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DIAGNOSTIC / FEASIBILITY STUDY

FOR THE MANAGEMENT OF

DIMMOCK POND

SPRINGFIELD, MASSACHUSETTS

BAYSTATE
ENVIRONMENTAL
CONSULTANTS
INC.

DIAGNOSTIC/FEASIBILITY STUDY
FOR THE MANAGEMENT OF
DIMMOCK POND,
SPRINGFIELD, MASSACHUSETTS

PREPARED FOR
THE
CITY OF SPRINGFIELD
AND THE
MASSACHUSETTS DIVISION OF WATER POLLUTION CONTROL

UNDER
MGL CHAP. 628
MASSACHUSETTS CLEAN LAKES PROGRAM

BY
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FINAL REPORT

NOVEMBER, 1988

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PROJECT SUMMARY

Dimmock Pond and its watershed were investigated and evaluated in 1987 and 1988 by Baystate Environmental Consultants, Inc., on behalf of the City of Springfield. The study was made possible by funding through the Massachusetts Clean Lakes Program of the Department of Environmental Quality Engineering and the citizens of Springfield. The physical, chemical and biological features of the pond were assessed and management recommendations have been prepared.

The results of the study indicate that Dimmock Pond is receiving excessive loads of sediment and nutrients associated with storm water runoff generated in the urban watershed and resuspension of sediments accumulating in the pond. Current nutrient levels support algal blooms and dense growths of macrophytes, but turbidity is high even when plant biomass is low as a consequence of sediment resuspension and very slow settling rates. Erosion at shoreline access points adds to the unsightly condition of this water resource. Flooding of park lands sometimes occurs in response to periods of intense precipitation.

Review of available management options has eliminated many techniques from consideration. Evaluation of the remaining alternatives in light of technical and economic considerations has yielded a recommended management plan incorporating in-lake detention at the outfall points, diversion of some stormwater (Parker St. drainage system) to the ground via leaching catch basins, dredging of Dimmock Pond, and environmental education of watershed residents.

The proposed management plan is expected to yield substantial reductions in the loads of phosphorus (48 to 77%) and nitrogen (55 to 85%) to Dimmock Pond. A considerable increase in water clarity (85 to 120%) and a major decline in nearshore plant density (70 to 80%) are also expected. Favorable changes in aquatic plant species and distribution are anticipated as well. Oxygen levels throughout the pond will be favorable for all species of fish currently in Dimmock Pond. The physical features and appearance of Dimmock Pond will be altered to provide a more ecologically functional and aesthetically appealing water body. Habitat quality is expected to increase appreciably for most forms of aquatic life, and pond condition will be more appropriate to its desired uses.

The total anticipated cost of the proposed management plan is $1,422,700.00, which includes the basic elements described above and a monitoring program for assessment of results and adjustment of management actions. A five-year implementation schedule has been outlined, with monitoring continued for an additional three years (post-implementation monitoring). Additional management actions may be desirable (e.g., fishery manipulation or leaching basins in the Ludlow Ave. drainage area), but the proposed project should yield conditions acceptable for the desired uses of Dimmock Pond and the surrounding park land.

PART I

DIAGNOSTIC EVALUATION

INTRODUCTION

As an environmentally aware and concerned community, the City of Springfield had funded preliminary studies and improvements of most of the lakes in the City prior to 1980. The establishment of the Massachusetts Clean Lakes Program under Chapter 628 of the Acts of 1981 encouraged many municipalities and lake associations to acquire funding for study and restoration of their lakes. Springfield opted to continue its water resources management program through the Clean Lakes Program, and has received grants for Phase I diagnostic/feasibility studies and Phase II implementation projects. Under a Phase I grant received in 1986, the City contracted Baystate Environmental Consultants, Inc. to conduct the study of Dimmock Pond.

Concern over the present and future status of Dimmock Pond and the surrounding Hubbard Park prompted the request for a study. Natural features of the pond and the impacts of urbanization in the Dimmock Pond watershed had resulted in water quality deterioration, reduced recreational opportunity, and aesthetic impairment at Dimmock Pond. Mitigation of any current negative influences on the pond and prevention of future degradation of this water resource were desired.

DATA COLLECTION METHODS

Previous studies of Dimmock Pond were reviewed, and historic conditions were discussed with City officials and other parties involved with the park and pond. Maps and reports prepared by the United States Geological Survey (USGS) and Soil Conservation Services (SCS) were used to initially assess watershed characteristics. Of particular use were the USGS (1970) Springfield North and (1969) Ludlow Quadrangle Sheets from the 7.5 minute series, the USGS-Massachusetts Department of Public Works Bedrock Geologic Map (Zen, 1983), the Hampden County soil survey report prepared by SCS (1978), and aerial infrared photographs obtained from the National Cartographic Information Center (1985). Areal measurements were made with a Planix Electronic Planimeter. Determinations made from maps were verified by field inspection by staff engineers, biologists, and a geo-hydrologist.

Historical lake and land use were investigated through conversations with watershed residents, newspaper and technical articles, previous reports and maps, state agency correspondence, and field inspection. There is relatively little documentation of historic events at Dimmock Pond, relative to other, larger City lakes.

A bathymetric map was generated by plumb-lining along cross-lake transects. Soft sediment depth was assessed by driving a probe to first refusal; these measurements were also performed in conjunction with the bathymetric check.

A comprehensive monitoring and investigative research program was implemented to assess the physical, chemical, and biological characteristics of Dimmock Pond. Sampling stations were selected from topographic maps and field inspection. These stations are described in Table 1 and shown in Figure 1. Stations associated with the nearby Kettlehole Lakes (Fivemile, Lorraine and Loon) are also presented, as comparisons were drawn during the concurrent studies of these ponds. The in-lake station was sampled with a Scott bottle at the surface and bottom. Samples were collected approximately biweekly between April and October and monthly during other times of the year.

Fifteen parameters were routinely assessed at regular sampling locations (non-storm stations) (Table 2). Temperature and dissolved oxygen levels were measured with a YS1 model 57 meter, with vertical profiles obtained at the in-lake stations (0.5 m intervals). The pH was measured with an Orion model SA 250 pH meter. Conductivity was assessed with a YSI model 33 S-C-T meter. Turbidity was measured with a Hach model 1860 turbidimeter. A two liter water sample was taken at each sampling location and transported to Berkshire Enviro-Labs in

TABLE 1

SAMPLING STATIONS FOR THE DIAGNOSTIC/FEASIBILITY STUDY OF DIMMOCK POND AND THE KETTLEHOLE PONDS OF SPRINGFIELD

Station No.	Location
DIMMOCK POND:	
DP-1S	North central deep hole (0-3 ft)
DP-1B	North central deep hole (9-11 ft)
DP-2	Storm drain off Parker Rd. on east side
DP-3	Storm drain off Ludlow Ave. ext. on north side
FIVEMILE POND:	
FM-1S	Northwest deep hole, surface (0-3 ft)
FM-1M	Northwest deep hole, mid-depth (15-20 ft)
FM-1B	Northwest deep hole, bottom (33-35 ft)
FM-2S	East deep hole, surface (0-3 ft)
FM-2M	East deep hole, mid-depth (12-16 ft)
FM-2B	East deep hole, bottom (18-20 ft)
FM-3S	South basin, surface (0-2 ft)
FM-4	Storm drain, end of Bexhill Rd.
FM-5	Storm drain, off Pine Grove St.
FM-6	Storm drain, off Boston Rd. @ SE wetland
FM-7	Storm drain, off Boston Rd. @ South Basin
FM-8	Storm drain, off Brandon St. @ South Basin
FM-9	Runoff channel from U-Haul lot to South Basin
LAKE LORRAINE:	
LL-1S	Deep hole @ south end (0-3 ft)
LL-1M	Deep hole @ south end (12-16 ft)
LL-1B	Deep hole @ south end (33-35 ft)
LL-2	Storm drain, end of Michigan St.
LL-3	Storm drain, end of Superior St.
LL-4	Storm drain, end of Lorimer St.
LL-5	Storm drain, end of Steuben St.
LL-6	Storm drain, end of Ogden St.
LL-7	Storm drain, end of Seneca St.
LL-8	Storm drain, end of Oneida St.
LL-9	Storm drain, end of Blanding St. (indirect)
LOON POND:	
LP-1S	Central deep hole (0-3 ft)
LP-1M	Central deep hole (14-16 ft)
LP-1B	Central deep hole (20-25 ft)
LP-2	Storm drain off Glenmore St. (near dock)
LP-3	Storm drain off Boston Rd. (Marshall's Lot)
LP-4	Motel discharge on south side (Gables Motel)
LP-5	Overflow ditch to Pasco Rd. Bog

FIGURE 1

DIMMOCK POND AND THE

SPRINGFIELD KETTLEHOLE LAKES

SAMPLING STATIONS

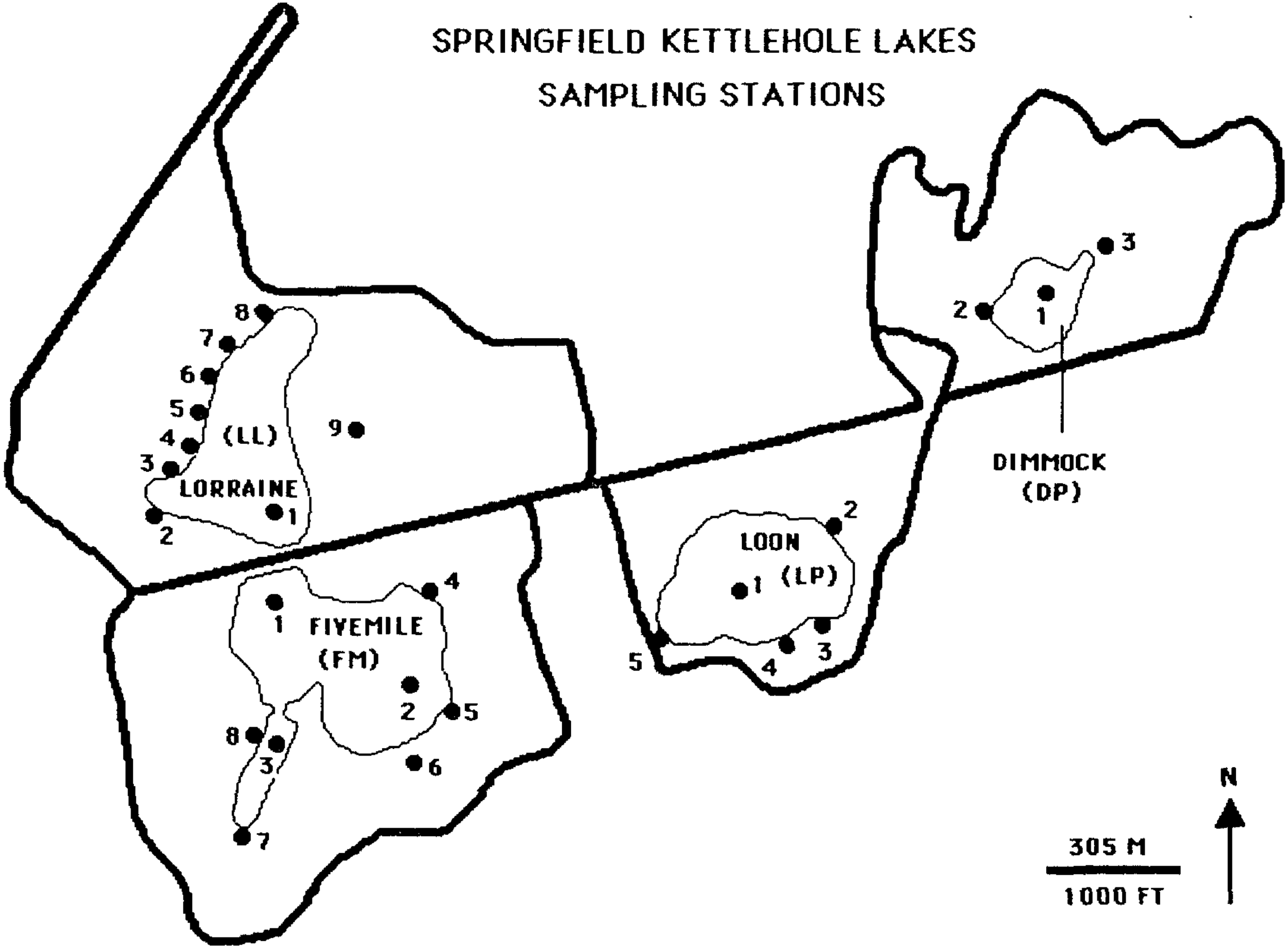


TABLE 2

ANALYSIS PARAMETERS FOR THE DIAGNOSTIC/FEASIBILITY STUDY OF DIMMOCK POND AND THE KETTLEHOLE PONDS OF SPRINGFIELD

Parameters to be assessed by lab:

In-lake/outlet:

Total phosphorus	Alkalinity	Fecal coliform
Orthophosphorus	Total suspended solids	Fecal streptococci
Ammonia nitrogen	Chlorides	
Nitrate nitrogen		
Total Kjeldahl nitrogen		

Storm drains:

All of the above, plus

Cadmium	Iron	Zinc
Chromium	Lead	Oil and grease
Copper	Manganese	

BEC Analyses:

Temperature	Conductivity	Secchi disk transparency
Dissolved oxygen	Turbidity	Chlorophyll
pH	Flow	Phytoplankton
	Rainfall	Zooplankton (seasonal)

Lee, MA for analysis of suspended solids, total alkalinity, chlorides, total Kjeldahl nitrogen, nitrate nitrogen, ammonia nitrogen, total phosphorus, and orthophosphorus by accepted standard methods (e.g., Kopp and McKee, 1979; APHA et al., 1985). Separate bacterial samples were collected for fecal coliform and fecal streptococci analyses, also performed by Berkshire Enviro-Labs by standard methods (membrane filter technique). Missing data result primarily from site inaccessiblity..

A data quality evaluation program was conducted in conjunction with the Dimmock Pond and Kettlehole Ponds studies. A split sample was collected from a randomly chosen station on fourteen dates and processed for analysis as part of the routine sampling schedule. Average percent difference and standard error were calculated for ten parameters.

Storm sampling was conducted on five dates, with some variation in procedures and sampling stations on each date. The two drainage systems discharging into Dimmock Pond were sampled on a flow weighted composite basis three times, and through the use of temporally sequential samples twice. Flow was assessed at the storm drain stations using a pipe/weir equation (SCS 1975a). In addition to the parameters routinely surveyed, composite samples were analyzed for oil and grease on three dates and seven heavy metals on four dates. A composite sample from the two storm drain stations was size fractionated prior to analysis. Size fraction limits were set at 250 um, 100 um, 53 um, 10 um, and 0.45 um. A total sample was also assessed. Fractionation was carried out by gravity filtration of composite samples through nylon mesh of the appropriate size, except for the 0.45 um fraction, which was obtained by suction filtration through a glass fiber filter.

A 20 cm Secchi disk was lowered on the shady side of the boat to evaluate water transparency at the in-lake station. Analyses of chlorophyll concentration and features of the phytoplankton and zooplankton communities were made for that location as well. Phytoplankton samples were obtained from a depth integrated composite sample, while zooplankton samples were collected by oblique tow of an 80 micron mesh net. Phytoplankton samples were preserved with Lugol's solution and zooplankton samples were preserved with a formalin solution. Plankton samples were analyzed microscopically for species composition, relative abundance and biomass. The size distribution of the zooplankton was also assessed, and all data were recorded and tallied using a microcomputer routine developed by BEC and Cornell University personnel.

Groundwater interaction with Dimmock Pond was assessed through assessment of the pressure differential (hydraulic head) between groundwater and the pond, direct measurement of seepage into and out of the pond, and sampling of porewater near its point of entry or exit from the pond (Mitchell et al. 1988). Pressure differences were evaluated with a manometer having probes inserted into the pond and the groundwater near the shoreline. Water in the column represented by the groundwater will be higher than that in the surface water column, if the tendency is for water to seep into the pond, and vice versa.

Seepage measures were accomplished with meters constructed from 208 liter barrels cut in half and modified to accept a fitting to which a bag with a predetermined volume of water is attached. The meter is set into the sediment, open end down. After several hours in situ, the bag will have accumulated detectable additional water if there is seepage into the open end of the barrel, and the bag loses water if there is seepage into the groundwater from the pond.

Porewater samples were collected with a littoral interstitial porewater (LIP) sampler, which functions as a miniature well when inserted into the groundwater near the shoreline. A hand pump draws water into an intermediate glass trap, yielding a sample of groundwater near the pond. LIP samples are processed at the laboratory in the same manner as other water quality samples, but for a reduced set of parameters.

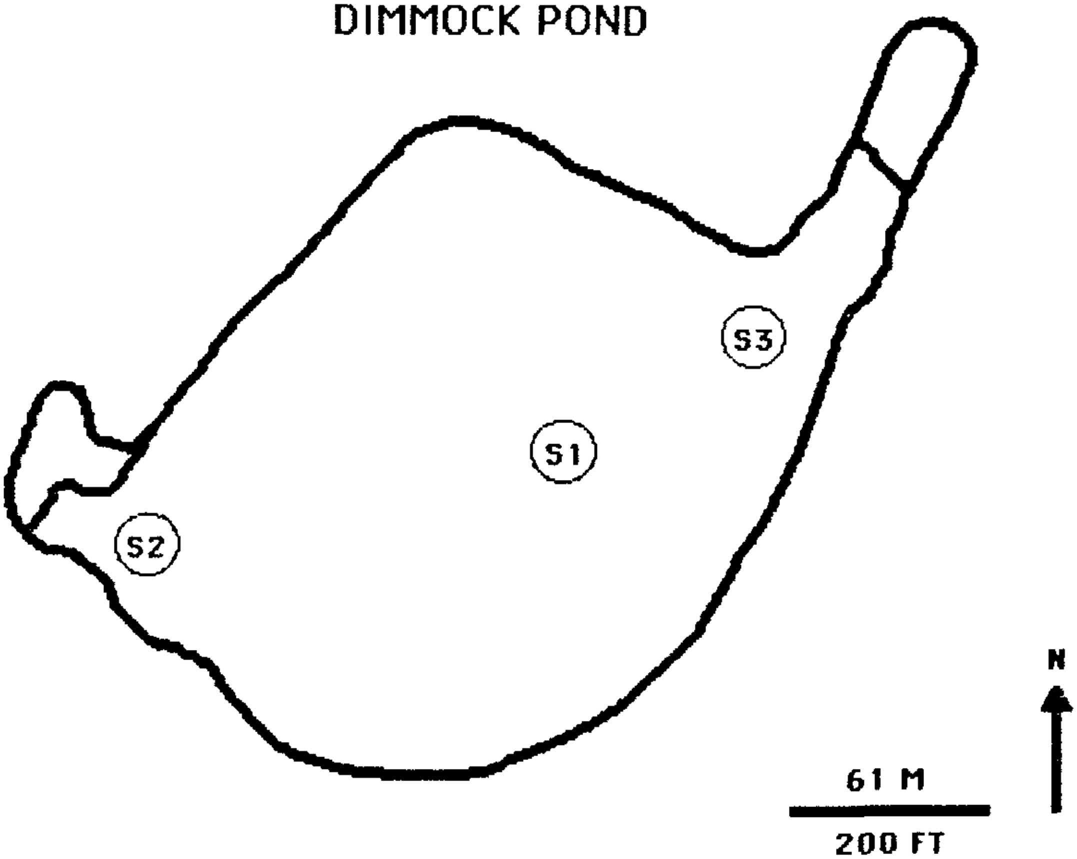
Sediment samples were obtained from three in-lake stations (Figure 2) with an Ekman dredge and with manually operated probes which facilitated cross-sectional sampling. Samples were analyzed by Arnold Greene Testing Laboratories for total kjeldahl and nitrate nitrogen, total phosphorus, organic/inorganic fraction, heavy metals (As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, V, Zn), and oil and grease. A pesticide scan was also conducted for two of the samples. Settling rate, bulking factor, and residual turbidity were determined by BEC personnel for a composite of the sediment samples.

Macrophyte species composition and areal extent of cover were assessed by visual inspection from a boat and by grappling samples. The distribution of summer bottom cover was mapped, noting dominant species in each area. Qualitative notes were made on the subsurface density, composition, and distribution of macrophyte stands. Vegetation of the two bordering emergent wetlands was also mapped.

Benthic macroinvertebrate composition was examined several times during this study, most carefully in association with the macrophyte survey. Samples collected with a D-net and an Ekman dredge were analyzed in the field to the level of family, and a semi-quantitative assessment of abundance was made.

FIGURE 2

SEDIMENT SAMPLING STATIONS AT DIMMOCK POND



As there had been only a partial survey of the Dimmock Pond fishery performed recently, BEC conducted a fish survey in October of 1987. A 122 m seine with 1 cm mesh was laid out from shore in a semi-circle and hauled in to collect fish. Captured fish were placed in holding tanks until they could be measured and scale-sampled, after which they were returned to the pond. Collected scales were assessed in the laboratory to facilitate age and growth determinations.

LAKE AND WATERSHED DESCRIPTION AND HISTORY

Lake Description

Dimmock Pond is located in the City of Springfield, Hampden County, Massachusetts. It lies at latitude 42°08'50" and longitude 72°29'25", encompassing an open water area of 3.8 ha (9.5 ac) (Table 3). If the emergent wetlands that encroach upon the open water area of the pond were included in the pond area, Dimmock Pond would be listed at 4.2 ha (10.4 ac). Dimmock Pond has a generally circular shape (Figure 3), with the adjacent emergent wetlands forming small arms off the main body of the pond. The ratio of the shoreline length to the circumference of a circle having the same area as the pond, known as the shoreline development factor, is 1.14.

Depth contours form a single depression. The mean depth is 1.2 m (3.9 ft) and the maximum depth is 3.4 m (11.2 ft), with the deepest point near the center of the pond. The hypsograph for Dimmock Pond (Figure 4), based only on the open water portion of the pond, indicates that approximately 62% of the pond is deeper than 1 m, while only 16% of the pond is deeper than 2 m. Annual fluctuations in water level expose only a small portion of the pond bottom, but allow a substantial amount of accumulated debris to impair the visual aesthetics of the pond.

When the pond is full, a total volume of 45,600 cu.m of water is impounded, but seasonal fluctuation of the water level alters the volume of the pond appreciably. The detention time for water in Dimmock Pond ranges from 0.4 to 0.9 years (146 to 329 days), with a predicted long-term mean of 0.7 years (256 days). The variability of the detention time is largely a function of weather pattern. Flushing rate is simply the inverse of detention time; for Dimmock Pond, a flushing rate of 1.1 to 2.5 times per year is calculated. The quality of water in Dimmock Pond is therefore likely to be a function of both input quality and natural processes within the pond.

Direct precipitation, direct and piped runoff, and groundwater seepage are the only sources of water for Dimmock Pond. The pond lies in a natural depression within an area shaped largely by glacial action, and is a remnant of a larger wetland which has been filled for development. Dimmock Pond exists primarily as a consequence of precipitation exceeding evaporation in New England, although hydrologic inputs are now substantially augmented by stormwater runoff. The pond has no natural inlets or outlets, but water can exit the pond via surcharging of the Parker St. stormwater pipe during periods of extremely high water. A manually operated flap valve in a manhole on Parker St. allows surcharging water to be routed to nearby Loon Pond. This arrangement was engineered after the late May, 1984 flooding of Hubbard Park and surrounding neighborhoods.

TABLE 3

CHARACTERISTICS OF DIMMOCK POND AND ITS WATERSHED

Lake Parameters

Location: Hampden County, City of Springfield, $42^{\circ}08'50''$ lat.
$72^{\circ}29'25''$ long.

Area:	3.8 ha	(9.5 acres)
Depth: Mean	1.2 m	(3.9 ft.)
Maximum	3.4 m	(11.2 ft)
Volume:	45,600 cu.m	(37 acre-ft.)
Detention Time: Mean	0.7 yr	(256 days)
Range	0.4 - 0.9 yr	(146-329 days)
Maximum Length	0.27 km	(875 ft)
Maximum Width	0.21 km	(687 ft)
Shoreline Length	0.79 km	(2600 ft)
Shoreline Development	1.14	

Watershed Parameters

Area (Including Dimmock Pond):		41.8 ha	(103.4 acres)
Watershed Area/Lake Area		10.9	
Land Use:	% Residential (High Density)	39.5	
	% Commercial	4.5	
	% Railroad	2.6	
	% Park/Recreation	16.0	
	% Forest	19.4	
	% Wetland	7.9	
	% Wetland/Pond	1.0	
	% Lake/Pond	9.1	

FIGURE 3

DIMMOCK POND
BATHYMETRIC MAP
(All contours given in 1 meter intervals)

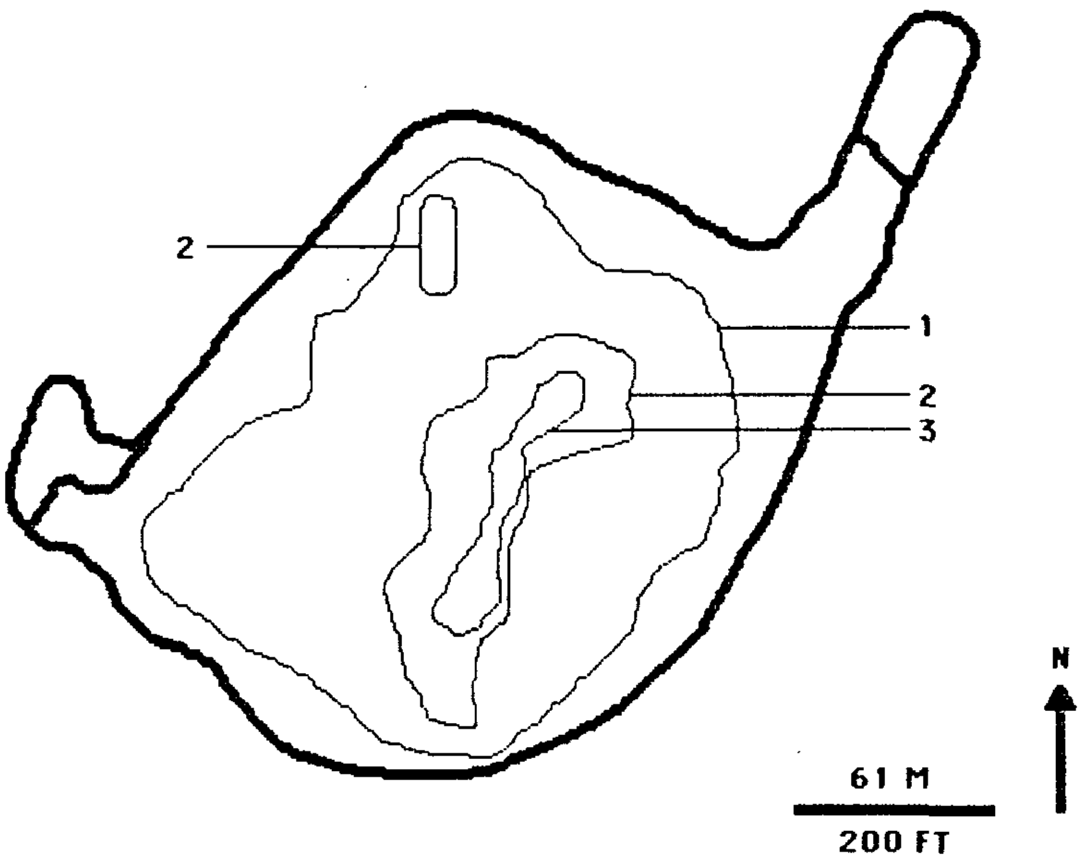
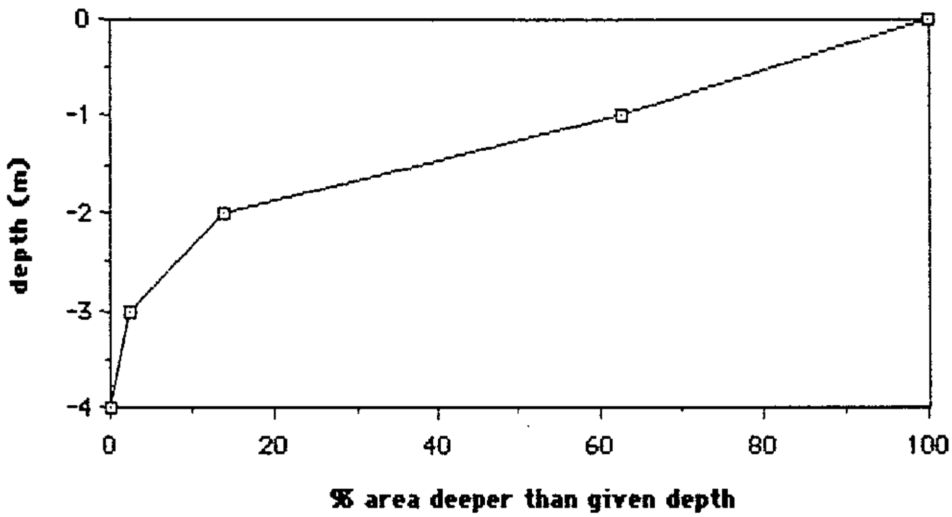


FIGURE 4

Hypsographic Curve of Dimmock Pond, Springfield, MA.



Prior to the installation of the gate valve, water left the pond at its northeastern corner during high water periods, flooding the adjacent ballfields.

Accumulated muck in the pond has effectively sealed it, minimizing exchange with the groundwater and promoting noticable water level fluctuations. Rising water levels in Dimmock Pond have caused peripheral flooding many times over the last few decades, as its watershed has become increasingly developed and runoff has been routed to the pond. The low-lying ballfields in Hubbard Park, created from wetlands several decades ago, are subject to the worst flooding.

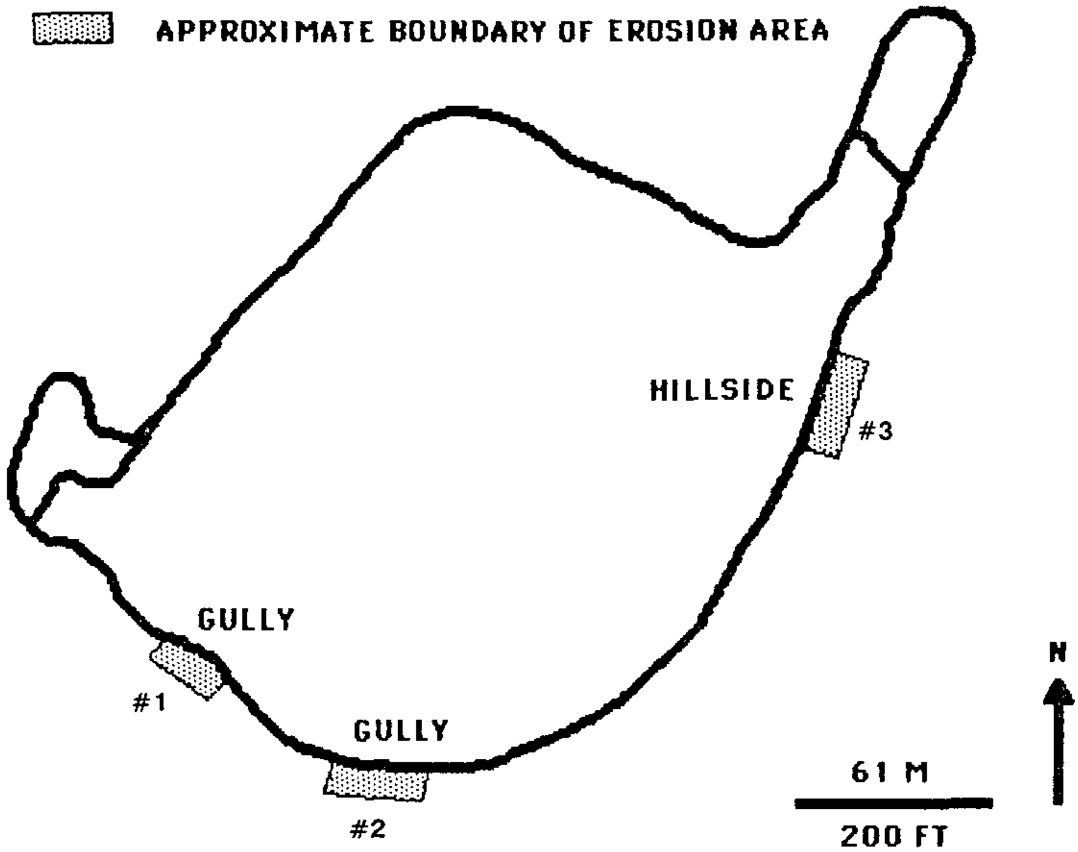
The shoreline of Dimmock Pond is sandy and slopes steeply in most areas to a walking path/access road which rims the pond. Much of the land area between the shoreline and the trail is vegetated, but informally created access points are subject to serious erosion damage as a consequence of moderately steep slopes and the generation of substantial runoff on the access road. Three problem areas were observed in this study (Figure 5), two along the south side of the pond and one to the east. Fill has been placed in these areas in the past to counteract gully formation, but erosion and deltaic build-up have continued. While the addition of the associated sediment to the pond is not particularly troublesome relative to water quality problems, the nature of the fill used to patch gullies (street sweepings, organic debris, and solid waste in some cases) is of concern.

As no explicit records of erosion control activities at the pond were uncovered by BEC, it is not possible to evaluate past impacts of erosion on the pond. Current impacts seem restricted to deltaic build-up, which actually provides a solid base from which fishermen can cast, and diminished aesthetic appeal and safety hazards in the vicinity of erosion gullies. The pond is not in danger of being completely filled in this manner, but corrective actions are warranted for aesthetic and safety reasons.

Dimmock Pond is small, but it is an important focal point for activities in Hubbard Park. Although the park is not large enough to provide a complete respite from the noises of the city, the forest character of the land immediately surrounding the pond provides visual separation from city life. Except during winter, when one commercial establishment, the railroad, and a few houses are visible through the leafless trees, visitors to the pond are *treated to one of the most natural vistas in Springfield.* Although the appearance of Dimmock Pond is less than appealing most of the year, it possesses at least as much aesthetic potential as the other lakes in Springfield and offers a greater feeling of seclusion than all but Porter Lake in Forest Park.

FIGURE 5

EROSION AREAS AROUND DIMMOCK POND



There are currently no developed beaches on Dimmock Pond, and the condition of Dimmock Pond discourages even the most adventurous youngsters who frequent the park. Non-motorized boating is possible, although there are no official boat ramps and the access road along the south and east sides of the pond is blocked to prevent vehicular traffic. Shoreline fishing, strolling the shoreline trail, birdwatching, and other passive uses are prevalent at Dimmock Pond. Many residents of Indian Orchard, the section of Springfield in which Dimmock Pond is located, have expressed an interest in increased recreational opportunity at the pond, including boating and swimming as they recall from their childhoods. Such activities will not be rewarding without a major restoration effort.

Watershed Description

The watershed of Dimmock Pond covers 41.8 hectares (103.4 ac), including the open water area of the pond itself, in an urban/suburban/park setting (Table 3, Figure 6). This is not large in an absolute or relative sense; the resultant watershed to pond area ratio is a low to moderate 10.9 to 1. In our aquatic survey work throughout Massachusetts and the Northeast U.S. in general, BEC, Inc. has found that ratios of around 10:1 indicate great potential for successful watershed management and desirable pond condition. Given the urban/suburban nature of the Dimmock Pond watershed, the potential for water quality degradation is quite high, however. There are no point sources of pollution (registered discharges) in the watershed of Dimmock Pond, but non-point sources are substantial.

High density residential areas (e.g., <0.1 ha or 0.25 ac lots) account for almost 40% of the watershed area (including the pond), with commercial land comprising another 4.5% (Tables 3 and 4, Figure 7). The railroad corridor constitutes 2.6% of the watershed, and extensively used park area accounts for 16%. Forests and wetlands make up just over 28% of the watershed of Dimmock Pond. The large amount of impervious surface typically associated with an urbanized watershed increases the runoff generated by precipitation events and snowmelt. The routing of this runoff to minimize transportation hazards and property damage results in substantial stormwater inputs to Dimmock Pond.

Land use in the Dimmock Pond watershed is similar to that in the watersheds of the nearby Kettlehole Ponds (Table 4, Figure 7). The Dimmock Pond watershed possesses slightly more recreational land, but the pollutant loads generated per unit area in each of the four watersheds depicted in Figure 7 are likely to be very similar. Isolated events within a small watershed draining into a small waterbody could markedly affect water quality in the system, but there is no indication that the observed differences between Dimmock Pond and the Kettleholes are a function of basic land use differences.

FIGURE 6

DIMMOCK POND WATERSHED BOUNDARY AND TOPOGRAPHY

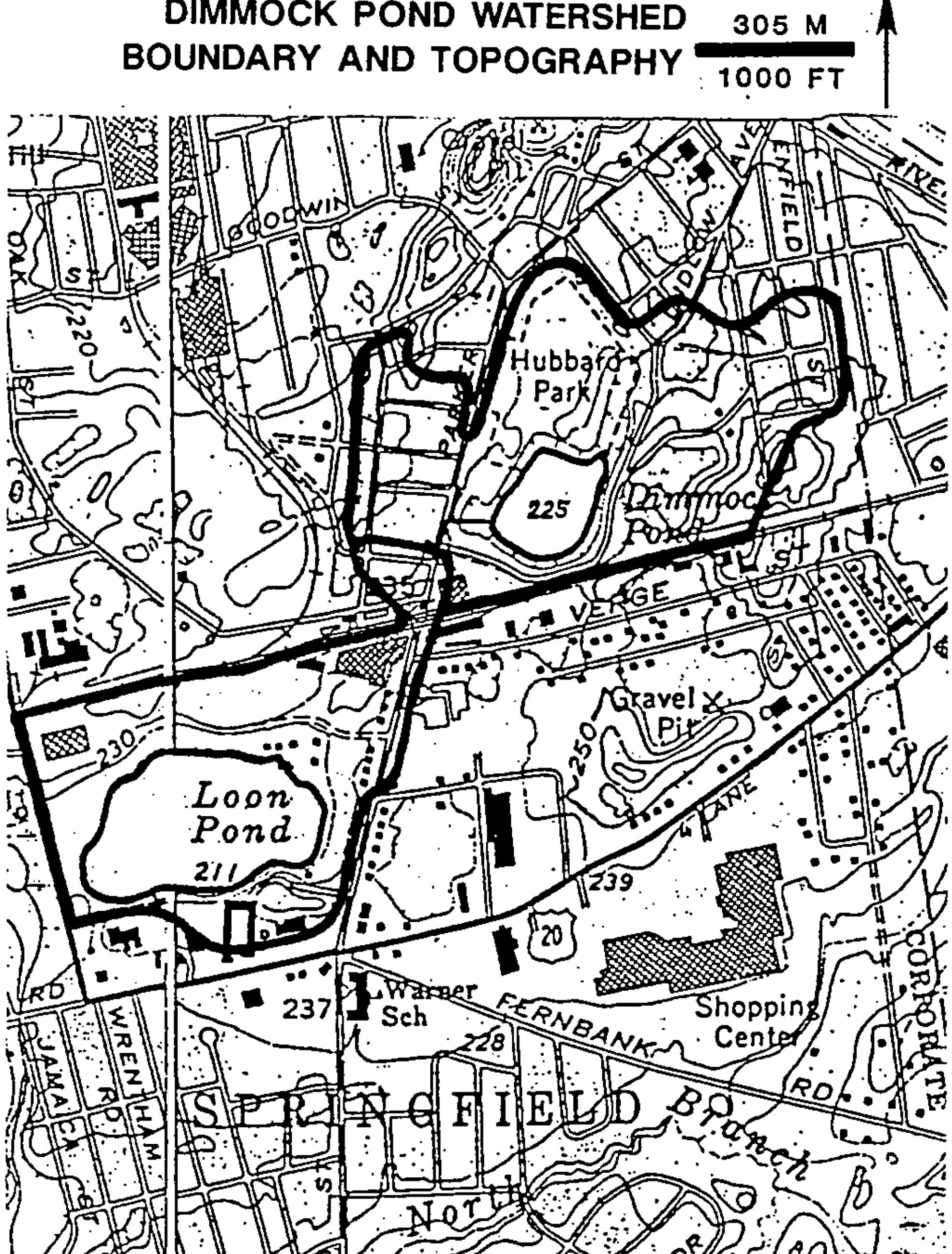


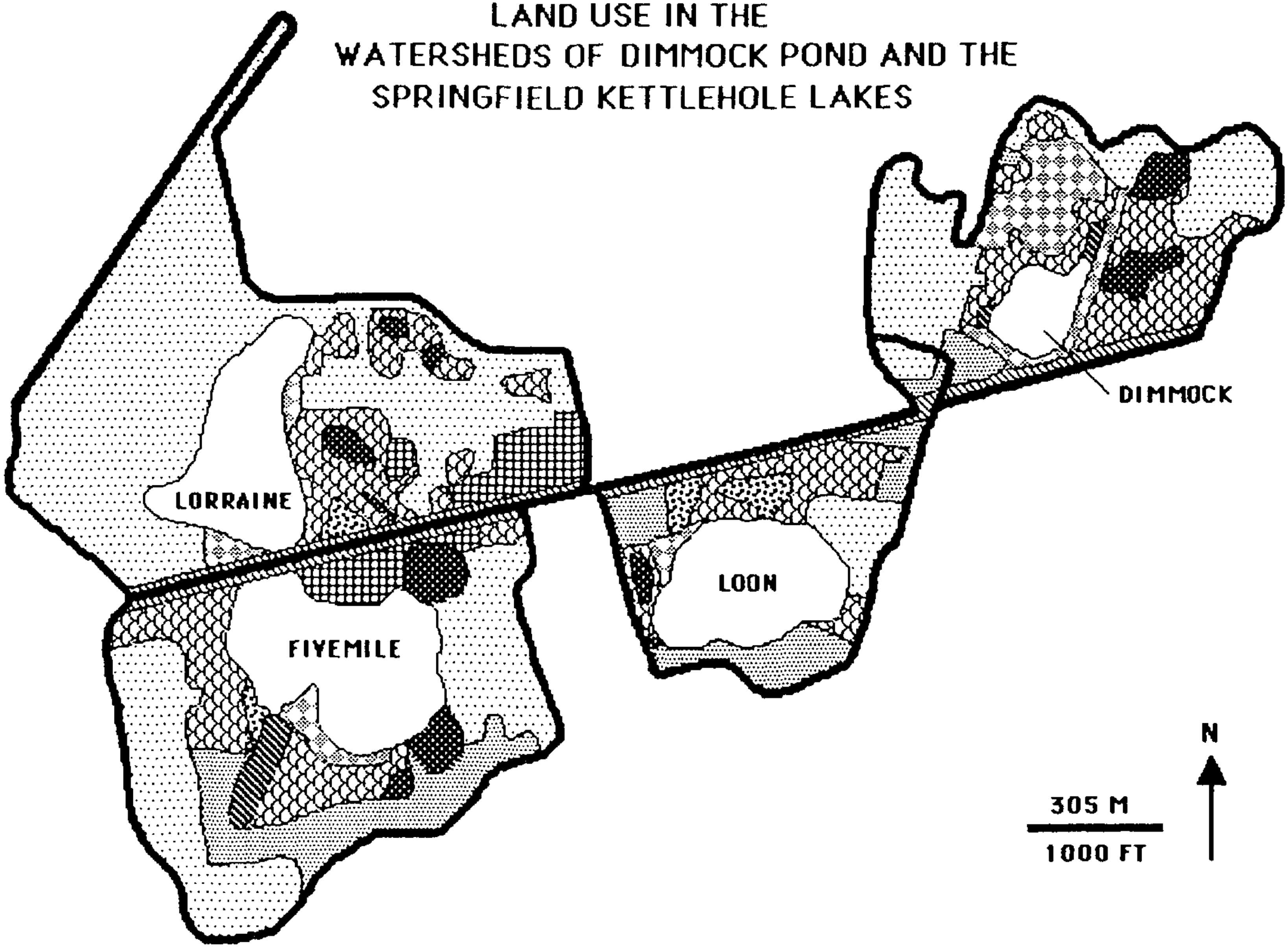
TABLE 4

KEY FOR LAND USE IN THE WATERSHEDS OF DIMMOCK POND AND THE SPRINGFIELD KETTLEHOLE LAKES

SYMBOL	LAND USE	LAND AREA FIVEMILE AC	HA	%	LORRAINE AC	HA	%	LOON AC	HA	%	DIMMOCK AC	HA	%
	RESIDENTIAL	55.3	22.4	33.7	119.8	48.5	61.2	12.4	5.0	14.2	40.7	16.5	39.5
	COMMERCIAL	22.4	9.1	13.7				19.9	8.1	23.0	4.8	1.9	4.5
	COMMERCIAL/ INDUSTRIAL/OPEN	7.5	3.0	4.5	11.1	4.5	5.7						
	RAILROAD	5.2	2.1	3.1	5.4	2.2	2.7	3.0	1.2	3.4	2.7	1.1	2.6
	OPEN	1.0	0.4	0.6	2.4	1.0	1.3	5.7	2.3	6.5			
	PARK/RECREATION	4.5	1.8	2.7	4.0	1.6	2.0	2.7	1.1	3.1	16.5	6.7	16.0
	FOREST	20.2	8.2	12.3	20.2	8.2	10.4	16.3	6.6	18.8	20.0	8.1	19.4
	WETLAND	8.6	3.5	5.3	4.2	1.7	2.2	1.7	0.7	2.0	8.2	3.3	7.9
	LAKE/WETLAND	4.2	1.7	2.6							1.0	0.4	1.0
	LAKE/POND	35.3	14.3	21.5	28.5	11.5	14.5	25.4	10.2	29.0	9.5	3.8	9.1
	TOTAL	164.2	66.5	100	195.6	79.2	100	87.1	35.2	100	103.4	41.8	100

FIGURE 7

LAND USE IN THE
WATERSHEDS OF DIMMOCK POND AND THE
SPRINGFIELD KETTLEHOLE LAKES



The piping of storm drainage and human-influenced lay of the land results in three major sub-drainage basins within the Dimmock Pond watershed (Table 5, Figure 8). Direct drainage to Dimmock Pond comprises slightly more than half of the land area within the watershed. This area is actually a mosaic of smaller drainage areas, many of which do not drain surficially to Dimmock Pond at all. Several of the ballfields to the north of the pond in Hubbard Park are poorly drained, and there are isolated wetland depressions to the east of the pond. The area designated as direct drainage could contribute water to Dimmock Pond via groundwater flows, although the influx of groundwater to the pond appears to be quite limited.

The remaining two drainage areas are served by stormwater drainage systems which deliver runoff directly to Dimmock Pond. The larger of the two, called the Parker St. drainage system, occupies 27.4% of the watershed. This drainage area includes mainly residential land use, but is also occupied by some commercial property, including the UniFirst facility. The other stormwater drainage system, known as the Ludlow Ave. drainage system, comprises 19.4% of the watershed. It is also a largely residential drainage area, but with more vacant lots and fewer catch basins than the Parker St. drainage system.

The nearby Kettlehole Ponds are also subject to stormwater drainage inputs from similar percentages of their respective watersheds (Table 5, Figure 8), although only Lake Lorraine has as much watershed drained directly to the main body of the pond as does Dimmock Pond. Nevertheless, Dimmock Pond is not unique among Springfield Lakes in terms of stormwater input; other factors (e.g., runoff quality, internal processes) must contribute to its more deteriorated condition.

Dimmock Pond is almost always a completely separate system from the other ponds in Figure 8. Under conditions of extreme high water, however, the Parker St. drainage system can be surcharged with Dimmock Pond water. As noted in the description of the pond, this surcharging can be alleviated by a manual gate valve which routes the runoff to Loon Pond to avoid flooding in the Dimmock Pond watershed. While Dimmock Pond waters can be routed to Loon Pond under potential flood conditions, no water from the Loon Pond watershed can be routed to Dimmock Pond. Flooding around Loon Pond is prevented by an overflow pipe to Pasco Road Bog, which drains into the North Branch Mill River.

Watershed Geology and Soils

Dimmock Pond appears to have originated in conjunction with the stagnation and break-up of Late Wisconsin Period glaciers some 11,000 to 12,000 years before present. A bedrock ridge which runs roughly parallel to or coincident with Parker St. in Springfield formed a high point upon which the glacier broke up,

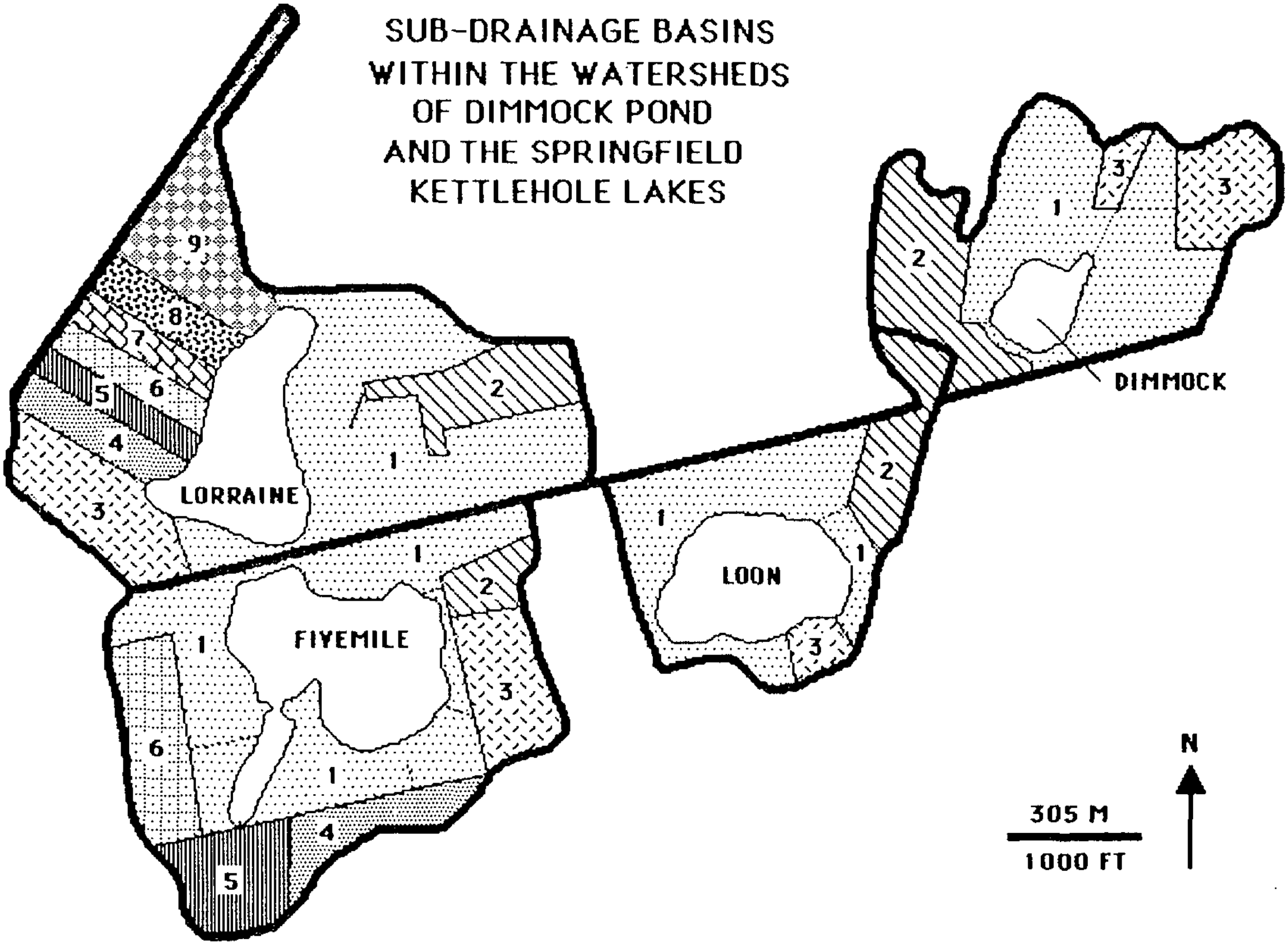
TABLE 5

KEY FOR SUB-DRAINAGE BASINS IN THE WATERSHEDS OF DIMMOCK POND AND THE KETTLEHOLE PONDS

SYMBOL	NO.	DESCRIPTION	SUB-BASIN AREA											
			FIVEMILE			LORRAINE			LOON			DIMMOCK		
			AC	HA	%	AC	HA	%	AC	HA	%	AC	HA	%
	1	DIRECT DRAINAGE	61.8	25.0	49.5	67.6	27.3	40.4	42.0	17.0	68.0	49.4	20.0	53.2
	2	STORM DRAINAGE SYSTEM	7.2	2.9	5.7	16.1	6.5	9.6	15.4	6.2	24.8	25.5	10.3	27.4
	3	STORM DRAINAGE SYSTEM	14.3	5.8	11.5	24.2	9.8	14.5	4.4	1.8	7.2	18.0	7.3	19.4
	4	STORM DRAINAGE SYSTEM	12.1	4.9	9.7	7.3	2.9	4.3						
	5	STORM DRAINAGE SYSTEM	13.8	5.6	11.1	6.7	2.7	4.0						
	6	STORM DRAINAGE SYSTEM	15.6	6.3	12.5	6.4	2.5	3.7						
	7	STORM DRAINAGE SYSTEM				7.0	2.8	4.2						
	8	STORM DRAINAGE SYSTEM				7.9	3.2	4.7						
	9	STORM DRAINAGE SYSTEM				23.9	9.9	14.6						
		LAKE/POND												
		TOTAL	124.8	50.5	100	167.1	67.6	100	61.8	25.0	100	92.9	37.6	100

FIGURE 8

SUB-DRAINAGE BASINS WITHIN THE WATERSHEDS OF DIMMOCK POND AND THE SPRINGFIELD KETTLEHOLE LAKES



sending meltwater and glacial outwash to the west and southwest. The Kettlehole Ponds west of Dimmock Pond were formed in the outwash by blocks of stranded ice. The area now included in Hubbard Park rests on or slightly east of that ridge, an area exposed to less meltwater and outwash. Deposition of sands and silts in this area was less orderly, creating a region of glacial till with less permeability than the outwash zone to the west.

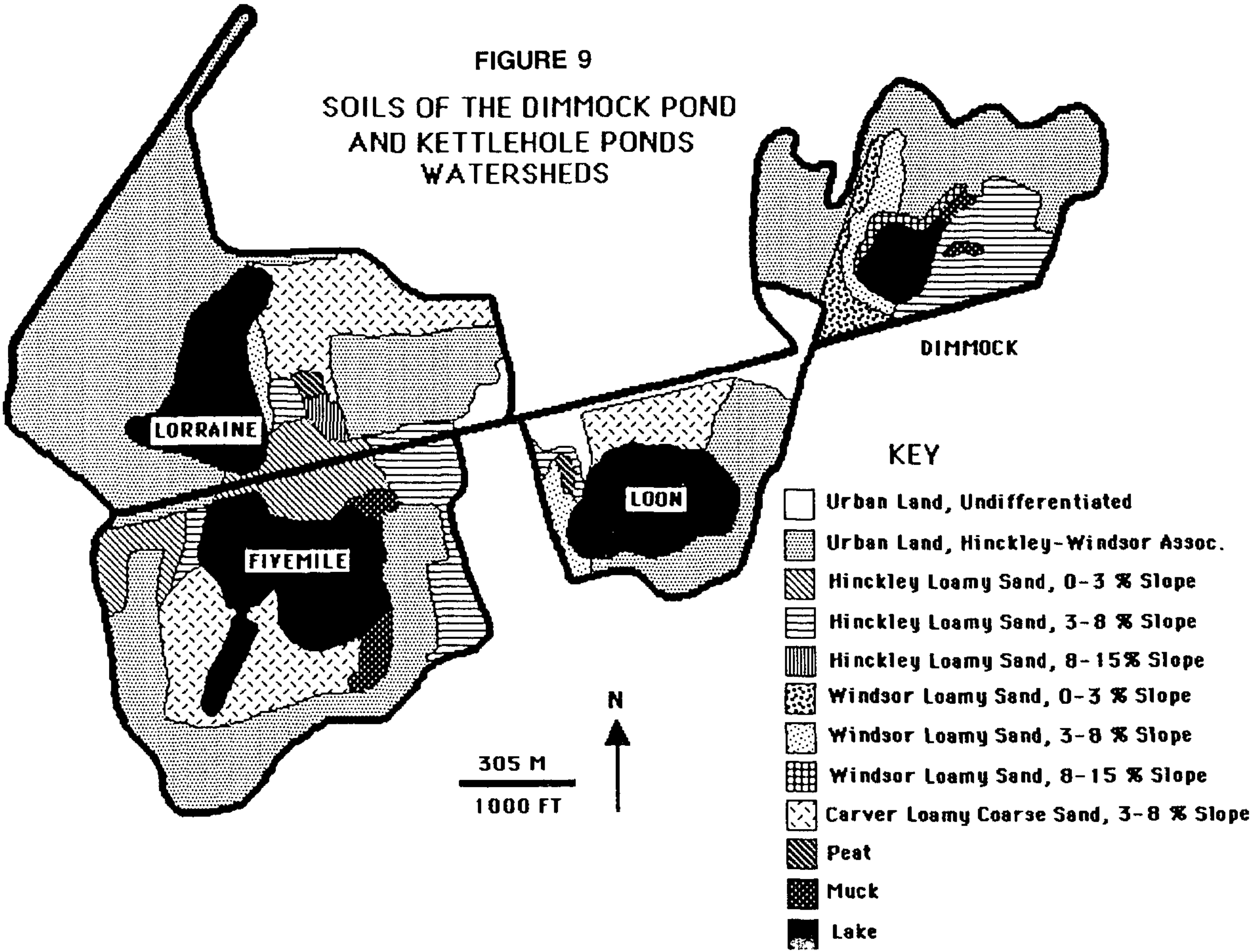
Dimmock Pond and the surrounding wetland depressions were probably created by glacial ice which melted in place and deposited its sediment as a lining in the depressions. The water table is somewhat higher in this area as a consequence of higher surface elevations and less permeable sediments. In some areas there may even be some perched water, held in place by silt layers below the sands which are observed at the ground surface. Borings made at UniFirst Corporation and probings conducted in Dimmock Pond both indicate an appreciable layer of silty sand and clays beginning about 3 m below the ground or pond surface. This layer has undoubtedly helped to maintain Dimmock Pond as a body of open water, although the build-up of organic muck since the retreat of the glaciers appears sufficient to hold water in the pond at this time. Dimmock Pond could best be described as a modified kettlehole pond.

The soils of the Dimmock Pond watershed (Figure 9) are largely loamy sands of the Hinckley and Windsor series, similar to the soils found in the watersheds of the Kettlehole Ponds to the west. Hinckley-Windsor soils are moderately permeable and usually well drained, but the presence of subsurface silt and clay layers in the Dimmock Pond area alters the overall properties of the soils in that area. The very permeable Carver sands present in the watersheds of the Kettleholes are absent from the Dimmock Pond watershed. As with the Kettlehole Ponds watersheds, much of the watershed of Dimmock Pond has been disturbed by human activities, resulting in soil cover denoted as Urban Land. These are soils of the Hinckley-Windsor series which have been modified, usually with fill or impervious cover. While subsurface properties of the original soil may remain intact, the surficial characteristics frequently bear no resemblance to those of the Hinckley and Windsor sands.

Passage of water through the natural soils of the Dimmock Pond watershed should be very beneficial to water quality within the pond, as most pollutants would be removed by these soils. Unfortunately, much of the potentially contributing area north and east of the pond has been transformed into Urban Land, subject to runoff generation and stormwater routing. Additionally, the seemingly well sealed nature of the pond bottom

FIGURE 9

SOILS OF THE DIMMOCK POND AND KETTLEHOLE PONDS WATERSHEDS



appears to inhibit seepage into Dimmock Pond. The natural soils and geology of the Dimmock Pond watershed therefore appear to have minimal influence on the water quality of the pond or the rate of inflow.

Historical Lake and Land Use

Prior to 1900 the Dimmock Pond watershed was largely a mixture of forest, wetland, and agricultural land. Much of the watershed west of Parker St. was apple orchard (the Nichols Farm), while much of the land north and northeast of Dimmock Pond was what would today be considered protectable wetland. The land near the pond and the pond itself belonged to the Dimmock family, which later sold it to Ludlow Mills. Wetland areas were gradually filled, and the resulting fields became the White Eagle Ballfields.

The railroad, put through in the mid-1800's, created a major transportation corridor through the area, but the watershed of Dimmock Pond remained minimally developed until well after the turn of the century. Ludlow Mills sold its land holdings in the watershed in blocks and lots, beginning in the 1920's; the last of it was sold in the early 1950's. Homes were built on most of these parcels. The land now occupied by the Hubbard Park recreational facilities was transferred from Ludlow Mills to the City of Springfield early in this period.

The slow development of the Indian Orchard section of Springfield accelerated after each world war, and sanitary sewers, stormwater drainage systems, and Hubbard Park were built to serve the burgeoning community. The first ballfields in Hubbard Park were created out of wetland in the 1930's, during the WPA era. These fields were modified and improved in the 1950's and 1960's, although they remained at low elevation and were often flooded. The highest field, nearest Dimmock Pond, was constructed in the late 1960's. The access road, or Ludlow Ave. Extension, was a 1930's WPA project which gave Dimmock Pond a more distinct shoreline and isolated the wetland to the east of the pond.

Water levels have probably fluctuated markedly in Dimmock Pond throughout its history, but documented fluctuations from the last three decades illustrate the possible extremes well. In the mid-1960's, during a major drought, Dimmock Pond was little more than an acre in area. At the start of June, 1984, after a week of heavy rains which produced major flooding, the surface of Dimmock Pond was almost as high as the access road. The lower ballfields in Hubbard Park were completely under water which spilled out of the pond. In response to this flooding, a connection between the Parker St. storm drainage line and the adjacent drainage system leading to Loon Pond was established, providing a manually operated outlet for Dimmock Pond during periods of extremely high water level.

Prior to the intensive development phase and for a short while thereafter, Dimmock Pond was a popular swimming hole for area children and adults. There was a beach along the southeast side of the pond, and the use of canoes and rowboats was also popular. While the water had the distinctive brown color of acid waters laden with humic substances (a natural condition), long-time area residents recall good visibility and enjoyable swimming in the pond during the 1930's and into the 1950's.

Fishing by local residents has remained popular at Dimmock Pond for over 50 years. The pond has provided a nearby warmwater fishery alternative to the trout-stocked Kettlehole Ponds for almost 30 years, with trophy largemouth bass taken by area anglers. The pond has never been managed as a fishery, however, and has therefore not reached its potential for providing fishing opportunity.

Some of the fill used to grade Hubbard Park during its construction is reputed to have been slag from coal burning operations at commercial establishments within the City. While this is believed by some to have fostered degradation of the groundwater and increased acidity in the pond, it is unlikely that these materials have had much impact on the pond; the very low groundwater seepage into the pond has been overshadowed by other sources of water and pollutants for at least three decades.

The installation of sanitary sewerage in this part of Springfield is certainly a benefit to all the ponds in the area, but the value of routing sanitary wastes out of the Dimmock Pond watershed to the health of the pond is limited, given the apparent groundwater situation. There are only four non-sewered residences in the watershed, these having been recently constructed on Oak Ridge St. Each is served by a conventional on-site, in-ground wastewater disposal facility (i.e., a septic system). At over 60 m (200 ft) from the pond, these pose little threat to its water quality.

The construction of stormwater drainage systems to minimize hazards for motorists and property owners appears to have had an obviously negative impact on the condition of the pond, into which the runoff is discharged. In addition to the pollutants which accumulate on streets between storm events, the construction of the UniFirst plant on Parker St. just south of the pond has presented additional problems. Improper disposal of industrial waste products in the early 1980's resulted in these wastes reaching the pond via the Parker St. storm drainage system, into which a portion of the UniFirst property is tied.

Leakage from underground storage tanks on the UniFirst property has posed less of a threat, as groundwater flow is away from the pond in that area. Storm drainage systems and the UniFirst operation are discussed in more detail later in this report.

By 1980 only one significant developable land parcel remained in private hands, that being the forested tract east of the pond. In 1987 four homes were built on a portion of this tract, at the end of Oak Ridge Rd., as noted previously. The buildable remainder of the parcel was zoned commercial, but a local developer requested a zoning change to allow construction of housing. The vanishing woodland was brought to public attention, the zoning change was denied, and the City has recently acquired the property as an addition to Hubbard Park. This acquisition will protect the pond in several ways, and represents a major step in the thoughtful management of the Dimmock Pond system.

Security problems have forced the closing of the access road to vehicular traffic. Shopping carts, metal barrels, and other large debris have been dumped illegally into Dimmock Pond, creating unaesthetic conditions, particularly during dry periods when the water level declines. Illegal dumping of mattresses, wood, and other refuse on park land has also been a problem. Some of the debris may have been brought in by vandals without vehicles, but the closing of the access road represents both a deterrent and an opportunity to improve the park experience for visitors.

Parking facilities are provided elsewhere in Hubbard Park; future opening of the access road would likely be contingent on the construction of adequate parking areas along the road and security improvements (e.g., fencing along the railroad, nightly gate closure). Although the area around the pond is now reserved for foot traffic, off-road vehicles, mainly motorcyles, are sometimes ridden around the pond without permission. Erosion associated with the railroad embankment and the foot trail/access road has created gullies and formed deltas extending into the pond. The initial regulatory steps have been taken, but what is needed now is a restoration program designed to modify Dimmock Pond and its immediate surroundings in a manner consistent with the desired recreational goals.

LIMNOLOGICAL DATA BASE

Limnological data were collected for one year in an effort to assess pond condition and evaluate temporal and spatial variability in physical, chemical, and biological features. Through this data collection effort we attempt to learn how the system functions and which factors are important to its well-being. Considerable information is generated, and one must sort out the critical items from those of general interest or minimal utility in the management of the system. Therefore, in the interest of brevity, most raw data have been incorporated into a technical appendix (Appendix A). Calculation sheets which detail the derivation of useful values and other information of secondary importance have also been included in an appendix (Appendix B).

Flows and Water Chemistry

The chemical nature of Dimmock Pond influences biological characteristics, and is itself greatly influenced by the rate of transfer of substances into and out of the water column. Water inflow from tributaries determines this rate of transfer in many lakes, but there are no tributaries feeding Dimmock Pond. Inflow to this pond is a function of only stormwater runoff, groundwater seepage, and direct precipitation. The flow attributable to each is addressed in the Hydrologic Budget section of this report.

Phosphorus is usually viewed as the key plant nutrient in aquatic (and often terrestrial) systems. It is most often the element in shortest supply in relation to the needs of plants, and is more easily controlled than most other essential plant nutrients. The level of phosphorus in a lake is therefore of critical importance to the condition of the system.

The measured concentration of total phosphorus in Dimmock Pond ranged from a minimum of 10 ug/l to a maximum of 1990 ug/l during this study (Table 6), suggesting extreme variability. Both the maximum and the minimum values were recorded at Station 1B, at the bottom of the pond. Mean concentrations at the surface and bottom of the pond were 148 and 278 ug/l, respectively, both of which are considered high values. These values may or may not represent a significant difference, depending upon the statistic used and the level of confidence accepted. Based on the paired T-test (Sokal and Rohlf 1981), a commonly invoked statistical procedure, there is a 90% chance that the surface and bottom values for total phosphorus are different. This suggests that the bottom waters of the pond have an additional source of phosphorus, probably resuspended sediment or phosphorus resolubilized from the sediment during periods of anoxia.

TABLE 6

VALUES OF MONITORED PARAMETERS IN THE DIMMOCK POND SYSTEM

PARAMETER	UNITS	VALUE TYPE	DP-1S	DP-1B
ORTHOPHOSPHORUS	UG/L	MEAN	33	50
		MAXIMUM	100	110
		MINIMUM	0	0
TOTAL PHOSPHORUS	UG/L	MEAN	148	278
		MAXIMUM	960	1990
		MINIMUM	10	10
AMMONIA NITROGEN	MG/L	MEAN	.27	.34
		MAXIMUM	.64	.87
		MINIMUM	.04	.05
NITRATE NITROGEN	MG/L	MEAN	.09	.11
		MAXIMUM	.57	.67
		MINIMUM	.01	.04
TOTAL KJELDAHL NITROGEN	MG/L	MEAN	1.09	1.48
		MAXIMUM	2.25	3.38
		MINIMUM	.45	.70
NITROGEN:PHOSPHORUS RATIO	NONE	MEAN	47.0	48.0
		MAXIMUM	168.0	225.0
		MINIMUM	5.0	4.0
TEMPERATURE	CELSIUS	MAXIMUM	24.2	19.0
		MINIMUM	-2.1	-.1
DISSOLVED OXYGEN	MG/L	MEAN	9.7	2.9
		MAXIMUM	13.8	9.4
		MINIMUM	7.0	.1
D.O. SATURATION	%	MEAN	88	23
		MAXIMUM	108	75
		MINIMUM	62	1
PH	S.U.	MAXIMUM	6.6	6.5
		MINIMUM	5.5	5.3
TOTAL ALKALINITY	MG/L	MEAN	3.2	3.4
		MAXIMUM	12.0	15.0
		MINIMUM	.5	.5

TABLE 6 CONTINUED

VALUES OF MONITORED PARAMETERS IN THE DIMMOCK POND SYSTEM

PARAMETER	UNITS	VALUE TYPE	DP-1S	DP-1B
CONDUCTIVITY	UMHOS/CM	MEAN	83	84
		MAXIMUM	107	108
		MINIMUM	68	73
CHLORIDE	MG/L	MEAN	23.5	24.7
		MAXIMUM	33.3	47.0
		MINIMUM	11.5	12.1
TOTAL SUSPENDED SOLIDS	MG/L	MEAN	5.5	17.0
		MAXIMUM	15.2	40.5
		MINIMUM	.4	2.6
TURBIDITY	NTU	MEAN	2.3	4.0
		MAXIMUM	4.5	8.5
		MINIMUM	.5	.6
FECAL COLIFORM	N/100ML	MEAN	5	
		MAXIMUM	22	
		MINIMUM	2	
FECAL STREPTOCOCCI	N/100ML	MEAN	6	
		MAXIMUM	60	
		MINIMUM	2	
FC:FS RATIO	NONE	MEAN	INVALID	
		MAXIMUM	INVALID	
		MINIMUM	INVALID	
CHLOROPHYLL A	UG/L	MEAN	8.6	
		MAXIMUM	35.1	
		MINIMUM	1.8	
SECCHI DISK TRANSPARENCY	METERS	MEAN	1.6	
		MAXIMUM	3.0	
		MINIMUM	1.0	

The high variability noted for total phosphorus and many of the other parameters assessed appears to be a function of several influences on Dimmock Pond. The two primary forces promoting chemical variability are stormwater inputs and wind mixing. Either force is capable of altering the chemistry of the pond in less than a day. During periods of calm and low precipitation, the pond processes the inputs received through stormwater routing or sediment resuspension, undergoing an almost daily change in chemical characteristics. Other less catastrophic forces, such as sediment oxygen demand and direct precipitation, also contribute to the observed variability.

Orthophosphorus, or soluble reactive phosphorus, was also assessed during this study. This form of phosphorus is more readily available for uptake by algae and higher plants than the remaining portion of the total phosphorus concentration. Total phosphorus and orthophosphorus values therefore provide a range of phosphorus bioavailability, a parameter of some relevance where nuisance growths are of concern.

Orthophosphorus concentrations were appreciably lower than the corresponding total phosphorus values, ranging from 0 to 100 ug/l and exhibiting mean values of 33 and 50 ug/l at the pond surface and bottom, respectively. Continual presence of measurable orthophosphorus indicate an ample supply of available phosphorus in Dimmock Pond.

From ecological and management viewpoints, both the total phosphorus and orthophosphorus means are rather high. Total phosphorus levels of more than 50 ug/l are often cause for concern, as they can fuel substantial algal blooms. However, bioavailability mediates the actual impact of phosphorus concentration, making evaluation of orthophosphorus levels desirable. The observed orthophosphorus levels approached the potential problem level for total phosphorus, however, suggesting great potential for algal growth, if other factors are favorable. The difference between observed total phosphorus and orthophosphorus levels was quite large, however, indicating that much of the total phosphorus in Dimmock Pond occurs in a particulate form. Much of this particulate phosphorus is probably associated with resuspended sediment.

Nitrogen is another important plant nutrient, and occurs in three major forms in aquatic systems: ammonia, nitrate, and organic compounds. Ammonia and nitrate can be measured directly, while organic nitrogen is assessed as the difference between total kjeldahl nitrogen (a digestion-based test result) and ammonia nitrogen. Ammonia and nitrate are readily available for uptake by plants, and the former can be toxic to most animals, depending on the temperature, pH, and dissolved solids level. Nitrogen inputs to aquatic systems are very difficult to control as a consequence of the high nitrogen concentration in the atmosphere and the high mobility of nitrate in soil.

Ammonia nitrogen levels at the surface and bottom of the pond were generally moderate, with respective mean values of 0.27 and 0.34 mg/l (Table 6). Decay processes continually release ammonia into the water column, but conversion to nitrate and uptake by plants appear to limit the ammonia level, even under low oxygen conditions. There is a seasonal trend to the ammonia concentrations; values are highest under the ice and during summer, when oxygen deficits are greatest. Production of ammonia by aerobic and anaerobic decay of organic particles and conversion to nitrate by bacteria which require oxygen is suggested as the primary cycling mechanism for this compound in Dimmock Pond.

Given the pH and other chemical features of the pond, ammonia toxicity poses no threat to aquatic life in Dimmock Pond. The loss of oxygen necessary for ammonia to become a problem in this system would eliminate desirable forms of aquatic life before ammonia could reach toxic levels.

Nitrate nitrogen values in Dimmock Pond were relatively stable during this study, deviating substantially from the mean on only one date (8/3/87). Respective surface and bottom mean values were 0.09 and 0.11 mg/l (Table 6), generally considered to be low for this parameter. Apparently the conversion of ammonia to nitrate is rapidly continued as a conversion of nitrate to organic nitrogen. Alternatively, periods of low oxygen availability in parts of Dimmock Pond may restrict conversion of ammonia to nitrate. Under certain conditions, nitrogen could become the limiting nutrient in Dimmock Pond, by virtue of its limited availability in the nitrate form. As ammonia is quickly converted to nitrate in the presence of oxygen and appropriate bacteria, and ammonia is taken up directly by many algal species, this is unlikely to provide any long-term limitation of algal growth, however.

Total kjeldahl nitrogen (TKN) concentrations in Dimmock Pond fluctuated noticably but not extremely over the course of the study. Average levels at the surface and bottom of the pond were 1.09 and 1.48 mg/l (Table 6), respectively. Subtracting the ammonia values from the TKN values, it is apparent that most of the nitrogen fraction represented by TKN is in particulate organic form. TKN values were highest during the growing season, although there was no strong seasonal trend; erratic and unpredictable resuspension of organic sediment is likely to obscure any such trend.

The nitrogen:phosphorus ratio, calculated as [(TKN + nitrate nitrogen)/total phosphorus]x2.21 (with all values expressed as mg/l), indicated phosphorus to be in relatively shorter supply than nitrogen (ratios greater than 12:1) in Dimmock Pond most of the time. This is the typical situation in freshwater lakes, and suggests that phosphorus would be a more appropriate target for control than nitrogen. The ratio does not prove that phosphorus is the limiting factor for growth in the system, however, as influences such as light and other elements are not considered by this approach.

In Dimmock Pond, plant growth appears to be limited by multiple factors, with frequent shifts in the controlling influence. Certainly phosphorus is a key factor in this system, since without it there could be no substantial growths. Yet levels of phosphorus in the water column do not indicate a continual shortage of available phosphorus, and levels of nitrate and ammonia are sometimes quite low in relation to the phosphorus concentration. Exclusion of the particulate organic nitrogen fraction from the N:P ratio calculation, or recalculation using ammonia, nitrate, and orthophosphorus values decreases the N:P ratio by more than 50%, suggesting the possibility of more frequent nitrogen limitation.

Other growth limiting factors must also be considered in this system. Toxic materials, most notably heavy metals deposited by storm events, could prevent algal growth or even reduce existing populations at the time of input or resuspension. The solubility of metals is increased under the acidic conditions which typically exist in Dimmock Pond. Certain essential trace elements, such as calcium, are likely to be scarce in this system, given the pH level and other chemical features of Dimmock Pond.

The most important growth limiting factor in the Dimmock Pond system, however, is likely to be light. Resuspension of fine sediment in this system, augmented by the natural coloration of the water by dissolved humic substances, has the potential to cause light limitation of both algal and rooted macrophyte growths. The latter depend less on water column nutrients than the former, and would be expected to cover the bottom of this shallow pond even if nutrient levels in the water column were very low. The substrate is favorable in both physical and chemical terms. Yet macrophyte growths are largely restricted to a peripheral band in this system. Water clarity and algal quantities do not correlate well in this system, with consistently lower clarity than would be expected based on phytoplankton abundance alone. Laboratory resuspension of sediment results in excessive turbidiy for a prolonged period. Except during periods of extended calm, light inhibition of plant growths is the primary growth limiting factor in Dimmock Pond.

Temperature in Dimmock Pond exhibited a typical temperate zone seasonal pattern of variation (Table 6). The surface of Dimmock Pond freezes during the winter and warms up to over 23°C in the summer. The temperature of the bottom water can be as much as 13 C° colder than the surface temperature, but there is no pronounced thermal stratification of Dimmock Pond (Appendix A). When major temperature differences exist between the surface and bottom of the pond, the change is most often gradual. The system exhibited signs of developing stratification during the spring (Appendix A), with an attendent depletion of oxygen at successively shallower strata, but periodic wind mixing of this shallow system brought the temperature of the pond to a uniform level after mid-July and aerated all but the deepest areas.

Dissolved oxygen levels varied appreciably over time and space within Dimmock Pond, partly as a function of temperature dependent solubility but largely as a consequence of the competing forces of wind mixing and sediment oxygen demand (SOD). The surface oxygen level ranged from 7.0 to 13.8 mg/l (Table 6), suggesting no problem for fish or other aerobic forms of aquatic life. Bottom oxygen levels were as high as 9.4 mg/l in April, but were consistently less than 1.0 mg/l between late May and mid-September; the mean oxygen level at the pond bottom was 2.9 mg/l. Most fish would not be able to survive in Dimmock Pond below a depth of 2 m, but this represents only about 16% of the volume of the pond.

The zone of substantial oxygen depletion moved up and down in the water column, depending on wind action for its precise location. The top meter of the pond was always well aerated. Oxygen depletion was observed only during the summer, when warmer temperatures promoted decomposition processes and inhibited mixing, and the zone of anoxia never rose to more than 1 m above the bottom (2 m from the pond surface). The water between 1 and 2 m of depth represented the transition zone. The calculated oxygen depletion rate (Appendix B) was moderate, at approximately 0.1 to 0.2 mg/l/d (volumetrically), or 100 to 200 mg/sq.m/d (areally).

The amount of oxygen that will dissolve in water is dependent on temperature, dissolved substances, and atmospheric pressure. The relation of the actual oxygen level to the maximum possible concentration is termed the percent saturation, and reveals much about the processes at work in a given system. In Dimmock Pond the percent saturation ranges from a low of 1% to a high of 108% (supersaturated) (Table 6). Low values are linked to sediment oxygen demand, while high values are probably a combined product of wind aeration and oxygen generation by plants during photosynthesis. Mean values at the surface and bottom were 88 and 23%, respectively. The bottom water was never more than 75% saturated, while the surface waters were never less than 62% saturated.

The pH of the water (Table 6) in Dimmock Pond is acidic, ranging from 5.3 to 6.6 SU. The acidity is a function of natural processes associated with decomposition, long detention time and acidic precipitation. Runoff generated by acidic precipitation landing on impervious watershed surfaces is at least partially neutralized by alkaline materials which accumulate on the streets or in the catch basins. Yet only rarely is the pH of incoming water above neutral.

The low pH of the system imparts some of the characteristics of bogs; humic substances are dissolved in the water of the pond and it has a generally high iron content (BEC 1980). This results in water with a brownish tint, or tea color. Humic acids and iron also tend to reduce the availability of phosphorus, although available supplies in Dimmock Pond appear sufficient to support excessive productivity at most times. The presence of certain bog features is consistent with the origin of Dimmock Pond and its tendency to accumulate organic matter.

The pH of Dimmock Pond is not low enough to eliminate most forms of aquatic life, but it does appear to affect species composition in this system. Molluscs (e.g., snails and clams), which require substantial quantities of calcium carbonates for shell formation, are not found in this system. Blue-green algae are less abundant in the plankton than would otherwise be anticipated. The low pH is therefore not a completely negative feature of the system, but it does have adverse effects.

Mean total alkalinity (Table 6) of Dimmock Pond is quite low, indicating minimal buffering capacity and the potential for substantial fluctuation in the pH level. Even the maximum recorded value of 15 mg/l is less than the desirable minimum level (20 mg/l) for buffering capacity. While the observed pH values are not exceptionally hazardous to most forms of aquatic life, rapid fluctuations in pH within the observed range could be lethal. The existing alkalinity provides little safeguard against such fluctuations.

Conductivity values (Table 6) ranged from 68 to 108 umhos/cm in Dimmock Pond, with little variation between the surface and bottom stations. Conductivity values are somewhat low relative to the potential fertility suggested by the nutrient chemistry of the system. The similarity of Dimmock Pond to a bog is further highlighted by the low to moderate conductivity values. More matter is present in the water column in particulate form than in a dissolved state.

Chloride concentrations (Table 6) are moderate and exhibit little spatial variation, much like the conductivity values to which chlorides contribute. Respective mean values of 23.5 and 24.7 mg/l were obtained for the surface and bottom of the pond. While the presence of some chloride is entirely natural, observed chloride values are higher than the likely background level. Most chloride is probably derived from road salt, entering the pond via stormwater runoff. There are few nearby wastewater disposal systems to contribute chloride, thereby eliminating the other common source.

Total suspended solids (TSS) concentrations (Table 6) did exhibit substantial variation between surface and bottom sampling locations, with respective mean values of 5.5 and 17.0 mg/l obtained. Values were also quite variable over time, consistent with erratic intensity of wind mixing. While mixing is apparently sufficient to keep certain dissolved substances fairly evenly distributed throughout the water column, it is inadequate to keep particles suspended at uniform density. Particles are kept suspended at levels above those observed at other area lakes, however, and contribute appreciably to turbidity and the unsightly appearance of the pond.

Turbidity levels (Table 6) were not continually high in Dimmock Pond, but reached visibly detectable levels at the surface of the pond on about two thirds of the sampling dates. Turbidity at the bottom of the pond was usually noticably higher than at the pond surface, consistent with TSS concentrations. The size distribution of particles is an important factor in determining how much turbidity will be imparted by a given particle concentration, altering the precise relationship between turbidity and TSS. Yet the correlation of TSS and turbidity in the Dimmock Pond system is undeniable, and much of the unaesthetic appearance of the pond is explained by these two parameters.

As the variability in chemical measures may be attributable to a variety of sources, a quality evaluation program was carried out during the course of this study. Duplicate samples from one randomly chosen station in Dimmock Pond or one of the Kettlehole Ponds were sent to the laboratory on fourteen dates. These samples were analyzed for ammonia nitrogen, nitrate nitrogen, kjeldahl nitrogen, orthophosphorus, total phosphorus, fecal coliform, fecal streptococci, alkalinity, suspended solids, and chloride. The average percent difference and standard deviation are reported in Appendix A, and yield an impression of the magnitude of difference necessary before two values can be reasonably assumed to be different as a consequence of factors other than sampling and laboratory error.

In general, the statistics resulting from the quality evaluation program are reassuring from a practical perspective. While the differences necessary to claim a real difference between water quality at two stations or a single station at two times are substantial, the necessary differences are not so large as to make the observed ranges of parameter values meaningless. For example, one can be 95% confident that two total phosphorus values with a difference of 27 ug/l do represent different conditions. A difference of several tenths of a milligram per liter represents a significant difference at the 95% confidence level for the three forms of nitrogen assessed in this study. It is therefore apparent that Dimmock Pond experiences substantial "natural" variability in water quality.

Bacteria

Fecal coliform (FC) and fecal streptococci (FS) bacteria were assessed during this study (Table 6, Appendix A). These bacteria come from the digestive system of all warm-blooded animals, human and non-human, and do not in themselves represent a serious health threat. However, as they are often accompanied by pathogens, they are considered indicators of a potential health hazard if present in substantial quantities. The mean FC values obtained during this study were not in excess of the Massachusetts standard for contact recreation, which is 200/100ml for multiple sample geometric means. The single sample standard of 400/100ml was never contravened. Levels of fecal coliform bacteria in Dimmock Pond were routinely low, precluding the necessity of even calculating a geometric mean.

As nearly all of the watershed is sewered, it is not too surprising that fecal coliform values are low. Yet pets and urban wildlife can contribute enough bacteria to result in elevated FC values. Waterfowl are not abundant at Dimmock Pond, however, and FC counts from runoff were low to moderate, suggesting that only limited fecal material is washed into the storm drainage system. By Massachusetts standards for FC, Dimmock Pond is suitable for swimming, although it is unsuitable by certain other criteria.

There are no bathing standards for FS, but values for this parameter were generally similar to those obtained for FC in the pond. Low bacteria inputs from human and non-human sources is indicated. For both FC and FS, however, it is possible that the acid condition of Dimmock Pond keeps observed levels low, even during periods of elevated inputs. Fecal bacteria can experience rapid die-off or inactivation (dormancy) in response to acidity and also oxygen.

FC:FS ratios may give some indication of the origin of observed bacteria, as ratios associated with human derived bacterial assemblages are considerably higher than those associated with non-human sources. The consideration of only those ratios for which both FC and FS values were over 200/100 ml is recommended (Millipore Corp. 1972). Therefore, the observed values do not allow a valid evaluation. Non-human sources are strongly suspected as the supplier of the small quantities of FC and FS observed.

Storm Water Assessment

As storm water runoff is apparently a dominant influence on the Dimmock Pond system, efforts have been made to adequately characterize the quantity and quality of storm water inputs to Dimmock Pond. Without nearly constant monitoring of a storm water dominated system, however, it is not possible to precisely quantify pollutant loads induced by storm events. A certain amount of error must be accepted and dealt with in a management context. We have attempted to minimize this error by expanding on the required storm water assessment program, but the variability in the quantity and quality of runoff in the Dimmock Pond system is high. The following account represents the best available appraisal of storm water generation, handling, quantity, and quality in the watershed of Dimmock Pond.

Storm water runoff in the Dimmock Pond watershed is generated by precipitation falling on impervious or minimally permeable surfaces such as roads, roof tops, parking areas, and compacted soils. To avoid property damage and transportation hazards, much of this water is routed to Dimmock Pond via pipes. While the percentage of the precipitation in any given storm which becomes runoff varies with storm characteristics and antecedent weather conditions, it is reasonable to assume that 10 to 95% of the precipitation falling anywhere in the watershed will become runoff (based on typical runoff coefficients given by the WPCF 1970).

For the overall Dimmock Pond watershed, an average runoff coefficient of 0.1 to 0.3 (10 to 30%) is estimated. This is a rather low rate for an urban area, but reflects the non-contributing nature of much of the watershed. While about half of the rainfall in the Parker st. and Ludlow Ave. drainage areas may reach the pond as runoff, virtually none of the rainfall landing on "direct drainage" areas more than 50 m from the pond enters the pond as runoff. The average runoff coefficient over the entire watershed is therefore quite low for an urban watershed. One could make a case for reducing the size of the watershed associated with Dimmock Pond, but all land included in the watershed does have the potential to interact with the pond.

The routing system for storm water in the Dimmock Pond watershed has been discussed to some extent in the Lake and Watershed Description section of this report. The sub-watersheds established in association with delineated storm drainage systems are presented in Figure 8. Sub-drainage basin #2, the Parker St. drainage system, drains the watershed area west of Parker St. plus a portion of the UniFirst property, discharging into Dimmock Pond via a 0.7 m (27 in.) pipe at the southwest corner of the pond. Sub-drainage basin #3, the Ludlow Ave. drainage system, includes the residential area northeast of the pond and discharges into the northeast wetland arm via a 0.6 m (24 in.) pipe. The stretch of pipe connecting the system at Primrose St. with that at Ludlow Ave. runs inside or on top of (much of the pipeline is exposed) a berm through a wooded wetland. The layout and sizing of pipes in each of the two storm drainage systems is presented in Figure 10.

Each system has catch basins with curb inlets, although the sumps in most are filled with sediment and debris, making them drop inlets from a functional viewpoint. This lack of detention will tend to worsen the quality of runoff discharged to Dimmock Pond. Clogging and surcharging have been observed in some locations, a consequence of the lack of maintenance of catch basins. The catch basins themselves are mostly of brick and mortar construction, with concrete fortification or modification in some cases. Many of the grates at the street surface have been partially paved over, limiting access for maintenance. One of the catch basins on the UniFirst property has been completely paved over to avoid inputs from that area.

Flows emanating from each delineated sub-watershed are roughly proportional to the area involved, with some adjustment for variations in runoff coefficients and piping arrangements. Delivery of runoff to the discharge point is relatively rapid, with substantial flows observed within twenty minutes of the start of a downpour. Storm hydrographs for the discharge pipes are highly dependent on the pattern of rainfall within each storm, which is unpredictable. Typical stream hydrographs are inapplicable. There does appear to be more clogging and delivery delay in the Ludlow Ave. drainage system; there is also more debris at its outlet on a regular basis.

Recorded storm flows (Tables 7-11) are highly variable, changing appreciably with rainfall intensity. Flows of more than several cu.m/min were not observed, although the calculated peak flow for a storm with a two-year frequency is about 40 cu.m/min. Only during the last monitored storm (Table 11)were the observed flows greater than 0.5 cu.m/min (0.3 cfs). The pipe layout in both stormwater drainage systems does not promote additive flows from different areas within each sub-drainage basin, making rainfall intensity the primary variable in the determination of flow.

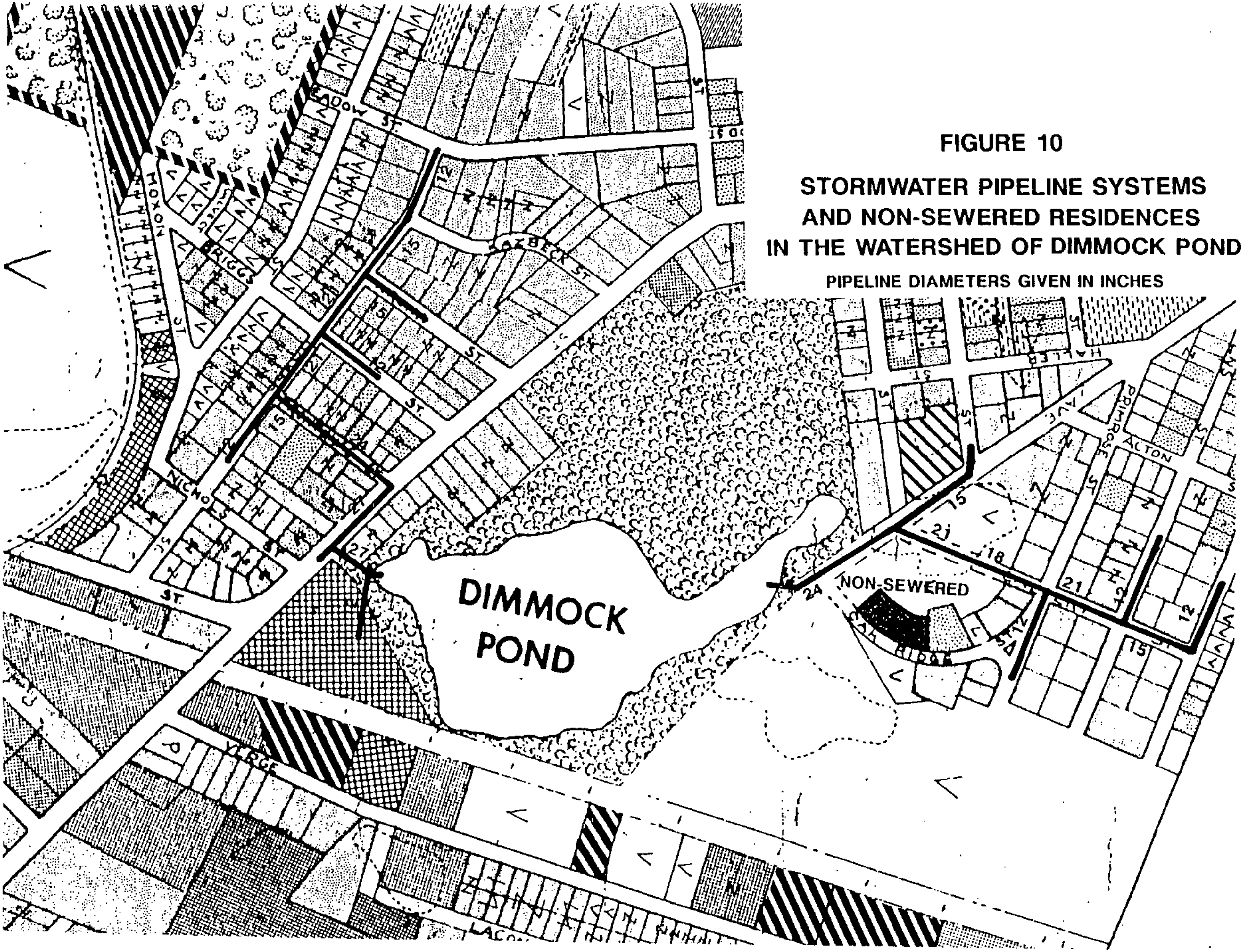


FIGURE 10

STORMWATER PIPELINE SYSTEMS AND NON-SEWERED RESIDENCES IN THE WATERSHED OF DIMMOCK POND

PIPELINE DIAMETERS GIVEN IN INCHES

TABLE 7

DIMMOCK POND STORM DATA 05/15/87

PARAMETER	UNITS	DP-2	DP-3
FLOW	(cu.m/min)	.31	.05
AMM-N	(mg/l)	2.31	1.92
NITRATE-N	(mg/l)	.12	.06
KNITRO	(mg/l)	4.91	4.55
ORTHO-P	(ug/l)	20	28
TOTAL P	(ug/l)	83	83
PH	(S.U.)	6.3	6.3
TALK	(mg/l)	20	20
TSS	(mg/l)	88	12
TURB	(NTU)	39	39
COND	(umhos/cm)	240	108
CHLORIDE	(mg/l)	45.6	8.9
Cd	(mg/l)	.002	.001
Cr	(mg/l)	.011	.004
Cu	(mg/l)	.103	.847
Fe	(mg/l)	5.015	1.987
Pb	(mg/l)	.102	.059
Mn	(mg/l)	.367	.176
Zn	(mg/l)	.347	.113

TOTAL RAINFALL REPRESENTED: 0.3 CM (0.1 IN)
SAMPLING DURATION: 1 HR

TABLE 8

DIMMOCK POND STORM DATA 08/03/87

PARAMETER	UNITS	DP-2	DP-3
FLOW	(cu.m/min)	.17	.17
AMM-N	(mg/l)	.43	.48
NITRATE-N	(mg/l)	.12	.22
KNITRO	(mg/l)	1.95	2.00
ORTHO-P	(ug/l)	40	30
TOTAL P	(ug/l)	190	180
FEC.COLI	(#/100ml)	2300	6000
FEC.STREP	(#/100ml)	10000	11000
PH	(S.U.)	6.0	5.9
TALK	(mg/l)	6.0	2.5
TSS	(mg/l)	6.5	6.0
TURB	(NTU)	3	6.5
COND	(umhos/cm)	33	23
CHLORIDE	(mg/l)	2.2	1.1

TOTAL RAINFALL REPRESENTED: 3.4 CM (1.4 IN)
SAMPLING DURATION: 4.5 HRS

TABLE 9

DIMMOCK POND STORM DATA 01/13/88

PARAMETER	UNITS	DP-2	DP-3
FLOW	(cu.m/min)	.10	0.00
AMM-N	(mg/l)	.40	
NITRATE-N	(mg/l)	.63	
KNITRO	(mg/l)	4.40	
ORTHO-P	(ug/l)	160	
TOTAL P	(ug/l)	300	
PH	(S.U.)	7.1	
TALK	(mg/l)	8	
TSS	(mg/l)	15	
TURB	(NTU)	10	
COND	(umhos/cm)	1400	
CHLORIDE	(mg/l)	398	
Cd	(mg/l)	.004	
Cr	(mg/l)	.004	
Cu	(mg/l)	.038	
Fe	(mg/l)	.71	
Pb	(mg/l)	.018	
Mn	(mg/l)	.33	
Zn	(mg/l)	.46	
OIL/GREASE		7.0	

TOTAL RAINFALL REPRESENTED: 0.3 CM (0.1 IN)
SAMPLING DURATION: 1 HR

TABLE 10

DIMMOCK POND STORM DATA 04/15/88

PARAMETER	UNITS	DP-2A	DP-2B	DP-2C	DP-2D
TIME		10:10	10:38	10:58	12:42
FLOW	(cu.m/min)	.02	.02	.02	.02
AMM-N	(mg/l)	.04	.09	.06	.29
NITRATE-N	(mg/l)	2.12	2.82	2.75	.54
KNITRO	(mg/l)	90.10	28.20	24.10	20.50
ORTHO-P	(ug/l)	3210	2420	2370	740
TOTAL P	(ug/l)	12100	3870	3410	2550
PH	(S.U.)	8.0	7.3	7.1	6.9
TALK	(mg/l)	310	149	110	45
TSS	(mg/l)	32	140	162	46
TURB	(NTU)	20.0	95.0	100.0	65.0
COND	(umhos/cm)	999	557	455	263
CHLORIDE	(mg/l)	50.0	38.8	33.7	18.4
FEC.COLI	(#/100ml)	100	50	40	120
FEC.STREP	(#/100ml)	460	20000	21000	6000
FROM COMPOSITE:					
Cd	(mg/l)	.003			
Cr	(mg/l)	.007			
Cu	(mg/l)	.081			
Fe	(mg/l)	1.56			
Pb	(mg/l)	.006			
Mn	(mg/l)	.150			
Zn	(mg/l)	.270			
OIL & GREASE	(mg/l)	8.00			

PARAMETER	UNITS	DP-3A	DP-3B	DP-3C	DP-3D
TIME		10:14	10:43	11:00	12:45
FLOW	(cu.m/min)	0.00	0.00	0.00	.01
AMM-N	(mg/l)				.06
NITRATE-N	(mg/l)				.35
KNITRO	(mg/l)				.55
ORTHO-P	(ug/l)				200
TOTAL P	(ug/l)				510
PH	(S.U.)				6.7
TALK	(mg/l)				29
TSS	(mg/l)				26
TURB	(NTU)				25.0
COND	(umhos/cm)				153
CHLORIDE	(mg/l)				28.6
FEC.COLI	(#/100ml)				300
FEC.STREP	(#/100ml)				100
FROM COMPOSITE:					
Cd	(mg/l)	.001			
Cr	(mg/l)	.013			
Cu	(mg/l)	.260			
Fe	(mg/l)	3.54			
Pb	(mg/l)	.032			
Mn	(mg/l)	.115			
Zn	(mg/l)	.074			
OIL & GREASE	(mg/l)	3.00			

TOTAL RAINFALL REPRESENTED: 0.8 CM (0.3 IN)
SAMPLING DURATION: 3 HRS

TABLE 11

DIMMOCK POND STORM DATA 04/28/88

PARAMETER	UNITS	DP-2A	DP-2B	DP-2C	DP-2D	DP-2E	DP-2F	DP-2G	DP-2H	DP-2I
TIME		5:50	6:01	6:52	7:40	8:20	9:05	9:35	10:05	13:22
FLOW	(cu.m/min)	.8	1.0	1.7	4.1	2.2	1.7	1.7	1.5	1.4
AMM-N	(mg/l)	.46	.44	.25	.15	.10	.10	.10	.13	.10
NITRATE-N	(mg/l)	.70	.70	.44	.19	.13	.12	.16	.12	.13
KNITRO	(mg/l)	3.50	3.50	3.00	2.50	2.00	1.50	1.50	1.50	1.50
ORTHO-P	(ug/l)	150	160	120	130	100	90	100	100	90
TOTAL P	(ug/l)	280	270	220	240	200	110	130	140	120
PH	(S.U.)	6.2	5.7	5.8	5.9	5.9	5.8	5.9	5.8	5.9
TALK	(mg/l)	3	1	2	2	2	2	2	2	2
TSS	(mg/l)	46	48	59	77	57	10	49	119	54
TURB	(NTU)	42.0	40.0	37.0	50.0	48.0	30.0	22.0	20.0	18.0
COND	(umhos/cm)	47	18	20	22	19	30	27	40	50
CHLORIDE	(mg/l)	5.9	6.9	4.9	3.9	2.9	2.0	2.9	2.0	2.0
FEC.COLI	(#/100ml)	10		10		60.0		40		30
FEC.STREP	(#/100ml)	50		180		530.0		360		180
FROM COMPOSITE:										
Cd	(mg/l)	.001								
Cr	(mg/l)	.004								
Cu	(mg/l)	.016								
Fe	(mg/l)	.72								
Pb	(mg/l)	.004								
Mn	(mg/l)	.027								
Zn	(mg/l)	.053								
OIL & GREASE	(mg/l)	.60								

PARAMETER	UNITS	DP-3A	DP-3B	DP-3C	DP-3D	DP-3E	DP-3F	DP-3G	DP-3H	DP-3I
TIME		5:55	6:03	6:55	7:44	8:23	9:08	9:39	10:08	13:25
FLOW	(cu.m/min)	.3	.7	.8	3.2	1.7	1.7	1.7	1.5	1.0
AMM-N	(mg/l)	.14	.17	.23	.11	.07	.08	.08	.06	.06
NITRATE-N	(mg/l)	.33	.18	.30	.12	.11	.10	.12	.11	.08
KNITRO	(mg/l)	4.00	3.50	2.50	2.50	1.50	2.00	1.00	.50	1.00
ORTHO-P	(ug/l)	180	160	110	80	70	50	70	70	80
TOTAL P	(ug/l)	390	320	240	210	170	200	100	100	80
PH	(S.U.)	5.7	5.8	5.7	5.8	5.8	5.8	5.7	5.8	5.8
TALK	(mg/l)	3	2	1	1	1	1	1	1	1
TSS	(mg/l)	175	161	87	83	80	70	45	40	35
TURB	(NTU)	90.0	87.0	92.0	86.0	45.0	32.0	22.0	20.0	19.0
COND	(umhos/cm)	50	52	40	18	12	18	22	20	30
CHLORIDE	(mg/l)	5.2	5.2	3.1	2.1	2.1	2.1	2.1	1.0	2.1
FEC.COLI	(#/100ml)	110		2000		280		340		420
FEC.STREP	(#/100ml)	1000		510		210		270		210
FROM COMPOSITE:										
Cd	(mg/l)	.001								
Cr	(mg/l)	.004								
Cu	(mg/l)	.029								
Fe	(mg/l)	.97								
Pb	(mg/l)	.005								
Mn	(mg/l)	.020								
Zn	(mg/l)	.018								
OIL & GREASE	(mg/l)	3.40								

TOTAL RAINFALL REPRESENTED: 4.6 CM (1.8 IN)
SAMPLING DURATION: 9 HRS

The quality of storm water runoff entering the Dimmock Pond system is highly variable over time, but is typically quite undesirable from the perspective of pond management (Tables 7-11). Phosphorus concentrations were routinely moderate to high; total phosphorus ranged from 83 to 12,100 ug/l while orthophosphorus was between 20 and 3210 ug/l. The extremely high values occurred during the fourth sampled storm event at Station 2 (Parker St. drainage system, Table 10), and appear to be related to some unusual input of fertilizer or another nutrient-rich material other than fecal matter (bacterial levels were low). Phosphorus levels in runoff would still be considered high, however, even if the fourth event was excluded from consideration.

Nitrate nitrogen values were low to moderate, except at Station 2 during the fourth sampled event (04/15/88). Values for most parameters at Station 2 were unusual during that fourth event. Nitrate values of over 2.0 mg/l were recorded during that fourth event, however. Ammonia levels were more variable, reaching 2.31 mg/l at Station 2 in the first sampled event (05/15/87), but were also generally low to moderate. Total kjeldahl nitrogen was typically above 1.5 mg/l, with values over 20 mg/l recorded at Station 2 during the fourth sampled event. Values for forms of nitrogen at Station 2 were slightly higher than or comparable to those at Station 3 during most events.

The pH and alkalinity varied appreciably among sampled storm events (Tables 7-11). Excluding the fourth event (04/15/88) values for Station 2, which provided very high alkalinities from undetermined but suspicious sources, the range of alkalinity values was 1 to 29 mg/l. The pH was typically slightly acidic, except during the fourth event, when pH values of 6.9 to 8.0 SU were recorded at Station 2. The lowest pH values were recorded during the fifth sampled storm event (04/28/88) (5.7 to 6.2 SU), which provided the greatest total flow and dilution capacity. The supply of alkaline materials on the streets and in the catch basins becomes depleted during larger storms, lowering the pH of runoff to a level approaching that of the precipitation.

Total suspended solids concentrations in sampled stormwater ranged from 6 to 175 mg/l (Tables 7-11). Values tend to vary with rainfall intensity; there is only a limited wash-out effect, and heavy rains at the end of a storm can produce TSS levels at least as high as at the start of the storm. Corresponding turbidity values are commensurate with the recorded TSS concentrations, with a range of 3 to 100 NTU. Most sampled runoff was distinctly turbid and included substantial debris (e.g., paper, leaves, twigs) in addition to suspended particulates.

The conductivity of sampled runoff was highly variable, ranging from 12 to 1400 umhos/cm (Tables 7-11). The lowest values were associated with the fifth sampled event (04/28/88), when dilution of the accumulated street load of pollutants was greatest. High values are associated with low flows and generally with higher chloride values, although the fourth event (04/15/88) data for Station 2 reveal higher conductivities than the chloride values would suggest. The extremely variable composition of stormwater runoff in this system is underscored.

Concentrations of fecal bacteria were variable but generally low to moderate, relative to runoff values from other areas of Springfield (BEC 1980, 1986). Recorded fecal coliform levels did not exceed 6000/100 ml, and were generally less than 400/100 ml (individual sample standard for contact recreation) (Tables 7-11). Corresponding fecal streptococci values were substantially higher in most cases, suggesting non-human sources of these bacteria.

Levels of oil and grease ranged from 0.6 to 8.0 mg/l (Tables 9-11). There was a noticable oil sheen associated with most runoff generated in this watershed, as is typical in urban drainage basins. Heavy oil/grease deposits were noticed on one occasion at Station 2, possibly as a consequence of improper disposal of engine oil or a degreasing operation. Observations at other times, however, suggested gasoline or light oils as the source of measured oil and grease.

Seven heavy metals assessed from composite samples obtained during four of the five sampled storm events were found at detectable levels on each date (Tables 7, 9-11). Iron, lead and manganese were found at elevated concentrations in a few samples from Station 2, based on the flag limits established by the USGS (1977). Iron was the only metal to exceed the flag limit at Station 3, although the copper concentration approached the limit on one occasion. Numerous sources of metals are possible in this watershed, although automobile-related ones are most likely to provide the greatest contribution.

Data were generated regarding the association of selected pollutants with various particle size fractions (Table 12). Size fractionation was performed for composite samples obtained at Stations 2 and 3. Samples were analyzed for total suspended solids, nitrate nitrogen, total kjeldahl nitrogen, and total phosphorus. Nearly all of the load of each assessed pollutant is associated with particles smaller than 53 um in at least one dimension. Most of the phosphorus and nitrogen loads are associated with particles less than 10 um in one dimension, but substantial portions of the total kjeldahl nitrogen and total

TABLE 12

SIZE FRACTIONATION OF POLLUTANT LOADS AT DIMMOCK POND.
(BASED ON SAMPLES COLLECTED ON MAY 3, 1988.)

	VALUE PER SIZE FRACTION					
PARAMETER	TOTAL	<250 um	<100 um	<53 um	<10 um	<0.45 um
TOTAL PHOSPHORUS (UG/L)	330	330	360	330	230	20
NITRATE NITROGEN (MG/L)	.55	.55	.57	.58	.58	.55
TOTAL KJELDAHL (MG/L AS N)	2.95	3.05	3.10	3.10	2.50	.55
TOTAL SUS. SOLIDS (MG/L)	27	23	23	20	6	4

phosphorus loads are tied up in particles greater than 0.45 um (virtually the dissolved fraction) in size. Suspended solids are mostly between 53 and 10 um in size. Nitrates were all in dissolved form, as would be expected for this chemical species.

The size fractionation data suggest that most of the nutrient and solids loads are particulate in nature, but that the bulk of these particulates are quite small in size. This means that for sedimentation processes to work, substantial detention times and minimal turbulence will be required. Biological processes or chemical reactions within a settling basin may aid settling, but the observed particle loads are not likely to be quickly removed from the runoff.

Groundwater Assessment

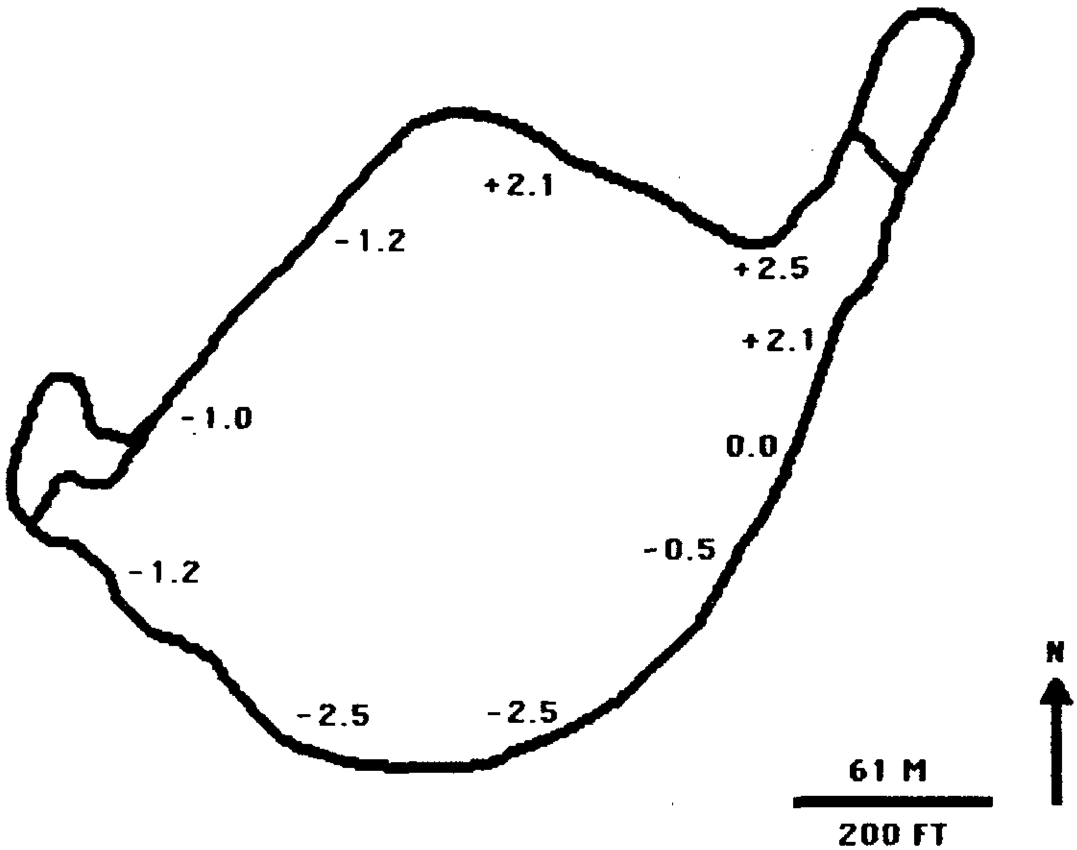
As groundwater has the potential to interact significantly with any pond lacking tributaries, the flow of groundwater into and out of Dimmock Pond was investigated. The relative pressure of surface water and groundwater was assessed through the use of a manometer, with probes placed into the pond and into the sediment below it at ten locations along the shoreline. Probes were inserted to a sediment depth of 0.5 to 0.8 m. Groundwater exerted greater pressure than the surface water in the northeastern portion of the pond (Figure 11), suggesting that there would be groundwater inflow to the pond at that point if the sediment were sufficiently permeable. Manometer readings at the other locations were negative, indicating a tendency for water to flow out of the pond and into the groundwater (recharge) at those points. Pressure differentials were not especially large, indicating no strong tendency for inflow or outflow at the existing water level, which was just slightly below average for the pond.

The manometer readings are consistent with what is known of the overall direction of groundwater flow in the area. Groundwater moves in a southwesterly to westerly direction, moving from the Dimmock Pond area toward Loon Pond, then on toward Fivemile Pond and the Lake Lorraine area. Localized groundwater flows may deviate from this pattern, but the general trend has been substantiated by seepage measurements and well tests performed by BEC personnel elsewhere in the area. Of particular note is the assessment performed using wells drilled on the UniFirst property (Appendix C) as part of an investigation of potentially leaky fuel and solvent tanks by ERT, Inc. (1987). Measurements of groundwater levels on three dates suggested the flow pattern described above.

To evaluate actual seepage rates, meters were installed in pairs (nearshore and offshore) at six locations in May, 1987, and at four locations in October, 1987 (Figures 12 and 13). Measured seepage rates were generally slight; the largest inflow was 48

FIGURE 11

MANOMETER READINGS AT DIMMOCK POND



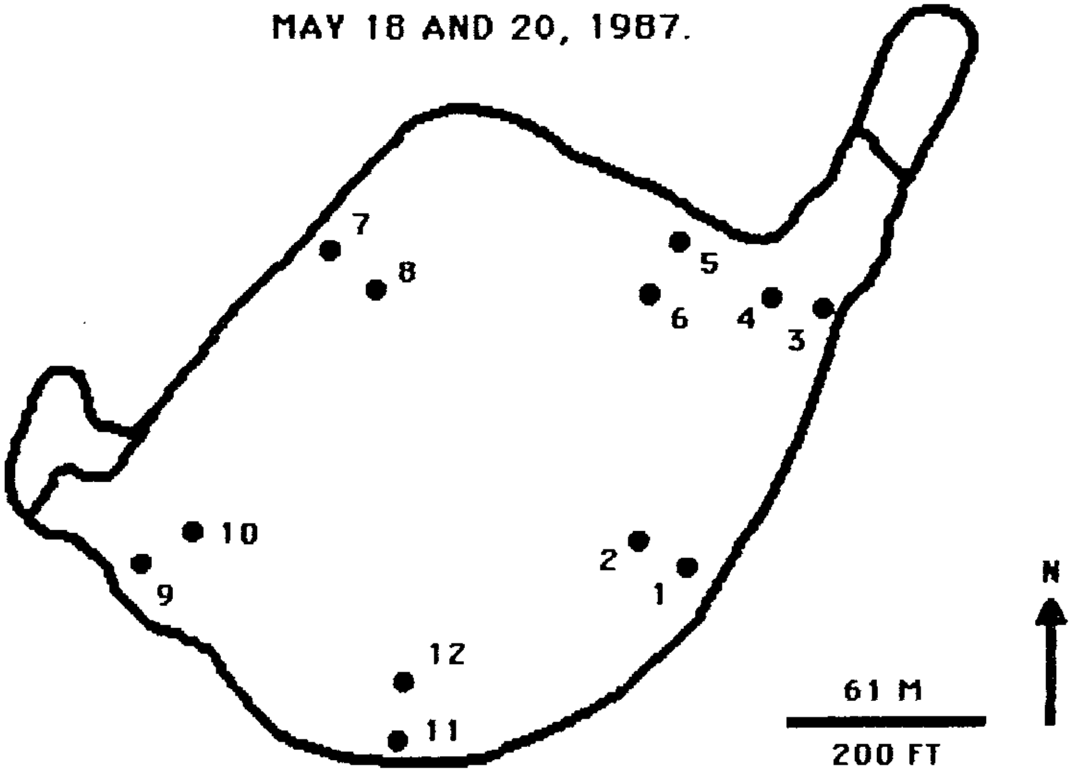
Readings are based on the differential head pressure between the ground water and the pond at the point of measurement. Readings are given in cm of head difference.

Positive readings denote areas where ground water is attempting to enter the pond. Negative readings signify that water is attempting to leave the pond. Actual seepage rates depend on the differential head pressure and the permeability of the pond bottom.

FIGURE 12

DIMMOCK POND

MEASURED SEEPAGE RATES (L/SQ.M/DAY)
MAY 18 AND 20, 1987.

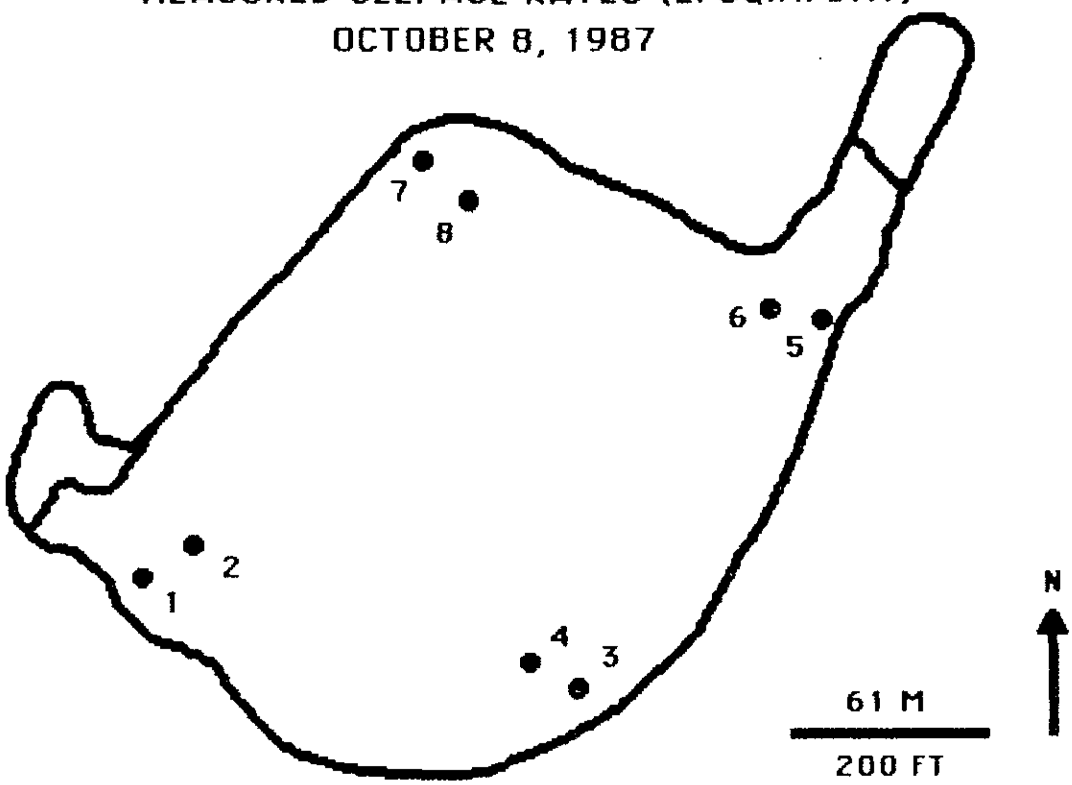


DATE	METER #	DIST. FROM SHORE (M)	SEEPAGE TIME (HR)	VOLUME CHANGE (L)	SEEPAGE RATE (L/SQ.M/D)
5/18/87					
	1	2.7	7.92	+0.340	+ 4.12
	2	8.5	7.75	-0.015	- 0.19
	3	3.7	7.75	+0.680	+ 8.42
	4	11.0	7.72	0.0	0.0
	5	2.7	7.67	+0.580	+ 7.26
5/20/87	6	9.2	7.67	+0.270	+ 3.36
	7	2.0	6.51	-0.100	- 1.47
	8	4.6	6.50	+0.360	+ 5.32
	9	3.5	6.45	+1.080	+16.07
	10	8.2	6.38	-0.440	- 6.62
	11	2.4	6.42	-0.420	- 6.28
	12	4.9	6.42	-0.770	-11.51

FIGURE 13

DIMMOCK POND

MEASURED SEEPAGE RATES (L/SQ.M/DAY)
OCTOBER 8, 1987



DIMMOCK POND SEEPAGE

Date	Meter #	Dist. from shore (M)	Seepage time (HR)	Volume change (L)	Seepage (L/SQ.M/D)
10/08/87	1	6.1	3.50	-.41	-11.25
	2	13.7	3.50	-.80	-21.94
	3	1.8	3.50	.45	12.34
	4	5.8	3.50	1.75	48.00
	5	2.7	5.00	-.80	-15.36
	6	8.2	5.00	-.09	-1.73
	7	2.4	4.80	-.18	-3.60
	8	8.8	4.80	-1.40	-28.00

NOTE: AREA OF SEEPAGE METER = 0.26 SQ.M. ADJUSTING FOR SEEPAGE LOSS DUE TO PRESSURE WITHIN THE METER AND ROUNDING OFF, THE SEEPAGE PER SQ.M IS CALCULATED AS 4 X THE OBSERVED VOLUME CHANGE IN THE SEEPAGE METER BAG.

l/sq.m/d and the largest outflow was 28 l/sq.m/d (Figures 12 and 13). Seepage rates did not correspond particularly well with the pattern of manometer readings, but variable sediment permeability and the low level of recorded seepage values confound any likely correlation. Total groundwater inflow during the May assessment was calculated to be 0.017 cu.m/min, while that for October was 0.045 cu.m/min (Table 13). Respective outflows during the two assessments were 0.009 and 0.098 cu.m/min.

Although the magnitude of groundwater flow through Dimmock Pond is not large, it is likely to represent a substantial portion of the hydrologic budget (about a fifth of all inputs), given the few sources of water available to the pond. An attempt was therefore made to quantify the quality of the porewater which seeps into the pond (Figure 14). Samples were successfully obtained from three of the four seepage measurement locations in October, 1987; low sediment permeability and deep organic muck minimized collection rates and caused repeated clogging of the sampling apparatus. Analysis of the collected porewater revealed high levels of total phosphorus, moderate to high levels of ammonia nitrogen, and low concentrations of nitrate nitrogen and fecal coliform bacteria. The pH and conductivity levels were low to moderate.

A sample of pond water was obtained at the same time as the porewater for reference purposes. The pH and conductivity of the reference sample are similar to those of the porewater samples, but substantial differences are noted for the other parameters. Chemical and biological activity at the sediment water interface may modify the quality of seepage inflow, or dilution of the relatively small inflow volumes may minimize the influence of those inflows.

It does appear that the porewater is not representative of groundwater away from the pond, as porewater quality is trongly conditioned by the features of the soft sediment in Dimmock Pond. However, as this water represents groundwater passing into the pond, the quality of groundwater farther from the pond is less relevant to pond water quality at this time. The lack of groundwater data from points away from the pond precludes prediction of seepage quality in the absence of the thick muck layer, however, and prevents accurate separation of subsurface nutrient inputs between true groundwater and internal recycling.

<u>Sediment Analysis</u>

Soft sediment depths in Dimmock Pond average approximately 1.6 m (5.2 ft), with the maximum soft sediment depth exceeding 4 m (13 ft) (Figure 15). The total volume of soft sediment in Dimmock Pond is over 66500 cu.m (approximately 87,500 cy) (Table 14). While soft sediment is focused toward the deeper portions of the pond, the resulting sediment depth contours are hardly

TABLE 13

DIMMOCK POND SEEPAGE CALCULATIONS: 05/18-20/87

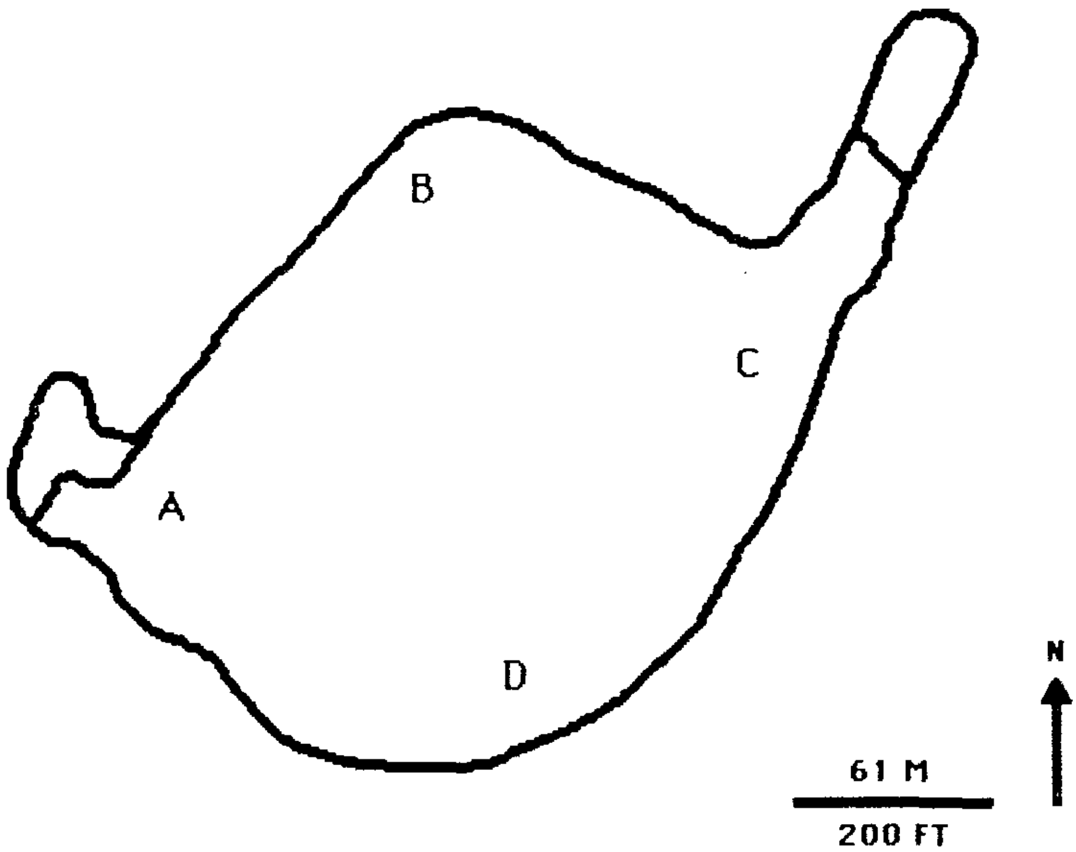
TRANSECT (METER #'S)	SEEPAGE L/SQ.M/D	LENGTH ALONG SHORELINE (M)	DISTANCE FROM SHORE (M)	AREAL SEEPAGE (L/D)
1-2	1.9	105	8	1596
3-4	4.2	200	10	8400
5-6	5.3	120	15	9540
7-8	1.9	145	5	1378
9-10	4.7	150	5	3525
11-12	-8.9	140	10	-12460
			INFLOW	24439 = 0.017 CU.M/MIN
			OUTFLOW	12460 = 0.009 CU.M/MIN

DIMMOCK POND SEEPAGE CALCULATIONS: 10/08/87

TRANSECT (METER #'S)	SEEPAGE L/SQ.M/D	LENGTH ALONG SHORELINE (M)	DISTANCE FROM SHORE (M)	AREAL SEEPAGE (L/D)
1-2	-16.6	215	20	-71380
3-4	30.2	215	10	64930
5-6	-8.5	215	10	-18275
7-8	-15.8	215	15	-50955
			INFLOW	64930 = 0.045 CU.M/MIN
			OUTFLOW	140610 = 0.098 CU.M/MIN

FIGURE 14

GROUND WATER SAMPLING LOCATIONS IN DIMMOCK POND (10/05/87)



Ground water samples are collected using a littoral interstitial pore water sampler. Samples are composites of three to five individual samples collected within 50 m of the letter designating the sample site.

DIMMOCK POND POREWATER DATA 10/05/87

PARAMETER	UNITS	DP-A	DP-C	DP-D	DP-1S*
AMM-N	(mg/l)	.72	1.00	1.08	.14
NITRATE-N	(mg/l)	.03	.02	.01	.02
TOTAL P	(ug/l)	390	290	370	40
FEC.COLI	(#/100ml)	10	10	10	410
PH	(S.U.)	5.98	5.92	5.91	6.08
COND	(umhos/cm)	70	78	121	60

* DP-1S SAMPLED AS REFERENCE

FIGURE 15

DIMMOCK POND
MAP OF SOFT SEDIMENTS
(All contours given in meters)

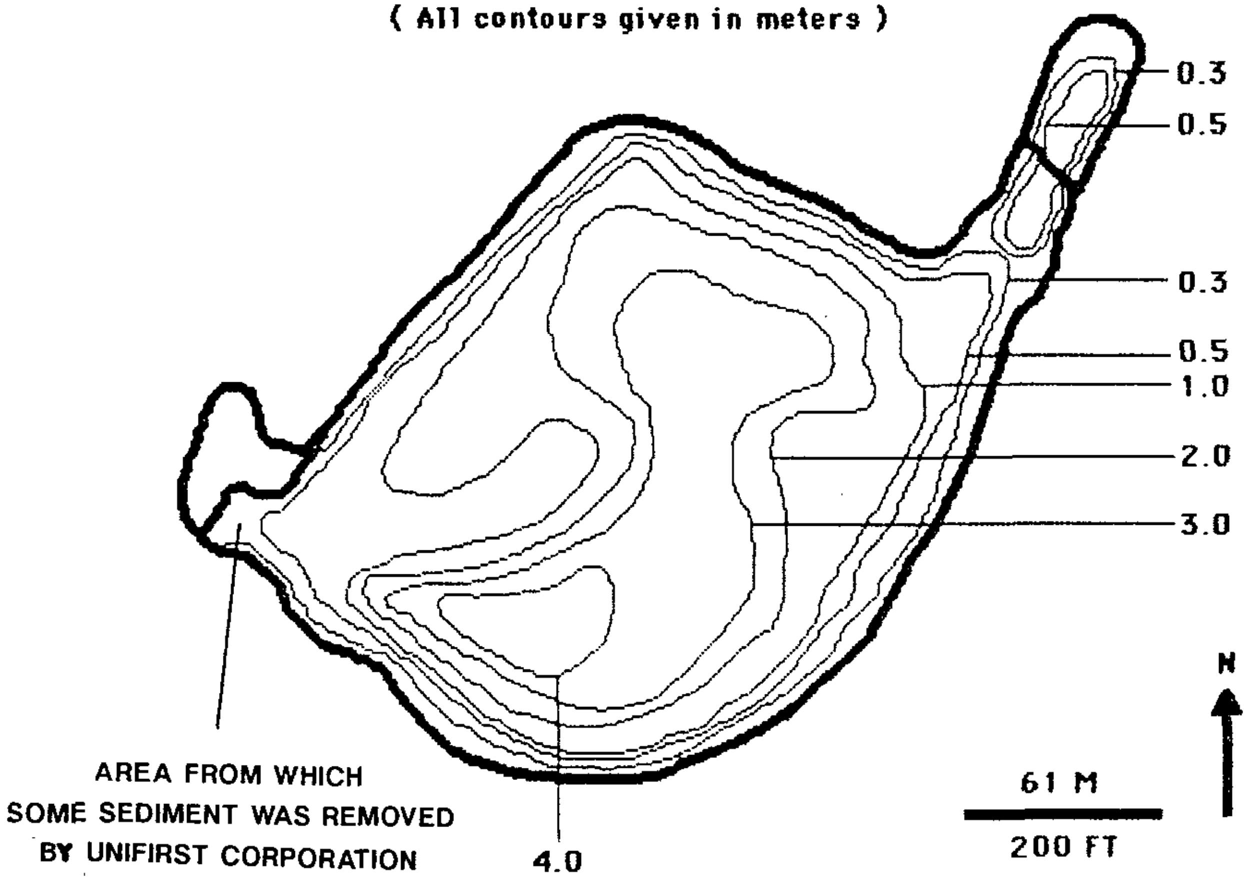


TABLE 14

SOFT SEDIMENT VOLUME IN DIMMOCK POND

Soft Sediment Depth Range (M)	Volume Contained Within Range (CU.M)
0.0 - 0.3	621
0.3 - 0.5	1441
0.5 - 1.0	5436
1.0 - 2.0	13357
2.0 - 3.0	14703
3.0 - 4.0	25657
>4.0	>5301
Total	>66516
	(61215 without the portion associated with depths >4.0 M)

regular; the deepest soft sediment patch is nearest the southern shoreline, and there is a central constriction in the contour pattern. If the soft sediment were removed from the pond, the result would be an irregularly contoured bottom with considerably greater ecological potential than the current morphometry. The depth of the pond would be more than doubled on average, as there is currently a greater volume of soft sediment than water.

The pond area is underlain by sand near its periphery, and by silts or clays toward its center. As detected by borings made on the UniFirst property just south of Dimmock Pond, there is a thick (>3 m) layer of silt and clay below the surface layer of sand and gravel, which is itself about 3 m thick (ERT 1987). The silty layer appears to produce a relatively high water table elevation which drops rather sharply in the southwest direction, where the subsurface soils are more sandy. The silts may also maintain the pond slightly above the background water table, although the thick layer of muck in the pond minimizes permeability on its own.

The soft sediment of Dimmock Pond is predominantly an organic muck soil, generated from many years of accumulated organic matter, with substantial quantities of sand mixed into it. It has an organic content of between 7.3 and 45% (Table 15), with the organic content increasing with distance from shore. Sandy deltas protrude into the thick muck where erosion channels have become established along the shoreline and in front of the Parker St. storm drain outfall. The muck is generally black in color, indicative of anoxic conditions at the sediment-water interface. In areas where organic constituents dominate over sand, the sediment is extremely soft and offers little resistence to a probe.

In addition to organic content (volatile solids), soft sediments collected from three stations in Dimmock Pond (Figure 2) were analyzed for selected metals, nutrients, and oil and grease (Table 15). There was substantial variability among the three sampled stations, as with the organic content. Comparison of recorded values with reference values obtained by the United States Geological Survey (USGS 1977) indicates that the sediments of Dimmock Pond near the Parker St. drain contain an exceptionally large amount of lead. Values for no other assessed parameters exceeded the USGS flag limits, which highlight the upper 10 to 15% of values obtained by that agency throughout the USA.

Comparison of sediment parameter values with the reference values established by the United States Environmental Protection Agency (USEPA 1977) for evaluating sediment quality in Great Lakes harbors would result in the sediment of Dimmock Pond being classified as moderately or heavily polluted with respect to most

TABLE 15

CHEMICAL CHARACTERISTICS OF DIMMOCK POND SEDIMENTS

Parameter	Value (mg/kg) at Sampled Stations		
	DP-1 (4/87)	DP-2 (3/88)	DP-3 (3/88)
Total Volatile Solids (%)	45.0	7.3	16.0
Nitrate Nitrogen	139	1.0	1.1
Total Phosphorus	1490	910	306
Total Kjeldahl-Nitrogen	27800	7200	42900
Oil & Grease	6370	13200	2670
Total Metals:			
Arsenic	17.0	16.3	22.3
Cadmium	1.0	.9	.8
Chromium	31.0	27.6	11.0
Copper	108	-	-
Iron	9900	11460	8756
Manganese	93	123	103
Nickel	31.0	44.7	14.3
Lead	387	660	212
Vanadium	526	90	54
Zinc	309	299	107
Mercury	<0.16	<0.034	<0.033
Biocides:			
Aldrin	-	< 1.8	<1.8
Heptachlor	-	< 2.4	<2.4
Heptachlorepoxide	-	< 2.0	<2.0
ppDDE	-	< 1.0	<1.0
ppDDD	-	< 2.0	<2.0
ppDDT	-	< 5.0	<5.0
Dieldrin	-	<10.0	<10.0
a-BHC	-	< 1.5	< 1.5
b-BHC	-	< 2.0	<2.0
d-BHC	-	< 2.0	<2.0
a-Endosulfan	-	< 2.0	<2.0
b-Endosulfan	-	< 2.0	<2.0
Endosulfan Sulfate	-	< 4.0	<4.0
Endrin Aldehyde	-	<12.0	<12.0
Endrin	-	<3.5	< 3.5
Lindane	-	< 1.8	< 1.8
Methoxychlor	-	< 6.6	< 6.6
Chlordane	-	<14.0	<14.0
Toxaphene	-	< 80.0	<80.0
PCB 1016	-	< 1.1	< 1.0

NOTE: Month and year of sampling given in parentheses adjacent to station.

parameters (arsenic, chromium, copper, lead, nickel, zinc, total phosphorus, total kjeldahl nitrogen, oil and grease, and organic content). Of the metals for which reference values have been established, only manganese was found at low levels.

Based on the Massachusetts Division of Water Pollution Control standards for dredged material disposal (MDWPC 1979), the sediment in Dimmock Pond is classified as Category I with respect to cadmium, chromium, copper and nickel, Category II with respect to zinc, and Category III with respect to arsenic, lead and vanadium. Based on the established criteria for oil and grease and organic content, the sediments in the pond are classified as Type C. In terms of disposal, pond sediments can be characterized as Category III, Type C, which means that they can be disposed of in an upland setting, but only with proper precautions relating to disposal area security and the quality of water leaving the disposal site.

It is important to note that the classifications given are based on the highest values obtained among the three sediment samples tested. Further testing and a composite rating would be appropriate in the design phase, should a dredging program be carried out. Tests of composite samples from complete core borings are recommended.

In addition to the parameters discussed above, a biocide scan was conducted on the two nearshore samples collected (Table 15). The corresponding limits of detection were not exceeded by any of the 20 compounds for which the samples were tested. The detection limits were not particularly low, however, and additional testing is recommended in the design phase, in conjunction with the additional metals testing suggested above. The agricultural history of the area warrants limited further investigation of the sediments, but since there were no storm drainage systems at the time when the area was being farmed it is unlikely that large quantities of any biocide reached the pond.

As BEC found no record of specific contaminants in the material removed from the pond by UniFirst, no other contaminant analyses were performed. However, a July 3, 1986 letter from ERT, Inc. to Stephen Joyce of the Springfield office of the DEQE notes the presence of toluene and xylene in soil samples collected from the UniFirst site. Total chromatographable organics (TCO) were found at a much higher level than the sum of the toluene and xylene concentrations, but the nature of the TCO was unknown. Assuming that the substances contaminating the UniFirst site soil are the same ones which reached Dimmock Pond in 1981, it would be advisable to run a similar TCO analysis on Dimmock Pond sediments as part of the preparation of an impact statement for the dredging work.

In anticipation of any dredging which may take place in the pond, the settling rate, bulking factor, and residual turbidities were assessed for a composite sample of Dimmock Pond sediment (Table 16). While much of the solids content settled out of the columns within half an hour, residual turbidities never reached an acceptable level for effluent discharge (<10 NTU), suggesting that a substantial portion of the sediment particles are very fine (silt or clay range, but mostly fine organics). This partly explains the persistence of turbidity in the pond after storm events or windy periods, and suggests that the effluent from any dredged material containment area will require treatment before discharge to a surface water resource.

Comparing the final (48 hr) sediment volume to the initial volume, a bulking factor of 1.4 is obtained. Initially, any dredged material will occupy about 40% more volume in the disposal area than it did in the pond. However, the moderate to high organic content of the soft sediment in the pond suggests that decomposition, shrinking, and compaction should at least offset the bulking factor, resulting in a final disposal volume equal to or less than the dredged volume.

Phytoplankton

Phytoplankton, or algae suspended in the water column, are an important link in aquatic food webs, but may also be responsible for reduced water clarity, detectable color, and noticable odor in lakes. One useful measure of phytoplankton quantity is chlorophyll *a*, a pigment critical to photosynthesis. It is the same pigment that makes grass and leaves green. Chlorophyll *a* usually represents 0.5 to 2% of the total phytoplankton biomass and has been correlated with production and standing crop at various levels of the food web, water clarity, and phosphorus concentration (e.g., Jones and Bachmann 1976, Oglesby and Schaffner 1978, Hanson and Leggett 1982, Vollenweider 1982). Chlorophyll levels in Dimmock Pond ranged from 1.8 to 35.1 ug/l, with an annual mean of 8.6 ug/l and a summer mean of 13 ug/l (Table 6,Appendix A).

Chlorophyll levels are closely tied to phosphorus concentrations in many lakes. Yet summer chlorophyll levels (Appendix A) in Dimmock Pond are much lower than would be predicted from phosphorus data (Jones and Bachmann 1976, Oglesby and Schaffner 1978). Some of the phosphorus in the water column may be unavailable for algal uptake, but the presence of orthophosphorus at levels appreciably greater than 10 ug/l during most of the summer suggests that phosphorus availability is not a chronic limiting factor. Grazing by zooplankton is not a substantial, constant influence, and there is no evidence to

TABLE 16

COLUMN TEST RESULTS: DIMMOCK POND COMPOSITE

Date of Test Start 04/15/87

Time (Hr)	Material Volume (Cu.cm)	Turbidity (NTU)
0.0	220	-
0.2	720	Infinite
0.5	355	Infinite
2.0	325	Infinite
8.3	320	132
25.1	315	138
32.1	310	137
48.0	310	136

suggest that there is any severe, persistent toxicity problem in the pond. Light limitation of plankton growth is the likely controlling factor in this system, considering the large quantities of suspended matter observed in the pond.

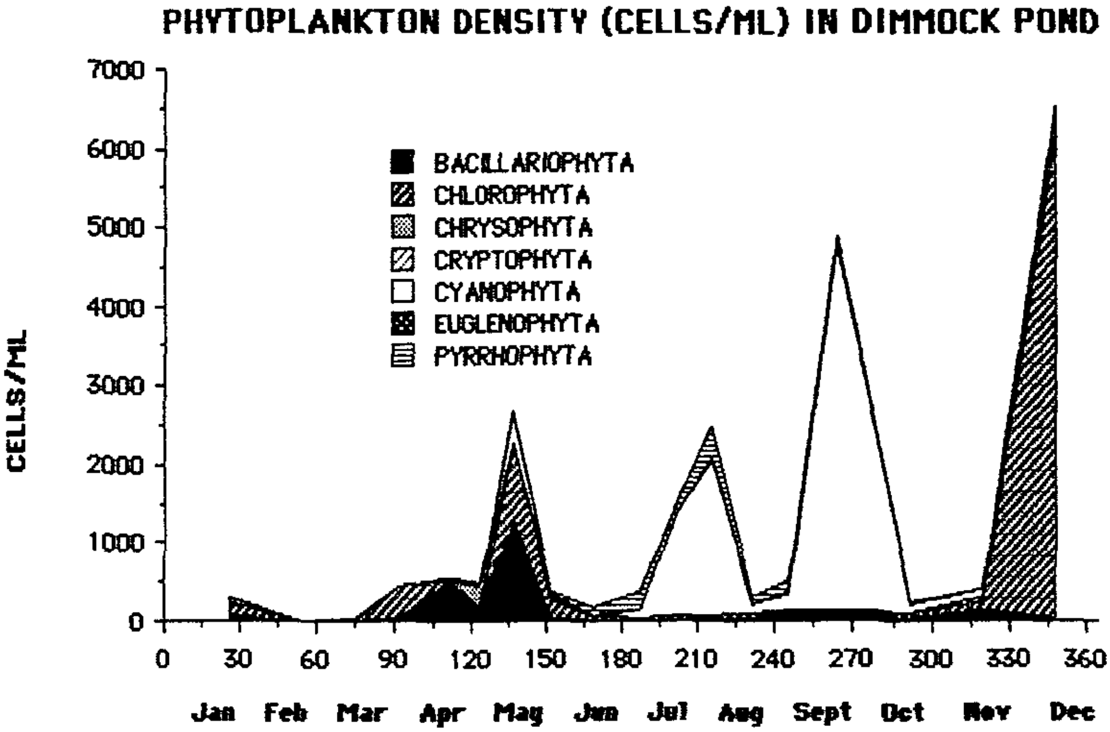
Phytoplankton biomass is likely to constitute a significant influence on water clarity in Dimmock Pond at times, although sediment-induced turbidity is likely to be a more important and continual influence. The mean summer Secchi disk reading of 1.6 m in Dimmock Pond is somewhat lower than the 1.9 m value predicted from chlorophyll measurements (Oglesby and Schaffner 1978), but the mean Secchi disk reading from other seasons (also 1.6 m) was much lower than the 3.0 m value predicted from the mean chlorophyll level (Vollenweider 1982) (Appendix A). This is certainly a consequence of high concentrations of suspended solids, although some toxic effect from metal-laden stormwater cannot be ruled out (Redfield and Jones 1982). Non-algal turbidity (i.e., resuspended sediment) certainly decreases water clarity in this system during periods of wind or substantial precipitation.

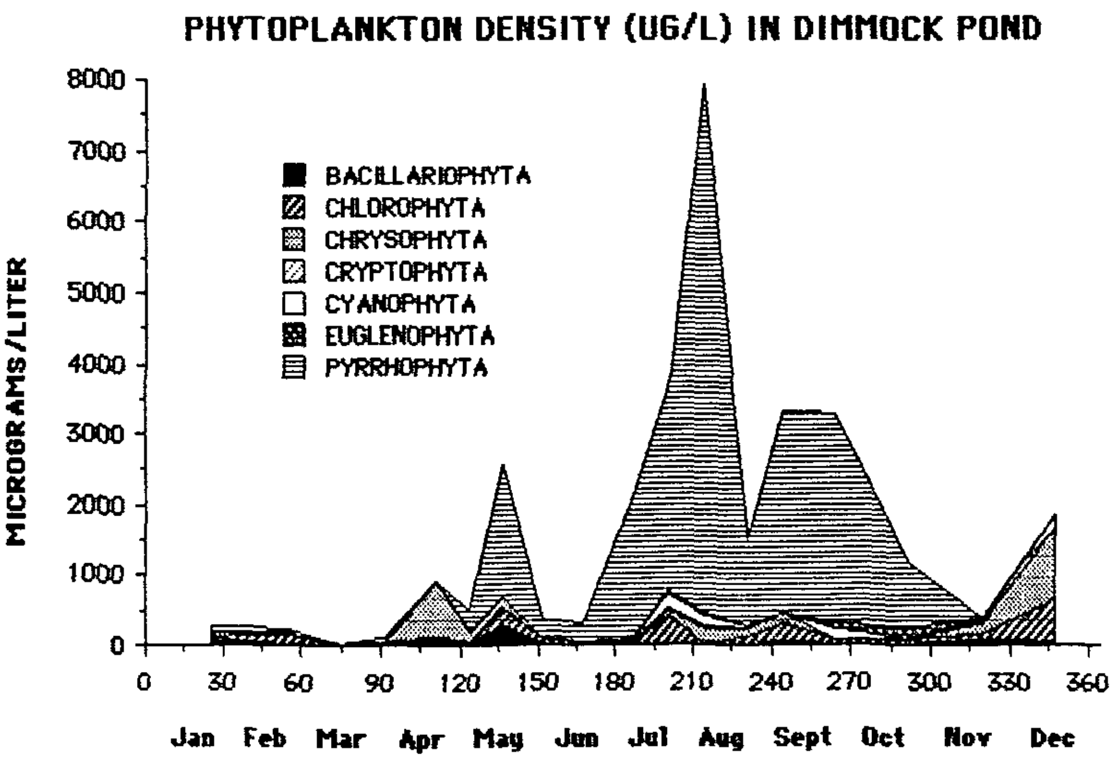
Secchi disk transparency, a measure of water clarity, ranged from 1.0 to 3.0 m during this study, with a mean of 1.6 m (Table 6). The highest value occurred in mid-June, coincident with a nearly average chlorophyll concentration and turbidity, and corresponding to high levels of suspended solids. The value of 3.0 m is entered clearly in the field logbook, but is inconsistent with the other data; an error in recording is suspected. Even allowing this questionable data point to stand, the transparency of the water is usually quite low, affected by suspended solids, phytoplankton and natural coloration of the water.

The state standard for Secchi disk transparency in waters used for contact recreation is 1.2 m (4 ft). Dimmock Pond could be considered marginally suitable for contact recreation (e.g., swimming), although its appearance deters virtually all would-be swimmers. Transparencies lower than 1.2 m are common between January and June; mixing and long-term suspension of fine particulates beneath the ice and during the spring transition period are believed to be responsible.

Assessment of phytoplankton composition and relative abundance reveals numerical dominance by Bacillariophyta (diatoms), Chlorophyta (green algae) and Cyanophyta (blue-green algae), but relatively greater biomasses of Pyrrhophyta (dinoflagellates) during the growing season (Figure 16, Appendix A). Flagellated chlorophytes and chrysophytes provided the greatest biomass during the colder months. While small-celled forms are numerically common, the much larger cells of the dinoflagellates represent the greatest portion of the biomass

FIGURE 16


PHYTOPLANKTON DENSITY (CELLS/ML) IN DIMMOCK POND
CELLS/ML
7000
6000
5000
4000
3000
2000
1000
0
BACILLARIOPHYTA
CHLOROPHYTA
CHRYSOPHYTA
CRYPTOPHYTA
CYANOPHYTA
EUGLENOPHYTA
PYRRHOPHYTA
0 30 60 90 120 150 180 210 240 270 300 330 360
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec


PHYTOPLANKTON DENSITY (UG/L) IN DIMMOCK POND
MICROGRAMS/LITER
8000
7000
6000
5000
4000
3000
2000
1000
0
BACILLARIOPHYTA
CHLOROPHYTA
CHRYSOPHYTA
CRYPTOPHYTA
CYANOPHYTA
EUGLENOPHYTA
PYRRHOPHYTA
0 30 60 90 120 150 180 210 240 270 300 330 360
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec

much of the time. All algae abundant in Dimmock Pond are of species known or suspected to be facultative heterotrophs; these forms utilize organic compounds from the water column as a supplement to photosynthesis. Facultative heterotrophy allows superior growth in environments where much of the nutrient base is bound up in particulates or by dissolved substances (e.g., humic acids), and/or where light is limiting. Dimmock Pond is such an environment.

The relative abundance of phytoplankton species appears to be a function of multiple influences, such as nutrient ratios, temperature, availability of organic compounds, pH, and light intensity. As conditions may change rapidly in this small system, the phytoplankton community is inherently unstable. Yet it does generally exhibit the properties commonly associated with eutrophic environments (Wetzel 1983), and is capable of causing unsightly conditions in the pond. Blue-green blooms were observed during mid- and late summer of the study year, but were less obtrusive in Dimmock Pond than in many other area systems. This is attributed to the presence of suspended matter and humic substances coloring the water, mixing which minimized the formation of surface scums, low pH levels, and a tendency for blue-green algae to aggregate into very large particles in Dimmock Pond.

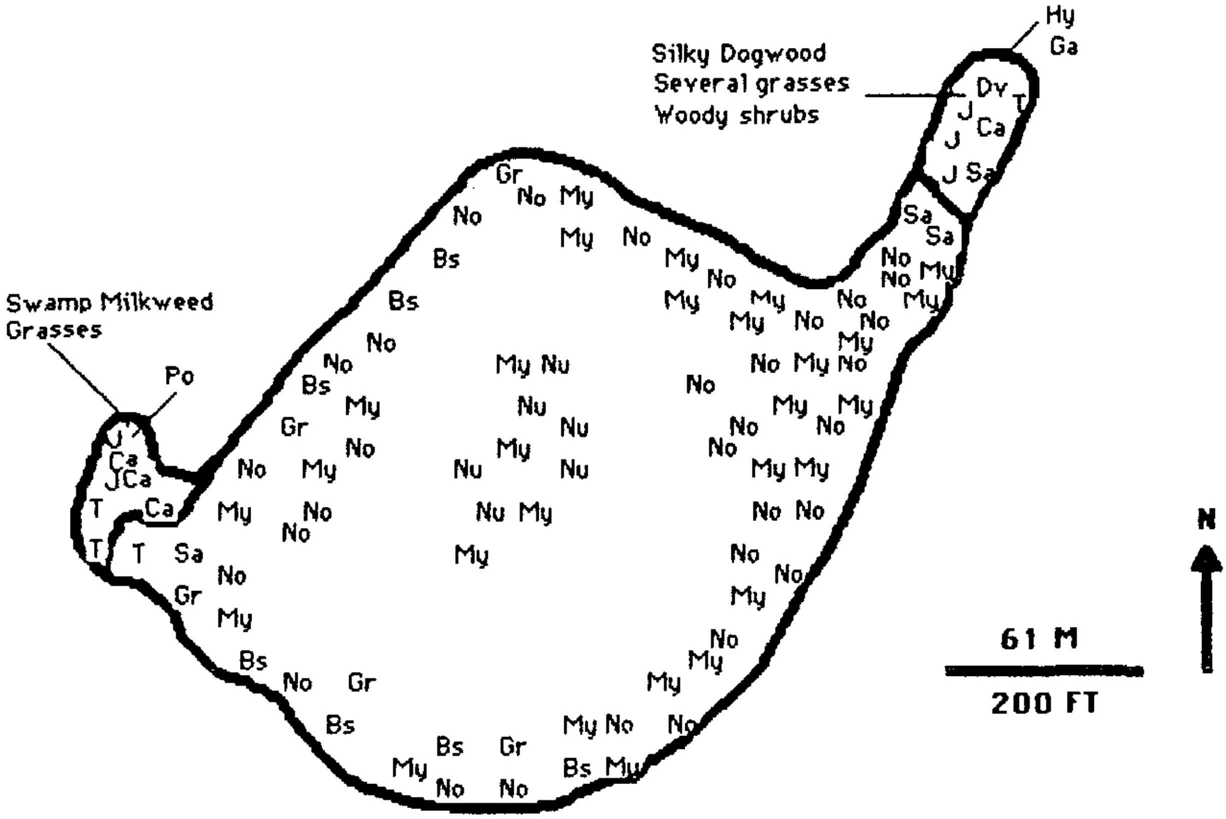
Genera of importance in the Dimmock Pond phytoplankton include Asterionella and Dinobryon, which were present during winter and became numerically dominant in April and May, although no clear biomass dominance was observed during that period. Chlorophytes such as Ankistrodesmus, Sphaerocystis, and certain Chlorococcales became common in spring, but were quickly overshadowed by the biomass of Peridinium, which was dominant or co-dominant until mid-autumn. At that time Dinobryon again became abundant, probably reflecting the seasonal change in temperature. Surface blooms of the cyanophytes Chroococcus and Microcystis were observed in August and September, but these genera did not represent the majority of the phytoplankton biomass in depth-integrated samples. No nitrogen-fixing species were detected in Dimmock Pond, and many of the common taxa are indicative of excessive nitrogen levels.

Macrophytes

Excluding the species strictly confined to the emergent wetland arms of the pond, seven species of macrophytes were identified in Dimmock Pond (Figure 17). Milfoil (Myriophyllum) dominates the submergent growth, while various lilies (Nymphaea and Nuphar) and watershield (Brasenia) are the most abundant species with leaves floating at the surface. Peripheral patches of cattail (Typha), arrowhead (Sagittaria), and hedge hyssop (Gratiola) were also observed. Additional species were found in the wetland arms.

FIGURE 17

DISTRIBUTION OF MACROPHYTE TAXA IN DIMMOCK POND



Macrophyte Taxonomic Composition

Bs	Brasenia schreberi	**My**	Myriophyllum spicatum
Ca	Carex sp.	**No**	Nymphaea odorata
Dv	Decodon verticillatus	**Nu**	Nuphar sp.
Ga	Galium tinctorium	**Po**	Polygonum sp.
Gr	Gratiola lutea	**Sa**	Sagittaria sp.
Hy	Hypericum sp.	**T**	Typha latifolia
J	Juncus sp.		

Macrophyte densities in Dimmock Pond (Figure 18) are moderate to high peripherally and in one area offshore, but a substantial fraction of the pond area (about 40%) is devoid of detectable macrophyte growths. The low density area is less coincidental with any bathymetric contour (Figure 3) than with soft sediment depth contours (Figure 15); areas with muck depths greater than about 1.5 m do not support rooted plant growths. This may be a consequence of substrate quality or instability, associated anoxia, or light limitation through continual suspension of particulate organic matter. The sediment-water interface is somewhat difficult to define with a probe in this area, making it less than hospitable for colonization by rooted plants. The soft sediment in the areas supporting dense plant growths has a distinctly higher sand content and a more discernible interface with the water column.

Peripheral nuisance growths of milfoil and lilies create difficulties for shoreline fishermen and discourage the launching and landing of boats and canoes. The maximum recorded macrophyte biomass was 2.6 kg/sq.m; this is not a large value in an absolute sense, but is quite high when the shallow depths (<1 m) where such densities occur are considered.

Zooplankton

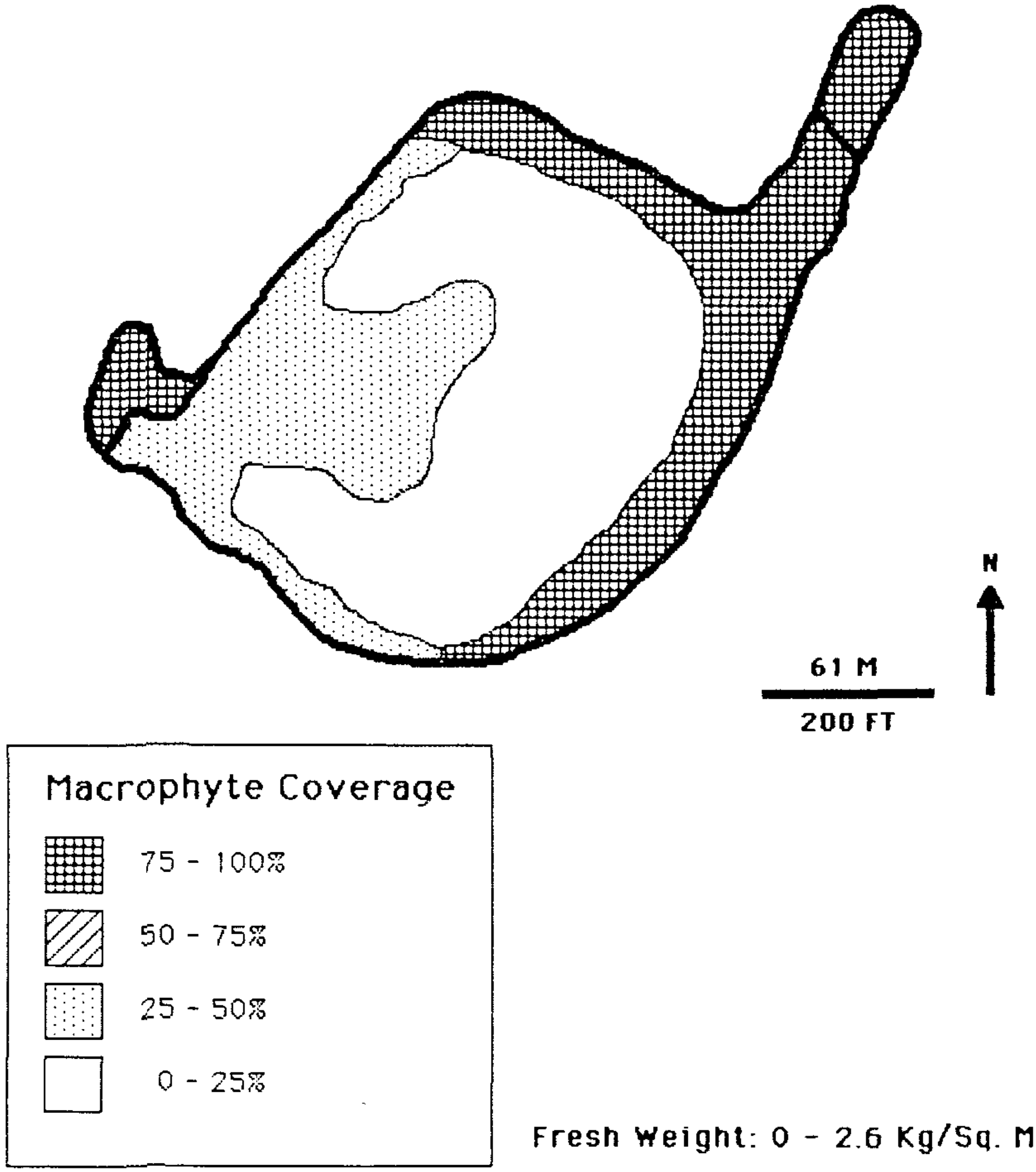
Two spring and one late summer zooplankton samples were collected from Dimmock Pond and analyzed for composition, relative abundance, biomass, and mean length of individuals. Zooplankton densities, either as individuals or micrograms per liter, were low in early spring and moderate in late spring and summer, and the mean individual length was moderate (Appendix A). Small-bodied cladocerans were the dominant component of the zooplankton community. While the grazing capacity of the late spring and summer zooplankton assemblage is not large, it is not likely to be negligibly small, and may contribute slightly to the lower than expected chlorophyll concentrations. The presence of the observed zooplankton community (and particularly the moderate mean length of individuals) in light of the dense panfish population is probably attributable to low visibility; the dominant panfish species is a visual predator.

Macroinvertebrates

Dimmock Pond hosts a small and minimally diverse macroinvertebrate community (Appendix A), including primarily odonate (dragonfly and damselfly) nymphs, surface-dwelling hemipterans (Gerridae and Mesoveliidae), chironomids (midges), and oligochaetes. No invertebrates were found in samples collected from the central bottom sediments, and apparent densities everywhere were low. Molluscs were noticably absent from this acid environment, while they are quite abundant in the

FIGURE 18

BOTTOM COVERAGE BY MACROPHYTES IN DIMMOCK POND



nearby Kettlehole Ponds. Aside from the acidity, anoxia and intense predation are believed to be depressing invertebrate diversity and density in Dimmock Pond.

Fish

The fish community of Dimmock Pond was assessed by BEC in October of 1987, using a seine with 1 cm mesh, laid between two shoreline points in a semi-circular fashion. Captured fish were held in a live well until sampling was complete and all fish were measured, after which they were released into the pond. Eight species were captured during the BEC survey, but bluegill sunfish comprised almost 89% of the catch by number (Table 17). Pumpkinseed sunfish provided more than 9% of the catch, leaving less than 2% of the sample to represent the remaining six species. Relative to desirable sizes from the angler's viewpoint, all fish encountered were small. Gamefish were too scarce to calculate proportional stock densities. Growth rates were generally average, although the sample sizes for most species were too small to provide a valid appraisal of growth among age classes.

Prior to the BEC study, there had been only one partial investigation of the fish community, and virtually no sanctioned management actions, although unofficial stocking of gamefish has been reported by area residents. The partial survey was conducted on September 30, 1986 by personnel from the Division of Fisheries and Wildlife and the Division of Water Pollution Control, using an electroshocking boat (Appendix C). The survey was performed in response to a request from the DWPC in support of investigations of the impact of activities at the UniFirst plant.

Several carp, a species not captured in the BEC survey, were observed in the DFW-DWPC survey. Two largemouth bass were shocked, one a two pound four-year old and the other a four pound five-year old. Other large bass have been taken from Dimmock Pond by anglers, and some may be native fish, but at least some have been released there after capture elsewhere. This may explain the large difference in weight between fish only a year apart in age. Brown bullheads were also shocked by the DFW-DWPC crew. There is no mention of the abundant sunfish in the resultant report, but these fish were almost certainly encountered.

The purpose of the DFW-DWPC survey was not to evaluate population statistics, but to assess the edibility of fish flesh removed from Dimmock Pond. Largemouth bass, brown bullheads and carp were captured and transported to the laboratory for flesh analysis. Although several organic compounds and metals were detected in the fish flesh analyzed, none were found to be in excess of the Food and Drug Administration's action levels

TABLE 17

DIMMOCK POND FISH SURVEY RESULTS

FISH SPECIES	COMMON NAME	# CAUGHT	% OF TOTAL #	MEAN LENGTH (MM)	MEAN WT. (g)	GROWTH RATE
Lepomis gibbosus	Pumpkinseed	107	9.3	113	36.9	Avg.
Lepomis macrochirus	Bluegill	1019	88.9	112	36.4	Avg.
Catostomus commersoni	White Sucker	1	0.1	400	--	--
Micropterus salmoides	Largemouth Bass	13	1.1	184	--	Poor to Avg.
Pomoxis nigromaculatus	Black Crappie	3	0.3	193	--	Avg.
Esox niger	Chain Pickerel	1	0.1	302	--	Avg.
Perca flavescens	Yellow Perch	1	0.1	197	--	Good
Ictalurus nebulosus	Brown Bullhead	1	0.1	192	--	--
TOTAL	8 SPECIES	1146	100			

Also known to be in Dimmock Pond but not captured during the BEC survey: Carp (Cyprinus carpio).
Large bass have been observed in the pond, but were not detected in this survey.

(Appendix C). The poor quality of the Dimmock Pond sediment with respect to several parameters is not reflected in the fish flesh analysis; the fish are apparently safe to consume, and no impact from activities at UniFirst is indicated.

Comparison with Other Studies

Most of what was known about Dimmock Pond and activities in its watershed was summarized in the 1980 BEC report on Springfield lakes and ponds. The general features and condition of the pond described in that report are consistent with the findings of the more recent study. Differences in certain details can be attributed to the longer duration and more intensive nature of the recent survey. The physical, chemical and biological characteristics of the pond remain virtually unchanged since the time of the original BEC survey.

The BEC report included data from the DWPC survey conducted in 1978. Differences between the DWPC data and the 1979 BEC data (in the 1980 report) were substantial with respect to certain parameters (e.g., total phosphorus), but fell within the temporal range of variability observed in the current BEC study. As both the 1978 DWPC survey and the 1979 BEC results come from a single day of sampling, the data generated by the current study provides a much more detailed impression of Dimmock Pond.

Despite the limited data base, the 1980 BEC study report made some observations and recommendations which still apply. The cost:benefit ratio for markedly improving the condition of the pond was not viewed as particularly favorable, but erosion control and dredging were viewed as desirable management actions. This situation has not changed dramatically, although the demand for recreational space has increased the perceived benefits of restoring Dimmock Pond. Potential funding through the Massachusetts Clean Lakes Program could reduce the cost of restoration to the City of Springfield, making a management program very appealing.

The only recent information of relevance to Dimmock Pond concerns activities at the UniFirst plant (Interstate Uniform Services Corporation) just south of Dimmock Pond and partially within its watershed. In 1981 a reportedly small quantity of solvent sludge was improperly deposited on the UniFirst property, resulting in its entry into the storm drainage system linked to the Parker St. storm drainage outfall into Dimmock Pond (Appendix C). Correspondence between consultants for Interstate Uniform Services Corporation, the corporation itself, and the DEQE Division of Hazardous Waste describe a chain of events during which the catch basin within the area in question was sealed to prevent further surface inputs, sediment was removed from the pond near the Parker St. drainage system outfall, underground tanks were unearthed to assess leakage, and borings were made to evaluate the groundwater level and direction of flow.

As there has been some leakage from the underground tanks, a remedial program is now underway. As the direction of groundwater flow is away from Dimmock Pond, this problem is of little consequence to the pond. No residual effect of the original solvent sludge dumping incident has been detected. While one catch basin on the UniFirst property is still active and connected to the Parker St. drainage system, it serves only an employee parking area and is unlikely to be involved in any episode similar to that reported in 1981.

The removal of sediment from the vicinity of the Parker St. drainage outfall involved no more than 15 cubic meters of sediment. No record of any sediment quality tests was found in the DEQE files (Springfield Office) by BEC personnel. While the dredging conducted by UniFirst may have prevented further impact by contaminants from the UniFirst facility, it does not appear to have detectably altered any feature of Dimmock Pond.

HYDROLOGIC BUDGET

Given the watershed area of 41.8 ha (103.4 ac), and a yield coefficient of 0.7 to 1.0 cu.m/min per square kilometer (1.0 to 1.5 cfs per square mile) of drainage area (Sopper and Lull 1970, for similar watersheds), an average flow of 0.3 to 0.4 cu.m/min (just over 0.2 cfs) would be expected to pass through Dimmock Pond. Based on the average annual New England runoff value of 53.3 cm/yr (Sopper and Lull 1970, Higgins and Colonell 1971), an average flow of 0.4 cu.m/min would be expected. As not all of the watershed has a surface connection with the pond, and the soft sediment in the pond restricts groundwater flow, actual flows are likely to be somewhat lower than these estimates, but it is clear that the flow of water through Dimmock Pond is low.

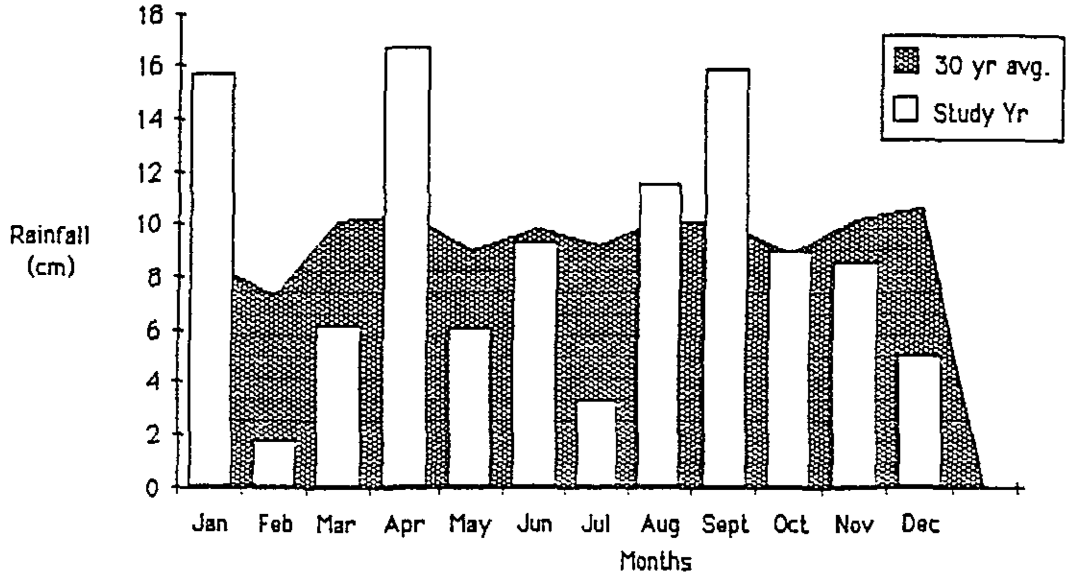
Precipitation is likely to be a major determinant of inflows and consequently influences the hydrologic budget to a great extent. Data available from the National Oceanographic and Atmospheric Administration (NOAA 1984) allows evaluation of long-term trends in the Springfield area. The long-term monthly precipitation pattern (Figure 19) indicates that precipitation is distributed relatively evenly throughout the year. The mean annual precipitation level is 114 cm, with a recorded maximum of 162.6 cm and a listed minimum of 83.8 cm.

Long-term trends frequently bear little resemblance to annual patterns, however. The total precipitation during the study year (1987 for routine monitoring purposes) was 109.2 cm, slightly below the long-term average. Three months exhibited distinctly above average precipitation and five months displayed precipitation far below average. Above and below average months were scattered throughout the year, yielding high temporal variability.

Another interesting assessment which can be made using the NOAA (1987) data base for Springfield involves the frequency of precipitation events depositing specified amounts of rain (Figure 19). Most events deposit less than 0.2 inches (0.5 cm) of rain, while successively lesser percentages of events deposit progressively greater quantities of rain. Compared to the long-term pattern, 1987 produced fewer low intensity and high intensity storms, but more events of intermediate intensity. As 24 hour events depositing less than 0.2 inches of rain rarely produce runoff, the 1987 pattern may have produced an annual runoff quantity slightly above average. The 1987 pattern of rainfall intensity is generally similar to the long-term pattern, however, suggesting that the study year was not particularly unusual.

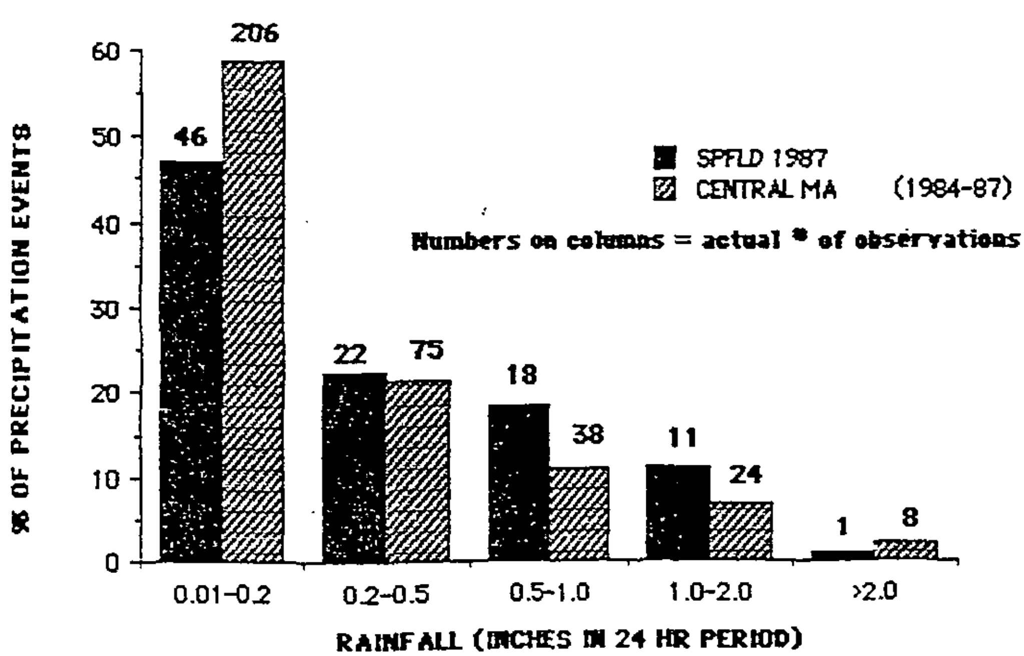
FIGURE 19

PRECIPITATION IN THE SPRINGFIELD, MASSACHUSETTS AREA



LONG-TERM MEAN = 114.0 CM (44.9 IN)
LONG-TERM MAXIMUM = 162.6 CM (64.0 IN)
LONG-TERM MINIMUM = 83.8 CM (33.0 IN)
1987 TOTAL = 109.2 CM (43.0 IN)
1987: 98 DAYS WITH PPT, 61 SEPARATE STORMS

FREQUENCY OF PRECIPITATION EVENTS



Partitioning the total inflow to and outflow from Dimmock Pond is made difficult by the low magnitude of the total throughflow and the absence of a regular water source of substantial nature. Calculations used to derive the various flow components are presented in Appendix B. The partioned flow values are summarized in Table 18 and Figure 20. Precipitation falling directly on the pond turns out to be the major source of water (52.6%) to Dimmock Pond, an atypical occurrence in New England. Stormwater runoff accounts for 27.6% of the total inflow, with the Parker St. drainage system providing 15.4% and the Ludlow Avenue drainage system contributing 12.2%. The remaining 19.8% of the inflow is attributable to groundwater.

Given the breakdown of the hydrologic budget and the information provided regarding area soils, the wetlands of the Dimmock Pond watershed have only minimal impact on the hydrology of the system. There are no substantial tributary flows to be mitigated by wetlands, and groundwater flow is restricted by soil conditions. As wetlands occupy topographic low points in this system, however, they may reduce the water load by holding drainage that might otherwise reach Dimmock Pond. This is reflected in rather low runoff coefficients for this urban watershed.

The calculated total inflow is 0.156 cu.m/min, although there is unquestionably substantial variability associated with this estimate. A range of perhaps 0.1 to 0.2 cu.m/min is appropriate for general discussion, but the variability inherent in the precipitation and stormwater components suggests an even greater possible range. Flow into Dimmock Pond is apparently quite low in an absolute sense, however.

Sources of outflow include only evaporation and groundwater recharge on a regular basis, although flooding of surrounding land is an episodic means of outflow. Evaporation accounts for 37.2% of the normal outflow, while seepage out of the pond is responsible for 62.8% of the calculated outflow. When inflow greatly exceeds the normal outflow, the water level in the pond rises. Water floods the Hubbard Park ballfields through the northeast wetland in extreme cases, but most often the groundwater outflow simply increases as the sandy shoreline is inundated. If inflow is very low, evaporation will cause the water level to decline, and groundwater outputs will decrease as the muck depths at the associated shoreline increase in thickness.

Dividing the volume of the pond by the mean inflow, a mean detention time of 0.7 years, or 256 days, is obtained. Fluctuations in actual flow result in a detention time range of 0.4 to 0.9 years, however (Table 18). This equates to a flushing rate of 1.1 to 2.5 times per year, with a mean of about 1.5

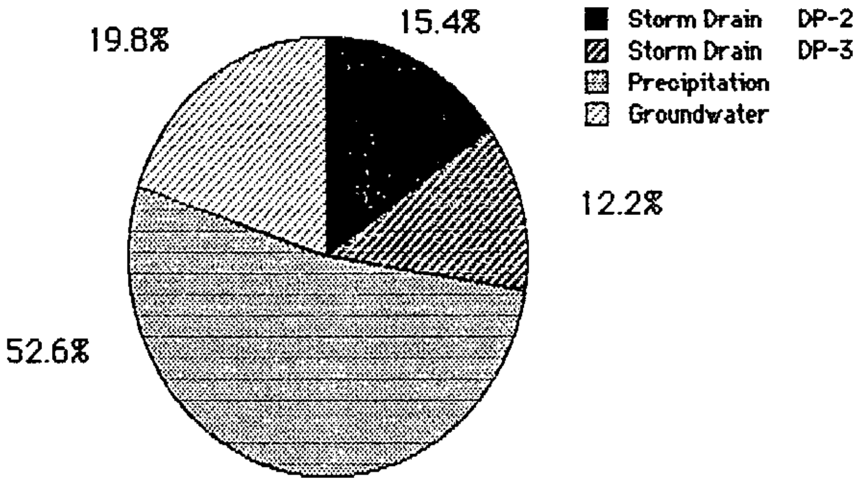
TABLE 18

HYDROLOGIC BUDGET FOR DIMMOCK POND

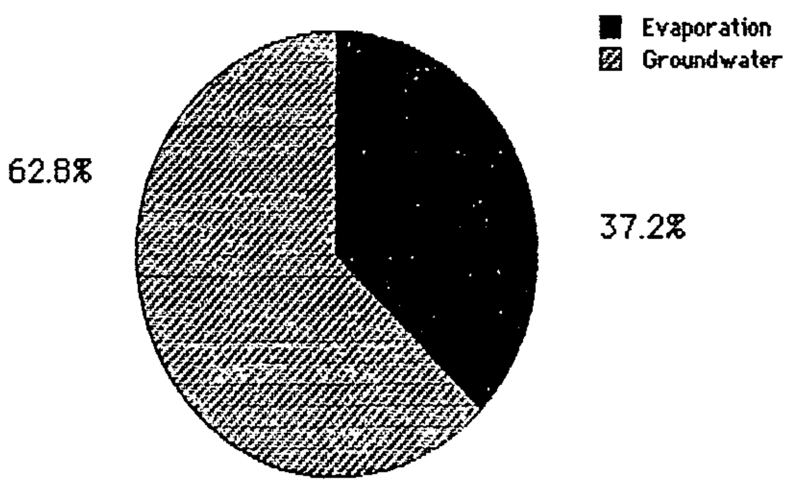
Inputs	cu.m/min	% of Total
Stormwater Runoff		
Parker St. Drain (DP-2)	0.024	15.4
Ludlow Ave. Drain (DP-3)	0.019	12.2
Precipitation (Direct Input)	0.082	52.6
Groundwater (Direct Input)	0.031	19.8
Total	0.156	100
Outputs		
Evaporation	0.058	37.2
Groundwater	0.098	62.8
Total	0.156	100
Detention Time	**Years**	**Days**
Mean	0.7	256
Annual Range	0.4 - 0.9	158 - 317
Response Time	0.2 - 0.4	73 - 146
Flushing Rate	**Per Year**	
Mean	1.5	
Annual Range	1.1 - 2.5	

FIGURE 20

Hydrologic Inputs to Dimmock Pond



Hydrologic Outputs from Dimmock Pond



flushings per year. This suggests that pollutants entering Dimmock Pond remain there for an extended period of time, interacting with the other components of the system to produce the observed conditions.

The response time, calculated according to Dillon and Rigler (1975), is between 0.2 and 0.4 years for Dimmock Pond (Table 18). The response time is an estimate of the detention time necessary for input pollutants to fully express their potential impact on the system. In the case of Dimmock Pond, the necessary response time is exceeded at all times. This means that nutrients entering the pond remain there long enough to be completely used in primary production, unless other factors (e.g., reduced bioavailability or non-nutrient limitation of primary production) intervene. Given that poor quality storm water runoff represents a substantial fraction of the water entering Dimmock Pond, water quality problems (e.g., high levels of suspended solids and turbidity) occur before this water can be flushed through the system.

Response time also aids prediction of the time frame over which post-implementation improvements become noticable. Unless major in-lake action is taken, reducing external nutrient loading will not lead to rapid improvement in the water quality of Dimmock Pond. Even then, it may be close to a year after restoration efforts are concluded before chemical equilibria are reached and the pond exhibits the desired conditions.

NUTRIENT BUDGETS

Phosphorus

Export coefficients for phosphorus can be used in conjunction with land use data to estimate the load generated in the Dimmock Pond watershed. The best of a wealth of literature values for areal phosphorus export have been summarized by Reckhow et al. (1980), and values can be selected from the range presented after evaluation of specific watershed traits such as vegetative features, soil types, and housing density. Estimation of internal loading of phosphorus is facilitated by coefficients of release given by Nurnberg (1984), who summarized another pertinent body of literature.

Chosen export coefficients and corresponding justification are presented in Table 19. The coefficients, corresponding land areas, and resultant nutrient loads are given in Table 20. Based on this analysis, 81 kg of phosphorus are generated in the watershed each year. Only a portion of this phosphorus can be expected to reach Dimmock Pond, however, given the lack of a stormwater drainage system or other surface water connection to the pond in over half of the watershed and the limited permeability of the pond bottom to groundwater flow. If the pollutant load was distributed evenly over the watershed, and 10% of the direct drainage load (associated with areas without storm drains) and 50% of the remaining areal load (associated with stormwater drainage systems) actually reached the pond, a phosphorus input of just over 23 kg/yr would be achieved.

Another model approach to quantifying inputs involves the use of empirical equations which rely on in-lake concentrations and hydrologic features of the system to estimate the load to the lake. These equations depend upon certain assumptions, however, which may not be precisely met at Dimmock Pond. Derivation of certain necessary paramenter values is subject to considerable uncertainty, but these models do provide estimates based on logic and empirical data. These estimates are often useful reference points when evaluating loading through a limited data for a variety of contributing sources.

Applying the model equations given in Table 21, and using the values presented in Table 22, the loading range given in Table 22 is obtained. Dimmock Pond functions as though it is receiving a phosphorus load of between 12.7 and 85.5 kg/yr, depending upon which model best represents processes in Dimmock Pond. The Kirchner-Dillon, Chapra, and Vollenweider models are least reliable here, as they depend upon variables for which the least precise estimates can be obtained from the available data. Eliminating these from consideration, the Jones-Bachmann and Larsen-Mercier models predict phosphorus loads of 17.5 and 18.6 kg/yr, respectively.

TABLE 19

NUTRIENT EXPORT COEFFICIENTS FOR LAND USES AND OTHER SOURCES IN THE WATERSHED OF DIMMOCK POND

NUTRIENT SOURCE	EXPORT COEFFICIENT (KG/HA/YR) NITROGEN	PHOSPHORUS	SELECTION CRITERIA
LAND USE:			
Residential	25.0	3.0	Densely populated, many storm drains
Commercial	25.0	3.0	Similar to residential areas
Railroad	5.0	.8	Low use corridor
Recreation/Park	15.0	.8	High use, but grassy and stable
Forest	2.5	.2	High use but stable vegetation
Wetland	1.5	.1	Stable soils and vegetation
OTHER SOURCES:			
Atmospheric Deposition	20.0	1.0	Urban area, substantial dryfall
Groundwater	10.0	.2	Limited inputs from human activities
Aquatic Birds	1.0	.2	A few ducks and migratory fowl
Internal Loading	0.0	25.0	Strong SOD, much resuspension of bottom sediment, but not stratified

TABLE 20

NUTRIENT LOAD GENERATION BY SOURCES IN THE WATERSHED OF DIMMOCK POND

NUTRIENT SOURCE	ASSOCIATED AREA (HECTARES)	EXPORT COEFFICIENT (KG/HA/YR) NITROGEN	PHOSPHORUS	LOAD GENERATED (KG/YR) NITROGEN	PHOSPHORUS
LAND USE:					
Residential	16.5	25.00	3.00	412	50
Commercial	1.9	25.00	3.00	48	6
Railroad	1.1	5.00	.80	6	1
Recreation/Park	6.7	15.00	.80	100	5
Forest	8.1	2.50	.20	20	2
Wetland	3.7	1.50	.10	6	0
OTHER SOURCES:		0.00	0.00	0	0
Atmospheric Deposition	3.8	20.00	1.00	76	4
Groundwater	1.0	10.00	.20	10	0
Aquatic Birds	3.0 bird-yr	1.00	.20	3	1
Internal Loading	.5 ha-yr	0.00	25.00	0	12
TOTAL				681	81

TABLE 21

EQUATIONS AND VARIABLES FOR DERIVING PHOSPHORUS LOAD ESTIMATES FROM IN-LAKE CONCENTRATIONS

Kirchner & Dillon, 1975 TP=L(1-R)/Z(F) L=TP(Z)(F)/(1-Rp)	(K-D)	TP=Total P as ug/l in spring L=P load as mg P/m^2/yr
Vollenweider, 1975 TP=L/(Z)(S+F) L=TP(Z)(S+F)	(V)	Z=mean depth as m F=flushing/yr
Chapra, 1975 TP=L(1-R)/(Z)(F) L=TP(Z)(F)/(1-R)	(C)	Pin=Flow weighted average input concentration of phosphorus Pout=Flow weighted average output concentration of phosphorus
Larsen & Mercier, 1975 TP=L(1-R_{LM})/Z(F) L=TP(Z)(F)/(1-R_{LM})	(L-M)	S=effluent TP/influent TP
Jones & Bachmann, 1976 TP=0.84 L/(Z)(0.65+F) L=TP(Z)(0.65+F)/0.84	(J-B)	qs=Areal water load=Z(F) m/yr Vs=Settling velocity=Z(S) m R=Retention coefficient (phosphorus) =(P in - P out)/P in Rp=Retention coefficient (water load) =Vs/(Vs+qs) (Vs=13.2) R_{LM}=1/1+($F^{.5}$)

TABLE 22

PHOSPHORUS LOAD TO DIMMOCK POND
BASED ON MODELS EMPLOYING IN-LAKE CONCENTRATIONS

Variable	Parameter Value
TP [ug/l]	150
Z [m]	1.2
F [yr^{-1}]	1.5
Pin [ug/l]	263
Pout [ug/l]	93
S=P out/P in	0.35
qs=Z(F) [m/yr]	1.8
Vs=Z(S) [m]	0.42
R=(P in - P out)/P in	0.65
Rp=13.2/(13.2+qs)	0.88
$R_{LM}=1/(1+F^{.5})$	0.45
Predicted Load ($g/m^2/yr$) By Each Model	
K-D	2.25
V	.33
C	.76
L-M	0.49
J-B	0.46
Predicted Load (kg/yr) By Each Model	
K-D	85.5
V	12.7
C	29.0
L-M	18.6
J-B	17.5
Vollenweider Criteria	
Critical Load	
$g/m^2/yr$	0.26
kg/yr	9.9
Permissible Load	
$g/m^2/yr$	0.13
kg/yr	4.9

Vollenweider (1968) established loading criteria based on system morphology and hydrology; a phosphorus load of less than 4.9 kg/yr would be considered permissible under this scheme, while a load in excess of 9.9 kg/yr would be deemed critical (in a detrimental sense). The apparent phosphorus load to Dimmock Pond exceeds these limits, suggesting that the process of eutrophication is proceeding rapidly and that undesirable conditions may be expected. This is a reasonable appraisal of the situation at Dimmock Pond, based on visual observations and monitoring data.

The most reliable approach to load assessment involves direct measurement, although not all inputs are amenable to this approach. A combination of direct measurements and calculations based on empirical data or export coefficients was therefore applied. Calculations essential to this approach are presented in Appendix B. Based on the simplistic notion that the phosphorus load to the pond should be equivalent to the average concentration times the volume times the annual flushing rate, a total load of 7.5 to 22.8 kg/yr is obtained.

Potential sources of phosphorus for Dimmock Pond include birds (mainly waterfowl), direct drainage (overland runoff), stormwater runoff, internal loading, groundwater inflow, and atmospheric deposition. The sum of the loads obtained for each of these sources individually provides another estimate of the total phosphorus load. The load attributable to birds is best estimated by the export coefficient approach (Tables 19 and 20), which suggests an input of 1 kg/yr. The load from overland direct drainage is likely to be very low, as only a very small portion of the Dimmock Pond watershed provides any overland flow to the pond.

Stormwater inputs of phosphorus can be estimated as the sum of the loads from assessed storm events divided by the fraction of the annual precipitation represented by those storms. The resulting load estimate is 3 to 7 kg/yr. The internal load, or recycled component, is a composite of loads contributed by sediment release of phosphorus under anoxic conditions, pumping of phosphorus from the sediments by macrophytes, and sediment resuspension and associated decay. Anoxic release accounts for almost 6 kg/yr, while macrophyte pumping is estimated to contribute just over 15 kg/yr. Loading from sediment resuspension is the most difficult to estimate, and a range of about 7 to 34 kg/yr was obtained. Given the high iron and humic acid content of the water in the pond and well oxygenated conditions above the 1 to 2 m depth mark, only a portion of this load is likely to actually become available. Assuming that somewhere between 10 and 25% of the internal load actually becomes available in the water column, a total internal load of 3 to 10 kg/yr is estimated.

The contribution of groundwater to the phosphorus load is estimated as the volume of inflow times the average phosphorus concentration. Assuming that interactions at the sediment-water interface keep this load at the low end of its range, a load of between 2 and 4 kg/yr is postulated. The groundwater load actually constitutes an additional component of internal loading, as the quality of incoming groundwater is a function of its interaction with the pond sediments. The load of phosphorus added by precipitation is calculated as the annual volume of direct precipitation times an assumed concentration of 50 ug/l, believed to represent the upper limit of likely rainfall phosphorus concentration. Assuming that dryfall contributes as much phosphorus as precipitation, a loading range of 3 to 5 kg/yr is obtained.

A summary of individual loading estimates is presented in Table 23, while the partitioning of the estimated total load among contributing sources is given in both Table 23 and Figure 21. The resulting total phosphorus load is 12 to 27 kg/yr, consistent with load estimates obtained by other means. While the range of the estimate is large in relation to the actual values obtained (over a twofold difference between upper and lower limits), the actual quantity of phosphorus represented by the range is quite low. Variability is likely to be high when dealing with such numbers. Unfortunately, these numbers are not low relative to the permissable and critical levels set (Table 22), and suggest excessive fertilization of Dimmock Pond.

The approximate partitioning of this load among potential sources suggests that internal loading is the largest contributing source of phosphorus for Dimmock Pond. Considering the large nutrient reserves stored in the bottom muck and the multiple mechanisms by which phosphorus can be recycled in this system, this is not especially surprising. Internal loading is not appreciably greater than that from stormwater, groundwater, or atmospheric deposition, however. Each of these other sources represents a substantial portion of the estimated phosphorus load. It will be necessary to reduce or eliminate the phosphorus contribution from more than one source if the condition of Dimmock Pond is to be markedly improved.

Nitrogen

Derivation of a nitrogen budget was approached in the same manner as was the phosphorus budget. Export coefficients and resulting loads are given in Tables 19 and 20. No model equations were applied to estimate the nitrogen load, as suitable equations have not been derived. A breakdown of the total nitrogen load by individual source is presented in Table 23 and shown in Figure 21. Calculation of individual loading components is presented in Appendix B.

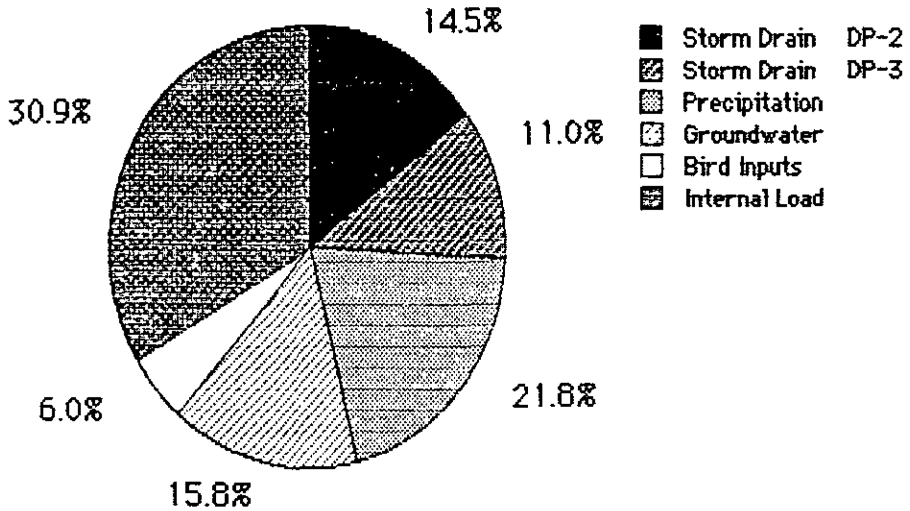
TABLE 23

NUTRIENT LOADS TO DIMMOCK POND BASED ON EMPIRICAL DATA AND SELECTED EXPORT COEFFICIENTS

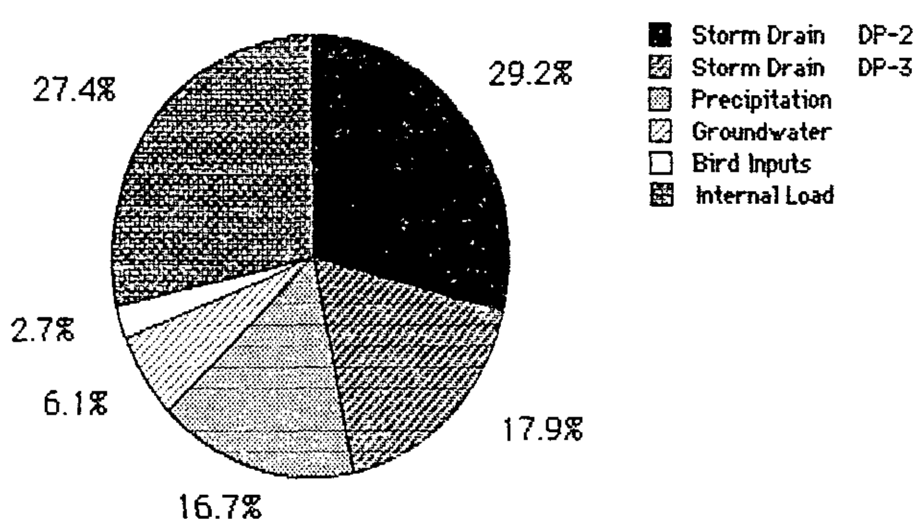
Source	Total Phosphorus kg/yr	Total Phosphorus % of total	Total Nitrogen kg/yr	Total Nitrogen % of total
Stormwater				
Parker St. Drain (DP-2)	1.7-4.0	14.2-14.8	24.8-46.5	28.5-29.9
Ludlow Ave. Drain (DP-3)	1.3-3.0	10.8-11.1	15.2-28.5	17.5-18.3
Precipitation (Direct Input)	3-5	18.5-25.0	15-25	15.3-18.1
Groundwater (Direct Input)	2-4	14.8-16.7	5-10	6.0-6.1
Bird Inputs (Direct Input)	1	3.7-8.3	3	1.8-3.6
Internal Load (Anoxic release, Macrophyte pumping, Sediment resuspension)	3-10	25.0-37.0	20-50	24.1-30.7
Total	12-27	100	83-163	100

FIGURE 21

Phosphorus Inputs to Dimmock Pond



Nitrogen Inputs to Dimmock Pond



Nitrogen export coefficients suggest that 681 kg of nitrogen are generated within the Dimmock Pond watershed each year. Assuming the same delivery scenario as postulated for phosphorus, slightly less than 200 kg of nitrogen would enter the pond each year. Based on the average concentration times the water load, a load of between 70 and 182 kg/yr is derived. Based on the summation of individually calculated loads from specific sources, a total nitrogen load of 83 to 163 kg/yr is obtained. Stormwater is the single largest contributor, while internal recycling and atmospheric deposition are both substantial but lesser contributors. The other itemized sources are relatively minor.

There is considerable interconversion of nitrogen forms in Dimmock Pond on a nearly continual basis. Much of the nitrogen supply in the bottom muck or incoming stormwater may remain unavailable in organic form, but there is an actively cycling pool of nitrogen which is released from organic matter through aerobic or anaerobic decay, most often as ammonia nitrogen. Ammonia is rapidly converted to nitrate in the presence of oxygen in this system, with ammonia accumulation in the anoxic zone minimized by mixing action and diffusion in this minimally stratified, shallow pond. Nitrate is in turn converted back into organic matter; some of the ammonia may be converted directly back into organic matter as well.

A Note on Uncertainty

In a system such as Dimmock Pond, precise levels of nutrient loading are difficult to quantify at the level of resolution afforded by such a study as this. The sporadic nature of many inputs and recycling within the pond introduce considerable potential for error, and one must be careful not to rely too heavily on any one number or equation. An error of just a few kilograms in a phosphorus budget as small as that of Dimmock Pond is substantial, necessitating the use of ranges which seem rather wide. A sincere effort has been made in this report to temper evaluations with knowledge gained from other studies and with intuition gained from experience. The different approaches employed in constructing the hydrologic and nutrient budgets have produced results which are in general agreement, and the partitioning of loads among sources is logical, albeit somewhat speculative.

It is clear that Dimmock Pond is overfertilized, and that the two key sources are stormwater and internal recycling. Stormwater may not be the greatest source of nutrients in an annual budget, but it supples much of the load which is recycled over time. Measures intended to produce major reductions in the pollutant loads from these sources are expected to lead to discernible improvement of water quality, despite uncertainty regarding the exact loading levels.

DIAGNOSTIC SUMMARY

Dimmock Pond is a small water body in a small but urban watershed which has 47% of its area drained directly to the pond through two stormwater drainage systems. This shallow pond is characterized by high concentrations of nutrients and suspended solids, and by low transparency and anoxia at the sediment-water interface. The thick layer of fine organic particulates at the bottom of Dimmock Pond is subject to easy sediment resuspension by wind action, resulting in persistent turbidity. Phytoplankton densities are lower than would be expected from nutrient levels, apparently as a consequence of light limitation. Peripheral growths of macrophytes are dense enough to create nuisance conditions.

Once a popular site for swimming, boating, fishing and other water-based activities, Dimmock Pond has experienced diminished recreational utility as a consequence of water quality deterioration. Although the pond is still a focal point within Hubbard Park, its real present use is limited to shoreline fishing and more passive activities such as walking around the shoreline trail. Although it has great potential as a park resource, the pond is aesthetically unappealing most of the year and requires a major overhaul to restore the desired level of recreational utility. Pollutant loading from several sources, most notably stormwater and internal recycling, must be sharply curtailed if the pond condition is to be suitably improved.

MANAGEMENT RECOMMENDATIONS

To improve Dimmock Pond to a condition appropriate to its desired uses and status as a recreational focal point of Hubbard Park, it will be necessary to reduce or eliminate loadings of all pollutants, but especially inputs of phosphorus, nitrogen and suspended solids. As direct precipitation and birds are largely unmanageable sources, the necessary reductions will have to center on stormwater inputs, internal recycling, and groundwater contributions. Groundwater contributions and internal recycling appear to be tightly linked in this system, as the quality of groundwater appears to be determined during passage through the sediments lining the pond. Phosphorus and nitrogen load reductions of approximately 50 to 75% and nearly complete elimination of sediment resuspension will be necessary to produce the appropriate change in water quality. If the inputs from the target sources can be reduced by 70 to 95%, the desired conditions should be achieved. It is therefore recommended that actions be taken to minimize the loading of pollutants from stormwater, groundwater, and internal recycling.

PART II

FEASIBILITY ASSESSMENT

EVALUATION OF MANAGEMENT OPTIONS

Management Objectives

The establishment of management objectives is critical to the evaluation of management options and necessary to the development of priorities for restoration activities. Through meetings with City officials and the Indian Orchard Association, it was determined that non-motorized boating, fishing, and aesthetic enjoyment are the desired uses of the pond. While swimming might be possible, the City has no plans to establish a swimming area at Dimmock Pond. Usable trails featuring pond vistas and connecting the different parts of the park are desired, facilitating walking, running and cross-country skiing. Access and parking off of Parker St. and Ludlow Ave. are also desired.

There is no official park master plan at this time, as has been produced for Forest Park across the City. Past management actions have centered on the recreational facilities in Hubbard Park, such as the ballfields, tennis courts, basketball facilities, and playground. With the acquisition of the wooded area east of the park and the potential for a major restoration program involving Dimmock Pond, the time is right for the City to think in terms of overall park planning. The elements for a truly great park surround Dimmock Pond, but need to be refined, improved, and tied together in a manner that will promote their use without undue degradation.

Available Techniques

The number of actual techniques available for lake and watershed management is not overwhelming (Table 24). The combination of these techniques and level of their application, however, result in a great number of possible management approaches. Since each lake is to some extent a unique system, a restoration and management program must be tailored to a specific waterbody. Techniques are essentially taken "off the rack" and altered to suit the individual circumstances of a specific lake ecosystem.

Review of the management options in light of the characteristics and problems of Dimmock Pond and its watershed allows elimination of certain alternatives from further consideration. Water level control cannot be practiced at Dimmock Pond without further exacerbating the fluctuations now experienced, and would provide little benefit. Although anoxia occurs near the bottom of the pond, there is no true hypolimnion which can be destratified or from which water could be withdrawn. There is no appropriate source of water for dilution and flushing, and no suitable outflow path for excess water.

TABLE 24

LAKE RESTORATION AND MANAGEMENT OPTIONS

Technique	Descriptive Notes
A. In-Lake Level	Actions performed within a water body.
1. Dredging	Removal of sediments under wet or dry conditions.
2. Macrophyte Harvesting	Removal of plants by mechanical means.
3. Biocidal Chemical Treatment And Dyes	Addition of inhibitory substances intended to eliminate target species.
4. Water Level Control	Flooding or drying of target areas to aid or eliminate target species.
5. Hypolimnetic Aeration Or Destratification	Mechanical maintenance of oxygen level and prevention of stagnation.
6. Hypolimnetic Withdrawal	Removal of oxygen poor, nutrient rich bottom waters.
7. Bottom Sealing/Sediment Treatment	Physical or chemical obstruction of plant growth, nutrient exchange, and/o oxygen uptake at the sediment-water interface.
8. Nutrient Inactivation	Chemical comlexing and precipitation of undesirable dissolved substances.
9. Dilution And Flushing	Increased flow to minimize retention o undesirable materials.
10. Biomanipulation/Habitat Management	Facilitation of biological interaction to alter ecosystem processes.
B. Watershed Level	Approaches applied to the drainage are of a water body.
1. Zoning/Land Use Planning	Management of land to minimize deleterious impacts on water.
2. Stormwater/Wastewater Diversion	Routing of pollutant flows away from a target water body.
3. Detention Basin Use And Maintenance	Lengthening of time of travel for pollutant flows and facilitation of natural purification processes.

TABLE 24 CONT.

4. Provision Of Sanitary Sewers	Community level collection and treatment of wastewater to remove pollutants.
5. Maintenance And Upgrade Of On-Site Disposal Systems	Proper operation of localized systems and maximal treatment of wastewater to remove pollutants.
6. Agricultural Best Management Practices	Application of techniques in forestry, animal, and crop science intended to minimize impacts.
7. Bank And Slope Stabilization	Erosion control to reduce inputs of sediment and related substances.
8. Increased Street Sweeping	Frequent removal of potential runoff pollutants from roads.
9. Behavioral Modifications	Actions by individuals.
a. Use Of Non-Phosphate Detergents.	Elimination of a major wastewater phosphorus source.
b. Eliminate Garbage Grinders	Reduce load to treatment system.
c. Minimize Lawn Fertilization	Reduce potential for nutrient loading to a water body.
d. Restrict Motorboat Activity	Reduce wave action, vertical mixing, and sediment resuspension.
e. Eliminate Illegal Dumping	Reduce organic pollution, sediment loads and potentially toxic inputs to a water body.

With the acquisition of the woodland east of the pond, there is virtually no developable land in the watershed upon which zoning or land use planning could act. While establishment and enforcement of City ordinances intended to minimize pollutant build-up in the watershed would be beneficial, the desired level of control is unlikely to be achieved in this manner. All but four lots in the watershed are tied into the sanitary sewer system, and those four lots have new wastewater disposal systems. There is no agricultural land remaining in the watershed.

Not all of the applicable management techniques are appropriate for Dimmock Pond, either. Macrophyte harvesting will not alter nutrient levels and may actually increase the quantity of suspended solids in the pond. Biocidal chemicals would be ineffective at controlling turbidity as well, would add to the already intolerable sediment oxygen demand, and present risks which make their use ecologically unsound. Current pond conditions, especially acidity, do not favor successful phosphorus inactivation by chemicals, and this technique would do little to solve the suspended solids problem in the long run. Inactivation of nutrients in the water column might be attempted, however, if remedial actions aimed at the sources of the nutrients alter the pond chemistry but yield an insufficient reduction of phosphorus.

Chemical treatment of bottom sediments for nutrient inactivation or oxidation is applicable, but could have deleterious side effects in this system and is unlikely to provide lasting benefit. Dyes could provide lasting (circa 0.5 yr/treatment) control of phytoplankton and some macrophytes, and could make the color of the water more pleasant, but could increase the extent of anoxia by warming the upper portion of the water column. Dyes are unlikely to completely mask the unsightly condition of the pond.

The letter report filed after the DFW-DWPC electroshocking expedition to Dimmock Pond indicated that large carp were observed and that these fish could be adding to pond turbidity by spitting muck into the water column while in search of food. Removal of bottom dwelling fish such as carp, suckers, and bullheads might help reduce turbidity under current conditions, but no detectable change in water clarity would be expected as a result. Wind-induced turbidity or additional algal biomass would mask any reduction of suspended solids loading achieved in this manner. As algae are not the only determinant of turbidity in this pond, promotion of grazing by zooplankton is unlikely to yield any noticable effect. Biomanipulation and habitat management would be more useful after a major restoration program has been carried out.

The techniques which will be most appropriate for the long-term management of the Dimmock Pond system are those which deal directly with stormwater and the layer of soft organic sediment in the pond. Management techniques remaining for consideration therefore include:

- Dredging
- Bottom Sealing
- Bank and slope stabilization
- Behavioral modifications for the reduction of pollutant accumulation in the watershed
- Increased street sweeping
- Stormwater diversion
- Detention basin use

Evaluation of Viable Alternatives

Dredging and bottom sealing are essentially competing techniques in this case, both aimed at altering the bottom properties of the pond and limiting sediment resuspension and macrophyte growths. The only bottom barrier appropriate for Dimmock Pond is a landfill liner such as Hypalon, manufactured by DuPont. At approximately $100,000/ha installed (modified from Cooke et al. 1986), it would cost close to $400,000 to cover the bottom of Dimmock Pond.

Sediment sequestering would not be complete if the recommended holes were punched in the bottom cover to allow gas exchange, but gas build-up could cause the cover to billow up if the holes were absent. Groundwater flow would be inhibited by the cover, impairing one mechanism for water level equilibration in the pond. If the shoreline were left uncovered, limited dredging and erosion control measures would be necessary near the pond edge. Macrophyte growths would be almost entirely eliminated, which is not considered to be an ecologically sound approach to habitat management, particularly where fishing is a desired pond use. If economically feasible, dredging would provide greater benefits and fewer adverse effects (if properly performed).

Dredging would remove the soft sediment from the pond, eliminating a major source of turbidity and nutrients. The average depth and volume of the pond would be approximately doubled, and macrophyte growths would be appreciably altered. Recolonization of a greater portion of the pond bottom at lower densities would be expected, producing an aesthetic and ecologically useful macrophyte community. Dredged material must be disposed in a suitable location, which may pose some difficulty in light of the chemical and physical features of the sediment, and the process is expensive. If the material can be properly disposed in an upland setting, which is a matter for engineering design and the permit process to decide, the lower ballfields at Hubbard Park could use the fill to prevent future flooding.

Dredging can be carried out under wet or dry conditions, by conventional excavating equipment, pontoon-mounted machinery, or by a hydraulic dredge which pumps a liquid-solid slurry to a dewatering area. Although it would be relatively easy to pump water out of Dimmock Pond and maintain a drawdown, the thick layer of bottom muck will not dewater sufficiently to allow conventional equipment to enter the pond or transport the sediment to a containment area or disposal site. The anticipated steep final slopes and small area of the pond preclude construction of an appropriate ramp system without substantial filling of the pond, increasing the cost and defeating the purpose of the project. Pontoon-mounted equipment will have similar difficulties picking up and manipulating the soft, watery sediment. Hydraulic dredging is therefore the dredging method of choice here, based strictly on technical considerations.

Hydraulic dredging involves cutting overlapping trenches through the soft sediment with an augur backed by a pumping system which transports the resultant slurry to a bermed containment area where the solids are allowed to settle. Treatment of the supernatant with flocculating polymers results in the return of clear water to the pond. The dewatered sediment can be left in place or moved to an ultimate disposal site with conventional earth-moving equipment.

The low rate of water inflow to Dimmock Pond will necessitate frequent recycling of water between the pond and the containment area, if dredging is to be continuous. Enough water must remain in the pond to float the barge-mounted dredge. Chemical treatment needs may increase somewhat as a consequence of the high rate of recycling.

The containment area at Dimmock Pond could be placed on the high ballfield nearest the pond, or on the lower fields further away. Use of the high field creates less interference with park users, minimizes pumping distance, allows gravity feed return of the supernatant to the pond, and will probably provide better drying conditions for the dredged material. Dried material will have to be moved from this site at least once, however, as its capacity is limited. As ultimate disposal is expected to be on the lower ballfields, there is some benefit to placing the containment area there to begin with. While ultimate disposal costs would be reduced, a booster pump may be required to reach this site, some pumping of the return flow to the pond is likely to be necessary, and dewatering of the dredged material may be inhibited in this low-lying area.

Given the engineering and permit restrictions under which the dredging operation would be conducted, a cost of around $12/cy is envisioned. This suggests a total sediment removal cost of slightly more than a million dollars (for 66,500 cy or 87,500 cu.m). This would include design and supervision services, construction of the containment area, actual dredging, and ultimate disposal of the dredged material on the lower ballfields in Hubbard Park.

As dredging is the only viable method by which the influence of the soft sediment in Dimmock Pond can be adequately controlled, the restoration of Dimmock Pond will be a costly endeavor. Given the importance of the park to the community of Indian Orchard and the great potential of the pond as an amenity to the park, the cost of the restoration is justified and desired by the community as a whole. Residents and City officials should understand the magnitude of this undertaking, however, and be prepared for the effort which will be necessary to bring it to fruition.

Bank and slope stabilization go hand in hand with a properly performed dredging program, as the benefits provided by dredging can be maximized by minimizing future sediment inputs. As erosion around the eastern and southern shoreline sections of Dimmock Pond is substantial (Figure 5), these areas must be stabilized. If other access points are to be opened, these areas should be treated to minimize subsequent erosion. Vegetation with dense root masses hold sediment well, but intense foot traffic tends to leave access areas devoid of such vegetation, and packs the soil such that colonization is minimal. It is therefore necessary to engineer access points for minimal erosion, and to repair areas currently subject to excessive sediment loss.

There are two main approaches to erosion control at access areas. One involves installing pavement, riprap, or other minimally permeable but very durable materials, while the other utilizes subsurface modifications to help hold soil in place and reduce packing. Filter fabric, enkamat, or other permeable, woven materials are most often used in the latter approach, which is preferred by City officials and Indian Orchard residents. Maintenance of vegetation on slopes stabilized in this manner is to be encouraged, usually involving grasses or related ground cover species. The erosion areas currently in question are approximately 165 sq.m (#1, Figure 5), 210 sq.m (#2), and 285 sq.m (#3). At approximately #30/sq. m, $20,000 would cover the necessary repair and stabilization of currently impacted access areas at Dimmock Pond.

The presence of a sanitary sewer system negates the benefits of eliminating the use of non-phosphate detergents and garbage grinders, and the prohibition of motorized craft on Dimmock Pond controls another potential negative influence on the pond. Yet behavioral modifications by watershed residents can appreciably reduce the loading of pollutants to the stormwater drainage system. Lawn fertilization, car washing, piling leaves in the street, and the disposal of various materials in catch basins all contribute to the degradation of Dimmock Pond. While elimination of these practices would not restore the pond to an acceptable condition, control of these activities is highly desirable from the viewpoint of long-term maintenance of the pond once it is restored.

While City ordinances prohibiting potentially deleterious actions could be passed and may be necessary, it would be more appropriate and potentially more successful to proceed through an education program designed to inform residents of their role in determining the quality of water in Dimmock Pond. At least some of the aforementioned activities can be modified to minimize water quality impacts without their complete elimination. As it is difficult to gather a majority of residents for a meeting or workshop, the distribution of an educational brochure is suggested for gaining cooperation in a watershed management program.

Increased street sweeping represents an attempt to remove accumulated street pollutants before they can combine with precipitation to become the poor quality runoff common to urban areas. Combined with behavioral modifications intended to reduce the accumulation rate for street pollutants, frequent street sweeping has the potential to substantially reduce the concentrations of certain pollutants in stormwater runoff. The suspended solids load could certainly be reduced in this manner, but the association of most of the phosphorus and nitrogen with very small particles negates the effectiveness of conventional (brush) street sweeping in controlling nutrient loads; these sweepers have a very low removal efficiency for small particles (Sartor and Boyd 1972).

Vacuum sweepers could provide greater removal efficiency, but the City would have to purchase at least one vacuum sweeper at a cost of around $250,000. While funding might be obtained for such a purchase, operation and maintenance costs would have to be paid by the City, and the sweeper would have to be in operation within the Dimmock Pond watershed several days per week to ensure proper pollutant removal. Regular parking on the street would have to be prohibited, and other logistic difficulties are likely to be encountered. Sweeping will not affect loading caused by accidental spills or illegal disposal of materials into catch basins, and would also be ineffective in controlling nutrient-rich runoff from fertilized lawns or unswept private surfaces.

In addition to removal of pollutants from the street, periodic cleaning of catch basins would be needed to prevent pollutants from combining with runoff. This aspect of watershed management also presents serious logistic problems, as many of the catch basins in the Dimmock Pond watershed are partially paved over, limiting access for cleaning equipment. Catch basin cleaning with vacuum equipment would be desirable, necessitating a capital expense of about $150,000. At a minimum, operation and maintenance expenses would have to be paid by the City.

Even in the absence of a high frequency street sweeping program, maintenance of the existing catch basins could provide a substantial reduction in suspended solids loading, as some settling time would be provided in the sump associated with each basin. As the sumps are now all virtually full, the catch basins are functionally drop inlets, providing no treatment of incoming runoff before it is passed into the drainage pipe system. Even conventional catch basin cleaning would represent an improvement over existing conditions. Size fractionation of the nitrogen and phosphorus loads, however, indicates that most of the load of each of these pollutants is associated with very small particles which would settle out very slowly in the sumps or would be easily resuspended during each storm. While maintenance of existing catch basins will provide desirable pollutant reduction, it will not provide the level of reduction necessary to achieve runoff quality goals.

Stormwater diversion was given careful consideration as a management option, since it could almost completely eliminate runoff-related pollutant inputs to the pond. The loss of approximately 28% of the water load to the pond is undesirable, although the commensurate reduction in phosphorus and even greater decline in nitrogen loading are essential to the restoration program. This represents a difficult trade-off, but one that probably would have been made if technically feasible. Yet it is not feasible as a consequence of the minimal elevational gradient between existing drainage systems and available discharge areas. Routing the drains to the wetland east of Dimmock Pond, the most advantageous location, would result in slopes of less than 0.1%. Pipeline siltation, clogging, and surcharge would ensue.

Other discharge locations suffer from either similar elevational gradient shortages or high probability of significantly adverse impact. The wetland northeast of the pond is not entirely public property and has insufficient capacity to prevent neighborhood flooding. Routing of the Parker St. drainage system to Loon Pond is possible, but would represent interference with another Clean Lakes Program project. In short, the runoff in the Parker St. and Ludlow Ave. drainage basins was apparently routed to Dimmock Pond because there was no other place to send it.

Another form of diversion is possible, however. The permeability of the soils in the Parker St. and Ludlow Ave. drainage basins is sufficient to allow substantial percolation of runoff held in leaching catch basins. Silt or clay layers in some areas may interfere, but most basins could be converted for successful leaching. The greatest drawback of this approach is the need to maintain the basins to avoid clogging; solids will fill the basin just as they do now. The City of Springfield has historically discouraged the use of leaching basins, but recognizes the potential benefits and will approve their use if an appropriate alternative cannot be found.

Existing catch basins can be retrofitted to facilitate leaching, at a total cost of between $5,000 and $6,000 per basin. If a leaching basin becomes clogged, or the rate of inflow exceeds the percolation rate, the basin will overflow into the stormwater drainage system just as it does now at lower inflows. Overflow from properly maintained leaching basins in sandy soils is negligible, but some overflow should be expected and contingency treatment plans made, if leaching basin are installed. Some form of detention prior to entry into the pond would be desirable.

The use of detention basins has become almost standard in conjunction with residential/commercial development in the eastern USA, with specific runoff controls and treatment schemes mandated in some areas. The most effective detention facility, the wet pond, contains a permanent pool of water, thereby harboring the aquatic life forms which accelerate nutrient removal when runoff is added. A wet pond can provide removal of 80% of the phosphorus and 60% of the nitrogen dissolved in the incoming runoff (Schueler 1987). Combined with the removal of particulate loads by settling, total phosphorus removal rates in the range of 70 to 90% are possible.

Given that the stormwater outfalls cannot be relocated away from the pond, any detention facilities will have to be created in the present area of each outfall. Appropriate areas are available, however, as each outfall is located in a wetland arm of Dimmock Pond. These wetland arms were at one time part of the open water portion of the pond, based on aerial photos from as recently as the late 1970's, but have become emergent or even shrub wetlands in response to sedimentation and fluctuating water levels. A small berm could be placed across the mouth of each of the two wetland arms, effectively creating detention areas for runoff discharged from the stormwater drainage systems. Excavation of some portion of the soft sediment in each of these areas would increase capacity and provide a standing pool of water, thus forming wet pond detention facilities.

Care must be taken to prevent more frequent flooding of surrounding uplands, most notably the Hubbard Park ballfields, which receive water overflowing from the northeastern wetland arm during rare periods of extremely high water level in the pond. The permanently wet portion of each detention area must be created by excavation below the pond level, not by maintenance of an artificially elevated water level within detention areas. The elevation of the top of the berm forming each detention area should not be higher than the maximum water level desired for Dimmock Pond.

The creation of wet pond detention areas would be greatly facilitated by the dredging program described above. After the soft sediment is removed from the pond and wetland arms, gabion weirs could be placed between the outfalls and the main body of the pond, creating the desired detention areas. Some peripheral grubbing, clearing, and grading will be necessary, and the outfalls from the stormwater drainage systems should be repaired/altered to reduce debris accumulation and turbulence at the point of entry to each detention area.

The available detention capacity of the western area (serving the Parker St. drainage area) is approximately 700 cu.m, while the capacity of the northeastern area (serving the Ludlow Ave. drainage area) is around 1,900 cu.m, with a storage depth of 0.46 m (1.5 ft) in each area. The invert elevations of the outfalls preclude greater storage depths. The available volume in each area appears insufficient to completely detain the runoff from storms approaching a frequency of once every two years (4,500 cu.m from the west, 2,300 cu.m from the northeast), but smaller, higher frequency events which contribute most of the pollutant load could be completely detained in the northeastern area.

With an established permanent pool and recolonization by wetland vegetation, the northeast detention area could provide sufficient treatment for runoff emanating from the Ludlow Ave. drainage basin. The western detention area will provide some measure of stormwater treatment for the Parker St. drainage basin, but additional stormwater management will be needed. The use of leaching basins in conjunction with construction of the small detention facility is advisable.

The desired pollutant load reductions can be achieved through a combination of the techniques described above, but there is always some degree of uncertainty and variability associated with a major overhaul of a lake system. If non-algal suspended solids and related turbidity are reduced substantially without a commensurate decrease in phosphorus loading, water clarity may not increase to the desired level as a consequence of greater biomass production by phytoplankton.

Currently, there appears to be a light limitation on algal growths, as well as other potentially limiting factors (e.g., pH and turbulence), but nutrients are not in short supply. An increase in acid-tolerant, motile phytoplankton (e.g., dinoflagellates and cryptomonads) is likely if non-algal turbidity is reduced without introducing a phosphorus limitation or altering the pH. As both phosphorus and turbidity reductions are achievable, any such effect is likely to be temporary.

If elevated phytoplankton biomass persists, chemical inactivation of phosphorus with alum or a similar substance could be performed. Care must be taken with such additions, however, to avoid raising the level of metals toxic to fish (e.g., aluminum). This is largely a function of pH, which is not favorable for such treatments at this time. As the post-implementation pH is not readily predictable, and management is intended to reduce both turbidity and phosphorus, no reliable assessment of the need for chemical inactivation of phosphorus or its likely impacts can be offered at this time.

While the current chemistry of the pond does not favor phosphorus inactivation by alum, the post-dredging chemistry of Dimmock Pond is likely to be quite different. The long detention time for water in the pond suggests the potential for more than a transient benefit. This technique should be kept in reserve, however, until sufficient monitoring data has been collected to evaluate the success of the recommended management plan and the potential for successful phosphorus inactivation.

While manipulation of the fishery will provide only nominal water quality benefits, effort should be put into improving the fishery of the pond. While some improvement should occur naturally after the restoration project as a result of habitat alteration, fishery improvement could be greatly accelerated by selectively removing fish to adjust size distributions and predator-prey ratios. This could best be accomplished by drawing down the water level of Dimmock Pond to allow netting and selective removal.

A drawdown could be easily accomplished as part of the dredging program, since the pumping rate of the dredge exceeds the average inflow to the pond. The return flow from the containment area could be routed to the wetland east of Dimmock Pond. Replacement water for the pond could be later supplied from fire hydrants as a one-time supplement to natural inflows. This would allow removal of any undesirable species or individuals, and would allow thinning of the overabundant bluegill sunfish population. A more accurate assessment of gamefish populations could also be performed.

Addition of return flow from the containment area to the wetland east of the pond would raise the water level in that wetland appreciably, albeit temporarily. Some difficulty with this approach may be encountered in the permit process, as impacts on sensitive species and overall habitat value must be considered. Yet this wetland has been naturally inundated multiple times in the recent past (1978 and 1984 events recorded in photos) without apparent adverse impacts.

Drawdown and refilling of the pond near the end of the dredging program would serve two other useful purposes; the condition of the pond bottom could be visually examined and the clean refill water could be added to the pond. Visual inspection of the pond bottom would be helpful in formulating any final adjustments in the dredging program. As continual recycling of water between the pond and containment area may result in an undesirable post-dredging water chemistry, the addition of water low in nutrients, turbidity and acidity could accelerate the recovery of the pond.

RECOMMENDED MANAGEMENT APPROACH

After consideration of pond and watershed characteristics and the available options for improving the existing conditions, the following actions are recommended for the management of Dimmock Pond:

1. Hydraulically dredge the pond to remove all accumulated organic soft sediments.

2. Repair erosion areas along the Dimmock Pond shoreline and stabilize the soil at shoreline access points.

3. Create detention basins in the western and northeastern arms of the pond to hold and purify incoming stormwater runoff from the Parker St. and Ludlow Ave. drainage areas.

4. Alter all catch basins in the Parker St. stormwater collection system to allow leaching of runoff into the surrounding soil.

5. Prepare an educational brochure informing watershed residents of their role in determining the water quality of Dimmock Pond and describing ways in which residents can minimize pollutant loading.

6. Monitor stormwater and pond condition during implementation of management actions and for at least three years after project completion, to assess improvements and facilitate informed future management decisions.

IMPACT OF RECOMMENDED MANAGEMENT ACTIONS

The recommended management program will result in substantial changes in the quality of water entering Dimmock Pond (Table 25). Phosphorus loading should decline by 48 to 77%, while nitrogen loading is expected to decrease by 55 to 80%. Water clarity should rise markedly, with the average secchi disk transparency increasing approximately twofold. The variability in these estimates of change are a function of uncertainty associated with multiple and possibly overlapping pollutant removal processes. The result of these changes should be a much more appealing pond appearance, making walks around the pond far more visually rewarding.

Macrophyte density will approach zero immediately after dredging, but recolonization at lower densities, probably over a greater portion of the pond area, will result in a long-term decrease of 70 to 80%. The change in distribution is as important as the change in density, providing improved habitat for most forms of aquatic life. Shoreline fishing will be noticably enhanced, as will the launching and landing of boats.

The oxygen level at the surface of the pond will not change appreciably, but the dissolved oxygen concentration near the bottom will increase tremendously when the sediment oxygen demand is removed through dredging. An eventual build-up of SOD is to be expected in any pond, but deep water oxygen levels should be quite high for decades to come. This will result in greatly expanded habitat for fish, which in turn should improve the fishery. Benthic invertebrate colonization of newly exposed and largely inorganic sediment should be rapid, providing an additional food base for fish.

The use of leaching basins will reduce the flow of runoff to the pond by up to 15%, and there may be slight additional losses of water inputs related to evaporation in detention basins and altered residential practices. Along with the increase in depth fostered by dredging, this will yield more than a doubling of detention time. As the current detention time is already greater than the response time (Table 18), this will not have any negative consequences. If the water in the pond has the postulated post-restoration nutrient chemistry, the increased detention time will be beneficial, allowing natural processes to control water quality and maintain desirable conditions.

The leaching basins are employed to reduce the magnitude of the phosphorus load and to minimize pulsed inputs, which are likely to be more ecologically deleterious than the same load spread evenly over time. Although there is some sacrifice in water load to Dimmock Pond, having less nutrient-rich water present for a longer period of time is appealing.

TABLE 25

ANTICIPATED CHANGES IN DIMMOCK POND
TO RESULT FROM THE PROPOSED MANAGEMENT PROGRAM

Management Plan Element	% Change in Selected Parameters: TP-Load	TN-Load	Water Clarity	Macrophyte Density
Installation of Leaching Basins (Parker Drainage)	-10 to -15	-20 to -30	+10 to +20	0
Detention Areas Created at Storm Drain Outfalls	-8 to -12	-15 to -20	+10 to +25	0
Dredging of Dimmock Pond	-30 to -45	-20 to -30	+65 to +75	-70 to -80
Education	0 to -5	0 to -5	0 to +5	0
Total	-48 to -77	-55 to -85	+85 to +120	-70 to -80

Management Plan Element	*Oxygen Level* *	*Water Load*	Detention Time	*Depth*
Installation of Leaching Basins (Parker Drainage)	+?	-10 to -15	+10 to +15	0
Detention Areas Created at Storm Drain Outfalls	+?	0 to -5	0 to +5	0
Dredging of Dimmock Pond	+10 to +90 **	0	+130	+130
Education	0 to +5	0 to -5	0 to +5	0
Total	>10 to >95	-10 to -25	+140 to +155	+130

* Measured as percentage of saturation level.
** Increase will be lowest at the surface and greatest near the bottom of the pond; overall increase will be greater than 50%.

Although the removal of great quantities of muck from the bottom of the pond will remove one barrier to groundwater seepage, the dense silt layers under and around the pond will still restrict groundwater flow. The base water level of Dimmock Pond may decline slightly, as exposure of the sandy edge of the pond may enhance groundwater outflow to the west and south, while inflows from the north and east will remain low. A slightly lower pond level (much as is encountered at Dimmock Pond during autumn) would be advantageous in terms of access and erosion control, considering local topography. A flat, sandy strip of land would be opened to foot traffic around much of the pond. An additional measure of flood control would be provided by a slightly lower (perhaps 1-2 ft) water level, while the average pond depth would be substantially increased by the proposed dredging.

The anticipated changes in water quality should make Dimmock Pond acceptable for its designated uses, and could be expected to make the pond suitable for certain unplanned uses (e.g., swimming). Dimmock Pond has the potential to be an outstanding water resource, providing benefits to area residents and functioning as a haven for aquatic life forms in an urban area where species diversity is often low and sensitive species are scarce. The costs are not trivial, but the tangible and intangible benefits are large and attainable.

EDUCATION PROGRAM

Environmental education is critical to the improvement and safeguarding of natural resources, as the potential impacts arising out of human demand can exceed the technological and economic capacity to repair the damage once it is done. By informing watershed residents of their role in determining the quality of water resources, it is hoped that many impacts can be avoided or reduced in magnitude, making technological fixes unnecessary or at least affordable. In the case of Dimmock Pond, much damage has already been done, and the necessary technological fix is an expensive one. An appropriate educational program, therefore, should be directed at preserving the improvements which technology (and many dollars) will provide, and at avoiding additional hazards not currently threatening the pond.

The distribution of a brochure to watershed residents is the recommended mode of education. This brochure should provide a summary of important relationships and make specific recommendations regarding residential practices which affect water quality. Although the brochure may be prepared by a consultant, it should be distributed under the auspices of a Springfield organization, such as the Department of Parks and Recreation or the Mayor's office. Involvement by the Indian Orchard Community Association is also advisable.

The primary target of the brochure should be the stormwater drainage system as a link between residents and the Dimmock Pond system. The concept of a watershed was not found to be especially familiar to public meeting participants, and is greatly complicated by the largely unseen storm drainage system. It is important that residents recognize that the inputs to that system reach the pond without treatment. The impact of the use of the storm drainage system as a disposal facility for waste oil, wash water, or solid refuse must be made clear. Residential practices which minimize inputs to this system (e.g., washing cars only on grass and with a minimum of water, bagging leaves or grass clippings) should be stressed.

A total of $8,000 has been allocated for an educational program. An informational brochure can be developed for this price, and several thousand brochures produced as well. The choice of distributional mode is left to City officials, but an approach which involves as many local citizens as possible in the actual transfer of information is desirable. An introductory meeting, including the press, would maximize exposure and program success. Expansion of this program to other areas of the City as a separate, supplementary operation is also appropriate, as most of the lakes in Springfield are impacted by stormwater runoff. Two or three informational articles, based on the prepared brochure, should also be made available to local papers and civic groups for use in promoting sound environmental management.

WATERSHED MANAGEMENT PROGRAM

Aside from the education program discussed in the previous section, the proposed modification of the Parker St. stormwater drainage system to incorporate leaching catch basins constitutes watershed management. The targeted area (Figure 22) lies mostly west of Parker St., but does include a portion of the UniFirst property and some of Parker St. itself. A total of 26 current catch basins would be modified to allow leaching of collected stormwater into the ground, thereby minimizing the flow of runoff to Dimmock Pond. As the elevations of the bottoms of most current basins are more than three meters above the groundwater table, adequate treatment should be provided as long as the proposed leaching basins are maintained to prevent clogging.

Schematic representations of a leaching catch basin are presented in Figure 23. The elements of the modification program and associated costs are given in Table 26. The grate on each existing basin will be dislodged from the pavement and the existing basin structure will be removed. A pre-formed leaching basin will be retrofitted, an overflow pipe will be connected to the main pipeline, and the pavement/grate area will be replaced. Maintenance of access to the basin for cleaning via a removable grate is necessary, requiring that the edges of the grate not be paved over (as is the case with most grates now).

Some form of agreement is likely to be required of the City by the DEQE, stipulating that the leaching basins are to be maintained for maximum effectiveness, if the Clean Lakes Program funds their installation. This is entirely appropriate, but as the City has not employed leaching basins in stormwater management previously and has only a rudimentary catch basin maintenance program, the requested committment should be seriously considered. Stormwater runoff is a problem for most Springfield ponds, and the City must make a long-term committment to stormwater management if its ponds are to be improved and protected. An annual cleaning of each leaching basin is recommended, preferably in late fall. The City will have to bear the cost of this maintenance program, as the Clean Lakes Program does not participate in maintenance and operation expenses.

A total cost of $143,000 is envisioned for this operation (Table 26). The permit-related costs are not fundable under the Clean Lakes Program, but the remainder of the listed program elements may be funded by the Clean Lakes Program at up to 75% of the associated costs. Maintenance costs (primarily periodic cleaning of the basins) are not included and must be borne by the City. An annual cleaning at a cost of $5,000 for all 26 basins is expected.

As the Ludlow Ave. stormwater drainage system will be managed by other means, no leaching basins are proposed for the corresponding area. Should such basins become necessary or highly desirable, however, a similar modification program with similar costs is possible in that drainage area.

FIGURE 22

LOCATIONS OF ELEMENTS OF THE PROPOSED MANAGEMENT PLAN FOR DIMMOCK POND

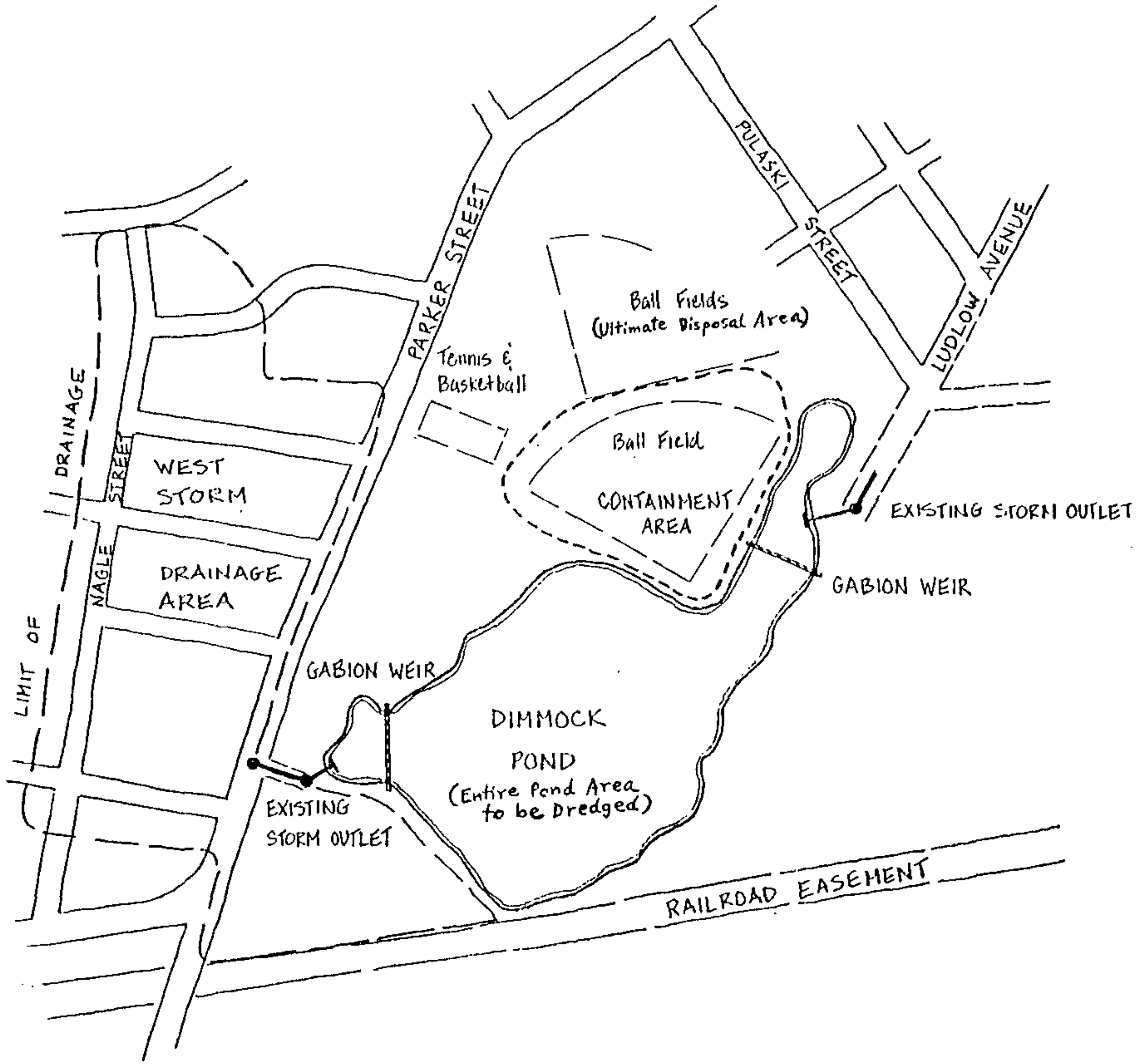
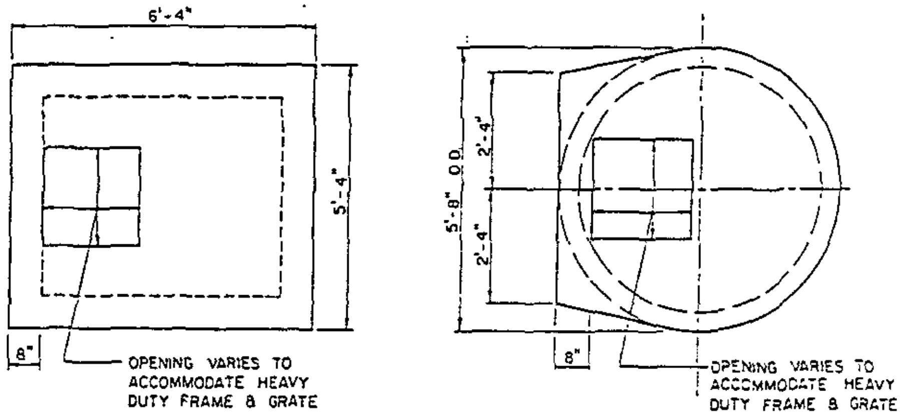


FIGURE 23

SCHEMATIC PLAN FOR A LEACHING CATCH BASIN



FROM ABOVE

FROM THE SIDE

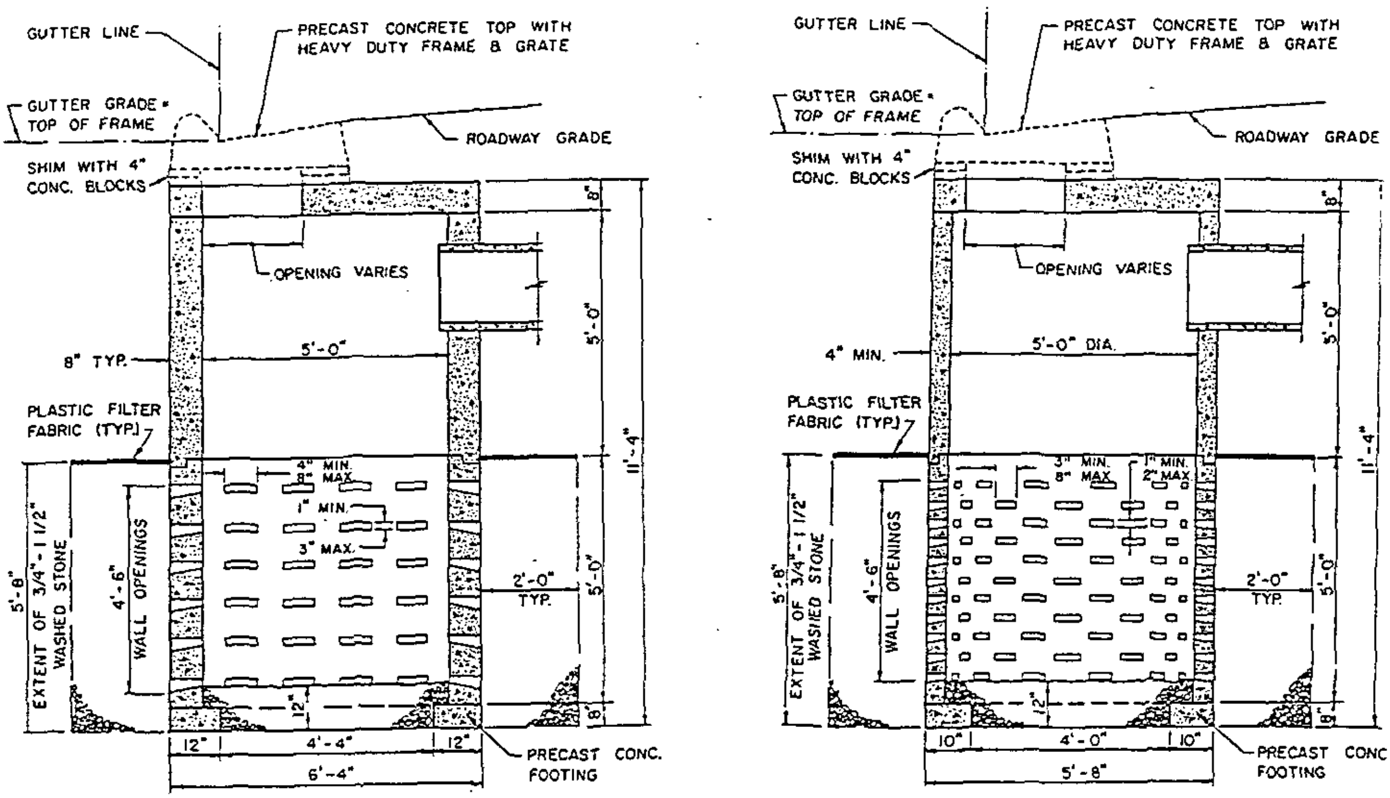


TABLE 26

ELEMENTS AND COSTS ASSOCIATED WITH THE PROPOSED INSTALLATION OF LEACHING BASINS IN THE DIMMOCK POND WATERSHED

ELEMENT	TOTAL COST ($)	MAX. FUNDING UNDER CLP*	REMAININ CITY Share**
Engineering design/specifications	11,000	8,250	2,750
Permits/environmental review	2,000	0	2,000
Bid document preparation/contractor selection	4,000	3,000	1,000
Construction supervision 5 days @ $500/day	2,500	1,875	625
Excavation of existing catch basins 26 basins @ $500/basin	13,000	9,750	3,250
Pre-formed leaching basins installed 26 @ $3000/basin	78,000	58,500	19,500
Overflow drain pipe 300 ft @ $50/ft	15,000	11,250	3,750
Reconnection to existing drainage system 26 @ $100/basin	2,600	1,950	650
Restoration of pavement 78 sq.yd @ $20/sq.yd	1,560	1,170	390
Subtotal	129,660	95,745	33,915
10% contingency	12,966	9,574	3,392
Total	$142,626	$105,319	$37,307
Round to	$143,000	$105,600	$37,400

*Clean Lakes Program
**Assumes max. funding level under CLP

IN-LAKE MANAGEMENT ACTIONS

Dredging and Bank Stabilization

The restoration of Dimmock Pond will be accomplished through dredging, with creation of stormwater detention areas near the two outfalls proposed as an in-lake solution to a watershed problem. The latter action will be facilitated and enhanced by the former, which includes the removal of 66,500 cu.m (87,500 cy) of soft sediment from the pond. This would involve dredging the entire area of Dimmock Pond, including the emergent wetland arms. It should be remembered that these wetland arms were once part of the open water portion of the pond, and are heavily impacted by stormwater inputs. As dredging contractors work with english units, dredged material volumes will be referred to in cubic yards (cy) in this discussion.

The dredging of Dimmock Pond will necessarily be by hydraulic means, requiring a specialized containment area in which solids can be settled out from the pumped slurry. Water will be returned to the pond from the containment area after treatment for reduction of turbidity and any other pollutants considered to be present at excessive levels. The ideal site for the containment area is within Hubbard Park on one or more of the existing ballfields. This creates a user conflict, but other appropriate sites are unavailable, and the ultimate use of the dried, dredged material will be for fill to raise the base elevation of the ballfields and reduce seasonal flooding. Placement of the containment area in or near the ultimate disposal site will result in a substantial cost savings.

The containment area could be placed on the higher ballfield nearest the pond (Figure 22), eliminating the need for a booster pump and facilitating gravity return flow to the pond. This area would also provide fewer security problems and could be excavated to increase capacity and provide materials for the necessary berms. This ballfield is not part of the actual ultimate disposal site, which includes the lower ballfields just to the north.

Use of either of the lower ballfields, or both, as a containment site would require only regrading in the ultimate disposal phase, and could provide greater overall capacity for containment. However, a booster pump may be needed to get the hydraulically lifted slurry to this area, and some pumping of return flow to the pond is likely to be necessary. Considerable quantities of berm material would have to be imported, and dewatering properties are likely to be less advantageous than at the higher ballfield site. Further consideration of the specific location of the containment area on the ballfields is warranted in the design phase, but the location shown in Figure 22 is the recommended site at this time.

A breakdown of program elements and costs is provided in Table 27. Design work and permit acquisition will cost approximately $90,000, with all but about $5,000 eligible for funding by the Clean Lakes Program at up to the 75% level. All other elements of the program are eligible for Clean Lakes funding at up to the 75% level. Containment area construction is a critical element, estimated to cost $230,000. A properly functioning containment area is essential to the success of the dredging program. The surrounding berm must hold the slurry and facilitate settling under a substantial hydrualic head (3 to 4 m), while minimizing erosion and the area occupied (as it subtracts from the overall basin capacity). Recommended berm features are shown in Figure 24; not shown is the security fencing necessary to prevent unauthorized access. A main settling basin and adjacent polishing lagoon will be needed, along with appropriate outlet devices (Figure 25). The use of underdrains to promote dewatering is also recommended.

Actual hydraulic dredging should cost approximately $300,000, with mobilization costs and supervision (of both dredging and containment area construction) adding another $25,000. The dredging program could be completed in two years, providing enough containment area capacity is provided and overwinter dewatering is sufficient to allow removal of accumulated material between the first and second dredging seasons. Capacity on the upper ballfield is marginal, but potentially adequate; greater capacity (at greater recreational inconvenience and technical difficulty) is available on the lower ballfields. Extension of the program to three years should be discussed in the design phase; this may be preferable to contractors and could minimize the disturbance to the park during actual dredging. It would, of course, extend the overall duration of recreational interference, but project success may be enhanced.

Ultimate disposal and restoration of the containment area and ultimate disposal sites to useful ballfields will cost around $336,000. This will include moving and grading the dried dredged material, adding 0.5 ft of cover to an approximately 10 ac area, seeding, and ballfield reconstruction. Restoration of current erosion areas around Dimmock Pond and minimization of future erosion at these and other access areas will cost about $40,000; this operation would be best accomplished in conjunction with the dredging program, and has therefore been included with it.

The total cost for dredging and bank stabilization is approximately $1,121,000. The program will both restore recreational utility and aesthetic appeal to Dimmock Pond (in conjunction with the stormwater management program) and allow upgrading of the lower ballfields in Hubbard Park to reduce future flooding. Although the price tag is large, the benefits

TABLE 27

ELEMENTS AND COSTS ASSOCIATED WITH THE PROPOSED DREDGING OF DIMMOCK POND

ELEMENT	TOTAL COST ($)	MAX. FUNDING UNDER CLP*	REMAINING CITY SHARE**
Engineering design/specifications	54,300	40,725	13,575
Permits/environmental review	20,000	11,250	8,750
Bid document preparation/contractor selection	13,600	10,200	3,400
Construction supervision 30 days @ $500/day	15,000	11,250	3,750
Containment area construction			
Embankment created (17,000 cy @ $8/cy)	136,000	102,000	34,000
Outflow devices installed (2 @ $5,000/outlet)	10,000	7,500	2,500
Underdrains installed	5,000	3,750	1,250
Polymer for flocculation	25,000	18,750	6,250
Polymer dispensing pump and generator	3,000	2,250	750
Return piping (350 ft @ $10/ft)	3,500	2,625	875
Security fencing (1500 ft @ $30/ft)	45,000	33,750	11,250
Erosion control	3,000	2,250	750
Hydraulic dredging (contracted job assumed)			
Mobilization costs	10,000	7,500	2,500
87,500 cy removed over two years @ 350 cy/day, or 250 days of dredging @ $1,200/day	300,000	225,000	75,000
Bank stabilization			
Repair of washout areas along access road (660 sq.m @$30/$m^2$)	19,800	14,850	4,950
Filter fabric installation and cover in erosion-prone areas (additional 660 sq.m @$30/$m^2$)	19,800	14,850	4,950

TABLE 27 CONTINUED

ELEMENT	TOTAL COST ($)	MAX. FUNDING UNDER CLP*	REMAINING CITY SHARE**
Containment area restoration			
Move dried dredged material to other areas of park and regrade (52,500 cy @ $4/cy)	210,000	157,500	52,500
Additional cover for ballfield area (8,000 cy @$12/cy)	96,000	72,000	24,000
Seeding and ballfield restoration	30,000	22,500	7,500
Subtotal	1,019,000	760,500	258,500
10% contingency	101,900	76,050	25,850
Total	$1,120,900	$836,550	$284,350
Round to	$1,121,000	$836,000	$284,400

*Clean Lakes Program
**Assumes max. funding level under CLP

FIGURE 24

SCHEMATIC PLAN FOR A CONTAINMENT AREA EMBANKMENT

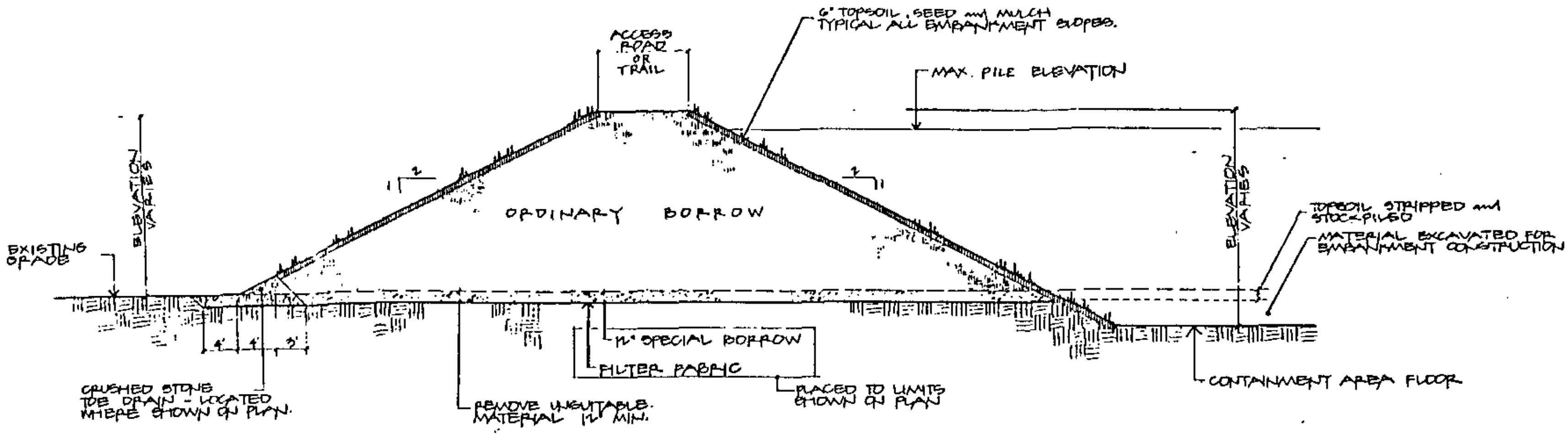
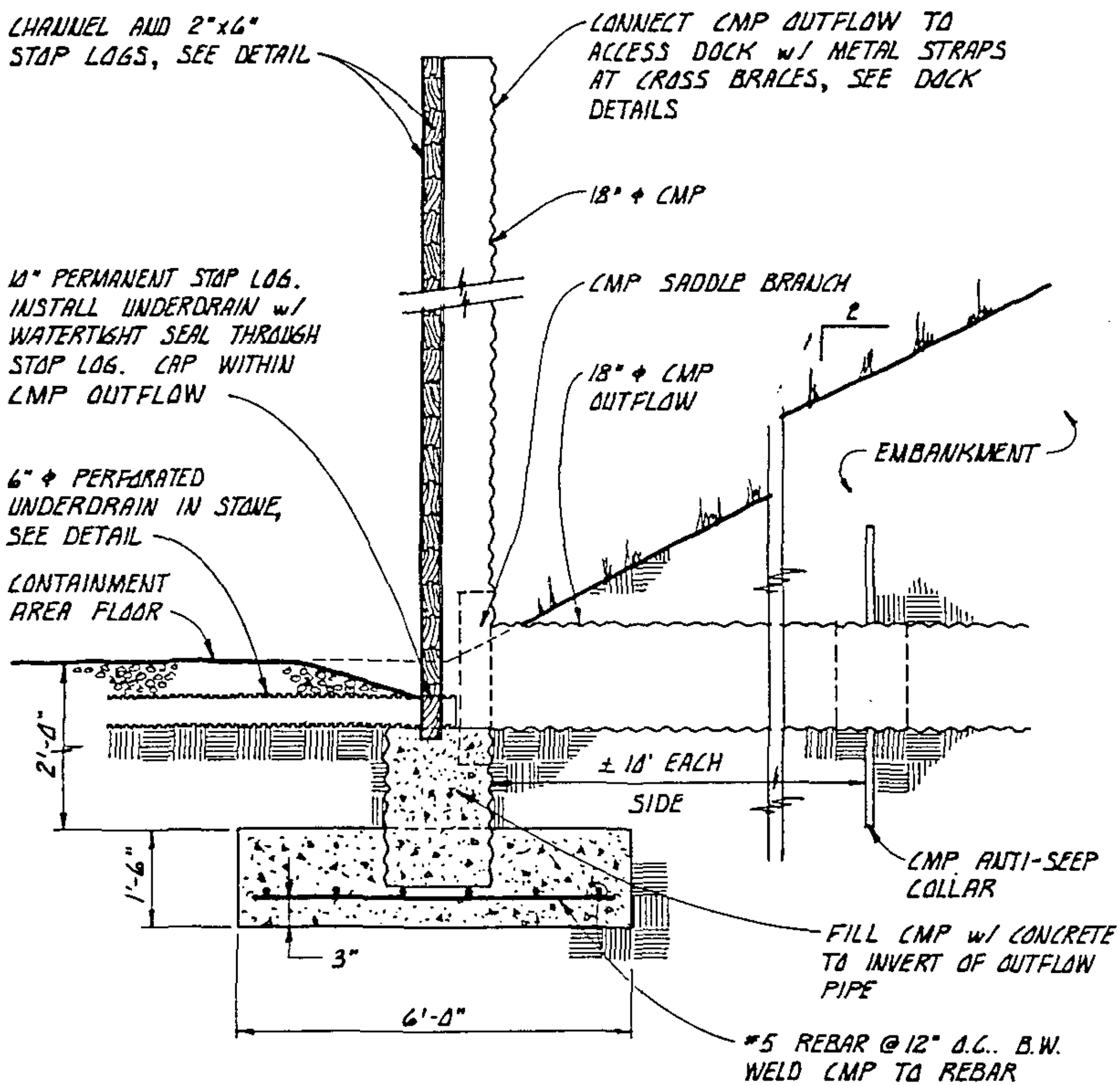


FIGURE 25



TYPICAL SECTION: CORRUGATED METAL PIPE OUTFLOW are great. This program represents a major overhaul of the pond and part of the park area, and should not be entered into without complete commitment; considerable effort over an approximately five year period will be necessary to bring the plan to fruition.

There are no maintenance costs associated with dredging for the forseeable future. The sediment will not reaccumulate at a noticable rate, unless erosion in uncontrolled. The erosion control plan proposed here will put the shoreline in an aesthetic, useable condition, but the City will need to continue erosion control activities in the future. An annual inspection and maintenance schedule is recommended for Hubbard Park as a whole.

Stormwater Detention

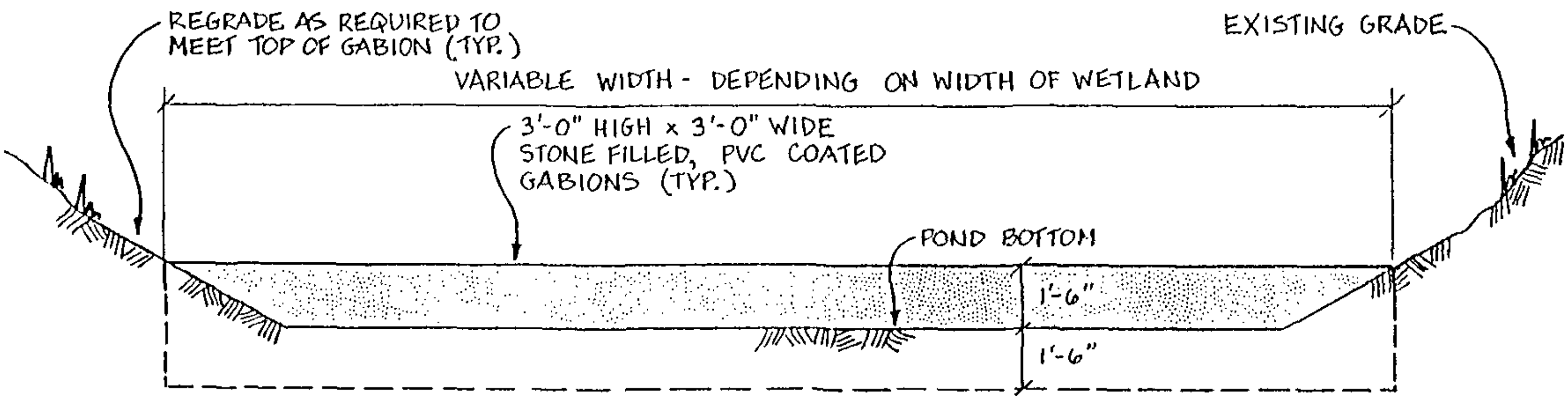
As the capacity of the northeastern wetland arm of Dimmock Pond is adequate to detain stormwater runoff generated in the Ludlow Ave. stormwater drainage basin by storms of less than a two-year frequency, creation of a detention facility in that area would appreciably reduce pollutant loads to the pond (Table 25). Dredging of that area will increase the detention capacity, further improving pollutant removal capabilities. As a supplement to the leaching catch basins to be installed in the Parker St. drainage area, establishment of a detention basin in the western wetland arm of the pond is also recommended. For relatively little cost, the established detention facilities could provide an invaluable measure of pollution control for the Dimmock Pond watershed. They are essentially watershed management measures taken in-lake.

The location of these basins is dictated by available space and the location of the outfalls. There are no alternatives for the Parker St. drainage area, and the only alternative for the Ludlow Ave. drainage basin is a partially private wetland tract. The in-lake locations (Figure 22) are former portions of the pond which have become emergent wetlands as a consequence of sediment deposition from storm drains and organic matter build-up from vegetative growth. Some regrowth of wetland species is expected in these areas after dredging, but maintenance of a permanent pool in each area will probably result in some species substitutions.

After dredging of the two proposed detention areas is completed, some grubbing and clearing will still be necessary, as portions of these areas are not always under water. Creation of a small berm at the northern end of the northeastern wetland area will prevent any spillover into the lower ballfield area. Installation of gabion weir units across the mouth of each area (Figure 26), separating them from the pond, will allow detention

FIGURE 26

SCHEMATIC PLAN FOR A GABION WEIR



of substantial water flows while facilitating gradual water level equalization through the gabions. Stormwater entering these basins will therefore be detained for a period inversely proportional to the magnitude of the storm.

A two-year storm deposits 7.9 cm (3.1 in) of water on the watershed in a 24 hr period, which translates into a runoff volume from the Ludlow Ave. drainage area slightly larger than the capacity of the proposed northeastern detention area. This detention area could hold the runoff generated by a 6.5 cm (2.6 in) rainfall in 24 hr. As no more than 2% of all storms in central Massachusetts deposit more than 5.1 cm (2 in) of rainfall in a 24 hr period (Figure 19), the northeastern detention basin would not be likely to overflow more than once or twice per year, as a consequence of large storms or moderate sequential storms. The quantity of water that would enter the pond with minimal detention (during periods of overflow) is estimated to be 5 to 10% of the total runoff generated in the Ludlow Ave. drainage area.

By comparison, the 700 cu.m capacity of the proposed western detention area will hold the runoff generated in the Parker St. drainage area by up to a 1.2 cm (0.5 in) *rainfall in 24 hr.* Over 30% of the storm events in central Massachusetts exceed this rainfall in a 24 hr period, and approximately 60 to 70% of the runoff would pass through this basin virtually undetained.

At a phosphorus removal rate of around 80% (Schueler 1987) for appropriate detention (2 to 3 days), and lesser percentages for lesser detention, it is expected that the northeastern detention area will remove about 85 to 90% of the phosphorus entering via the Ludlow Ave. drain. The western detention basin will remove between 40 and 50% of the phosphorus entering via the Parker St. drain. As the Parker St. drainage area contributes about 25% more phosphorus than the Ludlow Ave. drainage area, the actual quantity of phosphorus retained by the two detention basins will be more slightly similar than suggested by the percentages given above.

Modification of the existing storm drainage outfalls to minimize erosion and maximize sheet flow is also recommended. This would include installation of riprap to diffuse exit energy and split flow, which would reduce channeling. Restoration of peripheral areas disturbed during construction should be anticipated, to minimize erosional sedimentation of the basins or the pond. The establishment of detention basins could be carried out at the beginning of the second dredging season, after the appropriate areas have been dredged. Construction work could be facilitated by a drawdown induced by hydraulic dredging, with return water routed to the wetland east of the pond instead of back into the pond directly.

The cost of creating the detention areas is estimated at $48,000 (Table 28). Engineering design work, including some essential surveying, represents $12,000 of this total. A portion of the permit costs (probably $2,000) will not be eligible for funding under the Clean Lakes Program, but the remainder of the program costs are eligible at up to the 75% level.

After completion, the detention areas will provide nutrient and sediment removal commensurate with their detention capacity. While the main body of Dimmock Pond will be protected, the detention areas will suffer sediment accumulation at a potentially noticable rate. An annual inspection program is recommended, logically in conjunction with erosion control inspections, with solids removal occurring as needed. Restoration of complete detention capacity will probably not be necessary more often than once every five years, but will be essential at some point on a recurrent basis. Sediment removal with small amphibious equipment (a pontoon backhoe would work well) is appropriate, and would cost only several thousand dollars. The City will have to bear this maintenance cost as the Clean Lakes Program does not provide maintenance funds.

TABLE 28

ELEMENTS AND COSTS ASSOCIATED WITH THE PROPOSED INSTALLATION OF GABION WEIRS TO DETAIN STORMWATER ENTERING DIMMOCK POND

ELEMENT	COST ($)	MAX. FUNDING UNDER CLP*	REMAINING CITY SHARE**
Engineering design/specifications	12,000	9,000	3,000
Permits/environmental review	4,000	1,500	2,500
Bid document preparation and contractor selection	4,000	3,000	1,000
Construction supervision 8 days @ $500/day	4,000	3,000	1,000
Grubbing/area preparation 0.8 ac @ $5,000/ac	4,000	3,000	1,000
Gabion weir installation 35 units, ea. 3 ft X 9 ft @ $300/unit	10,500	7,875	2,625
Repair/upgrade existing storm drain outlets 2 outlets @ 1,500/outlet	3,000	2,250	750
Restoration of disturbed areas	2,000	1,500	500
Subtotal	43,500	31,125	12,375
10% contingency	4,350	3,112	1,238
Total	$47,850	34,237	13,613
Round to	$48,000	34,350	13,650

*Clean Lakes Program
**Assumes maximum funding level under CLP

MONITORING PROGRAM

A monitoring program will be necessary to assess the success of management actions and aid in the formulation of appropriate management policies and supplementary management programs. Of primary interest are changes in the concentrations of phosphorus, nitrogen and suspended solids, and resultant alteration of water clarity and overall system fertility. Changes in system pH and dissolved oxygen near the bottom of the pond are anticipated and should be documented. Both wet weather and dry weather conditions should be assessed, with sampling of the pond, detention areas and storm drains when active. Additional monitoring of the return flow from the containment area is also necessary, on a daily to weekly basis.

Recommended parameters, frequency of measurement, and associated costs are provided in Table 29. Corresponding stations are depicted in Figure 27. The cost of the entire monitoring program is estimated at $102,700. Monitoring costs, on a per unit basis, will rise annually or biennially in accordance with inflation.

Monitoring should be carried out over a five-year period, beginning several months prior to the first construction activity. The first two years of monitoring will constitute the implementation phase, while the last three years will comprise the post-implementation phase. Long-term monitoring at some simple level (e.g., seasonally for phosphorus, secchi disk transparency, and dissolved oxygen) should be instituted at the conclusion of the five-year project-oriented monitoring program.

This monitoring program will allow assessment of the success of the proposed management alternatives. Specific comparison of pre-project and post-project water clarity (based on secchi disk transparency, turbidity, and suspended solids level) is desirable. Interpretation should consider phosphorus levels, as reduction of sediment resuspension may foster increased algal growth if phosphorus levels are not substantially reduced. Changes in pH could also affect biological processes, thereby affecting water quality and clarity. The proposed project is intended to produce greater water clarity in spite of potentially confounding influences, but the timing of project elements is such that interim impacts are likely.

Monitoring during the project is also quite important, as there is a potential for interim impacts. Changes in the treatment of water being returned to the pond from the containment area (e.g., alum addition, change in polymer) may be warranted. A complex project such as that proposed is rarely performed without adjustments in the field, and the proposed monitoring program is essential to making informed operational decisions.

TABLE 29

ELEMENTS AND COSTS ASSOCIATED WITH A FIVE YEAR MONITORING PROGRAM

YEAR #1

Operation/Parameter	Stations	Freq. (#/st/yr)	Unit Cost ($)	Annual Cost ($)
DRY WEATHER MONITORING:				
Dry weather sampling (grabs)	-	4	600	2400
Water level (elevation)	1	4	-	-
Flow (cu.m/min)	4 (DP-2,3,4,5)	4	-	-
pH (SU)	4 (DP-1s,1b,4,5)	4	7	112
Conductivity (umhos/cm)	4 (DP-1s,1b,4,5)	4	7	112
Turbidity (NTU)	4 (DP-1s,1b,4,5)	4	7	112
Total suspended solids (mg/l)	4 (DP-1s,1b,4,5)	4	10	160
Total phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	15	240
Total filterable phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	15	240
Ammonia nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	15	240
Nitrate nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	10	160
Total Kjeldahl nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	20	320
Temperature (C)	4 (DP-1s,1b,4,5)	4	5	80
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	4	5	80
Chlorophyll a (ug/l)	1 (DP-1, integrated)	4	35	140
Phytoplankton (cells/ml, ug/l)	1 (DP-1, integrated)	4	35	140
Note: Sampling to be done seasonally.			Subtotal:	$4,536
WET WEATHER MONITORING:				
Storm event sampling (composites)	- (DP-1s,1b,2,3,4,5)	5	1000	5000
Water level (elevation)	1	5	-	0
Rainfall (cm/event)	1	5	-	0
Flow (cu.m/min)	4 (DP-2,3,4,5)	5	-	0
pH (SU)	6 (DP-1s,1b,2,3,4,5)	5	7	210
Conductivity (umhos/cm)	6 (DP-1s,1b,2,3,4,5)	5	7	210
Turbidity (NTU)	6 (DP-1s,1b,2,3,4,5)	5	7	210
Total suspended solids (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	10	300
Total phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	15	450
Total filterable phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	15	450
Ammonia nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	15	450
Nitrate nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	10	300
Total Kjeldahl nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	20	600
Temperature (C)	4 (DP-1s,1b,4,5)	5	5	100
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	5	5	100
Metals (As,Cd,Cr,Cu,Hg,Fe,Mn,Ni, Pb,V,Zn)	2 (DP-2,3)	1	300	600
Note: DP-2,3 to be sampled over 4 hr period or storm duration, whichever is shorter. DP-4,5 to be sampled for flow during storms and for flow and other parameters the day after the storm. DP-1 to be sampled the day after the storm, at the surface and near the bottom.			Subtotal:	$8,980
CONTAINMENT AREA MONITORING (BY CONSTRUCTION SUPERVISOR):				
Turbidity (NTU)	1 (Return flow)	170	7	1190
Total suspended solids (mg/l)	1 (Return flow)	34	10	340
Conductivity (umhos/cm)	1 (Return flow)	170	7	1190
pH (SU)	1 (Return flow)	34	7	238
Total phosphorus (ug/l)	1 (Return flow)	34	15	510
Total filterable phosphorus (ug/l)	1 (Return flow)	34	15	510
Ammonia nitrogen (mg/l)	1 (Return flow)	34	15	510
Nitrate nitrogen (mg/l)	1 (Return flow)	34	10	340
Total Kjeldahl nitrogen (mg/l)	1 (Return flow)	34	20	680
Temperature (C)	1 (Return flow)	34	5	170
Dissolved oxygen (mg/l)	1 (Return flow)	34	5	170
			Subtotal:	$5,848
Reports, meetings, and PALIS				$1,500
			Total:	$20,864
			Round to:	$21,000
YEAR #2: IDENTICAL TO YEAR #1			Total:	$20,864
			Round to:	$21,000

TABLE 29 CONTINUED

YEAR #3:

Operation/Parameter	Stations	Freq. (#/st/yr)	Unit Cost ($)	Annual Cost ($)
DRY WEATHER MONITORING:				
Dry weather sampling (grabs)	-	4	800	2400
Water level (elevation)	1	4	-	-
Flow (cu.m/min)	4 (DP-2,3,4,5)	4	-	-
pH (SU)	4 (DP-1s,1b,4,5)	4	8	128
Conductivity (umhos/cm)	4 (DP-1s,1b,4,5)	4	8	128
Turbidity (NTU)	4 (DP-1s,1b,4,5)	4	8	128
Total suspended solids (mg/l)	4 (DP-1s,1b,4,5)	4	11	176
Total phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	17	272
Total filterable phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	17	272
Ammonia nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	17	272
Nitrate nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	11	176
Total Kjeldahl nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	22	352
Temperature (C)	4 (DP-1s,1b,4,5)	4	6	96
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	4	6	96
Chlorophyll a (ug/l)	1 (DP-1, integrated)	4	40	160
Phytoplankton (cells/ml, ug/l)	1 (DP-1, integrated)	4	40	160
Note: Sampling to be done seasonally.			Subtotal:	$4,816
WET WEATHER MONITORING:				
Storm event sampling (composites)	- (DP-1s,1b,2,3,4,5)	5	1400	7000
Water level (elevation)	1	5	-	0
Rainfall (cm/event)	1	5	-	0
Flow (cu.m/min)	4 (DP-2,3,4,5)	5	-	0
pH (SU)	6 (DP-1s,1b,2,3,4,5)	5	8	240
Conductivity (umhos/cm)	6 (DP-1s,1b,2,3,4,5)	5	8	240
Turbidity (NTU)	6 (DP-1s,1b,2,3,4,5)	5	8	240
Total suspended solids (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	11	330
Total phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	17	510
Total filterable phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	17	510
Ammonia nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	17	510
Nitrate nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	11	330
Total Kjeldahl nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	22	660
Temperature (C)	4 (DP-1s,1b,4,5)	5	6	120
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	5	6	120
Metals (As,Cd,Cr,Cu,Hg,Fe,Mn,Ni, Pb,V,Zn)	2 (DP-2,3)	1	350	700
Note: DP-2,3 to be sampled over 4 hr period or storm duration, whichever is shorter. DP-4,5 to be sampled for flow during storms and for flow and other parameters the day after the storm. DP-1 to be sampled the day after the storm, at the surface and near the bottom.			Subtotal:	$11,510
Reports, meetings, and PALIS				$2,000
			Total:	$18,326
			Round to:	$18,500

TABLE 29 CONTINUED

YEAR #4

Operation/Parameter	Stations	Freq. (#/st/yr)	Unit Cost ($)	Annual Cost ($)
DRY WEATHER MONITORING:				
Dry weather sampling (grabs)	-	4	900	2400
Water level (elevation)	1	4	-	-
Flow (cu.m/min)	4 (DP-2,3,4,5)	4	-	-
pH (SU)	4 (DP-1s,1b,4,5)	4	9	144
Conductivity (umhos/cm)	4 (DP-1s,1b,4,5)	4	9	144
Turbidity (NTU)	4 (DP-1s,1b,4,5)	4	9	144
Total suspended solids (mg/l)	4 (DP-1s,1b,4,5)	4	12	192
Total phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	18	288
Total filterable phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	18	288
Ammonia nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	18	288
Nitrate nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	12	192
Total Kjeldahl nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	24	384
Temperature (C)	4 (DP-1s,1b,4,5)	4	7	112
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	4	7	112
Chlorophyll a (ug/l)	1 (DP-1, integrated)	4	42	168
Phytoplankton (cells/ml, ug/l)	1 (DP-1, integrated)	4	42	168
Note: Sampling to be done seasonally.			Subtotal:	$5,024
WET WEATHER MONITORING:				
Storm event sampling (composites)	- (DP-1s,1b,2,3,4,5)	5	1600	8000
Water level (elevation)	1	5	-	0
Rainfall (cm/event)	1	5	-	0
Flow (cu.m/min)	4 (DP-2,3,4,5)	5	-	0
pH (SU)	6 (DP-1s,1b,2,3,4,5)	5	9	270
Conductivity (umhos/cm)	6 (DP-1s,1b,2,3,4,5)	5	9	270
Turbidity (NTU)	6 (DP-1s,1b,2,3,4,5)	5	9	270
Total suspended solids (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	12	360
Total phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	18	540
Total filterable phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	18	540
Ammonia nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	18	540
Nitrate nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	12	360
Total Kjeldahl nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	24	720
Temperature (C)	4 (DP-1s,1b,4,5)	5	7	140
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	5	7	140
Metals (As,Cd,Cr,Cu,Hg,Fe,Mn,Ni, Pb,V,Zn)	2 (DP-2,3)	1	380	760
Note: DP-2,3 to be sampled over 4 hr period or storm duration, whichever is shorter. DP-4,5 to be sampled for flow during storms and for flow and other parameters the day after the storm. DP-1 to be sampled the day after the storm, at the surface and near the bottom.			Subtotal:	$12,910
Reports, meetings, and PALIS				$2,200
			Total:	$20,134
			Round to:	$20,100

TABLE 29 CONTINUED

YEAR #5

Operation/Parameter	Stations	Freq. (#/st/yr)	Unit Cost ($)	Annual Cost ($)
DRY WEATHER MONITORING:				
Dry weather sampling (grabs)	-	4	1000	2400
Water level (elevation)	1	4	-	-
Flow (cu.m/min)	4 (DP-2,3,4,5)	4	-	-
pH (SU)	4 (DP-1s,1b,4,5)	4	10	160
Conductivity (umhos/cm)	4 (DP-1s,1b,4,5)	4	10	160
Turbidity (NTU)	4 (DP-1s,1b,4,5)	4	10	160
Total suspended solids (mg/l)	4 (DP-1s,1b,4,5)	4	13	208
Total phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	20	320
Total filterable phosphorus (ug/l)	4 (DP-1s,1b,4,5)	4	20	320
Ammonia nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	20	320
Nitrate nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	13	208
Total Kjeldahl nitrogen (mg/l)	4 (DP-1s,1b,4,5)	4	25	400
Temperature (C)	4 (DP-1s,1b,4,5)	4	8	128
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	4	8	128
Chlorophyll a (ug/l)	1 (DP-1, integrated)	4	45	180
Phytoplankton (cells/ml, ug/l)	1 (DP-1, integrated)	4	45	180
Note: Sampling to be done seasonally.			Subtotal:	$5,272
WET WEATHER MONITORING:				
Storm event sampling (composites)	- (DP-1s,1b,2,3,4,5)	5	1800	9000
Water level (elevation)	1	5	-	0
Rainfall (cm/event)	1	5	-	0
Flow (cu.m/min)	4 (DP-2,3,4,5)	5	-	0
pH (SU)	6 (DP-1s,1b,2,3,4,5)	5	10	300
Conductivity (umhos/cm)	6 (DP-1s,1b,2,3,4,5)	5	10	300
Turbidity (NTU)	6 (DP-1s,1b,2,3,4,5)	5	10	300
Total suspended solids (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	13	390
Total phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	20	600
Total filterable phosphorus (ug/l)	6 (DP-1s,1b,2,3,4,5)	5	20	600
Ammonia nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	20	600
Nitrate nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	13	390
Total Kjeldahl nitrogen (mg/l)	6 (DP-1s,1b,2,3,4,5)	5	25	750
Temperature (C)	4 (DP-1s,1b,4,5)	5	8	160
Dissolved oxygen (mg/l)	4 (DP-1s,1b,4,5)	5	8	160
Metals (As,Cd,Cr,Cu,Hg,Fe,Mn,Ni, Pb,V,Zn)	2 (DP-2,3)	1	400	800
Note: DP-2,3 to be sampled over 4 hr period or storm duration, whichever is shorter. DP-4,5 to be sampled for flow during storms and for flow and other parameters the day after the storm. DP-1 to be sampled the day after the storm, at the surface and near the bottom.			Subtotal:	$14,350
Reports, meetings, and PALIS				$2,500
			Total:	$22,122
			Round to:	$22,100

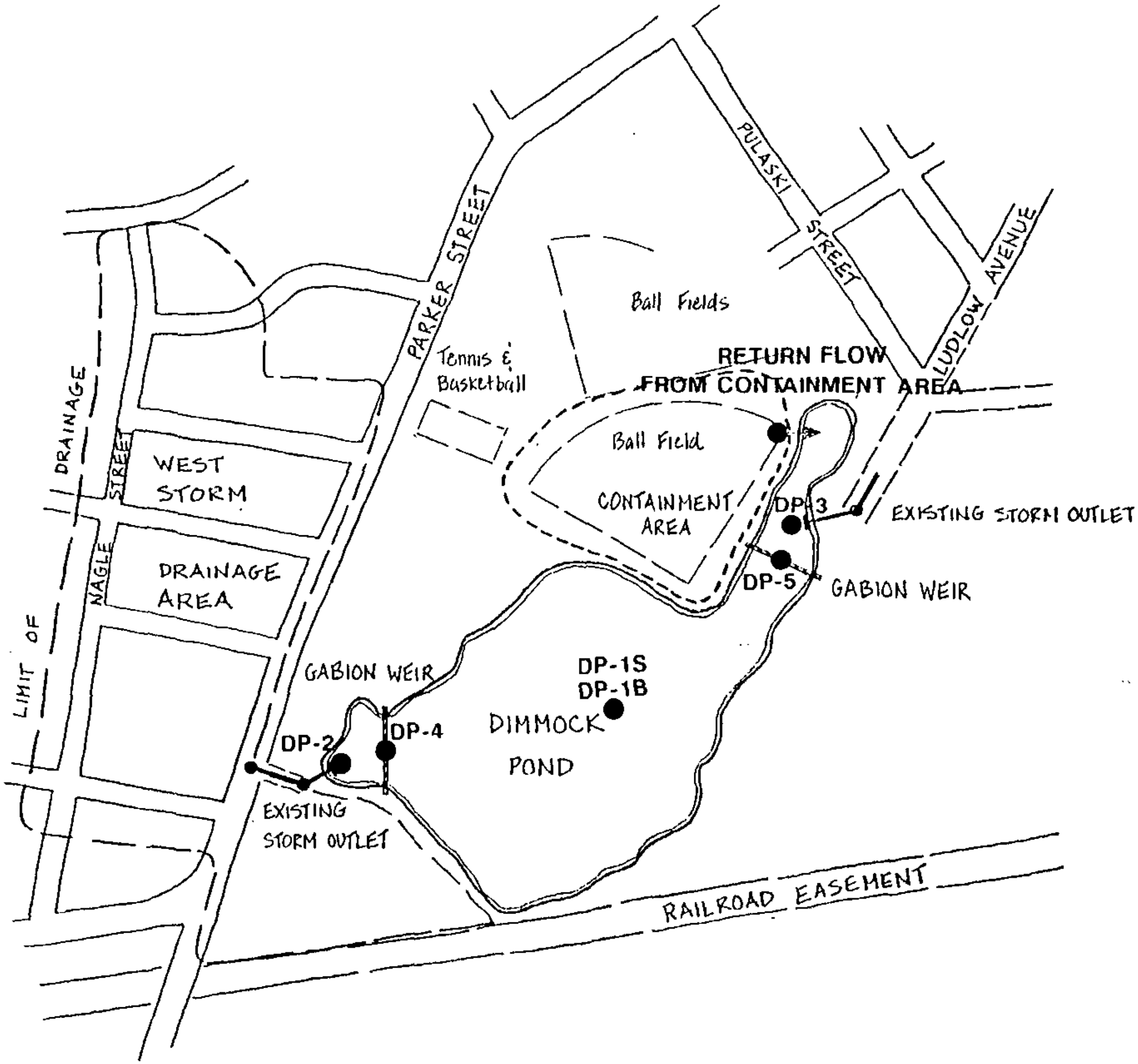
TOTAL FOR IMPLEMENTATION PHASE = $42,000

TOTAL FOR POST-IMPLEMENTATION PHASE = $60,700

TOTAL FOR ALL MONITORING = $102,700

FIGURE 27

LOCATIONS OF RECOMMENDED PHASE II MONITORING STATIONS



FUNDING ALTERNATIVES

Several sources of funding are available for management activities in Dimmock Pond and its watershed (Table 30). The Clean Lakes Program, which sponsored this study, is the likely key source of support. A project of this magnitude will likely require multiple sources of funding, however. Other sources noted in Table 30 are less stable or appropriate to the proposed project, but no potential source should be overlooked.

The matching of funds from different agencies of the Commonwealth is discouraged by the Massachusetts Clean Lakes Program, although most other agencies listed in Table 30 have no objection. The Clean Lakes Program seeks to gain local committtment through monetary involvement with projects, usually at the 25% level. This is often not a problem with small projects or large and wealthy communities, but does present financial difficulties for large projects or smaller communities. In-kind services are not currently recognized by the Massachusetts Clean Lakes Program as monetary contributions to a project, further reducing viable options for funding the portion of the project not covered by the Clean Lakes Program.

Several creative programs have recently been proposed in the Massachusetts legislature, but the current budgetary crisis leaves little hope of enactment in the near future. If the City wishes to restore Dimmock Pond and improve Hubbard Park, it is likely to require a substantial investment by Springfield residents.

TABLE 30

POTENTIAL FUNDING SOURCES FOR THE PROPOSED
MANAGEMENT OF DIMMOCK POND

Source	Maximum Funding Level	Notes
Massachusetts Clean Lakes Program (Ch. 628 of the Acts of 1981, DEQE)	75%	Sound program; July 1 application deadline; likely source.
Federal Clean Lakes Program (Sec. 314 of PL 92-500, USEPA)	50%	Financially restricted; few new projects accepted.
Rivers and Harbors Program (Division of Waterways, DEM)	75%	Annually variable program, Jan. 15 deadline. If renewed in subsequent FY appropriations it could supply funding.
Small Watershed Protection Program (PL 83-566, SCS)	100%	Requires high cost-benefit ratio. Funding cutbacks have limited this program.
Resource Conservation and Development Program (Food & Agric. Act of 1962, SCS)	100%	Requires established RC&D district, very limited funding opportunities at present.
Federal Land and Water Conservation Fund; Division of Conservation Services, EOEA (Federal Pass Through)	50%	Acquisition of lands for outdoor recreation; not very applicable in this case.
Mass. Self Help Program M.G.L. Chap. 132A, Sec. 11 (DCS/EOEA)	80%	Grants to Conservation Commissions for land acquisition; requires an approved open space plan. Not very applicable.

ENVIRONMENTAL EVALUATION

Appendix D contains the Environmental Notification Form (ENF) which must be filed under the Massachusetts Environmental Policy Act (MEPA). The MEPA unit will evaluate the proposed actions and their potential impacts and make a determination regarding the need for an impact study prior to implementation. The ENF also serves as a useful summary document for the project.

The major environmental issues surrounding the proposed project include temporary impairment of recreational activities in parts of Hubbard Park and the alteration of certain wetland areas. As the area has been highly impacted by past activities, and the management actions are for the betterment of a park and wetland (pond) environment, no serious opposition to the project is anticipated. An Environmental Impact Report may be required, however, to address any issues which the MEPA unit feels are in need of further elucidation.

The quality of the sediment to be dredged from Dimmock Pond gives cause for some concern, as high levels of some contaminants were detected in some samples. Additional testing is warranted in the design phase, to more accurately quantify average sediment chemistry. It is likely that the levels of contaminants derived from street pollution (e.g., lead) will be high near the storm drain outfalls, where two of the three sediment samples were collected. The average concentration of contaminants in the pond sediment is unknown, however. A test for total chromatographable organics may also be desirable, to investigate possible influence of past contamination episodes and their implications for dredged material disposal. No serious problems are anticipated, but information on specific contaminants may be requested by permitting agencies beyond that collected in this study.

As the Dimmock Pond system is virtually a closed system, no impact to other surface water bodies is anticipated. Discharges to groundwater are planned in this project, but no adverse impact on any current or proposed use of area water resources is anticipated. Air and noise pollution should be virtually undetectable against the background provided by the surrounding urban setting.

The impact of the dredging project on Dimmock Pond should not cause any concern, as the system is in need of a complete overhaul. This is not a natural freshwater system experiencing slight cultural eutrophication, but rather a grossly impacted, shallow, stormwater detention system with excessive sediment deposits which are highly susceptible to resuspension. The fish population is heavily imbalanced in favor of panfish and species considered undesirable by most anglers. There is only a minimal benthic fauna, and nothing exemplary is to be found in the plant community. If it were possible to pump the system dry and dewater the sediments in place, it would be recommended. Dimmock Pond could be as aesthetically appealing and ecologically interesting as any lake in the area, but not without a complete restructuring of its physical, chemical, and biological components.

Copies of this report or relevant excerpts have been sent to the Massachusetts Division of Water Pollution Control, Division of Fisheries and Wildlife, Historical Commission, and Natural Heritage Program for review and comment. Review by the Springfield Department of Parks and Recreation, the Conservation Commission, Department of Public Works, and the Mayor's Office have also been requested. Copies of all comments received can be found in Appendix E.

NECESSARY PERMITS

Under the current regulatory climate, the proposed project will require passage through 16 different approval processes involving 15 federal or state agencies (Table 31). To receive state funds for implementation, Springfield must comply with laws relating to discrimination, wage rates and housing, provide proof of title to the project site, and sign the appropriate intergovernmental (substate) agreement.

Review processes by the Division of Fisheries and Wildlife, the Massachusetts Historical Commission, and the Natural Heritage Program have been initiated with the filing of this report. The review by the EOEA (MEPA unit) will be initiated by the filing of the attached ENF (Appendix D); Springfield officials (Department of Parks and Recreation or the Mayor's Office) should file this document at their earliest convenience. The Springfield Conservation Commission will be reviewing this report, but a formal Notice of Intent should be filed by City officials to initiate the approval process associated with the Wetlands Protection Act.

An application must be filed with the Division of Waterways and Wetlands Regulation in Boston to receive approval of the operation and acquire a dredging permit (Chapter 91 Waterways License). The City of Springfield is responsible for filing this application, but the Phase II consultant can assist in its preparation; this application is not filed until a definitive dredging plan has been drafted.

A US Army Corps of Engineers permit, known as a Section 404 permit, must also be obtained through application to the ACOE in Waltham. This permit is required for any fill activities in wetlands (including ponds, and extending to the proposed gabion weir arrangement) and for state sponsored dredging programs. This application is also filed by City officials, but the Phase II consultant should assist in its preparation as with the Chapter 91 Waterways License request.

The Water Quality Certificate, issued by the MDWPC, endorses a project as consistent with water quality goals in the project area. Review of the project by the MDWPC is initiated along with the Chapter 91 and Section 404 permit approval processes. A copy of the application to be filed is attached to the ENF (which it also accompanies) in Appendix D.

TABLE 31

PERMITS AND OTHER APPROVAL PROCESSES ASSOCIATED WITH THE PROPOSED MANAGEMENT ACTIONS

PERMIT/CERTIFICATE/LICENSE/APPROVAL WHICH MUST BE OBTAINED	CONTACT AGENCY AND ADDRESS	REVIEW TIME (DAYS)	APPLICABILITY TO MANAGEMENT ACTIONS Leaching basins	Detention areas	Dredging
Title to Project Site	Lakes Section, DWPC, DEQE Lyman School, Westview Bldg. Westborough, MA 01581 508-366-9181	None, submit w/appl.	X	X	X
Intergovernmental Agreement	Lakes Section, DWPC, DEQE Lyman School, Westview Bldg. Westborough, MA 01581 508-366-9181	Local approval req'd	X	X	X
Fair Housing (EO 215)	Exec. Office Communities/Devel. 100 Cambridge St., Rm 1404 Boston, MA 02202 617-727-7824	None, Contact OECD for determination	X	X	X
Commission Against Discrimination	MA Comm. Against Discrimination 1 Ashburton Place Boston, MA 02108 617-727-7309	120	X	X	X
Wage Rate Compliance	Dept. Labor and Industries 100 Cambridge St., 11th Floor Boston, MA 02202 617-727-3454	None, submit within 15 days after work done.	X	X	X
MA Env. Policy Act (ENF Review)	Exec. Off. Env. Affairs (MEPA) 100 Cambridge St., 20th Floor Boston, MA 02202 617-727-5830	30 *	X	X	X
Natural Heritage Program	MA Natural Heritage Prog., DFW 100 Cambridge St. Boston, MA 02202 617-727-9194	Approx. 30 ** Submit letter of finding w/appl.	X	X	X
Historical Commission	MA Historical Commission 80 Boylston St. Boston, MA 02116 617-727-8570	Approx. 30 ** Submit letter of finding w/appl.	X	X	X
Div. Fisheries and Wildlife	Div. Fisheries and Wildlife Field Headquarters Westborough, MA 01581 508-366-4470	15 **		X	X

TABLE 31 CONT.

PERMITS AND OTHER APPROVAL PROCESSES ASSOCIATED WITH THE PROPOSED MANAGEMENT ACTIONS

PERMIT/CERTIFICATE/LICENSE/APPROVAL WHICH MUST BE OBTAINED	CONTACT AGENCY AND ADDRESS	REVIEW TIME (DAYS)	APPLICABILITY TO MANAGEMENT ACTIONS		
			Leaching basins	Detention areas	Dredging
US Army Corps of Engrs. (Sec 404)	Regulatory Branch, USACOE 424 Trapelo Rd. Waltham, MA 02254 1-800-362-4367	120 ***		X	X
Div. Waterways (Chap. 91)	Div. of Wetlands and Waterways DEQE, 1 Winter St. Boston, MA 02108 617-292-5519	90		X	X
DWPC Water Quality	Permits Section, DWPC, DEQE 1 Winter St. Boston, MA 02108 617-292-5673	90		X	X
Wetlands Protection Act	Springfield Conservation Comm. 1600 Columbus Ave. Springfield, MA 01103 413-787-6234	42		X	X
Div. Solid and Hazardous Waste	Div. Solid Waste, DEQE 436 Dwight St. Springfield, MA 01103 413-784-1100	***			X
NPDES (Point Source Control)	Regulatory Branch, DWPC, DEQE 1 Winter St. Boston, MA 02108 617-292-5673	180			X
Groundwater Discharge	DWPC, DEQE, Groundwater Section 1 Winter St. Boston, MA 02108 617-292-5673	180	X		X

* If EIR required, final approval will not be given until EIR is reviewed.

** Review of project by appropriate agency initiated by this report.

*** No statutory limit, longest when EIR is required.

The disposal of the dredged material will require approval by the Division of Hazardous Waste, and the return of containment area water to the pond may require a National Point Source Discharge Elimination System permit. The local field office of the DEQE should be consulted by City officials for determination of applicability with regard to the proposed dredging program.

The use of leaching basins in the Parker St. drainage system may require a groundwater discharge permit, as may the seepage of water from the containment area into the ground (a process encouraged for dewatering purposes). The routing of any containment area water to the wetland east of the pond for the purpose of conducting a partial drawdown of the pond during construction activiites may also require a groundwater discharge permit. An application should be filed by City officials with the Groundwater Section of the DWPC, DEQE, when definitive plans have been drawn up.

PHASE II TASK RESPONSIBILITIES

Grant arrangements and other administrative tasks which must be performed prior to the hiring of a Phase II consultant must be handled by City officials, presumably by representatives of the Department of Parks and Recreation. Permit application filings and much of the related documentation are also the responsibility of the City, although a qualified consultant can greatly ease the burden this process imposes, and the Clean Lakes Program will share in the cost of impact statement preparation and ACOE Section 404 permit documentation.

All tasks leading to the hiring of contractors to install leaching basins, construct a containment area, dredge the pond, handle the dried dredged material, build stormwater detention areas, or repair erosion-prone shoreline segments would be the responsibility of the Phase II consultant, with input from the City. The consultant will also be responsible for supervising all construction work. Monitoring and education program development are also assigned to the consultant, although City involvement with the educational program is strongly encouraged, particularly with respect to distribution and publicity.

PUBLIC PARTICIPATION

In addition to review by the agencies mentioned in the Environmental Evaluation section of this report, the public at large was involved with the development of management alternatives. To date, three public meetings and numerous informal discussions have been conducted by BEC in the City of Springfield. In addition to the official public meetings required by the Clean Lakes Program, BEC representatives attended several meetings related to the impact of proposed development in the Dimmock Pond watershed and the acquisition of additional park lands.

Participants in meetings were encouraged to express their views and make recommendations. Local support for the project has been high, as it is perceived as one of the major elements of a desired park revitalization program. Summaries of the public meetings and any written comments received are included in Appendix E.

RELATION OF PROJECT TO EXISTING PLANS AND PROGRAMS

The proposed project is intended to be entirely consistent with the goals of the Springfield Department of Parks and recreation, although its role in the revitalization, expansion and improvement of Hubbard Park might be better understood by the establishment of an official park master plan. The proposed project has been designed to minimize interference and maximize cooperation with public works projects. The proposed project will result in temporary inconvenience to park users, particularly ballplayers, but the overall improvement of the park environment is considered to offset this inconvenience. The project also necessitates increased maintenance of catch basins and proposed leaching basins by the City, but again the benefits are perceived to far outweigh any disadvantages.

With the recent acquisition of additional park land and the strength of community support for park improvements in Springfield, the time is right to restore Dimmock Pond, upgrade the ballfields, and establish a trail system which links the varied elements of Hubbard Park. The restoration of Dimmock Pond will have a marked effect on the other aspects of the park, precluding some improvements for several years but eventually facilitating all desired alterations and activities. It is therefore proper that the restoration of Dimmock Pond be conducted first among the desired park improvements.

FEASIBILITY SUMMARY

An evaluation of possible management options was conducted, and those alternatives which were not appropriate or feasible were eliminated from further consideration. Remaining options included storm water diversion (use of leaching basins) and detention, dredging of Dimmock Pond, bank and slope stabilization, and environmental education.

A tentative implementation schedule and associated costs are presented in Table 32. An implementation/post-implementation monitoring program and the production of an educational brochure are included. The total anticipated cost of the management program is $1,422,700.00. Potential funding sources have been discussed, with the Massachusetts Clean Lakes Program targeted as the likely primary source.

The anticipated impacts of the proposed management plan include reduction of the phosphorus load to Dimmock Pond by 48 to 77%, reduction of the corresponding nitrogen load by 55 to 85%, an 85 to 120% increase in water clarity, a 70 to 80% decrease in macrophyte density (with likely species and distributional changes), and an increase in bottom oxygen levels (relative to the saturation point) of up to 95%. Storm water runoff in the watershed will be managed to minimize impacts on the pond. The physical features of the pond itself will be altered to produce a more functional and aesthetically appealing water body consistent with recreational goals.

TABLE 32

SUMMARY OF MANAGEMENT ACTIONS, IMPLEMENTATION SCHEDULE, AND ASSOCIATED COSTS

Item/Task	Spring-Fall 1989	Winter 1990	Spring 1990	Summer 1990	Fall 1990	Winter 1991	Spring 1991	Summer 1991	Fall 1991
Grant Arrangements w/DEQE, Line up Potential Additional Funding Sources	X	X	X						
Permits					12,000	10,000		4,000	
Leaching Basins				6,000	5,000	4,000	63,000	63,000	
Dredging				20,000	20,000	29,000	235,000	127,100	127,100
Detention Structures							12,000	4,000	28,000
Monitoring						4,500	5,500	5,500	5,500
Education			4,000	4,000					
Total Cost ($)	X	X	4,000	30,000	37,000	47,500	315,500	203,600	160,600

Item/Task	Winter 1992	Spring 1992	Summer 1992	Fall 1992	Winter 1993	Spring 1993	Summer 1993-Fall 1996	Total Cost ($)
Grant Arrangements w/DEQE, Line up Potential Additional Funding Sources								Undetermined Administrative Costs
Permits								26,000
Leaching Basins								141,000
Dredging	10,000	199,400	109,400	56,000	10,000	158,000		1,101,000
Detention Structures								44,000
Monitoring	4,500	5,500	5,500	5,500	4,000	5,000	51,700	102,700
Education								8,000
Total Cost ($)	14,500	204,900	114,900	61,500	14,000	163,000	51,700	1,422,700

REFERENCES

APHA, AWWA, AND WPCF. 1985. Standard Methods for the Examination of Water and Wastewater (16th Edition). Published jointly by the authoring associations.

Baystate Environmental Consultants, Inc. 1980. Springfield Lakes and Ponds: Inventory and Restoration Plan. BEC, E. Longmeadow, MA.

Baystate Environmental Consultants, Inc. 1986. Diagnostic/Feasibility Study of Lake Massasoit. BEC, E. Longmeadow, MA.

Bordner, R., and J. Winter (eds.). 1978. Microbiological Methods for Monitoring the Environment. EPA600/8-78-017. Cincinatti, OH.

Chapra, S. 1975. Comment on: "An Empirical method of estimating the retention of phosphorus in lakes" by W.B. Kirchner and P.J. Dillon. Water Resour. Res. 11:1033-1034.

Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1986. Lake and Reservoir Restoration. Butterworths, Boston, MA.

Dillon, P.J., and F.H. Rigler. 1975. A simple method for predicting the capacity of a lake for development based on lake trophic status. J. Fish. Res. Bd. Canada 31: 1519-1522.

Dunne, T., and L.B. Leopold. 1978. Water in Environmental Planning. W. H. Freeman Co., San Francisco.

ERT, Inc. 1986. July 3rd letter to Mr. Stephen Joyce, Springfield DEQE, detailing the work plan for investigating contamination at the UniFirst site. ERT, Inc., Concord, MA.

ERT, Inc. 1987. Environmental Investigation: UniFirst, Springfield, MA site, DOC No. P-E209-003. ERT, Concord, MA.

Goldman, C.R., and A.J. Horne. 1983. Limnology. McGraw-Hill Co., New York.

Hanson, J.M., and W.C. Leggett. 1982. Empirical prediction of fish biomass and yield. Can. J. Fish. Aquat. Sci. 39:257-263.

Higgins, G.R., and J.M. Colonell, 1971. Hydrologic Factors in the Determination of Watershed Yields. Water Resour. Res. Ctr., Univ. Mass., Amherst, MA.

Jones, J.R., and R.W. Bachmann. 1976. Prediction of phosphorus and chlorophyll levels in lakes. JWPCF 48:2176-2184.

Kirchner, W.B., and P.J. Dillon. 1975. An empirical method of estimating the retention of phosphorus in lakes. Water Resour. Res. 11:182-183.

Kopp, J.F., and G.D. McKee. 1979. Methods for Chemical Analysis of Water and Wastes. USEPA 600/4-79-020, Wash., D.C.

Larsen, D.P., and H.T. Mercier. 1976. Phosphorus retention capacity of lakes. J. Fish. Res. Bd. Canada 33:1742-1750.

Martin, D.M., and D.R. Goff. 1972. The Role of Nitrogen in the Aquatic Environment. Contribution #2. Academy of Natural Sciences of Philadelphia, PA.

Massachusetts Division of Fisheries and Wildlife. 1979. Statewide Age and Growth of Warm Water Species. MDFW, Westborough, MA.

Massachusetts Division of Water Pollution Control. 1979. Certification for Dredging, Dredged Material Disposal, and Filling in Waters. 314 CMR, Vol. 12-534.

McKee, J.E., and H.W. Wolf. 1963. Water Quality Criteria. Publ. #3-A. State Water Res. Control Bd., Sacramento, CA.

Millipore Corp. 1972. Biological Analysis of Water and Wastewater. T.S. Rept. AM302. Millipore Corp., Bedford, MA.

Mitchell, D.M., K.J. Wagner, and C. Asbury. 1988. Direct measurement of groundwater flow and quality as a lake management tool. Lake Reserv. Manage. 4:169-178.

National Cartographic Information Center. 1985. Aerial Infrared Photographs of Massachusetts. Univ. of Massachusetts, Amherst, MA.

National Oceanographic and Atmospheric Administration. 1984. Microfiche record of precipitation at Massachusetts Monitoring Stations, 1951-1980. NOAA, Asheville, NC.

National Oceanographic and Atmospheric Administration. 1985. Climatography of the United States, Number 20, Massachusetts. NOAA, Asheville, NC.

National Oceanographic and Atmospheric Administration. 1987. Monthly Precipitation Summary Reports for New England Monitoring Stations. NOAA, Asheville, NC.

Nurnberg, G.K. 1984. The prediction of internal phosphorus load in lakes with anoxic hypolimnia. Limnol. Oceanogr. 29:111-124.

Oglesby, R.T., and W.R. Schaffner. 1978. Phosphorus loadings to lakes and some of their responses: Part II: Regression models of summer phytoplankton standing crops, winter total phosphorus, and transparency of New York lakes with known phosphorus loadings. Limnol. Oceanogr. 23:135-145.

Reckhow, K.H., M.N. Beaulac, and J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients. USEPA 440/5-80-011, Wash., D.C.

Redfield, G.W. and R.C. Jones. 1982. Effects of urbanization on lake ecosystems. Pages 42-60 in: Jones, R.C., G.W. Redfield, and D.P. Kelso (Eds.). Urbanization, Stormwater Runoff and the Aquatic Environment. George Mason Univ., Fairfax, Va.

Sartor, J.B. and G.B. Boyd. 1972. Water Pollution Aspects of Street Surface Contaminants. EPA-R2-72-081. USEPA, Washington, D.C.

Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's. Metropolitan Washington Council of Governments, Washington, D.C.

Smith, C.S. and M.S. Adams. 1986. Phosphorus transfer from sediments by Myriophyllum spicatum. Limnol. Oceanogr. 31:1312-1321.

Soil Conservation Service. 1975a. Engineering Field Manual for Conservation Practices. USDA, SCS, Wash., DC.

Soil Conservation Service. 1975b. Guidelines for Soil and Water Conservation in Urbanizing Areas of Massachusetts. USDA, Amherst, MA.

Soil Conservation Service. 1975c. Urban Hydrology for Small Watersheds. Tech. Release #55, USDA, Wash., DC.

Soil Conservation Service. 1978. Soil Survey of Central Hampden County. USDA, Amherst, MA.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. Second Edition. W.H. Freeman Co., New York.

Sopper, W.E., and H.W. Lull. 1970. Streamflow Characteristics of the Northeastern United States. Penn State Univ. Bull. 766, Univ. Park, PA.

United States Geological Survey. 1969. Ludlow Quadrangle Sheet, 7.5 Minute Series. USGS, Bethesda, MD.

United States Geological Survey. 1970. Springfield North Quadrangle Sheet, 7.5 Minute Series. USGS, Bethesda, MD.

United States Environmental Protection Agency. 1977. Report on the Bottom Sediment Survey for Port Ontario, NY. Region V EPA, Chicago, IL.

United States Geological Survey. 1977. Limiting Values for Water Quality Alert System. USGS Circular, August 22, 1977. USGS, Trenton, NJ.

Uttormark, P.D., J.D. Chapin, and K.M. Green. 1974. Estimating Nutrient Loadings of Lakes from Non-point Sources. USEPA 660/3-74-020, Wash., D.C.

Vollenweider, R.A. 1968. Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication. Tech. Rept. to OECD, Paris, France.

Vollenweider, R.A. 1975. Input-output models with special references to t phosphorus loading concept in limnology. Schweiz. Z. Hydrol. 37:53-6

Vollenwieder, R.A. 1982. Eutrophication of Waters: Monitoring, Assessment and Control. OECD, Paris, France.

Water Pollution Control Federation. 1970. Design and Construction of Sanitary and Storm Sewers. WPCF, Washington, DC.

Wetzel, R.G. 1975. Limnology. Saunders Co., Philadelphia, PA.

Zen, E. 1983. Bedrock Geologic Map. USGS and MA DPW, Boston, MA.

APPENDIX A

DATA GENERATED BY THE BEC STUDY

ORTHOPHOSPHORUS (UG/L) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	50	70
02/23/87	30	30
03/16/87	0	10
04/02/87	10	40
04/21/87	30	30
05/04/87	30	30
05/17/87	40	50
06/01/87	30	60
06/17/87	30	80
07/06/87	30	100
07/20/87	30	110
08/03/87	100	0
08/19/87	50	80
09/02/87	60	60
09/21/87	0	100
10/19/87	0	0
11/16/87	40	30
12/14/87	30	20
MAXIMUM	100	110
MINIMUM	0	0
MEAN	33	50

TOTAL PHOSPHORUS (UG/L) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	70	100
02/23/87	30	50
03/16/87	10	130
04/02/87	30	290
04/21/87	60	80
05/04/87	30	30
05/17/87	60	50
06/01/87	50	80
06/17/87	960	1440
07/06/87	70	110
07/20/87	800	1990
08/03/87	100	200
08/19/87	80	190
09/02/87	60	60
09/21/87	40	10
10/19/87	80	60
11/16/87	80	80
12/14/87	50	60
MAXIMUM	960	1990
MINIMUM	10	10
MEAN	148	278

AMMONIA NITROGEN (MG/L) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	.27	.34
02/23/87	.39	.35
03/16/87	.41	.51
04/02/87	.19	.23
04/21/87	.15	.23
05/04/87	.05	.05
05/17/87	.15	.62
06/01/87	.42	.46
06/17/87	.54	.69
07/06/87	.63	.78
07/20/87	.64	.87
08/03/87	.22	.09
08/19/87	.16	.15
09/02/87	.23	.28
09/21/87	.11	.14
10/19/87	.12	.16
11/16/87	.13	.14
12/14/87	.04	.06
MAXIMUM	.64	.87
MINIMUM	.04	.05
MEAN	.27	.34

NITRATE NITROGEN (MG/L AS N) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	.06	.05
02/23/87	.08	.07
03/16/87	.04	.07
04/02/87	.04	.05
04/21/87	.01	.04
05/04/87	.05	.05
05/17/87	.07	.08
06/01/87	.03	.05
06/17/87	.05	.08
07/06/87	.04	.08
07/20/87	.06	.07
08/03/87	.57	.67
08/19/87	.06	.06
09/02/87	.07	.07
09/21/87	.08	.07
10/19/87	.02	.04
11/16/87	.09	.10
12/14/87	.16	.19
MAXIMUM	.57	.67
MINIMUM	.01	.04
MEAN	.09	.11

KJELDAHL NITROGEN (MG/L AS N) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	1.12	1.78
02/23/87	.98	1.11
03/16/87	.72	.99
04/02/87	1.01	1.15
04/21/87	1.15	1.20
05/04/87	1.12	1.99
05/17/87	1.22	2.01
06/01/87	.99	1.16
06/17/87	2.10	2.99
07/06/87	1.46	1.67
07/20/87	2.25	3.38
08/03/87	1.10	1.55
08/19/87	.75	1.55
09/02/87	.60	.70
09/21/87	.45	.95
10/19/87	.85	.75
11/16/87	.95	.90
12/14/87	.75	.85
MAXIMUM	2.25	3.38
MINIMUM	.45	.70
MEAN	1.09	1.48

TOTAL N:TOTAL P RATIOS IN DIMMOCK POND

STATION DATE	DP-1S	DP-1B
01/26/87	37.25	40.44
02/23/87	78.09	52.16
03/16/87	167.96	18.02
04/02/87	77.35	9.14
04/21/87	42.73	34.26
05/04/87	86.19	150.28
05/17/87	47.52	92.38
06/01/87	45.08	33.43
06/17/87	4.95	4.71
07/06/87	47.36	35.16
07/20/87	6.38	3.83
08/03/87	36.91	24.53
08/19/87	22.38	18.73
09/02/87	24.68	28.36
09/21/87	29.28	225.42
10/19/87	24.03	29.10
11/16/87	28.73	27.62
12/14/87	40.22	38.31
MAXIMUM	168	225
MINIMUM	5	4
MEAN	47	48

TEMPERATURE (C) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	0.0	1.9
02/23/87	-2.1	1.0
03/16/87	0.0	1.0
04/02/87	6.2	5.9
04/21/87	13.0	9.0
05/04/87	10.8	7.9
05/17/87	15.5	9.2
06/01/87	24.2	11.0
06/17/87	20.8	14.5
07/06/87	21.6	15.8
07/20/87	21.5	15.0
08/03/87	19.4	17.3
08/19/87	23.0	19.0
09/02/87	16.1	14.5
09/21/87	12.8	12.2
10/19/87	8.2	7.3
11/16/87	.9	.2
12/14/87	.1	-.1
MAXIMUM	24.2	19.0
MINIMUM	-2.1	-.1
MEAN	11.8	9.0

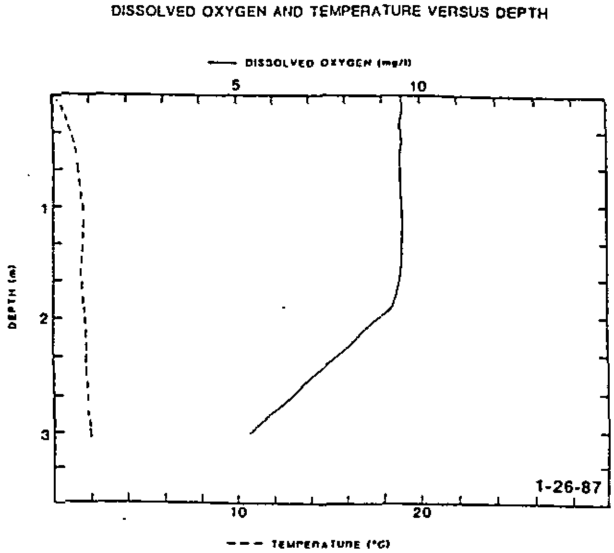
DISSOLVED OXYGEN (MG/L) IN THE DIMMOCK POND SYSTEM

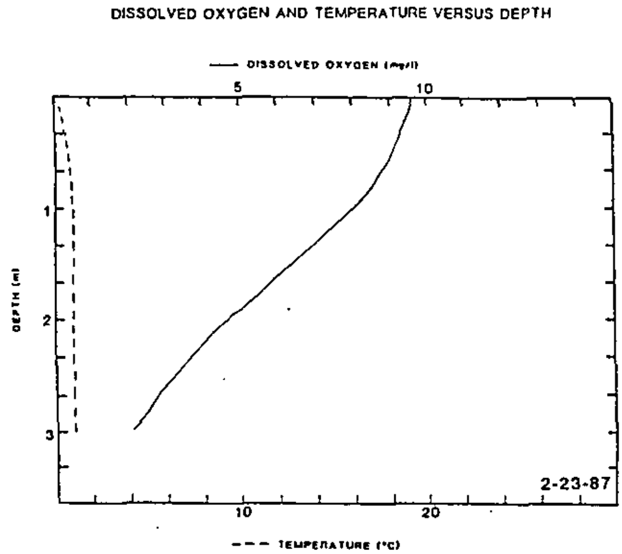
STATION DATE	DP-1S	DP-1B
01/26/87	9.2	5.9
02/23/87	9.6	2.1
03/16/87	9.5	6.3
04/02/87	10.1	9.4
04/21/87	10.0	7.5
05/04/87	9.7	4.5
05/17/87	10.1	1.1
06/01/87	8.4	.2
06/17/87	9.7	.1
07/06/87	9.4	.2
07/20/87	7.7	.2
08/03/87	7.1	.5
08/19/87	7.0	.3
09/02/87	10.0	.3
09/21/87	9.9	1.0
10/19/87	11.8	5.0
11/16/87	12.2	4.2
12/14/87	13.8	4.2
MAXIMUM	13.8	9.4
MINIMUM	7.0	.1
MEAN	9.7	2.9

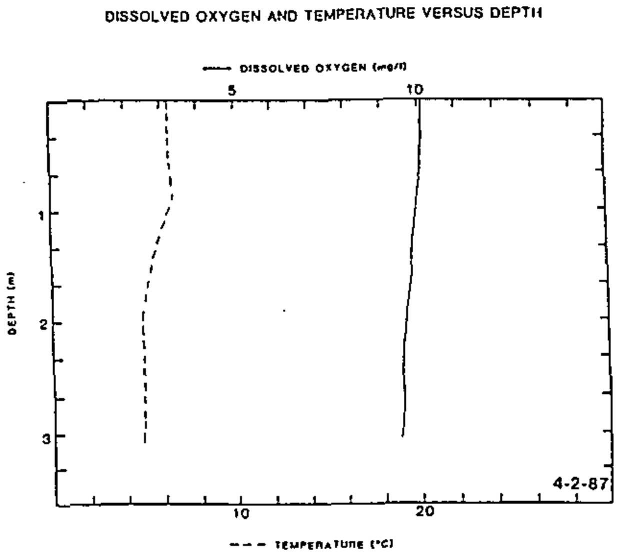
PERCENT OXYGEN SATURATION IN DIMMOCK POND

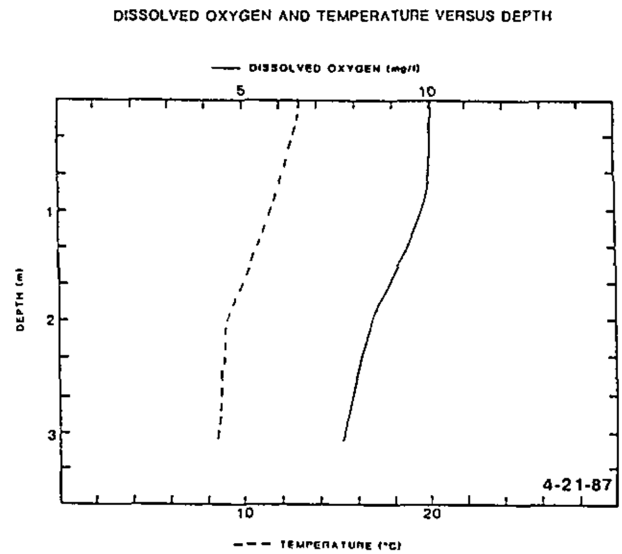
STATION DATE	DP-1S	DP-1B
01/26/87	63	43
02/23/87	62	15
03/16/87	65	44
04/02/87	82	75
04/21/87	95	65
05/04/87	88	38
05/17/87	101	10
06/01/87	100	2
06/17/87	108	1
07/06/87	107	2
07/20/87	87	2
08/03/87	77	5
08/19/87	82	3
09/02/87	102	3
09/21/87	94	9
10/19/87	100	42
11/16/87	86	29
12/14/87	95	29
MEAN	88	23
MAXIMUM	108	75
MINIMUM	62	1

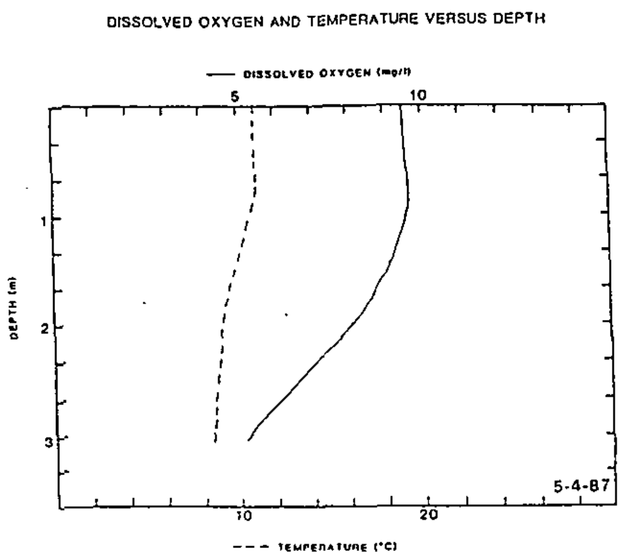
DIMMOCK POND T/DO PROFILES

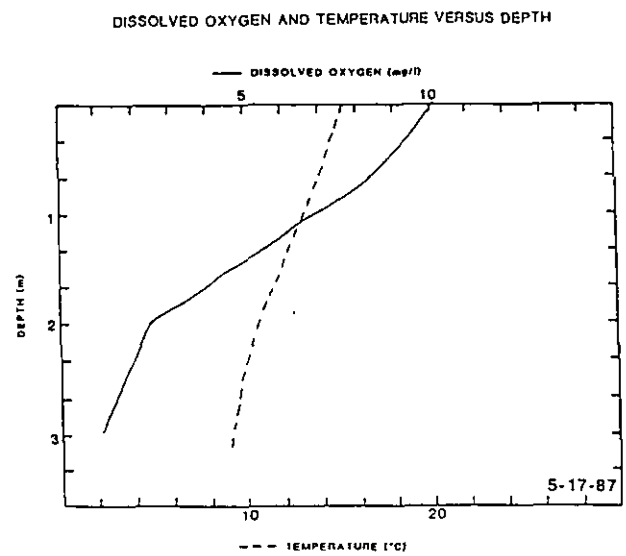






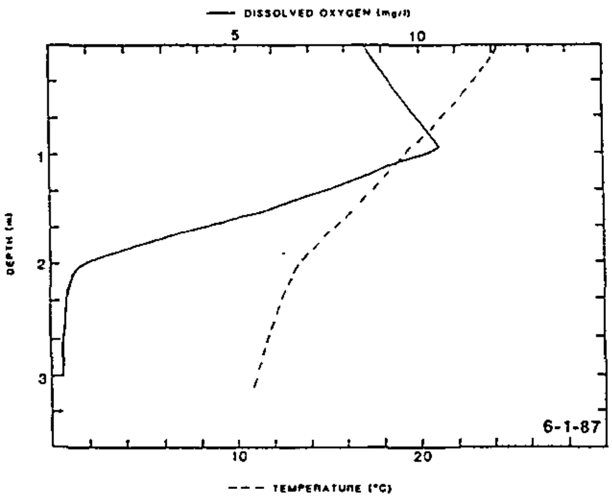






DIMMOCK POND T/DO PROFILES

DISSOLVED OXYGEN AND TEMPERATURE VERSUS DEPTH



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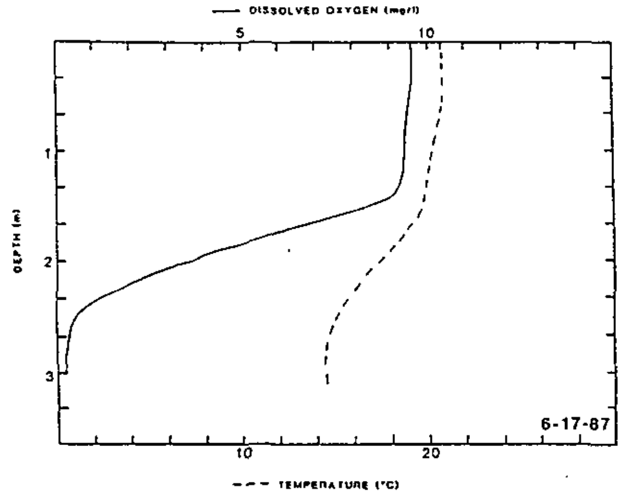

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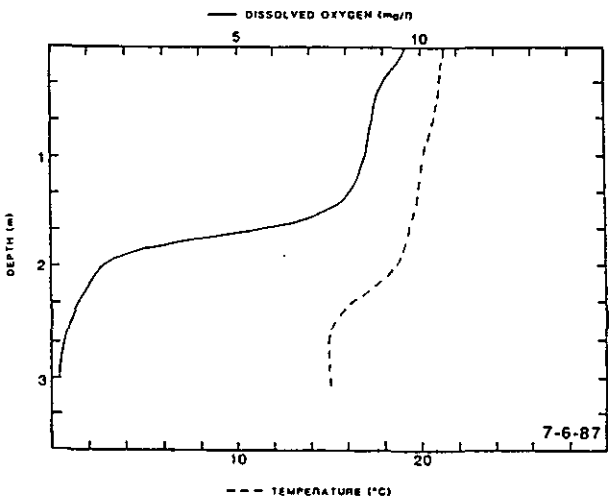

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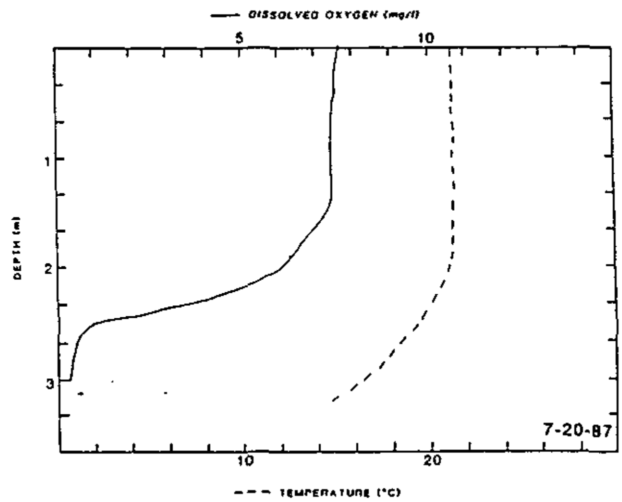

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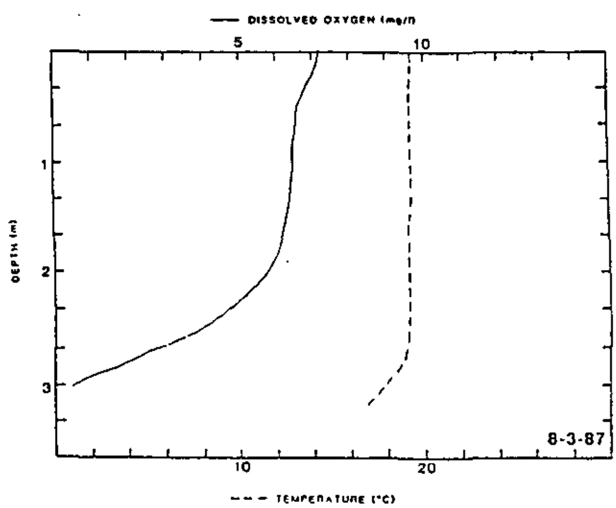

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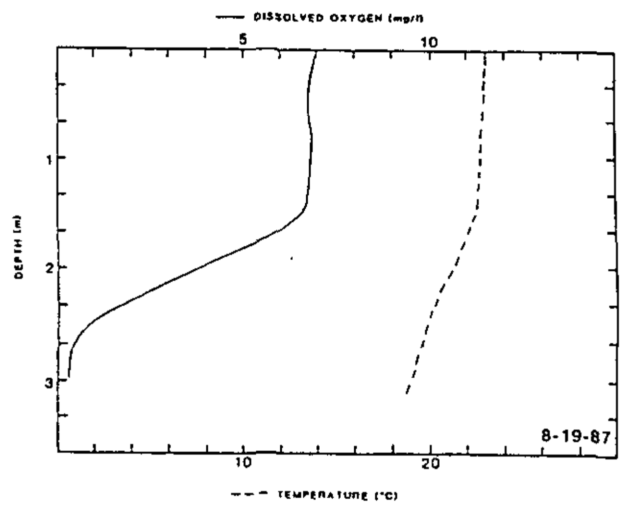
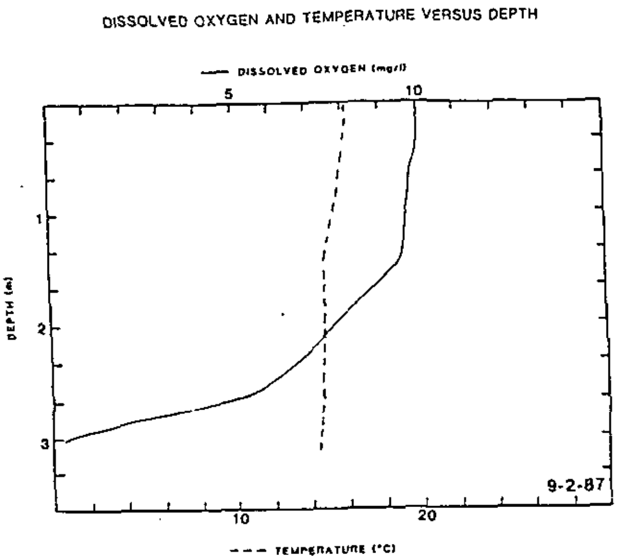
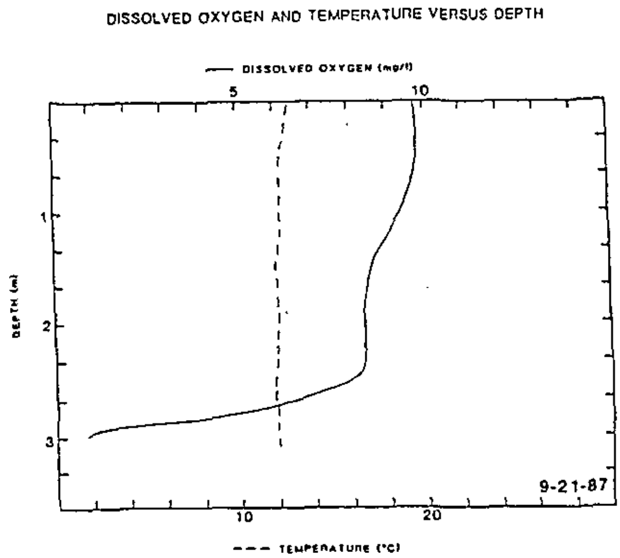
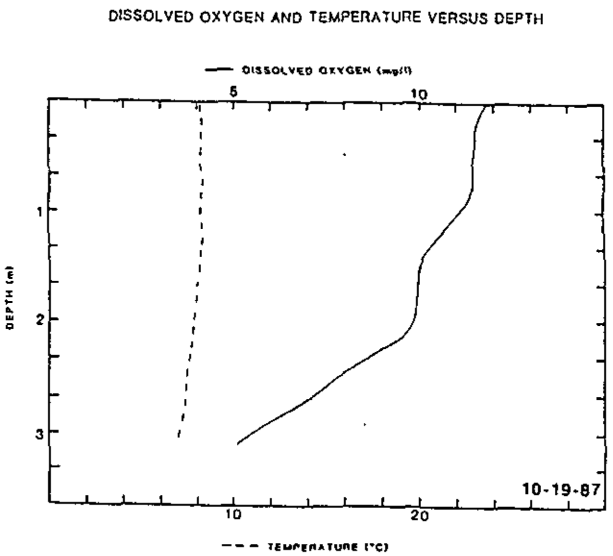
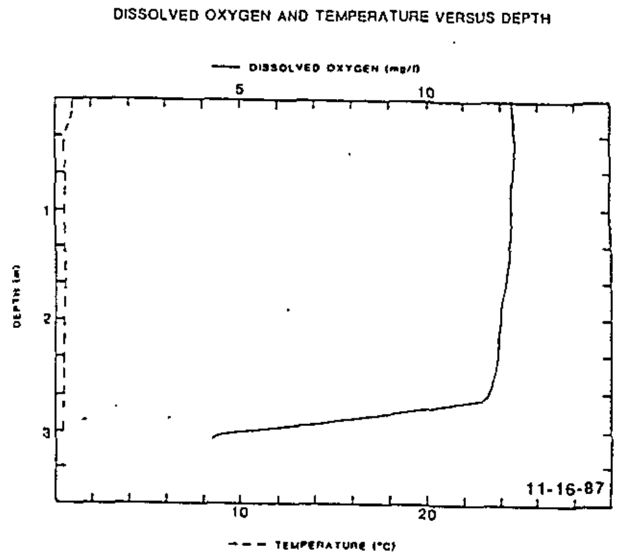


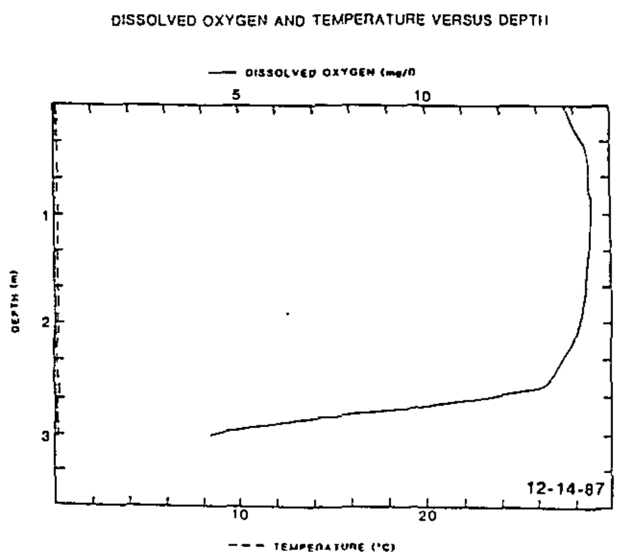
DIMMOCK POND T/DO PROFILES











PH (S.U.) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	5.5	5.4
02/23/87	5.7	5.3
03/16/87	5.5	5.5
04/02/87	5.8	5.6
04/21/87	5.6	5.5
05/04/87	5.7	5.4
05/17/87	5.8	5.7
06/01/87	5.6	6.2
06/17/87	6.4	6.0
07/06/87	6.0	5.4
07/20/87	6.3	5.9
08/03/87	5.9	5.9
08/19/87	5.8	5.8
09/02/87	6.2	5.8
09/21/87	6.6	6.5
10/19/87	6.4	6.3
11/16/87	6.3	6.3
12/14/87	6.5	6.4
MAXIMUM	6.6	6.5
MINIMUM	5.5	5.3

TOTAL ALKALINITY (MG/L AS CACO3) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	12.0	15.0
02/23/87	12.0	11.0
03/16/87	.7	1.0
04/02/87	5.0	5.0
04/21/87	.5	1.0
05/04/87	.5	2.0
05/17/87	1.0	2.0
06/01/87	1.0	.5
06/17/87	1.0	.5
07/06/87	1.5	.5
07/20/87	.5	.5
08/03/87	4.0	5.0
08/19/87	3.0	3.0
09/02/87	4.0	3.0
09/21/87	5.0	4.0
10/19/87	.5	3.0
11/16/87	3.0	2.0
12/14/87	3.0	2.0
MAXIMUM	12.0	15.0
MINIMUM	.5	.5
MEAN	3.2	3.4

CONDUCTIVITY (UMHOS/CM) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	68	97
02/23/87	106	105
03/16/87	89	100
04/02/87	84	82
04/21/87	83	83
05/04/87	80	79
05/17/87	85	81
06/01/87	79	82
06/17/87	85	83
07/06/87	73	73
07/20/87	74	75
08/03/87	77	77
08/19/87	76	74
09/02/87	78	77
09/21/87	75	73
10/19/87	97	95
11/16/87	107	108
12/14/87	78	75
MAXIMUM	107	108
MINIMUM	68	73
MEAN	83	84

CHLORIDE (MG/L) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	25.0	27.0
02/23/87	33.3	47.0
03/16/87	30.0	37.0
04/02/87	26.0	17.0
04/21/87	26.7	26.7
05/04/87	26.4	26.4
05/17/87	31.0	30.0
06/01/87	18.7	19.8
06/17/87	20.9	30.8
07/06/87	28.6	33.0
07/20/87	27.5	33.0
08/03/87	17.8	15.6
08/19/87	17.6	15.4
09/02/87	15.4	16.5
09/21/87	11.5	12.1
10/19/87	19.0	18.0
11/16/87	22.7	20.6
12/14/87	24.5	19.4
MAXIMUM	33.3	47.0
MINIMUM	11.5	12.1
MEAN	23.5	24.7

TOTAL SUSPENDED SOLIDS (MG/L) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	8.5	7.5
02/23/87	4.4	2.6
03/16/87	4.0	38.0
04/02/87	6.0	30.0
04/21/87	.4	11.2
05/04/87	4.0	22.0
05/17/87	4.8	12.2
06/01/87	6.4	17.6
06/17/87	13.2	36.4
07/06/87	15.2	26.4
07/20/87	6.8	12.0
08/03/87	4.0	4.0
08/19/87	2.0	18.5
09/02/87	4.8	4.0
09/21/87	3.0	40.5
10/19/87	4.8	10.4
11/16/87	3.2	6.0
12/14/87	3.2	6.0
MAXIMUM	15.2	40.5
MINIMUM	.4	2.6
MEAN	5.5	17.0

TURBIDITY (NTU) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S	DP-1B
01/26/87	1.3	2.5
02/23/87	1.4	1.3
03/16/87	1.8	6.6
04/02/87	3.4	8.5
04/21/87	2.2	4.9
05/04/87	4.4	7.7
05/17/87	4.5	6.6
06/01/87	3.1	7.0
06/17/87	1.9	3.5
07/06/87	.6	3.0
07/20/87	.5	.6
08/03/87	2.3	2.4
08/19/87	.9	1.4
09/02/87	2.5	3.4
09/21/87	3.3	3.1
10/19/87	2.6	4.2
11/16/87	2.0	2.1
12/14/87	3.4	3.2
MAXIMUM	4.5	8.5
MINIMUM	.5	.6
MEAN	2.3	4.0

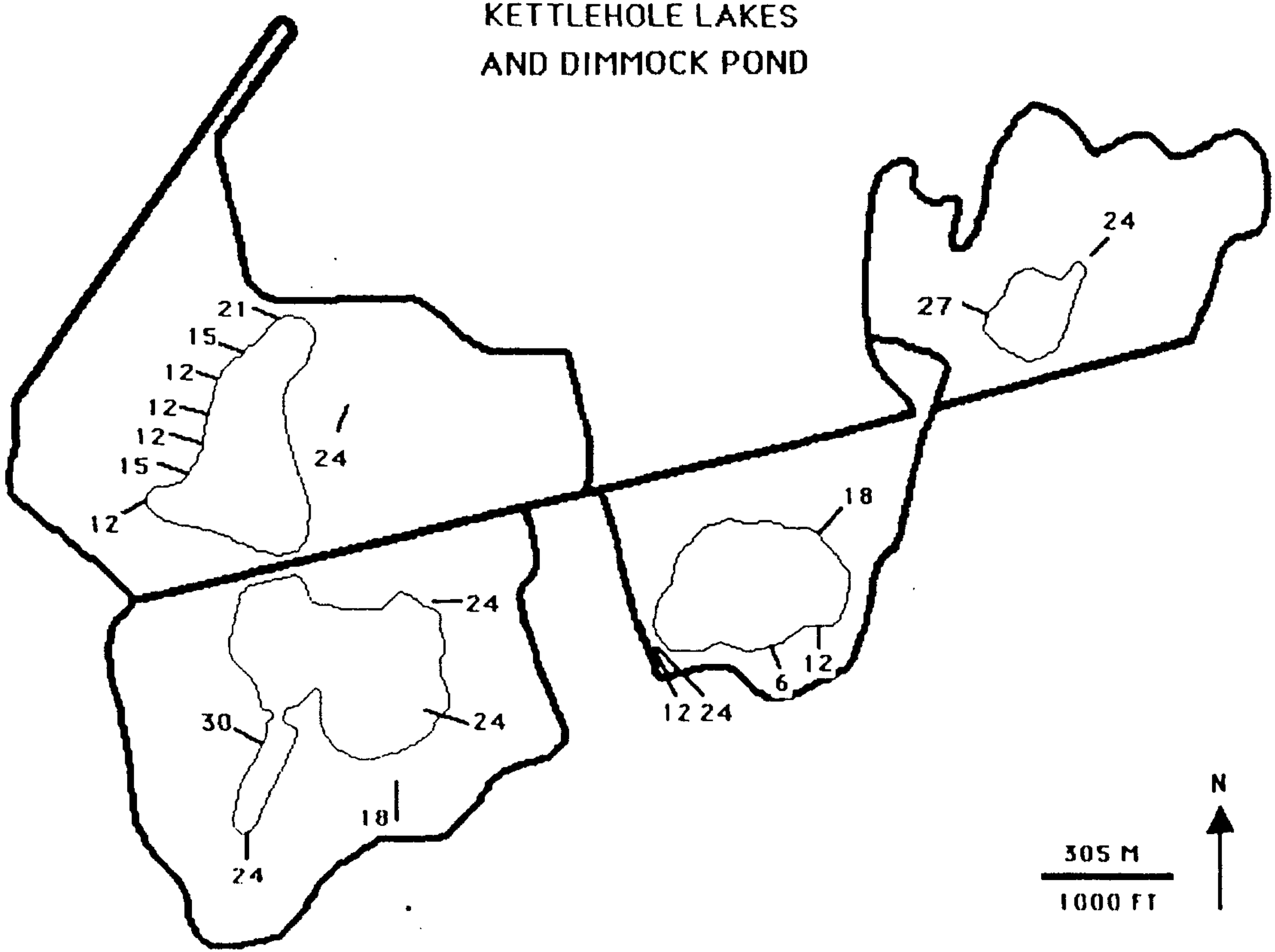
FECAL COLIFORM (#/100 ML) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S
01/26/87	2
02/26/87	2
03/16/87	2
04/02/87	2
04/21/87	2
05/04/87	6
05/17/87	2
06/01/87	4
06/17/87	4
07/06/87	2
07/20/87	2
08/03/87	16
08/19/87	
09/02/87	6
09/21/87	22
10/19/87	2
11/16/87	2
12/14/87	2
MAXIMUM	22
MINIMUM	2

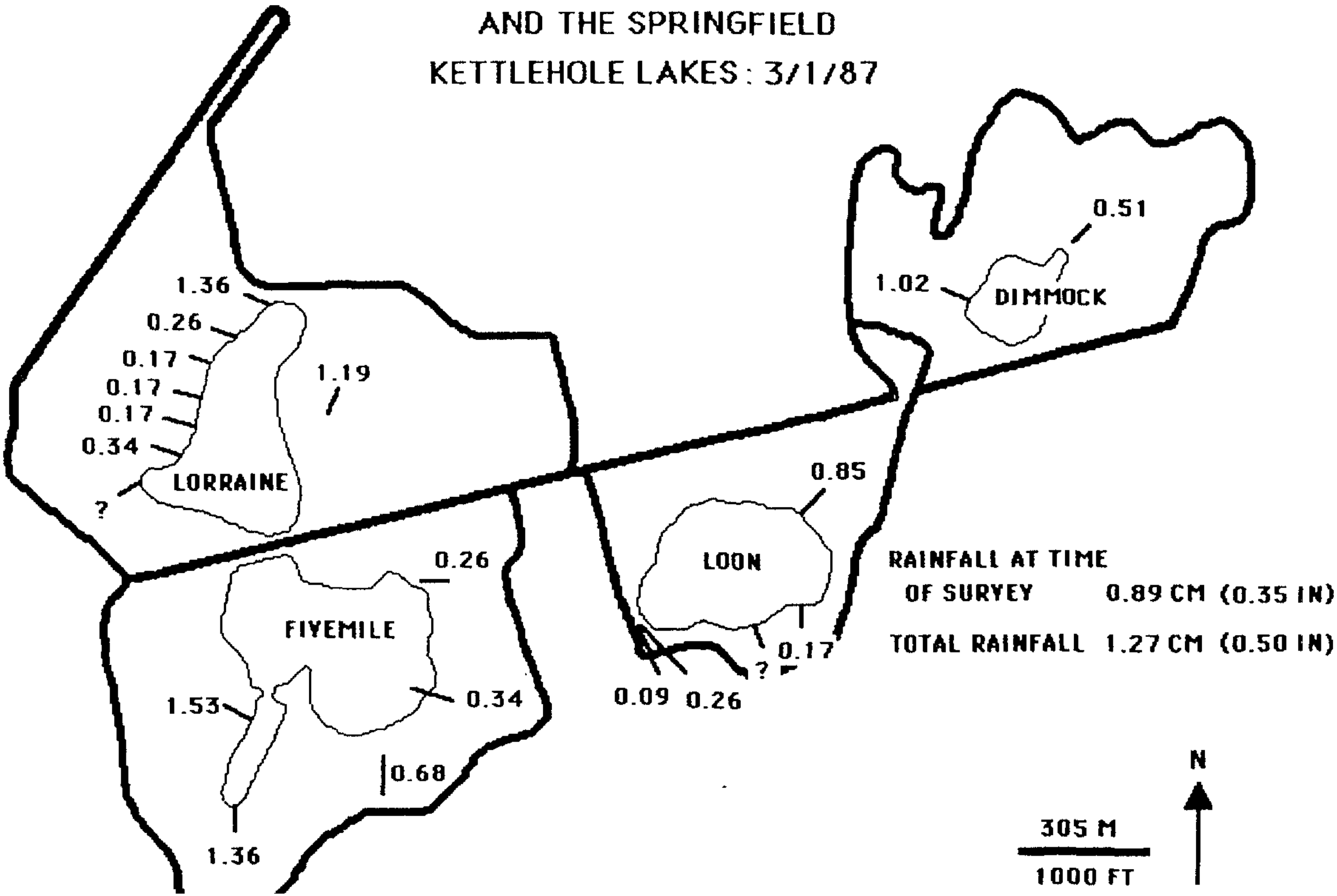
FECAL STREPTOCOCCI (#/100 ML) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S
01/26/87	2
02/23/87	2
03/16/87	2
04/02/87	2
04/21/87	2
05/04/87	2
05/17/87	2
06/01/87	12
06/17/87	2
07/06/87	2
07/20/87	2
08/03/87	4
08/19/87	
09/02/87	2
09/21/87	60
10/19/87	2
11/16/87	4
12/14/87	6
MAXIMUM	60
MINIMUM	2

LOCATIONS AND DIAMETERS (INCHES) OF DISCHARGE PIPES ASSOCIATED WITH THE SPRINGFIELD KETTLEHOLE LAKES AND DIMMOCK POND



FLOWS (CU.M/MIN) IN DISCHARGE
PIPES ASSOCIATED WITH DIMMOCK POND
AND THE SPRINGFIELD
KETTLEHOLE LAKES: 3/1/87



SECCHI TRANSPARENCY (M) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1S
01/26/87	1.1
02/23/87	1.4
03/16/87	1.0
04/02/87	1.0
04/21/87	1.6
05/04/87	1.0
05/17/87	1.0
06/01/87	1.0
06/17/87	3.0
07/06/87	1.7
07/20/87	1.6
08/03/87	1.3
08/19/87	1.4
09/02/87	1.9
09/21/87	1.4
10/19/87	2.1
11/16/87	2.5
12/14/87	2.5
MAXIMUM	3.0
MINIMUM	1.0
MEAN	1.6

CHLOROPHYLL (UG/L) IN THE DIMMOCK POND SYSTEM

STATION DATE	DP-1
01/26/87	8.8
02/23/87	6.2
03/16/87	4.3
04/02/87	9.6
04/21/87	2.5
05/04/87	5.6
05/17/87	9.5
06/01/87	6.9
06/17/87	6.9
07/06/87	7.9
07/20/87	4.1
08/03/87	35.1
08/19/87	13.7
09/02/87	12.1
09/21/87	7.8
10/19/87	3.7
11/16/87	1.8
12/14/87	8.7
MAXIMUM	35.1
MINIMUM	1.8
MEAN	8.6

DIMMOCK POND PHYTOPLANKTON

012687

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	26.4
Eunotia	1.1
Fragilaria	26.4
Neidium	1.1
Pinnularia	1.1
Tabellaria	2.2
CHLOROPHYTA	
Chlamydomonas	154
Closterium	2.2
Scenedesmus	13.2
Staurastrum	1.1
CHRYSOPHYTA	
Dinobryon	19.8
CRYPTOPHYTA	
Cryptomonas	41.8
PYRRHOPHYTA	
Peridinium	1.1
TOTAL	291.5
BACILLARIOPHYTA	58.3
CHLOROPHYTA	170.5
CHRYSOPHYTA	19.8
CRYPTOPHYTA	41.8
PYRRHOPHYTA	1.1

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	5.2
Eunotia	1.1
Fragilaria	7.9
Neidium	1.9
Pinnularia	66
Tabellaria	6.6
CHLOROPHYTA	
Chlamydomonas	15.4
Closterium	8.8
Scenedesmus	1.3
Staurastrum	13.2
CHRYSOPHYTA	
Dinobryon	59.4
CRYPTOPHYTA	
Cryptomonas	8.3
PYRRHOPHYTA	
Peridinium	49.5
TOTAL	244.8
BACILLARIOPHYTA	88.8
CHLOROPHYTA	38.7
CHRYSOPHYTA	59.4
CRYPTOPHYTA	8.3
PYRRHOPHYTA	49.5

022387

TAXON	CELLS/ML
CHLOROPHYTA	
Closterium	1.4
CRYPTOPHYTA	
Cryptomonas	14
PYRRHOPHYTA	
Peridinium	1.4
TOTAL	16.8
CHLOROPHYTA	1.4
CRYPTOPHYTA	14
PYRRHOPHYTA	1.4

TAXON	*UG/L*
CHLOROPHYTA	
Closterium	140
CRYPTOPHYTA	
Cryptomonas	14
PYRRHOPHYTA	
Peridinium	63
TOTAL	217
CHLOROPHYTA	140
CRYPTOPHYTA	14
PYRRHOPHYTA	63

031687

TAXON	CELLS/ML
BACILLARIOPHYTA	
Navicula	1.3
CHLOROPHYTA	
Staurastrum	1.3
CRYPTOPHYTA	
Cryptomonas	28.6
TOTAL	31.2
BACILLARIOPHYTA	1.3
CHLOROPHYTA	1.3
CRYPTOPHYTA	28.6

TAXON	UG/L
BACILLARIOPHYTA	
Navicula	6.5
CHLOROPHYTA	
Staurastrum	1.0
CRYPTOPHYTA	
Cryptomonas	5.7
TOTAL	13.2
BACILLARIOPHYTA	6.5
CHLOROPHYTA	1.0
CRYPTOPHYTA	5.7

040287

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	28.8
Nitzschia	1.8
CHLOROPHYTA	
Chlamydomonas	396
PYRRHOPHYTA	
Peridinium	1.8
TOTAL	428.4
BACILLARIOPHYTA	30.6
CHLOROPHYTA	396
PYRRHOPHYTA	1.8

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	5.7
Nitzschia	1.4
CHLOROPHYTA	
Chlamydomonas	39.6
PYRRHOPHYTA	
Peridinium	81
TOTAL	127.8
BACILLARIOPHYTA	7.2
CHLOROPHYTA	39.6
PYRRHOPHYTA	81

042187

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	509.6
CHRYSOPHYTA	
Dinobryon	260
CRYPTOPHYTA	
Cryptomonas	16.9
PYRRHOPHYTA	
Peridinium	5.2
TOTAL	791.7
BACILLARIOPHYTA	509.6
CHRYSOPHYTA	260
CRYPTOPHYTA	16.9
PYRRHOPHYTA	5.2

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	101.9
CHRYSOPHYTA	
Dinobryon	780
CRYPTOPHYTA	
Cryptomonas	3.3
PYRRHOPHYTA	
Peridinium	15.6
TOTAL	900.9
BACILLARIOPHYTA	101.9
CHRYSOPHYTA	780
CRYPTOPHYTA	3.3
PYRRHOPHYTA	15.6

050487

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	160
CHLOROPHYTA	
Ankistrodesmus	4
Closterium	1
Scenedesmus	4
Staurastrum	5
CHRYSOPHYTA	
Dinobryon	54
CYANOPHYTA	
Chroococcus	16
EUGLENOPHYTA	
Trachelomonas	2
PYRRHOPHYTA	
Peridinium	6
TOTAL	252
BACILLARIOPHYTA	160
CHLOROPHYTA	14
CHRYSOPHYTA	54
CYANOPHYTA	16
EUGLENOPHYTA	2
PYRRHOPHYTA	6

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	32
CHLOROPHYTA	
Ankistrodesmus	.4
Closterium	4
Scenedesmus	.4
Staurastrum	4
CHRYSOPHYTA	
Dinobryon	162
CYANOPHYTA	
Chroococcus	.1
EUGLENOPHYTA	
Trachelomonas	2
PYRRHOPHYTA	
Peridinium	270
TOTAL	474.9
BACILLARIOPHYTA	32
CHLOROPHYTA	8.8
CHRYSOPHYTA	162
CYANOPHYTA	.1
EUGLENOPHYTA	2
PYRRHOPHYTA	270

051787

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	1248
CHLOROPHYTA	
Ankistrodesmus	416
Sphaerocystis	546
Staurastrum	15.6
CHRYSOPHYTA	
Dinobryon	54.6
CYANOPHYTA	
Chroococcus	364
PYRRHOPHYTA	
Peridinium	41.6
TOTAL	2685.8
BACILLARIOPHYTA	1248
CHLOROPHYTA	977.6
CHRYSOPHYTA	54.6
CYANOPHYTA	364
PYRRHOPHYTA	41.6

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	249.6
CHLOROPHYTA	
Ankistrodesmus	41.6
Sphaerocystis	218.4
Staurastrum	12.4
CHRYSOPHYTA	
Dinobryon	163.8
CYANOPHYTA	
Chroococcus	3.6
PYRRHOPHYTA	
Peridinium	1872
TOTAL	2561.5
BACILLARIOPHYTA	249.6
CHLOROPHYTA	272.4
CHRYSOPHYTA	163.8
CYANOPHYTA	3.6
PYRRHOPHYTA	1872

060187

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	32
CHLOROPHYTA	
Ankistrodesmus	112
Coelastrum	24
Pediastrum	24
Scenedesmus	16
Staurastrum	48
CYANOPHYTA	
Chroococcus	28
PYRRHOPHYTA	
Peridinium	30
TOTAL	314
BACILLARIOPHYTA	32
CHLOROPHYTA	224
CYANOPHYTA	28
PYRRHOPHYTA	30

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	6.4
CHLOROPHYTA	
Ankistrodesmus	11.2
Coelastrum	4.8
Pediastrum	4.8
Scenedesmus	1.6
Staurastrum	38.4
CYANOPHYTA	
Chroococcus	.2
PYRRHOPHYTA	
Peridinium	258
TOTAL	325.4
BACILLARIOPHYTA	6.4
CHLOROPHYTA	60.8
CYANOPHYTA	.2
PYRRHOPHYTA	258

061787

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	13.6
Cymbella	1.7
CHLOROPHYTA	
Scenedesmus	6.8
Staurastrum	34
EUGLENOPHYTA	
Phacus	3.4
Trachelomonas	5.1
PYRRHOPHYTA	
Peridinium	91.8
TOTAL	156.4
BACILLARIOPHYTA	15.3
CHLOROPHYTA	40.8
EUGLENOPHYTA	8.5
PYRRHOPHYTA	91.8

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	2.7
Cymbella	2.5
CHLOROPHYTA	
Scenedesmus	.6
Staurastrum	27.2
EUGLENOPHYTA	
Phacus	1.0
Trachelomonas	5.1
PYRRHOPHYTA	
Peridinium	275.4
TOTAL	314.6
BACILLARIOPHYTA	5.2
CHLOROPHYTA	27.8
EUGLENOPHYTA	6.1
PYRRHOPHYTA	275.4

070687

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	10
CHLOROPHYTA	
Ankistrodesmus	17.5
Staurastrum	7.5
CRYPTOPHYTA	
Cryptomonas	7.5
CYANOPHYTA	
Chroococcus	90
EUGLENOPHYTA	
Euglena	5
Trachelomonas	5
PYRRHOPHYTA	
Peridinium	232.5
TOTAL	375
BACILLARIOPHYTA	10
CHLOROPHYTA	25
CRYPTOPHYTA	7.5
CYANOPHYTA	90
EUGLENOPHYTA	10
PYRRHOPHYTA	232.5

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	2
CHLOROPHYTA	
Ankistrodesmus	8.7
Staurastrum	6
CRYPTOPHYTA	
Cryptomonas	33.7
CYANOPHYTA	
Chroococcus	.9
EUGLENOPHYTA	
Euglena	2.5
Trachelomonas	5
PYRRHOPHYTA	
Peridinium	2062.5
TOTAL	2121.4
BACILLARIOPHYTA	2
CHLOROPHYTA	14.7
CRYPTOPHYTA	33.7
CYANOPHYTA	.9
EUGLENOPHYTA	7.5
PYRRHOPHYTA	2062.5

072087

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	6.8
CHLOROPHYTA	
Micrasterias	3.4
Pediastrum	54.4
Staurastrum	3.4
CHRYSOPHYTA	
Dinobryon	23.8
CRYPTOPHYTA	
Cryptomonas	3.4
CYANOPHYTA	
Chroococcus	268.6
Microcystis	1020
EUGLENOPHYTA	
Euglena	1.7
Phacus	1.7
PYRRHOPHYTA	
Peridinium	119
TOTAL	1506.2
BACILLARIOPHYTA	6.8
CHLOROPHYTA	61.2
CHRYSOPHYTA	23.8
CRYPTOPHYTA	3.4
CYANOPHYTA	1288.6
EUGLENOPHYTA	3.4
PYRRHOPHYTA	119

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	1.3
CHLOROPHYTA	
Micrasterias	408
Pediastrum	10.8
Staurastrum	2.7
CHRYSOPHYTA	
Dinobryon	71.4
CRYPTOPHYTA	
Cryptomonas	15.3
CYANOPHYTA	
Chroococcus	2.6
Microcystis	204
EUGLENOPHYTA	
Euglena	42.5
Phacus	.5
PYRRHOPHYTA	
Peridinium	2856
TOTAL	3615.3
BACILLARIOPHYTA	1.3
CHLOROPHYTA	421.6
CHRYSOPHYTA	71.4
CRYPTOPHYTA	15.3
CYANOPHYTA	206.6
EUGLENOPHYTA	43.0
PYRRHOPHYTA	2856

080387

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	29.6
CHLOROPHYTA	
Micrasterias	7.4
Staurastrum	14.8
CHRYSOPHYTA	
Dinobryon	14.8
CRYPTOPHYTA	
Cryptomonas	7.4
CYANOPHYTA	
Chroococcus	1213.6
Microcystis	740
EUGLENOPHYTA	
Trachelomonas	14.8
PYRRHOPHYTA	
Peridinium	425.5
TOTAL	2467.9
BACILLARIOPHYTA	29.6
CHLOROPHYTA	22.2
CHRYSOPHYTA	14.8
CRYPTOPHYTA	7.4
CYANOPHYTA	1953.6
EUGLENOPHYTA	14.8
PYRRHOPHYTA	425.5

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	5.9
CHLOROPHYTA	
Micrasterias	296
Staurastrum	11.8
CHRYSOPHYTA	
Dinobryon	222
CRYPTOPHYTA	
Cryptomonas	33.3
CYANOPHYTA	
Chroococcus	12.1
Microcystis	148
EUGLENOPHYTA	
Trachelomonas	14.8
PYRRHOPHYTA	
Peridinium	7492.5
TOTAL	8236.4
BACILLARIOPHYTA	5.9
CHLOROPHYTA	307.8
CHRYSOPHYTA	222
CRYPTOPHYTA	33.3
CYANOPHYTA	160.1
EUGLENOPHYTA	14.8
PYRRHOPHYTA	7492.5

081987

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	13.6
Eunotia	1.7
Melosira	10.2
Tabellaria	3.4
CHLOROPHYTA	
Ankistrodesmus	11.9
Dictyosphaerium	40.8
Staurastrum	5.1
Tetraedron	5.1
CHRYSOPHYTA	
Dinobryon	40.8
CRYPTOPHYTA	
Cryptomonas	3.4
CYANOPHYTA	
Aphanizomenon	47.6
Chroococcus	57.8
PYRRHOPHYTA	
Peridinium	91.8
TOTAL	333.2
BACILLARIOPHYTA	28.9
CHLOROPHYTA	62.9
CHRYSOPHYTA	40.8
CRYPTOPHYTA	3.4
CYANOPHYTA	105.4
PYRRHOPHYTA	91.8

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	2.7
Eunotia	1.7
Melosira	3.0
Tabellaria	10.2
CHLOROPHYTA	
Ankistrodesmus	5.9
Dictyosphaerium	4.0
Staurastrum	4.0
Tetraedron	65.2
CHRYSOPHYTA	
Dinobryon	122.4
CRYPTOPHYTA	
Cryptomonas	15.3
CYANOPHYTA	
Aphanizomenon	9.5
Chroococcus	.5
PYRRHOPHYTA	
Peridinium	1275
TOTAL	1519.8
BACILLARIOPHYTA	17.6
CHLOROPHYTA	79.3
CHRYSOPHYTA	122.4
CRYPTOPHYTA	15.3
CYANOPHYTA	10.0
PYRRHOPHYTA	1275

090287

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	54.4
Tabellaria	3.4
CHLOROPHYTA	
Ankistrodesmus	17
Micrasterias	5.1
Staurastrum	20.4
Tetraedron	3.4
CHRYSOPHYTA	
Dinobryon	47.6
CRYPTOPHYTA	
Cryptomonas	3.4
CYANOPHYTA	
Chroococcus	204
EUGLENOPHYTA	
Phacus	3.4
PYRRHOPHYTA	
Peridinium	158.1
TOTAL	520.2
BACILLARIOPHYTA	57.8
CHLOROPHYTA	45.9
CHRYSOPHYTA	47.6
CRYPTOPHYTA	3.4
CYANOPHYTA	204
EUGLENOPHYTA	3.4
PYRRHOPHYTA	158.1

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	10.8
Tabellaria	10.2
CHLOROPHYTA	
Ankistrodesmus	15.6
Micrasterias	204
Staurastrum	16.3
Tetraedron	43.5
CHRYSOPHYTA	
Dinobryon	142.8
CRYPTOPHYTA	
Cryptomonas	15.3
CYANOPHYTA	
Chroococcus	2.0
EUGLENOPHYTA	
Phacus	1.0
PYRRHOPHYTA	
Peridinium	2830.5
TOTAL	3292.2
BACILLARIOPHYTA	21.0
CHLOROPHYTA	279.4
CHRYSOPHYTA	142.8
CRYPTOPHYTA	15.3
CYANOPHYTA	2.0
EUGLENOPHYTA	1.0
PYRRHOPHYTA	2830.5

092187

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	55.2
CHLOROPHYTA	
Closteriopsis	11.5
Staurastrum	18.4
CYANOPHYTA	
Chroococcus	36.8
Microcystis	4600
EUGLENOPHYTA	
Phacus	4.6
Trachelomonas	20.7
PYRRHOPHYTA	
Peridinium	87.4
TOTAL	4834.6
BACILLARIOPHYTA	55.2
CHLOROPHYTA	29.9
CYANOPHYTA	4636.8
EUGLENOPHYTA	25.3
PYRRHOPHYTA	87.4

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	11.0
CHLOROPHYTA	
Closteriopsis	46
Staurastrum	14.7
CYANOPHYTA	
Chroococcus	.3
Microcystis	138
EUGLENOPHYTA	
Phacus	69
Trachelomonas	20.7
PYRRHOPHYTA	
Peridinium	2967
TOTAL	3266.8
BACILLARIOPHYTA	11.0
CHLOROPHYTA	60.7
CYANOPHYTA	138.3
EUGLENOPHYTA	89.7
PYRRHOPHYTA	2967

101987

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	41.6
CHLOROPHYTA	
Ankistrodesmus	15.6
Scenedesmus	20.8
Staurastrum	20.8
Tetraedron	2.6
CYANOPHYTA	
Chroococcus	93.6
EUGLENOPHYTA	
Trachelomonas	26
PYRRHOPHYTA	
Peridinium	20.8
TOTAL	241.8
BACILLARIOPHYTA	41.6
CHLOROPHYTA	59.8
CYANOPHYTA	93.6
EUGLENOPHYTA	26
PYRRHOPHYTA	20.8

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	8.3
CHLOROPHYTA	
Ankistrodesmus	18.7
Scenedesmus	2.0
Staurastrum	16.6
Tetraedron	33.2
CYANOPHYTA	
Chroococcus	.9
EUGLENOPHYTA	
Trachelomonas	137.8
PYRRHOPHYTA	
Peridinium	936
TOTAL	1153.7
BACILLARIOPHYTA	8.3
CHLOROPHYTA	70.7
CYANOPHYTA	.9
EUGLENOPHYTA	137.8
PYRRHOPHYTA	936

111687

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	38.4
Synedra	105.6
CHLOROPHYTA	
Ankistrodesmus	86.4
Scenedesmus	19.2
CHRYSOPHYTA	
Dinobryon	57.6
CRYPTOPHYTA	
Cryptomonas	9.6
CYANOPHYTA	
Chroococcus	76.8
TOTAL	393.6
BACILLARIOPHYTA	144
CHLOROPHYTA	105.6
CHRYSOPHYTA	57.6
CRYPTOPHYTA	9.6
CYANOPHYTA	76.8

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	7.6
Synedra	84.4
CHLOROPHYTA	
Ankistrodesmus	43.2
Scenedesmus	1.9
CHRYSOPHYTA	
Dinobryon	172.8
CRYPTOPHYTA	
Cryptomonas	22.5
CYANOPHYTA	
Chroococcus	30.7
TOTAL	363.3
BACILLARIOPHYTA	92.1
CHLOROPHYTA	45.1
CHRYSOPHYTA	172.8
CRYPTOPHYTA	22.5
CYANOPHYTA	30.7

121487

TAXON	CELLS/ML
BACILLARIOPHYTA	
Asterionella	16.8
Eunotia	2.1
Synedra	21
CHLOROPHYTA	
Ankistrodesmus	21
Chlamydomonas	6090
Scenedesmus	8.4
CHRYSOPHYTA	
Dinobryon	336
CRYPTOPHYTA	
Cryptomonas	42
TOTAL	6537.3
BACILLARIOPHYTA	39.9
CHLOROPHYTA	6119.4
CHRYSOPHYTA	336
CRYPTOPHYTA	42

TAXON	UG/L
BACILLARIOPHYTA	
Asterionella	3.3
Eunotia	2.1
Synedra	16.8
CHLOROPHYTA	
Ankistrodesmus	25.2
Chlamydomonas	609
Scenedesmus	.8
CHRYSOPHYTA	
Dinobryon	1008
CRYPTOPHYTA	
Cryptomonas	189
TOTAL	1854.3
BACILLARIOPHYTA	22.2
CHLOROPHYTA	635.0
CHRYSOPHYTA	1008
CRYPTOPHYTA	189

DIMMOCK POND ZOOPLANKTON 040287

TAXON	#/L
ROTIFERA	
Keratella	.5
COPEPODA	
Diaptomus	4.2
Nauplii	3.4
CLADOCERA	
Bosmina	2.2
Daphnia ambigua	.1
TOTAL	10.4
ROTIFERA	.5
COPEPODA	7.6
CLADOCERA	2.3

TAXON	UG/L
ROTIFERA	
Keratella	.1
COPEPODA	
Diaptomus	2.0
Nauplii	9.0
CLADOCERA	
Bosmina	2.2
Daphnia ambigua	.2
TOTAL	13.4
ROTIFERA	.1
COPEPODA	11.0
CLADOCERA	2.3
MEAN LENGTH (MM)	0.65

DIMMOCK POND ZOOPLANKTON 060187

TAXON	#/L
COPEPODA	
Mesocyclops	8.4
Diaptomus	8.8
Nauplii	2.4
CLADOCERA	
Bosmina	34.8
Daphnia ambigua	2
Sida	4
TOTAL	60.4
COPEPODA	19.6
CLADOCERA	40.8

TAXON	UG/L
COPEPODA	
Mesocyclops	10.5
Diaptomus	4.2
Nauplii	6.4
CLADOCERA	
Bosmina	103.7
Daphnia ambigua	3.2
Sida	23.2
TOTAL	151.2
COPEPODA	21.1
CLADOCERA	130.1
MEAN LENGTH (MM)	0.60

DIMMOCK POND ZOOPLANKTON 090[illegible]

TAXON	[illegible]
ROTIFERA	
Asplanchna	[illegible]
COPEPODA	
Mesocyclops	
Diaptomus	[illegible]
Nauplii	[illegible]
CLADOCERA	
Bosmina	[illegible]
Daphnia ambigua	
Sida	[illegible]
TOTAL	[illegible]
ROTIFERA	[illegible]
COPEPODA	[illegible]
CLADOCERA	[illegible]

TAXON	[illegible]
ROTIFERA	
Asplanchna	[illegible]
COPEPODA	
Mesocyclops	
Diaptomus	
Nauplii	[illegible]
CLADOCERA	
Bosmina	[illegible]
Daphnia ambigua	
Sida	[illegible]
TOTAL	[illegible]
ROTIFERA	[illegible]
COPEPODA	[illegible]
CLADOCERA	[illegible]
MEAN LENGTH (MM)	[illegible]

BENTHIC INVERTEBRATE TAXA OBSERVED IN DIMMOCK POND

INVERTEBRATE TAXON	ABUNDANCE RATING
MOLLUSCA	
LYMNAEIDAE	
PHYSIDAE	
SPHAERIIDAE	
UNIONIDAE	
VIVIPARIDAE	
ODONATA	
ANISOPTERA	*
ZYGOPTERA	*
COLEOPTERA	*
HYDROPTILIDAE	
HEMIPTERA	
GERRIDAE	*
MESOVELIIDAE	*
DIPTERA	
CHIRONOMIDAE	*
DECAPODA	
CAMBARIDAE	
AMPHIPODA	
GAMMARIDAE	
RHYNCHOBDELLIDA	
ERPOBDELLIDAE	
OLIGOCHAETA	*
PORIFERA	

* = PRESENT ** = COMMON *** = ABUNDANT

BERKSHIRE ENVIRO-LABS: KETTLEHOLE PONDS DATA

QUALITY CONTROL PROGRAM SAMPLES: SUMMARY STATISTICS

PARAMETER	UNITS	STD.ERR.	AVG%DIF	MAX.VALUE	MIN.VALUE
AMM-N	(mg/l)	.05	56.54	.850	.010
NITRATE-N	(mg/l)	.02	81.76	.550	.010
KNITRO	(mg/l)	.08	54.72	1.650	.250
ORTHO-P	(ug/l)	2.86	35.60	80.000	10.000
TOTAL P	(ug/l)	6.68	54.88	200.000	10.000
FEC.COLI	(#/100ml)	.30	16.67	8.000	2.000
FEC.STREP	(#/100ml)	.38	7.14	8.000	1.000
TALK	(mg/l)	1.42	46.26	21.000	.500
TSS	(mg/l)	1.42	124.76	22.100	.400
CHLORIDE	(mg/l)	1.64	78.45	53.800	2.100

APPENDIX B

CONVERSION FACTORS AND CALCULATION SHEETS

USEFUL CONVERSIONS

Multiply...	by...	to obtain...
Acre (ac)	0.4047	Hectare (ha)
Acre (ac)	43,560	Square Feet (sq.ft)
Acre (ac)	4,047	Square Meters (sq.m)
Acre (ac)	0.00156	Square Miles (sq.mi)
Acre Feet (af)	1613.3	Cubic Yards (cy)
Centimeters (cm)	0.3937	Inches (in)
Cubic Feet (cu.ft)	0.0283	Cubic Meters (cu.m)
Cubic Feet (cu.ft)	0.0370	Cubic Yards (cy)
Cubic Feet (cu.ft)	7.4805	Gallons (gal)
Cubic Feet (cu.ft)	28.32	Liters (l)
Cubic Feet/Second (cfs)	1.7	Cubic Meters/Minute (cu.m/min)
Cubic Feet/Second (cfs)	0.6463	Million Gallons/Day (mgd)
Feet (ft)	0.3048	Meters (m)
Feet (ft)	0.0001894	Mile (mi)
Kilograms (kg)	2.205	Pounds (lb)
Kilometers (km)	0.6214	Miles (mi)
Liters (l)	0.2642	Gallons (gal)
Liters (l)	1.057	Quarts (qt)
Meters (m)	1.094	Yards (yd)
Milligrams/Liter (mg/l)	1.0	Parts Per Million (ppm)
Micrograms/Liter (ug/l)	1.0	Parts Per Billion (ppb)
Square Kilometers (sq.km)	0.3861	Square Miles (sq.mi)
Square Meters (sq.m)	0.0001	Hectares (ha)

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JOB DIMMOCK POND
SHEET NO. 1 OF 1
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

Calculation of Oxygen Depletion Rate:

Period: Jan–Feb, 28 days

Depth	Volume (cu.m)	Init. DO (mg/l)	Final DO (mg/l)	Δ DO	DO Loss (kg)	
0–1	17328	9.5	8.5	1.0	17.3	
1–2	20976	9.5	4.5	5.0	104.9	
2–3	7296	5.0	2.0	3.0	21.9	
			Total Loss (kg)		154.1	126.8
			Areal Loss ($mg/m^2/d$)		145	192
			Volumetric Loss (mg/l/d)		0.12	0.16

Considering only portion >1m

Period Apr. – May, 60 days

Depth	Volume (cu.m)	Init. DO (mg/l)	Final DO (mg/l)	Δ DO	DO Loss (kg)	
0–1	17328	10.0	9.5	0.5	8.7	
1–2	20976	10.0	6.0	4.0	83.9	
2–3	7296	9.5	0.5	9.0	65.7	
			Total Loss (kg)		158.3	149.6
			Areal Loss ($mg/m^2/d$)		69	106
			Volumetric Loss (mg/l/d)		0.06	0.09

Considering only portion >1m

Given that aeration does occur, actual depletion rates are probably somewhat higher; a range of

$\boxed{0.1 \text{ to } 0.2 \text{ mg/l/d}}$ is suggested.

This is moderate, relative to other systems examined by BEC.

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JOB DIMMOCK POND
SHEET NO. 1 OF 2
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

HYDROLOGIC BUDGET CALCULATIONS

Inputs:

Direct Precipitation:

1.14 m/yr on 3.8 ha pond = 43320 cu.m/yr = **0.082 cu.m/min.**

Groundwater:

From seepage meter data, 24439–64930 l/d = **0.017–0.045 cu.m/min.**

Midpoint = 0.031 cu.m/min

Stormwater:

Stormwater flow from 5 events:

Event	Avg. Flow (cu.m/min)		Duration (hr)	Total Flow (cu.m)	
	DP-2	DP-3		DP-2	DP-3
1	0.31	0.05	1	18.6	3.0
2	0.17	0.17	4.5	45.9	45.9
3	0.10	0	1	6.0	0
4	0.02	0.003	3	3.6	0.5
5	1.79	1.40	9	967	756

Σ 5 events = 1846.5 cu.m (56% from DP-2, 44% from DP-3)
5 event rainfall = 9.4 cm = 0.094 m
Annual rainfall = 1.14 m
Obs. rainfall = 8.25% of annual rainfall
Assuming Obs. flow = 8.25% of annual flow,
total stormwater flow = 22382 cu.m/yr = **0.043 cu.m/min**

Note: Stormflow may vary appreciably from year to year, and certainly varies among storms, depending upon rainfall intensity.

@ Q = CIA, Q = flow, C = runoff coeff. = 0.1–0.3, I = rainfall = 1.14 m/yr, A = drainage area = 18 ha
∴ possible storm runoff = 20520 – 61560 cu.m/yr
= 0.039 – 0.117 cu.m/min

Total Inflow = Dir. Precip. + GW + SW = **0.142 – 0.170 cu.m/min.**

Midpoint = 0.156 cu.m/min.

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JOB DIMMOCK POND
SHEET NO. 2 OF 2
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

Outputs:

Evaporation:
60–70% of direct precipitation
(~27–31 in/yr) ⟶ 25992–30324 cu.m/yr = $\boxed{0.049 - 0.058 \text{ cu.m/min}}$
Assume 0.058 cu.m/min

Groundwater:
From seepage meter data, 12460–140610 ℓ/d = $\boxed{0.009 - 0.098 \text{ cu.m/min}}$
Assume 0.098 cu.m/min

Note: If excessive stormwater enters the pond, storage causes water level rise. Water then leaves as groundwater at sandy shoreline. Alternatively, flap valve can be opened in Parker St. manhole during storms, allowing diversion to Loon Pond.

Total outflow: Evap. + GW = $\boxed{0.058 - 0.156 \text{ cu.m/min}}$
Assume 0.156 cu.m/min

Detention Time:
~ 0.1 – 0.2 cu.m/min throughflow w/ Vol. = 45,600 cu.m

DT = 45,600 / 0.1 to 0.2 = 228,000 to 456,000 min = 158 to 317 days
= $\boxed{0.4 \text{ to } 0.9 \text{ yr}}$

Flushing Rate:
$F = 1/DT =$ $\boxed{2.5 \text{ to } 1.1 \text{ /yr}}$

Response Time:
$R = 3 \text{ to } 5 \times \ln 2 / (1/DT + 10/\bar{z})$
$= 3 \text{ to } 5 \times 0.693/[(1.1 \text{ to } 2.5) + (10/1.2)] = (3 \text{ to } 5)(.693)/(9.43 \text{ to } 10.8)$
$= \boxed{0.2 \text{ to } 0.4 \text{ yr}}$

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JOB DIMMOCK POND
SHEET NO. 1 OF 5
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

NUTRIENT BUDGET CALCULATIONS

P & N Loads = Avg. Conc. x Vol. x Flushing Rate

P: 150 to 200 ug/l X 45,600,000 l X 1.1 to 2.5
= $\boxed{7.5 \text{ to } 22.8 \text{ kg}}$

N: 1.4 to 1.6 mg/l X 45,600,000 l X 1.1 to 2.5
= $\boxed{70.2 \text{ to } 182.4 \text{ kg}}$

Stormwater Load: (See Hydrologic Calcs for Support Info)

Event	Total Flow (cu.m)		Avg. P Conc. (ug/l)		P Load (g)	
	DP-2	DP-3	DP-2	DP-3	DP-2	DP-3
1	18.6	3.0	83	83	1.5	0.2
2	45.9	45.9	190	180	8.7	8.3
3	6.0	0	300	—	1.8	—
4	3.6	0.5	5483	510	19.7	0.3
5	967	756	190	201	183.7	152.0
				Σ =	215.4	160.8

Event	DP-2	DP-3	Avg TN conc (mg/l) DP-2	Avg TN conc (mg/l) DP-3	N Load (g) DP-2	N Load (g) DP-3
1	18.6	3.0	5.03	4.61	93.6	13.8
2	45.9	45.9	2.07	2.22	95.0	101.9
3	6.0	0	5.03	—	30.2	—
4	3.6	0.5	42.78	0.90	154.0	0.5
5	967	756	2.58	2.22	2494.9	1678.3
				Σ =	2867.7	1794.5

57% DP-2, 43% DP-3 — 62% DP-2, 38% DP-3

TP in 5 storms = 376 g — TN in 5 storms = 4662 g

Storm precip. = 8.25% of annual precip.

376 g / 0.0825 = $\boxed{4.6 \text{ kg/yr}}$ — 4662 g / 0.0825 = $\boxed{56.5 \text{ kg/yr}}$

Given variation in storm intensity, duration, and frequency, annual ranges of $\boxed{3 \text{ to } 7 \text{ kg/yr}}$ and $\boxed{40 \text{ to } 75 \text{ kg/yr}}$ are in order.

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JOB DIMMOCK POND
SHEET NO. 2 OF 5
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

Internal Load of P:

From anoxic loading:

Approx. 17% of pond area has anoxia for 65 days.

At mean release rate of 14 mg/m²/d (Nurnberg 1984),

$.17 \times 38000\ m^2 \times 65 d/yr \times 14\ mg/m^2/d = \boxed{5.9\ kg/yr}$

From macrophyte pumping/decay:

Approx. 20% of pond covered by dense macrophytes, most notably Myriophyllum

At release rate of 2 g/m²/yr (Smith & Adams 1986),

$.20 \times 38000\ m^2 \times 2\ g/m^2/yr = \boxed{15.2\ kg/yr}$

From sediment resuspension:

If the top cm of sediment at depths <1.5 m is resuspended and is remineralized at a rate of 10% per yr (total assumption — not based on any data), then have

$0.6 \times 38000\ m^2 \times 0.01\ m \times 1000\ kg/m^3 \times 0.3\ to\ 1.5\ g/kg \times 0.1/yr = \boxed{6.8\ to\ 34.2\ kg/yr}$

Given high iron content and generally aerobic conditions in the upper waters of Dimmock Pond, a substantial portion of the internal P Load might be rendered unavailable.

If 10% of internal load is available, have		2.8 – 5.5
at 25%	→	7.0 – 13.8
at 50%	→	14.0 – 27.7
at 75%	→	20.9 – 41.5

As an approximation, the internal P Load will be assumed to provide $\boxed{3 - 10\ kg/yr}$

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JOB DIMMOCK POND
SHEET NO. 3 OF 5
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

Internal Load of N:

N Load usually not assumed to have internal component, but resuspension of sediment and macrophyte actions should provide some N in Dimmock Pond.

By same assumptions as for P load by resuspension,

$0.6 \times 38000\ m^2 \times 0.01\ m \times 1000\ kg/m^3 \times 7.3\ to\ 43\ g/kg \times 0.1/yr = \boxed{16.6\ to\ 98\ kg/yr}$

If macrophytes contain or pump 12 X as much N as P, but lose only a third as much (N is better bound than P), then have $\boxed{\sim 60\ kg/yr}$ N from macrophytes.

Total would be ~75 to 160 kg/yr, assuming all such N was available.

Assuming availability of

10% ⟶ 7.5 – 16.0 kg/yr
25% ⟶ 18.8 – 40 kg/yr
50% ⟶ 37.5 – 80 kg/yr
75% ⟶ 56 – 120 kg/yr

For simplification, it will be assumed that the Internal N Load provides $\boxed{20\ to\ 50\ kg/yr}$

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JOB DIMMOCK POND
SHEET NO. 4 OF 5
CALCULATED BY KW DATE
CHECKED BY DATE
SCALE

Groundwater: Loads of N & P:

Porewater analysis revealed high levels of N & P in the sediment lining the pond. This water is carried into or out of the pond via groundwater flow, which is slow, and greatly affected by local sediment conditions through prolonged exposure.

P: At avg. conc. of 350 ug/l & flow of 0.017-0.045 cu.m/mi
have $\boxed{\text{3.1 to 8.3 kg/yr}}$

N: At avg. conc. of 0.95 mg/l & flow of 0.017-0.045 cu.m/mi
have $\boxed{\text{8.5 to 22.5 kg/yr}}$

Much of the groundwater load may be immobile, however, or subject to conversion to unavailable forms near the sediment-water interface. Additionally, the groundwater is anoxic and much P may be lost to precipitation upon aeration.

Assume Groundwater Loads at the low end of the ranges given:

P @ $\boxed{\text{2 to 4 kg/yr}}$
N @ $\boxed{\text{5 to 10 kg/yr}}$

Note that the groundwater load really constitutes an additional component of internal loading, as the quality of the groundwater is largely a function of interaction with pond bottom sediment.

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JOB DIMMOCK POND

SHEET NO. 5 OF 5

CALCULATED BY KW DATE

CHECKED BY DATE

SCALE

Precipitation:

P: 43320 cu.m/yr at a phosphorus conc. of 50 ug/l would yield 2.2 kg/yr, about the highest value obtainable in the NE U.S. If dryfall contributed as much as actual precip., would expect a total of 4.4 kg/yr. A range of $\boxed{\text{3 to 5 kg/yr}}$ is appropriate

N: 43320 cu.m/yr at a nitrogen conc. of 0.5 mg/l (incl. dryfall) would yield 21.7 kg/yr. A range of $\boxed{\text{15-25 kg/yr}}$ is appropriate, although actual values at the low end are expected.

APPENDIX C

INFORMATION RELEVANT TO INTERSTATE UNIFORM SERVICES CORPORATION (UNIFIRST)

SUMMARY OF DEQE FILE INFORMATION RELATING TO UNIFIRST CORPORATION OPERATION ON PARKER STREET IN SPRINGFIELD, MA.

May and June, 1981: Solvent sludge dumped along railroad tracks on UniFirst property, some entered storm drainage system via runoff. UniFirst representatives stated that 35 to 40 gallons of sludge were dumped when no waste hauler was available. DEQE suspects that more was dumped directly into the drain behind the building. The potential impact on Dimmock Pond was noted, but no impact was observed.

April 22, 1986: Memo from C. Givens, DEQE, to file notes citation of violation.

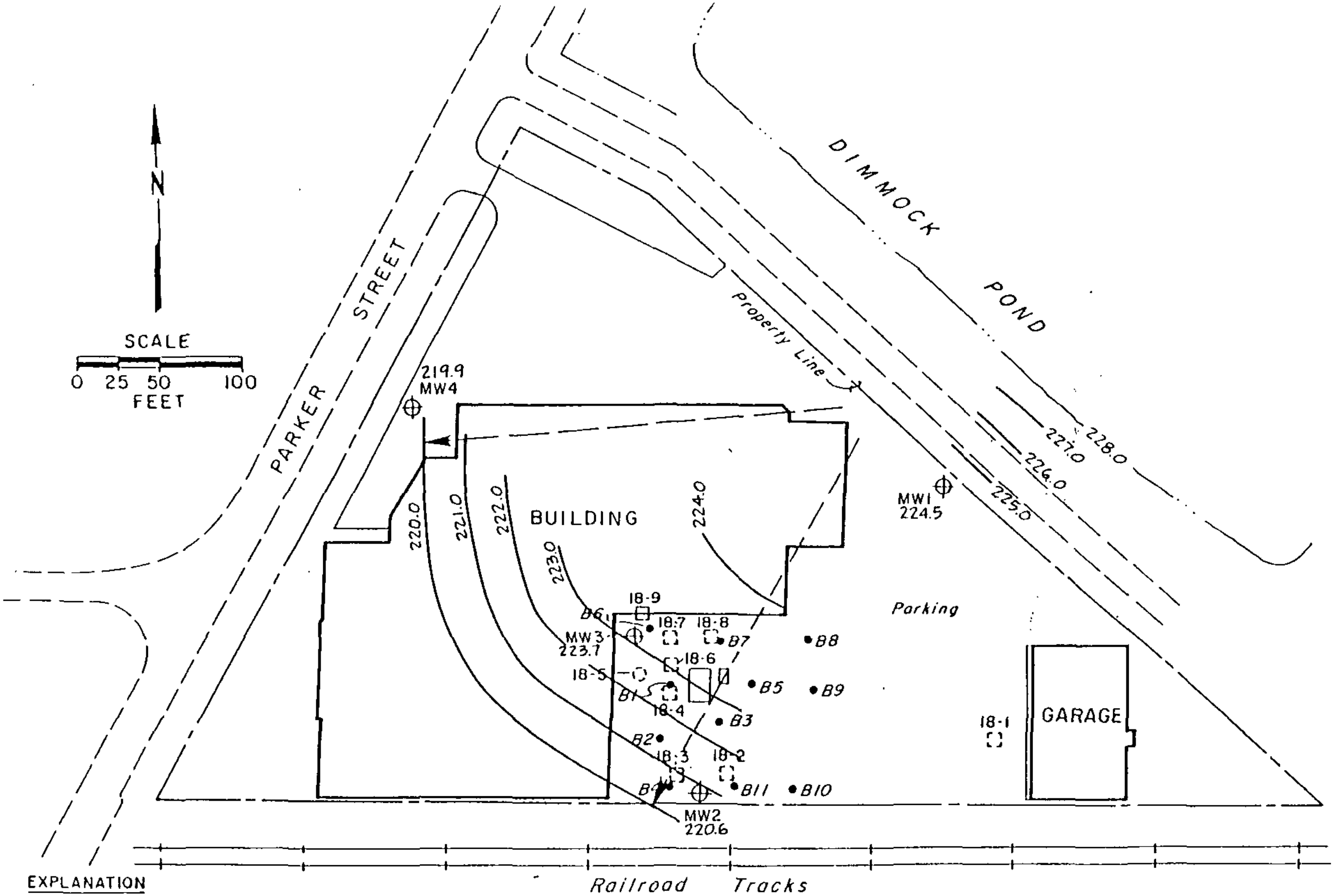
May 13, 1986: Memo from C. Givens, DEQE, to file notes that potential leaks in solvent/fuel tanks were noted while tanks being removed.

May 19, 1986: Memo from C. Givens, DEQE, to file notes that two truckloads of soil were removed from the vicinity of the outfall of the Parker Street drain by a private contractor under direction of UniFirst personnel.

1987 Site Assessment Review by C. Givens: UniFirst property was a vacant woodlot until 1956. Underground storage tanks store oil and gasoline for fuel use, plus petroleum based solvents used in the cleaning of industrial uniforms (Stoddard Solvent mentioned). Sludge builds up in cleaning process, normally hauled away by contractor, but disposed on property during 1981 lapse of contract for hauling.

1987 Report by ERT, Inc.: Environmental Investigation: UniFirst, Springfield, MA Site, DOC No. P-E209-003: Describes situation through 1986. Site has about 10 ft of sand, elev 238 to 227, then more than 10 ft of silty sand and clay (till area) at elev 227 to at least 217. Ground water moving away from pond, going northwest to southwest at a peak elev of 228. May have some perching. Ground water elev measured on three dates. See attached site maps.

October 9, 1987: Letter from G. Augustyn of UniFirst to DEQE notes hiring of Groundwater Technology to complete remedial investigation.



EXPLANATION

18-2 NUMERICAL DESIGNATION OF TANK

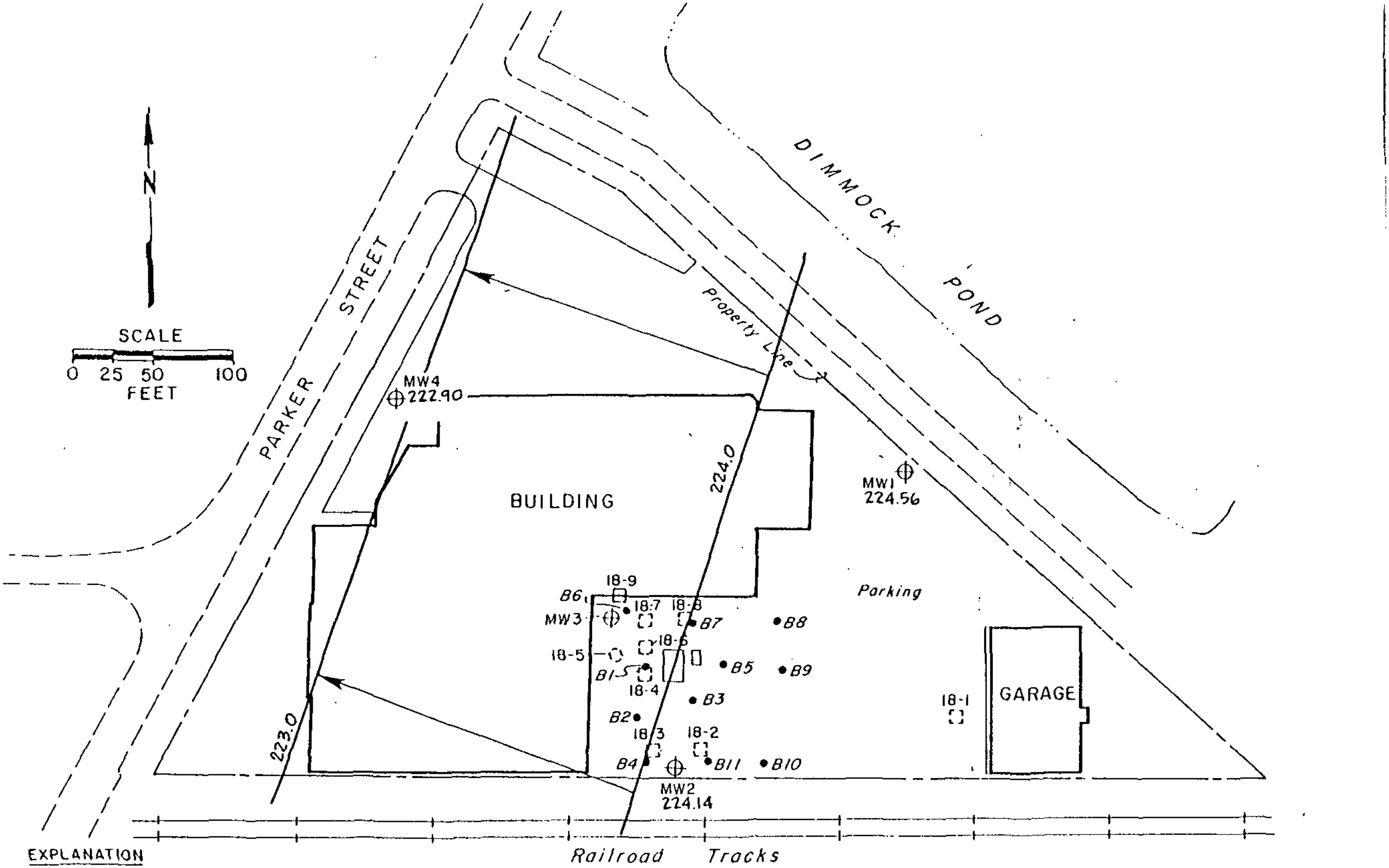
[ ] APPROXIMATE LOCATION OF REMOVED TANK

☐ APPROXIMATE LOCATION OF EXISTING TANK

⦶ APPROXIMATE LOCATION OF MONITORING WELL (MW)

• APPROXIMATE LOCATION OF BORING (B)

Figure 4-6 Ground-Water Contour Map
UniFirst, Springfield, Massachusetts
Water-Table Elevations Measured 11/21/86 - 11/24/86



EXPLANATION

18-2 NUMERICAL DESIGNATION OF TANK

[ ] APPROXIMATE LOCATION OF REMOVED TANK

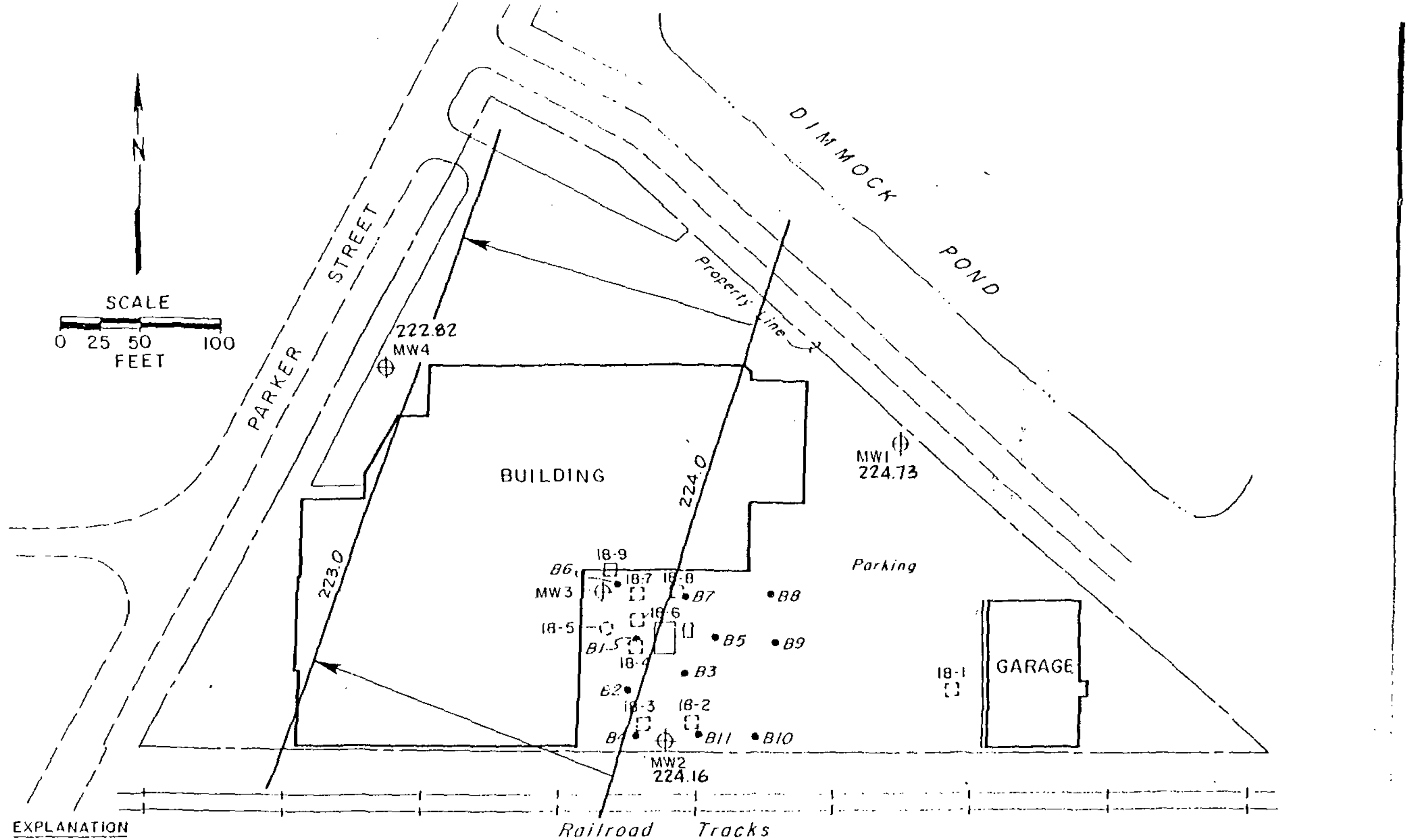
□ APPROXIMATE LOCATION OF EXISTING TANK

Φ APPROXIMATE LOCATION OF MONITORING WELL (MW)

• APPROXIMATE LOCATION OF BORING (B)

←— APPROXIMATE DIRECTION OF GROUND-WATER FLOW

Figure 4-7 Ground-Water Contour Map
UniFirst, Springfield, Massachusetts
Water-Table Elevations Measured 12/5/86



EXPLANATION

18-2 NUMERICAL DESIGNATION OF TANK

[ ] APPROXIMATE LOCATION OF REMOVED TANK

□ APPROXIMATE LOCATION OF EXISTING TANK

⊕ APPROXIMATE LOCATION OF MONITORING WELL (MW)

• APPROXIMATE LOCATION OF BORING (B)

←—— APPROXIMATE DIRECTION OF GROUND-WATER FLOW

Figure 4-8. Ground-Water Contour Map
UniFirst, Springfield, Massachusetts
Water-Table Elevations Measured 12/23/86

MEMORANDUM

TO: Elaine Hartman, Aquatic Biologist, DWPC/TSB, Westborough

FROM: RJM Robert J. Maietta, Aquatic Biologist, DWPC/TSB, Westborough

DATE: October 9, 1987

RE: 1986 Dimmock Pond Fish Toxics Monitoring Results

Dimmock Pond was sampled on September 30, 1986. Phil Brenner of the Massachusetts Division of Fisheries and Wildlife Valley District Office provided his manpower and eletroshocking equipment for the survey. Phil, you and I electroshocked the entire shoreline of the 13 acre pond in about one hour.

FIELD COLLECTION AND OBSERVATION

As you recall, the sample was small and intended for screening purposes only. The pond contained an assemblage of fish which is typical of a small shallow warm water pond. As I recall, we saw some large common carp Cyprinus carpio, one of which we collected and had analyzed. These fish are omnivores, eating many types of aquatic vegetation, as well as algae, worms and other aquatic invertebrates. They are known to actually suck up mud and detritus and spit it back into the water column to separate the food items. These fish could definitely contribute to the turbid conditions of Dimmock Pond.

Largemouth bass Micropterus salmoides, represent a top level predator which has been introduced into many Massachusetts ponds. We collected two individuals for analysis. Both were large sized individuals, 2-4 pounds and 4 and 5 years old respectively (see Table 1). Largemouth diets include fish, frogs, worms, insects and just about anything they can fit in their mouths. They are very sought after by sport fishermen and are highly palatable.

Brown bullheads Ictalurus nebulosus represent an opportunistic bottom feeding species. They are also omnivorous and live and feed in close association with the bottom. They are excellent eating which makes them a prime candidate when studies are concerned with aspects of edibility. These fish are scaleless and therefore the hard pectoral spines are used for aging. I was unable to age the fish from Dimmock Pond due to the fact that we do not have adequate equipment. I will try to age these at a future date and will report these results to you at that time.

LABORATORY METHODS

All fish were brought back to Westborough for preparation. They were weighed, measured, filleted, wrapped, and hard parts were taken for subsequent aging (Table 1 lists species, length, weight and ages). Two fillets were taken from each fish and the skin was removed. One fillet was wrapped in aluminum foil for organic scan, percent lipids and PCB analysis and the opposite fillet was wrapped in plastic for metals analysis. Composite samples were wrapped together in one package. The fish were frozen until delivery to Lawrence Experiment Station on December 18, 1986.

RESULTS

Results were received from LES in May of 1987 (see Table 2). The organic scan indicated that PCB Aroclor 1260 was present in three out of four samples. Concentrations ranged between "none detected" and 0.28 mg/kg. The carp, which was the largest and oldest fish, contained the highest amount of PCB. This fish also had a very high lipid content. It is known that PCB's and other organic compounds are lipophilic, and the data reflects this fact. This fish is still well below the 2.0 mg/kg FDA action level for PCB. All other samples contained what could be considered background levels of PCB. No other organic compounds were detected.

The results of metal analysis, along with the quality assurance quality/control data for metals, is also included in Table 2. Six of the eleven metals analyzed were below levels of detection. Total mercury was detected at concentrations of 0.013 to 0.097 mg/kg. These levels are well below the 1.0 mg/kg FDA action level. The FDA action level is based on methyl mercury, however, it is documented in the literature that 80 to 90 percent of the mercury in fish flesh is in the methylated form. These concentrations in fish from Dimmock Pond are low, nonetheless. Recent analyses of sediment from Dimmock Pond document the presence of lead (387 ppm), arsenic (17 ppm), and other metals at levels which are comparable to rivers which receive industrial wastewater. These slightly elevated levels are not reflected in the fish flesh which was examined.

Please find attached to this memorandum, a memo to Arthur Johnson providing background information on Dimmock Pond. Both memos will be sent to the DEQE Regional Office in Springfield, the Mass Division of Fisheries and Wildlife District Office and Field Headquarters, and the Massachusetts Department of Public Health.

Enclosures
RJM/p
cc: A. Cooperman
A. Johnson
Herman Covey, DFW, Valley District Office
Phil Brenner, DFW, Valley District Office
John Higgins, Regional Environmental Engineer, Springfield
Elaine Kruegar, MDPH, Boston
Mike Murphy, Office of Research and Standards ORS, Boston
Peter Oatis, MDFW, Westborough

TABLE 1

1986 Dimmock Pond Fish Toxics Monitoring

List of Species, Length, Weight

and Age Data

Sample Code	Species Code	Length(cm)	Weight(g)	Age(yrs.)
DPF86-1	C	73.1	4760	7+
DPF86-2	LMB	38.8	820	4+
DPF86-3	LMB	44.6	1520	5+
DPF86-4	BB	20.3	100	**
DPF86-5	BB	20.9	100	**
DPF86-6	BB	19.8	80	**
DPF86-7	BB	20.0	80	**
DPF86-8	BB	19.5	80	**

* C common carp *Cyprinus carpio*
LMC largemouth bass *Micropterus salmoides*
BB brown bullhead *Ictalurus nebulosus*

** age data not available due to equipment restraints

TABLE 2

1986 Dimmock Pond Fish Toxics Monitoring

Metals, PCB, and % Lipids Data

Sample Codes	Sample Type	Metals (mg/kg Wet Weight)											PCB (mg/kg)	
		Al	Ag	As	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn	1260	Lipids (%)
DPF86-1	Individual	<1.0	<0.2	.005	<0.20	<0.30	0.40	8.2	0.013	<0.50	<0.50	4.5	0.28	4.7
DPF86-2	Individual	<1.0	<0.2	.009	<0.20	<0.30	0.20	0.90	0.065	<0.50	<0.50	2.3	0.082	0.72
DPF86-3	Individual	<1.0	<0.2	.004	<0.20	<0.30	0.20	2.7	0.097	<0.50	<0.50	2.1	ND	0.25
DPF86-8	Composite	<1.0	<0.2	.004	<0.20	<0.30	0.30	3.5	0.015	<0.50	<0.50	2.1	0.059	1.0

Quality Assurance, Quality Control Data for Metals

		Al	Ag	As	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
DPF86-2 Original	Individual	<1.0	<0.2	.009	<0.20	<0.30	0.20	0.90	0.065	<0.50	<0.50	2.3
DPF86-2 Duplicate	Individual	<1.0	<0.2	.001	<0.20	<0.30	0.20	1.0	0.065	<0.50	<0.50	2.5
Percent	Spike	*	*	97%	*	*	94%	93%	90%	*	*	86%

* Raw data values were below detection, therefore spikes and % recoveries were not used.

MEMORANDUM

TO: Arthur S. Johnson, Biomonitoring Program Manager, DWPC/TSB, Westborough

FROM: RJM Robert J. Maietta, Aquatic Biologist, DWPC/TSB, Westborough

DATE: October 9, 1987

RE: 1986 Dimmock Pond Fish Toxics Monitoring - Background Information

We received the final set of data from the 1986 Dimmock Pond Fish Toxics Monitoring in May of this year. The following is a summary of events leading up to our 1986 survey.

Concern for Dimmock Pond revolves around illegal dumping events which took place during 1981 by Interstate Uniform Services Corp., 295 Parker St., Springfield, MA 01151. Evidently a dry cleaning solvent sludge which contained Naptha was dumped both on the company property and into a manhole on their property, which discharges directly to Dimmock Pond. The sludge from the dry cleaning process was analyzed in July of 1981 and reported as containing relatively high levels of cadmium (1.8 ppm) and lead (1.9 ppm).

The situation was evaluated by DEQE in June of 1981, and the Division of Hazardous Waste (DHW) recommended remedial actions. DHW documentation and correspondence indicated that all contaminated soils have been removed, including two truck loads from the head wall of the outfall at Dimmock Pond. This soil was tested and subsequently dumped at Partyka's Landfill in Chicopee, MA.

In 1986, while removing underground storage tanks, stained soil was observed on tanks 18-5, a conical shaped Stoddard solvent tank, and 18-8, a cylindrical shaped Stoddard solvent tank. The soils were tested and results documented the presence of toluene (11 ppm), xylenes (34 ppm), and total chromatgraphable organics (9600 ppm). I believe that most of these are volatile compounds although, evidently they must have some sediment affinity.

Elaine Hartman, project officer for the 628 Clean Lakes Program Diagostic/Feasibility Study which is currently being performed on Dimmock Pond requested fish toxics monitoring as outlined in my memorandum to you dated September 29, 1986.

RJM/p
cc: Al Cooperman
Elaine Hartman

APPENDIX D

ENVIRONMENTAL NOTIFICATION FORM

ENVIRONMENTAL NOTIFICATION FORM

I. SUMMARY

A. Project Identification

1. Project Name DIMMOCK POND
   Address/Location HUBBARD PARK
   PARKER STREET
   City/Town SPRINGFIELD, MA
2. Project Proponent DEPT. OF PARKS/RECREATION
   Address FOREST PARK ADMIN. BLDG., SPRINGFIELD, MA 01108
3. Est. Commencement Summer 1990. Est. Completion Fall 1993.
   Approx. Cost $ 1,365,900. Status of Project Design 0 % Complete.
4. Amount (if any) of bordering vegetated wetlands, salt marsh, or tidelands to be dredged, filled, removed, or altered (other than by receipt of runoff) as a result of the project.
   10.3 acres ________ square feet.
5. This project is categorically included and therefore requires preparation of an EIR.
   Yes X No ______?

B. Narrative Project Description
Describe project and site.

Dimmock Pond, in Hubbard Park, will be dredged to remove 87,500 CY of organic sediment. Currently eroded areas of the shoreline will be repaired, and soils at shoreline access points will be stabilized. Detention areas will be created in the western and northeastern area of the pond, once part of the open water but now emergent/shrub wetlands, where stormwater drainage outfall pipes deliver runoff to the pond. Catch basins within watershed west of Parker St. will be transformed into leaching basins. This project is intended to restore recreational utility to Dimmock Pond and improve habitat quality for aquatic life.

Copies of the complete ENF may be obtained from (proponent or agent):
Name: MS. Rita Coppola Firm/Agency: Spfld. Dept. of Parks/Recreation
Address: Forest Park Admin. Bldg. Phone No. 413-787-6445
Springfield, MA 01108

1986 THIS IS AN IMPORTANT NOTICE. COMMENT PERIOD IS LIMITED.
For Information, call (617) 727-5830

C. List the State or Federal agencies from which permits or other actions have been/will be sought:

Agency Name	Permit	Date filed; file no.

See Attached Table 31 from the BEC D/F Study Report.

D. List any government agencies or programs from which the proponent will seek financial assistance for this project:

Agency Name	Funding Amount
MA Clean Lakes Program, DWPC, DEQE	75% of total
Rivers and Harbors Program, DWWR, DEM	75% of total

E. Areas of potential impact (complete Sections II and III first, before completing this section).

1. Check all areas in which, in the proponent's judgment, an impact of this project may occur. Positive impacts, as well as adverse impacts, may be indicated.

	Construction Impacts	Long Term Impacts
Inland Wetlands	X	X
Coastal Wetlands/Beaches		
Tidelands		
Traffic	X	
Open Space/Recreation	X	X
Historical/Archaeological		
Fisheries/Wildlife	X	X
Vegetation/Trees	X	
Agricultural Lands		
Water Pollution	X	X
Water Supply/Use		
Solid Waste	X	
Hazardous Materials		
Air Pollution		
Noise	X	
Wind/Shadow		
Aesthetics	X	X
Growth Impacts		
Community/Housing and the Built Environment		
Other (Specify)		

2. List the alternatives which have been considered.

See Attached Table 24 from BEC D/F Study Report

F. Has this project been filed with EOEA before? No X Yes _____ EOEA No. _____

G. WETLANDS AND WATERWAYS

1. Will an Order of Conditions under the Wetlands Protection Act (c.131s.40) or a License under the Waterways Act (c.91) be required?
   Yes X No _____
2. Has a local Order of Conditions been:
   a. issued? Date of issuance _____; DEQE File No. _____.
   b. appealed? Yes _____; No _____;
3. Will a variance from the Wetlands or Waterways Regulations be required? Yes _____; No X.

II. PROJECT DESCRIPTION

A. Map; site plan. Include an original 8½ x 11 inch or larger section of the most recent U.S.G.S. 7.5 minute series scale topographic map with the project area location and boundaries clearly shown. If available, attach a site plan of the proposed project.

See Figures 6 & 22 from BEC D/F Study Report

B. State total area of project: 45.8 acres.
Estimate the number of acres (to the nearest 1/10 acre) directly affected that are currently:

1. Developed	25.5 acres	6. Tidelands	_____ acres
2. Open Space/ Woodlands/Recreation	10 acres	7. Productive Resources	
3. Wetlands	10.3 acres	Agriculture	_____ acres
4. Floodplain	_____ acres	Forestry	_____ acres
5. Coastal Area	_____ acres	8. Other	_____ acres

C. Provide the following dimensions, if applicable:

	Existing	Increase	Total
Length in miles			
Number of Housing Units			
Number of Stories			
Gross Floor Area in square feet			
Number of parking spaces			
Total of Daily vehicle trips to and from site (Total Trip Ends)			
Estimated Average Daily Traffic on road(s) serving site			
1.			
2.			
3.			

D. TRAFFIC PLAN. If the proposed project will require any permit for access to local roads or state highways, attach a sketch showing the location and layout of the proposed driveway(s).

III. ASSESSMENT OF POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS

Instructions: Explain direct and indirect adverse impacts, including those arising from general construction and operations. For every answer explain why significant adverse impact is considered likely or unlikely to result. Positive impact may also be listed and explained.

Also, state the source of information or other basis for the answers supplied. Such environmental information should be acquired at least in part by field inspection.

Unless otherwise stated, source is BEC 1988, Diagnostic/Feasibility Study for the management of Dimmock Pond.

A. Open Space and Recreation

1. Might the project affect the condition, use, or access to any open space and or recreation area?

Explanation and Source:

Temporary inconvenience expected during project, condition greatly improved by project end.

2. Is the project site within 500 feet of any public open space, recreation or conservation land?

Explanation and Source:

Part of project site is within Hubbard Park, and remainder is adjacent to it.

B. Historic and Archaeological Resources

1. Might any site or structure of historic significance be affected by the project? (Prior consultation with Massachusetts Historical Commission is advised.)

Explanation and Source:

See letter from MHC.

2. Might any archaeological site be affected by the project? (Prior consultation with Massachusetts Historical Commission is advised.)

Explanation and Source:

See letter from MHC.

C. Ecological Effects

1. *Might the project significantly affect* fisheries or wildlife, especially any rare or endangered *species? (Prior consultation with the* Massachusetts Natural Heritage Program is advised).

Explanation and Source:

See letter from MNHP.

2. Might the project significantly affect vegetation, especially any rare or endangered species of plant? (Prior consultation with the Massachusetts Natural Heritage Program is advised.)

(Estimate approximate number of mature trees to be removed: ____0____)

Explanation and Source:

See letter from MNHP

3. Agricultural Land. Has any portion of the site been in agricultural use within the last 15 years? If yes, specify use and acreage.

Explanation and Source:

No agricultrual usage in over 30 years.

D. Water Quality and Quantity

1. Might the project result in significant changes in drainage patterns?

Explanation and Source:

Some stormwater will be diverted from pond to groundwater.

2. Might the project result in the introduction of any pollutants, including sediments, into marine waters, surface fresh waters or ground water?

Explanation and Source:

Project will remove pollutants or reduce inputs to Dimmock Pond. Some pollutants may reach groundwater.

3. Does the project involve any dredging? No ______ Yes __x__ Volume 87,500 . If 10,000 cy or more, attach completed Standard Application Form for Water Quality Certification, Part I (314 CMR 9.02(3), 9.90, DEQE Division of Water Pollution Control).

4. Will any part of the project be located in flowed or filled tidelands, Great Ponds, or other waterways? (Prior consultation with the DEQE and CZM is advised.)

   Explanation and Source:

   Project is the restoration of a Great Pond.

5. Will the project generate or convey sanitary sewage? No __X__ Yes ______
   If Yes, Quantity: ________ gallons per day
   Disposal by: (a) Onsite septic systems .... Yes ______ No ______
   (b) Public sewerage systems (location; average and peak daily flows to treatment works) .... Yes ______ No ______
   Explanation and Source:

6. Might the project result in an increase in paved or impervious surface over a sole source aquifer or an aquifer recognized as an important present or future source of water supply?

   Explanation and Source:

   No increase in impervious surface planned.

7. Is the project in the watershed of any surface water body used as a drinking water supply?

   Explanation and Source:

   No surface water discharge from pond, which is not a drinking water source.

8. Are there any public or private drinking water wells within a 1/2-mile radius of the proposed project?

   Explanation and Source:

   No, all area water is supplied by City water mains.

9. Does the operation of the project result in any increased consumption of water?

   Approximate consumption ________ gallons per day. Likely water source(s) ________

   Explanation and Source:

   Only recycling of water between pond and containment area for dredged material.

E. Solid Waste and Hazardous Materials

1. Estimate types and approximate amounts of waste materials generated, e.g., industrial, domestic, hospital, sewage sludge, construction debris from demolished structures. How/where will such waste be disposed of?

   Explanation and Source:

   Only dredged material (muck) will be produced.

2. Might the project involve the generation, use, transportation, storage, release, or disposal of potentially hazardous materials?

   Explanation and Source:

   Sediments are high in lead, some contamination by other metals. See Table 15 of BEC report. Further analysis is planned.

3. Has the site previously been used for the use, generation, transportation, storage, release, or disposal of potentially hazardous materials?

   Explanation and Source:

   Possible historic disposal of slag. No other source known.

F. Energy Use and Air Quality

1. Will space heating be provided for the project? If so, describe the type, energy source, and approximate energy consumption.

   Explanation and Source:

   NO

2. Will the project require process heat or steam? If so, describe the proposed system, the fuel type, and approximate fuel usage.

   Explanation and Source:

   NO

3. Does the project include industrial processes that will release air contaminants to the atmosphere? If so, describe the process (type, material released, and quantity released).

   Explanation and Source:

   Only emissions from gasoline powered equipment.

4. Are there any other sources of air contamination associated with the project (e.g. automobile traffic, aircraft traffic, volatile organic compound storage, construction dust)?

   Explanation and Source:

   NO

5. Are there any sensitive receptors (e.g. hospitals, schools, residential areas) which would be affected by air contamination caused by the project?

   Explanation and Source:

   Area is ringed by residential/commercial areas.

G. Noise

1. Might the project result in the generation of noise?

   (Include any source of noise during construction or operation, e.g., engine exhaust, pile driving, traffic.)

   Explanation and Source:

   Noise of machinery used in excavation work is expected.

2. Are there any sensitive receptors (e.g., hospitals, schools, residential areas) which would be affected by any noise caused by the project?

Explanation and Source:

Area is ringed by residential/commercial area.

3. Is the project a sensitive receptor, sited in an area of significant ambient noise?

Explanation and Source:

Traffic near park on Parker St. is noisy.

H. Wind and Shadow

1. Might the project cause wind and shadow impacts on adjacent properties?

Explanation and Source:

NO

I. Aesthetics

1. Are there any proposed structures which might be considered incompatible with existing adjacent structures in the vicinity in terms of size, physical proportion and scale, or significant differences in land use?

Explanation and Source:

NO. Aesthetics of area will be improved by project.

2. Might the project impair visual access to waterfront or other scenic areas?

Explanation and Source:

Minor impairment by machinery and containment area on temporary basis.

IV. CONSISTENCY WITH PRESENT PLANNING

Discuss consistency with current federal, state and local land use, transportation, open space, recreation and environmental plans and policies. Consult with local or regional planning authorities where appropriate.

Project is intended to improve a water resource in an urban park.

V. FINDINGS AND CERTIFICATION

A. The public notice of environmental review has been/will be published in the following newspaper(s):

(NAME) ____________________ (Date) ____________________

____________________ ____________________

____________________ ____________________

B. This form has been circulated to all agencies and persons as required by 301 CMR 11.24.

________ Date	____________________ Signature of Responsible Officer or Project Proponent	________ Date	____________________ Signature of person preparing ENF (if different from above)
	____________________ Name (print or type)		____________________ Name (print or type)
	Address ____________________ ____________________		Address ____________________ ____________________
	Telephone Number ____________		Telephone Number ____________

DIVISION OF WATER POLLUTION CONTROL
ONE WINTER STREET
BOSTON, MASSACHUSETTS 02108

APPLICATION for WATER QUALITY CERTIFICATION
for Stream Crossing and Fill in Wetlands

Location (town) SPRINGFIELD
Project Name DIMMOCK POND
Applicant DEPT. PARKS/REC.

Address of applicant: Dept. Parks/Recreation, Forest Park Admin. Bldg.
Name and address of authorized agent if any: Springfield, MA 01108 Att: Rita Coppola

1. DEQE file number: ________ issued by ________ regional DEQE office.

2. Submit a copy of the Order of Conditions.

3. a) Indicate the status of this project with respect to MEPA
In Review
b) Give EOEA number and date of MEPA decision, if any

4. Briefly describe a) the overall scope of the project - See ENF

b) the scope of work in the wetlands - Dredging of up to 10.3 AC

5. Submit a USGS quad sheet showing the location of the project.
See ENF and BEC report

6. a) Provide a plan view of the whole project site showing all wetland areas
See BEC report
b) Provide a plan view clearly indicating, as appropriate to the proposed work:

(1) all areas where alteration of wetlands will occur See BEC Report

(2) areas where wetlands compensation will be provided "

(3) width and depth of waters within any construction site "

c) Please do not send any full sized plans which have not been requsted per 6(a) and (b).

7. Name all downstream surface waters within a 2 mile radius of the project site.
NONE

8. If fill is to be placed in wetland areas: Fill will be removed, except for gabion weirs near stormdrains.

a) What volume of fill will be placed? 105 CY

b) What material(s) will fill consist of? Rocks

c) What is the total area of wetland filled? 945 sq. ft.

d) Explain measures to be taken to control the discharge of pollutants (including oils, silt, and any other pollutants present) to waters and wetlands on site or adjacent to the project site.
Site is self-contained, project intended to remove poullants.

e) How much wetland compensation area will be provided? None planned.
(indicate type of wetland i.e. marsh, pond, etc.)

9. If construction will occur in the water, provide the following information:

a) Name of water body or waterway: Dimmock Pond

b) During what month(s) is the work to occur? Primarily summer through fall fo 2-3 years.

c) What is the duration of actual work in the waterway? Dredging - 250 days

d) During construction what is the expected width, depth, and flow in waterway? No change from background conditions. Flow << 1 cfs.

e) What is the nature of the affected sediments? Organic hydrosoils impacted by urban runoff.
Indicate the basis for your answer. Soil samples/analysis and visual obs.

f) If fill is to be placed in the waterway, what volume of fill will be placed? ______

g) Is fill temporary or permanent? ______

h) What material will be used as fill? ______

i) Are temporary siltation basins or permanent detention basins planned? (If yes, enclose plan showing location and dimensions) Yes. See BEC report. Fill placement is to establish basins.

j) How will turbidity in the waterway be controlled during the placing and removal of fill? (Please explain on a separate page). No surface outflow, turbidity shield on hydraulic dredge.

k) List the construction steps plannded for any work in the waterway (please use a separate page).

Please return to: Department of Environmental Quality Engineering
Division of Water Pollution Control - Permits
One Winter Street
Boston, MA 02108

______ ______
(date) (signature of applicant or authorized agent)

4-87

DIMMOCK POND CONSTRUCTION SEQUENCE.

1. Build containment area
2. Hydraulically dredge
3. Place gabion weirs for creation of detention basins

Dredged material to be distributed on low-lying ballfields after drying.

Conversion of catch basins to leaching basins as separate operation.

APPENDIX E

COMMENTS BY INTERESTED PARTIES

SUMMARY OF THE FIRST PUBLIC MEETING FOR
THE SPRINGFIELD KETTLEHOLE LAKES AND DIMMOCK POND.

On February 25, 1987, representatives of the Springfield Department of Public Works, Department of Parks and Recreation, and Baystate Environmental Consultants met with concerned citizens at the Pine Point Community Center, 335 Berkshire Ave., Springfield, Massachusetts. The meeting was advertised in the legal section of the February 11, 1987, Springfield Daily News, and 500 notices were distributed to watershed residents on February 18, 1987. The meeting was opened at about 7:30 PM. Representative Paul Caron and three members of the Springfield Conservation Commission attended the meeting, in addition to the concerned citizens. Mr. Joseph Superneau, Director of Public Works, opened the meeting by describing the Clean Lakes Program and the City's involvement therein. Dr. Carlos Carranza, President of Baystate Environmental Consultants, then discussed BEC's participation in the study and long-term involvement with environmental affairs in Springfield. Dr. Kenneth Wagner, Project Manager for BEC, then summarized the findings to date, illustrating land use, drainage considerations, sources of pollution, and the fish communities of the lakes with recent and historical slides.

At approximately 8:15 PM the presentations were completed and an opportunity was given to attendees to raise questions and make comments. Questions and comments can be summarized as follows:

1. Does acid rain substantially impact the lakes under study? (No impact has been demonstrated, but the current study will yield more information as it proceeeds).

2. The dumping of sand on private and semi-public beaches at Loon Pond is believed to be causing serious infilling of that pond.

3. Is there a connection between Fivemile Pond and Lake Lorraine? (At one time these lakes were one, and there are rumors of culverts under the railroad bed, but there is currently no evidence to support such claims. More will be learned from an upcoming dive survey).

4. What were the results of the DPW study of water levels in the ponds? (Daily to weekly data were obtained for lake level and water levels in ground water monitoring wells nearby. This data will be turned over to BEC for incorporation into their study).

5. Is storm water diversion a possibility at Lake Lorraine? (It appears to be, but further study is needed and planned).

6. The wetlands adjoining Fivemile Pond have been expanding and restricting circulation in associated portions of that pond. Accumulation of refuse and debris and odor problems were reported. A clean-up effort was requested.

7. Many questions were raised concerning the fishery status in the lakes. (Data analysis is not yet complete, but will be included in the BEC report. Preliminary findings were discussed).

8. Concern was expressed over the existence of on-site wastewater disposal systems in the watersheds of the lakes. Tie-in to local sanitary sewers was urged.

9. Problems with refuse accumulation and drainage at the Marshall's parking lot were reported. An appeal was made to BEC and the City to contact the management of that store and discuss the problems. (BEC will be contacting all businesses in the watershed for such discussions).

10. Refuse from other commercial areas was discussed. (BEC will look into all such complaints, but the scope of the study precludes intensive involvement in refuse disposal planning).

11. Oil contamination, input of old tires, and related pollution of Fivemile Pond by activities at the Temby Street Auto Yard were noted. (BEC has reviewed correspondence from the 1970's detailing similar pollution episodes, and will follow up on related complaints).

12. Several questions were raised regarding the impact of motorboats on the lakes, as relates to noise, oil spills, resuspension of sediments, and weed propagation/dispersal. The need for motors by some retired fishermen was noted by Rep. Caron. The City's current 10 HP limit for motors was noted by Mr. Friedman of the Conservation Commission. Rep. Caron noted that the City's policies regarding boating on all city lakes is currently being discussed by himself and Mr. L. Dowd of the Department of Parks and Recreation. (BEC will attempt to assess boating impacts during the study).

13. Oil contamination of Loon Pond has been observed. (BEC believes such contamination to be linked to storm drainage inputs).

14. Is there a macrophyte problem in these lakes? (Parts of Fivemile Pond and most of Dimmock Pond are experiencing excessive plant growths, but Lake Lorraine and Loon Pond have relatively light macrophyte communities. More information will be gained this summer).

15. Creosoted poles believed to originate at Orchard Beach have been washing up at the Parker Street end of Loon Pond. What is their impact and what can be done about them? (BEC will be studying this problem over the next year).

The meeting was adjourned at approximately 10:30 PM, and participants discussed the lakes informally for another 15 minutes before departing.

DIMMOCK POND SECOND PUBLIC MEETING 7-9 PM, WED., AUG. 19, 1987.

R. Coppola introduced speakers.

Rep. P. Caron spoke briefly on lake restoration in Springfield and storm drain issues facing Indian Orchard.

K. Wagner of BEC presented Dimmock Pond study findings to date. Probable need for a major restoration project discussed: dredging and storm water management as primary components.

Approx. 55 people in attendance, handout of computer-generated maps given to each attendee.

Questions and Comments:

1. Access questions common; need parking facility but have problems with security and illegal dumping.
2. Aesthetics vs. recreation discussed; some residents want a quiet place to walk, others want greater aquatic recreation potential, including swimming.
3. Pond acidity may be partly a function of use of slag as fill for nearby roads and Hubbard Park.
4. Concerns raised about trash, debris, and muck; removal desired, but high cost recognized.
5. Questions raised regarding costs, funding options, eligible items. Clean Lakes Program approach described.
6. Some big bass believed to be in pond; residents would like to see them salvaged if pond is dredged.
7. Questions raised regarding efficacy of ever allowing motorboats on Dimmock Pond.
8. Situation regarding Hallohan property reviewed. Eminent domain proceedings initiated on 22 ac. parcel to east of pond. Oak St. homes with septic systems, and road extension has created new access to Dimmock Pond area.
9. Re-routing of storm drains discussed; treatment/detention also options, but no clear, viable solution yet.
10. In-lake options discussed; dredging or bottom barriers preferable at this time.
11. Some plant cover, esp. lilies, is desired by most residents.
12. Recollections of pond include cleaner water and surroundings, sandy bottom at least near edge, greater water clarity, good fishing, not too much plant growth, extensive wetland in Hubbard Park area.
13. UniFirst problems discussed; current situation uncertain. Is facility still connected to Dimmock Pond?

SUMMARY OF THE JULY 21, 1988 PUBLIC MEETING

A public meeting was held from 7:30 to 10:00 PM on Thursday, July 21, 1988 in Indian Orchard to discuss the findings of the Dimmock Pond study and the recommended management program. Dr. K. Wagner of BEC described the study, presented a brief slide show, and discussed a series of handouts that were distributed to attendants.

Approximately 30 area residents attended, along with Ms. Rita Coppola of the Springfield Parks Dept. and Ms. Elaine Hartman of the MA Clean Lakes Program.

Comments/Questions:

All attendants were in favor of the proposed program; dredging favored over all other possible in-lake measures, stormwater control measures endorsed.

Concern expressed over ballfields; do not want to lose utility any longer than necessary (containment area to be on one field). Other containment locations discussed and dismissed.

Concern expressed over groundwater discharge of stormwater; will it cause basement flooding?

Area history discussed- notes taken for incorporation into report.

Debris/dumping problem at pond discussed. Security measures desired, but would like daily opening of access road eventually.

Access discussed- parking needed, should be along railroad, no strong desire for swimming beach, do not want motorized boating.

Recreational goals- prefer passive activities and non-motorized boating. Shoreline trail and vegetative amenities desired.

Park planning needs discussed. New acquisitions and opportunities make time right for establishing park master plan. Elements of existing park are correct, but need physical improvements.

Impacts of proposed program on pond and surrounding park/neighborhood discussed. Program desired, but community wishes to be kept informed and to be involved.

Clean Lakes Program process discussed extensively. Attendants very concerned about maximizing point total and getting fair consideration. Timetable, application process, and opportunities for public involvement in the process discussed.

September 27, 1988

Kenneth J. Wagner
Baystate Environmental Consultants
296 North Main Street
East Longmeadow, MA 01028

RE: Dimmock Pond, Clean Lakes Project, Springfield

Dear Dr. Wagner:

Thank you for supplying the Massachusetts Historical Commission with information concerning the proposed project listed above. Staff of the MHC have reviewed the materials you submitted.

MHC feels that this project is unlikely to affect significant historic or archaeological resources. No further review is required in compliance with Massachusetts General Laws, Chapter 9, Sections 26C and 27C, as amended by Chapter 152 of the Acts of 1982 (950CMR 71).

If you have any questions, please feel free to contact Peter Mills at this office.

Sincerely,

Brona Simon

Brona Simon
State Archaeologist
Director, Technical Services Division

Massachusetts Historical Commission

BS/PM/DI

Massachusetts Historical Commission, Valerie A. Talmage, *Executive Director, State Historic Preservation Officer*
80 Boylston Street, Boston, Massachusetts 02116 (617) 727-8470

Office of the Secretary of State, Michael J. Connolly, *Secretary*

Massachusetts
Natural Heritage
Program

26 September 1988

Mr. Kenneth Wagner
Baystate Environmental Consultants, Inc.
296 North Main Street
East Longmeadow, MA 01028

Re: Dimmock Pond Project
Springfield, MA

Dear Mr. Wagner:

Thank you for contacting the Natural Heritage and Endangered Species Program regarding rare species and ecologically significant natural communities in the vicinity of the proposed Dimmock Pond Project in Springfield, Massachusetts, as described in your 26 August 1988 letter.

At this time we do not have current records of any rare plants or animals or ecologically significant natural communities at Dimmock Pond. However, we have an historical record of Umbrella Grass (Fuirena pumila), a "Watch List" species, at Dimmock Pond. While sufficient numbers of this species have been located to warrant its removal from Special Concern status, it remains on a "Watch List" so that it may be monitored to prevent decreases in its numbers. We do have a current rare plant record at Loon Pond for Terete Arrowhead (*Sagittaria teres*), which is listed by the Division of Fisheries and Wildlife as a Species of Special Concern. Based on this rare species occurrence, we request to be informed if the proposed project will involve or affect Loon Pond. A Fact Sheet describing the habitat, biology, distribution and status of Terete Arrowhead has been enclosed for your reference.

If your project plans change, or if additional fieldwork and research results in an update of our database, this evaluation may require reconsideration.

Please note that rare species data should not be made public, in order to protect vulnerable habitats and populations from degradation through collecting and visitation (please see attached "Notice to Recipients.."). In cases where permission is ginven by this office for publication of data in environmental information documents, the NHESP should be credited as the source of this information.

Sincerely,

Karen Pelto

Karen Pelto
Environmental Review Assistant

Division of Fisheries and Wildlife 100 Cambridge Street, Boston, Mass. 02202 (617) 727-9194,-3151

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

Richard Cronin, *Director*

September 2, 1988

David Mitchell, Ph.D.
Baystate Environmental Consultants, Inc.
296 North Main Street
East Longmeadow, MA 01028

RE: Diagnostic/Feasibility Study Dimmock Pond, Springfield,MA

Dear Dr. Mitchell:

Thank you for providing the Division of Fisheries and Wildlife with a copy of the "Diagnostic/Feasibility Study for Dimmock Pond, Springfield, MA" for review and comment. Information concerning the fish population and recreational use of the fishery is very limited although the species composition is probably accurate as described in this report. Based on available information, the proximity of this small urban pond to several managed ponds such as Lake Lorraine (stocked trout pond), Five Mile Pond (also a stocked trout pond), and Loon Lake (warm water fishery with public access) would imply that fishing, as an activity, is rather minimal.

As noted in the report, the recommended management approach will involve substantial changes to Dimmock Pond. The present fish population is dominated by panfish. The presence of carp attests to the low quality of the fishery. The lowering of the water during dredging may well present an opportunity to selectively remove such undesirable species as the carp. The MDFW concurs that a healthier pond will ultimately result from the proposed management approach. Accordingly, we have no objections to the program as described.

Thank you for submitting this report to the MDFW for review. If you have any questions concerning any of these comments please do not hesitate to contact me.

Sincerely,

Robert P. Madore

Robert P. Madore
Aquatic Biologist II

cc. MDWPC - Clean Lakes
EOEA - Mepa Unit
MDFW - CVWD

Field Headquarters
Westborough, Massachusetts 01581 (617) 366-4470
An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement

APPENDIX F

GLOSSARY

GENERAL AQUATIC GLOSSARY

Abiotic - Pertaining to any non-biological factor or influence, such as geological or meteorological characteristics.

Acid precipitation - Atmospheric deposition (rain, snow, dryfall) of free or combined acidic ions, especially the nitrates, sulfates and oxides of nitrogen and sulfur fumes from industrial smoke stacks.

Adsorption - External attachment to particles, the process by which a molecule becomes attached to the surface of a particle.

Algae - Aquatic single-celled, colonial, or multi-celled plants, containing chlorophyll and lacking roots, stems, and leaves.

Alkalinity - A reference to the carbonate and bicarbonate concentration in water. Its relative concentration is indicative of the nature of the rocks within a drainage basin. Lakes in sedimentary carbonate rocks are high in dissolved carbonates (hard-water lakes) whereas lakes in granite or igneous rocks are low in dissolved carbonate (soft-water lakes).

Ammonia Nitrogen - A form of nitrogen present in sewage and is also generated from the decomposition of organic nitrogen. It can also be formed when nitrites and nitrates are reduced. Ammonia is particularly important since it has high oxygen and chemical demands, is toxic to fish in un-ionized form and is an important aquatic plant nutrient because it is readily available.

Anadromous - An adjective used to describe types of fish which spawn in freshwater rivers but spend most of their adult lives in the ocean. Before spawning, anadromous adult fish ascend the rivers from the sea.

Anoxic - Without oxygen.

Aphotic Zone - Dark zone, below the depth to which light penetrates. Generally equated with the zone in which most photosynthetic algae cannot survive, due to light deficiency.

Aquifer - Any geological formation that contains water, especially one that supplies wells and springs; can be a sand and gravel aquifer or a bedrock aquifer.

Artesian - The occurrence of groundwater under sufficient pressure to rise above the upper surface of the aquifer.

Assimilative Capacity - Ability to incorporate inputs into the system. With lakes, the ability to absorb nutrients or other potential pollutants without showing extremely adverse effects.

Attenuation - The process whereby the magnitude of an event is reduced, as the reduction and spreading out of the impact of storm effects or the removal of certain contaminants as water moves through soil.

Background Value - Value for a parameter that represents the conditions in a system prior to a given influence in space or time.

Bathymetry - The measurement of depths of water in oceans, seas, or lakes or the information derived from such measurements.

Benthic Deposits - Bottom accumulations which may contain bottom-dwelling organisms and/or contaminants in a lake, harbor, or stream bed.

Benthos - Bottom-dwelling organisms living on, within or attached to the sediment. The phytobenthos includes the aquatic macrophytes and bottom-dwelling algae. The zoobenthos (benthic fauna) includes a variety of invertebrate animals, particularly larval forms and molluscs.

Benthic - Living or occupying space at the bottom of a water body, on or in the sediment.

Best Management Practices - (BMP's) State-of-the-art techniques and procedures used in an operation such as farming or waste disposal in order to minimize pollution or waste.

Bio-available - Able to be taken up by living organisms, usually refers to plant uptake of nutrients.

Biocide - Any agent, usually a chemical, which kills living organisms.

Biological Oxygen Demand - The BOD is an indirect measure of the organic content of water. Water high in organic content will consume more oxygen due to the decomposition activity of bacteria in the water than water low in organic content. It is routinely measured for wastewater effluents. Oxygen consumption is proportional to the organic matter in the sample.

Biota - Plant (flora) and animal (fauna) life.

Biotic - Pertaining to biological factors or influences, concerning biological activity.

Bloom - Excessively large standing crop of algae, usually visible to the naked eye.

Bulk Sediment Analysis - Analysis of soil material or surface deposits to determine the size and relative amounts of particles composing the material.

CFS - Cubic feet per second, a measure of flow.

Chlorophyll - Major light gathering pigment of all photosynthetic organisms imparting the characteristic color of green plants. Its relative measurement in natural waters is indicative of the concentration of algae in the water.

Chlorophyte - Green algae, algae of the division Chlorophyta.

Chrysophyte - Golden or golden-brown algae, algae of the division Chrysophyta.

Color - Color is determined by visual comparison of a sample with known concentrations of colored solutions and is expressed in standard units of color. Certain waste discharges may turn water to colors which cannot be defined by this method; in such cases, the color is expressed qualitatively rather than numerically. Color in lake waters is related to solids, including algal cell concentration and dissolved substances.

Combined Sewer - A sewer intended to serve as both a santiary sewer and a storm sewer. It receives both sewage and surface runoff.

Composite Sample - A number of individual samples collected over time or space and composited into one representative sample.

Concentration - The quantity of a given constituent in a unit of volume or weight of water.

Conductivity - The measure of the total ionic concentration of water. Water with high total dissolved solids (TDS) level would have a high conductance. A conductivity meter tests the flow of electrons through the water which is heightened in the presence of electrolytes (TDS).

Confluence - Meeting point of two rivers or streams.

Conservative Substance - Non-interacting substance, undergoing no kinetic reaction; chlorides and sodium are approximate examples.

Cosmetic - Acting upon symptoms or given conditions without correcting the actual cause of the symptoms or conditions.

Cryptophyte - Small, flagellated algae of variable pigment composition, algae of the division Cryptophyta, which is often placed under other taxonomic divisions.

Cyanophyte - Bluegreen algae, algae of the division Cyanophyta, actually a set of pigmented bacteria.

Decomposition - The metabolic breakdown of organic matter, releasing energy and simple organic and inorganic compounds which may be utilized by the decomposers themselves (the bacteria and fungi).

Deoxygenation - Depletion of oxygen in an area, used often to describe possible hypolimnetic conditions, process leading to anoxia.

Diatom - Specific type of chrysophyte, having a siliceous frustule (shell) and often elaborate ornamentation, commonly found in great variety in fresh or saltwaters. Often placed in its own division, the Bacillariophyta.

Dinoflagellate - Unicellular algae, usually motile, having pigments similar to diatoms and certain unique features. More commonly found in saltwater. Algae of the division Pyrrhophyta.

Discharge Measurement - The volume of water which passes a given location in a given time period, usually measured in cubic feet per second (cfs) or cubic meters per minute (m^3/min).

Dissolved Oxygen (D.O.) - Refers to the uncombined oxygen in water which is available to aquatic life. Temperature affects the amount of oxygen which water can contain. Biological activity also controls the oxygen level. D.O. levels are generally highest during the afternoon and lowest just before sunrise.

Diurnal - Varying over the day, from day time to night.

Domestic Wastewater - Water and dissolved or particulate substances after use in any of a variety of household tasks, including sanitary systems and washing operations.

Drainage Basin - A geographical area or region which is so sloped and contoured that surface runoff from streams and other natural watercourses is carried away by a single drainage system by gravity to a common outlet. Also referred to as a watershed or drainage area. The definition can also be applied to subsurface flow in groundwater.

Dystrophic - Trophic state of a lake in which large quantities of nutrients may be present, but are generally unavailable (due to organic binding or other causes) for primary production. Often associated with acid bogs.

Ecosystem - A dynamic association or interaction between communities of living organisms and their physical evironment. Boundaries are arbitrary and must be stated or implied.

Elutriate - Elutriate refers to the washings of a sample of material.

Epilimnion - Upper layer of a stratified lake. Layer that is mixed by wind and has a higher average temperature than the hypolimnion. Roughly approximates the euphotic zone.

Erosion - The removal of soil from the land surface, typically by runoff water.

Eskar - A winding, narrow ridge of sand or gravel deposited by a stream flowing under glacial ice.

Euglenoid - Algae similar to green algae in pigment composition, but with certain unique features related to food storage and cell wall structure. Algae of the division Euglenophyta.

Eutrophic - High nutrient, high productivity trophic state generally associated with unbalanced ecological conditions and poor water quality.

Eutrophication - Process by which a body of water ages, most often passing from a low nutrient concentration, low productivity state to a high nutrient concentration, high productivity stage. Eutrophication is a long-term natural process, but it can be greatly accelerated by man's activities. Eutrophication as a result of man's activities is termed cultural eutrophication.

Evapotranspiration - Process by which water is lost to the atmosphere from plants.

Fauna - A general term referring to all animals.

Fecal Coliform Bacteria - Bacteria of the coli group that are present in the intestines or feces of warm-blooded animals. They are often used as indicators of the sanitary quality of the water. In the laboratory they are defined as all organisms which produce blue colonies within 24 hours when incubated at $44.5^{\circ}C \pm 0.2^{\circ}C$ on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 ml of sample.

Fecal Streptococci Bacteria - Bacteria of the Streptococci group found in intestines of warm-blooded animals. Their presence in water is considered to verify fecal pollution. They are characterized as gram positive, cocciod bacteria which are capable of growth in brain-heart infusion broth. In the laboratory they are defined as all the organisms which produce red or pink colonies within 48 hours at $35^{o}C \pm 1.0^{o}C$ on KF medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 ml of sample.

Flora - A general term referring to all plants.

Food Chain - A linear characterization of energy and chemical flow through organisms such that the biota can be separated into functional units with nutritional interdependence. Can be expanded to a more detailed characterization with multiple linkage, called a food web.

French (or Pit) Drain - Water outlet which allows fairly rapid removal of water from surface, but then allows subsurface percolation. Generally consists of sand and gravel layers under grating or similar structure, at lowest point of a sloped area. Water runs quickly through the coarse layers, then percolates through soil, often without the use of pipes. The intent is the purification of most percolating waters.

Grain Size Analysis - A soil or sediment sorting procedure which divides the particles into groups depending on size so that their relative amounts may be determined. Data from grain size analyses are useful in determining the origin of sediments and their behavior in suspension.

Groundwater - Water in the soil or underlying strata, subsurface water.

Hardness - A physical-chemical characteristic of water that is commonly recognized by the increased quantity of soap required to produce lather. It is attributable to the presence of alkaline earths (principally calcium and magnesium) and is expressed as equivalent calcium carbonate ($CaCO_3$).

Humus - Humic substances form much of the organic matter of sediments and water. They consist of amorphous brown or black colored organic complexes.

Hydraulic Detention Time - Lake water retention time, amount of time that a random water molecule spends in a water body; time that it takes for water to pass from an inlet to an outlet of a water body.

Hydraulic Dredging - Process of sediment removal using a floating dredge to draw mud or saturated sand through a pipe to be deposited elsewhere.

Hydrologic Cycle - The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hypolimnion - Lower layer of a stratified lake. Layer that is mainly without light, generally equated with the aphotic zone, and has a lower average temperature than the epilimnion.

Impervious - Not permitting penetration or percolation of water.

Intermittant - Non-continuous, generally referring to the occasional flow through a set drainage path. Flow of a discontinuous nature.

Kame - A short, steep ridge or hill of stratified sand or gravel deposited in contact with glacial ice.

Kjeldahl Nitrogen - The total amount of organic nitrogen and ammonia in a sample, as determined by the Kjeldahl method, which involves digesting the sample with sulfuric acid, transforming the nitrogen into ammonia, and measuring it.

Leachate - Water and dissolved or particulate substances moving out of a specified area, usually a landfill, by a completely or partially subsurface route.

Leaching - Process whereby nutrients and other substances are removed from matter (usually soil or vegetation) by water. Most often this is a chemical replacement action, prompted by the quality of the water.

Lentic - Standing, having low net directional motion. Refers to lakes and impoundments.

Limiting Nutrient - That nutrient of which there is the least quantity, in relation to its importance to plants. The limiting nutrient will be the first essential compound to disappear from a productive system, and will cause cessation of productivity at that time. The chemical form in which the nutrient occurs and the nutritional requirements of the plants involved are important here.

Limnology - The comprehensive study of lakes, encompassing physical, chemical and biological lake conditions.

Littoral Zone - Shallow zone occurring at the edge of aquatic ecosystems, extending from the shoreline outward to a point where rooted aquatic plants are no longer found.

Loading - Inputs into a receiving water that may exert a detrimental effect on some subsequent use of that water.

Lotic - Flowing, moving. Refers to streams or rivers.

Macrofauna - A general term which refers to animals which can be seen with the naked eye.

Macrophyte - Higher plant, macroscopic plant, plant of higher taxonomic position than algae, usually a vascular plant. Aquatic macrophytes are those macrophytes that live completely or partially in water. May also include algal mats under some definitions.

Mesotrophic - An intermediate trophic state, with variable but moderate nutrient concentrations and productivity.

Metalimnion - The middle layer of a stratified lake, constituting the transition layer between the epilimnion and hypolimnion and containing the thermocline.

Mixis - The state of being mixed, or the process of mixing in a lake.

MGD - Million gallons per day, a measure of flow.

Micrograms per Liter (ug/l) - A unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Nitrate - A form of nitrogen that is important since it is the end product in the aerobic decomposition of nitrogenous matter. Nitrogen in this form is stable and readily available to plants.

Nitrite - A form of nitrogen that is the oxidation product of ammonia. It has a fairly low oxygen demand and is rapidly converted to nitrate. The presence of nitrite nitrogen usually indicates that active decomposition is taking place (i.e., fresh contamination).

Nitrogen - A macronutrient which occurs in the forms of organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen. Form of nitrogen is related to a successive decomposition reaction, each dependent on the preceding one, and the progress of decomposition can be determined in terms of the relative amounts of these four forms of nitrogen.

Nitrogen fixation - The process by which certain bacteria and bluegreen algae make organic nitrogen compounds (initially NH_4+) from elemental nitrogen (N_2) taken from the atmosphere or dissolved in the water.

Non-point Source - A diffuse source of loading, possibly localized but not distinctly definable in terms of location. Includes runoff from all land types.

Nutrients - Are compounds which act as fertilizers for aquatic organisms. Small amounts are necessary to the ecological balance of a waterbody, but excessive amounts can upset the balance by causing excessive growths of algae and other aquatic plants. Sewage discharged to a waterbody usually contains large amounts of carbon, nitrogen, and phosphorus. The concentration of carbonaceous matter is reflected in the B.O.D. test. Additional tests are run to determine the concentrations of nitrogen and phosphorus. Storm water runoff often contributes substantial nutrient loadings to receiving waters.

Oligotrophic - Low nutrient concentration, low productivity trophic state, often associated with very good water quality, but not necessarily the most desirable stage, since often only minimal aquatic life can be supported.

Organic - Containing a substantial percentage of carbon derived from living organisms; of a living organism.

Outwash - Sand and gravel deposited by meltwater streams in front of glacial ice.

Overturn - The vertical mixing of major layers of water caused by seasonal changes in temperature. In temperate climate zones overturn typically occurs in spring and fall.

Oxygen Deficit - A situation in lakes where respiratory demands for oxygen become greater than its production via photosynthesis or its input from the drainage basin, leading to a decline in oxygen content.

Periphyton - Attached forms of plants and animals, growing on a substrate.

pH - A hydrogen concentration scale from 0 (acidic) to 14 (basic) used to characterize water solutions. Pure water is neutral at pH 7.0.

Phosphorus - A macronutrient which appears in waterbodies in combined forms known as ortho- and poly-phosphates and organic phosphorus. Phosphorus may enter a waterbody in agricultural runoff where fertilizers are used. Storm water runoff from highly urbanized areas, septic system leachate, and lake bottom sediments also contribute phosphorus. A critical plant nutrient which is often targeted for control in eutrophication prevention plans.

Secchi Disk Transparency - An approximate evaluation of the transparency of water to light. It is the point at which a black and white disk lowered into the water is no longer visible.

Secondary Productivity - The growth and reproduction (creation of biomass) by herbivorous (plant-eating) organisms. The second level of the trophic system.

Sedimentation - The process of settling and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.

Sewage (Wastewater) - The waterborne, human and animal wastes from residences, industrial/commercial establishments or other places, together with such ground or surface water as may be present.

Specific Conductance - Yields a measure of a water sample's capacity to convey an electric current. It is dependent on temperature and the concentration of ionized substances in the water. Distilled water exhibits specific conductance of 0.5 to 2.0 micromhos per centimeter, while natural waters show values from 50 to 500 micromhos per centimeter. In typical New England lakes, Specific Conductance usually ranges from 100-300 micromhos per cm. The specific conductance yields a generalized measure of the inorganic dissolved load of the water.

Stagnant - Motionless, having minimal circulation or flow.

Standing Crop - Current quantity of organisms, biomass on hand. The amount of live organic matter in a given area at any point in time.

Storm Sewer - A pipe or ditch which carries storm water and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes.

Stratification - Process whereby a lake becomes separated into two relatively distinct layers as the result of temperature and density differences. Further differentation of the layers usually occurs as the result of chemical and biological processes. In most lakes, seasonal changes in temperature will reverse this process after some time, resulting in the mixing of the two layers.

Stratified Drift - Sand, gravel or other materials deposited by a glacier or its meltwater in a layered manner, according to particle size.

Substrate - The base of material on which an organism lives, such as cobble, gravel, sand, muck, etc.

Succession - The natural process by which land and vegetation patterns change, proceeding in a direction determined by the forces acting on the system.

Surface Water - Refers to lakes, bays, sounds, ponds, reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, oceans and all other natural or artificial, inland or coastal, fresh or salt, public or private waters at ground level.

Suspended Solids - Those which can be removed by passing the water through a filter. The remaining solids are called dissolved solids. Suspended solids loadings are generally high in stream systems which are actively eroding a watershed. Excessive storm water runoff often results in high suspended solids loads to lakes. Many other pollutants such as phosphorus are often associated with suspended solids loadings.

Taxon (Taxa) - Any hierarchical division of a recognized classification system, such as a genus or species.

Taxonomy - The division of biology concerned with the classification and naming of organisms. The classification of organisms is based upon a hierarchical scheme beginning with Kingdom and progressing to the Species level or even lower.

Thermocline - Boundary level between the epilimnion and hypolimnion of a stratified lake, variable in thickness, and generally approximating the maximum depth of light penetration and mixing by wind.

Till - Unstratified, unsorted sand, gravel, or other material deposited by a glacier or its meltwater.

Trophic Level - The position in the food chain determined by the number of energy transfer steps to that level; 1 = producer; 2 = herbivore; 3, 4, 5 = carnivore.

Trophic State - The stage or condition of an aquatic system, characterized by biological, chemical and physical parameters.

Turbidity - The measure of the clarity of a water sample. It is expressed in Nephelometric Turbidity Units which are related to the scattering and absorption of light by the water sample.

Volatile Solids - That portion of a sample which can be burned off, consisting of organic matter, including oils and grease.

Photic Zone - Illuminated zone, surface to depth beyond which light no longer penetrates. Generally equated with the zone in which photosynthetic algae can survive and grow, due to adequate light supply.

Photosynthesis - Process by which primary producers make organic molecules (generally glucose) from inorganic ingredients, using light as an energy source. Oxygen is evolved by the process as a byproduct.

Phytoplankton - Algae which are suspended, floating or moving only slightly under their own power in the water column. Often this is the dominant algal form in standing waters.

Plankton - The community of suspended, floating, or weakly swimming organisms that live in the open water of lakes and rivers.

Point Source - A specific source of loading, accurately definable in terms of location. Includes effluents or channeled discharges that enter natural waters at a specific point.

Pollution - Undesirable alteration of the physical, chemical or biological properties of water, addition of any substance into water by human activity that adversely affects its quality. Prevalent examples are thermal, heavy metal and nutrient pollution.

Potable - Usable for drinking purposes, fit for human consumption.

Primary Productivity (Production) - Conversion of inorganic matter to organic matter by photosynthesizing organisms. The creation of biomass by plants.

Riffle Zone - Stretch of a stream or river along which morphological and flow conditions are such that rough motion of the water surface results. Usually a shallow rocky area with rapid flow and little sediment accumulation.

Riparian - Of, or related to, or bordering a watercourse.

Runoff - Water and its various dissolved substances or particulates that flows at or near the surface of land in an unchanneled path toward channeled and usually recognized waterways (such as a stream or river).

Saturation Zone - Volume of soil in which all pore spaces are filled with water; the volume below the water table.

Water Quality - A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose or use.

Watershed - Drainage basin, the area from which an aquatic system receives water.

Zone of Contribution - Area or volume of soil from which water is drawn into a well.

Zooplankton - Microscopic animals suspended in the water; protozoa, rotifers, cladocera, copepods and other small invertebrates.