streptococcus bacteria. Phytoplankton were collected every month from February through October at sampling locations SP1a and SP4. Samples were preserved with Lugol's solution and identified in the laboratory under phase optics at 400x magnification. Cell counts were converted to biomass based on size and species-specific biovolumes using a specific gravity of 1.0. Chlorophyll a was measured spectrophotometrically after extraction in 90% acetone, and calculated using the monochromatic equation. Zooplankton were collected during



NOTE:
- All locations and dimensions are approximate.

SOURCE:
- Fugro field reconnaissance.

Client: **Rhode Island Department Of Environmental Management**	**Sediment Sampling Locations At Stafford Pond (1996)**	**Figure 4**
	Job No. 16-16-9144	

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spring, summer, and late summer at a single sampling location (SP1). Samples were preserved with formalin and identified in the laboratory under brightfield optics at 100x magnification. Organism counts were converted to biomass based on size and species-specific relationships.

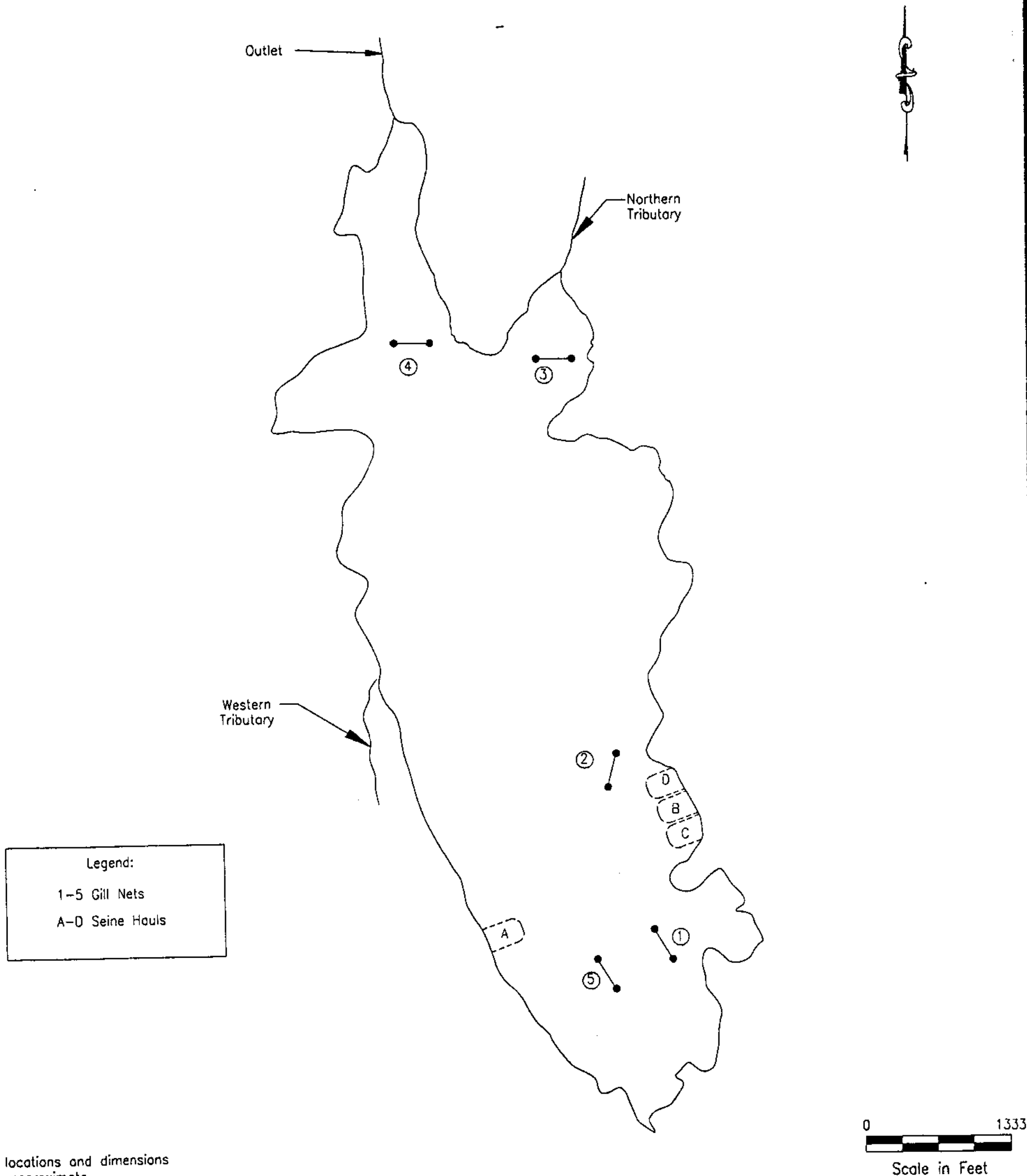
The aquatic vascular plant community of Stafford Pond was surveyed in June and August. During the June survey, a boat and diver equipped with snorkeling gear were used to map species composition and plant density throughout the pond. The August survey was less intense and basically consisted of cruising the shoreline in a boat and documenting any large changes in the plant community.

The fish community of Stafford Pond was determined by reviewing information provided by the Rhode Island Department of Environmental Management, Division of Fish and Wildlife. Additionally, a seining and gill-netting survey was conducted during the month of October as a supplement to this information. Seining was conducted in shallow near-shore areas of the pond and gill-nets were set throughout the pond (Figure 5). Fish were identified, examined for external anomalies, enumerated, measured (millimeters), weighed (grams), and released.

Approximate numbers of waterfowl were recorded on most sampling visits to the pond. Although aquatic invertebrate, amphibian, and reptile communities were not evaluated in detail as part of this investigation, a brief write-up on expected community composition is presented in the results section of this report.

Pond Use Evaluation

Existing pond uses, including water supply, boating, fishing, swimming/contact recreation, and other uses were evaluated largely through field observation and discussions with lake users. An effort was made to record the number and types of boats on the pond, and any other forms of recreation observed during visits. However, we were not present on weekends, when alternative use patterns would be most likely to occur.



NOTE:
- All locations and dimensions are approximate.

Client: Rhode Island Department Of Environmental Management	Fish Survey Sampling Locations At Stafford Pond (1996)	Figure 5
	Job No. 16-16-9144	

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DIAGNOSTIC ASSESSMENT

WATERSHED FEATURES

WATERSHED DELINEATION

The watershed draining to Stafford Pond is approximately 947 acres in size (Figure 6). Six sub-basins were designated and ranged in size from 81 to 308 acres. The watershed:lake area ratio is small (<2:1), indicating high potential for successful management.

DRAINAGE PATTERN

Two tributaries and two storm water pipes discharge into Stafford Pond (Figure 3). The northern tributary drains sub-basin 5, and the western tributary drains sub-basin 6. Both storm water pipes drain sections of sub-basin 2. The northern storm water pipe discharges directly into Stafford Pond, and is believed to drain sections of Old Stafford Road. The southern storm water pipe discharges into a forested area within 200 feet of the pond, and is believed to drain sections of Route 81. Drainage in the remaining sub-basins is a combination of sheet flow and ground water infiltration.

GEOLOGY

The available information on the geology of the Eastern Bay Area of the State of Rhode Island indicates that the Stafford Pond watershed is primarily underlain by a thin mantle of till. Till is a compact, unstratified, poorly sorted mixture of clay, silt, sand, gravel, and boulders, deposited by glacial activity. The till usually forms a thin discontinuous mantle over the bedrock with frequent outcroppings of the bedrock being present. Because of its clayey character, till generally has a relatively low infiltration capacity, although some soils derived from till can be well drained.

SOILS

Approximate distributions of soil types in the Stafford Pond watershed are presented in Figure 7. The Stafford Pond watershed is primarily composed of well drained (Broadbrook, Newport, Canton and Charlton) and moderately well drained (Pittstown, Woodbridge, Udorthent-Urban Land Complex) soils. However, poorly drained (Ridgebury, Stissing) and very poorly drained (Adrian, Mansfield) soils are present throughout the watershed as well.

Broadbrook soils compose a majority of the western shoreline of the pond and eastern perimeter of the watershed. Runoff rates range from slow to moderate. Runoff rates indicate the intensity of overland flow in response to precipitation. Broadbrook soils are generally suitable for community development. However, on-site sewage disposal systems need special design and installation to prevent effluent from seeping to the surface as permeability of the substratum is slow or very slow.

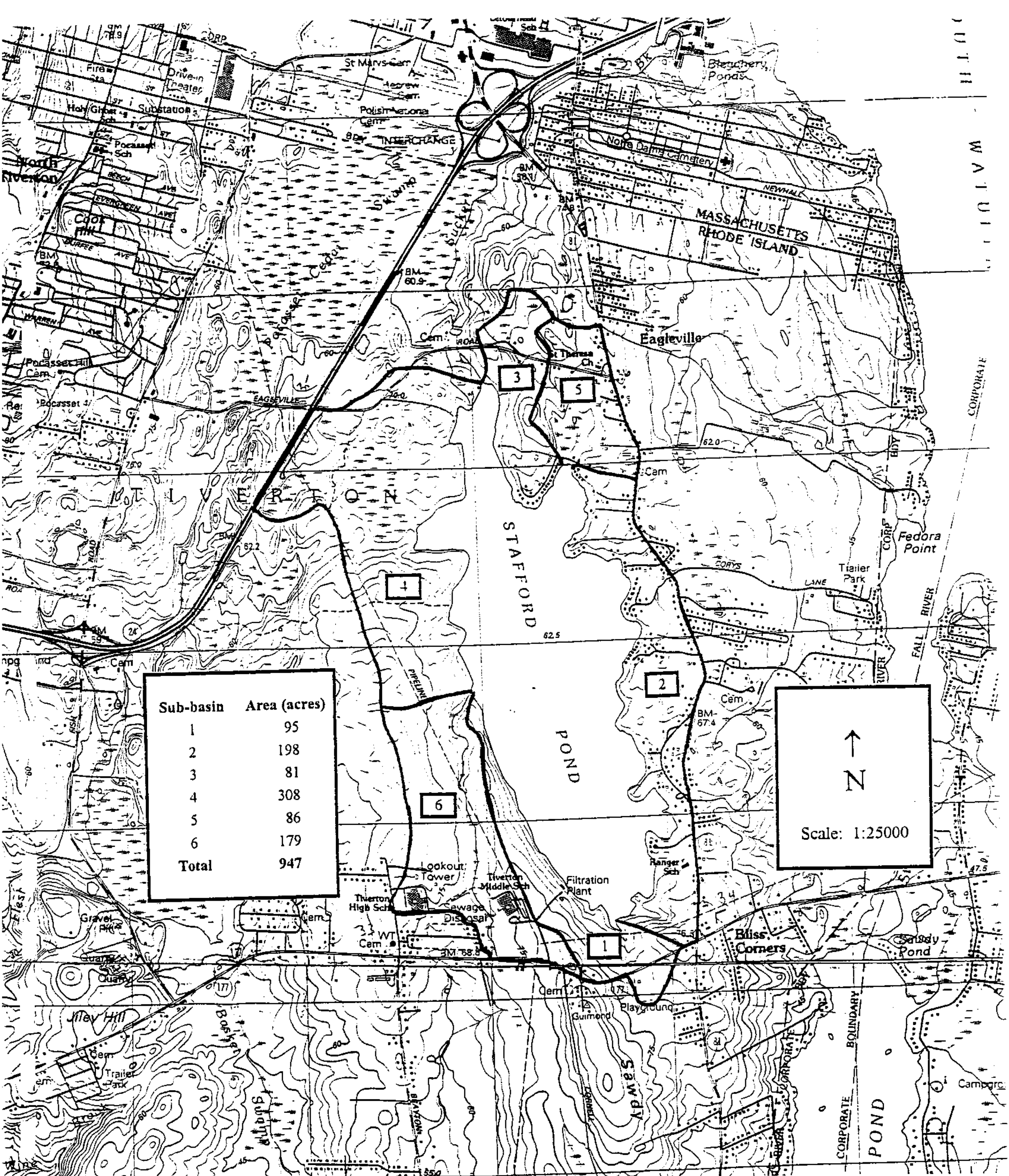
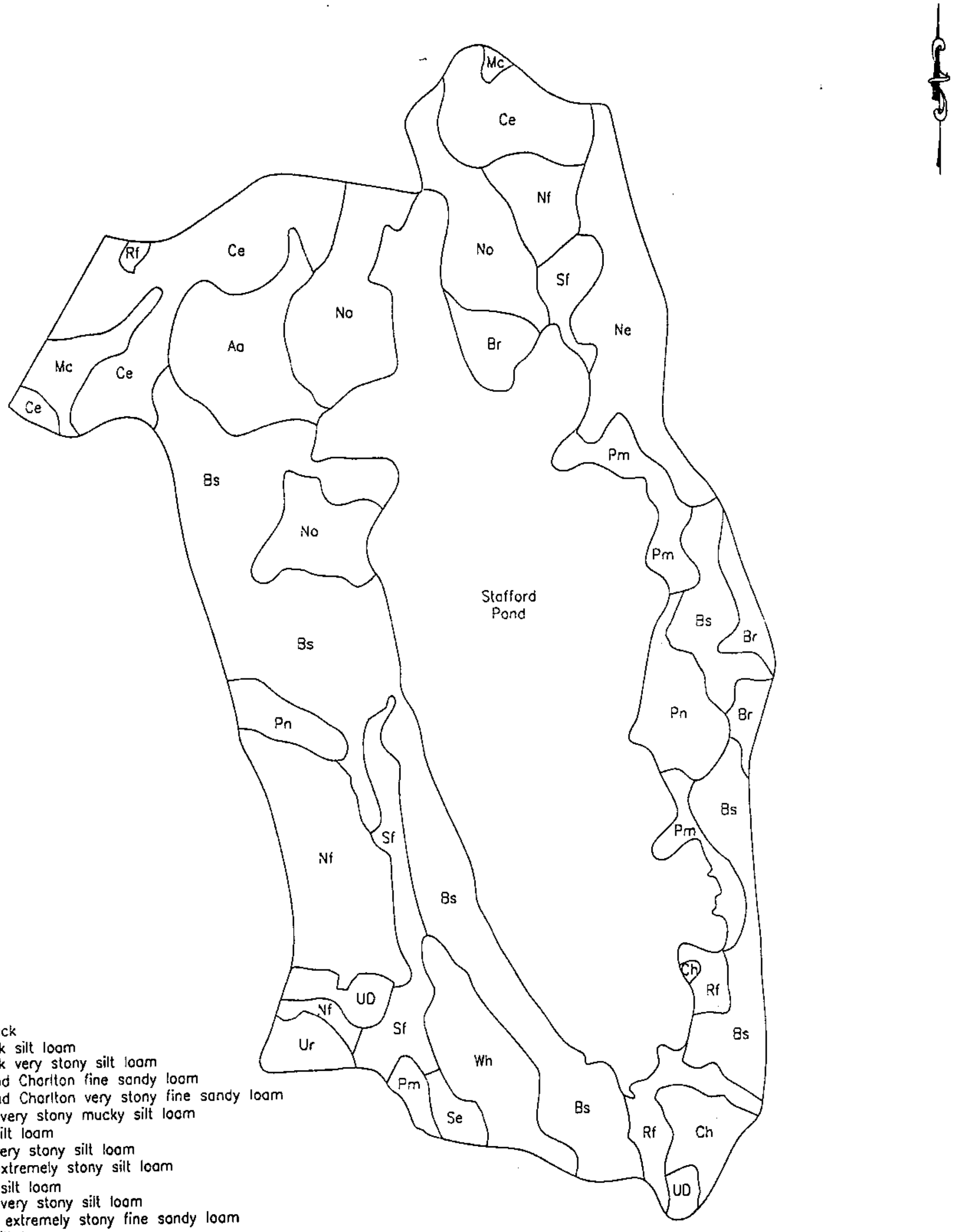


Figure 6. Stafford Pond Watershed.



KEY TO SOIL TYPES:

Aa	Adrian muck
Br	Broadbrook silt loam
Bs	Broadbrook very stony silt loam
Ce	Canton and Charlton fine sandy loam
Ch	Canton and Charlton very stony fine sandy loam
Mc	Mansfield very stony mucky silt loam
Ne	Newport silt loam
Nf	Newport very stony silt loam
No	Newport extremely stony silt loam
Pm	Pittstown silt loam
Pn	Pittstown very stony silt loam
Rf	Ridgebury extremely stony fine sandy loam
Se	Stissing silt loam
Sf	Stissing very stony silt loam
UD	Udorthents-Urban complex
Ur	Urban Land
Wh	Woodbridge fine sandy loam

NOTE:
- All locations and dimensions are approximate.

0 2000
Scale in Feet

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Client: Rhode Island Department Of Environmental Management

Approximate Distributions of Soil Types in the Stafford Pond Watershed

Figure 7

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Newport soils are found throughout the western and northern portions of the watershed. Runoff rates range from medium to rapid. These soils are generally suitable for community development and have the same constraints as the Broadbrook soils with regard to on-site sewage disposal systems.

Canton and Charlton soils are located in the northern and southeastern portions of the watershed. Runoff rates are typically moderate. These soils are suitable for community development but are limited by one or more factors including stoniness. On-site sewage disposal systems need special design and installation to prevent effluent from seeping to the surface.

Pittstown soils comprise most of the eastern shoreline where nearly all of the lakefront development has occurred. Runoff rates range from slow to moderate. These soils are generally suitable for community development, but are limited by a seasonal high water table and slow permeability of the substratum. Special design considerations are necessary for on-site sewage disposal.

Woodbridge soils are present in an isolated patch in the southern portion of the watershed at the crest of an upland hill. Runoff rates are typically slow. These soils are generally suitable for community development and have the same constraints as the Pittstown soils with regard to on-site sewage disposal systems.

Several small portions of Udorthent-Urban Land Complex are found in the southern portion of the watershed. This soil category is usually associated with disturbed soils that have been covered by buildings or pavement.

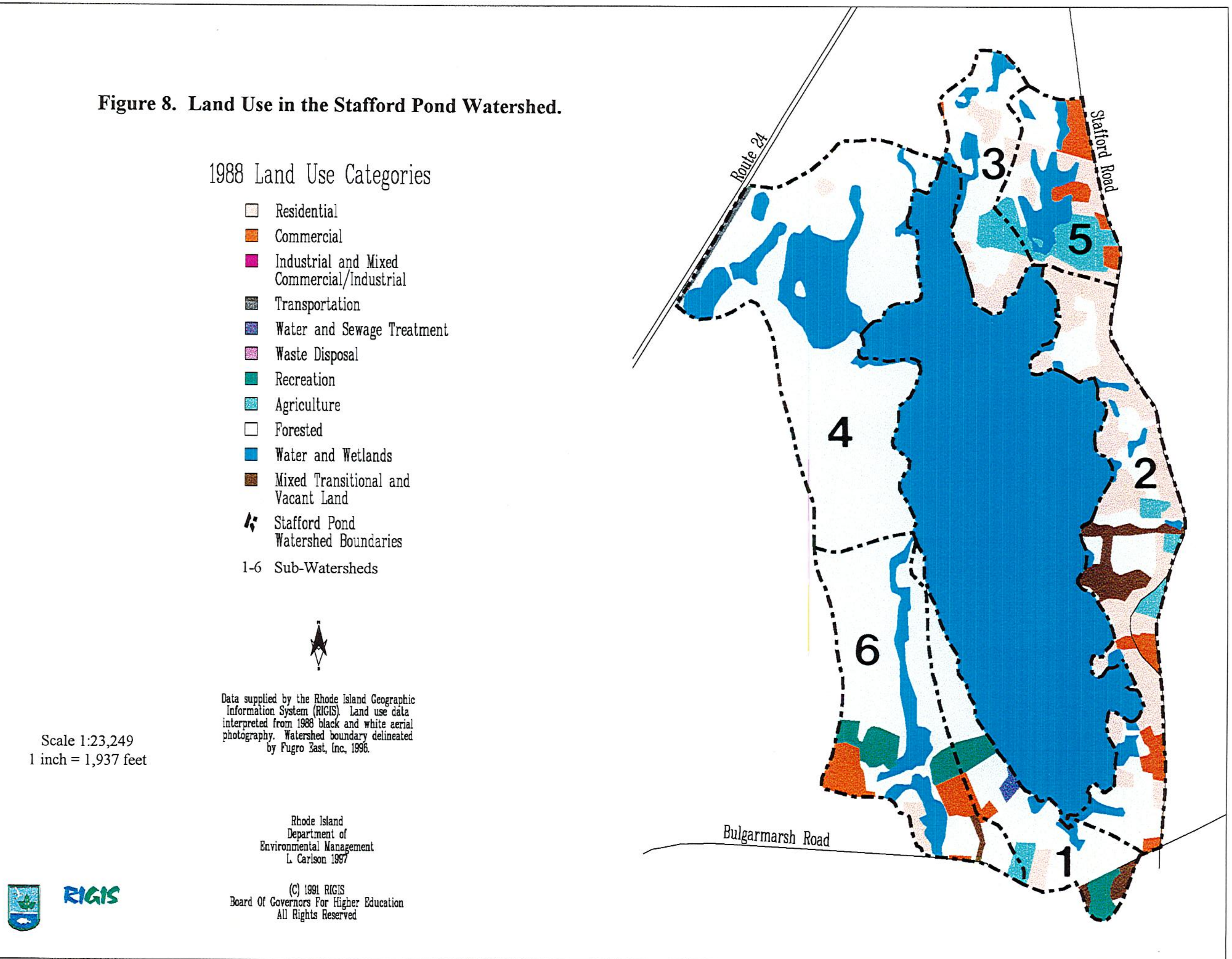
The remaining soil groups (Ridgebury, Stissing, Adrian, and Mansfield) are located throughout the watershed in isolated pockets and typically have slow or very slow runoff rates. These soils are generally not recommended for community development or on-site sewage disposal.

LAND USE

Forested and residential land use categories cover the greatest area in the Stafford Pond watershed (Figure 8). Sub-basin 1, covering 95 acres, is primarily forested and contains only a few buildings, including the Stone Bridge Fire District water treatment facility. The water treatment facility withdraws water from Stafford Pond on a daily basis via two sub-surface intakes. Additionally, treated pond water is used to backwash filters at least once every two days, and this water is eventually discharged back into the pond after settling of suspended solids. The normal mode of operation is to deliver post-backwash water to a pair of sequential settling tanks prior to discharge into the pond. Discharge from the settling tank occurs via two 4 inch diameter pipes. In circumstances where the settling tank is full, backwash can be discharged directly to the pond via a 12 inch diameter pipe.

Sub-basin 2, covering 198 acres, was the most heavily developed area in the entire watershed and includes most of the residential properties and some commercial properties. This sub-basin is bounded by Stafford Pond to the west and Route 81 to the east. Road runoff from this sub-basin is discharged to Stafford Pond via two stormwater pipes (Figure 3). Sub-basin 3, occupying 81

Figure 8. Land Use in the Stafford Pond Watershed.



acres, is a mix of residential, agricultural, wetland, and forested land uses. A number of summer cottages and year-round residences in this sub-basin are located in close proximity to the pond. Furthermore, many of these residences utilize cesspools or septic systems which appear to be at a low elevation relative to the ground water table. Sub-basin 4, with an area of 308 acres, is probably the least developed area in the entire watershed, with wetland and forested land use categories predominating.

Sub-basin 5, covering 86 acres, is a mix of residential, commercial, agricultural, wetland, and forested land use categories. An active dairy farm is present in this portion of the watershed. The farm encompasses approximately 55 acres, only half of which is actually frequented by cattle. The herd is comprised of approximately 120 milking cows and 40-60 dry cows and heffers. Dry cows and heffers are moved to off-site grazing areas from April through November. Herd size has not changed appreciably over the last decade (Pindell 1996). The northern tributary to Stafford Pond flows through the dairy farm (Figure 3). This tributary originates in a wetland area just north of Eagleville Road. From this point, the stream flows in a southerly direction, receiving stormwater from Eagleville Road and discharging into a small pond located at the north end of the dairy farm. The stream channel upstream of the pond is usually dry during dry weather. This pond also receives drainage from Washington Avenue during wet weather. The northern area of the dairy farm is well vegetated and is usually not frequented by cattle. The outlet from the pond combines with groundwater breakout from the west and flows through the southern section of the dairy farm and into Stafford Pond. The southern area of the dairy farm is frequented by cattle, and unvegetated hillsides drain directly into the northern tributary.

Sub-basin 6, with an area of 179 acres, is relatively undeveloped with forested land use predominating. Two significant developed properties are present in this sub-basin, near its upgradient limit: the Tiverton High School and the Tiverton Middle School. This sub-basin is drained by the western tributary to Stafford Pond (Figure 3). This tributary originates near route 177 and meanders to the pond through a series of wetlands. Runoff from the High School parking lot and possibly leachate from the waste water disposal system appear to reach this tributary.

POND FEATURES

PHYSICAL CHARACTERISTICS

Morphometry

Stafford Pond is approximately 487 acres in size. Average and maximum water depths were 13 and 25 feet, respectively (Figure 9). Pond volume was calculated at approximately 271,800,000 ft^3 or 7,700,000 m^3 or 2.04 billion gallons. The pond has only one definable basin, with the deepest area slightly northeast of center. Underwater slopes are moderate along east and west shoreline areas, minimizing soft sediment accumulations. Slopes are more gradual to the north and south.

Sediments

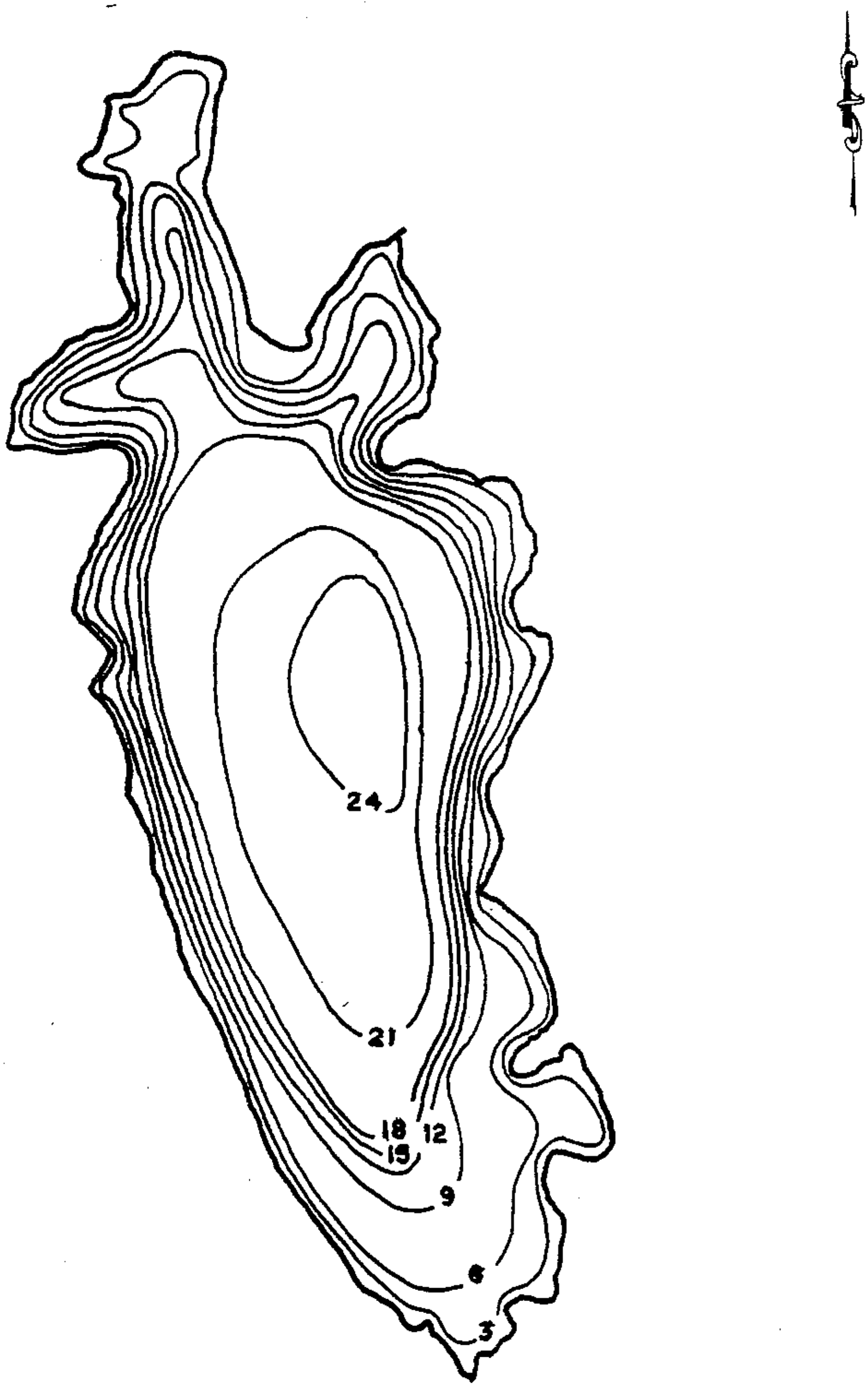
Benthic substrates were comprised mostly of boulder, cobble, gravel, and sand in water depths <15 feet, although some sandy muck was encountered in northern and southern areas of lesser underwater bottom slope. Mucky bottom sediments were more prevalent in the deeper areas of the pond. Although quantitative data was not collected for soft sediment volume at depths >15 ft, we would conservatively estimate that nearly 10 million cubic feet (370,000 cy) of soft sediment are present in water depths >15 feet. There is very little soft sediment at water depths <15 ft; thin layers of muck are found in some areas, and a substantial (10,000-15,000 cy) but isolated deposit is located near the mouth of the northern tributary.

Hydrology

Precipitation drives the hydrology of most aquatic systems in the northeastern United States. Data for weather stations in Providence and Newport, RI (Table 1) suggest long-term average annual precipitation of about 45 inches. Providence records for 1996 suggest a near average year, while records for Newport suggest much higher than average precipitation. Precipitation for 1995 was far below normal for each station. The distribution of precipitation tends to be fairly uniform over the months of the year on a long-term average basis, but any individual year is likely to have substantial variability among monthly values.

Two tributaries and two storm water pipes discharge to Stafford Pond. An outlet structure located along the northern perimeter of the pond controls the outward flow of pond water into Sucker Brook (Figure 3). This rectangular weir is maintained by the Fall River Water Department. However, water rights are actually owned by the Watuppa Reservoir Company. The management goal concerning the outlet structure has generally been to maintain full capacity in the pond, with the ability to release water during drought conditions.

Measurements of surface water flow are presented in Table 2. Observed tributary flows ranged from 0 to 2.6 cfs and outlet flows ranged from 0 to 10.7 cfs. As expected, the lowest flows were recorded during July, August, and early September. It is noted here that average estimates of flow were elevated, as precipitation during 1996 was higher than normal and measurements were occasionally recorded after recent precipitation events.



All Contours in Feet

SOURCE:
Guthrie & Stolgitis, 1990

Client: Rhode Island Department Of Environmental Management	Bathymetric Map Of Stafford Pond	Figure 9	FUGRO
	June, 1996	Job No. 16-16-9144	

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Table 1. Precipitation Data for the Stafford Pond Region.

Month	30 year average (in.)			1996 (in.)		
	Providence	Newport	Average	Providence	Newport	Average
Jan	3.88	3.83	3.86	5.02	5.47	5.25
Feb	3.61	3.63	3.62	2.19	4.13	3.16
Mar	4.05	4.14	4.10	2.71	2.73	2.72
Apr	4.11	4.15	4.13	4.88	6.31	5.60
May	3.76	3.68	3.72	2.44	2.97	2.71
Jun	3.33	3.14	3.24	2.17	2.29	2.23
Jul	3.18	2.85	3.02	5.49	3.61	4.55
Aug	3.63	3.31	3.47	2.19	3.71	2.95
Sep	3.48	3.47	3.48	5.75	7.94	6.85
Oct	3.69	3.52	3.61	6.23	7.50	6.87
Nov	4.43	4.71	4.57	2.23	4.71*	3.47
Dec	4.38	4.38	4.38	4.38*	4.38*	4.38
Total	45.53	44.81	45.17	45.68	55.75	50.72
1995 data (for comparison)				38.58	38.12	38.35

*Long Term average (1996 data unavailable).

Data provided by the Northeast Regional Climate Center - Ithaca, N.Y.

Table 2. Estimates of Flow Recorded at Stafford Pond (1996).

Sampling Date	Flow (cfs) SP5b	SP6	SP7
Dry Weather:			
21-Feb	2.4	2.6	10.7
19-Mar	1.5	1.1	8.8
14-May	0.3	0.6	9.4
29-May	0.3	1.3	6.1
10-Jun	0.1	0.3	3.6
27-Jun	<0.01	<0.01	0.9
17-Jul	<0.01	<0.01	<0.01
30-Jul	<0.01	0	0
8-Aug	<0.01	0	0
22-Aug	0	0	0
5-Sep	0	0	0
30-Sep	0.03	0.4	1.5
29-Oct	0.5	1.4	10.3
Mean (time weighted)	0.5	0.6	4.7
Minimum	0	0	0
Maximum	2.4	2.6	10.7

A map of shoreline segments for the ground water seepage and well surveys is presented in Figure 2. Results of the seepage survey indicate minimal ground water exchange at all four shoreline segments (Table 3). Seepage in excess of 5 $L/m^2/day$ would generally be considered significant. Positive values represent inseepage and negative values represent outseepage. Conditions for direct measurement of seepage were poor, given the rocky nature of the substrate and underlying till soils. Ground water inputs are likely to be patchy, as with spring activity; this makes assessment with a few conveniently placed seepage meters difficult and less meaningful. the low seepage rates, however, do suggest slow ground water movement in this system.

As an alternative, Darcy's equation was applied to each of the four shoreline segments, using an area equivalent to the shoreline length multiplied by the distance out from shore to a water depth of 15 ft (where significant muck deposits begin and impede seepage). Hydraulic conductivity was estimated from soils data, while the ground water table slope was measured as the gradient between wells in each pair on routine sampling dates. Seepage rates could then be calculated for the study period.

Results of the ground water well survey (Table 4) indicate that ground water exchange in the form of inseepage was relatively low along the southwest shoreline segment, and very low along the remaining segments. On an annual basis, ground water flow will result in a net gain to the pond; more ground water will flow into the pond than out of it. However, both total inflow and outflow via ground water appear very limited in this system. Most inseepage will normally occur along the pond edge, the zone of least resistance, but this system is prone to distinct spring activity and it would not be surprising to find scattered areas of higher inseepage.

According to 1996 data (Table 5), the Stone Bridge Fire District withdrew an average of 992,154 gallons of pond water per day (Sumner 1996). Most of this water was treated and delivered to nearly 1,000 customers. Some of this water (155,425 gal/day) was used as filter backwash and was eventually discharged back into the pond. Therefore, the average net withdrawal for 1996 was 836,729 gal/day. However, the pattern varies seasonally with greatest withdrawals during summer. Maximum net withdrawal was 1,020,258 gal/day during July of 1996.

Hydrologic Loading

Estimated hydrologic loading to Stafford Pond (Table 6) is derived from a combination of direct precipitation, ground water inseepage, surface water base-flow, and surface water storm-flow. Average annual inflow was estimated at 5.5 cfs, assuming normal precipitation conditions. Direct precipitation was the largest of all inputs with a contribution of 2.5 cfs or 46% of the total water input. This is unusual for water supply lakes in New England and is directly related to the small watershed:lake area ratio. In New England, most inflow is typically generated in the watershed as runoff or ground water breakout into streams. Where the watershed is small, however, such sources are limited. This in turn limits the amount of water which can be withdrawn without adversely impacting lake water level.

Table 3. Results of the Seepage Survey Conducted at Stafford Pond (1996).

Station	Seepage Time *hours*	Volume Change *liters*	Seepage *L/m2/day*
NE1	5.0	-0.08	-1.5
NE2	5.0	0.05	1.0
NW1	4.8	-0.03	-0.6
NW2	4.8	0.04	0.8
SE1	ND	ND	ND
SE2	4.7	0.08	1.6
SW1	4.6	0.02	0.4
SW2	4.6	-0.05	-1.0

Sampling conducted in June of 1996.
ND= No Data.

Table 4. Results of the Ground Water Well Survey Conducted at Stafford Pond (1996).

Date	Flow per Lake Segment (cfs)			
	Northeast	Northwest	Southeast	Southwest
17-Apr	0.04	-0.92	0.48	1.57
14-May	0.03	0.33	-0.11	1.58
29-May	0.03	0.25	-0.06	0.63
10-Jun	0.02	0.15	-0.06	0.53
27-Jun	-0.02	0.02	-0.03	<0.50
17-Jul	-0.43	0.09	0.02	<0.50
30-Jul	-0.02	-0.07	-0.09	<0.50
8-Aug	0.03	0.02	-0.04	<0.50
22-Aug	0.00	-0.09	-0.05	<0.50
5-Sep	0.13	0.12	0.09	<0.50
28-Oct	0.09	0.54	-0.16	1.41

Estimates were based upon Q=CIA

Q= Discharge

C= Hydraulic conductivity (0.5 in/hr)

I= Slope based on well pair readings

A= Seepage area terminated at water depth of 15 ft.

Table 5. Withdrawals from the Stone Bridge Fire District Drinking Water Plant (1996).

Month	# days in month	Monthly Totals Raw Water	Monthly Totals Effluent	Raw Water Gallons/Day	Effluent Gallons/Day	Backwash Gallons/Day
Jan	31	27,256,000	*23,105,000	879,226	745,323	133,903
Feb	29	24,082,000	*20,704,000	830,414	713,931	116,483
Mar	31	23,904,000	*22,432,000	771,097	723,613	47,484
Apr	30	28,143,000	*22,760,000	938,100	758,667	179,433
May	31	28,304,000	23,707,000	913,032	764,742	148,290
Jun	30	38,250,000	29,564,000	1,275,000	985,467	289,533
Jul	31	37,804,000	31,628,000	1,219,484	1,020,258	199,226
Aug	31	34,128,000	28,327,000	1,100,903	913,774	187,129
Sep	30	30,742,000	26,009,000	1,024,733	866,967	157,767
Oct	31	31,086,000	26,615,000	1,002,774	858,548	144,226
Nov	30	28,768,000	25,582,000	958,933	852,733	106,200
Average	**30**	**30,224,273**	**27,347,429**	**992,154**	**836,729**	**155,425**

*Effluent meter out of service, readings are from bulk sales and customer meters.

Table 6. Estimated Hydrologic Loading to Stafford Pond.

Sources	cfs	ft³/yr	m³/yr	% of Total
Inputs				
Direct precipitation	2.52	79,470,720	2,250,372	46.0
Ground water inseepage	*0.5-1.5	*15,768,000 - 47,304,000	*446,502 - 1,339,507	
Best estimate	1.0	31,536,000	893,005	18.2
Surface water - base flow				
Sub-basin				
#1 - Southwest	0 &	0	0	0.0
#2 - Southeast	0 &	0	0	0.0
#3 - Northeast	0 &	0	0	0.0
#4 - Northwest	0 &	0	0	0.0
#5 - Northern tributary	0.32 #	10,091,520	285,762	5.8
#6 - Western tributary	0.39 #	12,299,040	348,272	7.1
Surface water - storm flow				
Sub-basin				
#1 - Southwest	0.13	4,099,680	116,091	2.4
#2 - Southeast	0.35	11,037,600	312,552	6.4
#3 - Northeast	0.12	3,784,320	107,161	2.2
#4 - Northwest	0.30	9,460,800	267,901	5.5
#5 - Northern tributary	0.13	4,099,680	116,091	2.4
#6 - Western tributary	0.22	6,937,920	196,461	4.0
Total	5.48	172,817,280	4,893,667	100
Outputs				
Evaporation	1.7	53,611,200	1,518,108	30.9
Ground water outseepage	*0.1-0.3	*3,153,600 - 9,460,800	*89,300 - 267,901	*2-5
Best estimate	0.2	6,307,200	178,601	3.6
Surface outflow	2.3	72,532,800	2,053,911	41.8
Net Withdrawal	1.3	40,996,800	1,160,906	23.6
Total	5.5	173,448,000	4,911,527	100

Additional calculations are provided in Appendix B
*Approximate range of values, not added into totals.
& Baseflow included as groundwater only; no stream system in basin
# Baseflow remaining after groundwater estimate partitioned among two stream systems based on measured relative flow (B5 @ 45%, B6 @ 55%)

	Years	Days
Calculated Detention Time	1.54	562
Calculated Flushing Rate	0.65/	0.002/
Calculated Response Time	0.65-1.08	237-394

Ground water inseepage accounted for 18% of all inputs, with total inflow averaging 1.0 cfs. Estimation of ground water inputs was difficult in this case and may be substantially more or less at times, but is not very large in any case. Surface water storm flows accounted for 23% of all inputs, at 1.25 cfs, with individual basin inputs ranging from 0.12 to 0.35 cfs. Significant runoff would be expected in this watershed according to geology/soils information. Surface water base-flows accounted for the remainder of all inputs with an estimated contribution of 0.7 cfs or 13%. Base flow, exclusive of ground water inputs to the pond, include dry weather flow in the tributaries. Measured tributary flows include base flow and storm flows, and appear higher than would be expected, probably due to higher than normal precipitation during 1996.

Pond outputs were derived from a combination of evaporation, ground water outseepage, surface outflow, and withdrawal (by the water treatment facility). Surface outflow accounted for the greatest single output at 2.3 cfs or 42% of the total; this value is lower than might be expected from 1996 field measurements, but is consistent with other outputs and known watershed yield relationships. Evaporation accounted for 1.7 cfs or 31% of the total, a substantial percentage for this part of the country; this is a result of the small watershed:lake area ratio. Net withdrawal from the water treatment facility accounted for 1.3 cfs or slightly less than 24% of all pond outputs. Finally, ground water outseepage accounted for 0.2 cfs or slightly less than 4% of the total.

According to morphometric features and hydrologic data, Stafford Pond has a flushing rate of 0.65 times per year, a detention time of 1.54 years (562 days), and a response time of 0.65-1.08 years (237-394 days). The flushing rate is the actual number of times in a given year that the entire water volume could be replaced by inputs. The inverse of flushing rate is the detention time, the average length of time that water remains in the pond. The response time is the amount of time required for the pond to fully respond to inputs. These values are important to the manner in which the system processes pollutant inputs, and the relative length of the detention and response times suggest that pollutants stay in the pond long enough to fully impact water quality. Alternatively, if changes in pollutant loading were made, it would take most of a year before appreciable changes in water quality became detectable.

Based on the known general seasonal pattern for inputs and outputs in southern New England (Sopper and Lull 1970), a seasonal hydrologic budget can be derived (Table 7). The inputs and outputs balance on average and during fall and winter, but not in spring and summer. Owing largely to changes in storm flow and tributary base flow on the input side and evaporation on the output side, inputs exceed outputs by 1.2 cfs during the spring and outputs exceed inputs by 1.2 cfs during summer. Conditions in wet or dry years could vary considerably, much as with long-term average and actual annual precipitation, but this pattern helps explain changing water levels in Stafford Pond. Based on the average conditions, one would expect to lose about 9,540,000 ft^3 of water over the summer, and to regain in the following spring. This equates to a water level fluctuation of approximately 0.5 ft. In a wet year (1996), there might be minimal fluctuation, while in a dry year (1995) the fluctuation could be as great as 2.0 ft (0.8 ft from withdrawal, 1.2 ft from evaporation).

Table 7. Generalized Seasonal Hydrologic Budget for Stafford Pond.

Source	Winter	Spring	Summer	Fall	Average
Inputs*					
Precipitation	2.5	2.8	2.2	2.5	2.5
Inseepage	1.3	1.3	0.6	0.8	1
Base Flow	0.7	1.4	0.0	0.7	0.7
Storm Flow	1.5	2.5	0.2	1.0	1.3
Total	6.0	8.0	3.0	5.0	5.5
Outputs*					
Evaporation	0.8	2.0	2.6	1.4	1.7
Outseepage	0.2	0.3	0.1	0.2	0.2
Overflow	3.9	3.2	0.0	2.1	2.3
Withdrawal	1.1	1.3	1.5	1.3	1.3
Total	6.0	6.8	4.2	5.0	5.5

*All values in cfs.

CHEMICAL CHARACTERISTICS

Routine Water Chemistry

Values for routine water monitoring parameters are summarized in Table 8. Detailed data tables are included in Appendix A.

Dissolved oxygen, as the name implies, is the amount of molecular oxygen dissolved in the water column. Dissolved oxygen below 5.0 mg/L is generally considered undesirable for many species of aquatic life, especially trout. Additionally, release of phosphorus from benthic sediments is often a concern under anoxic or very low oxygen (<1.0 mg/L) conditions. Tributary values ranging from 2.2-5.0 mg/L were recorded during early summer, just before both tributaries went dry (Appendix A). Dissolved oxygen profile values ranging from 1.0-5.0 mg/L were recorded in the bottom two meters of the pond, primarily during the summer months (Figures 10a-10n and Appendix A). Atmospheric inputs appear to counteract sediment oxygen demand most of the time.

The lake geometry ratio (Hondzo and Stefan 1996) for Stafford Pond was 5.2. Lakes with ratios >8 are generally well mixed and have high dissolved oxygen concentrations. Lakes with ratios <2 are generally seasonally stratified and have low dissolved oxygen concentrations near the pond bottom during stratification. Stafford Pond falls between these categories and conditions in the pond can reflect both scenarios, depending upon weather conditions. During the 1996 study year, mixing was substantial nearly all of the time. However, the hot dry weather of the summer of 1995 and other years may have allowed greater stratification and lower oxygen levels than observed in 1996.

The temperature regime of an aquatic ecosystem is important in determining community structure. In general, values exceeding 20°C are undesirable for cold water species including trout. As expected, tributary values were low during the winter months and climbed to over 20°C during early summer, just before both tributaries went dry (Appendix A). In-pond temperature profiles revealed seasonal stratification and values exceeding 20°C at all water depths during July, August, and early September (Figures 10a-10n and Appendix A).

The pH is a measure of acidity. Minimum and maximum values were 4.3 and 9.5 SU, respectively (Table 8), which is a rather wide range. Average pH per sample site ranged from 5.6 to 7.9 SU, also a wide range. The likely range of pH values for unimpacted aquatic systems in this region is 5.5-7.5 SU. Values of 5.5 SU or less were recorded at SP3, SP5a, and SP6. A pH of 4.3 SU was recorded at SP3 in February; subsequent readings at this site were substantially higher. The reason for this low reading is not known. Low values at SP5a and SP6 are likely a result of the close proximity of these sites to up-gradient wetlands. Wetland waters are typically lower in pH due to normal wetland functions including decomposition. Values >7.5 SU were recorded at SP1a, SP1b, and SP3. Elevated pH at these sites is likely a result of increased biological activity, specifically algal blooms which remove CO_2 and raise the pH.

Table 8. Results of Routine Water Quality Monitoring at Stafford Pond (1996).

Parameter	Units	Sampling Locations SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP11	SP12
pH															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10		1	1
mean	SU	7.3	7.9	6.8	6.6	6.4	6.7	7.3	6.6	5.6	6.4	5.6		6.5	6.5
minimum	SU	6.4	6.7	6.6	6.5	6.0	6.3	4.3	6.2	5.5	6.3	5.4		6.5	6.5
maximum	SU	9.5	9.0	7.0	6.7	7.0	7.0	9.4	7.0	5.7	6.5	5.8		6.5	6.5
Total Alkalinity															
number of samples (n)		14				14	2	5	14	2	10	10		1	1
mean	mg/L	7				9	5	8	8	7	51	2		9	6
minimum	mg/L	5				6	3	1	5	5	20	<1		9	6
maximum	mg/L	10				14	7	11	11	9	66	3		9	6
Total Hardness															
number of samples (n)		14				14	2	5	14	2	10	5		1	1
mean	mg/L	19				20	18	18	19	27	78	15		18	18
minimum	mg/L	16				17	16	16	18	24	44	11		18	18
maximum	mg/L	21				23	19	20	20	30	106	28		18	18
Conductivity															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10		1	1
mean	umhos/cm	80	75	78	75	80	65	81	80	95	271	80		100	100
minimum	umhos/cm	50	70	75	70	65	60	65	65	80	125	45		100	100
maximum	umhos/cm	100	80	80	80	100	70	100	110	110	360	150		100	100
Turbidity															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10		1	1
mean	NTU	4.2	15.5	3.6	2.6	2.1	1.0	5.6	2.8	1.4	5.8	0.8		0.6	0.4
minimum	NTU	0.8	1.5	1.5	2.2	0.6	0.6	0.7	0.7	1.3	1.3	0.4		0.6	0.4
maximum	NTU	21.0	29.5	5.7	3.0	6.8	1.3	19.5	6.2	1.4	18.3	1.7		0.6	0.4
Secchi Transparency															
number of samples (n)		13													
mean	m	1.5													
minimum	m	0.5													
maximum	m	2.9													
Chlorophyll a															
number of samples (n)															
mean	ug/L	22							16						
minimum	ug/L	3							2						
maximum	ug/L	118							69						

Table 8. Continued.

Parameter	Units	Sampling Locations SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP11	SP12
Nitrite+Nitrate Nitrogen															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10	10	1	1
mean	mg/L	0.05	0.05	0.03	0.04	0.05	0.05	0.04	0.04	0.04	0.99	0.04	0.08	0.05	0.06
minimum	mg/L	<0.03	0.03	0.03	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	0.11	<0.03	<0.03	0.05	0.06
maximum	mg/L	0.16	0.06	0.03	0.04	0.17	0.08	0.10	0.09	0.06	2.50	0.16	0.22	0.05	0.06
Ammonium Nitrogen															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10	10	1	1
mean	mg/L	0.13	0.15	0.23	0.23	0.19	0.14	0.14	0.12	0.13	1.23	0.14	0.09	<0.05	0.10
minimum	mg/L	<0.05	0.08	0.14	0.15	<0.05	0.09	<0.05	<0.05	0.12	0.31	0.06	<0.05	<0.05	0.10
maximum	mg/L	0.44	0.21	0.31	0.30	0.48	0.18	0.22	0.28	0.13	4.60	0.24	0.15	<0.05	0.10
Inorganic Nitrogen															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10	10	1	1
mean	mg/L	0.17	0.19	0.26	0.27	0.24	0.19	0.18	0.16	0.17	2.22	0.19	0.17	0.08	0.16
minimum	mg/L	<0.04	0.11	0.17	0.19	0.04	0.17	0.04	0.04	0.14	0.72	0.11	0.08	0.08	0.16
maximum	mg/L	0.48	0.27	0.34	0.34	0.50	0.20	0.27	0.30	0.19	6.04	0.30	0.35	0.08	0.16
Total Kjeldahl Nitrogen															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10	10	1	1
mean	mg/L	0.9	1.1	1.0	0.9	1.0	0.9	1.0	0.9	1.0	2.4	0.7	0.7	0.3	0.4
minimum	mg/L	0.5	0.6	0.7	0.7	0.5	0.6	0.4	0.4	0.8	0.5	<0.1	0.1	0.3	0.4
maximum	mg/L	1.5	1.6	1.2	1.0	1.6	1.1	1.7	1.3	1.1	5.8	1.5	1.0	0.3	0.4
Total Nitrogen															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10	10	1	1
mean	mg/L	0.9	1.1	1.0	0.9	1.0	0.9	1.0	0.9	1.0	3.4	0.8	0.7	0.4	0.5
minimum	mg/L	0.5	0.6	0.7	0.7	0.6	0.7	0.4	0.5	0.9	1.3	0.1	0.1	0.4	0.5
maximum	mg/L	1.5	1.7	1.2	1.0	1.6	1.1	1.7	1.4	1.1	7.2	1.5	1.1	0.4	0.5
Total Phosphorus															
number of samples (n)		14	2	2	2	14	2	5	14	2	10	10	10	1	1
mean	mg/L	0.036	0.045	0.044	0.039	0.053	0.036	0.054	0.039	0.089	0.895	0.048	0.033	0.018	0.010
minimum	mg/L	0.019	0.042	0.039	0.031	0.027	0.030	0.032	0.022	0.040	0.290	0.014	0.020	0.018	0.010
maximum	mg/L	0.053	0.047	0.049	0.046	0.097	0.042	0.130	0.079	0.137	2.279	0.110	0.049	0.018	0.010
Dissolved Phosphorus															
number of samples (n)		12	1	1	1	12	2	4	12	2	9	9	9	1	1
mean	mg/L	0.023	0.037	0.038	0.017	0.033	0.023	0.038	0.027	0.065	0.618	0.038	0.024	0.005	0.005
minimum	mg/L	0.009	0.037	0.038	0.017	0.017	0.015	0.024	0.010	0.020	0.010	0.014	0.010	0.005	0.005
maximum	mg/L	0.046	0.037	0.038	0.017	0.081	0.030	0.055	0.045	0.109	1.900	0.075	0.044	0.005	0.005

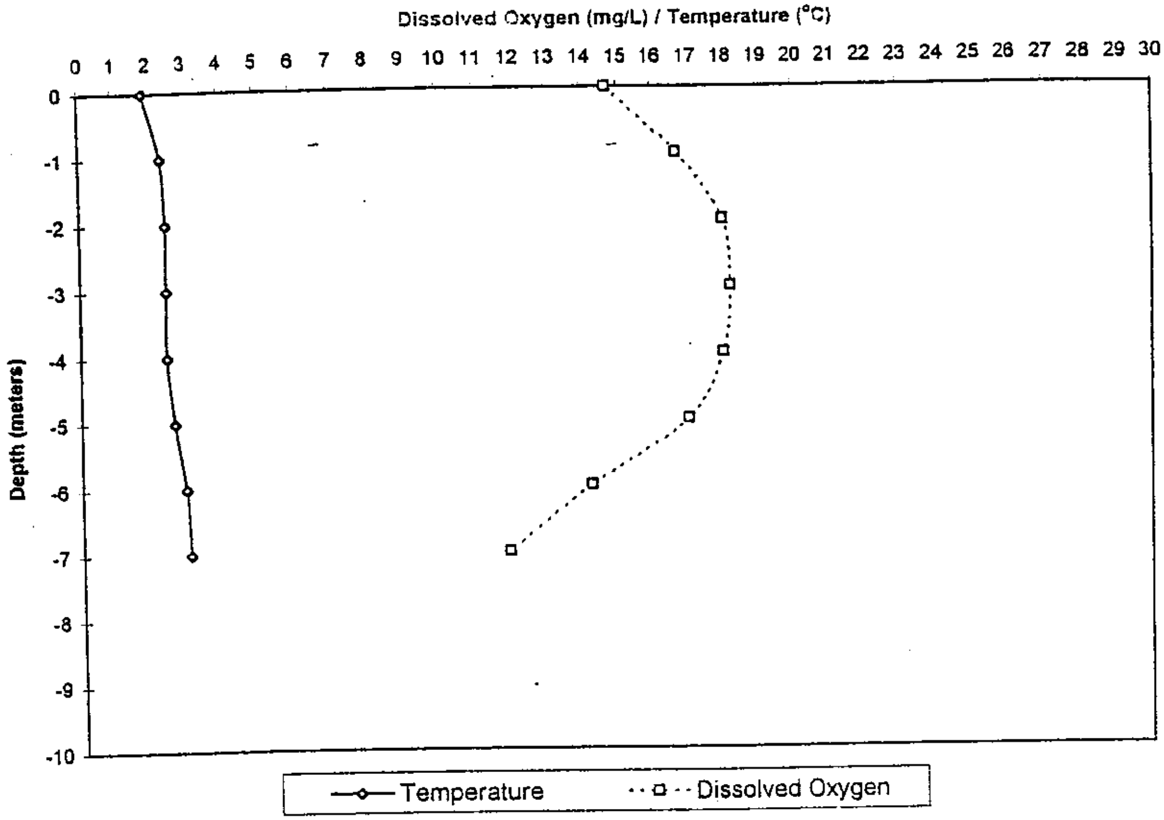


Figure 10a. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on February 21, 1996.

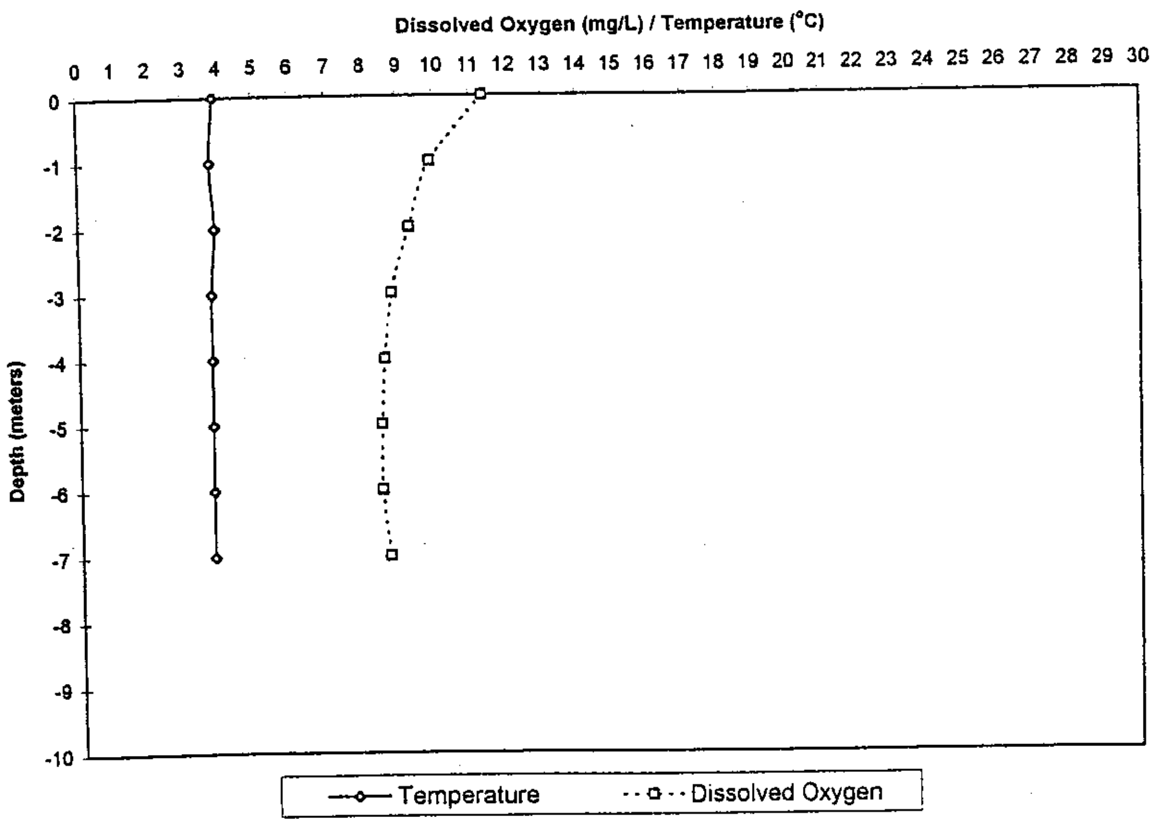


Figure 10b. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on March 19, 1996.

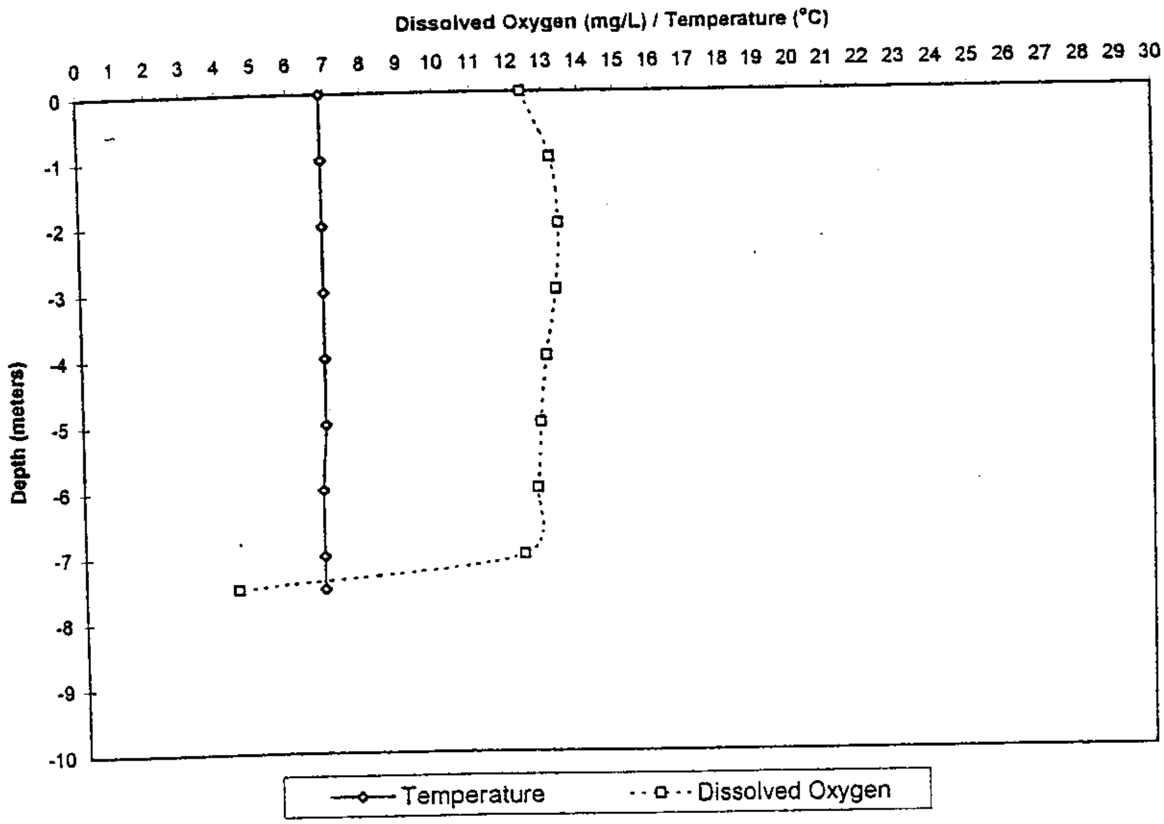


Figure 10c. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on April 17, 1996.

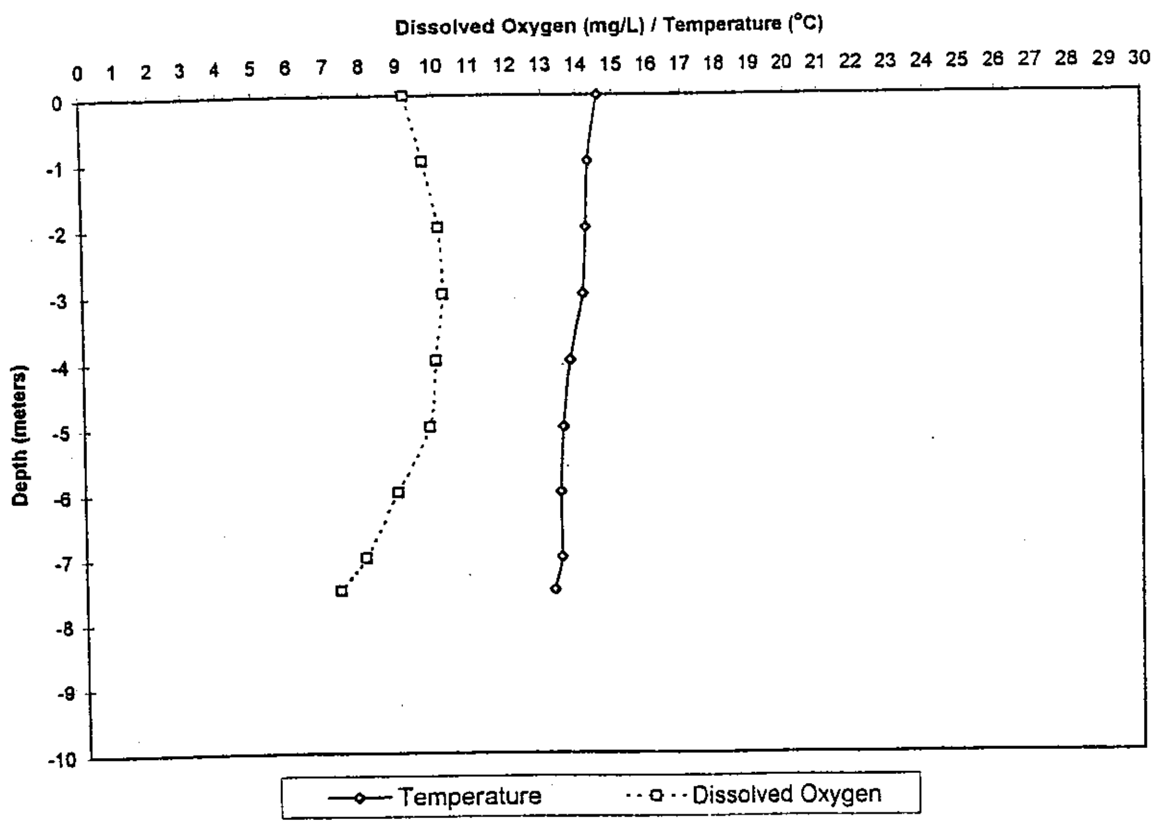


Figure 10d. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on May 14, 1996.

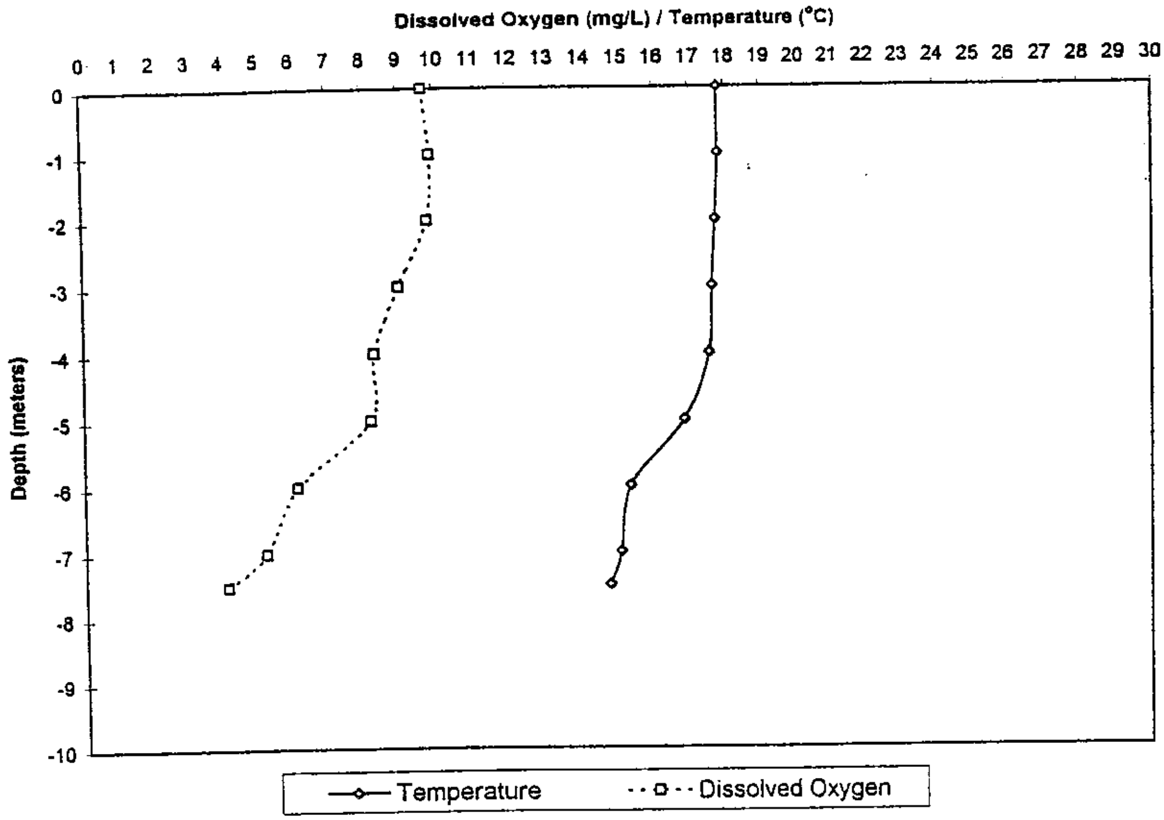


Figure 10e. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on May 29, 1996.

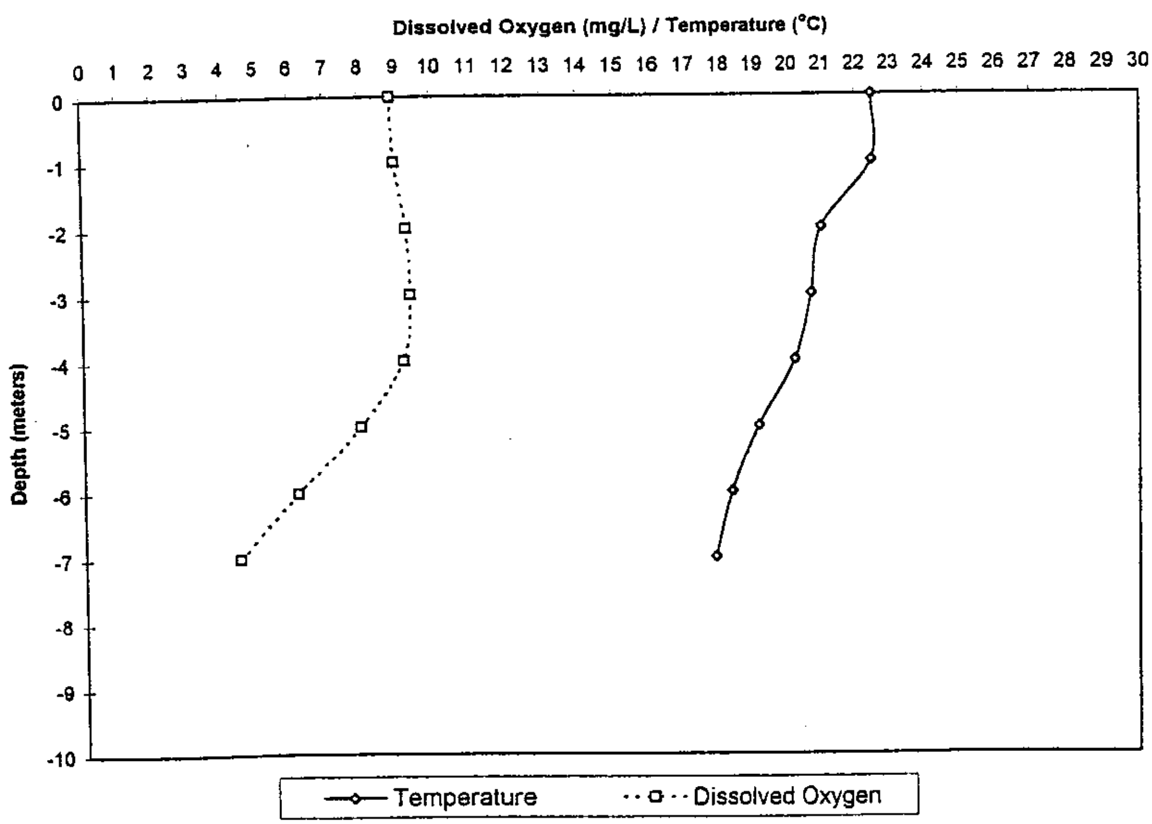


Figure 10f. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on June 10, 1996.

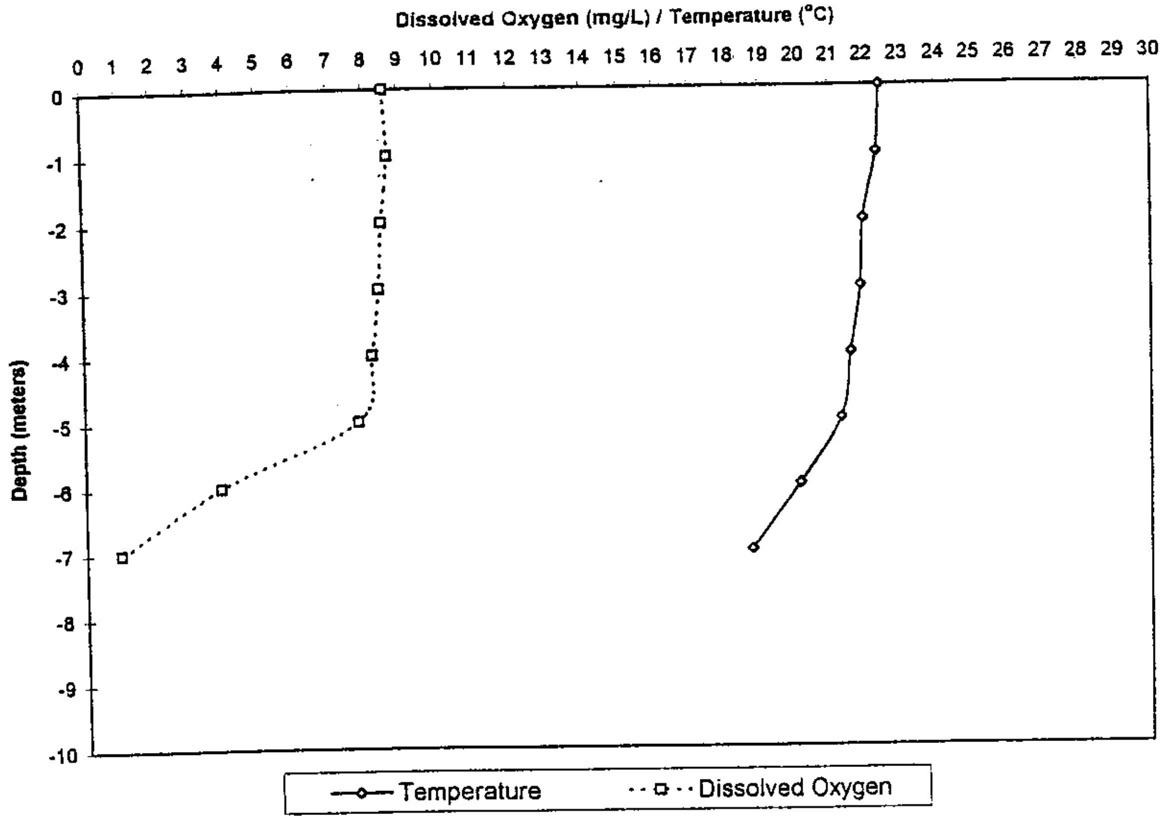


Figure 10g. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on June 27, 1996.

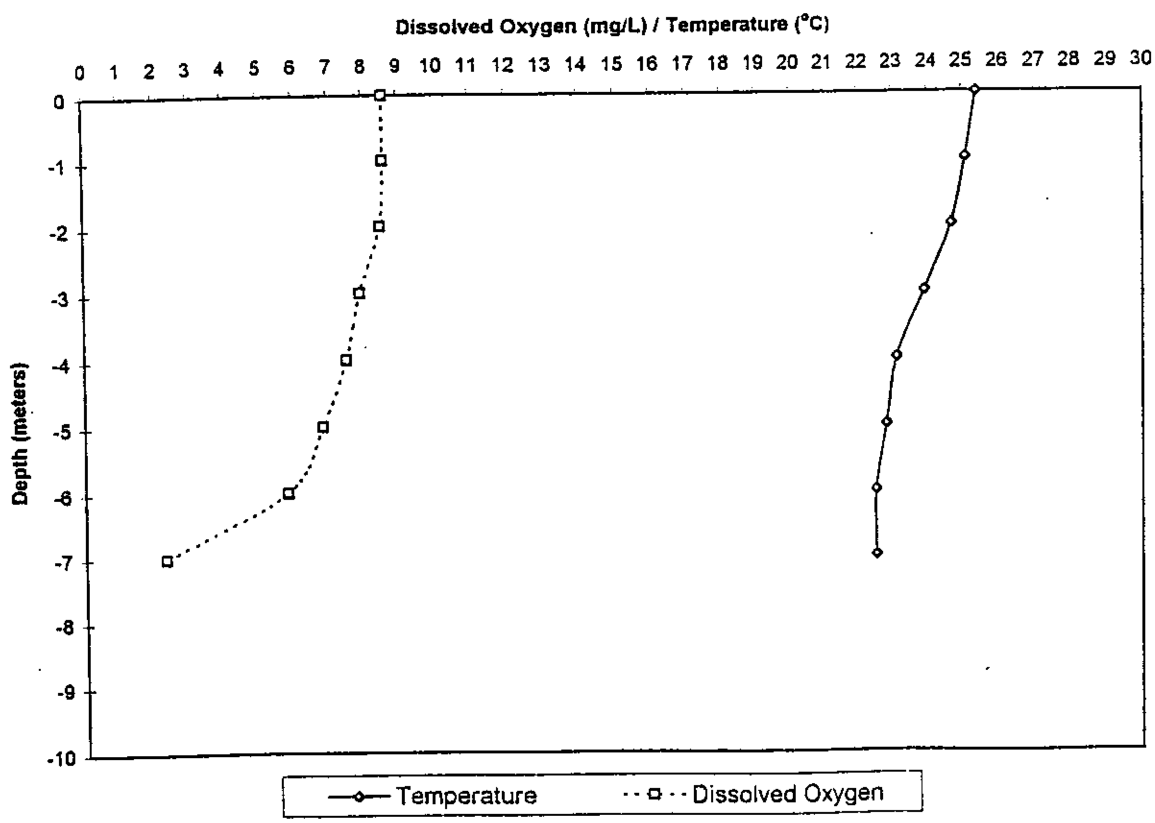


Figure 10h. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on July 17, 1996.

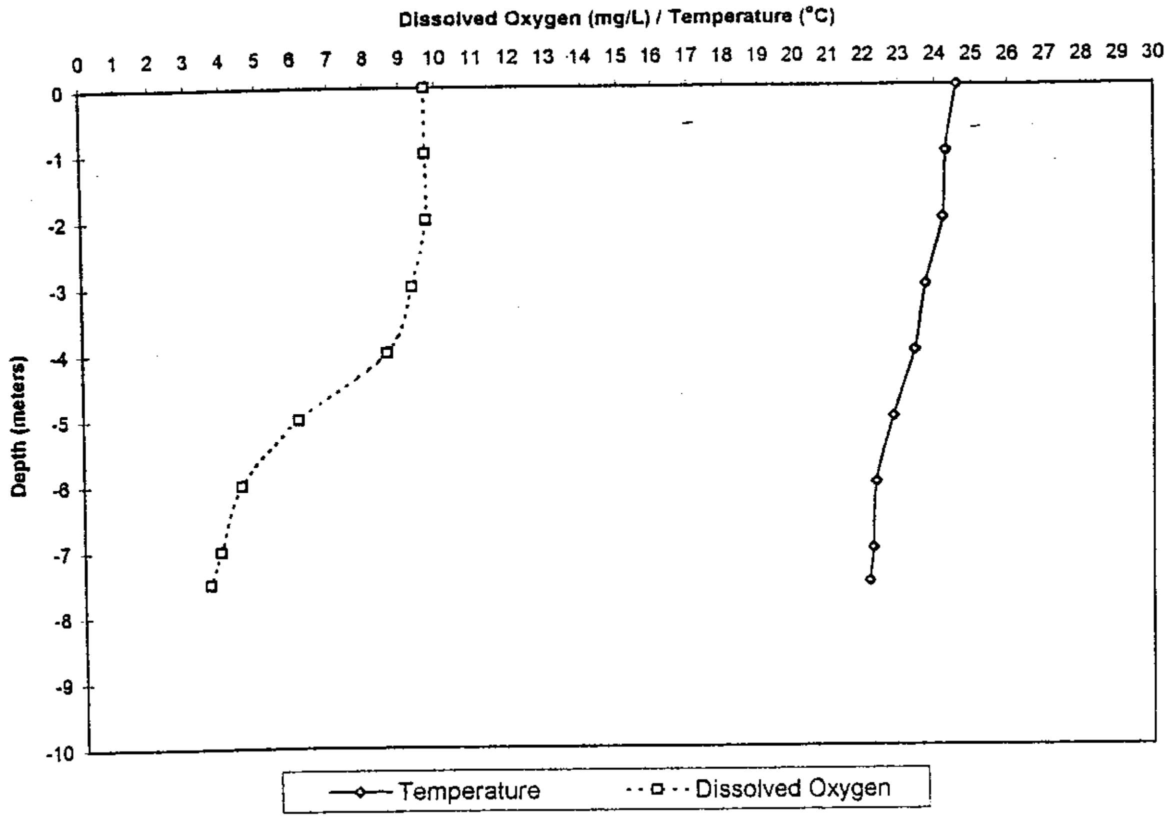


Figure 10i. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on July 30, 1996.

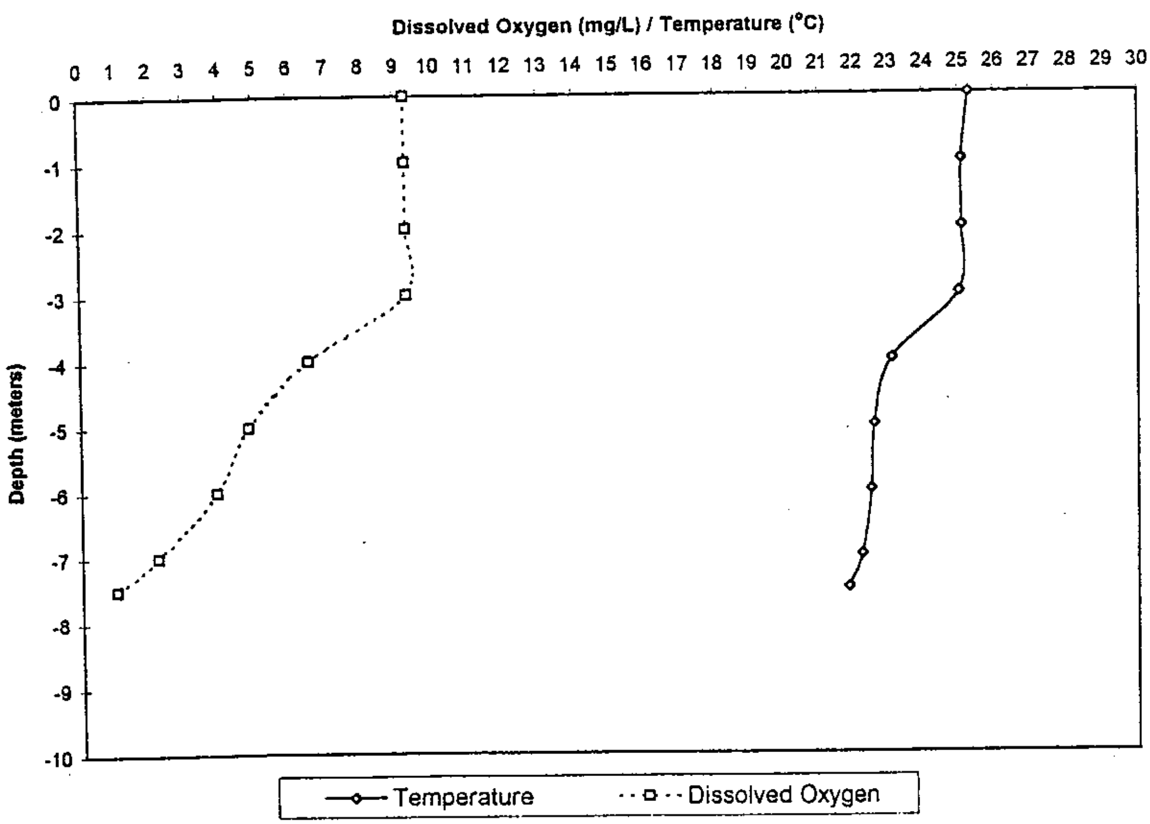


Figure 10j. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on August 8, 1996.

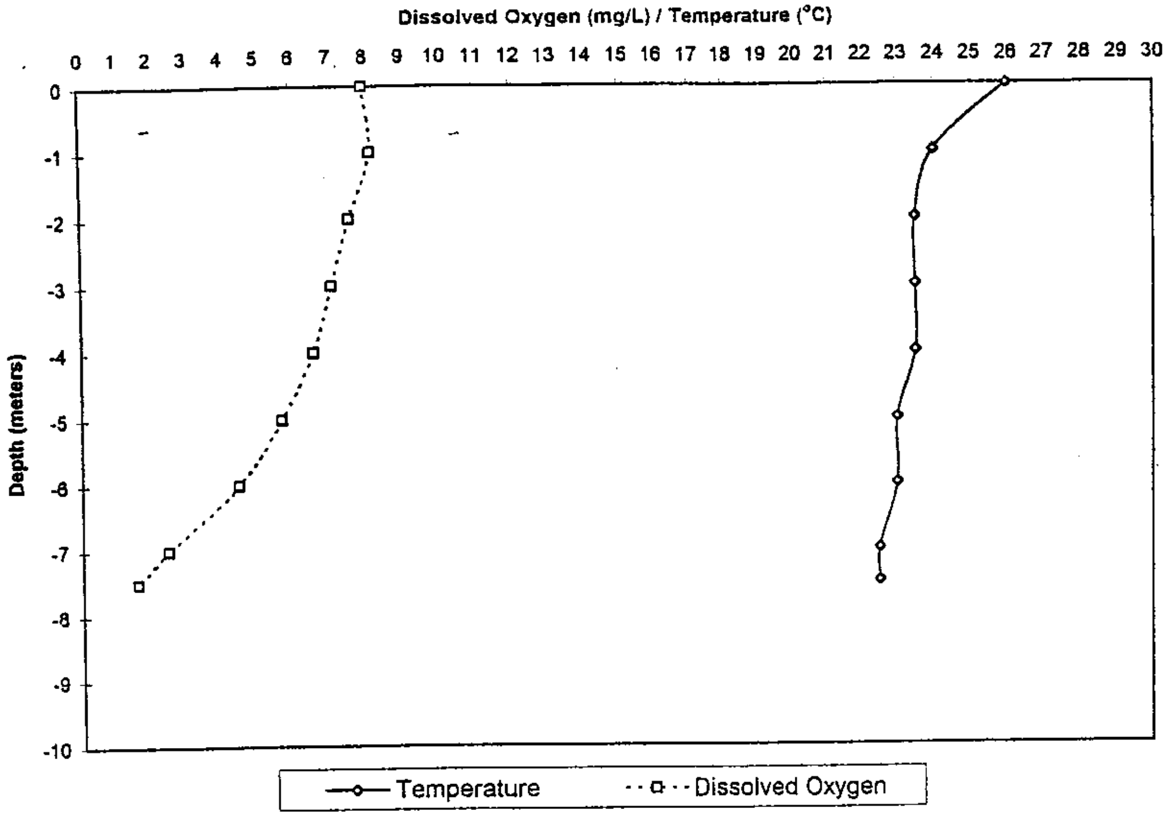


Figure 10k. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on August 22, 1996.

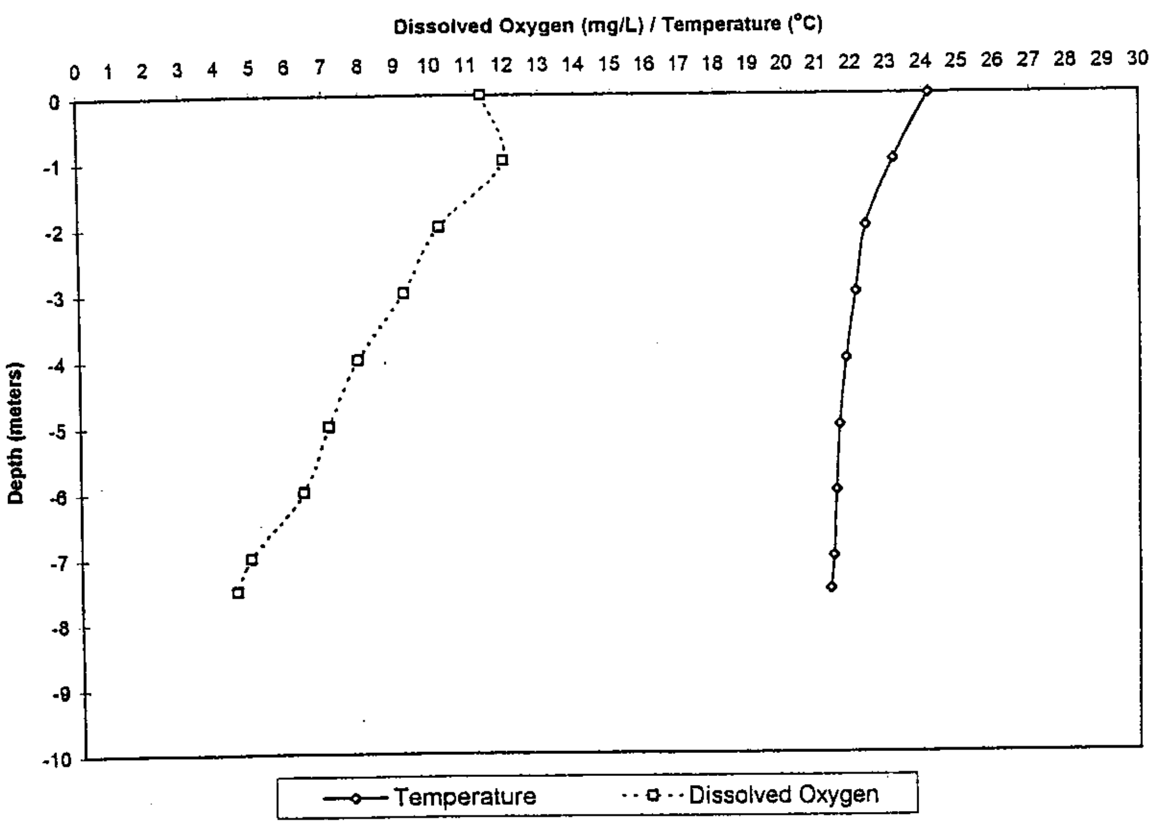


Figure 10l. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on September 5, 1996.

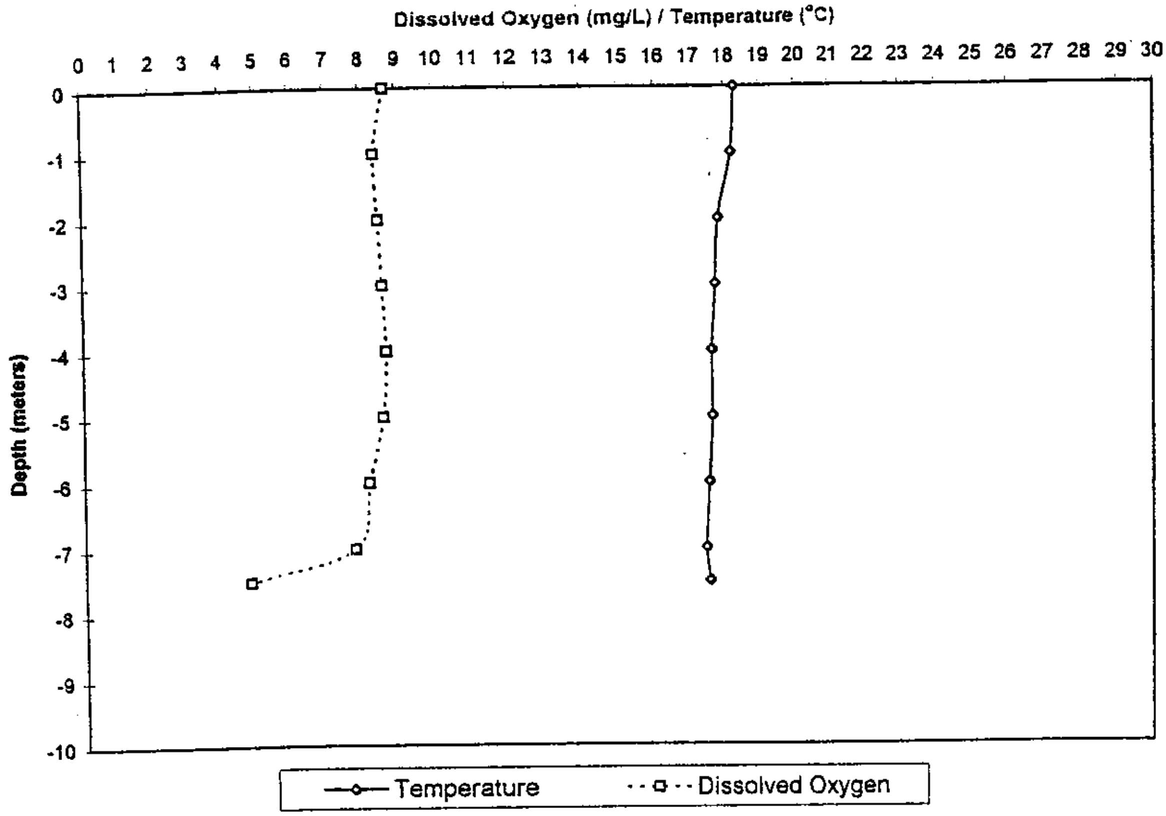


Figure 10m. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on September 30, 1996.

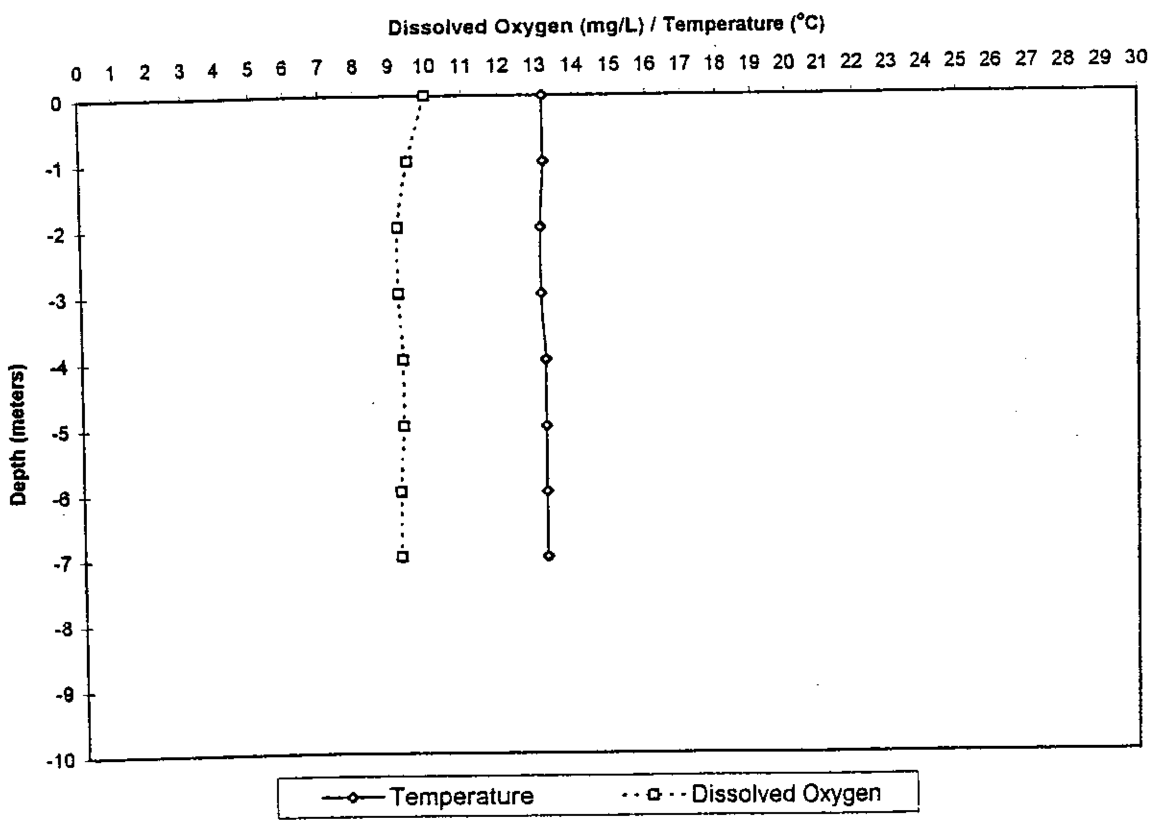


Figure 10n. Dissolved Oxygen/Temperature Profiles Recorded at Stafford Pond (SP1) on October 29, 1996.

Total alkalinity is a measure of buffering capacity or the ability of water to neutralize acids. Waters with a total alkalinity <20 mg/L are generally susceptible to acid precipitation. Sampling results indicate that values were significantly lower than 20 mg/L at all sites except SP5b (Table 8). Higher values at SP5b may be a result of inputs from a dairy farm located in this area of the watershed.

Total hardness is a measure of the amount of calcium and magnesium salts dissolved in the water column. Values <60 mg/L are generally considered low. Results indicate that total hardness was low at all sample sites except SP5b (Table 8). Higher values at SP5b may be a result of inputs from a dairy farm located in this area of the watershed.

Conductivity is the indirect measure of dissolved solids in the water column. Average conductivity was low (<100 umhos/cm) at all sites except SP5b, where an average of 271 umhos/cm was considered high (Table 8). Elevated values at SP5b may be a result of inputs from a dairy farm located in this area of the watershed.

Turbidity is a measure of the amount of particulate matter in the water column. Particulate matter may include everything from inorganic particles to plankton. Elevated values (>5 NTU) were documented at a number of sites on several dates (Table 8). Elevated in-pond values were most often a direct result of significant algal blooms. Elevated tributary values were most often a result of increased flows which carried higher loads of particulate matter from the watershed.

Secchi disk transparency is a measure of water clarity and is also a good indicator of trophic state. This value is obtained by lowering a circular disk in the water column until it is no longer visible. The most critical time of year to evaluate Secchi depth is during summer, when algal blooms are often a problem. Measurements less than 2 meters are generally considered indicative of eutrophic conditions. Values recorded in Stafford Pond ranged from 0.5 to 2.9 m, with lower values predominating during late summer and early fall, when algal blooms were common (Table 8). The average value for Stafford Pond was 1.5 m.

Chlorophyll is a green plant pigment essential to photosynthesis. Measuring the concentration of chlorophyll a is a useful indicator of a waterbody's trophic state or degree of nutrient enrichment. Values in Stafford Pond ranged from 2 to 118 ug/L, with a mean of 22 ug/L (Table 8). Higher concentrations predominated during late summer and early fall, when algal blooms were common. In general, values exceeding 10 ug/L are characteristic of eutrophic conditions. Average concentrations exceeded this threshold at both sampling locations, and summer values were consistently above this threshold.

Nitrogen and phosphorus are essential plant nutrients. Excessive concentrations can often fuel undesirable growths of algae, and accumulations in the sediment can promote the growth of rooted aquatic plants. Values of nitrite+nitrate nitrogen were low (<0.5 mg/L) at all sites except SP5b, where the average was 0.99 mg/L (Table 8). Values of ammonium nitrogen were low (<0.5 mg/L) at all sites except SP5b, where the average was 1.23 mg/L (Table 8). Inorganic nitrogen, or the combined concentration of ammonium+nitrite+nitrate was also low at all sites except SP5b, where the average was 2.22 mg/L (Table 8). Water column values exceeding 1.0

mg/L are undesirable. No distinct trends were observed with depth. Average TKN, which includes ammonium nitrogen and organically bound nitrogen was generally low (<1.0 mg/L) at all sites except SP1b and SP5b, where values were 1.1 mg/L and 2.4 mg/L, respectively (Table 8). Total nitrogen, or the combined concentration of TKN+nitrite+nitrate was low at all sites except SP5b, where the average was 3.4 mg/L (Table 8). Water column values exceeding 2.0 mg/L are undesirable. No distinct trends were observed with depth.

Concentrations of total phosphorus were generally elevated (>0.025 mg/L) and indicative of eutrophic conditions at all routine sampling locations except SP11 and SP12, the filter backwash discharges (Table 8). Phosphorus concentrations were low at the latter two sites, as samples at both sites consisted of treated water from the water treatment facility, but these were only sampled once each. Average phosphorus concentrations were high (>0.05 mg/L) at SP1e, SP3, and SP5a. Average phosphorus concentrations were exceedingly high (>0.1 mg/L) at SP5b.

The dissolved phosphorus fraction was typically greater than the particulate phosphorus fraction at most sampling locations, suggesting excess available phosphorus (Table 8). Comparison between in-pond surface (SP1a) and bottom (SP1e) samples revealed that total phosphorus was generally higher on the bottom, indicating some degree of internal recycling. The total nitrogen:total phosphorus ratio in Stafford Pond was typically greater than 15:1, indicating that phosphorus is most likely the limiting nutrient to plant growth in this system. However, factors other than nutrients (e.g. light) are likely to limit algal growth during summer in Stafford Pond. Additionally, N:P ratios may slip below 10:1 during mid- to late summer, when inputs are low and internal recycling of phosphorus is maximal.

Supplemental Water Chemistry

Values for supplemental water monitoring parameters are summarized in Table 9. Detailed data tables are included in Appendix A.

Cadmium is a toxic metal used in galvanizing, in nickel-cadmium batteries, and as a pigment (Brady 1990). Cadmium was not detected in water samples at Stafford Pond.

Lead is a toxic metal commonly found in aquatic ecosystems. Anthropogenic sources of lead include the combustion of oil, gasoline, and coal (Brady 1990). Lead was detected at sampling location SP1a. The lead concentration at this site was below the Maximum Contaminant Level for drinking water (USEPA 1996), but slightly above the chronic toxicity threshold for aquatic life (RIDEM 1988). Acute and chronic toxicity thresholds were determined for Stafford Pond using a total hardness value of 25 mg/L.

Mercury is a toxic metal used in metallurgy, thermometers, pesticides, and as a catalyst for synthetic polymers (Brady 1990). A single water sample was collected at SP1a during the month of October and was analyzed for total mercury. Mercury was not detected (<0.00255 ug/L) in this sample.

Table 9. Results of Supplemental Water Quality Monitoring at Stafford Pond (1996).

		Sampling Locations				
Parameter	**Units**	**SP1a**		**SP1e**	**SP3**	**SP4**
Cadmium (total)						
number of samples (n)		2	1	2	1	2
mean	mg/L	<0.001	<0.00013	<0.001	<0.001	<0.001
minimum	mg/L	<0.001	<0.00013	<0.001	<0.001	<0.001
maximum	mg/L	<0.001	<0.00013	<0.001	<0.001	<0.001
Cadmium (dissolved)						
number of samples (n)		2		2	1	2
mean	mg/L	<0.001		<0.001	<0.001	<0.001
minimum	mg/L	<0.001		<0.001	<0.001	<0.001
maximum	mg/L	<0.001		<0.001	<0.001	<0.001
Lead (total)						
number of samples (n)		2	1	2	1	2
mean	mg/L	<0.005	0.00079	<0.005	<0.005	<0.005
minimum	mg/L	<0.005	0.00079	<0.005	<0.005	<0.005
maximum	mg/L	<0.005	0.00079	<0.005	<0.005	<0.005
Lead (dissolved)						
number of samples (n)		2		2	1	2
mean	mg/L	<0.005		<0.005	<0.005	<0.005
minimum	mg/L	<0.005		<0.005	<0.005	<0.005
maximum	mg/L	<0.005		<0.005	<0.005	<0.005
Mercury (total)						
number of samples (n)			1			
mean	ug/L		<0.00255			
minimum	ug/L		<0.00255			
maximum	ug/L		<0.00255			
Copper (total)						
number of samples (n)		2		2	1	2
mean	mg/L	0.02		0.02	0.02	0.03
minimum	mg/L	0.01		0.01	0.02	0.02
maximum	mg/L	0.03		0.03	0.02	0.03
Copper (dissolved)						
number of samples (n)		2		2	1	2
mean	mg/L	0.02		0.02	0.01	0.02
minimum	mg/L	0.01		0.01	0.01	0.02
maximum	mg/L	0.02		0.02	0.01	0.02
Aluminum (total)						
number of samples (n)		2		2	1	2
mean	mg/L	0.02		<0.02	0.14	0.03
minimum	mg/L	<0.02		<0.02	0.14	<0.02
maximum	mg/L	0.03		<0.02	0.14	0.05
Aluminum (dissolved)						
number of samples (n)		2		2	1	2
mean	mg/L	0.02		<0.02	0.02	0.03
minimum	mg/L	<0.02		<0.02	0.02	<0.02
maximum	mg/L	0.03		<0.02	0.02	0.04

Table 9. Continued.

Parameter	Units	Sampling Locations SP1a	SP1e	SP3	SP4
Calcium (total)					
number of samples (n)		2	2	1	2
mean	mg/L	4.4	4.4	4.1	4.6
minimum	mg/L	4.3	4.3	4.1	4.6
maximum	mg/L	4.4	4.4	4.1	4.6
Magnesium (total)					
number of samples (n)		2	2	1	2
mean	mg/L	1.5	1.5	1.4	1.6
minimum	mg/L	1.5	1.5	1.4	1.6
maximum	mg/L	1.5	1.5	1.4	1.6
Sodium (total)					
number of samples (n)		2	2	1	2
mean	mg/L	9.2	9.2	9.4	9.6
minimum	mg/L	9.1	8.9	9.4	9.5
maximum	mg/L	9.2	9.4	9.4	9.7
Chloride (total)					
number of samples (n)		2	2	1	2
mean	mg/L	21	21	21	22
minimum	mg/L	20	20	21	21
maximum	mg/L	22	21	21	22
Iron (dissolved)					
number of samples (n)		2	2	1	2
mean	mg/L	0.07	0.09	0.04	0.05
minimum	mg/L	0.06	0.08	0.04	0.05
maximum	mg/L	0.07	0.10	0.04	0.05
Manganese (dissolved)					
number of samples (n)		2	2	1	2
mean	mg/L	0.01	0.09	0.01	0.01
minimum	mg/L	0.01	0.08	0.01	0.01
maximum	mg/L	0.01	0.10	0.01	0.01
TPH					
number of samples (n)		2	2	2	2
mean	mg/L	1.7	1.5	<0.5	1.5
minimum	mg/L	<0.5	<0.5	<0.5	<0.5
maximum	mg/L	3.2	2.7	<0.5	2.7
4,4'-DDT					
number of samples (n)		2	2	1	2
mean	ug/L	<0.05	<0.05	<0.05	<0.05
minimum	ug/L	<0.05	<0.05	<0.05	<0.05
maximum	ug/L	<0.05	<0.05	<0.05	<0.05

Table 9. Continued.

Parameter	Units	Sampling Locations SP1a	SP1e	SP3	SP4
PCB:*					
number of samples (n)		2	2	1	2
Aroclor 1016	ug/L	<0.5	<0.5	<0.5	<0.5
Aroclor 1221	ug/L	<1.0	<1.0	<0.5	<1.0
Aroclor 1232	ug/L	<0.5	<0.5	<0.5	<0.5
Aroclor 1242	ug/L	<0.5	<0.5	<0.5	<0.5
Aroclor 1248	ug/L	<0.5	<0.5	<0.5	<0.5
Aroclor 1254	ug/L	<0.5	<0.5	<0.5	<0.5
Aroclor 1260	ug/L	<0.5	<0.5	<0.5	<0.5
PAH:*					
number of samples (n)		2	2	1	2
Acenaphthene	ug/L	<1	<1	<1	<1
Acenaphthylene	ug/L	<1	<1	<1	<1
Anthracene	ug/L	<1	<1	<1	<1
Benzo(a)anthracene	ug/L	<1	<1	<1	<1
Benzo(b)fluoranthene	ug/L	<1	<1	<1	<1
Benzo(k)fluoranthene	ug/L	<1	<1	<1	<1
Benzo(ghi)perylene	ug/L	<1	<1	<1	<1
Benzo(a)pyrene	ug/L	<1	<1	<1	<1
Chrysene	ug/L	<1	<1	<1	<1
Dibenzo(a,h)anthracene	ug/L	<1	<1	<1	<1
Fluoranthene	ug/L	<1	<1	<1	<1
Fluorene	ug/L	<1	<1	<1	<1
Indeno(1,2,3-cd)pyrene	ug/L	<1	<1	<1	<1
2-Methylnaphthalene	ug/L	<1	<1	<1	<1
Naphthalene	ug/L	<1	<1	<1	<1
Phenanthrene	ug/L	<1	<1	<1	<1
Pyrene	ug/L	<1	<1	<1	<1

*Mean, minimum, and maximum values were identical.

Copper is categorized as a micro-nutrient essential to plant growth and is generally considered relatively low in toxicity compared to other heavy metals. Common anthropogenic sources of copper include mine tailings, fly ash, and fertilizers (Brady 1990). In recent years, copper sulfate has been used as an algicide in Stafford Pond. In lakes where copper sulfate has been used to control algae, it often accumulates as copper carbonate in benthic sediments. Furthermore, as is true for other metals, it may re-enter the water column through internal recycling (Cole 1983). Concentrations in Stafford Pond were below the MCL for drinking water (USEPA 1996), but were above acute and chronic toxicity thresholds for aquatic life (RIDEM 1988). Additionally, copper concentrations in a single precipitation sample were as high as the in-pond values.

Aluminum is a common element in the crust of the earth and naturally enters the aquatic environment through weathering of rock. It has a wide range of metallurgical uses, but has also been used extensively in a variety of water treatment applications, primarily owing to its coagulant properties. Aluminum has been linked to the toxicity of both plants and animals, including humans, but there is considerable controversy over the form and quantity of aluminum necessary to cause a toxic effect. Aluminum concentrations were normal at all sampling locations according to our experience in New England.

Calcium and magnesium are macro-nutrients essential to plant growth. In the aquatic environment, concentrations of these ions are responsible for water hardness, the quality of water that prevents soap from dissolving. Concentrations of total calcium and magnesium were low at all in-pond sampling locations. Sodium and chloride are often indicators of contamination from sewage and/or road salt. In-pond concentrations were moderate and did not indicate significant contamination.

Iron and manganese are micro-nutrients essential to plant growth. In the aquatic environment, dissolved fractions of these elements play an important role in phosphorus cycling. Both elements are known to complex with phosphorus, the end product being a compound that is highly insoluble under oxygenated conditions and moderate pH. Concentrations of both metals were considered relatively low at all in-pond sampling locations according to our experience in New England. Peak values for both metals occurred near the pond bottom (SP1e). This is likely a result of hypoxia at the sediment-water interface and the associated reduction and solubilization of selected metal ions in benthic sediments.

Monitoring of selected organic compounds in water from Stafford Pond indicated relatively low levels. In-pond concentrations of total petroleum hydrocarbons (TPH) ranged from <0.5 to 3.2 mg/L. Concentrations above 1 mg/L are sometimes cause for concern, but many natural compounds can register as TPH in typical laboratory tests. Polynuclear aromatic hydrocarbons (PAH) provide a better indication of anthropogenic hydrocarbon inputs. PAH, along with DDT and PCB's, were not detected.

Storm Water Chemistry

Values for storm water monitoring parameters are summarized in Table 10. Detailed data tables are included in Appendix A.

Average pH recorded during wet weather ranged from 5.1 to 6.5 SU. The lowest pH values were recorded at SP6 (western tributary) and SP10 (precipitation). Lower values at these sites were expected as SP6 was located just down-gradient of a wetland and SP10 was a direct precipitation sample; both wetland waters and normal precipitation are generally slightly acidic. As expected, the remaining sample sites had slightly higher values.

Conductivity values recorded during wet weather ranged from 5 to 23,000 umhos/cm, although values >310 umhos/cm were recorded only at SP9. Average concentrations were low at SP6 and SP10, moderate at SP5b and SP8, and exceedingly high at SP9.

Wet weather turbidity values ranged from <1 to 39 NTU. Values were low at SP6 and SP10, and elevated (>5 NTU) at the remaining sites. Low values were expected at SP10 as this was a direct precipitation sample. The two highest values were recorded at SP5b.

Average wet weather concentrations of nitrite+nitrate nitrogen were low (<0.5 mg/L) at SP6 and SP10, moderate at SP5b, and high (>1.0 mg/L) at SP8 and SP9. Values of ammonium nitrogen were low (<0.5 mg/L) at all sites except SP5b, where the average was 2.46 mg/L. Inorganic nitrogen, or the combined concentration of nitrite+nitrate+ammonium was low at SP6 and SP10, and high at the remaining sites. Water column values exceeding 1.0 mg/L are undesirable. Average TKN was low at SP10 (<1.0 mg/L), and ranged from moderate to high at the remaining sites. Total nitrogen, or the combined concentration of nitrite+nitrate+TKN was low at SP6 and SP10, and high at the remaining sites. Values exceeding 2.0 mg/L are undesirable.

Average wet weather concentrations of total phosphorus were high (>0.05 mg/L) at all sites except SP10. The highest concentrations were recorded at SP5b. The dissolved phosphorus fraction was typically greater than the particulate phosphorus fraction at most storm water sampling locations.

Cadmium was not detected in storm water entering Stafford Pond. Lead was non-detectable at all sites except SP9, where a total concentration of 0.03 mg/L was documented. This concentration was greater than the MCL for drinking water (USEPA 1996) and the acute and chronic toxicity thresholds for aquatic life (RIDEM 1988). Concentrations of copper were below the MCL for drinking water (USEPA 1996) at all storm water sampling locations. However, levels of copper did exceed acute and chronic toxicity thresholds for aquatic life (RIDEM 1988).

Storm water values for aluminum were generally greater than dry weather in-pond values, but were not considered high for storm water. Storm water concentrations of total calcium and magnesium were generally low at all sites except SP5b and SP8, where concentrations were higher than expected background levels, but still not high by regional comparison.

Table 10. Results of Storm Water Monitoring at Stafford Pond (1996).

Parameter	Units	Sampling Locations SP5b	SP6	SP8	SP9	SP10
pH						
number of samples (n)		3	3	2	3	3
mean	SU	6.5	5.2	6.1	5.7	5.1
minimum	SU	6.3	4.5	6.0	4.3	4.5
maximum	SU	6.8	5.5	6.2	6.4	5.6
Conductivity						
number of samples (n)		3	3	2	3	3
mean	umhos/cm	280	77	150	7800	22
minimum	umhos/cm	250	50	110	120	5
maximum	umhos/cm	310	90	190	23000	40
Turbidity						
number of samples (n)		3	3	2	3	3
mean	NTU	18.0	2.5	8.0	8.7	0.7
minimum	NTU	5.1	1.0	5.2	8.1	0.2
maximum	NTU	39.0	4.9	10.8	9.9	1.1
Nitrite+Nitrate Nitrogen						
number of samples (n)		3	3	2	3	3
mean	mg/L	0.83	0.03	1.64	1.07	0.25
minimum	mg/L	0.50	<0.03	0.78	0.78	0.07
maximum	mg/L	1.40	0.05	2.50	1.50	0.59
Ammonium Nitrogen						
number of samples (n)		3	3	2	3	3
mean	mg/L	2.46	0.12	0.25	0.20	0.16
minimum	mg/L	0.57	0.08	0.08	0.13	0.08
maximum	mg/L	5.00	0.18	0.41	0.32	0.23
Inorganic Nitrogen						
number of samples (n)		3	3	2	3	3
mean	mg/L	3.28	0.15	1.89	1.27	0.41
minimum	mg/L	1.15	0.12	1.19	0.92	0.17
maximum	mg/L	6.40	0.20	2.58	1.82	0.76
Total Kjeldahl Nitrogen						
number of samples (n)		3	3	2	3	3
mean	mg/L	6.4	1.4	1.2	2.3	0.6
minimum	mg/L	1.7	0.9	1.0	2.1	0.2
maximum	mg/L	15.0	1.7	1.3	2.5	1.0
Total Nitrogen						
number of samples (n)		3	3	2	3	3
mean	mg/L	7.3	1.4	2.8	3.4	0.9
minimum	mg/L	2.2	0.9	2.1	3.2	0.3
maximum	mg/L	16.4	1.8	3.5	3.6	1.6
Total Phosphorus						
number of samples (n)		3	3	2	3	3
mean	mg/L	2.354	0.052	0.133	0.184	0.025
minimum	mg/L	0.822	0.019	0.075	0.126	0.016
maximum	mg/L	3.170	0.073	0.190	0.294	0.043

Table 10. Continued.

Parameter	Units	Sampling Locations SP5b	SP6	SP8	SP9	SP10
Dissolved Phosphorus						
number of samples (n)		3	3	2	3	3
mean	mg/L	1.847	0.044	0.112	0.072	0.017
minimum	mg/L	0.632	0.019	0.074	0.027	0.015
maximum	mg/L	2.700	0.058	0.150	0.097	0.020
Cadmium (total)*	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (dissolved)*	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (total)*	mg/L	<0.005	<0.005	<0.005	0.030	<0.005
Lead (dissolved)*	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Copper (total)*	mg/L	0.03	0.01	0.02	0.02	0.03
Copper (dissolved)	mg/L	0.03	0.01	0.02	0.02	0.03
Aluminum (total)*	mg/L	0.35	0.83	0.19	1.1	<0.08
Aluminum (dissolved)*	mg/L	<0.08	0.63	0.13	0.15	<0.08
Calcium (total)*	mg/L	20.0	2.2	13.0	5.9	0.2
Magnesium (total)*	mg/L	7.0	0.9	2.3	0.9	<0.1
Sodium (total)*	mg/L	36.0	8.2	26.0	13.0	<0.5
Chloride (total)*	mg/L	78	19	46	26	<4
Iron (dissolved)*	mg/L	0.61	0.94	0.09	0.09	<0.08
Manganese (dissolved)*	mg/L	0.15	0.03	0.05	0.02	0.01
TPH*	mg/L	<0.5	<0.5	<0.5	0.9	<0.5
4,4'-DDT*	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05
PCB:*						
Aroclor 1016	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1221	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1232	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1242	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1248	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1254	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1260	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5
PAH:*						
Acenaphthene	ug/L	<1	<1	<1	<1	<1
Acenaphthylene	ug/L	<1	<1	<1	<1	<1
Anthracene	ug/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	ug/L	<1	<1	<1	<1	<1
Benzo(b)fluoranthene	ug/L	<1	<1	<1	<1	<1
Benzo(k)fluoranthene	ug/L	<1	<1	<1	<1	<1
Benzo(ghi)perylene	ug/L	<1	<1	<1	<1	<1
Benzo(a)pyrene	ug/L	<1	<1	<1	<1	<1
Chrysene	ug/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	ug/L	<1	<1	<1	<1	<1
Fluoranthene	ug/L	<1	<1	<1	<1	<1
Fluorene	ug/L	<1	<1	<1	<1	<1
Indeno(1,2,3-cd)pyrene	ug/L	<1	<1	<1	<1	<1
2-Methylnaphthalene	ug/L	<1	<1	<1	<1	<1
Naphthalene	ug/L	<1	<1	<1	<1	<1
Phenanthrene	ug/L	<1	<1	<1	<1	<1
Pyrene	ug/L	<1	<1	<1	<1	<1

*Number of samples=1.

Storm water concentrations of total sodium and chloride were low at SP10, moderate at SP6, and high at SP5b, SP8, and SP9. High concentrations at SP5b were likely a result of dairy farming activities and road runoff. Road runoff was likely responsible for contamination at the latter two sites. Concentrations of dissolved iron and manganese were relatively low at all sites. However, dissolved iron was somewhat higher than the expected background level at SP5b and SP6, and dissolved manganese was somewhat higher than the expected background level at SP5b. Flushing of anoxic ground water laden with iron or manganese into the tributaries may be responsible.

Storm water monitoring for selected organic compounds indicated relatively low levels. Total petroleum hydrocarbons ranged from <0.5 to 0.9 mg/L. DDT, PCB's, and polynuclear aromatic hydrocarbons were not detected.

Ground Water Chemistry

Shoreline segments sampled during the ground water monitoring investigation are presented in Figure 2. Ground water quality monitoring results are presented in Table 11. Nitrite+nitrate nitrogen values ranged from <0.03 mg/L to 0.28 mg/L. In ground water, the likely range of nitrite+nitrate nitrogen under most "pristine" conditions is 0.01 mg/L to 0.5 mg/L. Values over 1.0 mg/L are unusual without some form of urban or agricultural influence, while values over 10.0 mg/L are considered a health hazard for human consumption. Ammonium nitrogen has a similar range of possible values, as the sources are often the same.

Measured ammonium nitrogen concentrations ranged from <0.05 mg/L to 4.29 mg/L in ground water entering Stafford Pond. Elevated concentrations are probably converted to nitrite and then nitrate shortly after entering oxygenated lake waters, therefore reducing the likelihood of toxicity to aquatic life. The sum of nitrite+nitrate and ammonium nitrogen, or soluble inorganic nitrogen, could be expected to reach up to about 1.0 mg/L under natural conditions. Values much over this concentration raise suspicions of septic leachate influence or other contamination. Ground water concentrations in Stafford Pond were >1.0 mg/L at all sampling locations on either one or both sampling dates, mainly as a consequence of high ammonium nitrogen. This suggests inadequate oxygen in the ground water to convert ammonium to nitrate. The sources could be sewage, agricultural waste, or decaying vegetation.

Dissolved phosphorus concentrations were elevated along all four sampling segments. In general, values in excess of 0.05 mg/L are of concern in terms of eutrophication, and values in excess of 0.10 mg/L can cause serious deterioration of conditions if the phosphorus is biologically available. However, larger values in porewater do not necessarily translate into pond water column values of the same magnitude. Iron and manganese are known to complex with phosphorus, the end product being a compound that is highly insoluble under oxygenated conditions. For phosphorus to become available in the water column at a significant level, it must therefore enter at an elevated concentration with concurrent iron and/or manganese levels at less than five times the phosphorus level. In the case of Stafford Pond, groundwater sampling results indicate that sufficient levels of iron were available to bind phosphorus, as the

Table 11. Results of Groundwater Monitoring at Stafford Pond (1996).

Sample Site	Sampling Date	Nitrate/Nitrite mg/L	Ammonium mg/L	Dissolved Phosphorus mg/L	Dissolved Iron mg/L	Dissolved Manganese mg/L
southeast	10-Jun	0.03	1.30	0.210	1.90	0.10
southwest	10-Jun	0.28	4.29	0.048	0.29	0.10
northeast	10-Jun	<0.03	<0.05	0.090	12.00	2.10
northwest	10-Jun	<0.03	2.46	0.047	4.10	0.40
southeast	22-Aug	<0.03	0.95	0.300	3.00	0.11
southwest	22-Aug	0.05	0.22	0.180	<0.08	<0.05
northeast	22-Aug	<0.03	3.00	0.074	9.00	1.60
northwest	22-Aug	<0.03	1.00	0.061	4.60	0.74

iron:phosphorus ratio was >5:1 at all but one sampling location. Sampling in August revealed that the southwest segment had a ratio <5:1 and a phosphorus concentration >0.05 mg/L. Low flows limit the magnitude of this input, but some phosphorus input from ground water is likely in this area.

Sediment Chemistry

Sediment sampling locations are presented in Figure 4. Sediment sampling results are presented Table 12. Sediments at SP1 and SP2 were primarily composed of medium sand, fine sand, and silt/clay. The silt/clay fraction includes most organic matter, and sediments such as those at SP1 and SP2 with silt/clay levels >30% would be considered mucky. Sediments at SP3 were primarily composed of gravel, medium sand, and fine sand. Sediments such as those at SP3 with silt/clay levels <5% would be considered sandy. Organic carbon content was especially high at SP2, most likely a direct result of inputs from the northern tributary, including a substantial amount of manure. Solids content was low at SP1 and SP2, and high at SP3; low solids content indicates less compacted and typically more organic sediment. Total phosphorus concentrations were high at SP2 and low at the remaining two sites. TKN was low at SP3, moderate at SP1, and high at SP2. Higher nutrient concentrations at SP2 are likely a direct result of inputs from the northern tributary, including manure from the dairy farm.

Metal concentrations were generally within acceptable ranges. Concentrations of cadmium, copper, and lead were below average values for Massachusetts lake sediments (Rojko 1992), which are considered appropriate for evaluation of Rhode Island lakes. This suggests that the use of copper as an algicide has not had a lasting effect on sediments in Stafford Pond at this point in time. Concentrations of iron and manganese were below average values for Massachusetts lake sediments at SP2 and SP3, and slightly above average at SP1. Concentrations of aluminum and calcium were normal, according to our own experience in New England.

Total petroleum hydrocarbons were relatively low at all three sampling locations. DDT and PCB's were not detected in lake sediments. Polynuclear aromatic hydrocarbons (PAH) were detected at all three sampling locations. Elevated PAH concentrations were documented at SP2 and SP3, and are most likely a result of road runoff. Guidance criteria from the National Oceanic and Atmospheric Administration was available for 12 of the 17 PAH's evaluated at Stafford Pond (Long and Morgan 1990). Results indicated that values for all 12 PAH's were below the ER-M, but at least half exceeded the ER-L at sampling locations SP2 and SP3. The ER-L represents the low effects range and the ER-M represents the moderate effects range.

These guidelines are used to assess potential impacts to aquatic life from polluted sediments. According to these guidelines, negative effects to aquatic life are possible if concentrations are between the ER-L and ER-M, and negative effects to aquatic life are probable if concentrations exceed the ER-M. Effects are therefore possible in the cove areas associated with SP2 and SP3, but are unlikely in the main body of the lake.

Table 12. Results of Sediment Sampling at Stafford Pond (1996).

Parameter	Units	Deep Hole SP1	N.E. Bay SP2	Boat Ramp SP3
		Sampling Locations		
Grain size analysis:				
gravel	%	<0.1	0.1	26.2
coarse sand	%	1.6	2.2	11.7
medium sand	%	24.8	17.1	31.9
fine sand	%	38.9	40.1	26.3
silt/clay	%	34.6	40.5	3.8
Total organic carbon	mg/kg	29,000	175,000	10,000
Solids content	%	23	17	80
Total phosphorus	mg/kg	9.9	170	4.2
TKN	mg/kg	2,600	15,000	91
Total Metals:				
Cadmium	mg/kg	0.4	0.7	<0.4
Copper	mg/kg	210	71	21
Lead	mg/kg	130	48	41
Aluminum	mg/kg	7,600	6,300	350
Iron	mg/kg	18,000	10,000	13,000
Manganese	mg/kg	670	260	140
Calcium	mg/kg	1,200	5,400	350
Total Petroleum Hydrocarbons	mg/kg	76	240	110
4,4'-DDT	ug/kg	<15	<21	<4
PCB:				
Aroclor-1016	ug/kg	<21	<21	<20
Aroclor-1221	ug/kg	<21	<21	<40
Aroclor-1232	ug/kg	<21	<21	<20
Aroclor-1242	ug/kg	<21	<21	<20
Aroclor-1248	ug/kg	<21	<21	<20
Aroclor-1254	ug/kg	<21	<21	<20
Aroclor-1260	ug/kg	<21	<21	<20
Polynuclear Aromatic Hyrdrocarbons:				
Acenaphthene	ug/kg	<16	<300	<39
Acenaphthylene	ug/kg	<12	560	160
Anthracene	ug/kg	<8.4	360	88
Benzo(a)anthracene	ug/kg	<10	860	310
Benzo(b)fluoranthene	ug/kg		800	580
Benzo(k)fluoranthene	ug/kg		<380	460
Benzo (b,k) fluoranthene	ug/kg	110		
Benzo(ghi)perylene	ug/kg	<8	350	140
Benzo(a)pyrene	ug/kg	48	600	370
Chrysene	ug/kg	80	820	490
Dibenzo(a,h)anthracene	ug/kg	<8	<510	<120
Fluoranthene	ug/kg	130	1100	840
Fluorene	ug/kg	<12	250	45
Indeno(1,2,3-cd)pyrene	ug/kg	40	330	150
2-Methylnaphthalene	ug/kg	<16	210	<39
Naphthalene	ug/kg	<18	<230	<39
Phenanthrene	ug/kg	56	1300	530
Pyrene	ug/kg	110	1500	96

PAH analysis at SP1 was conducted by Alpha Analytical, Inc. Analysis at SP2 and SP3 was conducted by Mitkem Corporation.

Sampling conducted on 3/19/96, 5/14/96, and 7/30/96.

Fish Tissue Analysis

Results of the fish tissue analysis (composite of edible portions from 3 white perch, fish ranged in size from 11-12" total length) revealed that levels of selected contaminants were relatively low (Table 13). Cadmium, lead, and PCB's were not detected. Mercury was detected, but the concentration (102 ng/g) was below the recommended Maximum Permissible Level for human consumption according to the Rhode Island Department of Health (Vanderslice 1996). A number of polynuclear aromatic hydrocarbons were also detected, but concentrations were far below recommended Maximum Permissible Levels for human consumption (Vanderslice 1996).

Data Quality Investigations

Data quality monitoring results for water chemistry analyses are included in Appendix A. Variability in most parameters was tolerable, but variation among duplicate nutrient samples was undesirably high. Differences among duplicate nitrogen and phosphorus parameters were not consistent, but suggested considerable lab error. Total phosphorus comparisons between laboratories indicated that samples analyzed by Mitkem Corporation were consistently higher than those analyzed by the University of Rhode Island. This suggests that actual concentrations in Stafford Pond could be somewhat lower than the measured values. This could limit our ability to determine if slightly elevated concentrations are a result of pollution or variability in chemical analyses, and is most troublesome with respect to detection of internal recycling. However, this will not greatly affect our overall interpretation of the chemical data. Even with this significant degree of variability, major sources of pollution are quite obvious, and multiple approaches to nutrient loading provide increased reliability in overall conclusions.

Nitrogen and Phosphorus Loading

Although a variety of pollutants can pose problems for water supply and recreational use of a water body, nitrogen and particularly phosphorus are particularly troublesome. While not toxic at typically observed concentrations, these elements are essential plant nutrients and control the growth of algae. Elevated algal biomass results in aesthetic and functional impairment of water resources, including objectionable odors and tastes, unsafe visibility, oxygen level depression through decay, increased cost of treatment, possible production of toxic compounds (naturally or in combination with treatment), and possible fish kills. Nitrogen is more difficult to control than phosphorus, as it is abundant in the atmosphere, moves readily through soils, and exists in a variety of forms in water. Phosphorus, more often the limiting nutrient than nitrogen, is less common and less mobile, but less of it is required to cause problems. While phosphorus is the more critical target of most lake water quality management efforts, the ratio of nitrogen to phosphorus is a key determinant of the composition of the algal community, and must be considered as well.

The most straightforward approach to estimating nutrient loads is to multiply annual flow volumes by the measured concentration of each nutrient for each defined flow component (e.g., precipitation, tributaries). For sources without measured flow or nutrient levels, estimates can be derived from either comparison with measured sources or literature values to complete the evaluation. Application of this approach to the Stafford Pond system (Table 14) included itemization of inputs from direct precipitation, ground water inseepage, surface water storm flow

Table 13. Results of Fish Tissue Analysis at Stafford Pond (1996).

Parameter	Units	Result
Sample weight	(g-dry)	5.65
Sample dry weight	%	21.6
Sample lipid	%	12.1
Cadmium (total)	ng/g	<13
Lead (total)	ng/g	<33
Mercury (total)	ng/g	102
PCB:		
Aroclor 1016	ng/g	<20
Aorclor 1221	ng/g	<40
Aroclor 1232	ng/g	<20
Aroclor 1242	ng/g	<20
Aroclor 1248	ng/g	<20
Aroclor 1254	ng/g	<20
Aroclor 1260	ng/g	<20
Polynuclear Aromatic Hydrocarbons:		
Acenaphthene	ng/g	<4.34
Acenaphthylene	ng/g	<2.68
Anthracene	ng/g	1.17
Benzo(a)anthracene	ng/g	<2.57
Benzo(b)fluoranthene	ng/g	<3.17
Benzo(k)fluoranthene	ng/g	<7.05
Benzo(g,h,i)perylene	ng/g	<4.73
Benzo(a)pyrene	ng/g	<5.36
Chrysene	ng/g	<3.41
Dibenzo(a,h)anthracene	ng/g	<4.48
Fluoranthene	ng/g	2.92
Fluorene	ng/g	2.41
Indeno(1,2,3-c,d)pyrene	ng/g	<4.47
2-Methylnaphthalene	ng/g	4.76
Naphthalene	ng/g	7.67
Phenanthrene	ng/g	5.63
Pyrene	ng/g	0.47

Edible portions of three white Perch *(Morone americana)*
were composited and analyzed for the above parameters.
Fish ranged in size from 11-12 inches TL.
Samples collected on 10/29/96.
All units ng/g dry weight.

TABLE 17a. IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS: Current Conditions

THE TERMS

PHOSPHORUS

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE	
				To Be Predicted	Dependent Variable
TP	Lake Total Phosphorus Conc.	ppb	From in-lake models		
KG	Phosphorus Load to Lake	kg/yr	From export model	445	
L	Phosphorus Load to Lake	g P/m2/yr	KG*1000/A	0.226	
TPin	Influent (Inflow) Total Phosphorus	ppb	From export model	91	
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data, if available	33	Enter Value (TP out)
I	Inflow	m3/yr	From export model	4881215	
A	Lake Area	m2	From data	1970818	Enter Value (A)
V	Lake Volume	m3	From data	7696005	Enter Value (V)
Z	Mean Depth	m	Volume/area	3.905	
F	Flushing Rate	flushings/yr	Inflow/volume	0.634	
S	Suspended Fraction	no units	Effluent TP/Influent TP	0.362	
Qs	Areal Water Load	m/yr	Z(F)	2.477	
Vs	Settling Velocity	m	Z(S)	1.415	
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.747	
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.557	

NITROGEN

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE	
				To Be Predicted	Dependent Variable
TN	Lake Total Nitrogen Conc.	ppb	From in-lake models		
KG	Nitrogen Load to Lake	kg/yr	From export model	8110	
L1	Nitrogen Load to Lake	g N/m2/yr	KG*1000/A	4.12	
L2	Nitrogen Load to Lake	mg N/m2/yr	KG*1000000/A	4115	
C1	Coefficient of Attenuation, from F	fraction/yr	2.7183^(0.5541(ln(F))-0.367)	0.54	
C2	Coefficient of Attenuation, from L	fraction/yr	2.7183^(0.71(ln(L2))-6.426)	0.60	
C3	Coefficient of Attenuation, from L/Z	fraction/yr	2.7183^(0.594(ln(L2/Z))-4.144)	0.99	

TABLE 17[illegible]. IN-LAKE MODELS FOR [illegible]

THE MODELS					PREDICTED CHL AND WATER CLARITY	
	PHOSPHORUS	PRED.	PERMIS.	CRITICAL		
		CONC.	CONC.	CONC.		
NAME	FORMULA	(ppb)	(ppb)	(ppb)	MODEL	Value
Mass Balance	TP = L/(Z(F)) * 1000	91				
(Maximum Conc.)					**Mean Chlorophyll (ug/L)**	
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	23	16	32	Dillon and Rigler 1974	15.2
(K-D)					Jones and Bachmann 1976	17.6
Vollenweider 1975	TP=L/(Z(S+F))*1000	58	40	81	Oglesby and Schaffner 1978	19.9
(V)					Modified Vollenweider 1982	19.2
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	40	28	56	**"Maximum" Chlorophyll (ug/L)**	
(L-M)					Modified Vollenweider (TP) 1982	61.2
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	38	26	53	Vollenweider (CHL) 1982	55.7
(J-B)					Modified Jones, Rast and Lee 1979	61.4
					Secchi Transparency (M)	
Average of Model Values		40	28	55	Oglesby and Schaffner 1978 **(Avg)**	1.4
(without mass balance)					Modified Vollenweider 1982 **(Max)**	3.5
Reality Check Conc.		39				
From Vollenweider 1968						
Permis. Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.16				
Critical Load (g/m2/yr)	Lc=2(Cp)	0.31				
	NITROGEN					
Mass Balance	TN = L/(Z(F)) * 1000	1662				
(Maximum Conc.)						
Bachmann 1980	TN=L/(Z(C1+F))*1000	899				
Bachmann 1980	TN=L/(Z(C2+F))*1000	856				
Bachmann 1980	TN=L/(Z(C3+F))*1000	649				
Reality Check Conc.		900				

TABLE 17b. IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS: Current Conditions

THE MODELS	*PHOSPHORUS*	PRED. CONC. (ppb)	PERMIS. CONC. (ppb)	CRITICAL CONC. (ppb)	*PREDICTED CHL AND WATER CLARITY* MODEL	Value
NAME	**FORMULA**					
Mass Balance	TP=L/(Z(F))*1000	91				
(Maximum Conc.)					**Mean Chlorophyll (ug/L)**	
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	23	16	32	Dillon and Rigler 1974	15.2
(K-D)					Jones and Bachmann 1976	17.6
Vollenweider 1975	TP=L/(Z(S+F))*1000	58	40	81	Oglesby and Schaffner 1978	19.9
(V)					Modified Vollenweider 1982	19.2
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	40	28	56	**"Maximum" Chlorophyll (ug/L)**	
(L-M)					Modified Vollenweider (TP) 1982	61.2
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	38	26	53	Vollenweider (CHL) 1982	55.7
(J-B)					Modified Jones, Rast and Lee 1979	61.4
					Secchi Transparency (M)	
Average of Model Values		40	28	55	Oglesby and Schaffner 1978 **(Avg)**	1.4
(without mass balance)					Modified Vollenweider 1982 **(Max)**	3.5
Reality Check Conc.		39				
From Vollenweider 1968						
Permis. Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.16				
Critical Load (g/m2/yr)	Lc=2(Cp)	0.31				
	NITROGEN					
Mass Balance	TN=L/(Z(F))*1000	1662				
(Maximum Conc.)						
Bachmann 1980	TN=L/(Z(C1+F))*1000	899				
Bachmann 1980	TN=L/(Z(C2+F))*1000	856				
Bachmann 1980	TN=L/(Z(C3+F))*1000	649				
Reality Check Conc.		900				

blooms, with average chlorophyll levels between 15 and 22 ug/L and peaks in excess of 60 ug/L. This depresses water clarity, leading to an average Secchi transparency of 1.4-1.5 m. The highest water clarity results in a Secchi depth of 2.9-3.5 m, but this occurs only briefly during the growing season.

Relative to known relationships for phosphorus, chlorophyll and water clarity in lakes (Figures 11a and 11b), Stafford Pond values fall within the expected range. Average chlorophyll concentration is almost exactly what the linear relationship with phosphorus level would predict, while the water clarity is near the low end of the possible range associated with the given phosphorus level. Dominance by small celled phytoplankton and additional turbidity from non-algal sources (incoming sediment, resuspension of fine organic particles by wind or waterfowl) is the expected cause of the lower than average water clarity.

Considering the range of possible conditions (Figures 11a and 11b), chlorophyll levels could increase substantially with additional loading, but water clarity cannot decrease much more. On the other hand, small decreases in loading and phosphorus level could yield substantial improvement in water clarity. Even without a major change in loading, there is appreciable room for improved water clarity if the causative agents aside from high nutrient levels can be controlled.

BIOLOGICAL CHARACTERISTICS

Fecal Bacteria

Results of fecal coliform and fecal streptococcus monitoring are presented in Table 18 and 19. Fecal coliform and fecal streptococcus are not harmful by themselves, but are indicators of contamination from animal and/or human wastes. Values of fecal coliform and fecal streptococcus recorded during dry weather were generally low (<100/100 mL) at all sites except SP5b, where values were consistently high (>500/100 mL). A high fecal streptococcus value was also recorded at SP1a on 4/17/96. This value may have been a result of exceedingly high inputs from SP5b and/or waterfowl using this area of the pond. Values recorded during wet weather ranged from low to high. However, high concentrations were documented at all wet weather sampling locations on at least one date, with the exception of SP8 and SP10. Values were either low or moderate at SP8, and bacteria were not monitored at SP10 as this was a direct precipitation sample. In conclusion, most striking were the values at SP5b, which often exceeded 10,000/100 mL even during dry weather. Dairy farm inputs are strongly indicated, as bacterial levels at SP5a were low.

The fecal coliform:fecal streptococcus ratio can often indicate whether bacterial pollution is of human or non-human origin. Ratios >4 are mainly human wastes, whereas ratios <1 are mainly non-human animal wastes. Ratios between 1 and 4 are inconclusive, and differential die-off can skew ratio results except where bacterial concentrations are high and the sample is collected near the source. Results were generally inconclusive at all sites, probably a result of differential bacterial die-off. The range of encountered conditions is exemplified by Table 20. The ratios for even station SP5b, with an obvious nearby source of non-human fecal bacteria, did not consistently indicate non-human sources.

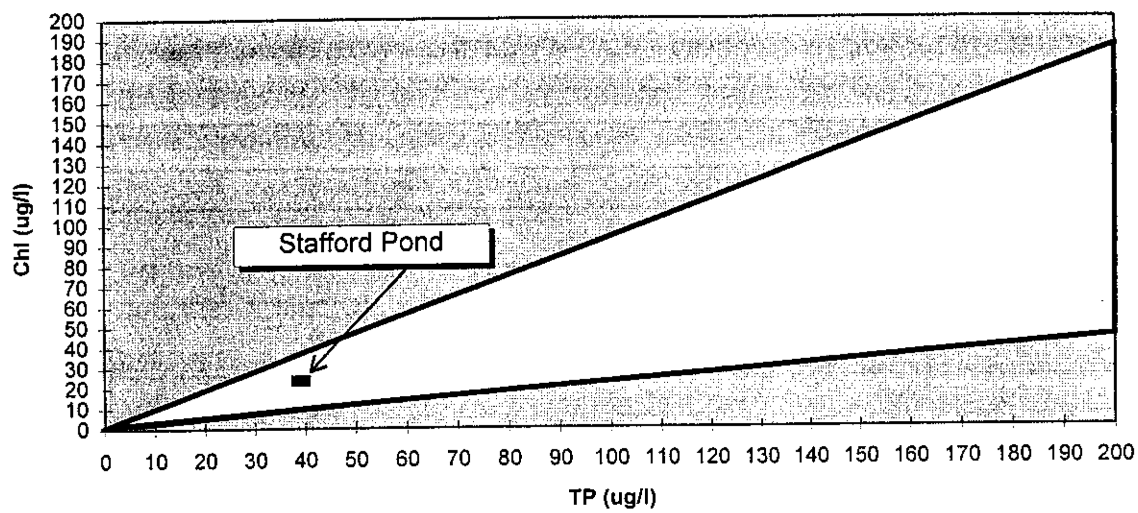


Figure 11a. Total Phosphorus vs. Chlorophyll a.

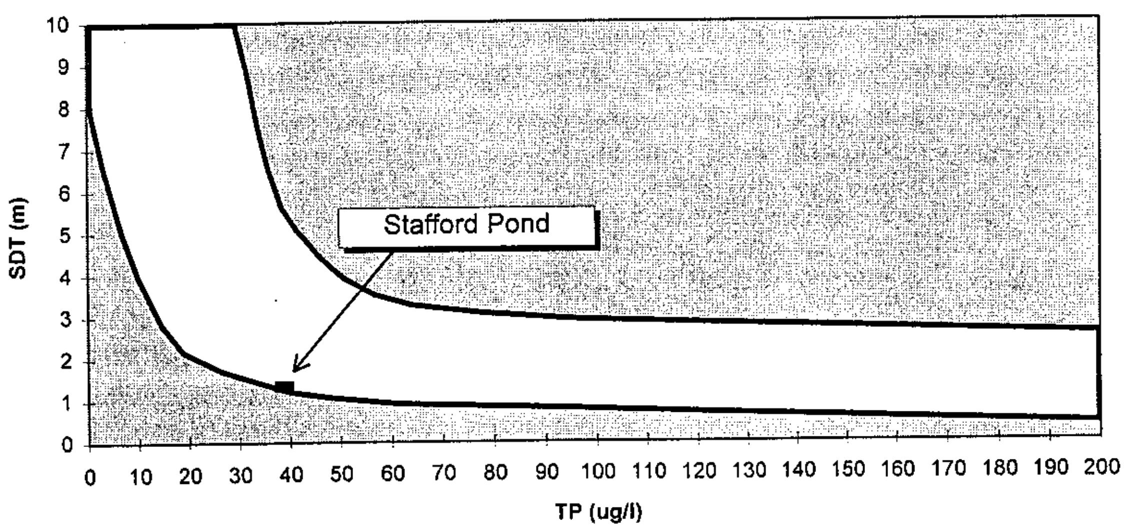


Figure 11b. Total Phosphorus vs. Secchi Disk Transparency.

Table 18. Results of Fecal Coliform Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Fecal Coliform (#/100 mL)									
	SP1a	SP2	SP3	SP4	SP5a	SP5b	SP6	SP8	SP9	SP11	SP12
Dry Weather:											
21-Feb	<1	<1	<1	<1		2,300	<1				
19-Mar	1	2	5	<1		1,300	1				
17-Apr	470			9		7,300	8				
14-May	2			3	21	600	<1				
29-May	1			<1		41,000	6			<1	<1
10-Jun	55			5		23,000	64				
27-Jun	<1			<1		3,400	17				
17-Jul	2			<1		6,400	78				
30-Jul	1			<1							
8-Aug	<1		1	4							
22-Aug	<1		1	6							
5-Sep	<2		<2	4							
30-Sep	5			2		41,000	12				
29-Oct	54			31	<100	2,300	5				
Mean (geometric)	4	1	2	3	46	5,500	7			<1	<1
Minimum	<1	<1	<1	<1	21	600	<1			<1	<1
Maximum	470	2	5	31	50	41,000	78			<1	<1
Wet Weather:											
20-Mar						51,000	1		2		
16-Apr								50			
24-Jul							940		42,000		
12-Sep						3,100	440	64	50,000		
18-Sep						49,000					
Mean (geometric)						19,800	75	57	1,600		
Minimum						3,100	1	50	2		
Maximum						51,000	940	64	50,000		

Table 19. Results of Fecal Streptococcus Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Fecal Streptococcus (#/100 mL) SP1a	SP2	SP3	SP4	SP5a	SP5b	SP6	SP8	SP9	SP11	SP12
Dry Weather:											
21-Feb	<1	1	<1	<1		2,600	<1				
19-Mar	<1	2	2	<1		740	<1				
17-Apr	3,500			8		41,000	34				
14-May	<1			<1	<1	140	2				
29-May	<1			<1		3,400	15			<1	<1
10-Jun	13			<1		2,500	420				
27-Jun	<1			13		3,500	80				
17-Jul	<1			<1		3,000	100				
30-Jul	<1			1							
8-Aug	6		9	5							
22-Aug	1		1	6							
5-Sep	4		<2	<2							
30-Sep	<1			1		50,000	16				
29-Oct	5			<1	<100	19,000	2				
Mean (geometric)	3	1	2	2	10	4,000	13			<1	<1
Minimum	<1	1	<1	<1	<1	140	<1			<1	<1
Maximum	3,500	2	9	13	50	50,000	420			<1	<1
Wet Weather:											
20-Mar						1,900	2		130		
16-Apr								410			
24-Jul							580		42,000		
12-Sep						3,100	320	4	50,000		
18-Sep						38,000					
Mean (geometric)						6,100	72	40	6,500		
Minimum						1,900	2	4	130		
Maximum						38,000	580	410	50,000		

Table 20. Fecal Coliform:Fecal Streptococcus Ratios for Several Sampling Locations at Stafford Pond (1996).

Sampling Location	Date	Weather	FC:FS ratio
SP5b	21-Feb	Dry	0.9
SP5b	19-Mar	Dry	1.8
SP5b	17-Apr	Dry	0.2
SP5b	14-May	Dry	4.3
SP5b	29-May	Dry	12.1
SP5b	10-Jun	Dry	9.2
SP5b	27-Jun	Dry	1.0
SP5b	17-Jul	Dry	2.1
SP5b	30-Sep	Dry	0.8
SP5b	29-Oct	Dry	0.1
SP5b	20-Mar	Wet	26.8
SP5b	12-Sep	Wet	1.0
SP5b	18-Sep	Wet	1.2
SP6	24-Jul	Wet	1.6
SP6	12-Sep	Wet	1.4
SP9	24-Jul	Wet	1.0
SP9	12-Sep	Wet	1.0

Phytoplankton

Floating algae, or phytoplankton, are the primary manifestation of overfertilization in Stafford Pond. Samples are collected and analyzed by the Stone Bridge Fire District on a regular basis, but for this study samples were collected from two stations (SP-1a and SP4) and analyzed by Fugro East (ENSR) personnel. Estimates of phytoplankton density as cells/mL for Stafford Pond are presented in Table 21a and Figure 12a. Estimates of phytoplankton biomass as ug/L for Stafford Pond are presented in Table 21b and Figure 12b.

The phytoplankton of Stafford Pond are not especially rich (number of taxa); only 32 genera were encountered in the entire sample collection, with an individual sample range of 4 to 15 genera. Diversity and evenness (distribution of cells among taxa) were highly variable, with a range of 0.01 to 0.92, suggesting unstable conditions. Total cell counts ranged from 900 to 307260 cells/mL, with counts over 40,000 cells/mL throughout March and April and again in August and September. Biomass estimates ranged from 384 to 40,110 ug/L, with two distinct peaks as with the cell counts; the spring peak included mainly the diatom *Asterionella* and had biomasses of 8807 to 10,455 ug/L, while the summer peak consisted mainly of the bluegreen Aphanizomenon and had biomasses of 6659 to 40,110 ug/L.

There was generally close agreement between the surface station (SP1a) and the water intake station (SP4) for taxonomic composition, relative abundance, cell counts and biomass, although there was not complete agreement. Aside from the inherent variability in algal counts (±10% is about the minimum expected difference), buoyancy of bluegreens and sinking of diatoms during periods of calm largely account for the observed differences.

The spring pulse of the diatom *Asterionella* is a typical occurrence at Stafford Pond and other fertile southern New England lakes. High available nutrients (including silica as well as nitrogen and phosphorus) upon ice out, coupled with increased light but continued cold temperatures, promotes such diatom blooms. Also present during this time are other cold water tolerant forms such as the diatom *Fragilaria*, the golden algae *Mallomonas* and *Synura*, and the green alga *Sphaerocystis*.

There is a clear water period in late May and early June, also typical for eutrophic temperate zone lakes. This period is produced by a combination of factors, including warming temperatures, changing nutrient levels and ratios, and increased grazing by zooplankton. *Asterionella* persists, but at greatly reduced levels. A few grazer-resistant greens such as *Elakatothrix*, *Oocystis* and *Pediastrum* appear, as do the motile golden algae *Chrysococcus* and *Dinobryon* and several other transient algal forms, but densities are generally low (<1000 ug/L) into mid-June.

In late June and early July, bluegreens typically begin to dominate eutrophic temperate zone lakes. In Stafford Pond, blooms of *Anabaena* have been documented in the past and such a bloom was in its early stages in late June of 1996 when the Stone Bridge Fire District applied copper sulfate to the pond. The timing of this treatment was appropriate, as production appeared to be in the exponential growth phase but actual biomass was not yet over 2000 ug/L. However, limits on the dosage and frequency of such treatments does not always allow a complete kill, and the release of nutrients from decaying bluegreens generally fosters subsequent blooms. A second

Table 21a. Phytoplankton Density in Stafford Pond (1996).

	PHYTOPLANKTON DENSITY (CELLS/ML)									
	Stafford #1a	Stafford #4	Stafford #1a	Stafford #4	Stafford #1a	Stafford #4	Stafford #1a	Stafford #4	Stafford #1a	Stafford #4
TAXON	2/21/96	2/21/96	3/19/96	3/19/96	4/17/96	4/17/96	5/14/96	5/14/96	5/29/96	5/29/96
BACILLARIOPHYTA										
Achnanthes	0	0	0	0	0	0	0	0	0	0
Asterionella	1512	2064	41200	46000	40656	46170	1980	1080	180	120
Fragilaria	294	192	500	700	168	90	0	0	180	0
Gomphonema	0	0	0	0	0	0	0	0	0	0
Navicula	0	48	0	50	42	45	45	0	0	0
Nitzschia	0	96	0	50	0	0	0	0	0	0
Tabellaria	0	0	0	0	0	0	0	0	0	0
CHLOROPHYTA										
Ankistrodesmus	0	0	0	0	0	0	0	0	0	0
Coelastrum	0	0	0	0	0	0	0	0	0	0
Cosmarium	0	0	0	0	0	0	0	30	0	0
Crucigenia	0	0	0	0	0	0	0	0	0	0
Elakatothrix	84	0	0	0	0	0	0	0	0	0
Kirchneriella	0	0	0	0	0	0	0	0	0	0
Oocystis	0	0	0	0	0	0	0	0	90	60
Paulschultzia	0	0	0	0	0	0	0	0	0	0
Pediastrum	0	0	0	0	0	0	0	0	0	0
Scenedesmus	0	0	0	0	0	0	1260	1920	90	240
Schroederia	0	0	0	0	0	0	0	0	0	0
Sphaerocystis	336	576	2400	2800	3024	3240	1800	3120	0	0
Staurastrum	0	0	50	0	0	0	0	0	0	0
Treubaria	0	0	0	0	0	0	0	0	0	0
CHRYSOPHYTA										
Chrysococcus	0	96	50	0	0	0	180	120	225	360
Chrysosphaerella	0	96	0	0	0	0	0	0	0	0
Dinobryon	0	0	0	0	0	0	45	0	270	60
Mallomonas	462	1248	100	300	0	0	0	0	0	0
Synura	168	96	0	0	0	0	0	0	0	0
CRYPTOPHYTA										
Cryptomonas	0	0	50	50	0	45	45	60	90	60
CYANOPHYTA										
Anabaena	0	0	0	0	0	0	0	0	0	0
Aphanizomenon	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA										
Trachelomonas	0	0	50	50	0	0	0	0	23	0
PYRRHOPHYTA										
Ceratium	0	0	0	0	0	0	0	0	0	0
Peridinium	0	0	0	100	0	0	0	0	0	0
RHODOPHYTA										
SUMMARY STATISTICS										
DENSITY (#/ML)										
BACILLARIOPHYTA	1806	2400	41700	46800	40866	46305	2025	1080	360	120
CHLOROPHYTA	420	576	2450	2800	3024	3240	3060	5070	180	300
CHRYSOPHYTA	630	1536	150	300	0	0	225	120	495	420
CRYPTOPHYTA	0	0	50	50	0	45	45	60	90	60
CYANOPHYTA	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA	0	0	50	50	0	0	0	0	23	0
PYRRHOPHYTA	0	0	0	100	0	0	0	0	0	0
RHODOPHYTA	0	0	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	2856	4512	44400	50100	43890	49590	5355	6330	1148	900
TAXONOMIC RICHNESS										
BACILLARIOPHYTA	2	4	2	4	3	3	2	1	2	1
CHLOROPHYTA	2	1	2	1	1	1	2	3	2	2
CHRYSOPHYTA	2	4	2	1	0	0	2	1	2	2
CRYPTOPHYTA	0	0	1	1	0	1	1	1	1	1
CYANOPHYTA	0	0	0	0	0	0	0	0	0	0
EUGLENOPHYTA	0	0	1	1	0	0	0	0	1	0
PYRRHOPHYTA	0	0	0	1	0	0	0	0	0	0
RHODOPHYTA	0	0	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	6	9	8	9	4	5	7	6	8	6
S-W DIVERSITY INDEX	0.60	0.65	0.14	0.16	0.12	0.12	0.57	0.50	0.83	0.66
EVENNESS INDEX	0.77	0.68	0.15	0.17	0.20	0.17	0.67	0.65	0.92	0.85

Table 21a. Continued.

TAXON	Stafford #1a 6/10/96	Stafford #4 6/10/96	Stafford #1a 6/27/96	Stafford #4 6/27/96	Stafford #1a 7/16/96	Stafford #4 7/16/96	Stafford #1a 7/30/96	Stafford #4 7/30/96	Stafford #1a 8/8/96	Stafford #4 8/8/96
	PHYTOPLANKTON DENSITY (CELLS/ML)									
BACILLARIOPHYTA										
Achnanthes	0	0	0	0	0	0	0	0	0	0
Asterionella	288	180	72	50	0	45	0	0	0	0
Fragilaria	0	0	0	25	45	0	2700	2970	0	600
Gomphonema	0	0	0	0	0	0	0	0	0	0
Navicula	0	0	0	0	0	0	0	0	0	0
Nitzschia	0	0	24	25	45	45	0	0	48	50
Tabellaria	0	0	0	0	0	0	0	0	0	0
CHLOROPHYTA										
Ankistrodesmus	0	0	0	0	0	0	0	33	0	0
Coelastrum	0	0	0	100	540	1080	10080	7920	11520	8000
Cosmarium	0	0	0	0	0	0	0	0	0	0
Crucigenia	0	0	0	0	0	0	180	132	0	0
Elakatothrix	36	36	0	0	0	0	0	0	0	0
Kirchneriella	0	0	0	0	0	0	0	0	96	100
Oocystis	0	0	48	0	0	0	180	132	96	50
Paulschultzia	0	0	96	200	360	90	0	0	96	100
Pediastrum	0	0	48	0	0	0	90	132	96	0
Scenedesmus	144	144	96	100	2160	1800	1080	528	0	100
Schroederia	36	36	0	25	45	45	0	0	48	0
Sphaerocystis	0	0	192	150	90	360	720	792	0	0
Staurastrum	0	0	0	0	45	0	0	0	0	0
Treubaria	0	0	0	0	0	0	0	0	48	0
CHRYSOPHYTA										
Chrysococcus	2448	3024	288	200	0	0	0	0	0	0
Chrysosphaerella	0	0	0	0	0	0	0	0	0	0
Dinobryon	0	0	24	25	0	0	0	0	0	0
Mallomonas	0	0	0	0	0	0	0	0	0	0
Synura	0	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA										
Cryptomonas	36	36	24	25	225	45	45	33	0	0
CYANOPHYTA										
Anabaena	0	0	6000	5250	0	0	0	0	33600	1000
Aphanizomenon	0	0	0	0	0	0	1350	990	19200	1000
EUGLENOPHYTA										
Trachelomonas	36	72	48	50	0	90	0	33	96	50
PYRRHOPHYTA										
Ceratium	0	7	12	13	0	0	5	7	24	150
Peridinium	0	0	0	0	0	0	0	0	0	0
RHODOPHYTA										
SUMMARY STATISTICS										
DENSITY (#/ML)										
BACILLARIOPHYTA	288	180	96	100	90	90	2700	2970	48	650
CHLOROPHYTA	216	216	480	575	3240	3375	12330	9669	12000	8350
CHRYSOPHYTA	2448	3024	312	225	0	0	0	0	0	0
CRYPTOPHYTA	36	36	24	25	225	45	45	33	0	0
CYANOPHYTA	0	0	6000	5250	0	0	1350	990	52800	2000
EUGLENOPHYTA	36	72	48	50	0	90	0	33	96	50
PYRRHOPHYTA	0	7	12	13	0	0	5	7	24	150
RHODOPHYTA	0	0	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	3024	3535	6972	6238	3555	3600	16430	13702	64968	11200
TAXONOMIC RICHNESS										
BACILLARIOPHYTA	1	1	2	3	2	2	1	1	1	2
CHLOROPHYTA	3	3	5	5	6	5	6	7	7	5
CHRYSOPHYTA	1	1	2	2	0	0	0	0	0	0
CRYPTOPHYTA	1	1	1	1	1	1	1	1	0	0
CYANOPHYTA	0	0	1	1	0	0	1	1	2	2
EUGLENOPHYTA	1	1	1	1	0	1	0	1	1	1
PYRRHOPHYTA	0	1	1	1	0	0	1	1	1	1
RHODOPHYTA	0	0	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	7	8	13	14	9	9	10	12	12	11
S-W DIVERSITY INDEX	0.33	0.28	0.30	0.34	0.57	0.58	0.55	0.57	0.47	0.47
EVENNESS INDEX	0.39	0.31	0.27	0.30	0.60	0.61	0.55	0.53	0.43	0.45

Table 21a. Continued.

TAXON	PHYTOPLANKTON DENSITY (CELLS/ML)							
	Stafford #1a 8/22/96	Stafford #4 8/22/96	Stafford #1a 9/4/96	Stafford #4 9/4/96	Stafford #1a 9/30/96	Stafford #4 9/30/96	Stafford #1a 10/29/96	Stafford #4 10/29/96
BACILLARIOPHYTA								
Achnanthes	0	0	0	12	0	0	0	0
Asterionella	0	0	14	0	0	60	50	60
Fragilaria	0	288	0	24	0	120	0	60
Gomphonema	0	0	0	0	0	0	0	30
Navicula	18	24	14	48	0	0	50	60
Nitzschia	36	144	0	24	0	0	0	0
Tabellaria	0	0	14	12	0	0	50	60
CHLOROPHYTA								
Ankistrodesmus	0	48	14	12	0	60	50	60
Coelastrum	288	384	56	288	400	480	400	240
Cosmarium	36	48	14	0	0	0	0	0
Crucigenia	0	0	0	0	0	0	0	0
Elakatothrix	0	0	0	0	0	0	0	0
Kirchneriella	0	0	0	0	0	0	0	0
Oocystis	0	0	0	0	0	240	200	240
Paulschultzia	288	96	28	36	0	0	0	0
Pediastrum	0	0	0	0	0	0	0	0
Scenedesmus	144	768	280	336	600	240	200	240
Schroederia	36	48	0	0	0	0	0	0
Sphaerocystis	0	0	56	96	0	0	0	120
Staurastrum	36	48	0	12	25	0	0	0
Treubaria	0	0	0	0	0	0	0	0
CHRYSOPHYTA								
Chrysococcus	0	0	0	0	0	0	0	0
Chrysosphaerella	0	0	0	0	0	0	0	0
Dinobryon	0	0	0	0	0	0	0	0
Mallomonas	0	48	14	0	0	0	0	0
Synura	0	0	0	0	0	0	0	0
CRYPTOPHYTA								
Cryptomonas	0	0	0	24	0	0	5500	4740
CYANOPHYTA								
Anabaena	0	0	0	0	0	0	0	0
Aphanizomenon	111600	148800	168000	69600	47500	306000	0	0
EUGLENOPHYTA								
Trachelomonas	0	96	42	36	150	60	0	60
PYRRHOPHYTA								
Ceratium	4	0	0	0	10	0	0	0
Peridinium	0	0	0	12	0	0	0	0
RHODOPHYTA								
SUMMARY STATISTICS								
DENSITY (#/ML)								
BACILLARIOPHYTA	54	456	42	120	0	180	150	270
CHLOROPHYTA	828	1440	448	780	1025	1020	850	900
CHRYSOPHYTA	0	48	14	0	0	0	0	0
CRYPTOPHYTA	0	0	0	24	0	0	5500	4740
CYANOPHYTA	111600	148800	168000	69600	47500	306000	0	0
EUGLENOPHYTA	0	96	42	36	150	60	0	60
PYRRHOPHYTA	4	0	0	12	10	0	0	0
RHODOPHYTA	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	112486	150840	168546	70572	48685	307260	6500	5970
TAXONOMIC RICHNESS								
BACILLARIOPHYTA	2	3	3	5	0	2	3	5
CHLOROPHYTA	6	7	6	6	3	4	4	5
CHRYSOPHYTA	0	1	1	0	0	0	0	0
CRYPTOPHYTA	0	0	0	1	0	0	1	1
CYANOPHYTA	1	1	1	1	1	1	0	0
EUGLENOPHYTA	0	1	1	1	1	1	0	1
PYRRHOPHYTA	1	0	0	1	1	0	0	0
RHODOPHYTA	0	0	0	0	0	0	0	0
TOTAL PHYTOPLANKTON	10	13	12	15	6	8	8	12
S-W DIVERSITY INDEX	0.03	0.04	0.01	0.04	0.06	0.01	0.29	0.41
EVENNESS INDEX	0.03	0.04	0.01	0.04	0.08	0.02	0.33	0.38

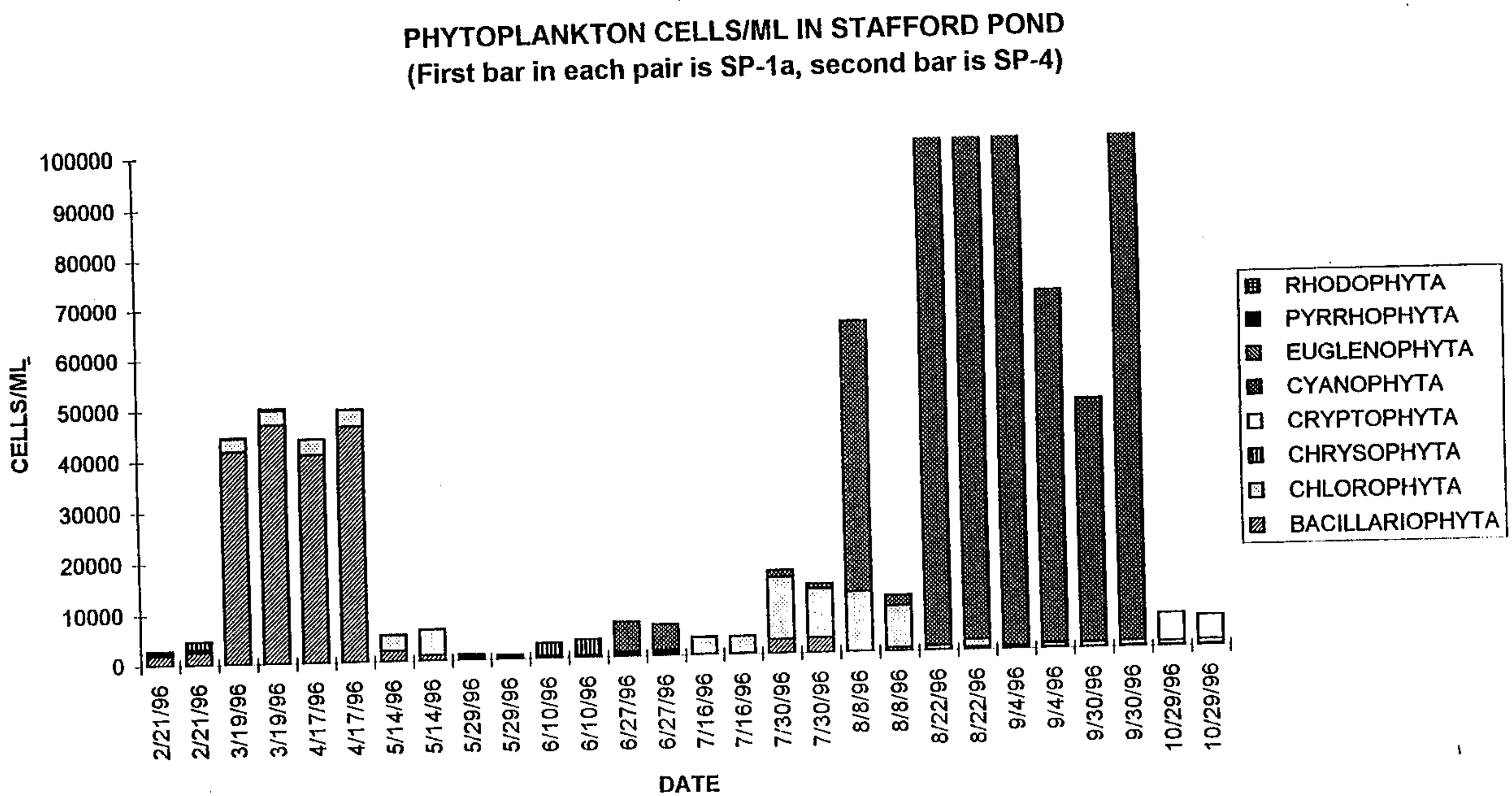


Figure 12a. Phytoplankton Density in Stafford Pond (1996).

Table 21b. Phytoplankton Biomass in Stafford Pond (1996).

	PHYTOPLANKTON BIOMASS (UG/L)									
	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford
	#1a	#4	#1a	#4	#1a	#4	#1a	#4	#1a	#4
TAXON	2/21/96	2/21/96	3/19/96	3/19/96	4/17/96	4/17/96	5/14/96	5/14/96	5/29/96	5/29/96
BACILLARIOPHYTA										
Achnanthes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asterionella	302.4	412.8	8240.0	9200.0	8131.2	9234.0	396.0	216.0	36.0	24.0
Fragilaria	88.2	57.6	150.0	210.0	50.4	27.0	0.0	0.0	54.0	0.0
Gomphonema	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula	0.0	24.0	0.0	25.0	21.0	22.5	22.5	0.0	0.0	0.0
Nitzschia	0.0	76.8	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0
Tabellaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHLOROPHYTA										
Ankistrodesmus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coelastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cosmarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	0.0	0.0
Crucigenia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elakatothrix	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oocystis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	24.0
Paulschultzia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pediastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scenedesmus	0.0	0.0	0.0	0.0	0.0	0.0	126.0	192.0	9.0	24.0
Schroederia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerocystis	67.2	115.2	480.0	560.0	604.8	648.0	360.0	624.0	0.0	0.0
Staurastrum	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Treubaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHRYSOPHYTA										
Chrysococcus	0.0	9.6	5.0	0.0	0.0	0.0	18.0	12.0	22.5	36.0
Chrysosphaerella	0.0	38.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dinobryon	0.0	0.0	0.0	0.0	0.0	0.0	135.0	0.0	810.0	180.0
Mallomonas	231.0	624.0	50.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0
Synura	134.4	76.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA										
Cryptomonas	0.0	0.0	10.0	10.0	0.0	9.0	9.0	12.0	81.0	96.0
CYANOPHYTA										
Anabaena	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aphanizomenon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA										
Trachelomonas	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	22.5	0.0
PYRRHOPHYTA										
Ceratium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Peridinium	0.0	0.0	0.0	210.0	0.0	0.0	0.0	0.0	0.0	0.0
RHODOPHYTA										
SUMMARY STATISTICS										
BIOMASS (UG/L)										
BACILLARIOPHYTA	390.6	571.2	8390.0	9475.0	8202.6	9283.5	418.5	216.0	90.0	24.0
CHLOROPHYTA	75.6	115.2	520.0	560.0	604.8	648.0	486.0	840.0	45.0	48.0
CHRYSOPHYTA	365.4	748.8	55.0	150.0	0.0	0.0	153.0	12.0	832.5	216.0
CRYPTOPHYTA	0.0	0.0	10.0	10.0	0.0	9.0	9.0	12.0	81.0	96.0
CYANOPHYTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	22.5	0.0
PYRRHOPHYTA	0.0	0.0	0.0	210.0	0.0	0.0	0.0	0.0	0.0	0.0
RHODOPHYTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PHYTOPLANKTON	831.6	1435.2	9025.0	10455.0	8807.4	9940.5	1066.5	1080.0	1071.0	384.0

Table 21b. Continued.

	PHYTOPLANKTON BIOMASS (UG/L)									
	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford	Stafford
	#1a	#4	#1a	#4	#1a	#4	#1a	#4	#1a	#4
TAXON	6/10/96	6/10/96	6/27/96	6/27/96	7/16/96	7/16/96	7/30/96	7/30/96	8/8/96	8/8/96
BACILLARIOPHYTA										
Achnanthes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asterionella	57.6	36.0	14.4	10.0	0.0	9.0	0.0	0.0	0.0	0.0
Fragilaria	0.0	0.0	0.0	7.5	13.5	0.0	810.0	891.0	0.0	180.0
Gomphonema	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia	0.0	0.0	19.2	20.0	36.0	36.0	0.0	0.0	38.4	40.0
Tabellaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHLOROPHYTA										
Ankistrodesmus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
Coelastrum	0.0	0.0	0.0	20.0	108.0	216.0	2016.0	1584.0	2304.0	1600.0
Cosmarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0	0.0	0.0	0.0	18.0	13.2	0.0	0.0
Elakatothrix	3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	10.0
Oocystis	0.0	0.0	19.2	0.0	0.0	0.0	72.0	52.8	38.4	20.0
Paulschultzia	0.0	0.0	38.4	80.0	144.0	36.0	0.0	0.0	38.4	40.0
Pediastrum	0.0	0.0	9.6	0.0	0.0	0.0	18.0	26.4	19.2	0.0
Scenedesmus	14.4	14.4	9.6	10.0	216.0	180.0	108.0	52.8	0.0	10.0
Schroederia	90.0	90.0	0.0	62.5	112.5	112.5	0.0	0.0	120.0	0.0
Sphaerocystis	0.0	0.0	38.4	30.0	18.0	72.0	144.0	158.4	0.0	0.0
Staurastrum	0.0	0.0	0.0	0.0	36.0	0.0	0.0	0.0	0.0	0.0
Treubaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0
CHRYSOPHYTA										
Chrysococcus	244.8	302.4	28.8	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysosphaerella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dinobryon	0.0	0.0	72.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0
Mallomonas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Synura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA										
Cryptomonas	7.2	7.2	4.8	5.0	45.0	9.0	9.0	6.6	0.0	0.0
CYANOPHYTA										
Anabaena	0.0	0.0	1200.0	1050.0	0.0	0.0	0.0	0.0	6720.0	200.0
Aphanizomenon	0.0	0.0	0.0	0.0	0.0	0.0	175.5	128.7	2496.0	130.0
EUGLENOPHYTA										
Trachelomonas	36.0	72.0	151.2	50.0	0.0	90.0	0.0	33.0	96.0	50.0
PYRRHOPHYTA										
Ceratium	0.0	125.3	208.8	217.5	0.0	0.0	78.3	114.8	417.6	2610.0
Peridinium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RHODOPHYTA										
SUMMARY STATISTICS										
BIOMASS (UG/L)										
BACILLARIOPHYTA	57.6	36.0	33.6	37.5	49.5	45.0	810.0	891.0	38.4	220.0
CHLOROPHYTA	108.0	108.0	115.2	202.5	634.5	616.5	2376.0	1890.9	2539.2	1680.0
CHRYSOPHYTA	244.8	302.4	100.8	95.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	7.2	7.2	4.8	5.0	45.0	9.0	9.0	6.6	0.0	0.0
CYANOPHYTA	0.0	0.0	1200.0	1050.0	0.0	0.0	175.5	128.7	9216.0	330.0
EUGLENOPHYTA	36.0	72.0	151.2	50.0	0.0	90.0	0.0	33.0	96.0	50.0
PYRRHOPHYTA	0.0	125.3	208.8	217.5	0.0	0.0	78.3	114.8	417.6	2610.0
RHODOPHYTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PHYTOPLANKTON	453.6	650.9	1814.4	1657.5	729.0	760.5	3448.8	3065.0	12307.2	4890.0

Table 21b. Continued.

	PHYTOPLANKTON BIOMASS (UG/L)							
TAXON	Stafford #1a 8/22/96	Stafford #4 8/22/96	Stafford #1a 9/4/96	Stafford #4 9/4/96	Stafford #1a 9/30/96	Stafford #4 9/30/96	Stafford #1a 10/29/96	Stafford #4 10/29/96
BACILLARIOPHYTA								
Achnanthes	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0
Asterionella	0.0	0.0	2.8	0.0	0.0	12.0	10.0	12.0
Fragilaria	0.0	86.4	0.0	7.2	0.0	36.0	0.0	18.0
Gomphonema	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0
Navicula	9.0	12.0	7.0	24.0	0.0	0.0	25.0	30.0
Nitzschia	28.8	115.2	0.0	19.2	0.0	0.0	0.0	0.0
Tabellaria	0.0	0.0	11.2	9.6	0.0	0.0	40.0	48.0
CHLOROPHYTA								
Ankistrodesmus	0.0	4.8	1.4	1.2	0.0	6.0	5.0	6.0
Coelastrum	57.6	76.8	11.2	57.6	80.0	96.0	80.0	48.0
Cosmarium	28.8	38.4	11.2	0.0	0.0	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elakatothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oocystis	0.0	0.0	0.0	0.0	0.0	96.0	80.0	96.0
Paulschultzia	115.2	38.4	11.2	14.4	0.0	0.0	0.0	0.0
Pediastrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scenedesmus	14.4	76.8	28.0	33.6	60.0	24.0	20.0	24.0
Schroederia	90.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	11.2	19.2	0.0	0.0	0.0	24.0
Staurastrum	28.8	38.4	0.0	9.6	20.0	0.0	0.0	0.0
Treubaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHRYSOPHYTA								
Chrysococcus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysosphaerella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dinobryon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mallomonas	0.0	24.0	7.0	0.0	0.0	0.0	0.0	0.0
Synura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA								
Cryptomonas	0.0	0.0	0.0	4.8	0.0	0.0	1310.0	1116.0
CYANOPHYTA								
Anabaena	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aphanizomenon	14508.0	19344.0	21840.0	9048.0	6175.0	39780.0	0.0	0.0
EUGLENOPHYTA								
Trachelomonas	0.0	96.0	42.0	36.0	150.0	60.0	0.0	60.0
PYRRHOPHYTA								
Ceratium	62.6	0.0	0.0	0.0	174.0	0.0	0.0	0.0
Peridinium	0.0	0.0	0.0	25.2	0.0	0.0	0.0	0.0
RHODOPHYTA								
SUMMARY STATISTICS								
BIOMASS (UG/L)								
BACILLARIOPHYTA	37.8	213.6	21.0	61.2	0.0	48.0	75.0	138.0
CHLOROPHYTA	334.8	393.6	74.2	135.6	160.0	222.0	185.0	198.0
CHRYSOPHYTA	0.0	24.0	7.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	0.0	0.0	0.0	4.8	0.0	0.0	1310.0	1116.0
CYANOPHYTA	14508.0	19344.0	21840.0	9048.0	6175.0	39780.0	0.0	0.0
EUGLENOPHYTA	0.0	96.0	42.0	36.0	150.0	60.0	0.0	60.0
PYRRHOPHYTA	62.6	0.0	0.0	25.2	174.0	0.0	0.0	0.0
RHODOPHYTA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PHYTOPLANKTON	14943.2	20071.2	21984.2	9310.8	6659.0	40110.0	1570.0	1512.0

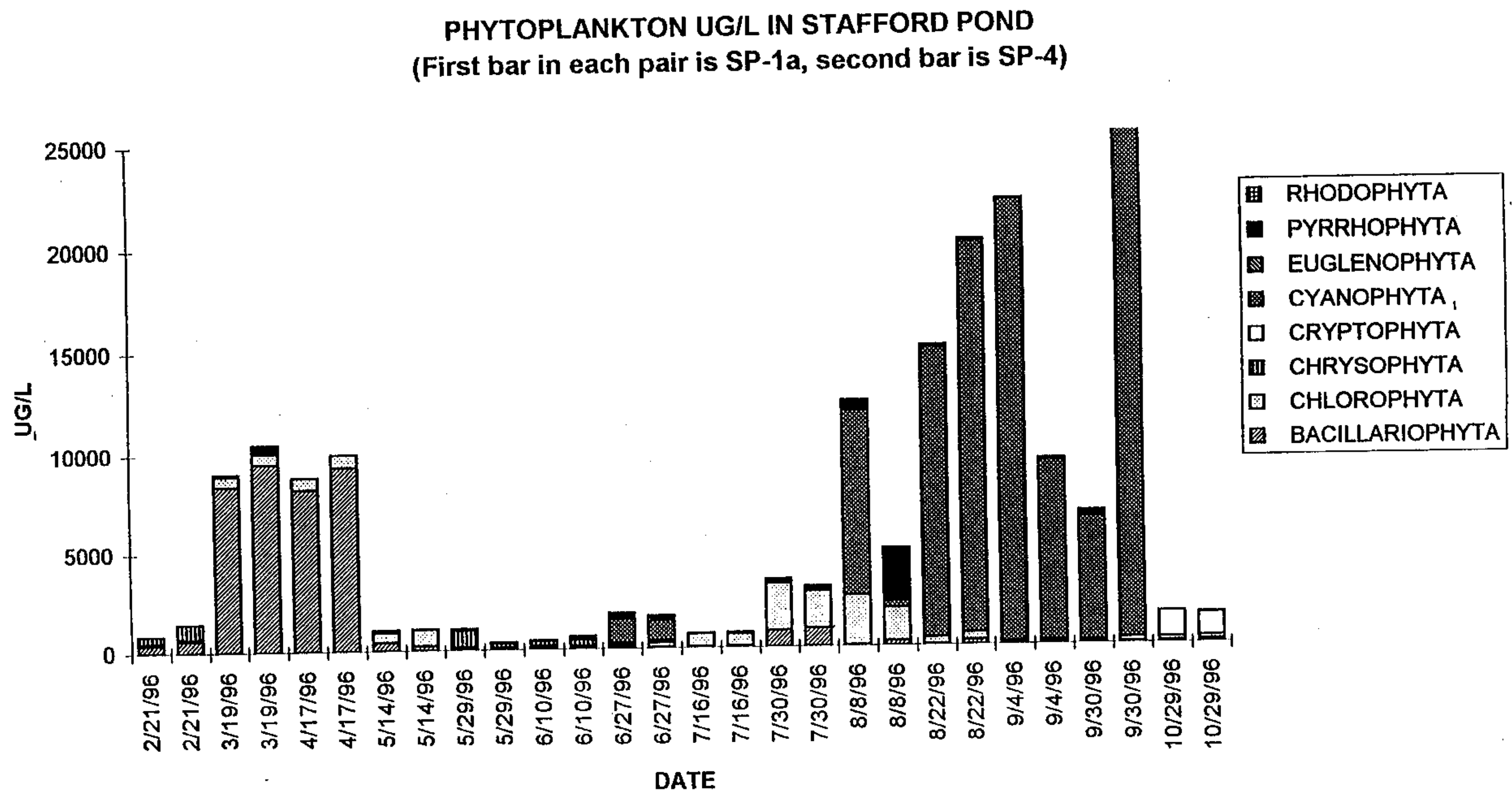


Figure 12b. Phytoplankton Biomass in Stafford Pond (1996).

treatment was conducted two weeks later, and it appears that these two treatments limited algal biomass through mid-July. While copper treatments are a relatively crude means of control with a number of possible and undesirable side effects, it is virtually certain that greater algal biomass would have been experienced earlier in the season without such treatment.

Green algae become dominant during the period of copper treatment, including mainly members of the order Chlorococcales (*Coelastrum, Oocystis, Paulschultzia, Pediastrum, Scenedesmus, Schroederia* and *Sphaerocystis*), which prefer high N:P ratios, are minimally affected by copper, and are generally resistant to grazing (they have gelatinous sheaths that allow safe passage through zooplankton digestive tracts). Green algal biomass peaked in late July at slightly over 3000 ug/L, enough to be noticeable but not enough to represent a major threat to water treatment or recreation.

In late July the bluegreen *Aphanizomenon* was first noticed. This genus is a major problem species in many lakes. It consists of small (<10 um) barrel shaped cells in a short filamentous form (usually 20-100 cells). In some cases the filaments bind together to form flakes which appear as chopped grass clippings, but in Stafford Pond and many other lakes with limited grazing capacity at the time, the filaments remain solitary.

Aphanizomenon can form heterocysts which fix dissolved nitrogen into forms usable in building proteins and other necessary compounds, much as is done by the root nodules of legumes. This strategy allows growth in nitrogen limited habitats. However, few heterocysts were observed in Stafford Pond *Aphanizomenon*, suggesting little nitrogen limitation. *Aphanizomenon* also produces akinetes, or resting cells, which sink to the bottom and re-start the population upon appropriate stimulation at a later time.

Strains of *Aphanizomenon* can also produce nerve toxins which are not removed by filtration. It is not known if the Stafford Pond *Aphanizomenon* is a toxic strain, but the treatment process employed by the Stone Bridge Fire District is among the best for removing any such toxin.

Three other features of Aphanizomenon are noteworthy. It is less temperature sensitive than most bluegreens, rarely beginning a bloom in cold temperatures but often persisting and thriving through the winter under the ice. Additionally, it is buoyant by virtue of gas vesicle in each cell, and will form surface scums in the absence of significant wind mixing. Finally, and very importantly in this case, it is more resistant to copper than most bluegreens. The treatments which controlled *Anabaena* may therefore have hastened the arrival of *Aphanizomenon.*

The late summer *Aphanizomenon* bloom has been a problem in Stafford Pond for at least 6 years, and appears to be intensifying. The logical progression would be for the bloom to persist longer each year, extending into fall or even winter, although the variability induced by weather pattern may obscure any trend for many years. In 1996 the bloom became unstable in September, with concentrations becoming patchy, and was gone by the end of October. The cryptophyte *Cryptomonas* was the most common post-bloom genus; this genus thrives in waters of high organic carbon content, as would be expected upon die off of an algal bloom. Biomass was much reduced at this time, however, transitioning rapidly from values in excess of 6000 ug/L to levels around 1500 ug/L. The Stone Bridge Fire District has reported no serious algal problems into March of 1997.

Zooplankton

Zooplankton are useful in the assessment of algal dynamics and fish community structure, and were assessed on three dates in 1996. Estimates of zooplankton density and biomass for Stafford Pond are presented in Table 22. The zooplankton assemblage was not very rich, but exhibited moderate to high diversity and evenness. protozoans were virtually absent in our samples, and rotifers were rare, both unusual occurrences in this region. Only two copepod genera were detected, neither at great abundance. Represented Cladocera included *Bosmina, Ceriodaphnia*, and three species of *Daphnia*, as well as the predatory *Leptodora*. Numerical abundance was generally low, although the mid-summer increase in *Daphnia galeata* produced moderate biomass in that one sample. Such a mid-summer abundance is also unusual, since predation by young fish on this favored food is normally most intense at this time. More frequent sampling would be necessary to better assess community dynamics.

The presence of large bodied *Daphnia* (a crustacean form known as a cladoceran) at densities of more than about 10/L and biomasses in excess of about 100 ug/L can produce substantial grazing pressure on algae and aid control of algal biomass. These conditions were approached in the late July sample, but were not achieved in either the May or August samples. It is probable that zooplankton biomasses rose sharply after the May sampling, and that grazing was partly responsible for the clear water period in June. Persistence of *Daphnia* into late July suggests that the grazing pressure from young fish was not substantial until at least that time. Collapse of the *Daphnia* population by late August may have been a combined effect of predation and poor quality food resources (mainly *Aphanizomenon*). *Daphnia* appear to have survived the copper treatments, suggesting that the dose was not excessive, and by late July would have normally laid resting eggs which ensure annual late spring population rejuvenation in this type of habitat.

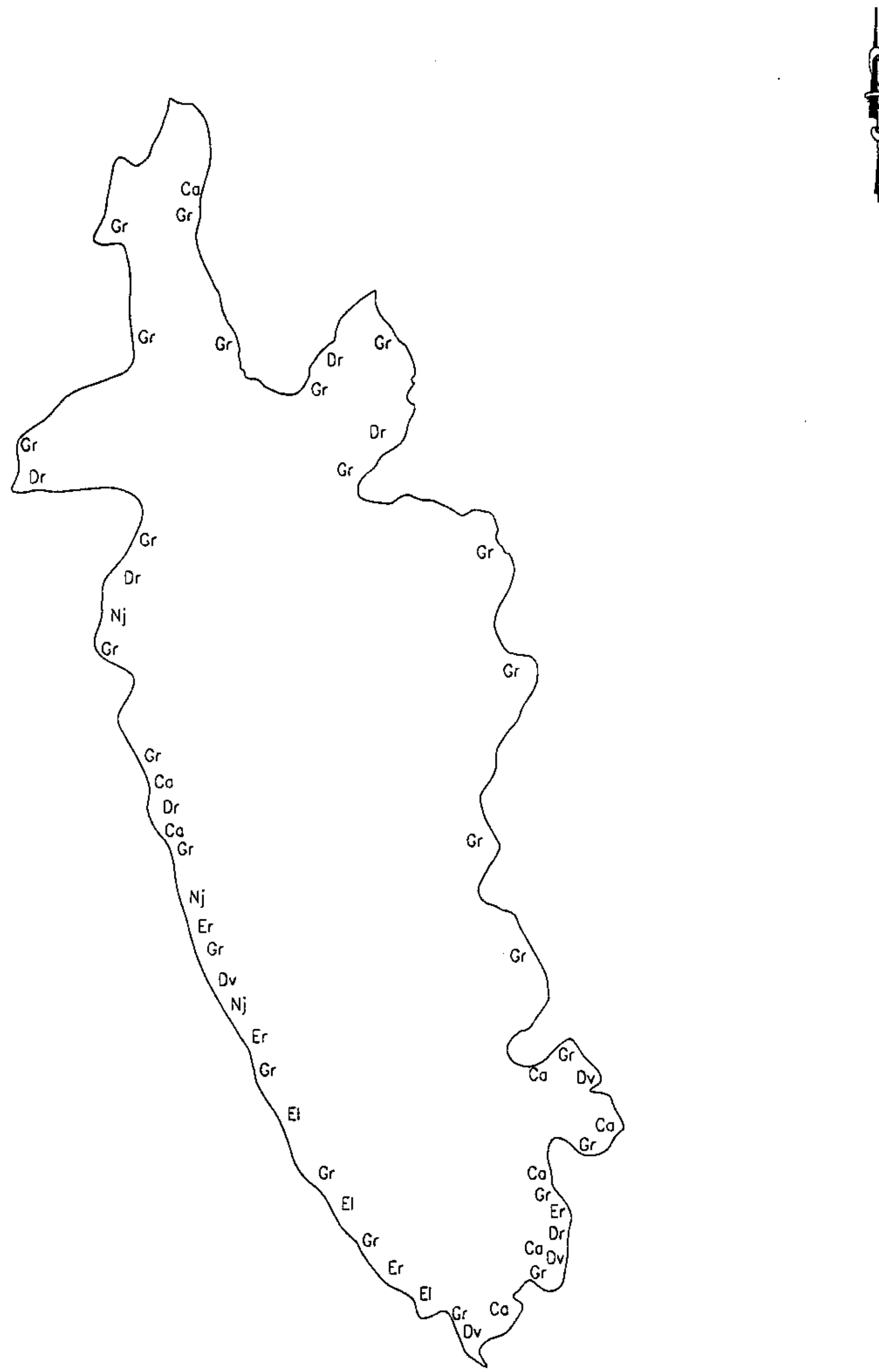
The mean size of crustacean zooplankton provides and indication of fishery conditions (Mills et al. 1987), with small mean length (<0.5 mm) indicating dominance of the fish community by small planktivores and large mean length (>0.9 mm) suggesting dominance by older, larger fish. This latter condition sounds great for fishing, but may indicate a lack of recruitment for smaller/younger size classes and possible fishery instability. Mean length was approximately 0.5 mm in May and August, but 1.2 mm in July. Further investigation is warranted from a fishery perspective.

Aquatic Vascular Plants

Maps of vascular plant community composition and density are presented in Figure 13a and 13b. Results of the aquatic vascular plant surveys revealed that rooted plant growth was minimal in Stafford Pond. Rooted plants grew only near the periphery of the pond and plant densities did not exceed 25 percent cover or biovolume. Community structure and composition was basically the same between the June and August surveys. Only seven taxa of aquatic vascular plants were documented in the pond. These included *Drapanocladus* sp. (fish moss), *Eleocharis* sp.

Table 22. Zooplankton Density and Biomass in Stafford Pond (1996).

TAXON	ZOOPLANKTON DENSITY (#/L) Stafford 5/14/96	Stafford 7/30/96	Stafford 8/22/96	ZOOPLANKTON BIOMASS (UG/L) Stafford 5/14/96	Stafford 7/30/96	Stafford 8/22/96
PROTOZOA						
Ciliophora	0.0	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0	0.0
ROTIFERA						
Keratella	0.1	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.1	0.0	0.0	0.0	0.0	0.0
COPEPODA						
Copepoda-Cyclopoida						
Mesocyclops	0.8	1.4	0.0	3.4	12.0	0.0
Copepoda-Calanoida						
Diaptomus	0.0	1.2	0.0	0.0	4.4	0.0
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	0.5	0.3	0.0	1.3	0.8	0.1
CLADOCERA						
Bosmina	5.0	0.0	0.0	9.9	0.0	0.0
Ceriodaphnia	0.2	0.2	0.0	0.5	0.4	0.0
Daphnia ambigua	1.5	0.0	0.0	5.8	0.0	0.0
Daphnia galeata	0.0	9.0	0.0	0.0	103.3	0.0
Daphnia pulex	0.0	0.2	0.0	0.0	3.9	0.1
Leptodora	0.0	0.1	0.0	0.0	6.6	0.0
OTHER ZOOPLANKTON						
Bryozoa	0.0	0.0	0.0	0.0	0.0	0.0
Chaoboridae	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae	0.0	0.0	0.0	0.0	0.0	0.0
Coelentarata	0.0	0.0	0.0	0.0	0.0	0.0
Culicidae	0.0	0.0	0.0	0.0	0.0	0.0
Eubranchiopoda	0.0	0.0	0.0	0.0	0.0	0.0
Gastrotrichia	0.0	0.0	0.0	0.0	0.0	0.0
Hydracarina	0.0	0.0	0.0	0.0	0.0	0.0
Mysidacea	0.0	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0
SUMMARY STATISTICS						
DENSITY						
PROTOZOA	0.0	0.0	0.0	0.0	0.0	0.0
ROTIFERA	0.1	0.0	0.0	0.0	0.0	0.0
COPEPODA	1.3	3.0	0.1	4.7	17.2	0.1
CLADOCERA	6.7	9.5	0.0	16.3	114.3	0.1
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	8.1	12.5	0.1	21.0	131.6	0.2
TAXONOMIC RICHNESS						
PROTOZOA	0	0	0			
ROTIFERA	2	0	2			
COPEPODA	2	3	3			
CLADOCERA	3	4	2			
OTHER ZOOPLANKTON	0	0	0			
TOTAL ZOOPLANKTON	7	7	7			
S-W DIVERSITY INDEX	0.51	0.42	0.80			
EVENNESS INDEX	0.61	0.50	0.95			
MEAN LENGTH (MM): ALL FORMS	0.49	1.20	0.43			
MEAN LENGTH (MM): CRUSTACEA	0.50	1.20	0.49			



Legend:

- Ca = Callitriche sp.
- Dr = Drepanocladus
- Dv = Decodon verticillatus
- El = Eleocharis sp.
- Er = Eriocaulon sp.
- Gn = Gratiola neglecta
- Nj = Najas sp.

0 1333
Scale in Feet

Client: **Rhode Island Department Of Environmental Management**

Aquatic Macrophyte Community Composition In Stafford Pond (1996)

Figure 13a

FUGRO

June 1996	Job No. 16-16-9144

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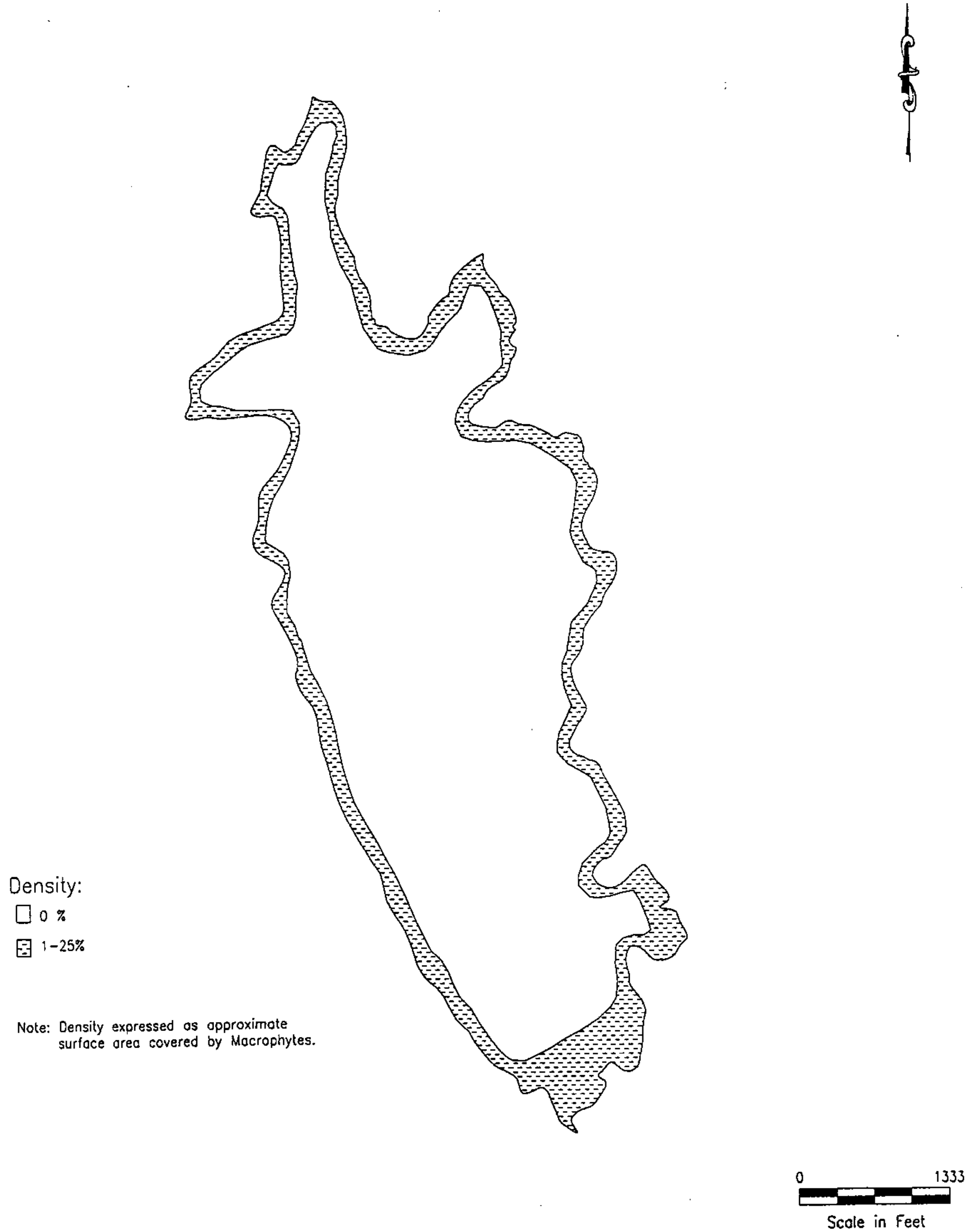
REV. 12FEB97 E. B.



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Client: Rhode Island Department Of Environmental Management	Density Of Aquatic Macrophyte Assemblages In Stafford Pond (1996)	Figure 13b	FUGRO
	June 1996 / Job No. 16-16-9144		

REV. 12FEB97 E. B.

(spikerush), *Gratiola neglecta* (hedge hyssop), *Callitriche* sp. (starwort), *Decodon verticillatus* (swamp loosestrife), *Najas* sp.(waterweed), *and Eriocaulon* sp. (pipewort) All seven taxa are native to New England and only one (*Najas* sp.) is sometimes considered a nuisance.

Light and substrate factors combine to severely limit rooted plant growth in Stafford Pond. Low light from algal bloom induced turbidity reduces the maximum depth at which rooted plants can grow, but even if the water was quite clear there would be limited growth on the rather rocky pond bottom.

Fish

The fish community of Stafford Pond is typical of many warm water New England lakes. Expected species composition is as follows: bluegill *(Lepomis macrochirus)*, pumpkinseed *(Lepomis gibbosus)*, smallmouth bass *(Micropterus dolomieui)*, largemouth bass *(Micropterus salmoides)*, yellow perch *(Perca flavescens)*, white perch *(Morone americana)*, brown bullhead *(Ameiurus nebulosus)*, and stocked trout (Salmonidae). Species composition was derived from Guthrie and Stolgitis (1990) and an unpublished electrofishing survey conducted in June of 1994 by the Rhode Island Department of Environmental Management, Division of Fish and Wildlife.

Seining and gill-netting were conducted during October of 1996 to supplement historic fishery data. Sampling locations are presented in Figure 5. Results are presented in Table 23a through 23e. Only four species of fish were collected during this investigation. Yellow perch and white perch dominated the total catch, with 112 and 49 individuals, respectively. Two rainbow trout *(Oncorhynchus mykiss)* and 20 young-of-year bluegills were also collected in a single seine haul. Yellow perch ranged in size from 175-248 mm. White perch ranged in size from 278-342 mm. Younger age classes of yellow and white perch were not represented in the total catch. This is either a result of sampling bias (gear selectivity) or inadequate reproduction/recruitment, either of which is possible in this case.

Tumors, fungus, and other external anomalies were not present on any of the collected fish. Review of life history data from Carlander (1950) and Mullan (1973) indicated that length/weight relationships for yellow perch were about average and length/weight relationships for white perch were slightly above average for north central and northeastern regions of the United States. Length/weight relationships provide a general indication of well being, and in the case of Stafford Pond these relationships indicate that individual fish were in relatively good health.

Waterfowl

Approximate numbers of waterfowl recorded during sampling visits to Stafford Pond are presented in Table 24. The greatest numbers of waterfowl were documented during spring and late summer/early fall. All observations were recorded during daylight hours. The majority of waterfowl sitings involved gulls (Larinae), Canada geese (*Branta canadensis*), mallards (*Anas platyrhynchos*), black ducks (*Anas rubripes*), and ruddy ducks (*Oxyura jamaicensis*). Numbers of waterfowl were not insignificant, especially when the birds congregated near the water treatment facility intake, but most birds were sighted near Pelletier point at the outlet end of the lake, and overall density was not large on a regular basis.

Table 23a. Results of the Fish Survey Conducted at Stafford Pond (1996).

Gill Net	Date	Time Set	Time Pulled	Duration (hr)	Location	Type of Gill-Net	Type of Set	Result
1	28-Oct	10:02	11:38	1:36	Figure 10	Experimental (1"-2"-3")	bottom	Table 43b
2	28-Oct	12:30	13:30	1:00	Figure 10	Experimental (1"-2"-3")	bottom	No Fish
3	28-Oct/29-Oct	14:30	10:00	19:30	Figure 10	Experimental (1"-2"-3")	bottom	Table 43c
4	29-Oct	11:40	12:51	1:11	Figure 10	Experimental (1"-2"-3")	bottom	No Fish
5	29-Oct	14:00	15:20	1:20	Figure 10	Experimental (1"-2"-3")	bottom	Table 43d

Seine Haul	Date	Start Time	End Time	Duration (hr)	Location	Type of Seine	Result
A	28-Oct	10:30	11:15	0:45	Figure 10	300'x8' (1/4" mesh)	No fish
B	28-Oct	11:50	12:25	0:35	Figure 10	300'x8' (1/4" mesh)	Table 43e
C	28-Oct	12:55	13:40	0:45	Figure 10	300'x8' (1/4" mesh)	No fish
D	28-Oct	14:40	15:20	0:40	Figure 10	300'x8' (1/4" mesh)	No fish

Table 23b. Fish Collected in Gill-Net Set #1.

Common Name	Scientific Name	Length (millimeters)	Weight (grams)
white perch	*Morone americana*	295	451
white perch	*Morone americana*	285	379
white perch	*Morone americana*	280	365
white perch	*Morone americana*	295	427
white perch	*Morone americana*	290	405
white perch	*Morone americana*	295	443
white perch	*Morone americana*	300	469
yellow perch	*Perca flavescens*	200	95
yellow perch	*Perca flavescens*	175	61
yellow perch	*Perca flavescens*	205	91
yellow perch	*Perca flavescens*	220	131
yellow perch	*Perca flavescens*	194	90
yellow perch	*Perca flavescens*	205	121
yellow perch	*Perca flavescens*	205	107
yellow perch	*Perca flavescens*	194	92
yellow perch	*Perca flavescens*	193	87
yellow perch	*Perca flavescens*	180	78
yellow perch	*Perca flavescens*	191	84
yellow perch	*Perca flavescens*	190	87
yellow perch	*Perca flavescens*	198	90
yellow perch	*Perca flavescens*	175	68
yellow perch	*Perca flavescens*	204	105

A total of 64 yellow perch were caught in the gill-net. Lengths/weights for a sub-sample of 15 fish are provided in the above table.

Table 23c. Fish Collected in Gill-Net Set #3.

Common Name	Scientific Name	Length (millimeters)	Weight (grams)
white perch	*Morone americana*	342	743
white perch	*Morone americana*	308	497
white perch	*Morone americana*	284	399
white perch	*Morone americana*	300	430
white perch	*Morone americana*	300	468
white perch	*Morone americana*	278	372
white perch	*Morone americana*	290	439
white perch	*Morone americana*	290	408
white perch	*Morone americana*	281	383
white perch	*Morone americana*	335	728
white perch	*Morone americana*	285	395
white perch	*Morone americana*	311	574
white perch	*Morone americana*	300	488
white perch	*Morone americana*	295	443
white perch	*Morone americana*	288	415
yellow perch	*Perca flavescens*	187	84
yellow perch	*Perca flavescens*	220	110
yellow perch	*Perca flavescens*	248	199
yellow perch	*Perca flavescens*	195	96
yellow perch	*Perca flavescens*	195	83
yellow perch	*Perca flavescens*	228	151
yellow perch	*Perca flavescens*	193	86
yellow perch	*Perca flavescens*	224	140
yellow perch	*Perca flavescens*	210	105
yellow perch	*Perca flavescens*	215	121
yellow perch	*Perca flavescens*	233	164
yellow perch	*Perca flavescens*	187	76
yellow perch	*Perca flavescens*	206	96
yellow perch	*Perca flavescens*	222	123
yellow perch	*Perca flavescens*	214	97

A total of 42 white perch and 35 yellow perch were caught in the gill-net.
Lengths/weights for a sub-sample of 15 fish are provided in the above table.

Table 23d. Fish Collected in Gill-Net Set #5.

Common Name	Scientific Name	Length (millimeters)	Weight (grams)
yellow perch	*Perca flavescens*	193	72
yellow perch	*Perca flavescens*	201	81
yellow perch	*Perca flavescens*	196	84
yellow perch	*Perca flavescens*	179	68
yellow perch	*Perca flavescens*	212	101
yellow perch	*Perca flavescens*	208	97
yellow perch	*Perca flavescens*	193	82
yellow perch	*Perca flavescens*	202	97
yellow perch	*Perca flavescens*	201	89
yellow perch	*Perca flavescens*	215	115
yellow perch	*Perca flavescens*	191	79
yellow perch	*Perca flavescens*	205	98
yellow perch	*Perca flavescens*	196	79

Table 23e. Fish Collected in Seine-Haul B.

Common Name	Scientific Name	Length (millimeters)	Weight (grams)
rainbow trout	*Oncorhynchus mykiss*	342	449
rainbow trout	*Oncorhynchus mykiss*	365	522
bluegill	*Lepomis macrochirus*	35	<1
bluegill	*Lepomis macrochirus*	45	<1
bluegill	*Lepomis macrochirus*	45	<1
bluegill	*Lepomis macrochirus*	40	<1
bluegill	*Lepomis macrochirus*	40	<1
bluegill	*Lepomis macrochirus*	28	<1
bluegill	*Lepomis macrochirus*	38	<1
bluegill	*Lepomis macrochirus*	40	<1
bluegill	*Lepomis macrochirus*	45	<1
bluegill	*Lepomis macrochirus*	37	<1
bluegill	*Lepomis macrochirus*	30	<1
bluegill	*Lepomis macrochirus*	45	<1
bluegill	*Lepomis macrochirus*	44	<1
bluegill	*Lepomis macrochirus*	38	<1
bluegill	*Lepomis macrochirus*	35	<1

A total of 20 bluegill were caught in the seine-haul. Lengths/weights for a sub-sample of 15 fish are provided in the above table.

Table 24. Approximate Numbers of Waterfowl Recorded During Sampling Visits to Stafford Pond (1996).

Date	# Birds
21-Feb	25
19-Mar	25
17-Apr	350
14-May	25
29-May	25
10-Jun	25
27-Jun	25
17-Jul	25
30-Jul	25
8-Aug	25
22-Aug	500
5-Sep	100
29-Oct	500
mean	*129*

Aquatic Invertebrates

A detailed survey of the invertebrate community of Stafford Pond was not conducted as part of this investigation. However, it is expected that Stafford Pond would harbor a warm water macroinvertebrate assemblage typical of many New England lakes. Based upon the morphological characteristics of the pond, its substrate and the presence of some rooted aquatic plants, the macroinvertebrate community is expected to be dominated by four Orders; Diptera (flies), Coleoptera (beetles), Hemiptera (true bugs), and Odonata (dragonflies and damselflies).

Amphibians and Reptiles

Amphibian and reptile populations were not specifically investigated as part of this study. However, it is expected that a number of species would inhabit the perimeter of the pond and adjacent wetlands, as suitable habitat is abundant. Turtle, snake, frog, and salamander species that are likely to inhabit this ecosystem include: snapping turtle (*Chelydra serpentina*), painted turtle (*Chrysemys picta*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans melnota*), American toad (*Bufo americana*), gray treefrog (*Hyla versicolor*), spring peeper (*Hyla crucifer*), wood frog (*Rana sylvatica*), pickerel frog (*Rana palustris*), red spotted newt (*Notophthalmus v. viridescens*), and red backed salamander (*Plethodon cinereus*).

POND USE EVALUATION

WATER SUPPLY AND WITHDRAWAL IMPACTS

As previously mentioned under the Physical Pond Features-Hydrology section of this report, during 1996 the net withdrawal for drinking water purposes averaged 836,729 gal/day. This would equate to a 0.16 foot decrease in pond water elevation during a 30 day month, assuming no inflows to offset the withdrawal. Under the very dry summer conditions of 1995, this could have resulted in a 0.5 ft decline in water level. Even at elevated summer withdrawal rates, no more than a 1.0 ft drawdown would be possible from withdrawal alone. Withdrawing water from the pond does increase the likelihood that surface outflow will cease during the summer months, when pond outputs are typically greater than inputs. However, even without the drinking water withdrawal it is likely that surface outflow would cease; pond outputs would still be greater than pond inputs, as evaporation significantly increases during this time of year. Evaporation can cause the loss of close to 1.0 ft of water during a typical summer, with peaks to about 1.2 ft. Water withdrawal from Stafford Pond is therefore significant during the summer, but is not the major component of system hydrology.

Discharge of filter backwash into the lake is another mode of possible impact by the water withdrawal and treatment operation. Backwash includes primarily contaminants removed from the lake water, but also may include coagulants and other additives used in the treatment process. Discharge of this water and associated contaminants to Stafford Pond is undesirable, but is mitigated to some extent by inactivation with aluminum and prior settling in clarification tanks. Only during times of frequent backwashing (e.g., summer algal blooms) is settling time inadequate. As most contaminants are inactivated by aluminum, which is very stable at most encountered pH ranges, recycling into the lake is unlikely to be substantial, even when backwash is inadequately settled prior to discharge. Testing of backwash water revealed the lowest levels of phosphorus encountered in this study. While discharge of backwash to the pond is not an ideal situation, it does not appear to represent a significant threat to water quality.

BOATING AND WATERCRAFT IMPACTS

Motorized boating activities may influence lake ecology in a number of ways, some positive but most negative (Wagner 1990, Table 25a). Although most conceivable boating impacts appear adverse to lake ecology, their impact is highly variable and may not be obvious or even detectable in many cases. Degree of impact is a function of both lake features and motorized watercraft characteristics.

Many features of a lake predispose it to certain impacts and may protect it from others (Wagner 1990, Table 25b). Stafford Pond is a relatively large body of water that could potentially experience a significant amount of boat traffic. The regularly mixed volume of Stafford Pond is moderate, thus providing a moderate amount of dilution water to counteract pollution inputs from boats or re-suspension of bottom sediments. However, the hydraulic residence time is very high (>365 days), indicating that water and pollutants stay in the pond for a long period of time. The shoalness ratio for Stafford Pond is high, with greater than 60% of the total lake area being less than 20 feet in depth. Additionally, the shallowness ratio for Stafford Pond is also relatively

Table 25a. Potential Motorized Watercraft Impacts on Water Resources and Associated Biota.

A. Altered water quality
1. Increased turbidity
2. Increased nutrient levels
3. Increased hydrocarbon concentrations
4. Increased metals levels
5. Increased oxygenation
6. Increased contamination by pathogens
7. Changes in taste and odor

B. Altered sediment quality
1. Redistribution of particles
   a. Shoreline erosion
   b. Littoral zone changes
2. Increased nutrient accumulations
3. Increased hydrocarbon accumulations
4. Increased metals accumulations

C. Altered flora
1. Epilimnetic mixing of plankton
2. Inhibition of algal growth
3. Stimulation of algal growth
4. Inhibition of rooted plant growth
   a. Direct damage
   b. Indirect suppression
5. Dispersal of rooted plants

D. Altered fauna
1. Collision-induced mortality
2. Reduced reproductive success
3. Changes through food resource modification
4. Changes through habitat modification
   a. Physical habitat
   b. Chemical habitat
5. Flesh tainting

Table 25b. Characteristics of Lake Ecosystems that Influence Ecological Impact by Motorized Watercraft.

1. Lake area
   a. Low (<20 ac)
   b. Medium (20-100 ac)
   c. Large (100-300 ac)
   d. Very Large (>300 ac)
2. Epilimnetic volume
   a. Low (<300 million gal)
   b. Medium (130-653 million gal)
   c. Large (653-1960 million gal)
   d. Very large (>1960 million gal)
3. Hydraulic residence time
   a. Low (<21 days)
   b. Medium (21-90)days
   c. High (90-365 days)
   d. Very high (>365 days)
4. Shoalness ratio
   (area <20 ft deep/total area)
   a. Low (<0.25)
   b. Medium (0.25-0.50)
   c. High (0.5-0.75)
   d. Very high (0.75-1.00)
5. Shallowness ratio
   (area <5 ft deep/total area)
   a. Low (<0.10)
   b. Medium (0.10-0.25)
   c. High (0.25-0.50)
   d. Very high (>0.50)
6. Shoreline configuration
   (shoreline length/circumference of circle with lake area)
   a. Low (<1.5)
   b. Medium (1.5-3.0)
   c. High (>3.0)
7. Littoral zone bottom coverage by rooted plants
   a. Low (<25%)
   b. Medium (25-50%)
   c. High (50-75%)
   d. Very high (75-100%)
8. Substrate type
   a. Cobble
   b. Gravel and sand
   c. Silt or clay
   d. Organic muck

high, with nearly 25% of the total lake area less than 5 feet in depth. The shoalness and shallowness ratios are indicators of the portion of the pond bottom that could potentially be impacted by turbulence from motorized watercraft. However, the lack of fine sediments in shallow portions of the lake offsets the potential for impact suggested by shallowness and shoalness ratios.

Shoreline configuration at Stafford Pond indicates that only a few small coves are present, and boulders limit boat use of these coves. Littoral zone bottom coverage by rooted aquatic plants appears to be low (<25%), according to field investigations conducted during the summer of 1996. Rooted aquatic plant coverage can help to minimize resuspension of bottom sediments. Again however, benthic substrates in Stafford Pond are primarily comprised of boulder, cobble, gravel, and sand in water depths <15 feet; turbulence impacts by boating are therefore minimized.

During 1996, approximate numbers and types of boats were recorded on most sampling visits to Stafford Pond (Table 25c). Boat use was very low during this period of time, probably related to poor water quality conditions, including frequent algal blooms, and the cool, wet and cloudy conditions prevalent during 1996. Weekend visits were not conducted, however, and boating density would be expected to be greater on weekends. The boat ramp parking area could support about 20 vehicles with trailers, although no more than 5 vehicles were ever observed in this area. The greatest number of watercraft was documented on May 14, 1996 when a total of four boats were present. The majority of watercraft documented were small fishing boats with outboard engines. A few personal watercraft were observed. The largest boats and engines tend to be associated with shorefront property owners who moor and operate those boats seasonally. There is a 10 hp limit for boats on Stafford Pond which appears to be observed by most people bringing boats to the lake, but not by shoreline residents.

In terms of safety, boater enjoyment, and general environmental protection, each boat should be afforded 10-20 acres of obstacle-free water area with a depth of at least 5 ft. at any given time. This is especially important at Stafford Pond, where submerged and protruding boulders pose a definite safety threat and create greater risk of a fuel spill. Although the lake has an area of 487 acres, much of this area is not boatable as a consequence of boulder obstacles. Additionally, a 200 ft limit should be observed with relation to the shoreline to minimize wake damage and user conflicts; Rhode Island boating law allows for a 200 ft separation between boating and swimming areas. This limit should be expanded further if the water is shallow (<5 ft deep) at a distance of 200 ft from shore. For Stafford Pond, about half of the lake, or 250 acres, is boatable. Therefore, a density of 12-25 motorized watercraft should be tolerable. Although such densities are possible, they were not observed or reported during this investigation.

Given the use of Stafford Pond as a drinking water supply, there is a definite risk posed by the use of motorized watercraft in the pond. Although some physical features of the pond make it susceptible to impacts, actual boating densities appear low and no impacts were clearly observed. Water quality data described previously suggest no substantive impacts on water quality which could be ascribed to motorized watercraft. The same conditions which generate concern by those using the lake for other purposes are of concern to boaters, most notably the decreased water

Table 25c. Approximate Numbers and Types of Boats Recorded on Sampling Visits to Stafford Pond (1996).

Date	# Boats	Engine Type
21-Feb	0	
19-Mar	0	
17-Apr	2	gas-outboard
14-May	4	gas-outboard
29-May	1	gas-outboard
	1	electric
10-Jun	3	gas-outboard
27-Jun	2	gas-outboard
17-Jul	2	gas-outboard
	1	no motor
30-Jul	3	gas-outboard
8-Aug	1	gas-inboard
	1	no motor
22-Aug	1	gas-inboard
	1	no motor
5-Sep	2	gas-outboard
29-Oct	0	

clarity. Should Stafford Pond regain its former clarity and become a popular boating resource, management of motorized watercraft densities may be necessary to minimize environmental impacts and user conflicts. For now, however, there does not appear to be a major threat from boating in accordance with state and local laws.

FISHING AND FISHERY CONSIDERATIONS

Depending upon how the situation is viewed, present conditions in the pond can either be positive or negative regarding fishing and fisheries. One school of thought holds that nutrient enrichment means greater production and biomass and thus more and bigger fish, suggesting that conditions in Stafford Pond may be favorable. However, nutrient enrichment in the case of Stafford Pond is excessive and has many potential negative impacts on fishing and fisheries.

Excessive nutrient loading is directly related to a high degree of decomposition on the pond bottom. During the summer of 1996, it was noted that decomposition of organic matter created an oxygen deficit in the bottom two meters of the pond, and this zone could increase in volume during a drier, calmer summer. This area of the pond is crucial habitat for cold water species such as trout as they seek refuge from the warmer upper waters during summer. Additionally, increased nutrient enrichment has resulted in an accumulation of oxygen-demanding organic muck in the pond, thus reducing usable habitat for many invertebrate species and potentially reducing spawning habitat for a self sustaining population of smallmouth bass. Frequent algal blooms can create physical or chemical stress on fish, including irritation and clogging of gill membranes. Finally, frequent algal blooms associated with excessive nutrient enrichment are aesthetically unpleasant to most lake users, including anglers.

Questions of quantity and quality must be considered in lake management for fish production. Greater productivity may not be desirable if it causes longer term instability or if qualitative aspects of the fishery (type and condition of fish) or fishing experience (sense of sight or smell) are impaired. The eutrophication experienced by Stafford Pond does appear to have negative effects on stability, as evidenced by discontinuous size distributions for captured species, and on fishing, as demonstrated by angler dissatisfaction with pond appearance.

SWIMMING AND RELATED CONTACT RECREATION

Stafford Pond is categorized as a Class B waterbody by the State of Rhode Island (RIDEM 1988). Designated uses under the Class B category include public water supply with appropriate treatment, agricultural uses, primary contact recreation, and fish/wildlife habitat. Present conditions in the pond are distinctly undesirable for swimming, especially during algal bloom conditions or anywhere in the vicinity of the northern tributary. Low clarity creates unsafe conditions during much of the swimming season, while fecal bacterial levels near the northern tributary suggest a possible health hazard. While there is no public beach on Stafford Pond, use by shorefront residents is certainly possible, although inadvisable under current conditions. Waterskiing and other forms of contact recreation are inherently unsafe under such low water clarity, especially in light of the many boulders in the lake.

As most drinking water supply reservoirs have restrictions regarding contact recreation, there would be a potential conflict among users if conditions were improved in Stafford Pond. A ban on contact is often invoked, at least within some horizontal distance of the water intake, for the purpose of avoiding pathogenic contamination of the water supply. Given the long detention time in Stafford Pond and the tendency for pathogens to die off under oxic conditions, some spatial arrangement might be possible to allow contact recreation to coexist with water supply functions. However, mixing appears substantial in this system, both horizontally and vertically, and further evaluation is necessary before a scientifically based decision could be made. Under current conditions, swimming is to be discouraged for safety and health reasons, minimizing any conflict with water supply.

OTHER USES

The primary other uses of the pond are for aesthetic enjoyment and landing of an occasional float plane. Aesthetic enjoyment and related passive uses are most impaired by summer algal blooms, and improvement for water supply purposes and aesthetic appeal are entirely consistent; no conflict exists. Use by float planes poses the same risk as use by motorized watercraft, but given the nominal use of the lake for such purposes, this is not a major threat to other uses or lake condition.

Diagnostic Summary

The watershed draining to Stafford Pond is approximately 947 acres in size. The watershed:lake area ratio is small (<2:1), indicating high potential for successful management. Available geology and soils information indicate that infiltration capacity is slow and average runoff rates are moderate. Forested and residential land use categories predominate in the Stafford Pond watershed.

Stafford Pond is approximately 487 acres in size. Average and maximum water depths were 13 and 25 feet, respectively. Pond volume was approximately 271,800,000 ft^3 or 2.04 billion gallons. Benthic sediments were comprised mostly of boulder, cobble, gravel, and sand in water depths <15 ft. Mucky bottom sediments were more prevalent in the deeper areas of the pond, and also at the mouth of the northern tributary. Two tributaries and two stormwater pipes discharge to Stafford Pond. An outlet structure located along the northern perimeter of the pond controls the outward flow of water into Sucker Brook and is managed by downstream parties.

Average annual water load to Stafford Pond is approximately 5.5 cfs, assuming normal precipitation conditions. Flow into Stafford Pond is derived from a combination of direct precipitation (46%), ground water inseepage (18%), surface water base-flow (13%), and surface water storm-flow (23%). Pond outputs were derived from a combination of evaporation (31%), ground water outseepage (4%), surface outflow (42%), and withdrawal (water treatment facility @ 23%). Stafford Pond has a flushing rate of 0.65 times per year, a detention time of 1.54 years, and a response time of 0.65-1.08 years.

The most salient results of routine chemical monitoring are as follows: Low levels of dissolved oxygen were recorded in the bottom two meters of the pond, primarily during the summer months. Total alkalinity, total hardness, and conductivity were low at all sites except SP5b. Higher values at SP5b appear to be a result of inputs from a dairy farm located in this area of the watershed. Average Secchi transparency and concentrations of chlorophyll a in Stafford Pond were indicative of eutrophic conditions. Values of inorganic and total nitrogen were low at all sites except SP5b, where concentrations were high. Concentrations of total phosphorus were generally elevated (>0.025 mg/L) and indicative of eutrophic conditions at all sampling locations except SP11 and SP12 (water treatment plant backwash). Average total phosphorus concentrations were exceedingly high (>0.1 mg/L) at SP5b. The total nitrogen:total phosphorus ratio in Stafford Pond was greater than 15:1, indicating that phosphorus is most likely the limiting nutrient for plant growth in this system, although light is probably the most critical limiting factor much of the time.

The most salient results of supplemental chemical monitoring are as follows: Cadmium was not detected in water samples from Stafford Pond. Lead was detected only at sampling location SP1a, where the lead concentration was below the Maximum Contaminant Level for drinking water, but slightly above the chronic toxicity threshold for aquatic life. A single water sample was collected at SP1a during the month of October and was analyzed for mercury; results indicated that mercury was non-detectable (<0.00255 ug/L). Copper was detected at all sampling

Sodium

locations. Concentrations were below the MCL for drinking water, but were above acute and chronic toxicity thresholds for aquatic life. Aluminum concentrations were normal at all sampling locations.

Concentrations of calcium and magnesium were low at all in-pond sampling locations. Concentrations of sodium and chloride were moderate at all in-pond sampling locations and did not indicate significant pollution. Concentrations of dissolved iron and manganese were considered relatively low at all in-pond sampling locations. Monitoring of selected organic compounds in water from Stafford Pond indicated relatively low levels. In-pond concentrations of total petroleum hydrocarbons ranged from <0.5 to 3.2 mg/L. Concentrations above 1 mg/L are sometimes cause for concern, but many natural compounds can register as TPH in typical laboratory tests. Polynuclear aromatic hydrocarbons provide a better indication of anthropogenic hydrocarbon inputs, and were not detected. DDT and PCB's were also not detected.

The most salient results of storm water chemical monitoring are as follows: Average values of conductivity were high at SP5b and exceedingly high at SP9. Values of inorganic and total nitrogen were low at SP6 and SP10, and high at the remaining sites. The highest values were recorded at SP5b. Average wet weather concentrations of total phosphorus were high (>0.05 mg/L) at all sites except SP10 (precipitation). Once again, the highest concentrations were recorded at SP5b. Cadmium was not detected in storm water entering Stafford Pond. Lead was non-detectable at all sites except SP9, where a total concentration of 0.03 mg/L was documented. This concentration was greater than the MCL for drinking water and the acute and chronic toxicity thresholds for aquatic life. Concentrations of copper were below the MCL for drinking water at all storm water sampling locations. However, levels of copper did exceed acute and chronic toxicity thresholds for aquatic life.

Storm water values for aluminum were generally greater than dry weather in-pond values, but were not considered high for storm water. Storm water concentrations of total calcium and magnesium were generally low at all sites except SP5b and SP8, where concentrations were higher than expected background levels, but still not high by regional comparison. Storm water concentrations of total sodium and chloride were high at SP5b, SP8, and SP9. High concentrations at SP5b were likely a result of dairy farming activities and road runoff. Road runoff was likely responsible for contamination at the latter two sites. Concentrations of dissolved iron and manganese were relatively low at all sites. Storm water monitoring for selected organic compounds indicated relatively low levels. Total petroleum hydrocarbons ranged from <0.5 to 0.9 mg/L. DDT, PCB's, and polynuclear aromatic hydrocarbons were not detected.

Elevated nitrogen concentrations were documented at all ground water monitoring locations on either one or both sampling dates. The sources could be sewage, agricultural waste, or decaying vegetation. Dissolved phosphorus concentrations were also elevated along all four shoreline segments, but concurrently elevated iron levels minimize the availability of this phosphorus. Only in the southwest segment was there any potentially significant phosphorus input, and low flows limit the magnitude of this input.

Sediments in the main body of the pond and near the northern tributary were mucky, whereas sediments near the boat launch were sandy. Organic carbon content was especially high near the mouth of the northern tributary, most likely a direct result of inputs from the upstream dairy farm. Total phosphorus concentrations were high in this area and low at the remaining sites. TKN was low near the boat launch, moderate in the main body of the pond, and high at the mouth of the northern tributary. Metal concentrations were generally within acceptable ranges at all sites. Total petroleum hydrocarbons were relatively low at all three sampling locations. DDT and PCB were not detected in pond sediments. Polynuclear aromatic hydrocarbons were detected at all three sampling locations, with elevated concentrations documented near the boat launch and at the mouth of the northern tributary.

Edible portions from three white perch were composited and analyzed for cadmium, lead, PCB's, mercury, and polynuclear aromatic hydrocarbons. Results of the fish tissue analysis revealed that levels of selected contaminants were relatively low, posing no apparent ecological or health threat.

Data quality monitoring results for water chemistry analyses indicated that variability in most parameters was tolerable, but variation among duplicate nutrient samples was undesirably high. This could limit the ability to determine if slightly elevated concentrations are a result of pollution or variability in chemical analyses, but will not greatly affect overall interpretation of the chemical data. Even with this significant degree of variability, major sources of pollution are quite obvious, and multiple approaches to nutrient loading provide increased reliability in overall conclusions.

Nitrogen and phosphorus loading were assessed by multiple means. The resultant nitrogen load is expected to be between 4719 and 7839 kg/yr (available vs. total), with about 66% derived from watershed sources, 20-25% from direct precipitation, and the remaining 9-14% from waterfowl and internal loading. Considering only the load from watershed sources, about 44% of the that load was associated with storm flow, while 26% was attributable to base flow in the two tributaries and 30% was related to ground water inputs. No source was a clearly dominant loading factor. A predictive model for later use in evaluating management scenarios sets the nitrogen load at 8111 kg/yr.

The resultant phosphorus load is expected to be between 404 and 630 kg/yr (available vs. total), with about 75-79% derived from watershed sources, 10-14% from internal loading, 9% from direct precipitation, and 2% from waterfowl. Considering only the load from watershed sources, about 52-64% of the watershed load was associated with storm flow, while 26-29% was attributable to base flow in the two tributaries and 7-22% was related to ground water inputs. Of particular note is that close to half of the entire load comes from Basin 5, which includes the dairy farm. A predictive model for later use in evaluating management scenarios sets the phosphorus load at 445 kg/yr.

Observed and predicted current conditions suggest excessive phosphorus loading, with Basin 5 contributing the greatest itemized portion of the total effective load. Nitrogen loads are also high, but not as clearly associated with any one basin or source. Resultant in-lake average concentrations for nitrogen and phosphorus range from 0.8-1.0 mg/L and 36-40 ug/L, respectively. These concentrations facilitate periodic algal blooms, with average chlorophyll levels between 15 and 22 ug/L and peaks in excess of 60 ug/L. This depresses water clarity, leading to an average Secchi transparency of 1.4-1.5 m. The highest water clarity results in a Secchi depth of 2.9-3.5 m, but this occurs only briefly during the growing season.

Results of bacteria monitoring in surface waters at Stafford Pond revealed that concentrations recorded during dry weather were generally low (<100/100 mL) at all sites except SP5b, where values were consistently high (>500/100 mL). Values recorded during wet weather ranged from low to high.

Phytoplankton exhibited spring and late summer peaks, with the diatom *Asterionella* dominating the spring bloom and the bluegreen *Aphanizomenon* dominating the summer bloom. A traditional temperate zone successional pattern was exhibited, interrupted only by reduction of biomass and delay of bluegreen dominance by two early summer copper treatments.

Zooplankton included few forms and low to moderate biomass, but the presence of large bodied *Daphnia* suggests some potential for both grazing control of algae and desirable food for planktivorous fish. The *Daphnia* population crashed in August, however, probably from a combination of predation pressure and poor food quality. Zooplankton size distribution suggested either a balanced fish size structure or a tendency toward older, larger fish; further investigation into the stability of the fish community is warranted.

Results of the aquatic vascular plant surveys revealed that rooted plant growth was minimal in Stafford Pond. Rooted plants only grew near the periphery of the pond and plant densities did not exceed 25 percent. Only seven taxa of aquatic vascular plants were documented in the pond. All seven taxa are native to New England and only one is sometimes considered a nuisance. Rocky substrate in shallow areas is expected to minimize rooted plant growths even in the absence of the current light limitation induced by algal blooms.

The fish community of Stafford Pond is typical of many warm water New England lakes. Expected species composition includes bluegill, pumpkinseed, smallmouth bass, largemouth bass, yellow perch, white perch, brown bullhead, and stocked trout. A gill net and seine survey captured trout, bluegills, yellow perch and white perch, with the latter two species most abundant. Although condition factors were at least average, lack of multiple size classes suggests possible recruitment problems and instability.

Results of the waterfowl investigation indicated that numbers were not insignificant (average = 129), especially when the birds congregated near the water treatment facility intake, but most birds were sighted near Pelletier point at the outlet end of the pond, and overall density was not large on a regular basis. Detailed surveys of the aquatic invertebrate and amphibian/reptile communities of Stafford Pond were not conducted, but typical New England assemblages are expected.

Water withdrawal from Stafford Pond for drinking water purposes can draw the water level down by up to one foot under drought conditions, but is less of a loss factor than evaporation. Discharge of filter backwash into the pond is another mode of possible impact by the water treatment facility. Although this is not an ideal situation, it does not appear to represent a significant threat to water quality in the pond, since pollutants are largely coagulated and settled prior to water discharge.

Designated uses under Stafford Pond's Class B category include public water supply with appropriate treatment, agricultural uses, primary contact recreation, and fish/wildlife habitat. Given the use of Stafford Pond as a drinking water supply, there is a definite risk posed by the use of motorized watercraft on the pond. Certain physical features of Stafford Pond make it somewhat susceptible to boating impacts, however, actual boating densities during 1996 were very low and no impacts were observed.

Nutrient enrichment of Stafford Pond is excessive and has many potential negative impacts on fishing and the fish community. Excessive nutrient enrichment may have negative effects on fish community stability, as evidenced by discontinuous size distributions for captured species, and on fishing, as demonstrated by angler dissatisfaction with pond appearance.

Present conditions in the pond are distinctly undesirable for swimming, especially during algal bloom conditions or anywhere in the vicinity of the northern tributary as an implication of fecal bacteria levels. As most drinking water supply reservoirs have restrictions regarding contact recreation, there would be a potential conflict among users if water quality conditions were improved in Stafford Pond. Further evaluation regarding this issue is certainly necessary.

Other uses of Stafford Pond include aesthetic enjoyment and landing of an occasional float plane. Aesthetic enjoyment and related passive uses are most impaired by summer algal blooms, and improvement for water supply purposes and aesthetic appeal are entirely consistent. Use by float planes poses the same risk as use by motorized watercraft, but given the nominal use of the lake for such purposes, this is not a major threat to other uses or lake condition.

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APPENDIX A

COLLECTED DATA

DATA TABLES

Table A-1. Results of Dissolved Oxygen/Temperature Monitoring in Tributaries to Stafford Pond (1996).

Sampling Date	Dissolved Oxygen (mg/L)		Temperature (°C)	
	SP5b	SP6	SP5b	SP6
Dry Weather:				
21-Feb	12.8	12.7	3.1	2.0
19-Mar	12.4	12.6	7.8	5.5
17-Apr	9.9	10.6	7.1	8.4
14-May	10.4	8.8	16.3	13.5
29-May	5.8	7.0	15.2	13.5
10-Jun	3.5	5.4	18.6	17.0
27-Jun	*	3.5	*	17.0
17-Jul	2.2	5.1	23.1	22.3
30-Jul	*	*	*	*
8-Aug	*	*	*	*
22-Aug	*	*	*	*
5-Sep	*	*	*	*

*Stream discharge minimal or non-existent.

Table A-2. Dissolved Oxygen/Temperature Profiles at the Deep Hole Sampling Location (SP1) in Stafford Pond (1996).

	Depth (m)								
	0	1	2	3	4	5	6	7	7.5
21-Feb									
Dissolved Oxygen	14.7	16.7	18.0	18.2	18.0	17.0	14.2	11.9	
Temperature	1.9	2.4	2.5	2.5	2.5	2.7	3.0	3.1	
19-Mar									
Dissolved Oxygen	11.4	9.9	9.3	8.8	8.6	8.5	8.5	8.7	
Temperature	3.9	3.8	3.9	3.8	3.8	3.8	3.8	3.8	
17-Apr									
Dissolved Oxygen	12.4	13.2	13.4	13.3	13.0	12.8	12.7	12.3	4.4
Temperature	6.9	6.9	6.9	6.9	6.9	6.9	6.8	6.8	6.8
14-May									
Dissolved Oxygen	9.2	9.7	10.1	10.2	10.0	9.8	8.9	8.0	7.3
Temperature	14.6	14.3	14.2	14.1	13.7	13.5	13.4	13.4	13.2
29-May									
Dissolved Oxygen	9.7	9.9	9.8	9.0	8.3	8.2	6.1	5.2	4.1
Temperature	17.8	17.8	17.7	17.6	17.5	16.8	15.3	15.0	14.7
10-Jun									
Dissolved Oxygen	8.9	9.0	9.3	9.4	9.2	8.0	6.2	4.5	
Temperature	22.5	22.5	21.0	20.7	20.2	19.1	18.3	17.8	
27-Jun									
Dissolved Oxygen	8.6	8.7	8.5	8.4	8.2	7.8	3.9	1.0	
Temperature	22.5	22.4	22.0	21.9	21.6	21.3	20.1	18.7	
17-Jul									
Dissolved Oxygen	8.6	8.6	8.5	7.9	7.5	6.8	5.8	2.3	
Temperature	25.4	25.1	24.7	23.9	23.1	22.8	22.5	22.5	
30-Jul									
Dissolved Oxygen	9.7	9.7	9.7	9.3	8.6	6.1	4.5	3.9	3.6
Temperature	24.6	24.3	24.2	23.7	23.4	22.8	22.3	22.2	22.1
8-Aug									
Dissolved Oxygen	9.3	9.3	9.3	9.3	6.5	4.8	3.9	2.2	1.0
Temperature	25.3	25.1	25.1	25.0	23.1	22.6	22.5	22.2	21.8
22-Aug									
Dissolved Oxygen	8.0	8.2	7.6	7.1	6.6	5.7	4.5	2.5	1.6
Temperature	26.0	24.0	23.5	23.5	23.5	23.0	23.0	22.5	22.5
5-Sep									
Dissolved Oxygen	11.4	12.0	10.2	9.2	7.9	7.1	6.4	4.9	4.5
Temperature	24.2	23.2	22.4	22.1	21.8	21.6	21.5	21.4	21.3
30-Sep									
Dissolved Oxygen	8.7	8.4	8.5	8.6	8.7	8.6	8.2	7.8	4.8
Temperature	18.3	18.2	17.8	17.7	17.6	17.6	17.5	17.4	17.5
29-Oct									
Dissolved Oxygen	10.0	9.5	9.2	9.2	9.3	9.3	9.2	9.2	
Temperature	13.2	13.2	13.1	13.1	13.2	13.2	13.2	13.2	

Table A-3. Results of pH Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	pH (standard units))															
	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP8	SP9	SP10	SP11	SP12
Dry Weather:																
21-Feb	6.6				6.4	6.3	4.3	6.5		6.5	5.5					
19-Mar	7.0				7.0	7.0	7.0	7.0		6.5	5.7					
17-Apr	6.7				6.7			6.5		6.5	5.4					
14-May	6.4				6.4			6.2	5.5	6.5	5.4					
29-May	6.4				6.1			6.5		6.5	5.5				6.5	6.5
10-Jun	7.0				6.0			6.6		6.4	5.5					
27-Jun	6.6				6.3			6.7		6.4	5.6					
17-Jul	6.7	6.7	6.6	6.5	6.4			6.5		6.5	5.5					
30-Jul	8.2				6.5			6.8								
8-Aug	8.9				6.4		8.9	6.3								
22-Aug	8.5				6.0		7.0	7.0								
5-Sep	9.5	9.0	7.0	6.7	6.5		9.4	7.0								
30-Sep	7.4				6.8			6.6		6.3	5.8					
29-Oct	6.7				6.7			6.6	5.7	6.3	5.6					
Mean	7.3	7.9	6.8	6.6	6.4	6.7	7.3	6.6	5.6	6.4	5.6				6.5	6.5
Minimum	6.4	6.7	6.6	6.5	6.0	6.3	4.3	6.2	5.5	6.3	5.4				6.5	6.5
Maximum	9.5	9.0	7.0	6.7	7.0	7.0	9.4	7.0	5.7	6.5	5.8				6.5	6.5
Wet Weather:																
20-Mar										6.3	5.5		6.3	5.1		
16-Apr												6.0				
24-Jul											4.5		4.3	4.5		
12-Sep										6.4	5.5	6.2	6.4			
18-Sep										6.8				5.6		
Mean										6.5	5.2	6.1	5.7	5.1		
Minimum										6.3	4.5	6.0	4.3	4.5		
Maximum										6.8	5.5	6.2	6.4	5.6		

Table A-4. Results of Total Alkalinity Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Alkalinity (mg/L) SP1a	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP11	SP12
Dry Weather:										
21-Feb	5		3	1	5		50	<1		
19-Mar	7	7	7	7	7		36	<1		
17-Apr	6	6			6		20	<1		
14-May	7	7			7	5	65	2		
29-May	6	7			7		55	3	9	6
10-Jun	7	8			7		59	3		
27-Jun	8	13			7		54	2		
17-Jul	7	8			8		64	3		
30-Jul	9	11			10					
8-Aug	9	13		9	9					
22-Aug	9	14		10	10					
5-Sep	10	11		11	11					
30-Sep	9	9			9		66	<1		
29-Oct	6	6			6	9	41	2		
Mean	7	9	5	8	8	7	51	2	9	6
Minimum	5	6	3	1	5	5	20	<1	9	6
Maximum	10	14	7	11	11	9	66	3	9	6

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-5. Results of Total Hardness Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Hardness (mg/L)									
	SP1a	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP11	SP12
Dry Weather:										
21-Feb	16		16	16	18		61	28		
19-Mar	20	19	19	18	19		71	12		
17-Apr	18	18			18		44	11		
14-May	20	19			18	24	70	12		
29-May	19	19			19		83	N/D	18	18
10-Jun	17	18			19		106	N/D		
27-Jun	19	22			18		99	N/D		
17-Jul	16	17			18		104	N/D		
30-Jul	19	19			18					
8-Aug	20	23		19	19					
22-Aug	20	20		20	19					
5-Sep	21	21		19	20					
30-Sep	20	20			20		84	14		
29-Oct	19	19			19	30	59	N/D		
Mean	19	20	18	18	19	27	78	15	18	18
Minimum	16	17	16	16	18	24	44	11	18	18
Maximum	21	23	19	20	20	30	106	28	18	18

N/D= No Data, iron interference

Table A-6. Results of Conductivity Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Conductivity (umhos/cm) SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP8	SP9	SP10	SP11	SP12
Dry Weather:																
21-Feb	50				70	60	100	70		290	150					
19-Mar	70				65	70	65	65		220	75					
17-Apr	80				75			75		125	45					
14-May	80				80			80	110	260	80					
29-May	80				80			75		305	50				100	100
10-Jun	100				100			75		320	80					
27-Jun	100				100			110		360	110					
17-Jul	70	70	75	70	70			75		300	70					
30-Jul	70				70			80								
8-Aug	80				80		80	80								
22-Aug	90				85		80	85								
5-Sep	80	80	80	80	80		80	80								
30-Sep	90				90			90		310	75					
29-Oct	85				80			80	80	220	60					
Mean	80	75	78	75	80	65	81	80	95	271	80				100	100
Minimum	50	70	75	70	65	60	65	65	80	125	45				100	100
Maximum	100	80	80	80	100	70	100	110	110	360	150				100	100
Wet Weather:																
20-Mar										310	90		280	20		
16-Apr												110				
24-Jul											90		23,000	40		
12-Sep										280	50	190	120			
18-Sep										250				5		
Mean										280	77	150	7,800	22		
Minimum										250	50	110	120	5		
Maximum										310	90	190	23,000	40		

Table A-7. Results of Turbidity Monitoring in Surface Waters at Stafford Pond (1996).

Sampling	Turbidity (NTU)														
Date	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP8	SP9	SP10	SP11	SP12
Dry Weather:																
21-Feb	0.8				0.6	0.6	0.7	0.7		18.3	0.6					
19-Mar	1.8				1.6	1.3	1.7	1.8		1.9	0.5					
17-Apr	3.6				2.6			2.6		9.2	1.7					
14-May	1.4				1.0			1.3	1.3	1.4	0.4					
29-May	1.1				1.3			1.5		4.4	0.8				0.6	0.4
10-Jun	0.9				1.2			1.2		4.5	0.7					
27-Jun	3.0				1.9			2.2		4.8	0.6					
17-Jul	1.4	1.5	1.5	2.2	1.4			3.8		4.0	0.9					
30-Jul	2.5				3.2			2.3								
8-Aug	3.1				2.7		1.3	2.0								
22-Aug	7.2				2.0		4.6	6.2								
5-Sep	21.0	29.5	5.7	3.0	2.6		19.5	4.8								
30-Sep	9.9				6.8			6.1		8.0	0.8					
29-Oct	1.5				0.9			2.0	1.4	1.3	0.6					
Mean	4.2	15.5	3.6	2.6	2.1	1.0	5.6	2.8	1.4	5.8	0.8				0.6	0.4
Minimum	0.8	1.5	1.5	2.2	0.6	0.6	0.7	0.7	1.3	1.3	0.4				0.6	0.4
Maximum	21.0	29.5	5.7	3.0	6.8	1.3	19.5	6.2	1.4	18.3	1.7				0.6	0.4
Wet Weather:																
20-Mar										39.0	1.5		8.2	0.9		
16-Apr												10.8				
24-Jul											4.9		8.1	1.1		
12-Sep										5.1	1.0	5.2	9.9			
18-Sep										10.0				0.2		
Mean										18.0	2.5	8.0	8.7	0.7		
Minimum										5.1	1.0	5.2	8.1	0.2		
Maximum										39.0	4.9	10.8	9.9	1.1		

Table A-8. Results of Secchi Transparency Monitoring in Stafford Pond (1996).

Date	Secchi Transparency (m) SP1
19-Mar	1.2
17-Apr	1.0
14-May	1.8
29-May	2.9
10-Jun	2.7
27-Jun	1.4
17-Jul	2.1
30-Jul	1.3
8-Aug	1.5
22-Aug	0.8
5-Sep	0.5
30-Sep	0.9
29-Oct	0.8
Mean	1.5
Mininum	0.5
Maximum	2.9

Table A-9. Results of Chlorophyll a Monitoring in Stafford Pond (1996).

Sampling Date	Chlorophyll a (µg/L) SP1a	SP4
Dry Weather:		
21-Feb	6	6
19-Mar	31	24
17-Apr	4	2
14-May	4	4
29-May	3	2
10-Jun	3	4
27-Jun	10	9
17-Jul	9	5
30-Jul	8	13
8-Aug	17	
22-Aug	9	13
5-Sep	118	43
30-Sep	79	69
29-Oct	11	11
Mean	22	16
Minimum	3	2
Maximum	118	69

Table A-10. Results of Nitrite+Nitrate Nitrogen Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Nitrite+Nitrate Nitrogen (mg/L)															
	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.04				0.17	0.08	0.10	0.08		1.44	0.16	0.22					
19-Mar	<0.03				<0.03	<0.03	<0.03	<0.03		2.50	<0.03	<0.03					
17-Apr	<0.03				<0.03			<0.03		1.20	<0.03	0.05					
14-May	0.07				0.05			0.04	0.06	1.30	0.05	0.05					
29-May	0.16				0.08			0.05		1.60	0.06	0.07				0.05	0.06
10-Jun	<0.03				<0.03			0.03		0.48	<0.03	<0.03					
27-Jun	<0.03				<0.03			<0.03		0.11	0.04	<0.03					
17-Jul	0.06	0.03	0.03	0.04	0.07			0.05		0.26	0.03	<0.03					
30-Jul	<0.03				<0.03			<0.03									
8-Aug	<0.03				0.04		<0.03	<0.03									
22-Aug	<0.03				<0.03		0.03	<0.03									
5-Sep	0.04	0.06	0.03	0.04	0.06		<0.03	0.05									
30-Sep	<0.03				<0.03			<0.03		0.27	<0.03	0.12					
29-Oct	0.15				0.16			0.09	<0.03	0.76	<0.03	0.18					
Mean	0.05	0.05	0.03	0.04	0.05	0.05	0.04	0.04	0.04	0.99	0.04	0.08				0.05	0.06
Minimum	<0.03	0.03	0.03	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	0.11	<0.03	<0.03				0.05	0.06
Maximum	0.16	0.06	0.03	0.04	0.17	0.08	0.10	0.09	0.06	2.50	0.16	0.22				0.05	0.06
Wet Weather:																	
20-Mar										1.40	<0.03			1.50	0.09		
16-Apr													0.78				
24-Jul											0.05			0.78	0.59		
12-Sep										0.58	<0.03		2.50	0.93			
18-Sep										0.50					0.07		
Mean										0.83	0.03		1.64	1.07	0.25		
Minimum										0.50	<0.03		0.78	0.78	0.07		
Maximum										1.40	0.05		2.50	1.50	0.59		

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-11. Results of Ammonium Nitrogen Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Ammonium Nitrogen (mg/L)																
	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.44				0.17	0.09	0.17	0.12		4.60	0.14	0.13					
19-Mar	0.17				0.17	0.18	0.22	0.28		0.36	0.12	0.15					
17-Apr	0.13				0.14			0.18		0.54	0.09	0.09					
14-May	0.10				0.13			0.13	0.13	0.31	0.06	0.10					
29-May	0.06				0.06			0.10		0.88	0.12	0.06				<0.05	0.10
10-Jun	0.09				0.14			0.09		1.43	0.23	0.09					
27-Jun	0.09				0.18			0.08		1.90	0.21	0.06					
17-Jul	0.22	0.08	0.14	0.15	0.34			0.17		1.50	0.24	0.12					
30-Jul	0.10				0.28			0.09									
8-Aug	<0.05				0.31		<0.05	<0.05									
22-Aug	0.11				0.48		0.18	0.15									
5-Sep	0.15	0.21	0.31	0.30	0.13		0.08	0.08									
30-Sep	<0.05				<0.05			0.12		0.45	0.12	<0.05					
29-Oct	0.09				0.10			0.13	0.12	0.33	0.10	0.11					
Mean	0.13	0.15	0.23	0.23	0.19	0.14	0.14	0.12	0.13	1.23	0.14	0.09				<0.05	0.10
Minimum	<0.05	0.08	0.14	0.15	<0.05	0.09	<0.05	<0.05	0.12	0.31	0.06	<0.05				<0.05	0.10
Maximum	0.44	0.21	0.31	0.30	0.48	0.18	0.22	0.28	0.13	4.60	0.24	0.15				<0.05	0.10
Wet Weather:																	
20-Mar										5.00	0.10			0.32	0.08		
16-Apr													0.41				
24-Jul											0.08			0.14	0.17		
12-Sep										0.57	0.18		0.08	0.13			
18-Sep										1.80					0.23		
Mean										2.46	0.12		0.25	0.20	0.16		
Minimum										0.57	0.08		0.08	0.13	0.08		
Maximum										5.00	0.18		0.41	0.32	0.23		

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-12. Results of Inorganic Nitrogen ($NO_2+NO_3+NH_4$) Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Inorganic Nitrogen (mg/L) SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.48				0.34	0.17	0.27	0.20		6.04	0.30	0.35					
19-Mar	0.19				0.19	0.20	0.24	0.30		2.86	0.14	0.17					
17-Apr	0.15				0.16			0.20		1.74	0.11	0.14					
14-May	0.17				0.18			0.17	0.19	1.61	0.11	0.15					
29-May	0.22				0.14			0.15		2.48	0.18	0.13				0.08	0.16
10-Jun	0.11				0.16			0.12		1.91	0.25	0.11					
27-Jun	0.11				0.20			0.10		2.01	0.25	0.08					
17-Jul	0.28	0.11	0.17	0.19	0.41			0.22		1.76	0.27	0.14					
30-Jul	0.12				0.30			0.11									
8-Aug	<0.04				0.35		0.04	0.04									
22-Aug	0.13				0.50		0.21	0.17									
5-Sep	0.19	0.27	0.34	0.34	0.19		0.15	0.13									
30-Sep	<0.04				0.04			0.14		0.72	0.14	0.15					
29-Oct	0.24				0.26			0.22	0.14	1.09	0.12	0.29					
Mean	0.17	0.19	0.26	0.27	0.24	0.19	0.18	0.16	0.17	2.22	0.19	0.17				0.08	0.16
Minimum	<0.04	0.11	0.17	0.19	0.04	0.17	0.04	0.04	0.14	0.72	0.11	0.08				0.08	0.16
Maximum	0.48	0.27	0.34	0.34	0.50	0.20	0.27	0.30	0.19	6.04	0.30	0.35				0.08	0.16
Wet Weather:																	
20-Mar										6.40	0.12			1.82	0.17		
16-Apr													1.19				
24-Jul											0.13			0.92	0.76		
12-Sep										1.15	0.20		2.58	1.06			
18-Sep										2.30					0.30		
Mean										3.28	0.15		1.89	1.27	0.41		
Minimum										1.15	0.12		1.19	0.92	0.17		
Maximum										6.40	0.20		2.58	1.82	0.76		

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-13. Results of Total Kjeldahl Nitrogen (TKN) Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	TKN (mg/L) SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.7				1.0	0.6	1.1	0.7		5.8	0.5	0.8					
19-Mar	1.3				1.1	1.1	0.4	1.3		2.1	0.7	1.0					
17-Apr	1.5				0.9			0.7		1.7	0.7	1.0					
14-May	0.6				0.5			0.6	0.8	1.4	0.7	0.5				0.3	0.4
29-May	0.6				0.5			0.4		1.9	0.8	0.5					
10-Jun	0.8				1.6			0.7		3.2	1.1	0.8					
27-Jun	0.8				0.7			1.1		3.3	0.2	0.1					
17-Jul	0.8	0.6	0.7	0.7	0.9			1.0		2.6	1.5	0.5					
30-Jul	1.0				1.2			1.0									
8-Aug	0.5				1.0		0.8	0.9									
22-Aug	0.9				1.0		0.8	1.1									
5-Sep	1.4	1.6	1.2	1.0	1.0		1.7	1.1									
30-Sep	0.7				1.1			0.7		1.9	<0.1	0.6					
29-Oct	0.5				1.1			1.3	1.1	0.5	1.2	0.7					
Mean	0.9	1.1	1.0	0.9	1.0	0.9	1.0	0.9	1.0	2.4	0.7	0.7				0.3	0.4
Minimum	0.5	0.6	0.7	0.7	0.5	0.6	0.4	0.4	0.8	0.5	<0.1	0.1				0.3	0.4
Maximum	1.5	1.6	1.2	1.0	1.6	1.1	1.7	1.3	1.1	5.8	1.5	1.0				0.3	0.4
Wet Weather:																	
20-Mar										15.0	0.9			2.1	0.6		
16-Apr													1.3				
24-Jul											1.7			2.5	1.0		
12-Sep										2.6	1.5		1.0	2.3			
18-Sep										1.7					0.2		
Mean										6.4	1.4		1.2	2.3	0.6		
Minimum										1.7	0.9		1.0	2.1	0.2		
Maximum										15.0	1.7		1.3	2.5	1.0		

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-14. Results of Total Nitrogen (NO_2+NO_3+TKN) Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Nitrogen (mg/L)																
	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.7				1.2	0.7	1.2	0.8		7.2	0.7	1.0					
19-Mar	1.3				1.1	1.1	0.4	1.3		4.6	0.7	1.0					
17-Apr	1.5				0.9			0.7		2.9	0.7	1.1					
14-May	0.7				0.6			0.6	0.9	2.7	0.8	0.6					
29-May	0.8				0.6			0.5		3.5	0.9	0.6				0.4	0.5
10-Jun	0.8				1.6			0.7		3.7	1.1	0.8					
27-Jun	0.8				0.7			1.1		3.4	0.2	0.1					
17-Jul	0.9	0.6	0.7	0.7	1.0			1.1		2.9	1.5	0.5					
30-Jul	1.0				1.2			1.0									
8-Aug	0.5				1.0		0.8	0.9									
22-Aug	0.9				1.0		0.8	1.1									
5-Sep	1.4	1.7	1.2	1.0	1.1		1.7	1.2									
30-Sep	0.7				1.1			0.7		2.2	0.1	0.7					
29-Oct	0.7				1.3			1.4	1.1	1.3	1.2	0.9					
Mean	0.9	1.1	1.0	0.9	1.0	0.9	1.0	0.9	1.0	3.4	0.8	0.7				0.4	0.5
Minimum	0.5	0.6	0.7	0.7	0.6	0.7	0.4	0.5	0.9	1.3	0.1	0.1				0.4	0.5
Maximum	1.5	1.7	1.2	1.0	1.6	1.1	1.7	1.4	1.1	7.2	1.5	1.1				0.4	0.5
Wet Weather:																	
20-Mar										16.4	0.9			3.6	0.7		
16-Apr													2.1				
24-Jul											1.8			3.3	1.6		
12-Sep										3.2	1.5		3.5	3.2			
18-Sep										2.2					0.3		
Mean										7.3	1.4		2.8	3.4	0.9		
Minimum										2.2	0.9		2.1	3.2	0.3		
Maximum										16.4	1.8		3.5	3.6	1.6		

Table A-15. Results of Total Phosphorus Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Phosphorus (mg/L)																
	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.040				0.040	0.030	0.040	0.040		1.900	0.040	0.040					
19-Mar	0.032				0.027	0.042	0.032	0.029		0.383	0.014	0.030					
17-Apr	0.040				0.070			0.040		0.720	0.040	0.040					
14-May	0.020				0.060			0.060	0.040	0.290	0.040	0.020					
29-May	0.019				0.033			0.023		0.433	0.047	0.024				0.018	0.010
10-Jun	0.025				0.037			0.041		0.433	0.110	0.030					
27-Jun	0.028				0.097			0.031		0.900	0.067	0.049					
17-Jul	0.043	0.047	0.049	0.046	0.054			0.041		0.970	0.079	0.045					
30-Jul	0.033				0.073			0.037									
8-Aug	0.049				0.086		0.033	0.052									
22-Aug	0.046				0.059		0.130	0.079									
5-Sep	*0.053	*0.042	*0.039	*0.031	*0.042		*0.037	*0.022									
30-Sep	*0.047				*0.041			*0.032		*2.279	*0.015	*0.024					
29-Oct	*0.022				*0.027			*0.025	*0.137	0.640	*0.026	*0.023					
Mean	0.036	0.045	0.044	0.039	0.053	0.036	0.054	0.039	0.089	0.895	0.048	0.033				0.018	0.010
Minimum	0.019	0.042	0.039	0.031	0.027	0.030	0.032	0.022	0.040	0.290	0.014	0.020				0.018	0.010
Maximum	0.053	0.047	0.049	0.046	0.097	0.042	0.130	0.079	0.137	2.279	0.110	0.049				0.018	0.010
Wet Weather:																	
20-Mar										3.170	0.019			0.131	0.016		
16-Apr													0.190				
24-Jul											0.063			0.294	0.016		
12-Sep										0.822	0.073		0.075	0.126			
18-Sep										3.070					0.043		
Mean										2.354	0.052		0.133	0.184	0.025		
Minimum										0.822	0.019		0.075	0.126	0.016		
Maximum										3.170	0.073		0.190	0.294	0.043		

*Samples analyzed by the University of Rhode Island - Watershed Watch Program.

Table A-16. Results of Dissolved Phosphorus Monitoring in Surface Waters at Stafford Pond (1996).

Sampling	Dissolved Phosphorus (mg/L)																
Date	SP1a	SP1b	SP1c	SP1d	SP1e	SP2	SP3	SP4	SP5a	SP5b	SP6	SP7	SP8	SP9	SP10	SP11	SP12
Dry Weather:																	
21-Feb	0.030				0.030	0.030	0.040	0.040		1.900	0.040	0.040					
19-Mar	0.013				0.017	0.015	0.024	0.015		0.290	0.014	0.015					
17-Apr	0.020				0.030			0.020		0.600	0.040	0.020					
14-May	0.020				0.020			0.020	0.020	0.010	0.020	0.010					
29-May	0.009				0.017			0.010		0.333	0.040	0.023				0.005	0.005
10-Jun	0.025				0.029			0.033		0.433	0.066	0.029					
27-Jun	0.024				0.056			0.019		0.670	0.022	0.044					
17-Jul	0.023	0.037	0.038	0.017	0.029			0.035		0.690	0.075	0.015					
30-Jul	0.015				0.041			0.031									
8-Aug	0.027				0.081		0.033	0.045									
22-Aug	0.046				0.024		0.055	0.035									
29-Oct	*0.020				*0.021			*0.020	*0.109	*0.640	*0.024	*0.020					
Mean	0.023	0.037	0.038	0.017	0.033	0.023	0.038	0.027	0.065	0.618	0.038	0.024				0.005	0.005
Minimum	0.009	0.037	0.038	0.017	0.017	0.015	0.024	0.010	0.020	0.010	0.014	0.010				0.005	0.005
Maximum	0.046	0.037	0.038	0.017	0.081	0.030	0.055	0.045	0.109	1.900	0.075	0.044				0.005	0.005
Wet Weather:																	
20-Mar										2.700	0.019			0.027	0.015		
16-Apr													0.150				
24-Jul											0.055			0.092	0.016		
12-Sep										0.632	0.058		0.074	0.097			
18-Sep										2.210					0.020		
Mean										1.847	0.044		0.112	0.072	0.017		
Minimum										0.632	0.019		0.074	0.027	0.015		
Maximum										2.700	0.058		0.150	0.097	0.020		

*Samples analyzed by the University of Rhode Island - Watershed Watch Program.

Table A-17a. Results of Total Cadmium Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Cadmium (mg/L) SP1a		SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:										
17-Jul	<0.001		<0.001		<0.001					
5-Sep	<0.001		<0.001	<0.001	<0.001					
29-Oct		<0.00013								
Mean	<0.001	<0.00013	<0.001	<0.001	<0.001					
Minimum	<0.001	<0.00013	<0.001	<0.001	<0.001					
Maximum	<0.001	<0.00013	<0.001	<0.001	<0.001					
Wet Weather:										
12-Sep						<0.001	<0.001	<0.001	<0.001	
18-Sep										<0.001

Table A-17b. Results of Dissolved Cadmium Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Dissolved Cadmium (mg/L) SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	<0.001	<0.001		<0.001					
5-Sep	<0.001	<0.001	<0.001	<0.001					
Mean	<0.001	<0.001	<0.001	<0.001					
Minimum	<0.001	<0.001	<0.001	<0.001					
Maximum	<0.001	<0.001	<0.001	<0.001					
Wet Weather:									
12-Sep					<0.001	<0.001	<0.001	<0.001	
18-Sep									<0.001

Table A-18a. Results of Total Lead Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Lead (mg/L)									
	SP1a		SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:										
17-Jul	<0.005		<0.005		<0.005					
5-Sep	<0.005		<0.005	<0.005	<0.005					
29-Oct		0.00079								
Mean	<0.005	0.00079	<0.005	<0.005	<0.005					
Minimum	<0.005	0.00079	<0.005	<0.005	<0.005					
Maximum	<0.005	0.00079	<0.005	<0.005	<0.005					
Wet Weather:										
12-Sep						<0.005	<0.005	<0.005	0.030	
18-Sep										<0.005

Table A-18b. Results of Dissolved Lead Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Dissolved Lead (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	<0.005	<0.005		<0.005					
5-Sep	<0.005	<0.005	<0.005	<0.005					
Mean	<0.005	<0.005	<0.005	<0.005					
Minimum	<0.005	<0.005	<0.005	<0.005					
Maximum	<0.005	<0.005	<0.005	<0.005					
Wet Weather:									
12-Sep					<0.005	<0.005	<0.005	<0.005	
18-Sep									<0.005

Table A-19a. Results of Total Copper Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Copper (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	0.03	0.03		0.03					
5-Sep	0.01	0.01	0.02	0.02					
Mean	0.02	0.02	0.02	0.03					
Minimum	0.01	0.01	0.02	0.02					
Maximum	0.03	0.03	0.02	0.03					
Wet Weather:									
12-Sep					0.03	0.01	0.02	0.02	
18-Sep									0.03

Table A-19b. Results of Dissolved Copper Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Dissolved Copper (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	0.02	0.02		0.02					
5-Sep	0.01	0.01	0.01	0.02					
Mean	0.02	0.02	0.01	0.02					
Minimum	0.01	0.01	0.01	0.02					
Maximum	0.02	0.02	0.01	0.02					
Wet Weather:									
12-Sep					0.03	0.01	0.02	0.02	
18-Sep									0.03

Table A-20a. Results of Total Aluminum Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Aluminum (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	<0.02	<0.02		<0.02					
5-Sep	0.03	<0.02	0.14	0.05					
Mean	0.02	<0.02	0.14	0.03					
Minimum	<0.02	<0.02	0.14	<0.02					
Maximum	0.03	<0.02	0.14	0.05					
Wet Weather:									
12-Sep					0.35	0.83	0.19	1.10	
18-Sep									<0.08

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-20b. Results of Dissolved Aluminum Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Dissolved Aluminum (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	<0.02	<0.02		<0.02					
5-Sep	0.03	<0.02	0.02	0.04					
Mean	0.02	<0.02	0.02	0.03					
Minimum	<0.02	<0.02	0.02	<0.02					
Maximum	0.03	<0.02	0.02	0.04					
Wet Weather:									
12-Sep					<0.08	0.63	0.13	0.15	
18-Sep									<0.08

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-21. Results of Total Calcium Monitoring in Surface Waters at Stafford Pond (1996).

Sampling				Total Calcium (mg/L)					
Date	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	4.4	4.3		4.6					
5-Sep	4.3	4.4	4.1	4.6					
Mean	4.4	4.4	4.1	4.6					
Minimum	4.3	4.3	4.1	4.6					
Maximum	4.4	4.4	4.1	4.6					
Wet Weather:									
12-Sep					20.0	2.2	13.0	5.9	
18-Sep									0.2

Table A-22. Results of Total Magnesium Monitoring in Surface Waters at Stafford Pond (1996).

Sampling				Total Magnesium (mg/L)					
Date	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	1.5	1.5		1.6					
5-Sep	1.5	1.5	1.4	1.6					
Mean	1.5	1.5	1.4	1.6					
Minimum	1.5	1.5	1.4	1.6					
Maximum	1.5	1.5	1.4	1.6					
Wet Weather:									
12-Sep					7.0	0.9	2.3	0.9	
18-Sep									<0.1

Table A-23. Results of Total Sodium Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Sodium (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	9.1	8.9		9.7					
5-Sep	9.2	9.4	9.4	9.5					
Mean	9.2	9.2	9.4	9.6					
Minimum	9.1	8.9	9.4	9.5					
Maximum	9.2	9.4	9.4	9.7					
Wet Weather:									
12-Sep					36.0	8.2	26.0	13.0	
18-Sep									<0.5

Table A-24. Results of Total Chloride Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Chloride (mg/L)								
	SP1a	SP1e	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	20	20		21					
5-Sep	22	21	21	22					
Mean	21	21	21	22					
Minimum	20	20	21	21					
Maximum	22	21	21	22					
Wet Weather:									
12-Sep					78	19	46	26	
18-Sep									<4

Table A-25. Results of Dissolved Iron Monitoring in Surface Waters at Stafford Pond (1996).

Sampling	Dissolved Iron (mg/L)								
Date	SP1a	SP1c	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	0.07	0.08		0.05					
5-Sep	0.06	0.10	0.04	0.05					
Mean	0.07	0.09	0.04	0.05					
Minimum	0.06	0.08	0.04	0.05					
Maximum	0.07	0.10	0.04	0.05					
Wet Weather:									
12-Sep					0.61	0.94	0.09	0.09	
18-Sep									<0.08

Table A-26. Results of Dissolved Manganese Monitoring in Surface Waters at Stafford Pond (1996).

Sampling	Dissolved Manganese (mg/L)								
Date	SP1a	SP1c	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	0.01	0.08		0.01					
5-Sep	0.01	0.10	0.01	0.01					
Mean	0.01	0.09	0.01	0.01					
Minimum	0.01	0.08	0.01	0.01					
Maximum	0.01	0.10	0.01	0.01					
Wet Weather:									
12-Sep					0.15	0.03	0.05	0.02	
18-Sep									0.01

Table A-27. Results of Total Petroleum Hydrocarbon Monitoring in Surface Waters at Stafford Pond (1996).

Sampling Date	Total Petroleum Hydrocarbon (mg/L)								
	SP1a	SP1c	SP3	SP4	SP5b	SP6	SP8	SP9	SP10
Dry Weather:									
17-Jul	3.2	2.7		2.7					
30-Jul			<0.5						
5-Sep	<0.5	<0.5	<0.5	<0.5					
Mean	1.7	1.5	<0.5	1.5					
Minimum	<0.5	<0.5	<0.5	<0.5					
Maximum	3.2	2.7	<0.5	2.7					
Wet Weather:									
12-Sep					<0.5	<0.5	<0.5	0.9	
18-Sep									<0.5

Values less than (<) the detection limit were multiplied by 0.5 prior to averaging.

Table A-28. Results of DDT and PCB Monitoring in Surface Waters at Stafford Pond (1996).

Analyte	Units	SP1a		Sp1c		Sp3	Sp4		Sp5b	Sp6	Sp8	Sp9	SP10
		17-Jul	5-Sep	17-Jul	5-Sep	5-Sep	17-Jul	5-Sep	12-Sep (wet weather)				
4,4'-DDT	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
PCB:													
Aroclor 1016	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1221	ug/L	<1.0	<0.5	<1.0	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1232	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1242	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1248	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1254	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aroclor 1260	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Table A-29. Results of Polynuclear Aromatic Hydrocarbon Monitoring in Surface Waters at Stafford Pond (1996).

Analyte	Units	SP1a		Sp1e		Sp3	Sp4		Wet Weather				
									Sp5b	Sp6	Sp8	Sp9	SP10
		17-Jul	5-Sep	17-Jul	5-Sep	5-Sep	17-Jul	5-Sep	12-Sep	12-Sep	12-Sep	12-Sep	18-Sep
Acenaphthene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthylene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anthracene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)anthracene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(b)fluoranthene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(k)fluoranthene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(ghi)perylene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chrysene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Indeno(1,2,3-cd)pyrene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2-Methylnaphthalene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenanthrene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pyrene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table A-30a. Data Quality Monitoring - Comparison of Duplicate Samples from SP1a.

			Duplicate Samples from SP1a							
Parameter	Units	Sample Analysis	8-Aug		22-Aug		5-Sep		30-Sep	
Total Alkalinity	mg/L	Fugro	9	9	9	10	10	10	ND	ND
Total Hardness	mg/L	Fugro	20	20	20	20	21	20	ND	ND
pH	su	Fugro	8.9	8.9	8.5	8.5	9.5	9.5	7.4	7.4
Conductivity	umhos/cm	Fugro	ND	ND	90	75	80	80	92	90
Turbidity	NTU	Fugro	3.1	2.8	7.2	6.0	21	19	10	9
Fecal coliform	#/100 mL	Mitkem	<1	<1	<1	2	<2	<2	5	2
Fecal streptococcus	#/100 mL	Mitkem	6	2	1	<1	4	4	<1	10
Ammonia	mg/L	Mitkem	<0.05	<0.05	0.11	0.20	0.31	0.15	0.13	<0.05
Nitrite+Nitrate	mg/L	Mitkem	0.26	<0.03	<0.03	0.03	0.05	0.04	<0.03	0.03
TKN	mg/L	Mitkem	0.9	0.5	1.0	0.9	1.4	2.0	0.8	0.7
Dissolved Phosphorus	mg/L	Mitkem	0.072	0.027	0.051	0.052	ND	ND	ND	ND
Total Phosphorus	mg/L	Mitkem	0.072	0.049	0.046	0.050	ND	ND	0.08	0.28

Table A-30b. Data Quality Monitoring - Total Phosphorus Comparisons between Laboratories.

	Duplicate Samples					
	5-Sep		30-Sep		29-Oct	
Station	URI	Mitkem	URI	Mitkem	URI	Mitkem
SP1a	0.05	0.06	0.05	0.08	0.02	0.06
SP1e	ND	ND	0.04	0.10	0.03	0.07
SP4	ND	ND	0.03	0.42	ND	ND
SP5b	ND	ND	2.30	3.60	0.64	0.53
SP6	ND	ND	0.02	0.21	ND	ND
SP7	ND	ND	0.02	0.35	ND	ND

URI= University of Rhode Island, Kingston, Rhode Island.
Mitkem= Mitkem Corporation, Warwick, Rhode Island.

APPENDIX B

CALCULATIONS

NOTES:

Hydrologic Calculations

I. Watershed Yield

Historic region avg. = 2.0 cfs/sq. mi of drainage area
= 1,781,700 cu.m/yr per sq. mi. drainage

For Stafford P., watershed = 947 ac = 1.48 sq. mi
∴ Avg. flow = 2,636,400 cu.m/yr from watershed

Add Precip. direct to pond @ 1.14 m on 1,979,818 m^2 = 2,250,000 m^3

Total Flow = 4,886,400 m^3/yr

II Pond Yield (1996)

Avg. measured outflow = 4.7 cfs = 4,187,000 m^3/yr
Evaporation = 2/3 of Precip. = 1,500,000 m^3/yr
Withdrawal = 837,000 gpd = 1,151,000 m^3/yr

Ignoring any outseepage, Total = 6,838,000 m^3/yr

However, 1996 precip. was 12-20% above normal, and Nov-Jan not tested, suggesting flow < 5,470,000 m^3/yr (flow increases disproportionately to precip., low flow in Nov-Jan)

III Export Coefficients

Basin	Area (ac)	(sq. mi)	cfs @ 2/sq. mi	Rcoeff.*	Runoff cfs	Base cfs**
1	95	0.148	0.30	0.26	0.13	0.17
2	198	0.309	0.62	0.34	0.35	0.27
3	81	0.127	0.25	0.28	0.12	0.13
4	308	0.481	0.96	0.19	0.30	0.66
5	86	0.134	0.27	0.30	0.13	0.14
6	179	0.280	0.56	0.24	0.22	0.34
			2.96		1.25	1.71

* see attached calc. table (based on land use)
** Total cfs - Runoff cfs

Groundwater would be part of baseflow.
Add precip. @ 2.52 cfs ⟶ Total = 5.48 cfs

DETERMINATION OF BASIN RUNOFF COEFFICIENTS

	Runoff	BASIN AREAS						BASIN RUNOFF/YEAR					
	Coefficient	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6
LAND USE	(Fraction)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)
Urban 1 (LDR)	0.40	1.01	28.63	0.65	0.53	1.35		4606	130553	2964	2417	6156	0
Urban 2 (MDR/Hwy)	0.50	0.47	7.74	2.38	1.29	5.00	0.06	2679	44118	13566	7353	28500	342
Urban 3 (HDR/Com)	0.60	0.00	1.44	3.72		3.38	1.77	14	9850	25445	0	23119	12107
Urban 4 (Ind)	0.60							0	0	0	0	0	0
Urban 5 (P/I/R/C)	0.40	6.43	1.69			2.12	12.44	29321	7706	0	0	9667	56726
Agric 1 (Cvr Crop)	0.15							0	0	0	0	0	0
Agric 2 (Row Crop)	0.25		0.00			1.99		0	6	0	0	5672	0
Agric 3 (Grazing)	0.30		3.21	3.11		4.84		0	10978	10636	0	16553	0
Agric 4 (Feedlot)	0.45					0.92		0	0	0	0	4720	0
Forest 1 (Upland)	0.23	28.21	25.19	19.28	98.08	7.09	45.64	72359	64612	49453	251575	18186	117067
Forest 2 (Wetland)	0.05							0	0	0	0	0	0
Open 1 (Wetland/Lake)	0.05			3.63	24.64	8.06	11.21	0	0	2069	14045	4594	6390
Open 2 (Meadow)	0.15	2.34	5.38				1.36	4001	9200	0	0	0	2326
Open 3 (Excavation)	0.40	0.00	6.78					5	30917	0	0	0	0
Other 1	0.10							0	0	0	0	0	0
Other 2	0.35							0	0	0	0	0	0
Other 3	0.60												
TOTAL		38.46	80.06	32.77	124.54	34.75	72.48	112984	307940	104133	275390	117166	194957
Total Rainfall on Basin (cu.m/yr)								438978	913748	374004	1421375	396602	827214
Calculated Runoff Coefficient								0.26	0.34	0.28	0.19	0.30	0.24

DAILY PRECIPITATION (INCHES) FOR PROVIDENCE GREEN ST, RI
YEAR: 1996

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.00	0.00	0.07	0.02	0.00	----	0.28	0.14	0.00	0.00	----
2	0.07	0.03	0.30	0.52	0.02	0.00	0.00	0.00	0.13	0.02	0.00	----
3	0.22	0.09	0.02	0.00	0.25	0.45	0.51	0.00	0.00	Tr	0.00	----
4	Tr	0.00	0.00	0.00	Tr	0.18	0.34	0.00	0.01	0.00	0.00	----
5	Tr	0.00	0.19	Tr	0.03	0.07	0.00	0.00	0.00	0.00	0.01	----
6	0.00	0.00	0.83	Tr	0.26	0.00	0.00	Tr	0.00	0.00	0.00	----
7	0.06	0.00	0.48	0.42	0.00	0.00	0.00	0.00	1.21	0.00	0.16	----
8	0.12	Tr	0.03	0.03	0.18	0.00	0.00	0.00	0.02	2.06	0.08	----
9	Tr	0.12	0.00	0.32	0.00	Tr	0.03	Tr	0.02	0.30	0.53	----
10	0.05	0.00	0.00	0.13	0.27	0.05	0.00	0.07	0.01	0.01	0.00	----
11	0.00	0.27	0.00	Tr	0.15	Tr	0.00	0.00	0.00	0.00	0.00	----
12	1.08	0.00	0.00	0.04	0.10	Tr	0.00	0.00	0.04	0.00	0.00	----
13	0.00	0.00	0.00	0.04	0.00	0.00	3.56	0.93	0.13	Tr	0.00	----
14	0.00	0.16	0.00	0.01	0.00	0.00	0.00	0.00	0.03	Tr	0.00	----
15	0.00	0.00	0.17	0.00	0.00	0.00	----	0.00	0.00	0.00	0.00	----
16	Tr	0.05	0.00	2.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	----
17	0.03	Tr	0.00	Tr	0.14	0.03	0.00	0.00	0.93	0.00	0.00	----
18	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	1.91	0.00	0.00	----
19	0.98	0.00	0.04	0.00	0.00	0.10E	0.10	0.00	0.00	0.25	0.04	----
20	0.00	0.00	0.64	0.00	0.00	0.46	0.00	0.00	0.00	2.81	0.00	----
21	Tr	0.73	0.00	Tr	0.19	0.14	0.00	Tr	0.00	0.00	0.00	----
22	0.00	Tr	0.00	Tr	0.00	0.02	0.00	0.00	0.41	0.10	0.00	----
23	0.00	0.02	Tr	0.04	0.00	Tr	0.44	0.05	0.26	0.34	0.00	----
24	0.85	0.57	0.00	0.04	Tr	0.35	0.00	0.39	0.05	0.01	0.00	----
25	Tr	0.00	Tr	Tr	0.00	0.04	0.00	0.01	0.17	0.00	0.00	----
26	0.00	0.00	0.01	0.03	0.00	0.00	0.07	0.01	0.00	0.00	1.41	----
27	1.42	0.02	0.00	0.00	0.00	Tr	0.00	0.00	0.00	0.00	0.00	----
28	Tr	0.13	0.00	0.00	0.00	Tr	0.00	0.45	0.03	0.21	0.00	----
29	0.11	0.00	0.00	0.69	Tr	Tr	0.00	0.00	0.24	0.00	0.00	----
30	0.02		0.00	0.50	0.36	0.22	0.00	0.00	0.01	0.12	0.00	----
31	0.01		0.00		0.00		0.44	0.00		Tr		----
TOTAL	5.02	2.19	2.71	4.88	2.44	2.17	5.49	2.19	5.75	6.23	2.23	----
NORMAL	3.88	3.61	4.05	4.11	3.76	3.33	3.18	3.63	3.48	3.69	4.43	4.38

---- = missing data
Tr = a trace
A = accumulation over one or more previous days
S = value is included in a subsequent value
Observation time - Midnight

Data for November 15-30 is preliminary.

This report was prepared by the Northeast Regional Climate Center.

+ normal Dec. value → 1996 Precip. = 45.68"

DAILY PRECIPITATION (INCHES) FOR NEWPORT, RI
YEAR: 1996

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	0.09	0.00	0.00	0.35	0.00	0.22	0.90	0.00	0.00	----	----
2	----	0.02	0.00	1.00	0.00	0.00	0.00	0.90	0.80	0.00	----	----
3	1.00	0.41	0.57	0.00	0.00	Tr	0.00	Tr	0.05	0.01	----	----
4	0.01	0.00	Tr	0.00	0.45	0.38	1.04	0.00	0.00	0.00	----	----
5	0.00	0.00	0.00	0.00	0.05	Tr	0.00	0.00	Tr	0.00	----	----
6	0.00	0.00	0.40	Tr	0.17	Tr	0.00	0.00	Tr	0.00	----	----
7	0.00	0.00	0.65	0.02	0.13	Tr	0.00	0.00	Tr	0.00	----	----
8	0.70	Tr	0.29	0.85	0.07	Tr	Tr	0.00	3.70	0.00	----	----
9	0.05	0.17	0.07	Tr	Tr	0.03	0.08	0.00	0.01	2.80	----	----
10	0.01	0.00	Tr	0.96	0.01	0.09	0.16	0.05	0.02	0.00	----	----
11	0.01	0.00	0.00	0.17	0.13	0.25	0.00	0.00	0.00	Tr	----	----
12	0.00	0.34	0.00	Tr	0.15	0.01	0.00	0.00	0.02	0.00	----	----
13	0.86	0.00	0.00	0.14	0.00	0.02	0.45	0.63	0.28	0.00	----	----
14	0.00	Tr	0.00	0.00	0.00	0.02	0.94	0.60	0.20	0.00	----	----
15	0.00	0.23	0.00	0.02	0.00	0.00	Tr	0.00	0.01	0.00	----	----
16	0.00	0.00	0.26	0.52	0.00	0.00	0.04	0.00	0.00	0.00	----	----
17	0.11	0.38	0.00	0.73	0.93	0.09	0.00	0.00	0.40	0.00	----	----
18	0.01	0.03	0.00	0.00	0.00	0.16	0.00	0.00	1.46	0.00	----	----
19	0.00	0.00	0.00	0.00	0.00	Tr	0.14	0.02	0.15	0.00	----	----
20	0.90	0.00	0.48	0.00	0.00	0.76	0.22	0.00	0.00	3.36	----	----
21	0.00	0.00	0.00	0.02	0.00	0.36	0.00	0.00	0.00	0.27	----	----
22	Tr	0.90	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.12	----	----
23	0.00	0.20	0.00	0.00	0.00	0.01	0.00	0.00	0.36	0.22	----	----
24	Tr	0.50	0.00	0.12	0.02	0.00	0.20	0.07	0.00	0.36	----	----
25	0.48	0.80	0.00	0.00	0.00	0.10	0.00	0.10	0.19	0.00	----	----
26	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	----	----
27	0.00	0.00	0.00	0.07	Tr	0.00	0.10	0.00	0.00	0.00	----	----
28	1.10	0.04	0.00	0.00	0.00	0.01	0.00	0.34	0.00	0.00	----	----
29	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.10	0.27	0.23	----	----
30	0.22		0.00	1.69	0.06	0.00	0.00	0.00	0.02	0.00	----	----
31	0.01		0.00		0.31		0.00	0.00		0.13		----
TOTAL	5.47	4.13	2.73	6.31	2.97	2.29	3.61	3.71	7.94	7.50	0.00	0.00
NORMAL	3.83	3.63	4.14	4.15	3.68	3.14	2.85	3.31	3.47	3.52	4.71	4.38

---- = missing data
Tr = a trace
A = accumulation over one or more previous days
S = value is included in a subsequent value
Observation time - 8am

This report was prepared by the Northeast Regional Climate Center.

+ Normal Nov/Dec values → 1996 Precip = 55.75"

SEEPAGE CALCULATIONS WITH WELL DATA AND DARCY'S EQUATION

Date	Well Pair	Unadjusted Measurements (ft)			Adjusted Measurements (ft)			Difference between on-shore/ off-shore wells (ft). Neg #= out-seepage.	Difference between off-shore gw level and lake level (ft). Neg#= out-seepage.	Distance between IS and OS well (ft)	slope (ft/ft) neg #= out-seepage	Hydraulic Conductivity (ft/sec)	cfs per section
		On-shore to groundwater	Off-shore to groundwater	Off-shore to lake	On-shore to groundwater	Off-shore to groundwater	Off-shore to lake						
17-Apr	northeast	4.83	0.76	0.51	4.83	4.93	4.68	0.10	-0.25	81.7	0.0012	0.000012	0.042689
	northwest	4.97	1.45	1.46	4.97	3.78	3.79	-1.19	0.01	45.0	-0.0264	0.000012	-0.92231
	southeast	3.34	1.83	1.10	3.34	4.01	3.28	0.67	-0.73	49.0	0.0137	0.000012	0.476894
	southwest	4.82	1.20	1.41	4.82	7.15	7.36	2.33	0.21	51.8	0.0450	0.000012	1.568805
14-May	northeast	5.13	1.03	1.00	5.13	5.20	5.17	0.07	-0.03		0.0009	0.000012	0.029883
	northwest	3.87	1.97	1.92	3.87	4.30	4.25	0.43	-0.05		0.0096	0.000012	0.333272
	southeast	3.83	1.5	1.6	3.83	3.68	3.78	-0.15	0.10		-0.0031	0.000012	-0.10677
	southwest	6.38	2.78	2.88	6.38	8.73	8.83	2.35	0.10		0.0454	0.000012	1.582272
29-May	northeast	5.10	1.00	1.07	5.10	5.17	5.24	0.07	0.07		0.0009	0.000012	0.029883
	northwest	4.01	2.00	2.10	4.01	4.33	4.43	0.32	0.10		0.0071	0.000012	0.248016
	southeast	3.78	1.51	1.65	3.78	3.69	3.83	-0.09	0.14		-0.0018	0.000012	-0.06406
	southwest	6.82	1.80	1.90	6.82	7.75	7.85	0.93	0.10		0.0180	0.000012	0.626176
10-Jun	northeast	5.18	1.06	1.00	5.18	5.23	5.17	0.05	-0.06		0.0006	0.000012	0.021345
	northwest	4.21	2.07	2.07	4.21	4.40	4.40	0.19	0.00		0.0042	0.000012	0.14726
	southeast	3.87	1.61	1.73	3.87	3.79	3.91	-0.08	0.12		-0.0016	0.000012	-0.05694
	southwest	7.03	1.86	2.00	7.03	7.81	7.95	0.78	0.14		0.0151	0.000012	0.525179
27-Jun	northeast	5.64	1.43	1.45	5.64	5.60	5.62	-0.04	0.02		-0.0005	0.000012	-0.01708
	northwest	4.68	2.38	2.37	4.68	4.71	4.70	0.03	-0.01		0.0007	0.000012	0.023252
	southeast	4.22	2.00	2.05	4.22	4.18	4.23	-0.04	0.05		-0.0008	0.000012	-0.02847
	southwest	dry	2.29	2.33	dry	8.24	8.28	ND	0.04		ND	0.000012	#VALUE!

SEEPAGE CALCULATIONS WITH WELL DATA AND DARCY'S EQUATI SEEPAGE CALCULATIONS WITH WELL DATA AND DARCY'S EQUATION

		Unadjusted Measurements (ft)			Adjusted Measurements (ft)			Difference between on-shore/off-shore wells (ft). Neg #= out-seepage.	Difference between off-shore gw level and lake level (ft). Neg#= out-seepage.	Distance between IS and OS well (ft)	slope (ft/ft) neg #= out-seepage	Hydraulic Conductivity (ft/sec)	cfs per section
Date	Well Pair	On-shore to groundwater	Off-shore to groundwater	Off-shore to lake	On-shore to groundwater	Off-shore to groundwater	Off-shore to lake						
17-Jul	northeast	5.63	0.45	0.45	5.63	4.62	4.62	-1.01	0.00		-0.0124	0.000012	-0.43116
	northwest	4.65	2.43	2.45	4.65	4.76	4.78	0.11	0.02		0.0024	0.000012	0.085256
	southeast	4.2	2.05	2.1	4.20	4.23	4.28	0.03	0.05		0.0006	0.000012	0.021353
	southwest	dry	2.3	2.39	dry	8.25	8.34	ND	0.09		ND	0.000012	#VALUE!
30-Jul	northeast	5.7	1.48	1.56	5.70	5.65	5.73	-0.05	0.08		-0.0006	0.000012	-0.02134
	northwest	4.9	2.48	2.5	4.90	4.81	4.83	-0.09	0.02		-0.0020	0.000012	-0.06975
	southeast	4.4	2.1	2.16	4.40	4.28	4.34	-0.12	0.06		-0.0024	0.000012	-0.08541
	southwest	dry	2.36	2.44	dry	8.31	8.39	ND	0.08		ND	0.000012	#VALUE!
8-Aug	northeast	5.6	1.5	1.5	5.60	5.67	5.67	0.07	0.00		0.0009	0.000012	0.029883
	northwest	4.8	2.49	2.49	4.80	4.82	4.82	0.02	0.00		0.0004	0.000012	0.015501
	southeast	4.28	2.05	2.17	4.28	4.23	4.35	-0.05	0.12		-0.0010	0.000012	-0.03559
	southwest	dry	2.37	2.43	dry	8.32	8.38	ND	0.06		ND	0.000012	#VALUE!
22-Aug	northeast	5.81	1.64	1.65	5.81	5.81	5.82	0.00	0.01		0.0000	0.000012	0
	northwest	5.07	2.63	2.66	5.07	4.96	4.99	-0.11	0.03		-0.0024	0.000012	-0.08526
	southeast	4.5	2.25	2.33	4.50	4.43	4.51	-0.07	0.08		-0.0014	0.000012	-0.04982
	southwest	dry	2.54	2.6	dry	8.49	8.55	ND	0.06		ND	0.000012	#VALUE!
5-Sep	northeast	5.5	1.63	1.71	5.50	5.80	5.88	0.30	0.08		0.0037	0.000012	0.128068
	northwest	4.81	2.63	2.65	4.81	4.96	4.98	0.15	0.02		0.0033	0.000012	0.116258
	southeast	4.26	2.2	2.32	4.26	4.38	4.50	0.12	0.12		0.0024	0.000012	0.085414
	southwest	dry	2.5	2.6	dry	8.45	8.55	ND	0.10		ND	0.000012	#VALUE!
Sep	northeast											0.000012	
	northwest		NOT SAMPLED									0.000012	
	southeast											0.000012	
	southwest											0.000012	
28-Oct	northeast	4.65	0.7	0.78	4.65	4.87	4.95	0.22	0.08		0.0027	0.000012	0.093917
	northwest	3.34	1.71	1.71	3.34	4.04	4.04	0.70	0.00		0.0156	0.000012	0.542536
	southeast	3.56	1.16	1.4	3.56	3.34	3.58	-0.22	0.24		-0.0045	0.000012	-0.15659
	southwest	5.3	1.45	1.65	5.30	7.40	7.60	2.10	0.20		0.0405	0.000012	1.413945

NOTES:

Internal P & N Load Estimates

By Surface – Bottom Differential:

	TP	DP	TN	DN	
Mean Surface	0.036	0.023	0.90	0.17	mg/l or g/m³
Mean Bottom	0.053	0.033	1.00	0.24	mg/l or g/m³
Difference	0.017	0.010	0.10	0.07	mg/l or g/m³

Applied over area >18' deep (primary release area from anoxic sediment) = 767,000 m², in 1m vertical increments over 7m profile, with additive 1/7 decrease in concentration in each successive increment and a flushing factor of 0.65

Depth (m)	Calculation		Conc. (g/m³) TP	DP	TN	DN	Load (kg/yr) TP	DP	TN	DN
7.5-6.5	767,000 m³ x 0.65 ÷ 1000 g/kg	x 7/7	x 0.017	0.010	0.10	0.07	8.5	5.0	49.9	34.9
6.5-5.5	↓	6/7	↓				7.3	4.3	42.7	29.9
5.5-4.5		5/7					6.1	3.6	35.6	24.9
4.5-3.5		4/7					4.8	2.8	28.5	19.9
3.5-2.5		3/7					3.6	2.1	21.4	15.0
2.5-1.5		2/7					2.4	1.4	14.2	10.0
1.5-0.5		1/7					1.2	0.7	7.1	5.0
						Total	33.9	19.9	199.4	139.6

By Accumulation over Time:

June – Sept is period of least external input & outflow and greatest likely release from sediment.

	TP	DP	TN	DN
Late May	0.019	0.009	0.8	0.22
Early June	0.025	0.025	0.8	0.11
Late Aug	0.046	0.046	0.9	0.13
Early Sept	0.053	No Data	1.4	0.19
Mean Δ	0.028	0.029	0.35	0

All as mg/l or g/m³ for surface samples – Δ @ bottom assumed to be minimal for sed. release. Some other inputs exist, but partly offset by diffusion in whole pond

Applied over area >18' deep in 1m increments over 7m vertical profile, with additive 1/7 decrease for each increment but no flushing rate factor.

Depth (m)	Calculation		Concentration (g/m³) TP	DP	TN	DN	Load (kg/yr) TP	DP	TN	DN
0-1	767,000 m³ ÷ 1000 g/kg	X 7/7	x 0.028	0.029	0.35	0	21.5	22.2		0
1-2	↓	6/7	↓				18.4	19.1		0
2-3		5/7					15.3	15.9		0
3-4		4/7					12.3	12.7		0
4-5		3/7					9.2	9.5		0
5-6		2/7					6.1	6.4		0
6-7		1/7					3.1	3.2		0
							85.9	89.0		0

Note: DN would be initial recycle product, but no accumulation observed →

Water Volume Spreadsheet

Contour (feet below water level)	Planimetered Area (in^2)	Area (sq. ft.)	Avg. Area (sq. ft.)	Incremental Volume (cu. ft.)	Cumulative Volume (cu. ft.)
24.0	0.574	1092175			
21.0	2.33	4433394	2762785	8288354	8288354
18.0	4.34	8257911	6345652	19036957	27325312
15.0	5.04	9589832	8923871	26771613	54096925
12.0	5.64	10731478	10160655	30481965	84578890
9.0	6.6	12558113	11644795	34934386	119513276
6.0	8.2	15602504	14080308	42240925	161754201
3.0	9.6	18266346	16934425	50803274	212557475
0.0	11.15	21215600	19740973	59222918	271780393

Total Water Volume= 271,780,393 cu. ft.

EXPORT MODEL VARIABLES AND INPUT RANGES

VARIABLE	DESCRIPTION	FOR SOUTHERN NE AREA HIGH	MEDIUM	LOW
Standard Water Yield	Rate of water yield in CFS/Sq.Mi. by watershed	2.0	1.7	1.5
	Increases with increased runoff			
Precipitation	Annual rainfall in M	1.53	1.14	0.81
	Increases with wet year			
Runoff Coefficient	Portion of rainfall converted to overland flow	0.95	0.40	0.10
	Increases with steeper slope and lowered permeability			
Baseflow Coefficient	Portion of rainfall converted to baseflow	0.40	0.20	0.01
	Increases with flatter slope and higher permeability			

P, N AND TSS EXPORT COEFFICIENTS FOR RUNOFF

		PHOSPHORUS EXPORT (KG/HA/YR)				NITROGEN EXPORT (KG/HA/YR)				SUSPENDED SOLIDS EXPORT (KG/HA/YR)			
LAND USES		MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM
Urban 1 (LDR)	Low density residential (>1 ac lots)	6.23	1.91	1.10	0.19	38.47	9.97	5.50	1.48	250	77	93	14
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors	6.23	1.91	1.10	0.19	38.47	9.97	5.50	1.48	250	77	93	14
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial	6.23	1.91	1.10	0.19	38.47	9.97	5.50	1.48	250	77	93	14
Urban 4 (Ind)	Industrial	6.23	1.91	1.10	0.19	38.47	9.97	5.50	1.48	250	77	93	14
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery	6.23	1.91	1.10	0.19	38.47	9.97	5.50	1.48	250	77	93	14
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)	2.90	1.08	0.80	0.10	7.82	5.19	6.08	0.97	500	100	100	20
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)	18.60	4.46	2.20	0.26	79.60	16.09	9.00	2.10	2000	200	250	50
Agric 3 (Grazing)	Agricultural pasture with livestock	4.90	1.50	0.80	0.14	30.85	8.65	5.19	1.48	500	100	100	20
Agric 4 (Feedlot)	Concentrated livestock holding area	795.20	300.70	224.00	21.28	7979.90	3110.70	2923.20	680.50	40000	15000	15000	3500
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation	0.83	0.24	0.20	0.02	6.26	2.86	2.46	1.38	40	15	16	4
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation	0.83	0.24	0.20	0.02	6.26	2.86	2.46	1.38	40	15	16	4
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)	0.83	0.24	0.20	0.02	6.26	2.86	2.46	1.38	40	15	16	4
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)	0.83	0.24	0.20	0.02	6.26	2.86	2.46	1.38	40	15	16	4
Open 3 (Barren)	Mining or construction areas, largely bare soils	4.90	1.50	0.80	0.14	30.85	8.65	5.19	1.48	10000	1000	1000	100
Other 1	Define:	0.83	0.24	0.20	0.02	6.26	2.86	2.46	1.38	40	15	16	4
Other 2	Define:	6.23	1.91	1.10	0.19	38.47	9.97	5.50	1.48	250	77	93	14
Other 3	Define:	18.60	4.46	2.20	0.26	79.60	16.09	9.00	2.10	2000	200	250	50

P, N AND TSS EXPORT COEFFICIENTS FOR BASEFLOW		PHOSPHORUS EXPORT (KG/HA/YR)				NITROGEN EXPORT (KG/HA/YR)				SUSPENDED SOLIDS EXPORT (KG/HA/YR)			
		MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM
LAND USES													
Urban 1 (LDR)	Low density residential (>1 ac lots)	0.050	0.010	0.010	0.001	20.00	5.00	5.00	1.00	1.0	0.3	0.3	0.1
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors	0.050	0.010	0.010	0.001	40.00	10.00	10.00	2.00	1.0	0.3	0.3	0.1
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial	0.050	0.010	0.010	0.001	80.00	20.00	20.00	4.00	1.0	0.3	0.3	0.1
Urban 4 (Ind)	Industrial	0.050	0.010	0.010	0.001	20.00	5.00	5.00	1.00	1.0	0.3	0.3	0.1
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery	0.050	0.010	0.010	0.001	20.00	5.00	5.00	1.00	1.0	0.3	0.3	0.1
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)	0.050	0.010	0.010	0.001	10.00	2.50	2.50	0.50	1.0	0.3	0.3	0.1
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)	0.050	0.010	0.010	0.001	10.00	2.50	2.50	0.50	1.0	0.3	0.3	0.1
Agric 3 (Grazing)	Agricultural pasture with livestock	0.050	0.010	0.010	0.001	20.00	5.00	5.00	1.00	1.0	0.3	0.3	0.1
Agric 4 (Feedlot)	Concentrated livestock holding area	0.100	0.030	0.030	0.001	100.00	25.00	25.00	5.00	1.0	0.3	0.3	0.1
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation	0.010	0.004	0.004	0.001	1.00	0.50	0.50	0.05	1.0	0.3	0.3	0.1
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation	0.010	0.004	0.004	0.001	1.00	0.50	0.50	0.05	1.0	0.3	0.3	0.1
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)	0.010	0.004	0.004	0.001	1.00	0.50	0.50	0.05	1.0	0.3	0.3	0.1
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)	0.010	0.004	0.004	0.001	1.00	0.50	0.50	0.05	1.0	0.3	0.3	0.1
Open 3 (Barren)	Mining or construction areas, largely bare soils	0.010	0.004	0.004	0.001	1.00	0.50	0.50	0.05	1.0	0.3	0.3	0.1
Other 1	Define:	0.010	0.004	0.004	0.001	1.00	0.50	0.50	0.05	1.0	0.3	0.3	0.1
Other 2	Define:	0.050	0.010	0.010	0.001	20.00	5.00	5.00	1.00	1.0	0.3	0.3	0.1
Other 3	Define:	0.050	0.010	0.010	0.001	80.00	20.00	20.00	4.00	1.0	0.3	0.3	0.1
		PHOSPHORUS EXPORT (KG/HA/YR)				NITROGEN EXPORT (KG/HA/YR)				SUSPENDED SOLIDS EXPORT (KG/HA/YR)			
		MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM
OTHER AREAL SOURCES													
Atmospheric Deposition	Wet and dry deposition from aerial sources												
from Forested Area	Deposition originating in largely forested area	0.54	0.27	0.20	0.07	11.30	5.96	6.52	0.99	55	30	32	5
from Agricultural/Rural Area	Deposition originating in largely agricultural area	0.97	0.45	0.30	0.12	38.00	20.98	13.13	10.49	190	105	66	52
from Urban/Industrial Area	Deposition originating in largely urban area	3.67	1.27	1.00	0.26	24.80	18.51	21.36	7.40	124	93	107	37
Internal Loading	Release from sediments or macrophytes, oxic or anoxic	10.00	1.00	1.00	0.10	10.00	1.00	1.00	0.10	10.00	1.00	1.00	0.10
	(assumes anoxia for 90 days - adjust as needed)												
		PHOSPHORUS LOAD				NITROGEN LOAD				SUSPENDED SOLIDS LOAD			
		MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM	MAXIMUM	MEAN	MEDIAN	MINIMUM
NON-AREAL SOURCES													
Waterfowl	Direct inputs from birds (kg/bird/yr)	0.50	0.20	0.20	0.09	5.80	1.00	0.95	0.48	29.0	5.0	5.0	2.0
Point Sources	Direct discharge from facility												
	Wastewater - primary treatment (ppm)	6.00	4.00	4.00	1.00	70.00	45.00	45.00	20.00	100.0	50.0	50.0	10.0
	Wastewater - secondary treatment (ppm)	4.00	2.00	2.00	0.40	10.00	5.00	5.00	1.00	10.0	5.0	5.0	1.0
	Wastewater - tertiary treatment (ppm)	1.00	0.50	0.50	0.10	5.00	2.00	2.00	1.00	10.0	5.0	5.0	1.0
	Cooling water (ppm)	5.00	1.00	1.00	0.05	1.00	0.05	0.05	0.02	1.0	0.5	0.5	0.1

EXPORT MODEL INPUT AND CALCULATIONS

STD. WATER YIELD (CFS/SQ.MI)	2.0								
PRECIPITATION (in M)	1.14								
COEFFICIENTS			RUNOFF EXPORT COEFFICIENTS			BASEFLOW EXPORT COEFFICIENTS			
LAND USE	Runoff Coefficient (Fraction)	Baseflow Coefficient (Fraction)	P Export Coefficient (kg/ha/yr)	N Export Coefficient (kg/ha/yr)	TSS Export Coefficient (kg/ha/yr)	P Export Coefficient (kg/ha/yr)	N Export Coefficient (kg/ha/yr)	TSS Export Coefficient (kg/ha/yr)	
Urban 1 (LDR)	0.40	0.25	1.00	25.00	50	0.050	10.00	0.2	
Urban 2 (MDR/Hwy)	0.50	0.15	1.00	20.00	50	0.050	20.00	0.2	
Urban 3 (HDR/Com)	0.60	0.05	1.00	15.00	50	0.050	30.00	0.2	
Urban 4 (Ind)	0.60	0.05	1.00	10.00	50	0.050	5.00	0.2	
Urban 5 (P/I/R/C)	0.40	0.25	1.00	8.00	50	0.050	5.00	0.2	
Agric 1 (Cvr Crop)	0.15	0.30	1.00	6.00	50	0.050	5.00	0.2	
Agric 2 (Row Crop)	0.25	0.30	2.20	10.00	200	0.050	5.00	0.2	
Agric 3 (Grazing)	0.30	0.30	0.80	15.00	75	0.050	10.00	0.2	
Agric 4 (Feedlot)	0.45	0.30	250.00	1500.00	4000	0.100	50.00	0.2	
Forest 1 (Upland)	0.23	0.40	0.24	5.00	15	0.010	0.70	0.2	
Forest 2 (Wetland)	0.05	0.40	0.24	5.00	10	0.010	0.70	0.2	
Open 1 (Wetland/Lake)	0.05	0.40	0.24	5.00	10	0.010	0.70	0.2	
Open 2 (Meadow)	0.15	0.30	1.00	7.80	15	0.010	0.70	0.2	
Open 3 (Excavation)	0.40	0.20	1.50	8.70	500	0.010	0.70	0.2	
Other 1	0.10	0.40	0.20	2.46	16	0.010	0.70	0.2	
Other 2	0.35	0.25	1.10	5.50	93	0.050	5.00	0.2	
Other 3	0.60	0.05	2.20	9.00	250	0.050	5.00	0.2	

OTHER AREAL SOURCES	Affected Lake Area (ha)	P Export Coefficient (kg/ha/yr)	N Export Coefficient (kg/ha/yr)	TSS Export Coefficient (kg/ha/yr)
Atmospheric Deposition				
from Forested Area	0	0.20	6.52	32.0
from Agricultural/Rural Area	197.1	0.30	13.13	66.0
from Urban/Industrial Area	0	1.00	21.36	107.0
Internal Loading	76.7	0.75	8.20	0.1

NON-AREAL SOURCES	Number of Source Units	Volume (cu.m/yr)	P Load (kg/unit/yr)	N Load (kg/unit/yr)	TSS Load (kg/unit/yr)	P Load (ppm)	N Load (ppm)	TSS Load (ppm)
Waterfowl	65		0.20	0.95	5			
Point Sources								
PS-1		214000				0.01	0.45	1.0
PS-2		0						
PS-3		0						

Basin in which Point Source occurs (0=NO 1=YES)	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10
PS-1	0	0	0	0	0	0	0	0	0	0
PS-2	0	0	0	0	0	0	0	0	0	0
PS-3	0	0	0	0	0	0	0	0	0	0

BASIN AREAS

LAND USE	BASIN 1 AREA (HA)	BASIN 2 AREA (HA)	BASIN 3 AREA (HA)	BASIN 4 AREA (HA)	BASIN 5 AREA (HA)	BASIN 6 AREA (HA)	BASIN 7 AREA (HA)	BASIN 8 AREA (HA)	BASIN 9 AREA (HA)	BASIN 10 AREA (HA)	TOTAL AREA (HA)
Urban 1 (LDR)	1.01	28.63	0.65	0.53	1.35						32.17
Urban 2 (MDR/Hwy)	0.47	7.74	2.38	1.29	5.00	0.06					16.94
Urban 3 (HDR/Com)	0.002	1.44	3.72		3.38	1.77					10.312
Urban 4 (Ind)											0
Urban 5 (P/I/R/C)	6.43	1.69			2.12	12.44					22.68
Agric 1 (Cvr Crop)											0
Agric 2 (Row Crop)		0.002			1.99						1.992
Agric 3 (Grazing)		3.21	3.11		4.84						11.16
Agric 4 (Feedlot)					0.92						0.92
Forest 1 (Upland)	28.21	25.19	19.28	98.08	7.09	45.64					223.49
Forest 2 (Wetland)											0
Open 1 (Wetland/Lake)			3.63	24.64	8.06	11.21					47.54
Open 2 (Meadow)	2.34	5.38				1.36					9.08
Open 3 (Excavation)	0.001	6.78									6.781
Other 1											0
Other 2											0
Other 3											0
TOTAL	38.463	80.062	32.77	124.54	34.75	72.48	0	0	0	0	383.065

WATER LOAD GENERATION: RUNOFF											
	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
LAND USE	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)
Urban 1 (LDR)	4605.6	130552.8	2964	2416.8	6156	0	0	0	0	0	146695.2
Urban 2 (MDR/Hwy)	2679	44118	13566	7353	28500	342	0	0	0	0	96558
Urban 3 (HDR/Com)	13.68	9849.6	25444.8	0	23119.2	12106.8	0	0	0	0	70534.08
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	29320.8	7706.4	0	0	9667.2	56726.4	0	0	0	0	103420.8
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	5.7	0	0	5671.5	0	0	0	0	0	5677.2
Agric 3 (Grazing)	0	10978.2	10636.2	0	16552.8	0	0	0	0	0	38167.2
Agric 4 (Feedlot)	0	0	0	0	4719.6	0	0	0	0	0	4719.6
Forest 1 (Upland)	72358.65	64612.35	49453.2	251575.2	18185.85	117066.6	0	0	0	0	573251.85
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	2069.1	14044.8	4594.2	6389.7	0	0	0	0	27097.8
Open 2 (Meadow)	4001.4	9199.8	0	0	0	2325.6	0	0	0	0	15526.8
Open 3 (Excavation)	4.56	30916.8	0	0	0	0	0	0	0	0	30921.36
Other 1	0	0	0	0	0	0	0	0	0	0	0
Other 2	0	0	0	0	0	0	0	0	0	0	0
Other 3	0	0	0	0	0	0	0	0	0	0	0
TOTAL	112983.69	307939.65	104133.3	275389.8	117166.35	194957.1	0	0	0	0	1112569.89

WATER LOAD GENERATION: BASEFLOW	BASIN 1 (CU.M/YR)	BASIN 2 (CU.M/YR)	BASIN 3 (CU.M/YR)	BASIN 4 (CU.M/YR)	BASIN 5 (CU.M/YR)	BASIN 6 (CU.M/YR)	BASIN 7 (CU.M/YR)	BASIN 8 (CU.M/YR)	BASIN 9 (CU.M/YR)	BASIN 10 (CU.M/YR)	TOTAL (CU.M/YR)
Urban 1 (LDR)	2878.5	81595.5	1852.5	1510.5	3847.5	0	0	0	0	0	91684.5
Urban 2 (MDR/Hwy)	803.7	13235.4	4069.8	2205.9	8550	102.6	0	0	0	0	28967.4
Urban 3 (HDR/Com)	1.14	820.8	2120.4	0	1926.6	1008.9	0	0	0	0	5877.84
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	18325.5	4816.5	0	0	6042	35454	0	0	0	0	64638
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	6.84	0	0	6805.8	0	0	0	0	0	6812.64
Agric 3 (Grazing)	0	10978.2	10636.2	0	16552.8	0	0	0	0	0	38167.2
Agric 4 (Feedlot)	0	0	0	0	3146.4	0	0	0	0	0	3146.4
Forest 1 (Upland)	128637.6	114866.4	87916.8	447244.8	32330.4	208118.4	0	0	0	0	1019114.4
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland)	0	0	16552.8	112358.4	36753.6	51117.6	0	0	0	0	216782.4
Open 2 (Meadow)	8002.8	18399.6	0	0	0	4651.2	0	0	0	0	31053.6
Open 3 (Excavation)	2.28	15458.4	0	0	0	0	0	0	0	0	15460.68
Other 1	0	0	0	0	0	0	0	0	0	0	0
Other 2	0	0	0	0	0	0	0	0	0	0	0
Other 3	0	0	0	0	0	0	0	0	0	0	0
Point Source #1	0	0	0	0	0	0	0	0	0	0	0
Point Source #2	0	0	0	0	0	0	0	0	0	0	0
Point Source #3	0	0	0	0	0	0	0	0	0	0	0
TOTAL	158651.52	260177.64	123148.5	563319.6	115955.1	300452.7	0	0	0	0	1521705.1

LOAD GENERATION: RUNOFF P											
LAND USE	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)	TOTAL (KG/YR)
Urban 1 (LDR)	1.01	28.63	0.65	0.53	1.35	0	0	0	0	0	32.17
Urban 2 (MDR/Hwy)	0.47	7.74	2.38	1.29	5	0.06	0	0	0	0	16.94
Urban 3 (HDR/Com)	0.002	1.44	3.72	0	3.38	1.77	0	0	0	0	10.312
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	6.43	1.69	0	0	2.12	12.44	0	0	0	0	22.68
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0.0044	0	0	4.378	0	0	0	0	0	4.3824
Agric 3 (Grazing)	0	2.568	2.488	0	3.872	0	0	0	0	0	8.928
Agric 4 (Feedlot)	0	0	0	0	230	0	0	0	0	0	230
Forest 1 (Upland)	6.7704	6.0456	4.6272	23.5392	1.7016	10.9536	0	0	0	0	53.6376
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	0.8712	5.9136	1.9344	2.6904	0	0	0	0	11.4096
Open 2 (Meadow)	2.34	5.38	0	0	0	1.36	0	0	0	0	9.08
Open 3 (Excavation)	0.0015	10.17	0	0	0	0	0	0	0	0	10.1715
Other 1:	0	0	0	0	0	0	0	0	0	0	0
Other 2:	0	0	0	0	0	0	0	0	0	0	0
Other 3:	0	0	0	0	0	0	0	0	0	0	0
TOTAL	17.0	63.7	14.7	31.3	253.7	29.3	0.0	0.0	0.0	0.0	409.7
LOAD GENERATION: BASEFLOW P											
LAND USE	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)	TOTAL (KG/YR)
Urban 1 (LDR)	0.0505	1.4315	0.0325	0.0265	0.0675	0	0	0	0	0	1.6085
Urban 2 (MDR/Hwy)	0.0235	0.387	0.119	0.0645	0.25	0.003	0	0	0	0	0.847
Urban 3 (HDR/Com)	0.0001	0.072	0.186	0	0.169	0.0885	0	0	0	0	0.5156
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	0.3215	0.0845	0	0	0.106	0.622	0	0	0	0	1.134
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0.0001	0	0	0.0995	0	0	0	0	0	0.0996
Agric 3 (Grazing)	0	0.1605	0.1555	0	0.242	0	0	0	0	0	0.558
Agric 4 (Feedlot)	0	0	0	0	0.092	0	0	0	0	0	0.092
Forest 1 (Upland)	0.2821	0.2519	0.1928	0.9808	0.0709	0.4564	0	0	0	0	2.2349
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	0.0363	0.2464	0.0806	0.1121	0	0	0	0	0.4754
Open 2 (Meadow)	0.0234	0.0538	0	0	0	0.0136	0	0	0	0	0.0908
Open 3 (Excavation)	0.00001	0.0678	0	0	0	0	0	0	0	0	0.06781
Other 1:	0	0	0	0	0	0	0	0	0	0	0
Other 2:	0	0	0	0	0	0	0	0	0	0	0
Other 3:	0	0	0	0	0	0	0	0	0	0	0
Point Source #1	0	0	0	0	0	0	0	0	0	0	0
Point Source #2	0	0	0	0	0	0	0	0	0	0	0
Point Source #3	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0.7	2.5	0.7	1.3	1.2	1.3	0.0	0.0	0.0	0.0	7.7

LOAD GENERATION: RUNOFF N											
LAND USE	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)	TOTAL (KG/YR)
Urban 1 (LDR)	25.25	715.75	16.25	13.25	33.75	0	0	0	0	0	804.25
Urban 2 (MDR/Hwy)	9.4	154.8	47.6	25.8	100	1.2	0	0	0	0	338.8
Urban 3 (HDR/Com)	0.03	21.6	55.8	0	50.7	26.55	0	0	0	0	154.68
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	51.44	13.52	0	0	16.96	99.52	0	0	0	0	181.44
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0.02	0	0	19.9	0	0	0	0	0	19.92
Agric 3 (Grazing)	0	48.15	46.65	0	72.6	0	0	0	0	0	167.4
Agric 4 (Feedlot)	0	0	0	0	1380	0	0	0	0	0	1380
Forest 1 (Upland)	141.05	125.95	96.4	490.4	35.45	228.2	0	0	0	0	1117.45
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	18.15	123.2	40.3	56.05	0	0	0	0	237.7
Open 2 (Meadow)	18.252	41.964	0	0	0	10.608	0	0	0	0	70.824
Open 3 (Excavation)	0.0087	58.986	0	0	0	0	0	0	0	0	58.9947
Other 1:	0	0	0	0	0	0	0	0	0	0	0
Other 2:	0	0	0	0	0	0	0	0	0	0	0
Other 3:	0	0	0	0	0	0	0	0	0	0	0
TOTAL	245.4	1180.7	280.9	652.7	1749.7	422.1	0.0	0.0	0.0	0.0	4531.5

LOAD GENERATION: BASEFLOW N											
LAND USE	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)	TOTAL (KG/YR)
Urban 1 (LDR)	10.1	286.3	6.5	5.3	13.5	0	0	0	0	0	321.7
Urban 2 (MDR/Hwy)	9.4	154.8	47.6	25.8	100	1.2	0	0	0	0	338.8
Urban 3 (HDR/Com)	0.06	43.2	111.6	0	101.4	53.1	0	0	0	0	309.36
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	32.15	8.45	0	0	10.6	62.2	0	0	0	0	113.4
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0.01	0	0	9.95	0	0	0	0	0	9.96
Agric 3 (Grazing)	0	32.1	31.1	0	48.4	0	0	0	0	0	111.6
Agric 4 (Feedlot)	0	0	0	0	46	0	0	0	0	0	46
Forest 1 (Upland)	19.747	17.633	13.496	68.656	4.963	31.948	0	0	0	0	156.443
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	2.541	17.248	5.642	7.847	0	0	0	0	33.278
Open 2 (Meadow)	1.638	3.766	0	0	0	0.952	0	0	0	0	6.356
Open 3 (Excavation)	0.0007	4.746	0	0	0	0	0	0	0	0	4.7467
Other 1:	0	0	0	0	0	0	0	0	0	0	0
Other 2:	0	0	0	0	0	0	0	0	0	0	0
Other 3:	0	0	0	0	0	0	0	0	0	0	0
Point Source #1	0	0	0	0	0	0	0	0	0	0	96.3
Point Source #2	0	0	0	0	0	0	0	0	0	0	0
Point Source #3	0	0	0	0	0	0	0	0	0	0	0
TOTAL	73.1	551.0	212.8	117.0	340.5	157.2	0.0	0.0	0.0	0.0	1547.9

LOAD GENERATION: RUNOFF TSS											
LAND USE	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)	TOTAL (KG/YR)
Urban 1 (LDR)	50.5	1431.5	32.5	26.5	67.5	0	0	0	0	0	1608.5
Urban 2 (MDR/Hwy)	23.5	387	119	64.5	250	3	0	0	0	0	847
Urban 3 (HDR/Com)	0.1	72	186	0	169	88.5	0	0	0	0	515.6
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	321.5	84.5	0	0	106	622	0	0	0	0	1134
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0.4	0	0	398	0	0	0	0	0	398.4
Agric 3 (Grazing)	0	240.75	233.25	0	363	0	0	0	0	0	837
Agric 4 (Feedlot)	0	0	0	0	3680	0	0	0	0	0	3680
Forest 1 (Upland)	423.15	377.85	289.2	1471.2	106.35	684.6	0	0	0	0	3352.35
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	36.3	246.4	80.6	112.1	0	0	0	0	475.4
Open 2 (Meadow)	35.1	80.7	0	0	0	20.4	0	0	0	0	136.2
Open 3 (Excavation)	0.5	3390	0	0	0	0	0	0	0	0	3390.5
Other 1:	0	0	0	0	0	0	0	0	0	0	0
Other 2:	0	0	0	0	0	0	0	0	0	0	0
Other 3:	0	0	0	0	0	0	0	0	0	0	0
TOTAL	854.4	6064.7	896.3	1808.6	5220.5	1530.6	0.0	0.0	0.0	0.0	16375.0

LOAD GENERATION: BASEFLOW TSS											
LAND USE	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)	TOTAL (KG/YR)
Urban 1 (LDR)	0.202	5.726	0.13	0.106	0.27	0	0	0	0	0	6.434
Urban 2 (MDR/Hwy)	0.094	1.548	0.476	0.258	1	0.012	0	0	0	0	3.388
Urban 3 (HDR/Com)	0.0004	0.288	0.744	0	0.676	0.354	0	0	0	0	2.0624
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	1.286	0.338	0	0	0.424	2.488	0	0	0	0	4.536
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0.0004	0	0	0.398	0	0	0	0	0	0.3984
Agric 3 (Grazing)	0	0.642	0.622	0	0.968	0	0	0	0	0	2.232
Agric 4 (Feedlot)	0	0	0	0	0.184	0	0	0	0	0	0.184
Forest 1 (Upland)	5.642	5.038	3.856	19.616	1.418	9.128	0	0	0	0	44.698
Forest 2 (Wetland)	0	0	0	0	0	0	0	0	0	0	0
Open 1 (Wetland/Lake)	0	0	0.726	4.928	1.612	2.242	0	0	0	0	9.508
Open 2 (Meadow)	0.468	1.076	0	0	0	0.272	0	0	0	0	1.816
Open 3 (Excavation)	0.0002	1.356	0	0	0	0	0	0	0	0	1.3562
Other 1:	0	0	0	0	0	0	0	0	0	0	0
Other 2:	0	0	0	0	0	0	0	0	0	0	0
Other 3:	0	0	0	0	0	0	0	0	0	0	0
Point Source #1	0	0	0	0	0	0	0	0	0	0	214
Point Source #2	0	0	0	0	0	0	0	0	0	0	0
Point Source #3	0	0	0	0	0	0	0	0	0	0	0
TOTAL	7.7	16.0	6.6	24.9	7.0	14.5	0.0	0.0	0.0	0.0	290.6

ROUTING PATTERN (Which basin flows to which)

1=YES 0=NO XXX=BLANK	PASSES THROUGH...									
	BASIN 1 (CU.M/YR)	BASIN 2 (CU.M/YR)	BASIN 3 (CU.M/YR)	BASIN 4 (CU.M/YR)	BASIN 5 (CU.M/YR)	BASIN 6 (CU.M/YR)	BASIN 7 (CU.M/YR)	BASIN 8 (CU.M/YR)	BASIN 9 (CU.M/YR)	BASIN 10 (CU.M/YR)
INDIVIDUAL BASIN	1	1	1	1	1	1	1	1	1	1
BASIN 1 OUTPUT	XXX	0	0	0	0	0	0	0	0	0
BASIN 2 OUTPUT	0	XXX	0	0	0	0	0	0	0	0
BASIN 3 OUTPUT	0	0	XXX	0	0	0	0	0	0	0
BASIN 4 OUTPUT	0	0	0	XXX	0	0	0	0	0	0
BASIN 5 OUTPUT	0	0	0	0	XXX	0	0	0	0	0
BASIN 6 OUTPUT	0	0	0	0	0	XXX	0	0	0	0
BASIN 7 OUTPUT	0	0	0	0	0	0	XXX	0	0	0
BASIN 8 OUTPUT	0	0	0	0	0	0	0	XXX	0	0
BASIN 9 OUTPUT	0	0	0	0	0	0	0	0	XXX	0
BASIN 10 OUTPUT	0	0	0	0	0	0	0	0	0	XXX

WATER ROUTING AND ATTENUATION

SOURCE	BASIN 1 (CU.M/YR)	BASIN 2 (CU.M/YR)	BASIN 3 (CU.M/YR)	BASIN 4 (CU.M/YR)	BASIN 5 (CU.M/YR)	BASIN 6 (CU.M/YR)	BASIN 7 (CU.M/YR)	BASIN 8 (CU.M/YR)	BASIN 9 (CU.M/YR)	BASIN 10 (CU.M/YR)
INDIVIDUAL BASIN	271635.21	568117.29	227281.8	838709.4	233121.45	495409.8	0	0	0	0
BASIN 1 OUTPUT	XXX	0	0	0	0	0	0	0	0	0
BASIN 2 OUTPUT	0	XXX	0	0	0	0	0	0	0	0
BASIN 3 OUTPUT	0	0	XXX	0	0	0	0	0	0	0
BASIN 4 OUTPUT	0	0	0	XXX	0	0	0	0	0	0
BASIN 5 OUTPUT	0	0	0	0	XXX	0	0	0	0	0
BASIN 6 OUTPUT	0	0	0	0	0	XXX	0	0	0	0
BASIN 7 OUTPUT	0	0	0	0	0	0	XXX	0	0	0
BASIN 8 OUTPUT	0	0	0	0	0	0	0	XXX	0	0
BASIN 9 OUTPUT	0	0	0	0	0	0	0	0	XXX	0
BASIN 10 OUTPUT	0	0	0	0	0	0	0	0	0	XXX
CUMULATIVE TOTAL	271635.2	568117.3	227281.8	838709.4	233121.5	495409.8	0	0	0	0
BASIN ATTENUATION	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OUTPUT VOLUME	271635.2	568117.3	227281.8	838709.4	233121.5	495409.8	0	0	0	0
Reality Check for Indiv. Basin (Based on std water yield)	265548.6	552748.0	226244.1	859824.2	239914.0	500401.9	0	0	0	0

LOAD ROUTING AND ATTENUATION: PHOSPHORUS										
	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)
BASIN 1 INDIVIDUAL	17.7	66.2	15.5	32.6	254.9	30.6	0.0	0.0	0.0	0.0
BASIN 1 OUTPUT	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 2 OUTPUT	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 3 OUTPUT	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 4 OUTPUT	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 5 OUTPUT	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0
BASIN 6 OUTPUT	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0
BASIN 7 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0
BASIN 8 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0
BASIN 9 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0
BASIN 10 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX
CUMULATIVE TOTAL	17.7	66.2	15.5	32.6	254.9	30.6	0.0	0.0	0.0	0.0
BASIN ATTENUATION	0.90	0.80	0.80	0.60	0.75	0.75	1.00	1.00	1.00	1.00
OUTPUT LOAD	16.0	52.9	12.4	19.6	191.2	22.9	0.0	0.0	0.0	0.0

LOAD AND CONCENTRATION SUMMARY: PHOSPHORUS											
	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
OUTPUT (CU.M/YR)	271635	568117	227282	838709	233121	495410	0	0	0	0	
OUTPUT (KG/YR)	16.0	52.9	12.4	19.6	191.2	22.9	0.0	0.0	0.0	0.0	
OUTPUT (MG/L)	0.059	0.093	0.054	0.023	0.820	0.046	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
REALITY CHECK CONC.					0.385-1.61	0.047-0.053					
(Based on real data)											
TERMINAL DISCHARGE?	1	1	1	1	1	1	1	1	1	1	
(1=YES 2=NO)											
LOAD TO RESOURCE											
WATER (CU.M/YR)	271635	568117	227282	838709	233121	495410	0	0	0	0	2634275
PHOSPHORUS (KG/YR)	16.0	52.9	12.4	19.6	191.2	22.9	0.0	0.0	0.0	0.0	314.9
PHOSPHORUS (MG/L)	0.059	0.093	0.054	0.023	0.820	0.046	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.120

LOAD ROUTING AND ATTENUATION: NITROGEN

	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)
BASIN 1 INDIVIDUAL	318.5	1731.7	493.7	769.7	2090.1	579.4	0.0	0.0	0.0	0.0
BASIN 1 OUTPUT	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 2 OUTPUT	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 3 OUTPUT	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 4 OUTPUT	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 5 OUTPUT	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0
BASIN 6 OUTPUT	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0
BASIN 7 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0
BASIN 8 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0
BASIN 9 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0
BASIN 10 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX
CUMULATIVE TOTAL	318.5	1731.7	493.7	769.7	2090.1	579.4	0.0	0.0	0.0	0.0
BASIN ATTENUATION	0.90	0.90	0.90	0.80	0.70	0.80	1.00	1.00	1.00	1.00
OUTPUT LOAD	286.7	1558.6	444.3	615.7	1463.1	463.5	0.0	0.0	0.0	0.0

LOAD AND CONCENTRATION SUMMARY: NITROGEN

	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
OUTPUT (CU.M/YR)	271635	568117	227282	838709	233121	495410	0	0	0	0	
OUTPUT (KG/YR)	286.7	1558.6	444.3	615.7	1463.1	463.5	0.0	0.0	0.0	0.0	
OUTPUT MG/L	1.055	2.743	1.955	0.734	6.276	0.936	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
REALITY CHECK CONC.					3.6-4.6	0.88-0.96					
(Based on real data)											
TERMINAL DISCHARG	1	1	1	1	1	1	1	1	1	1	
(1=YES 2=NO)											
LOAD TO RESOURCE											
WATER (CU.M/YR)	271635	568117	227282	838709	233121	495410	0	0	0	0	2634275
NITROGEN (KG/YR)	286.7	1558.6	444.3	615.7	1463.1	463.5	0.0	0.0	0.0	0.0	4831.9
NITROGEN (MG/L)	1.055	2.743	1.955	0.734	6.276	0.936	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.834

LOAD ROUTING AND ATTENUATION: SUSPENDED SOLIDS

	BASIN 1 (KG/YR)	BASIN 2 (KG/YR)	BASIN 3 (KG/YR)	BASIN 4 (KG/YR)	BASIN 5 (KG/YR)	BASIN 6 (KG/YR)	BASIN 7 (KG/YR)	BASIN 8 (KG/YR)	BASIN 9 (KG/YR)	BASIN 10 (KG/YR)
BASIN 1 INDIVIDUAL	862.0	6080.7	902.8	1833.5	5227.4	1545.1	0.0	0.0	0.0	0.0
BASIN 1 OUTPUT	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 2 OUTPUT	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 3 OUTPUT	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 4 OUTPUT	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 5 OUTPUT	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0
BASIN 6 OUTPUT	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0
BASIN 7 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0
BASIN 8 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0
BASIN 9 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0
BASIN 10 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX
CUMULATIVE TOTAL	862.0	6080.7	902.8	1833.5	5227.4	1545.1	0.0	0.0	0.0	0.0
BASIN ATTENUATION	0.70	0.70	0.70	0.50	0.60	0.60	1.00	1.00	1.00	1.00
OUTPUT LOAD	603.4	4256.5	632.0	916.8	3136.4	927.1	0.0	0.0	0.0	0.0

LOAD AND CONCENTRATION SUMMARY: SUSPENDED SOLIDS

	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
OUTPUT (CU.M/YR)	271635	568117	227282	838709	233121	495410	0	0	0	0	
OUTPUT (KG/YR)	603.4	4256.5	632.0	916.8	3136.4	927.1	0.0	0.0	0.0	0.0	
OUTPUT MG/L	2.221	7.492	2.781	1.093	13.454	1.871	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
REALITY CHECK CONC.					5.8-18	0.8-2.5					
(Based on real data)											
TERMINAL DISCHARG	1	1	1	1	1	1	1	1	1	1	
(1=YES 2=NO)											
LOAD TO RESOURCE											
WATER (CU.M/YR)	271635	568117	227282	838709	233121	495410	0	0	0	0	2634275
TSS (KG/YR)	603.4	4256.5	632.0	916.8	3136.4	927.1	0.0	0.0	0.0	0.0	10472.1
TSS (MG/L)	2.221	7.492	2.781	1.093	13.454	1.871	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	3.975

LOADING SUMMARY:				
	WATER	P	N	TSS
DIRECT LOADS TO LAKE	(CU.M/YR)	(KG/YR)	(KG/YR)	(KG/YR)
ATMOSPHERIC	2246940	59.1	2587.9	13008.6
INTERNAL	0	57.5	628.9	7.7
WATERFOWL	0	13.0	61.8	325.0
WATERSHED LOAD	2634275	314.9	4831.9	10472.1
TOTAL LOAD TO LAKE	4881215	444.6	8110.5	23813.4
(Watershed + direct loads)				
TOTAL INPUT CONC. (MG/L)		0.091	1.662	4.879

IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS: Current Conditions

THE TERMS

PHOSPHORUS

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE	
TP	Lake Total Phosphorus Conc.	ppb	From in-lake models	To Be Predicted	Dependent Variable
KG	Phosphorus Load to Lake	kg/yr	From export model	445	
L	Phosphorus Load to Lake	g P/m2/yr	KG*1000/A	0.226	
TPin	Influent (Inflow) Total Phosphorus	ppb	From export model	91	
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data, if available	33	Enter Value (TP out)
I	Inflow	m3/yr	From export model	4881215	
A	Lake Area	m2	From data	1970818	Enter Value (A)
V	Lake Volume	m3	From data	7696005	Enter Value (V)
Z	Mean Depth	m	Volume/area	3.905	
F	Flushing Rate	flushings/yr	Inflow/volume	0.634	
S	Suspended Fraction	no units	Effluent TP/Influent TP	0.362	
Qs	Areal Water Load	m/yr	Z(F)	2.477	
Vs	Settling Velocity	m	Z(S)	1.415	
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.747	
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.557	

NITROGEN

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE	
TN	Lake Total Nitrogen Conc.	ppb	From in-lake models	To Be Predicted	Dependent Variable
KG	Nitrogen Load to Lake	kg/yr	From export model	8110	
L1	Nitrogen Load to Lake	g N/m2/yr	KG*1000/A	4.12	
L2	Nitrogen Load to Lake	mg N/m2/yr	KG*1000000/A	4115	
C1	Coefficient of Attenuation, from F	fraction/yr	2.7183^(0.5541(ln(F))-0.367)	0.54	
C2	Coefficient of Attenuation, from L	fraction/yr	2.7183^(0.71(ln(L2))-6.426)	0.60	
C3	Coefficient of Attenuation, from L/Z	fraction/yr	2.7183^(0.594(ln(L2/Z))-4.144)	0.99	

IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS: Current Conditions

THE MODELS	PHOSPHORUS				PREDICTED CHL AND WATER CLARITY	
NAME	FORMULA	PRED. CONC. (ppb)	PERMIS. CONC. (ppb)	CRITICAL CONC. (ppb)	MODEL	Value
Mass Balance	TP = L/(Z(F)) * 1000	91				
(Maximum Conc.)					**Mean Chlorophyll (ug/L)**	
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	23	16	32	Dillon and Rigler 1974	15.2
(K-D)					Jones and Bachmann 1976	17.6
Vollenweider 1975	TP=L/(Z(S+F))*1000	58	40	81	Oglesby and Schaffner 1978	19.9
(V)					Modified Vollenweider 1982	19.2
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	40	28	56	**"Maximum" Chlorophyll (ug/L)**	
(L-M)					Modified Vollenweider (TP) 1982	61.2
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	38	26	53	Vollenweider (CHL) 1982	55.7
(J-B)					Modified Jones, Rast and Lee 1979	61.4
					Secchi Transparency (M)	
Average of Model Values		40	28	55	Oglesby and Schaffner 1978 **(Avg)**	1.4
(without mass balance)					Modified Vollenweider 1982 **(Max)**	3.5
Reality Check Conc.		39				
From Vollenweider 1968						
Permis. Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.16				
Critical Load (g/m2/yr)	Lc=2(Cp)	0.31				
	NITROGEN					
Mass Balance	TN = L/(Z(F)) * 1000	1662				
(Maximum Conc.)						
Bachmann 1980	TN=L/(Z(C1+F))*1000	899				
Bachmann 1980	TN=L/(Z(C2+F))*1000	856				
Bachmann 1980	TN=L/(Z(C3+F))*1000	649				
Reality Check Conc.		900				

IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS:

Maximum Loading Reduction Through Detention in Basins #2, 3, 5 and 6.

THE MODELS

NAME	*PHOSPHORUS* FORMULA	PRED. CONC. (ppb)	PERMIS. CONC. (ppb)	CRITICAL CONC. (ppb)
Mass Balance (Maximum Conc.)	TP=L/(Z(F))*1000	64		
Kirchner-Dillon 1975 (K-D)	TP=L(1-Rp)/(Z(F))*1000	16	16	32
Vollenweider 1975 (V)	TP=L/(Z(S+F))*1000	40	39	78
Larsen-Mercier 1976 (L-M)	TP=L(1-Rlm)/(Z(F))*1000	28	28	56
Jones-Bachmann 1976 (J-B)	TP=0.84(L)/(Z(0.65+F))*1000	27	26	53
Average of Model Values (without mass balance)		28	27	55
From Vollenweider 1968				
Permis. Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.16		
Critical Load (g/m2/yr)	Lc=2(Cp)	0.31		
	NITROGEN			
Mass Balance (Maximum Conc.)	TN=L/(Z(F))*1000	1604		
Bachmann 1980	TN=L/(Z(C1+F))*1000	868		
Bachmann 1980	TN=L/(Z(C2+F))*1000	837		
Bachmann 1980	TN=L/(Z(C3+F))*1000	634		

PREDICTED CHL AND WATER CLARITY

MODEL	Value
Mean Chlorophyll (ug/L)	
Dillon and Rigler 1974	9.0
Jones and Bachmann 1976	10.3
Oglesby and Schaffner 1978	13.0
Modified Vollenweider 1982	13.5
"Maximum" Chlorophyll (ug/L)	
Modified Vollenweider (TP) 1982	41.7
Vollenweider (CHL) 1982	34.5
Modified Jones, Rast and Lee 1979	39.1
Secchi Transparency (M)	
Oglesby and Schaffner 1978 **(Avg)**	1.8
Modified Vollenweider 1982 **(Max)**	3.9

IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS: 67% Reduction in Load from Basin #5 Feedlot.

THE MODELS					*PREDICTED CHL AND WATER CLARITY*	
	PHOSPHORUS	PRED.	PERMIS.	CRITICAL		
		CONC.	CONC.	CONC.		Value
NAME	FORMULA	(ppb)	(ppb)	(ppb)	MODEL	
Mass Balance	TP=L/(Z(F))*1000	68				
(Maximum Conc.)					**Mean Chlorophyll (ug/L)**	
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	17	16	32	Dillon and Rigler 1974	9.7
(K-D)					Jones and Bachmann 1976	11.2
Vollenweider 1975	TP=L/(Z(S+F))*1000	42	39	79	Oglesby and Schaffner 1978	13.9
(V)					Modified Vollenweider 1982	14.3
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	30	28	56	**"Maximum" Chlorophyll (ug/L)**	
(L-M)					Modified Vollenweider (TP) 1982	44.3
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	28	26	53	Vollenweider (CHL) 1982	37.1
(J-B)					Modified Jones, Rast and Lee 1979	42.0
					Secchi Transparency (M)	
Average of Model Values		29	27	55	Oglesby and Schaffner 1978 **(Avg)**	1.7
(without mass balance)					Modified Vollenweider 1982 **(Max)**	3.8
From Vollenweider 1968						
Permis. Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.16				
Critical Load (g/m2/yr)	Lc=2(Cp)	0.31				
	NITROGEN					
Mass Balance	TN=L/(Z(F))*1000	1530				
(Maximum Conc.)						
Bachmann 1980	TN=L/(Z(C1+F))*1000	827				
Bachmann 1980	TN=L/(Z(C2+F))*1000	811				
Bachmann 1980	TN=L/(Z(C3+F))*1000	615				

IN-LAKE MODELS FOR PREDICTING CONCENTRATIONS:

Alteration of Basin #5 Feedlot to Expected Grazing Land Export Values (Approx. 99% Reduction)

THE MODELS	*PHOSPHORUS*	PRED. CONC. (ppb)	PERMIS. CONC. (ppb)	CRITICAL CONC. (ppb)	*PREDICTED CHL AND WATER CLARITY* MODEL	Value
NAME	**FORMULA**					
Mass Balance	TP=L/(Z(F))*1000	56				
(Maximum Conc.)					**Mean Chlorophyll (ug/L)**	
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	14	16	32	Dillon and Rigler 1974	7.4
(K-D)					Jones and Bachmann 1976	8.5
Vollenweider 1975	TP=L/(Z(S+F))*1000	34	39	78	Oglesby and Schaffner 1978	10.9
(V)					Modified Vollenweider 1982	11.9
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	25	28	56	**"Maximum" Chlorophyll (ug/L)**	
(L-M)					Modified Vollenweider (TP) 1982	36.2
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	23	26	53	Vollenweider (CHL) 1982	28.8
(J-B)					Modified Jones, Rast and Lee 1979	33.1
					Secchi Transparency (M)	
Average of Model Values		24	27	55	Oglesby and Schaffner 1978 **(Avg)**	2.0
(without mass balance)					Modified Vollenweider 1982 **(Max)**	4.0
From Vollenweider 1968						
Permis. Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.16				
Critical Load (g/m2/yr)	Lc=2(Cp)	0.31				
	NITROGEN					
Mass Balance	TN=L/(Z(F))*1000	1466				
(Maximum Conc.)						
Bachmann 1980	TN=L/(Z(C1+F))*1000	793				
Bachmann 1980	TN=L/(Z(C2+F))*1000	788				
Bachmann 1980	TN=L/(Z(C3+F))*1000	598				