Nutt Pond Watershed Restoration Plan

Final Report
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Nutt Pond Watershed Restoration Plan

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1.0 Introduction

This report describes the results and evaluation of the Nutt Pond Watershed to develop a Watershed Restoration Program to address phosphorus and sediment loadings to Nutt Pond. Nutt Pond is currently listed on the *2008 List of Threatened or Impaired Waters that Require a TMDL* for chlorides and dissolved oxygen, both which impact aquatic life, and for chlorophyll-a, which is a measure of algae growth, and impact recreation uses of the pond. Chlorides typically come from salting of roads and impervious surfaces within the watershed. Low dissolved oxygen levels can occur when plants within the pond die and the bacteria feed on them, using up the oxygen. This can lead to fish kills. Chlorophyll-a can be correlated with phosphorus concentrations in the pond. Phosphorus is the limiting food source for algae and plant growth in fresh water systems and when it increases, an increase in chlorophyll-a also occurs as plants growth becomes more abundant. In addition to these impairments, Nutt Pond has received significant loadings of sediment as evidenced by large sediment deltas in the pond at the East and North inlets and a smaller sediment delta at the South inlet. This plan focuses on implementation actions to reduce phosphorus and sediment loadings into the pond.

The Nutt Pond watershed occupies about 557 acres in Manchester, New Hampshire. The pond occupies about 16 acres and is one of Manchester's few natural ponds to have never been dammed. The pond offers recreation with unmotorized boating, nearby fields and a nearby trail network.

The restoration plan is described in six sections beginning with this introduction. Section 2.0 describes the watershed source analysis of pollutants using a watershed model developed to evaluate stormwater impacts and issues. Section 3.0 lays out the numeric targets or goals for water quality. The necessary reductions needed are then described in Section 4.0. Section 5.0 describes a watershed evaluation to identify potential locations for phosphorus and sediment load reduction. Section 6.0 describes options and control strategies plus the restoration plan and overall schedule.

1.1 Background

Pond Characteristics

Nutt Pond is one of Manchester's few natural ponds; a natural treasure in an otherwise man-made, urbanized environment. It was once the location of summer fun, including boating, fishing and swimming, and winter commerce, but degrading water quality associated with urban encroachment has limited its uses in more recent years. The pond is located adjacent to the rail trail and Precourt Park, with its ball fields. This location offers a unique opportunity for local residents to walk to the pond and park.

The pond is fed by one perennial stream that enters on the east side of the pond and has one perennial stream outlet, Tannery Brook, which exits on the north side of the pond. There are also several stormwater outfalls into the pond, which along with the inlet stream, have been used to divide the watershed into four major subwatersheds: North; East; South; and West. Two stormwater outfalls are located in the West subwatershed, one in the North subwatershed and two in the South subwatershed. Figure 1-1 shows an overview of the subwatersheds, inlets and outlet of the pond. Figures 1-2 through 1-7 are photographs of pond inlets.

Figure 1-2. North Inlet Structure

Figure 1-3. North Inlet Structure Looking Into Pond

Figure 1-4. South Inlet 1

Figure 1-5. South Inlet 2

Figure 1-6. East Inlet Culvert Near Home Depot

Figure 1-7. East Inlet (view from pond)

The watershed is about 557 acres and is heavily developed with a mix of commercial, institutional and high density residential land uses, and a small amount of forested and wetland areas (5% of watershed).

The pond has an average depth of 13 feet, with a maximum depth of 30 feet. The volume of the pond is about 69 million gallons with about 16 acres of surface area. Stratification has been observed April through October, with an average thermocline depth (transition layer between deep and shallow water as defined by temperature) of about 10 feet. The estimated pond flushing rate is about 62 days based on estimated hydraulic loads from stream flows, stormwater runoff and direct precipitation into the pond. However, the pond is also believed to be fed by groundwater springs, which are not accounted for in the hydraulic analysis and retention time. This would result in a more rapid flushing rate, which is supported by the water quality in the pond, which is much better than would be expected with the level of urbanization and estimated flushing rate based on surface flows alone.

Historical Uses

Between the 1860s and 1920s the pond was used for ice harvesting. Between the 1930s and 1960s, the pond was a popular swimming and recreation location. However, in the 1950s and 1960s the pond was unsuccessfully treated with chlorine to combat a bacteria problem. Continued contamination from bacteria resulted in the pond being closed to swimming in 1968. The primary source of the contamination was a sewer outfall that discharged directly into the pond. While the sewer lines were replaced and redirected, development in the watershed led to extensive filling of wetlands and massive areas of imperviousness from parking lots and rooftops of industries and commercial sites, as well as high intensity residential development. The development of these vast impermeable areas prevents the natural infiltration of rainfall into the soils. As a result, rainfall now flows across these impermeable surfaces, washing off pollutants that have collected there, and conveys the polluted water directly to Nutt Pond, resulting in declining water quality.

Restoration Efforts

As part of a solution to address Manchester's combined sewer overflows, the City established the Manchester Urban Ponds Restoration Program (UPRP) in 2000 to assess the health of seven urban ponds in Manchester, including Nutt Pond, and to then implement measures to restore the ponds to the greatest extent possible.

Initial assessments of Nutt Pond by UPRP identified untreated urban runoff from heavily used paved areas as the largest issue facing the pond. Recommendations for pond improvements were outlined in a January 2003 letter report prepared by Comprehensive Environmental Inc. (CEI) and included: evaluating sewer lines around the pond; evaluating aeration; evaluating the feasibility of wetlands treatment at the southern inlet; evaluating the feasibility of treatment at the north inlet; enhancing open drainage channels in the East Inlet subwatershed; implementing stormwater design standards for new and redevelopment projects; evaluating the drainage network for illicit discharges; public education targeting residents and businesses; and limiting fertilizer application on public grounds.

Following these initial evaluations, the City of Manchester sought funding from the NH Department of Environmental Services (DES) for implementation of key recommendations, including the design and installation of in-pond forebays to trap sediments from the stormwater inlets and associated dredging. This led to a more refined evaluation of pollution sources within the watershed to ensure sources were addressed before any dredging was implemented. The refined evaluation resulted in the design and implementation of an in-line sediment forebay at the East inlet before this tributary entered the pond, and the design and implementation of a forebay and wetland treatment system at the South inlet.

Simultaneous with the implementation of these BMPs at the pond's inlets, the City initiated an effort to prepare a Watershed Restoration Plan and in the process to reevaluate and reprioritize its efforts to rehabilitate Nutt Pond. This would provide the City with one working plan from which to focus future remediation efforts. This report presents this plan.

1.2 Purpose of the Watershed Restoration Plan

This Watershed Restoration Plan provides a comprehensive outlook of the work performed within the watershed by the City and others to date and a reevaluation of what is needed to restore the water quality of Nutt Pond and recreation opportunities it offers. A quantitative approach was used that included the development of a desktop model to evaluate existing sources of pollution and to further evaluate how proposed watershed restoration actions would affect the total pollution load. The objectives were:

1) to identify water quality goals based on the latest information and water quality data;
2) to calibrate the data to match observed pollutant concentrations in the pond to the extent practical; and
3) to match proposed future projects to the restoration goals for the watershed.

This report presents the findings, modeling results and actions proposed for improving water quality in the pond. Consistent use of quantified loadings provides a basis to evaluate the effectiveness of projects towards achieving water quality goals. Implementation of this plan will help restore the recreational and aesthetic value this pond offers to City residents and businesses.

Figure 1-1

Nutt Pond Watershed Map

City of Manchester, NH

Legend

- Stormdrain Outfall
- Stream/Brook
- Nutt Pond Watershed Boundary

Data Source: City of Manchester

0 750 1,500 2,250 Feet

0 0.1 0.2 0.3 0.4 0.5 Miles

Comprehensive Environmental Inc.

2.0 Pollutant Source Analysis

Setting water quality goals for Nutt Pond and identifying measures needed to meet these goals requires an understanding of existing pollutant loadings into the pond and the pond's reaction to these loadings. To assist with the estimation of pollutant loadings from the watershed, the team selected an empirical modeling method, which uses land use based loadings obtained through literature and applies these to the Nutt Pond watershed to estimate loadings from the watershed. This was combined with the Reckhow Phosphorus Lake Model to calibrate loadings to in-pond concentrations. The modeling procedure was outlined in the *Nutts Pond Watershed Restoration Project: Abbreviated Quality Assurance Project Plan for Non-Monitoring Projects Involving Pollutant Load Reduction Modeling or Engineering Calculations*, dated March 5, 2008, which was approved by the New Hampshire Department of Environmental Services (NH DES) and Environmental Protection Agency (EPA). The cover page with approval signatures is included in Appendix A. More information on the modeling procedure and calibration is included in this section.

2.1 Input Data and Assumptions

The model relies on land use and pond data to estimate pollutant loadings and the impact on pond concentrations. The data used in the model along with a description of their purpose is described below:

Subwatersheds

The Nutt Pond watershed was divided into four major subwatersheds (Figure 1-1): North; East; South; and West, each representing the drainage area to a stormwater outfall and/or tributary. This provides more localized information that allows for prioritization of future remedial actions by identifying the areas with the greatest pollutant loadings.

The subwatershed boundaries are natural boundaries dictated by the local topography. These boundaries generally follow ridgelines or high points and represent the area that drains to the furthest downgradient point, which was typically chosen where the stream entered the pond, or in the case of further subdivision, where flows entered a proposed BMP.

Land Use and Land Cover

Land use and land cover within the watershed has a direct relationship with the amount of runoff and pollutant loadings to the pond. Generally, more intensely developed land uses with larger impervious area will produce more runoff and pollutant loadings than undeveloped forested areas. Land use data in the watershed was used to estimate stormwater runoff and pollutant loads from the watershed.

Land use data within the Nutt Pond watershed was obtained from GRANIT. Table 2-1 shows the type and quantity of each land use by subwatershed along with the associated percent impervious area. Table 2-2 shows the existing land use within each subwatershed as a percentage. Figure 2-1 shows the existing land uses throughout the watershed.

Table 2-1. Existing Land Use by Subwatershed (acres)					
Land Use	% Impervious	North Area (Acres)	East Area (Acres)	South Area (Acres)	West Area (Acres)
Commercial/Industrial	83%	45.83	36.10	84.05	0.00
High Density Residential	44%	41.12	186.43	11.30	46.60
Low Density Residential	15%	0.00	4.06	0.00	2.50
Institutional	65%	0.00	54.58	0.00	0.00
Recreational (Parks, Cemetery, Open Space)	5%	9.90	0.00	0.00	6.00
Woody Wetlands	0%	0.00	1.66	11.70	3.00
Deciduous Forest	0%	0.00	0.00	0.00	6.90
Total		**96.85**	**283.83**	**111.85**	**65.00**

Table 2-2. Existing Land Use by Subwatershed Existing as a Percent of Watershed Area					
Land Use	% Impervious	North Area (%)	East Area (%)	South Area (%)	West Area (%)
Commercial/Industrial	83%	47	13	75	0
High Density Residential	44%	43	66	10	71
Low Density Residential	15%	0	1	0	4
Institutional	65%	0	19	0	0
Recreational (Parks, Cemetery, Open Space)	5%	10	0	4	9
Woody Wetlands	0%	0	1	10	5
Deciduous Forest	0%	0	0	0	10

Soils

Soils data is used to determine the permeability of soils throughout the watershed, which is used to help determine runoff coefficients, as well as to determine the feasibility of implementing infiltration techniques. Figure 2-2 shows the hydrologic soil groups throughout the watershed.

Pollutant Loadings

Phosphorus

The model selected for evaluating pollutant loadings to Nutt Pond estimates pollutant loadings as a function of land use, with loadings obtained from literature for various land uses. Table 2-3 shows the initial pollutant loads by land use used in the model for total phosphorus.

Table 2-3. Initial Phosphorus Pollutant Loadings by Land Use		
Land Use	Phosphorus Load (lb/acre/day)	Source
Commercial/Industrial	0.00690	Northern Virginia (Kuo, 1988)
High Density Residential	0.00830	Northern Virginia (Kuo, 1988)
Low Density Residential	0.00120	Northern Virginia (Kuo, 1988)
Institutional	0.00580	Northern Virginia (Kuo, 1988)
Recreational (Parks, Cemetery, Open Space)	0.00160	Reckhow
Woody Wetlands	0.00055	Reckhow
Deciduous Forest	0.00055	Reckhow

TSS

TSS loadings were also based on loadings obtained from literature for various land uses. Table 2-4 shows the initial TSS loads by land use used in the model for TSS.

Table 2-4. Initial TSS Pollutant Loadings by Land Use		
Land Use	TSS Load (lb/acre/day)	Source
Commercial/Industrial	2.19	Northern Virginia (Kuo, 1988)
High Density Residential	3.53	Northern Virginia (Kuo, 1988)
Low Density Residential	1.32	Northern Virginia (Kuo, 1988)
Institutional	1.60	Northern Virginia (Kuo, 1988)
Recreational (Parks, Cemetery, Open Space)	0.49	Reckhow
Woody Wetlands	0.17	Reckhow
Deciduous Forest	0.17	Reckhow

Precipitation

Precipitation data is necessary to estimate a water budget for the pond. The total volume of water generated is calculated by multiplying the annual precipitation by the watershed area. The volume of stormwater runoff, evapotranspiration and baseflow make up this total volume. This water budget is used to evaluate the ponds' response to the estimated pollutant loadings.

Annual precipitation data was obtained from the website The Weather Underground (www.wunderground.com) for the City of Manchester, NH. Annual rainfall data for a nine-year period (2000-2008) was used in this analysis to correspond with available in-pond water quality data. The average precipitation over this period was approximately 42.9 inches per year. This results in an average of 667 million gallons of water generated in the watershed annually.

Stormwater Runoff

Stormwater runoff was calculated using a modified version of the Rational Method:

Q = CiA, where

Q = annual stormwater runoff
C = runoff coefficient based on land use
i = average annual precipitation
A = watershed area

The runoff coefficients and totals by land use are provided in Table 2-5.

Table 2-5. Stormwater Runoff by Land Use

Land Use	Area (acre)	Runoff Coefficient, c	Average Precipitation (in/yr)	Product (c x area)	Runoff (cf/yr)
Commercial/Industrial	165.5	0.70	42.90	115.86	18,043,460
High Density Residential	285.9	0.50	42.90	142.94	22,259,894
Low Density Residential	6.9	0.33	42.90	2.26	352,625
Institutional	54.6	0.70	42.90	38.22	5,952,117
Recreational (Parks, Cemetery, Open Space)	20.7	0.15	42.90	3.10	483,312
Woody Wetlands	16.4	0.00	42.90	0.00	0.00
Deciduous Forest	6.9	0.10	42.90	0.69	106,731
TOTAL				303.07	47,198,140

Evapotranspiration

Evapotranspiration represents the volume of precipitation that is lost to evaporation or is taken up by plants and recycled back into the atmosphere. It was used along with precipitation and stormwater runoff to estimate baseflow into the Pond. The average annual evapotranspiration was estimated as 40% of the average annual precipitation.[1]

Baseflow

Baseflow represents the water entering the pond through the inlet stream or direct groundwater inputs from the watershed. It does not represent inputs from groundwater springs, which may come from an aquifer that reaches outside of the watershed. It was calculated as:

Baseflow = Precipitation Volume – Stormwater Runoff – Evapotranspiration

Figure 2-3 shows the breakdown of the average annual water budget.

[1]Hanson, R.L., 1991, Evapotranspiration and Droughts, in Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., Compilers, National Water Summary 1988-89—Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 99-104.

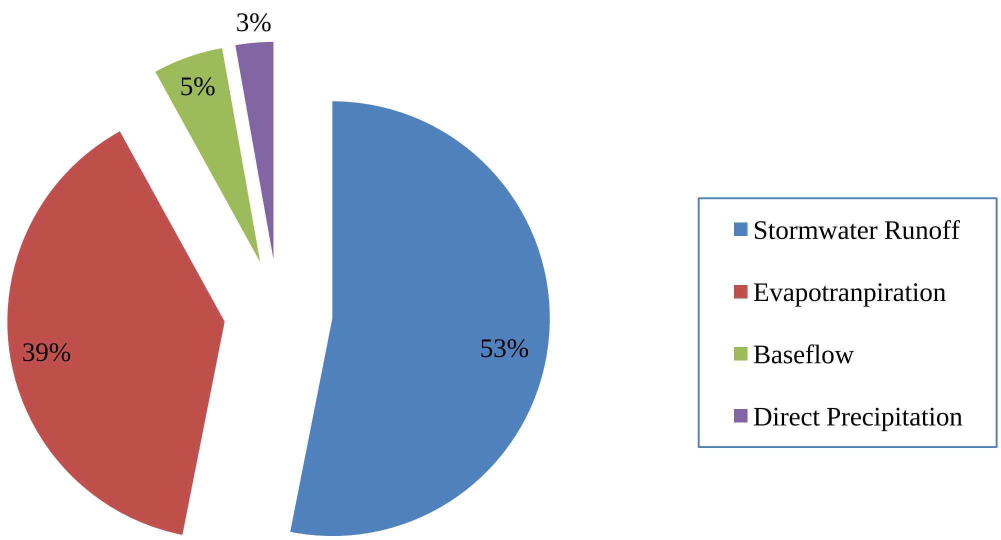

Figure 2-3. Nutt Pond Average Annual Water Budget

Bathymetric Data

The bathymetry of Nutt Pond was obtained from the Volunteer Lake Assessment Program (VLAP) and is included in Appendix B, along with the Lake Trophic Data from 1995. It is used to determine the mean depth and water storage capacity of the pond, which is in turn used to determine the in-pond phosphorus concentrations resulting from the estimated phosphorus loadings. It is also used to determine the deepest part of the pond for sampling.

2.2 Monitoring Data

The majority of water quality data collected within the Nutt Pond watershed was collected from the deep spot of the pond itself between 2000 and the present. A few in-pond samples were also collected in 1981, 1995 and 1996. Data was primarily collected by the New Hampshire Department of Environmental Services (DES) as part of trophic surveys of the pond and under DES's VLAP which was combined with the efforts of the Manchester Urban Ponds Restoration Program (UPRP). This data is available through DES' OneStop database of water quality data. A map of the sampling locations is shown in Figure 2-4.

In-Pond Sampling

In-pond data focuses on the deep spot of the pond (NUTMAND) to assess water quality under stratified lake conditions (Figure 2-4). This data was the most useful for calibrating phosphorus loadings calculated in the model as it allowed for a direct comparison of modeled phosphorus concentrations to observed phosphorus concentrations.

Under stratified conditions, samples were collected from the epilimnion (top), metalimnion (middle) and hypolimnion (bottom) layers of the pond. As expected, the bottom layer typically has a much higher phosphorus concentration than the top, since low oxygen levels allow for the release of phosphorus from bottom sediments back into the water column. However, this only occurs for a portion of the year. As a result, a weighted average pond concentration was calculated using the volumes of water associated with each layer to estimate the in-pond concentration during stratification with the internal release of phosphorus. Based on the sampling data, the pond is stratified between April and October; however, the bottom phosphorus concentrations do not typically see a significant increase from top concentrations until June. The release of phosphorus from bottom sediments will vary from year to year, but for the purposes of this model and using the available data, sediments are assumed to release significant amounts of phosphorus into the water column between June and October, 5 months of the year. The average in-pond concentration for the remaining seven months is assumed to be consistent with samples collected from the top layer, with no internal release of phosphorus. This was supported by samples collected in January, which show similar concentrations in the top and bottom layers of the pond. Thus, an average annual in-pond phosphorus concentration was calculated as follows:

$$Pond_{ave} = (5 \text{ months x } ((Hyp_{ave} \text{ x } Hyp_{vol}) + (Epi_{ave} \text{ x } Epi_{vol})) / Pond_{vol}) + 7 \text{ months x } Epi_{ave}) / 12$$

Where:

$Pond_{ave}$ = Average concentration in the pond (mg/l)
Hyp_{ave} = Average concentration in the hypolimnion layer = 0.13 mg/l
Hyp_{vol} = Volume of water in the hypolimnion layer (from trophic study in Appendix B) = 24,500 m^3
Epi_{ave} = Average concentration in the epilimnion layer = 0.023 mg/l
Epi_{vol} = Volume of water in the epilimnion layer = 236,000 m^3
$Pond_{vol}$ = Total volume of water in the pond = 260,500 m^3
5 months = No. of months in the year bottom sediments are contributing phosphorus
7 months = No. of months in the year bottom sediments are not contributing phosphorus

This results in an average in-pond concentration of 0.028 mg/l. The sampling data used to estimate this average is provided in Table 2-6.

Tributary/Inlet Sampling
Samples were collected at the inlets (NUTMANI1, NUTMANI2) and outlet (NUTMANO) to the pond under the VLAP program. A summary of the phosphorus results is included in Table 2-7.

Additionally, the City of Manchester collected first flush wet weather samples from three stormwater outfalls into Nutt Pond in June and July of 2002 under a separate contract. Two rounds of wet weather samples were collected from locations N1, N2, and N5. Wet weather sampling locations are shown in Figure 2-4 and the results are presented in Table 2-8.

Table 2-6. Observed In-Pond Phosphorus Concentrations (mg/l)			
Date	**Epilimnion (top) (3-10 feet below surface)**	**Metalimnion (middle) (13-16 feet below surface)**	**Hypolimnion (bottom) (1) (16-26 feet below surface)**
07/29/1981	0.025	0.053	
07/06/1995	0.025	0.017	0.217
04/20/2000	0.021	0.026	0.052
06/28/2000	0.01	0.017	0.117
07/24/2000	0.013	0.05	0.129
08/30/2000	0.012	0.039	0.27
09/22/2000	0.02	0.038	0.28
10/27/2000	0.023		0.368
04/25/2001	0.041	0.031	0.032
05/29/2001	0.019	0.022	0.03
06/26/2001	0.015	0.029	0.111
07/25/2001	0.017	0.031	0.11
10/02/2001	0.019	0.037	0.144
10/25/2001	0.026		0.154
04/30/2002	0.019	0.032	0.083
06/13/2002	0.022	0.029	0.171
07/16/2002	0.029	0.031	0.101
08/23/2002	0.024	0.02	0.255
09/20/2002	0.027	0.028	0.441
10/22/2002			0.025
04/21/2003	0.034	0.067	0.038
05/27/2003	0.029	0.027	0.055
06/10/2003	0.029	0.019	0.119
07/03/2003	0.026	0.019	0.17
08/13/2003	0.018	0.021	0.106
09/29/2003	0.046	0.059	0.097
10/29/2003	0.029	0.013	0.177
04/20/2004	0.016	0.032	0.039
05/25/2004	0.017	0.025	0.054
06/29/2004	0.016	0.03	0.073
08/04/2004	0.013	0.015	0.091
08/30/2004	0.027	0.034	0.112
09/27/2004	0.039	0.022	0.125
10/27/2004		0.016	
04/28/2005	0.039	0.04	0.046
04/28/2005			0.041
05/23/2005	0.036	0.036	0.045
06/23/2005	0.017	0.022	0.073
09/22/2005	0.021	0.03	0.093
06/12/2006	0.033	0.029	0.058
07/16/2006	0.019		0.095
08/13/2006	0.02	0.031	0.11
06/24/2007	0.019	0.019	0.069
07/22/2007	0.028	0.032	0.048
08/26/2007	0.022	0.034	0.017
06/29/2008	0.025	0.022	0.024
07/27/2008	0.016	0.019	0.029
08/17/2008	0.016	0.031	0.065
Average by Layer	**0.023**		**0.13**
Annual Pond Average (2) = 0.028			
(1) Average hypolimnion concentration excludes April and May data.			
(2) Average annual in-pond concentration calculated as: (5*((Avg Hypo Conc*Hypo Vol + Avg Epi Conc*Epi Vol)/Total Pond Vol) + 7*Avg Epi Conc)/12			

Table 2-7. Nutt Pond Inlet and Outlet Phosphorus Concentrations (mg/l)			
Date	**NUTMANI1**	**NUTMANI2**	**NUTMANO**
4/20/2000		0.026	0.022
6/28/2000			0.013
09/15/2000	0.184		
9/22/2000			0.021
10/27/2000			0.03
4/25/2001		0.014	0.042
05/29/2001			0.018
06/26/2001			0.018
07/25/2001			0.033
10/02/2001			0.032
10/25/2001			0.087
04/30/2002	0.018		0.022
07/16/2002			0.025
09/20/2002			0.023
10/22/2002			0.015
04/21/2003			0.03
05/27/2003			0.018
06/10/2003			0.023
07/03/2003			0.034
08/13/2003			0.014
09/29/2003			0.021
04/20/2004			0.016
05/25/2004			0.014
06/29/2004			0.017
08/04/2004			0.036
08/30/2004			0.033
09/27/2004			0.023
10/27/2004			0.017
04/28/2005		0.029	0.056
05/23/2005			0.025
06/23/2005			0.026
06/12/2006		0.16	0.024
07/16/2006		0.027	0.02
08/13/2006		0.039	0.019
06/24/2007	0.038		0.019
07/22/2007	0.054		0.024
08/26/2007	0.034		
06/29/2008		0.036	0.027
07/27/2008		0.038	0.012
08/17/2008		0.029	0.014

Table 2-8. Wet Weather Sampling Results						
Inorganic Parameters	**N1-1 06/13/02**	**N1-2 07/24/02**	**N2-1 06/13/02**	**N2-2 07/24/02**	**N5-1 06/13/02**	**N5-2 07/24/02**
Dissolved Oxygen (mg/l)	12.39	9.13	11.32	5.27	6.13	3.9
Temperature (°C)	20.59	26.75	27.72	32.23	27.59	29.82
pH	5.85	5.32	5.62	6.18	5.94	6.26
Total Phosphorus (mg/l)	5.6	1.82	3.67	2.2	0.51	0.98
TSS (mg/l)	ND	26	466	179	150	63
Ammonia Nitrogen (mg/l)	0.11	0.26	1.57	1.2	1.28	0.65
Nitrate as N (mg/l)	2.66	1.72	1.36	0.334	1.08	0.413
Total Kjeldahl Nitrogen (mg/l)			6.1	5.1	5.1	2.3
Chloride (mg/l)	269	169	26	32.2	12	38.4
Total Phenols (mg/l)		0.019	0.03	0.041	0.02	0.028
Specific Conductivity (umhos/cm)	964	725	212	137	128	278
Surfactants (mg/l)	0.031	0.12	0.24	0.75	0.17	0.24
Turbidity (NTU)	70.4	15	403	24.7	1510	42.8
Oil and Grease (mg/l)			6.5	7.6	6.8	
Metals:						
Sodium (ug/l)	139000	71700	13600	17800	6060	22300
Lead (ug/l)		9	147	57	27	14
Zinc (ug/l)		189	537	750	194	430
Mercury (ug/l)						
Copper (ug/l)	220	610	510	580	440	680

Urban Pond Wet Weather Sampling Data; Malcolm Pirnie-November 2002

Flow data was not collected at the time of sampling, therefore the data cannot be used to determine loads associated with streamflows. However, the data does show that phosphorus levels increase under wet weather conditions, as would be expected.

2.3 Pollutant Load Calibration

Phosphorus

The model was calibrated to the 9-year analysis period between 2000 and 2008, since in-pond phosphorus data was available for this period. Average pollutant loadings and runoff rates were calculated using the average annual precipitation for this period and current land use data. The Reckhow steady-state lake model was used to estimate the in-pond concentration using these input values. The most important component of this model is the “apparent settling velocity” of phosphorus within the pond. In actuality, this represents the net effect of phosphorus deposition and resuspension from the bottom surface. To use this model, it is essential that the simulated water body is representative of the basis of the model (Reckhow, 1983), as shown on Table 2-9. This table shows the minimum and maximum data set levels for which the model can be used along with the corresponding levels for Nutt Pond. As shown in Table 2-9, this model is appropriate for Nutt Pond.

Table 2-9. Reckhow Model Minimum and Maximum Loading Values		
	Reckhow Acceptable Range	**Nutt Pond**
Phosphorus Concentration – P (µg/l)	4 – 135	26
Annual Areal Phosphorus Loading – L (g/m2-yr)	0.07 – 31.4	0.98
Areal Water Loading – qs (m/yr)	0.75 - 187	21.7

The Reckhow steady-state lake model is expressed as:

$P = L/(11.6 + 1.2q_s)$

Where:

L = annual areal phosphorus loading (g/m^2-yr), $L = W/A_s$
W = total phosphorus mass loading (includes stormwater, internal recycling, baseflow) (g/yr)
q_s = areal water loading (m/yr), $q_s = Q/A_s$
Q = inflow water volume to lake (m^3/yr), $Q = (A_d \times r) + (A_s \times Pr)$
A_d = watershed area (land surface) (m^2)
A_s = lake surface area (m^2)
r = total annual unit runoff (m/yr)
Pr = mean annual net precipitation (m/yr)

Internal recycling of phosphorus was estimated as a percentage of the total loading to the pond using average sampling results from the hypolimnion and epilimnion layers as follows:

% Seasonal Internal Load = $P_{internal} / P_{pond}$

Where:

% Seasonal Internal Load = percent of total phosphorus load to the pond attributed to internal recycling between the months of Jun and Oct

$P_{internal}$ = phosphorus load in Hypolimnion layer from bottom sediments = $(Hyp_{ave} – Epi_{ave} / Hyp_{vol})$

P_{pond} = total phosphorus in the pond = $(Epi_{ave} \times Epi_{vol}) + (Hyp_{ave} \times Hyp_{vol})$

The assumption is that the concentration in the hypolimnion layer, minus the concentration in the epilimnion layer, represents the internal loading from bottom sediments. The percent seasonal internal load was then converted to a percent annual internal load as follows:

$$\%\ \text{Annual Internal Load} = \frac{\%\ \text{Seasonal Internal Load x 5 months} + 0\%\ \text{Internal Load x 7 months}}{\text{12 months}}$$

The result is that internal loading accounts for 30% of the total phosphorus loading to the pond on a seasonal basis and 13% on an annual basis.

Direct application of the calculated loads using the unadjusted pollutant loading values provided in Table 2-3 results in a predicted in-pond concentration of 0.282 mg/l compared to observed concentrations of 0.028 mg/l. Calibration involved adjusting the pollutant loading factors until estimated in-pond concentrations matched the observed in-pond concentrations with minimal error. Significant decreases to the literature based land use loading values were needed (91% reduction) to achieve calibration.

Possible reasons for the required significant decrease in loading factors include:

- The pond may be spring fed with cool, clean groundwater from an underground aquifer that reaches beyond the watershed boundaries. This is not accounted for in the areal water load. The historical use of the pond to harvest ice and documentation of an historical spring fed well adjacent to the pond, suggest that the pond is spring fed. A quote from one of the Manchester Urban Ponds Restoration Program reports states "The old well was supplied by some of the springs which help to make Nutt's Pond"[2] further indicating the influence of an underground spring. Clean water from the spring will dilute the higher phosphorus concentrations entering the pond in stormwater runoff. This helps to explain why the water quality of the pond is not worse considering the level of surrounding development.
- The loading values are based on values found in literature and actual loadings in the Nutt Pond watershed may be lower. Some phosphorus retention may occur in the limited wetlands in the watershed and in soils.

The spring water will influence the in-pond concentration by diluting the phosphorus loads into the pond. Although this in turn decreases the anticipated loadings into the pond, the modeling results are still appropriate and useful to determine the percent reduction needed to achieve water quality goals and to direct and prioritize actions to receive the most value for the dollar.

The predicted in-pond phosphorus concentration using the Reckhow steady-state in lake model after calibration is included in Table 2-10.

[2] Grindle, A. (April 2001). Manchester Urban Pond Restoration Program. Year 1 Report. P. 23.

Table 2-10. Reckhow Steady-state Phosphorus Model Results After Calibration	
Parameter	**Value**
Lake area – A_s (km2)	0.07
Mean Depth (m)	4.00
Watershed area – A_d (km2)	2.25
Stormwater runoff phosphorus loadings (kg/yr)	57
Phosphorus loadings from direct precipitation (kg/yr)	7.1
Phosphorus loadings from internal recycling (kg/yr)	9.5
Total phosphorus loadings – W (kg/yr)	73.3
Total phosphorus loadings – L (g/m^2-yr)	1.12
Runoff (m/yr)	20.6
New Streamflow (m/yr)	2.1
Direct Precipitation (m/yr)	1.1
Areal Water Loading – q_s (m/yr)	23.7
Predicted In-pond Phosphorus (mg/l)	**0.028**
Average Observed In-pond Phosphorus (mg/l)	**0.028**

Total Suspended Solids

TSS concentrations are typically encountered in turbulent conditions, such as flowing stormwater and rivers and streams. Sediment concentrations in stormwater may settle out on pervious surfaces, in catch basins, and in rivers and streams, before reaching the pond. That which reaches the pond will settle out where it enters, thus in-pond TSS concentrations cannot be used in the same manner as in-pond phosphorus concentrations to calibrate sediment loadings into the pond. Additionally, streambank erosion, as was observed in the East subwatershed, can also contribute significant loads of sediment to the pond that will not be accounted for in stormwater runoff coefficients. Although tributary and stormwater outfall samples into a pond can be used to estimate sediment loadings into a pond, it requires a significant amount of data, including flow data, to allow for proper calibration. This data is not available for Nutt Pond.

As a result, loads were calibrated against existing sediment deltas in the pond. The sediment loads were adjusted accordingly to represent a reasonable time frame for fill-in (e.g., about 25 years to create a sediment delta as exists in the pond today) based on the sediment deltas that exist today. This provides enough information to direct future sediment reduction actions.

2.4 Existing Pollutant Loadings

Phosphorus

Based on the calibrated modeling runs, the phosphorus loadings by subwatershed were estimated. These are presented in Table 2-11. Phosphorus loadings by source, including a breakout by land use are included in Table 2-12.

Table 2-11. Phosphorus Loadings by Source	
Phosphorus from Stormwater	
Subwatershed	Existing TP Loading (lb/yr)
North	21.61
South	22.13
East	68.05
West	13.02
Subtotal Stormwater Contribution	124.81
Phosphorus from Other Sources	
Internal Recycling	20.90
Direct Precipitation	15.61
Subtotal Other Contribution	36.51
TOTAL	**161.32**

Table 2-12. Phosphorus Loadings by Land Use	
Land Use	Existing TP Loading (lb/yr)
Commercial/Industrial	36.68
High Density Residential	76.21
Low Density Residential	0.26
Institutional	10.17
Recreational (Parks, Cemetery, Open Space)	1.06
Woody Wetlands	0.29
Deciduous Forest	0.12
TOTAL	**124.81**

Because the watershed is already built out, these loadings represent both existing and future potential loadings to the pond.

Total Suspended Solids

Estimated sediment loadings by subwatershed are presented in Table 2-13. As discussed above, these do not provide an accurate estimate of total sediment loadings to the pond, rather are more appropriate for comparing one subwatershed to the next to help prioritize sediment removal efforts.

Table 2-13. TSS Loadings by Subwatershed	
TSS from Stormwater	
Subwatershed	Existing TSS Loading (lb/yr)
North	15,751
South	14,392
East	52,207
West	10,871
TOTAL	**93,221**

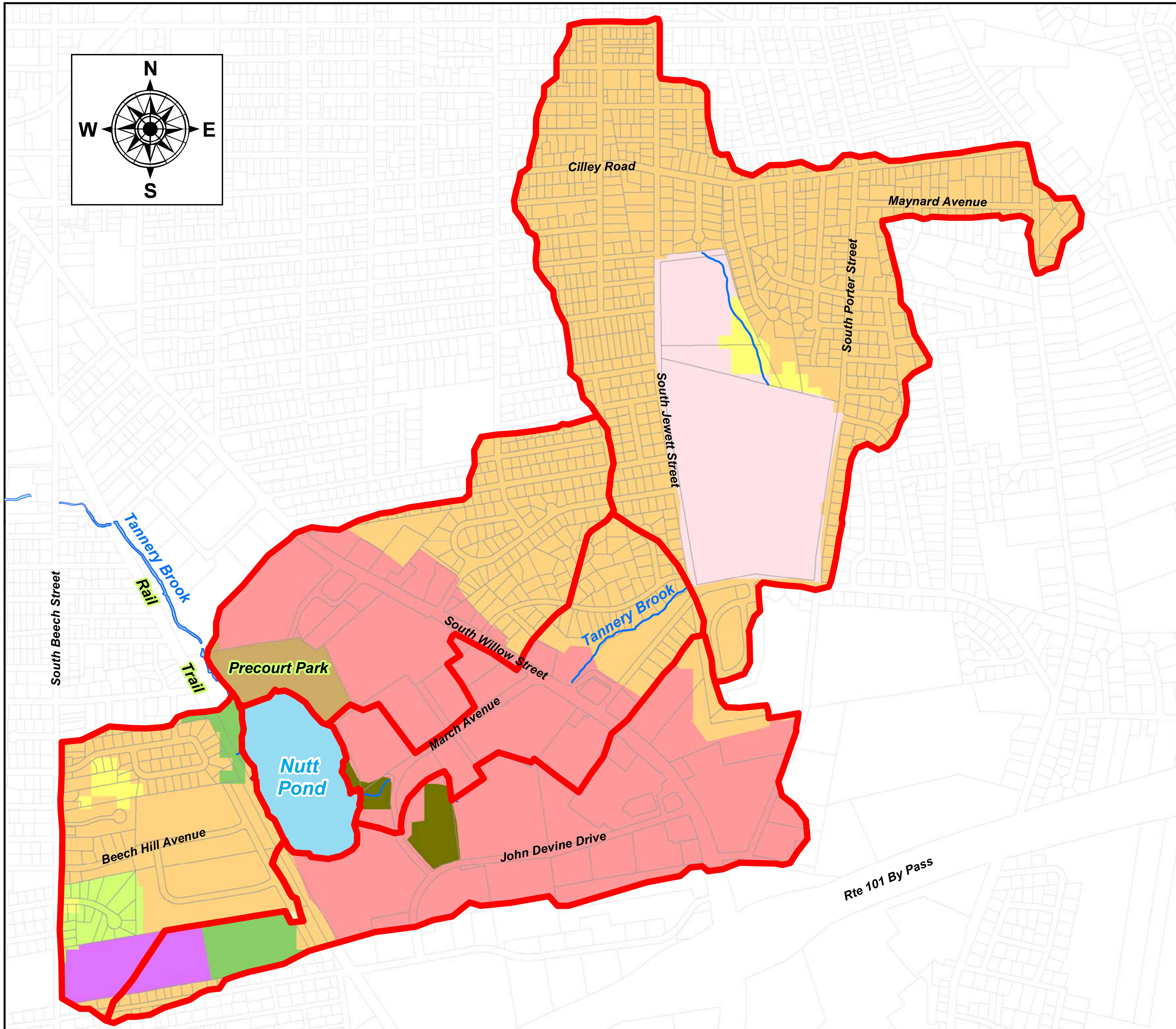

Figure 2-1

Existing Land Use

City of Manchester, NH

Legend

Nutt Pond Watershed Boundary

Land Use

- Low Intensity Residential
- High Intensity Residential
- Commercial/Industrial
- Institutional
- Cemetery
- Urban/Recreational
- Woody Wetland
- Mixed Forest
- Deciduous Forest
- Emergent Herbaceous Wetlands

Data Sources: City of Manchester, GRANIT GIS

0 750 1,500 2,250 Feet

0 0.1 0.2 0.3 0.4 0.5 Miles

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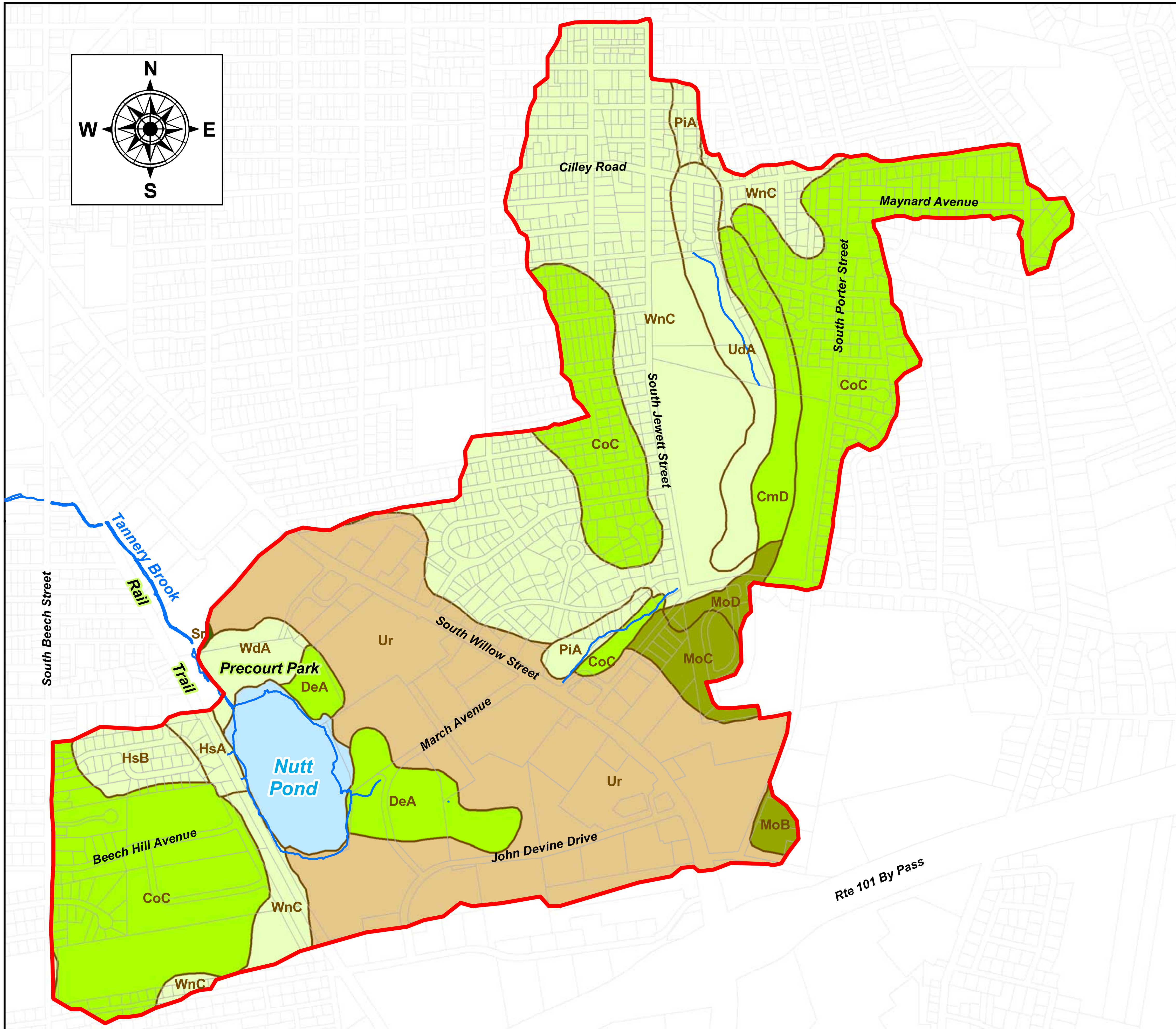

Figure 2-2

Soil Map

City of Manchester, NH

Legend

Nutt Pond Watershed Boundary

Soils

Hydrologic Group

- A
- B
- C
- D
- Urban
- Water

Data Sources: City of Manchester, GRANIT GIS

0 750 1,500 2,250 Feet

0 0.1 0.2 0.3 0.4 0.5 Miles

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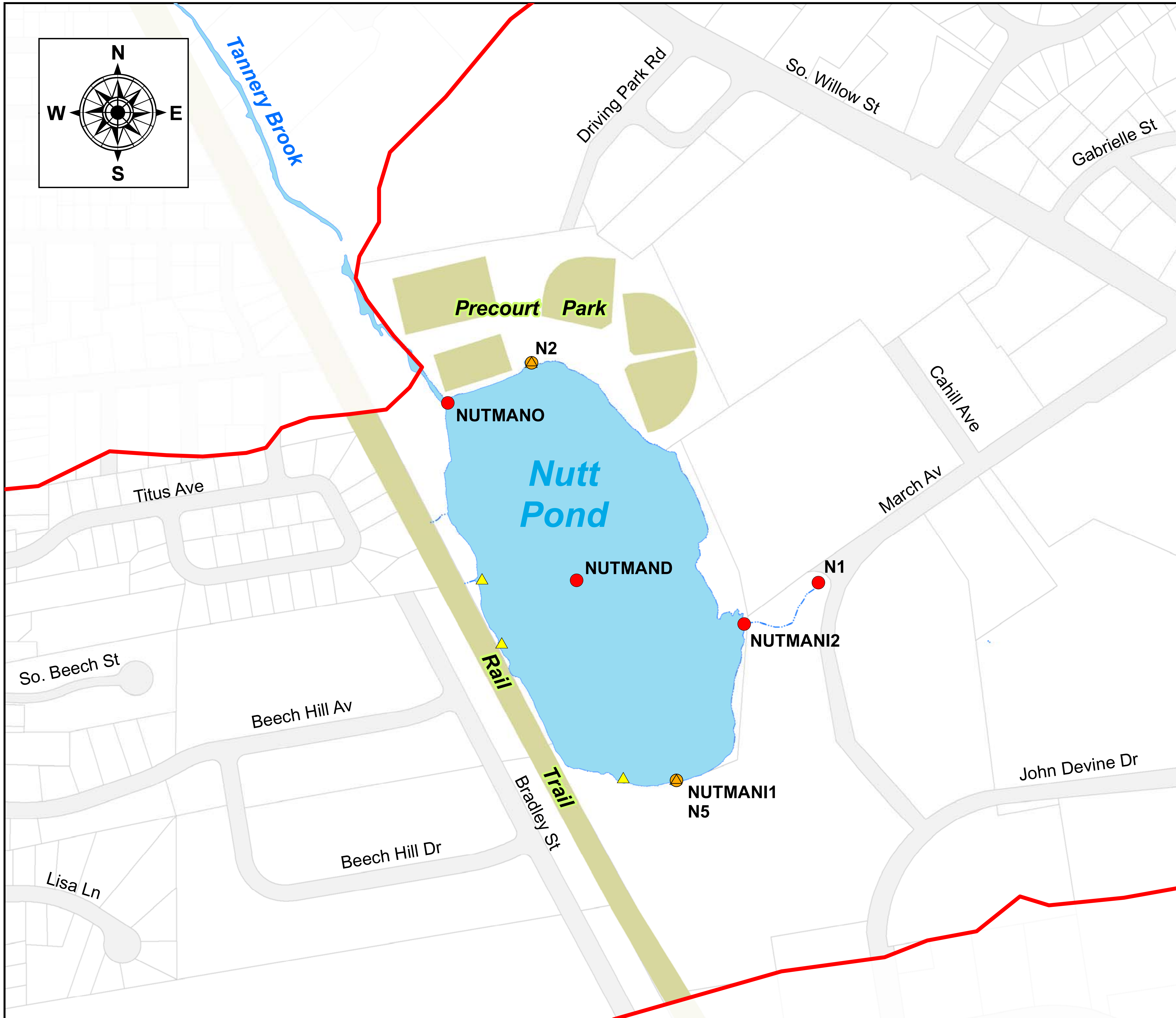
Figure 2-4

Historic Sampling Locations

City of Manchester, NH



Legend

- Sampling Locations
- Sampling Locations & Stormdrain Outfall
- Stormdrain Outfall
- Nutt Pond Watershed Boundary

Hydrography

- Lake/Pond
- Stream/Brook

Data Sources: City of Manchester, GRANIT GIS, Malcolm Pirnie, VLAP

0 250 500 750 1,000 Feet

0 0.05 0.1 0.15 0.2 Miles

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3.0 Numeric and Other Targets

Numeric targets or water quality goals are typically set as the desired water quality to achieve a particular use for a water body (e.g., recreational uses, drinking water). The purpose is to provide a benchmark to dictate and measure the actions needed in the water bodies watershed to achieve such goals. There are several steps to effective water quality goals:

1. measure or estimate existing water quality and pollutant loadings;
2. identify the most critical measurement point;
3. identify the appropriate water quality surrogates or indicators[1];
4. identify the desired water quality;
5. compare the existing pollutant loadings to desired water quality goals; and
6. identify how pollutant loads can be addressed to achieve the goals.

The first step, estimation of pollutant loadings based on existing water quality data, was described in Section 2.0. Steps 2-4 are described below in this section. A comparison of the loadings to the goals (Step 5) is discussed in Section 4.0 and the recommended actions to reduce pollutant loads and achieve the goals (Step 6) is discussed in Section 6.0.

3.1 Critical Measurement Point

To effectively measure the progress of actions taken to reach a goal, it is important to identify one critical point where watershed efforts can be measured. For Nutt Pond, the measurement point for setting goals is the deep spot in the pond, from which top and bottom samples should be collected under stratified conditions and averaged as discussed in this report to assess the water quality of the pond. It is expected that the goals may take years to achieve and actual in-pond measurements can vary widely from year to year due to climatic factors, therefore, the overall average and trend is important to review.

3.2 Water Quality Surrogates and Indicators

Phosphorus was chosen as the primary indicator of overall water quality because it is considered a limiting nutrient for plant life in fresh water systems and information was available on the existing phosphorus concentrations in the pond, which could be used to assess the overall water quality of the pond and calibrate loadings into the pond. Excess phosphorus can cause excess algae blooms and die off, which can interfere with fishing and swimming activities in the pond and can create anaerobic conditions, as seen in Nutt Pond, and filling in of ponds over time due to the excess production and die off of plant materials including algae.

Another frequently used indicator of water quality is total suspended solids (TSS). TSS loadings may come from erosion of streambeds or streambanks, as well as from roadways and parking lots, where winter sanding is performed. Elevated levels of TSS could also be caused by uncontrolled construction sites. There are large sediment deltas within Nutt Pond that were likely

[1] A 'surrogate' or 'indicator' parameter is something that represents the general water quality of the pond and that can be reliably measured and tracked.

deposited from a combination of these sources. An in-pond sediment concentration is not an appropriate water quality target since it tends to settle when it enters the pond. Thus, sediment was not selected as a surrogate for this watershed, however, it is still targeted as a pollutant to remove, which will be accomplished through many of the same techniques that remove phosphorus.

3.3 Desired Water Quality

Based on the accumulated historic water quality data (described in Section 2.0), the average phosphorus level in Nutt Pond is 0.028 mg/l.

There is no water quality standard for phosphorus in fresh water ponds in New Hampshire, however, NH DES uses 0.015 mg/l as a goal for good water quality that can support recreational uses. This has been selected as the water quality goal for Nutt Pond to restore the recreational value of the pond.

TSS water quality goals were also considered for Nutt Pond, however, since TSS settles in the pond, an in-pond concentration target is not a reasonable goal. Although a reasonable in-pond sediment goal cannot be developed, the long-term filling in of the pond from sediment is a concern that must still be addressed. These sediments have the potential to release phosphorus as decomposition of dead plants and algae occur and under anoxic conditions. Rather than setting a separate goal for sediment in the pond, sediment removal will rely on potential sediment loads and removals from individual subwatersheds in comparison to one another to help determine appropriate sediment removal techniques and placement of these techniques. In many cases, the same techniques used to remove phosphorus will also be relied upon to reduce the amount of sediment reaching the pond.

4.0 Pollutant Removal Goals

Phosphorus

Since the Nutt Pond watershed is fully developed, pollutant loadings to the ponds must be removed from existing sources to achieve the proposed water quality goals in Section 3.0. Based on the in-pond lake model, 47% or 75 pounds of phosphorus need to be removed to achieve the water quality goal of 0.015 mg/l.

The distribution of the pollutant loads by land use is shown in Table 4-1. As shown in the table, the greatest loads are from high density residential land uses, followed by commercial industrial.

Table 4-1. Pollutant Loads by Land Use

Land Use	Existing TP Loading (lb/yr)	TSS Loading (lbs/yr)
Commercial/Industrial	36.68	22,799
High Density Residential	76.21	63,471
Low Density Residential	0.26	570
Institutional	10.17	5,495
Recreational (Parks, Cemetery, Open Space)	1.06	638
Woody Wetlands	0.29	176
Deciduous Forest	0.12	73
TOTAL	**124.81**	**93,221**

Note: The total phosphorus loading is from stormwater runoff only. The 161 lbs of total phosphorus loading to the pond comes from stormwater, direct precipitation and internal recycling.

5.0 Watershed Evaluation

A watershed evaluation at the field level was performed to identify and prioritize locations for structural BMPs to reduce pollutant loads entering Nutt Pond. The evaluation included multiple site visits, a drainage system review, evaluation of conceptual BMPs, anticipated pollutant removals, cost estimates and prioritization.

This analysis lead to identification and selection of ten top priority structural BMPs that provide the best pollutant removal per dollar spent. These top priority BMPs were proposed to the City of Manchester and SEPP committee and lead to the preparation of this restoration plan to not only quantify the amount of pollutants removed per dollar, but to also define their overall impact to the pond's water quality in combination with other recommended actions. A description of the watershed evaluation and outcome is provided below.

5.1 Watershed Site Visits & Evaluations

The two primary land uses in the Nutt Pond watershed are commercial properties with large impervious parking/building areas and densely populated residential areas.

The lower watershed area directly surrounding the pond is made up of several large commercial properties with closed drainage systems located in the parking lots and connector roads. These private drainage systems discharge into larger trunk lines located in the main thoroughfares. These larger trunk lines also collect stormwater runoff from the upper watershed drainage systems and discharge directly into Nutt Pond at four major inlets: North, South, East and West.

The upper watershed is made up of mostly densely populated residential properties with multiple side and collector roads. Tannery Brook flows from the upper watershed into the lower watershed as an open stream in some locations and through the closed drainage system in other locations prior to discharging at the East Inlet. The outlet stream is also known as Tannery Brook.

BMP locations were evaluated throughout the watershed. Due to the highly developed and urbanized characteristics within the watershed, locations with adequate space to implement larger structural stormwater BMPs with higher pollutant removals were identified first. Ease of access, future maintenance considerations, land ownership and surrounding topography were all considered in identifying potential sites for BMP implementation. It was determined that greater removal per dollar could be achieved closer to the pond, however, BMPs for the upper watershed were also identified after reviewing the drainage systems and conducting site visits. The initial focus for the upper watershed was retrofits to the existing closed drainage system, with below-ground installation within the City Right of Way to avoid private ownership issues. BMPs reviewed included large underground storage units such as baffle tanks and proprietary pollutant removal units. Smaller above-ground BMPs, such as rain gardens, were also evaluated for commercial parking lots and residential areas to minimize flows and loadings entering the drainage network at the source, rather than the end of the pipe.

During the site visits, it was noted that several areas along Tannery Brook, where it was an open stream, had significant eroded and undermined banks. BMP sites were identified downstream of these open stream locations which would assist in capturing the pollutants transported from erosion, but these would not assist in addressing the source of the loadings which would provide even more cost effective load reductions. Increased stormwater flows associated with development have likely contributed to the streambank erosion by increasing the frequency and duration with which erosive flows occur. Solutions to address the streambank erosion should include a combination of techniques to reduce stormwater flows to the stream through infiltration and techniques to stabilize the streambanks.

The City is in the process of implementing some remedial actions to address this streambank erosion, including dredging of sediment, re-contouring streambanks and stabilizing banks with erosion control mats, biologs and vegetation. Permits have been submitted for this work and are currently under review at the State level.

The site investigations identified 22 potential BMP sites throughout the watershed with up to eight different BMP options available for a given site. All of the 22 proposed BMP locations are shown in Figure 5-1, along with the corresponding subwatersheds. A breakdown of land use by these subwatersheds is provided in Table 5-1.

5.2 BMP Prioritization

Additional data including length of roads, size of impervious parking areas, type of land-uses, underlying soil characteristics, and BMP removal efficiencies was collected for the 22 identified sites for potential BMP installation. Potential pollutant loadings to each location were also estimated using the methods outlined in Section 2.0.

Various BMPs were evaluated for each location, considering all of the factors outlined above. In some cases, smaller underground units or proprietary units were eliminated from further evaluation at specific locations when the calculated annual pollutant loading or runoff volumes exceeded the capacity of the BMP.

The total quantity of pollutant removed was evaluated for each option investigated at each location. Documented removal efficiencies were used from the NH DES Pollutant Removal Efficiencies for Best Management Practices for Use in Pollutant Loading Analysis and from manufacturer's literature in the case of proprietary BMPs. Construction cost estimates for each of the BMP options were prepared and a dollar per pound of phosphorus and TSS removed was calculated to help prioritize the BMPs further. Construction costs estimates were prepared using standard estimating methods and Cost Means data. A lower cost per pound of pollutant removed was selected as the best option at a given location, with other more costly options (on a pound of pollutant removed basis) at the same site eliminated from further review. The top ten structural BMPs were identified as the most viable alternatives to reduce the pollutant loadings to Nutt Pond. Table 5-2 shows the total pollutants removed and the dollar per pound removal cost for each of the top ten priority BMP locations. See Appendix C for more information on the evaluation for all 22 sites and options evaluated for each.

Table 5-1. Land Use by Micro-subwatershed

Micro -subwatershed ID	Land Use	Area (acres)	% of Sub-watershed
NORTH SUBWATERSHED			
N1	Recreational	9.9	100%
N2	Commercial	10.4	100%
N3	Commercial	5.4	100%
N4	Commercial	7.7	57%
	HD Residential	5.8	43%
N5	Commercial	13.3	100%
N6	Commercial	5.8	100%
N7	Commercial	3.3	19%
	HD Residential	14.3	81%
N8	HD Residential	21.0	100%
SOUTH SUBWATERSHED			
S1	Commercial	8.9	100%
S2	Commercial	5.8	100%
S3	Commercial	10.9	100%
S4	Commercial	7.5	100%
S5	Commercial	3.7	100%
S6	Commercial	2.8	100%
S7	Commercial	2.4	100%
S8	Commercial	2.5	100%
S9	Commercial	0.9	100%
S10	Commercial	1.2	100%
S11	Commercial	0.7	100%
S12	Commercial	9.3	100%
S13	Commercial	4.2	49%
	HD Residential	4.3	51%
S14	Commercial	16.1	94%
	HD Residential	1.0	6%
S15	Commercial	3.9	100%
S16	Woody Wetlands	5.1	100%
S17	Recreational (Cemetery)	4.8	25%
	Commercial	1.9	10%
	Woody Wetlands	6.6	34%
	HD Residential	6.0	31%
S18	Commercial	1.4	100%
EAST SUBWATERSHED			
E1.1	Commercial	5.4	100%
	Woody Wetlands	0.0	0%
E1.2	Commercial	6.0	90%
	Woody Wetlands	0.7	10%
E1.3	Commercial	9.0	100%
E1.4	Commercial	3.7	100%
E1.5	Commercial	4.9	100%
E1.6	Commercial	2.4	35%
	HD Residential	4.4	65%
E1.7	Commercial	4.8	21%
	HD Residential	18.6	79%
E1.8	Commercial	0.0	2%
	Woody Wetlands	1.0	99%
E2.1	HD Residential	6.1	100%
E2.2	HD Residential	14.0	20%
	Institutional	50.6	74%
	LD Residential	4.0	6%
E2.3	HD Residential	11.7	97%
	Institutional	0.4	3%
E2.4	HD Residential	41.4	95%
	Institutional	2.0	5%
E2.5	HD Residential	29.6	100%
E2.6	HD Residential	40.9	96%
	Institutional	1.6	4%
	LD Residential	0.1	0%
E2.7	HD Residential	19.8	100%
WEST SUBWATERSHED			
W1	HD Residential	26.8	83%
	LD Residential	2.5	8%
	Woody Wetlands	3.0	9%
W2	Deciduous Forest	6.9	21%
	HD Residential	19.8	61%
	Cemetery	6.0	18%
	Total	**557**	**acres**

Table 5-2. BMP Pollutant Removal and Ranking

BMP Description	Sub-watershed	Associated Micro-Subwatershed ID	Amount of Sub-watershed Treated (%)	Sediment			Phosphorus			Price to Install	Cost / Phosphorus Removed (10-Year) ($/lb)
				BMP Removal Efficiency	Annual Sediment Removal (lbs/yr)	Sediment Removal Over 10 Years (lbs)	BMP Removal Efficiency	Annual Phosphorus Removal (lbs/yr)	Phosphorus Removal Over 10 Years (lbs)		
Site 1 - Detention Pond at end of 60" Pipe at Weston Rd.	East	E2.2-E2.7	100%	60%	24,030	240,301	45%	23.13	231.31	$26,750	$116
Site 3 - Swirl Pond at end of Open Channel 2 - Near Dunkin Donuts	East	E1.6-E1.7 E2.1-E2.7	100%	60%	28,502	285,017	45%	27.34	273.40	$50,000	$183
Site 5 - Forebay located at end of Open Channel 1 - Near School	East	E1.6-E1.7 E2.1-E2.7	100%	60%	24,932	249,315	45%	24.12	241.25	$56,250	$233
Site 2 - East Inlet Energy Dissipation and Forebay at Home Depot Wetland	East	E1.1-E2.7	100%	85%	43,844	438,441	45%	30.30	303.01	$71,875	$237
Site 19 - 3 Rain Gardens (10'x20') located along Jobin Drive and Miami Court.	North	N8	50%	75%	1,750	17,502	60%	1.68	16.81	$18,750	$1,115
Site 16 - 5 Rain Gardens (10'x20') located along Jewett Street near Cilley Road.	East	E2.5	50%	75%	2,468	24,681	60%	2.37	23.71	$31,250	$1,318
Site 15 - 5 Rain Gardens (10'x20') located along Titus Ave. Subdivision.	West	W1	50%	75%	2,321	23,212	60%	2.19	21.88	$31,250	$1,428
Site 4 - Wetland Detention at Henry's Auto Repair.	South	S3-S15	100%	65%	6,334	63,339	45%	6.84	68.39	$95,125	$1,391
Site 20 - 10 Vegetated Swales (10'x20') located along Gabrielle Street near South Willow Street.	North	N7	50%	60%	1,089	10,889	25%	0.57	5.68	$9,375	$1,651
Site 22 - Detention Pond located between Rail Trail & Bradley Street on City property.	West	W1-W2	100%	65%	7,049	70,491	45%	5.85	58.51	$100,000	$1,709

Notes:

1) The pollutant removal efficiencies in this table represent the removal associated with an individual BMP, assuming it is the only BMP constructed for the subwatershed. This allows for comparison of the BMPs to determine which will provide the best cost benefit. Some of these BMPs may be constructed in series with a portion of the subwatershed receiving treatment through one BMP and this treated flow entering another downgradient BMP. Thus, the overall pollutant removal associated with construction of all ten BMPs is not additive. Table 6-1 in Section 6.0 provides the estimated pollutant removal assuming all ten BMPs are constructed and accounting for overlap in treatment.
2) Construction of BMPs at sites 2 and 4 was completed in 2007. Their removal efficiencies are included since they will continue to remove phosphorus and were not accounted for in historic sampling data.

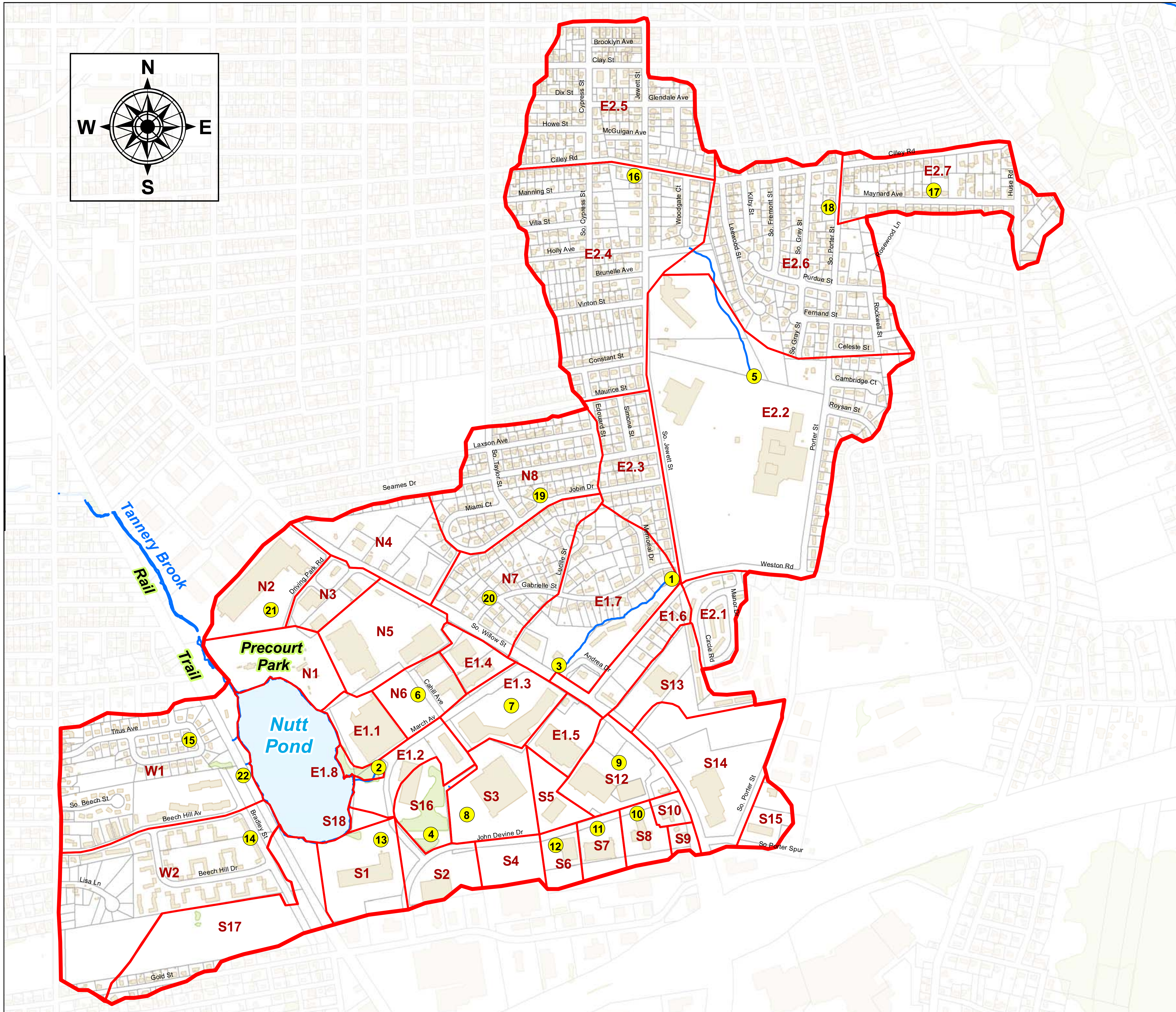
Based on this analysis, most of the smaller under-ground BMPs were eliminated due to the high cost per pound of removal. Another consideration, in addition to the cost per pound of removal, was the location of the BMP. A BMP located further up in the watershed may not have received as great of a priority if another BMP could be installed closer to the pond at a similar cost and with the ability to capture pollutants from upper, mid and/or lower reaches of the watershed. Sediment may also settle out as it travels through the watershed, thus, removing it further up the watershed may result in less than the anticipated reduction due to natural settling before reaching the pond. However, upper watershed BMPs still provide value, particularly where stormwater can be infiltrated to mimic the natural hydrologic cycle, increasing clean baseflows to the pond.

Based on the prioritization, a forebay/detention area located at the East Inlet and a detention pond within the South inlet subwatershed were part of the top ten priority BMPs. Both of these BMPs were designed and constructed based on their proximity to the pond, with the construction being completed in the Spring of 2007.

Figure 5-1

Potential Structural BMP Sites

City of Manchester, NH



Legend

- BMP Sites
- Micro-Watersheds
- Nutt Pond Watershed Boundary
- Buildings

Hydrography

- Lake/Pond
- Wetland
- Stream/Brook

Data Sources: City of Manchester, GRANIT GIS

0 750 1,500 2,250 Feet

0 0.1 0.2 0.3 0.4 0.5 Miles

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6.0 Recommendations

6.1 Introduction

Average phosphorus concentrations in Nutt Pond are 0.028 mg/l. This is associated with a total average annual phosphorus loading of 161 lbs from the watershed. A target in-pond phosphorus water quality goal of 0.015 mg/l was established based on NHDES's water quality standard for phosphorus for recreational uses of ponds. To get to this goal, a total of 75 pounds of phosphorus needs to be prevented from entering the pond. Since the watershed is nearly built out to its potential, measures to restore the pond to meet this water quality goal need to focus on removal from existing sources.

This section describes an implementation program that will help restore the pond to meet the proposed water quality goals. Recommendations are presented below and shown in Table 6-1 in terms of costs and phosphorus removal rates. A milestone schedule for these recommendations is provided in Figure 6-1.

6.2 Recommendations

#1. Eliminate Sewer Line Contributions

The November 2002 report, Urban Ponds: Wet Weather Outfall Assessment Report, prepared by Malcolm Pirnie, Inc. showed that samples taken around the North, South and East Inlet Outfalls had elevated levels of surfactants and phosphorus, and Malcolm Pirnie indicated this suggests a possible sewer connection. Existing data suggests that the lines are 1939 vitrified clay. Sewer lines are located in close proximity to the pond and tributaries to the pond as shown in Figure 6-2. Due to their age and material, the sewer pipes may be compromised with collapsed, cracked or broken sections.

The City has investigated some of the sewer lines in the Woodgate Court and surrounding area as part of ongoing CSO work in the City and repairs/upgrades have been made as necessary. The remaining sewer lines with a potential to contribute pollutants to Nutt Pond should also be investigated.

Recommendation: Evaluate whether the sewer lines are contributing pollutants to Nutt Pond through a combined sampling program and TV inspection of sewer lines.

Actions:

1) Conduct dry weather sampling of the head and tail waters of open channel segments within the East subwatershed (See Figure 6-2). Sample for E. coli, ammonia, fluoride and chlorine to determine whether there may be sewer contributions and where.
2) Based on the results of the sampling program, inspect identified sewer lines using a TV camera to determine their condition.
3) Replace or repair sewer lines as needed based on the results of the inspection.

Objectives: Determine whether adjacent sewer lines may be contributing phosphorus to the pond and eliminate those loadings.

Partners: None

Budgeted Costs: Sampling and analysis performed by the City of Manchester. About $50,000 to inspect 5,700 linear feet of pipe (sewer along March Avenue up to Woodgate Court). The actual amount of piping requiring inspection will depend on sampling results.

Funding Source: City of Manchester.

Measurement: Inspection results and repair/replacement records.

#2. Find and Eliminate Any Illicit Discharges

The sampling results from the Malcolm Pirnie study showed the presence of oil and grease, likely from restaurants or car repair facilities. The report also suggested a sewer connection to the storm drain system. Under its Phase II National Pollutant Discharge and Elimination System (NPDES) discharge permit, the City is required to inspect all stormwater outfalls in the City for illicit discharges. This may require multiple inspections, depending on the location, surrounding uses and observations made during the initial inspection.

Recommendation: Evaluate all stormwater outfalls within the Nutt Pond watershed for illicit discharges under dry weather conditions.

Actions:

1) Develop an inspection log to document observations made during the inspection, including: weather; discharge pipe material, size and condition; amount of water in the pipe; sediment accumulation within the pipe and at the outfall; condition of vegetation at the outfall; presence of trash or floatables; water quality data that can be measured in the field.
2) Inspect all outfalls within the watershed under dry weather conditions, with at least 72 hours of dry weather prior to the inspection.
3) Sample dry weather flows for pH, conductivity, temperature, E. coli, ammonia nitrogen, surfactants, chlorine and fluoride residual.
4) Document the results of inspections.
5) Perform followup activities where needed to identify the source of illicit discharges.
6) Take corrective actions to remove illicit discharges.

Objectives: Eliminate all illicit discharges to Nutt Pond and its tributaries, which will also reduce pollutant loadings to the pond.

Partners: None

Budgeted Costs: No cost carried as this is already being completed as part of the City's Phase II program.

Funding Source: City of Manchester.

Measurement: Inspection logs and removal of any illicit discharges identified.

#3. Eliminate Phosphorus Loading from Bottom Sediments

The low dissolved oxygen levels and elevated concentrations of phosphorus in the hypolimnion layer under stratified conditions suggest internal loading of phosphorus in the pond. Internal phosphorus recycling was estimated as 13% of the total average annual loadings and approximately 30% on a seasonal basis. The simplest and most cost-effective method to control the internal loading in the short term is typically aeration. Once lake conditions improve and the pollutant loads to the pond are reduced, alum treatment may be considered for long-term control of the internal loadings.

Recommendation: Design and install an aeration system at the pond.

Actions:
1) Evaluate aeration rates and effectiveness of an aeration system for the pond.
2) Identify a site for the aeration equipment and desired type of equipment.
3) Determine long-term operation and maintenance costs.
4) Design and construct or install an aeration system.
5) Evaluate alum treatment for long-term control after pond conditions improve.

Objectives: Prevent the release of phosphorus and other contaminants from the bottom sediments back into the pond. It is anticipated that an aeration system could reduce average annual phosphorus loads by about 21 pounds. However, annual weather conditions may impact phosphorus reductions from year to year.

Partners: None

Budgeted Costs: $15,000 for evaluation and design of an aeration system, up to $85,000 for installation.

Funding Source: City of Manchester and potential funds from NH DES grant funds.

Measurement: Continued monitoring of hypolimnion and surface for total phosphorus.

#4. Adopt new State of NH Rules on a Smaller Scale

The watershed is nearly at buildout with 30% older commercial/industrial development that produces uncontrolled stormwater runoff. Large impervious areas associated with this development pose a hazard to the water quality of Nutt Pond, contributing large amounts of phosphorus and sediment associated with winter sanding practices.

Retrofitting each of these properties with stormwater controls could be a costly endeavor if the City were to try and take this on. However, the City could require stormwater improvements from developers as redevelopment of these properties are proposed with minimal cost to either the City or developers. If a property is undergoing a major redevelopment, the costs to incorporate better stormwater controls will be minimal, but the benefits will be great. Benefits can include reduced maintenance frequency by the owner, reduced flooding in the neighborhood, reduced pollutant loadings to Nutt Pond and reduced streambank erosion.

The City has a Stormwater Ordinance (Chapter 54: Storm Water to Title V: Public Works) that requires submittal of a Stormwater Pollution Prevention Plan (SWPPP) for any land disturbance greater than an acre, which would cover new and redevelopment projects that meet this threshold. However, the supporting regulations refer to outdated manuals for stormwater system design and management standards.

Recommendation: Adopt the new Alteration of Terrain (AoT) rules and NH Department of Environmental Services. *Stormwater Management Handbook*. Concord, NH. December 2008 as the City's Storm Water Design and Best Management Practices Manual. Encourage the use of low impact development (LID) techniques that keep stormwater on the site where it falls and recharge to the extent feasible. Seek NH DES funds to design and install a demonstration project on City property or a private commercial property, that uses LID techniques to reduce and control stormwater runoff while providing adequate treatment.

Actions:

1) Update the City of Manchester's, Department of Highways, Storm Water Regulations Manual to adopt the new Alteration of Terrain (AoT) rules and NH Department of Environmental Services. *Stormwater Management Handbook*. Concord, NH. December 2008. as the City's Storm Water Design and Best Management Practices Manual.
2) Identify potential properties for the installation of LID techniques, focusing on properties with larger impervious rooftops and parking lots. Properties with known flooding issues or problems may be good candidates for private property partnerships if the proposed controls will also address these problems. The school on S. Jewett Street may be a good candidate since the City is responsible for the school grounds at this school.
3) Seek NH DES grant funds to design and implement demonstration projects.
4) Incorporate the demonstration projects into future public education activities.

Objectives: Adopt stormwater controls and encourage LID practices for redevelopment projects, towards a goal of reducing 29 lbs of phosphorus with the redevelopment of all commercial properties. Demonstrate the techniques on a commercial property in the watershed.

Partners: NH DES, private property owner for demonstration project.

Budgeted Costs: None for the adoption of the new AoT rules, as the City already has a mechanism to include this. $100,000 to design and install LID techniques at a selected site for demonstration purposes.

Funding Source: City of Manchester, NH DES

Measurement: City adopts AoT rules and Stormwater Management Handbook for development and redevelopment projects disturbing an acre or greater. Installation of a demonstration project.

#5. Public Education

About 52% of the Nutt Pond watershed is comprised of high density residential development, which produces about 76 pounds or 61% of the total stormwater phosphorus load to the pond. Sources of this phosphorus and other pollutants include: uncontrolled pet wastes; lawn and garden fertilizers; car washing; and uncontrolled runoff.

Another 30% of the watershed is comprised of commercial/industrial property, much of which is located in close proximity to the pond. In addition to phosphorus, these properties can contribute large amounts of sediment to the pond through parking lot sanding practices and lack of maintenance of existing catch basins and stormwater infrastructure on these properties.

A public education program that addresses both the residential and commercial/industrial properties in the watershed is needed to reduce pollutants from these sources. The City has already undertaken some public education activities directed at commercial businesses within the watershed. This involved preparing an educational brochure that was distributed to local commercial property owners and managers. The brochure detailed effects of sediment loading on local water resources and maintenance measures and BMP options that can be implemented by commercial properties to reduce sediment loadings. A web-based survey was created and distributed to the same local commercial properties to determine the effectiveness of the public education and if any activities have been implemented to reduce sediment loadings in the watershed. A second brochure was produced, which will be distributed to all the local residents in the watershed detailing the results of the watershed restoration plan once it is finalized. Copies of the brochures and survey are included in Appendix D.

The following components are proposed to expand and build off the activities already taken by the City.

5A. Promote Catch Basin Cleaning at Private Properties

Recommendation: Evaluate the feasibility of developing an ordinance requiring private entities to clean catch basins. The frequency can be tied to requirements applied to municipal entities in the General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems. Establish a procedure for tracking and enforcing catch basin cleaning on private properties.

Actions:

1) Update the City's stormwater ordinance to include requirements for private entities to clean catch basins.
2) Notify businesses of the new ordinance through mailings and website.
3) Establish a procedure for tracking and enforcing catch basin cleaning on private properties.

Objectives: Reduce sediment loadings to the pond from businesses within the watershed.

Partners: NH DES

Budgeted Costs: Completed using City staff.

Funding Source: City of Manchester.

Measurement: Revised ordinance. Mailings and postings of the new ordinance requirements on the website. Less sediment entering the pond.

5B. Website

The City's website includes information on the Urban Ponds Restoration Program, with a link specific to Nutt Pond, including bathymetric mapping, facts and history of the pond, water quality data, vegetation data and information on fish species. Other areas of the website also discuss the impacts of stormwater runoff and what residents can do to minimize these impacts, however, there is no linkage between these areas of the site.

Recommendation: Enhance the existing website to provide additional information and more linkage between the Urban Ponds Restoration Program and Stormwater sections of the website.

Actions:

1) Under the Nutt Pond page of the Urban Ponds Restoration Program site, add a map clearly showing the watershed boundaries, so residents and businesses are aware of their location within the watershed;
2) Under the same, add a description of the recreation opportunities in and around the pond;
3) Provide links to the stormwater sections of the website that provide information on the impacts of stormwater and information on how business and resident practices can impact the pond and what businesses and citizens can accomplish with small changes in how they deal with wastes and rainwater;
4) Add links to advertisements for Household Hazardous Waste collection days and locations;
5) Add updates with photographs showing demonstration and other BMP projects in the watershed (e.g., the recently installed BMPs at the west inlet and the north inlet wetlands).
6) Include the website address on informational materials distributed.

Objectives: Reduce phosphorus loadings from residential areas by 20% through increased awareness of more environmentally friendly practices in combination with Recommendations 5A. Followup to Business Brochure and Survey, 5C. Door Hangers, 5D. School Education Program.

Partners: NH DES

Budgeted Costs: $5,000

Funding Source: City of Manchester and potential grant funding from NH DES.

Measurement: The number of hits to the Nutt Pond portion of the website, indicating how often the site is visited.

5C. Door Hangers

Recommendation: Develop and place door hangers highlighting how residents can improve water quality in the residential neighborhoods of the watershed. Include links to the City's website.

Actions:

1) Develop information to be included on door hangers.
2) Print door hangers.
3) Place door hangers in residential neighborhoods.

Objectives: Increase resident awareness of Nutt Pond and environmentally friendly practices that are protective of water quality. In combination with Recommendations 5A. Followup to Business Brochure and Survey, 5B. Website, 5D. School Education Program, collectively reduce phosphorus loadings from residential areas by 20%.

Partners: DES

Budgeted Costs: $10,000 for printing and distribution of materials.

Funding Source: City of Manchester and potential grant funding from NH DES.

Measurement: The number of door hangers handed out. The number of hits to the website, which residents will be directed to by the door hangers, after the door hangers have been distributed.

5D. School Education Program

The education of children can go a long way to protect the environment as they gain an understanding of the environment and how it works at a young age and also bring materials home to their parents and discuss it with them. The *Project Wet* program was developed to fit into a school curriculum and teaches kids to understand and improve local water quality. It has been successful in other areas of New Hampshire and the country.

Recommendation: Develop a school education program, such as *Project Wet* adapting it to Manchester's urban pond watersheds including Nutt Pond.

Actions:

1) Coordinate with NH DES Project Wet staff and local schools to bring information on Manchester's urban ponds and watershed into the school curriculum.

Objectives: Educate students about Manchester's urban ponds and practices that are protective of water quality. In combination with Recommendations 5A. Followup to Business Brochure and Survey, 5B. Website, 5C. Door Hangers, collectively reduce phosphorus loadings from residential areas by 20%.

Partners: Local schools

Budgeted Costs: City of Manchester to coordinate directly with NH DES Project Wet Coordinator.

Funding Source: City of Manchester and potential grant funding from NH DES.

Measurement: Copy of the curriculum developed for the schools. Identify the number of schools, teachers and students involved in the program.

#6. Evaluate Sediment Accumulations and Address Streambank Erosion

A large amount of sediment has been transported to the pond from the watershed, as evidenced by the large sediment deltas at the East and North inlets. This is likely associated with bank erosion that is occurring in some areas of the stream network, as observed during field investigations (discussed in Section 5.0), as well as from winter sanding practices on the extensive commercial parking areas and roadways within the watershed. These contributions may lead to further filling in of the pond, as well as a phosphorus loading.

Recommendation: Survey sediment depths in the pond to establish a baseline sediment depth map. Design and install a sediment depth measurement protocol to track the infilling of the pond over the long term. Address the streambank erosion in Tannery Brook in the East subwatershed. Adopt AoT rules, which include channel protection requirements to promote the flow attenuation necessary to prevent channel erosion associated with stormwater runoff.

Actions:

1) Survey sediment depths in the pond.
2) Design a sediment depth measurement protocol to measure long-term sediment depths in the pond.
3) Address the streambank erosion in Tannery Brook in the East subwatershed. The City has already submitted permits for the dredging of sediments from this stream and the stabilization of streambanks, beginning at the end of Woodgate Court. Complete stabilization and sediment removal activities upon approval of permits.
4) Adopt design criteria and regulations that incorporate peak controls that are geared towards channel protection.

Objectives: Reduce sediment loadings to the ponds caused by streambank erosion.

Partners: None

Budgeted Costs: $10,000 to survey sediment depths. Streambank stabilization and sediment removal from Tannery Brook are being handled in conjunction with CSO activities for the area. The project cost is estimated at $500,000. The City is evaluating funding sources to complete this project.

Funding Source: City of Manchester and potential funds from NH DES grants.

Measurement: Sediment depth map and protocol for long-term sediment depth measurements in the pond. Final report on severity of streambank erosion and the need for additional measures to address it. Adoption of regulations with stormwater design criteria.

#7. Implement Structural BMP's Throughout the Watershed

During field investigations, as described in Section 5.0, CEI identified a number of locations where stormwater controls could be installed to reduce phosphorus and sediment loads to the pond. 22 locations were evaluated, with 10 prioritized and selected for implementation based on estimated pollutant removals and associated cost per pound removed. The ten sites are described below and shown in Figure 5-1.

Top Ten Structural BMPs	
1.	Site 1 - Detention Pond at end of 60" Pipe at Weston Rd.
2.	Site 3 - Swirl Pond at end of Open Channel 2 - Near Dunkin Donuts
3.	Site 5 - Forebay located at end of Open Channel 1 - Near School
4.	*Site 2 (completed) - East Inlet Energy Dissipation and Forebay at Home Depot Wetland*
5.	Site 19 - 5 Rain Gardens (10'x20') located along Jobin Drive and Miami Court.
6.	Site 16 - 5 Rain Gardens (10'x20') located along Jewett Street near Cilley Road.
7.	Site 15 - 5 Rain Gardens (10'x20') located along Titus Ave. Subdivision.
8.	*Site 4 (completed) - Wetland Detention at Henry's Auto Repair*
9.	Site 20 - 10 Vegetated Swales (10'x20') located along Gabrielle Street near South Willow Street.
10.	Site 22 - Detention Pond located between Rail Trail & Bradley Street on City property.

Note: The BMPs at sites 2 and 4 were constructed in 2006 and 2007. They are included in this table so that credit may be taken for the pollutant removal associated with them since the pollutant loadings and removals estimated for Nutt Pond do not account for these BMPs being in place.

Recommendation: Design and install BMPs for the above locations.

Actions:
1) Secure funding for design and construction through the Watershed Restoration Grant Program.
2) Prepare design plans and specifications for the construction of the BMPs.
3) Obtain necessary permits for construction.
4) Develop an Operations and Maintenance (O&M) Plan for each BMP.
5) Construct BMPs.

Objectives: Reduce sediment and phosphorus loads to Nutt Pond from the surrounding watershed. Remove about 45 pounds of phosphorus per year.

Partners: NH DES, private land owners.

Budgeted Costs: $323,625 for design, permitting and construction.

Funding Source: City of Manchester and NH DES.

Measurement: Photo documentation of completed BMPs, as-built designs, pounds of sediment removed per year as measured from cleaning of BMPs.

#8. Dredge Sediments in the East Inlet

There is a significant amount of sediment accumulated at the east inlet to the pond, throughout the wetland and within the pond itself. The City recently constructed a sediment forebay at this inlet, adjacent to the Home Depot parking lot to provide an accumulation point that would be easy to maintain in the future. However, past accumulated sediment remains in the wetland and pond at this inlet.

Recommendation: Dredge sediment at the East inlet wetland and within the pond where this inlet discharges to restore wetland habitat and reduce internal loadings of phosphorus from sediment.

Actions:

1) Prepare plans and specifications for dredging the East inlet sediment delta and wetland.
2) Obtain necessary permits.
3) Perform dredging.

Objectives: Remove sediments from the pond and adjacent wetland to reduce internal loadings from sediment.

Partners: None

Budgeted Costs: $1,000,000 assuming 500 cubic yards of sediment to be removed.

Funding Source: City of Manchester, potential funds from NH DES grants

Measurement: Quantity of sediment removed from the pond.

#9. Continue Long-Term Monitoring Program Under VLAP

Long-term monitoring of the in-pond water quality will provide information about water quality trends in the pond and how these relate to the activities within the watershed (e.g., implementation of restoration recommendations). In-pond samples are currently collected about three times a year under NH DES's Volunteer Lake Assessment Program (VLAP). This monitoring program should continue, along with some additional monitoring activities (e.g., tributary sampling) to evaluate the watershed and track the progress of the proposed improvements.

Recommendation:

1) Perform three in pond sampling rounds at the deep spot (NUTMAND) under dry weather conditions during the months of:

    - End of March/beginning of April;
    - July; and
    - September/October.

Measure temperature and DO at ½ meter intervals throughout the water column to define where the pond stratifies. Sample ponds at the top (three feet below the surface) and the bottom (three feet above the bottom) for the parameters listed under 4) below.

2) Sample the East tributary inlet and the outlet for the parameters listed under 4) below during the months of:

   - February
   - End of March/beginning of April
   - July
   - September/October

   This data will help define pollutant loads associated with baseflow conditions, which can be used to help determine additional non-stormwater sources of pollutants.

3) Collect two wet weather sampling rounds at the five stormwater inlets, see Figure 1-1 (two in the West subwatershed, one in the North subwatershed, two in the South subwatershed), East tributary inlet and the outlet of the pond for the parameters listed under 4) below between the months of May and September. A composite sample during the first flush of the storm should be collected.

4) Analyze all samples for:
   a. Alkalinity
   b. Chloride
   c. Chlorophyll-a
   d. Nitrate-N
   e. Ammonia-N
   f. TKN
   g. TSS
   h. Total Phosphorus
   i. E. coli
   j. pH
   k. temperature
   l. DO
   m. Conductivity
   n. Turbidity

Actions:

1) Sample pond, inlets and outlets as described above.
5) Continue to add the sampling results to the NH DES OneStop database.
6) Evaluate long-term water quality trends to help determine the success of the Watershed Restoration Plan.

Objectives: Establish long-term trends of water quality data in the pond and tributaries to help determine the success of the Watershed Restoration Plan.

Partners: NH DES VLAP

Budgeted Costs: Conducted under the VLAP program and by City of Manchester staff. $5,000 to perform the analytical testing.

Funding Source: City of Manchester, NH DES

Measurement: Decreasing phosphorus concentration trends in ponds and inlets.

6.3 Success Indicators

The success of the implementation of the Watershed Restoration Plan must be measurable to ensure the plan is working and to make adjustments as needed to achieve the desired results. The following success indicators are proposed:

1) Data collected from the proposed long-term monitoring program will be used to assess long-term trendlines within the pond, with a gradual decrease in average in-pond concentrations anticipated over a course of years as the recommendations are implemented. This will be the primary measurement of success since it reflects actual water quality improvements. Actual in-pond concentrations will be compared with anticipated concentrations as recommendations are implemented and pollutant loads are removed from the pond. If the estimated and observed data sets do not match, then revisions to the plan will be proposed to account for these discrepancies (e.g., additional actions may be recommended is lesser reductions are observed than anticipated).

2) Accumulated sediments removed from BMPs in the watershed will be measured to determine the total sediment loads prevented from entering the pond. Additionally, an in-pond sediment depth measurement program will be developed and used to assess the sediment loadings into the pond from tributaries and stormwater. This will provide some information on the rate that sediment is entering the pond over time, with anticipated decreases as BMPs are installed.

3) The amount of sediment removed from constructed BMPs will be tracked to estimate the amount of sediment prevented from entering the pond.

4) The number of redevelopment projects constructed under the revised regulations promoting LID design standards will be tracked with associated estimated phosphorus removals. This can be used to correlate anticipated improvements to pond water quality with actual improvements.

Table 6-1: Nutt Pond 10-Year Watershed Restoration Program Capital Improvement Program Budget						
Option	**Capital Cost**	**Source**	**Lbs Removed per Year**	**Lbs Removed Over 10 Years**	**$/lb (1-Yr)**	**$/lb (10-Yr)**
1. Eliminate Sewer Line Contributions	$50,000	City of Manchester	0.0	0	$0	$0
2. Find and Eliminate Any Illicit Discharges	$0	City of Manchester	0.0	0	$0	$0
3. Eliminate Phosphorus Loading from Bottom Sediments						
3A. Evaluate aeration rates and effectiveness of aeration on the pond. Identify site for aeration equipment. Determine long term operation and maintenance costs.	$15,000	City of Manchester				
3B. Design and construct or install aeration system.	$85,000	City of Manchester & Grants				
Total	$100,000		20.9	209	$4,785	$478
4. Adopt New State of NH Rules on a Smaller Scale						
4A. Update the City of Manchester's, Department of Highways, Storm Water Regulations Manual to adopt the new Alteration of Terrain (AoT) rules and NH Department of Environmental Services.	$0	City of Manchester				
4B. Design and install a demonstration project.	$100,000	City of Manchester				
Total	$100,000		29.3	293	$3,408	$341
5. Public Education						
5A. Promote Catch Basin Cleaning at Private Properties	$0	City of Manchester				
5B. Update the City Website.	$5,000	City of Manchester & Grants				
5C. Distribute Door Hangers.	$10,000	City of Manchester & Grants				
5D. Develop a school education program, in conjunction with NH DES *Project Wet staff.*	$0	City of Manchester				
Total	$15,000		15.3	153	$981	$98
6. Evaluate Sediment Accumulations and Address Streambank Erosion						
6A. Survey sediment depths in the pond to establish a baseline sediment depth map. Design and install a sediment depth measurement protocol to track the infilling of the pond over the long term.	$10,000	City of Manchester				
coordination with CSO efforts.	$500,000	City of Manchester				
Total	$510,000		0.0	0	$0	$0
7. Implement Structural BMPs Throughout the Watershed						
Secure funding, design, permit and construct the following structural BMPs:		City of Manchester & Grants				
7A. Detention Pond at end of 60" Pipe at Weston Rd.	$26,750					
7B. Swirl Pond at end of Open Channel 2 - Near Dunkin Donuts	$50,000					
7C. Forebay located at end of Open Channel 1 - Near School	$56,250					
7D. East Inlet Energy Dissipation and Forebay at Home Depot Wetland	$0 (b)					
7E. 3 Rain Gardens (10'x20') located along Jobin Drive and Miami Court.	$18,750					
7F. 5 Rain Gardens (10'x20') located along Jewett Street near Cilley Road.	$31,250					
7G. 5 Rain Gardens (10'x20') located along Titus Ave. Subdivision.	$31,250					
7H. Wetland Detention at Henry's Auto Repair.	$0 (b)					
7I. 10 Vegetated Swales (10'x20') located along Gabrielle Street near South Willow Street.	$9,375					
7J. Detention Pond located between Rail Trail & Bradley Street on City property.	$100,000					
Total (b)	$323,625		45.2	452	$7,153	$715
8. Dredge Sediments in the East Inlet	$1,000,000	City of Manchester & Grants	0.0	0	$0	$0
9. Continue Long-Term Monitoring Program Under VLAP (annual costs)	$5,000	City of Manchester	0.0	0	$0	$0
Total for All Recommendations(d)	2,103,625		110.8	1,108	$18,989	$1,899
Removal Goal			**75**	**750**		

Notes:

(a) Potential offset revenues and grants should be sought.

(b) Items 7D. East Inlet Forebay and 7H. Henry's Wetland BMP were constructed in 2006 and 2007, therefore their costs were not included in the CIP. However, removal efficiencies were included since they will continue to remove phosphorus and were not accounted for in historic sampling data.

(c) The total pollutant removal assumes that all ten BMPs are constructed and accounts for overlap in treatment in cases where BMPs are constructed in series (e.g., downgradient from one another). This differs from the individual pollutant removals provided in Table 5-1, which are presented to determine the most cost effective solutions for prioritization.

(d) The total cost per pound includes the cost of all recommendations, however, pollutant removals are only quantified for those recommendations where a reasonable estimate could be made. Additional removal is expected for some of the other recommendations. Thus, the total cost per pound of phosphorus removed appears higher than anticipated.

Figure 6-1 Nutt Pond 10-Year Watershed Restoration Milestone Schedule										
	Year									
Option	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
1. Eliminate Sewer Line Contributions										
Conduct dry weather sampling at key locations										
Perform TV inspection of suspected area										
Replace or repair sewer lines as needed										
2. Find and Eliminate Any Illicit Discharges										
Develop inspection log										
Inspect all outfalls under dry weather conditions										
Take corrective actions										
3. Eliminate Phosphorus Loading from Bottom Sediments										
Evaluate and design aeration system										
Construct or install aeration system										
4. Adopt New State of NH Rules on a Smaller Scale										
Update City ordinance to incorporate new AoT Rules										
Seek funds for demonstration project										
Design and install demonstration project										
5. Public Education										
5A. Promote Catch Basin Cleaning at Private Properties										
Incorporate catch basin cleaning requirements into ordinance										
Provide notice of new ordinance by mailing and website										
Develop tracking and enforcement process										
5B. Update the City Website										
5C. Distribute City Door Hangers										
Develop information to be included on door hangers										
Print door hangers										
Place door hangers in residential neighborhoods										
5D. Develop a School Education Program										
Coordinate with NH DES Project Wet staff and local schools										
Weave Project Wet curriculum into school curriculum										
6. Evaluate Sediment Accumulations and Address Streambank Erosion										
Survey sediment depths in the ponds										
Design a long-term sediment depth measurement protocol										
Address streambank erosion in Tannery Brook										
7. Implement Structural BMPs Throughout the Watershed										
Secure funding, design and install the following:										
7A. Detention Pond at end of 60" Pipe at Weston Rd.										
7B. Swirl Pond at end of Open Channel 2 - Near Dunkin Donuts										
7C. Forebay located at end of Open Channel 1 - Near School										
7D. East Inlet Energy Dissipation and Forebay at Home Depot Wetland										
7E. 3 Rain Gardens (10'x20') located along Jobin Drive and Miami Court.										
7F. 5 Rain Gardens (10'x20') located along Jewett Street near Cilley Road.										
7G. 5 Rain Gardens (10'x20') located along Titus Ave. Subdivision.										
7H. Wetland Detention at Henry's Auto Repair.										
7I. 10 Vegetated Swales (10'x20') located along Gabrielle Street near South Willow Street.										
7J. Detention Pond located between Rail Trail & Bradley Street on City property.										
8. Dredge Sediments in the East Inlet										
Prepare plans and specifications for dredging										
Obtain permits										
Perform dredging										
9. Continue Long-Term Monitoring Program Under VLAP (annual costs)										

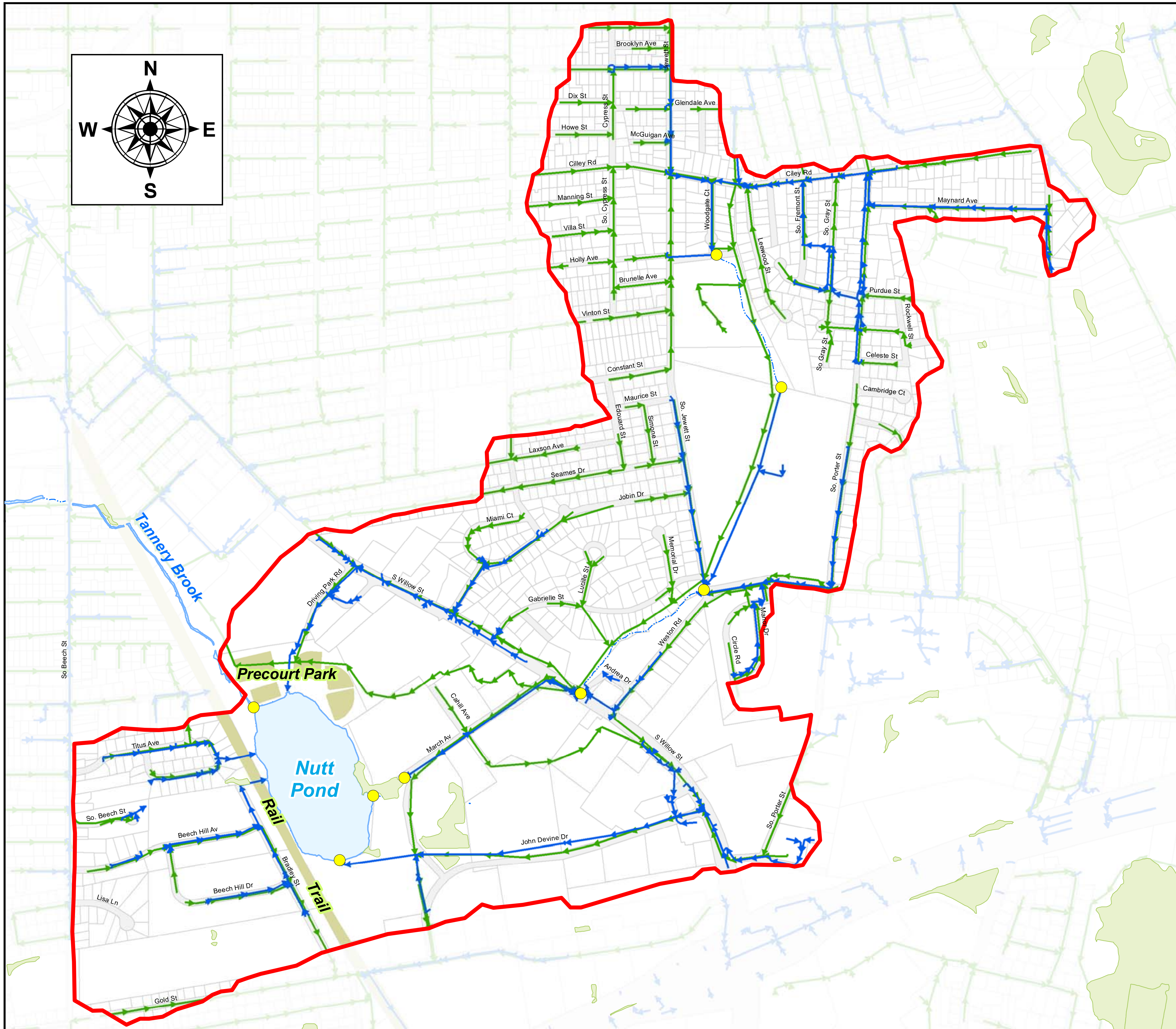


Figure 6-2

Drainage and Sewer Systems

City of Manchester, NH

Legend

- Proposed Sampling Locations
- Drain Pipe
- Sewer Pipe
- Nutt Pond Watershed Boundary

Hydrography

- Lake/Pond
- Wetland
- Stream/Brook

Data Sources: City of Manchester, GRANIT GIS

0 750 1,500 2,250 Feet

0 0.1 0.2 0.3 0.4 0.5 Miles

Comprehensive Environmental Inc.

Appendix A
QAPP Cover Page

Nutts Pond Watershed Restoration Project:

Abbreviated Quality Assurance Project Plan

for Non-Monitoring Projects Involving Pollutant Load Reduction

Modeling or Engineering Calculations

March 5, 2008

Prepared by

Katie Snyder

Comprehensive Environmental, Inc.

21 Depot Street

Merrimack, NH 03054

		Date
Project Manager:	Robert Robinson, City of Manchester EPD	3/20/08
Project Engineer & Technical Advisor	Rebecca Balke, Comprehensive Environmental, Inc.	3/5/08
QA/QC Officer & Technical Advisor	Ben Lundsted, Comprehensive Environmental, Inc.	3/5/08
NH DES Program QA Coordinator	Jillian McCarthy, NH DES	4/4/08
NH DES Program Manager	Eric Williams, NH DES	4/4/08
NH DES Quality Assurance Manager	Vincent Perelli, NH DES	4/4/08
U.S. EPA Project Manager	Warren Howard, U.S. EPA, Region 1	4/14/08

Appendix B
Nutt Pond Bathymetry and Trophic Report

DEPARTMENT of ENVIRONMENTAL SERVICES
Water Supply & Pollution Control Division - Biology Bureau

LAKE TROPHIC DATA

MORPHOMETRIC:

Lake:	NUTT POND	Lake Area (ha):	6.52
Town:	MANCHESTER	Maximum depth (m):	9.2
County:	Hillsborough	Mean depth (m):	4.0
River Basin:	Merrimack	Volume (m^3):	260500
Latitude:	42°57'37" N	Relative depth:	3.2
Longitude:	71°26'58" W	Shore configuration:	1.05
Elevation (ft):	237	Areal water load (m/yr):	12.30
Shore length (m):	950	Flushing rate (yr^{-1}):	3.10
Watershed area (ha):	168.0	P retention coeff.:	0.53
% watershed ponded:	0.0	Lake type:	natural w/dam

BIOLOGICAL:		31 January 1996	6 July 1995
DOM. PHYTOPLANKTON (% TOTAL)	#1	MALLOMONAS 45%	CERATIUM 85%
	#2	ASTERIONELLA 40%	
	#3		
PHYTOPLANKTON ABUNDANCE (units/mL)			
CHLOROPHYLL-A (µg/L)			5.97
DOM. ZOOPLANKTON (% TOTAL)	#1	KERATELLA 73%	CONOCHILOIDES 22%
	#2	LRG. RND. CILIATE 10%	BOSMINA 16%
	#3		NAUPLIUS LARVA 16%
ROTIFERS/LITER		140	146
MICROCRUSTACEA/LITER		26	132
ZOOPLANKTON ABUNDANCE (#/L)		188	282
VASCULAR PLANT ABUNDANCE			Scattered
SECCHI DISK TRANSPARENCY (m)			1.2
BOTTOM DISSOLVED OXYGEN (mg/L)		0.0	0.2
BACTERIA (E. coli, #/100 ml)	#1		17
	#2		49
	#3		37

SUMMER THERMAL STRATIFICATION:

stratified

Depth of thermocline (m): 2.7
Hypolimnion volume (m^3) : 24500
Anoxic volume (m^3) : 69000

CHEMICAL:

Lake: NUTT POND
Town: MANCHESTER

	31 January 1996		6 July 1995		
DEPTH (m)	3.0	6.0	1.0	4.5	8.0
pH (units)	6.3	6.3	8.9	6.4	6.7
A.N.C. (Alkalinity)	12.0	15.7	15.8		
NITRATE NITROGEN	0.33	0.41	< 0.10		0.06
TOTAL KJELDAHL NITROGEN	0.62	0.73	0.33	0.49	3.93
TOTAL PHOSPHORUS	0.040	0.037	0.025	0.017	0.217
CONDUCTIVITY (μmhos/cm)	567.0	771.0	467.0	569.0	1419.0
APPARENT COLOR (cpu)	40	43	32	33	90
MAGNESIUM			2.15		
CALCIUM			11.9		
SODIUM			72.2		
POTASSIUM			2.04		
CHLORIDE	170	246	139		471
SULFATE			12		2
TN : TP	24	31	13		18
CALCITE SATURATION INDEX			0.1		

All results in mg/L unless indicated otherwise

TROPHIC CLASSIFICATION: 1995

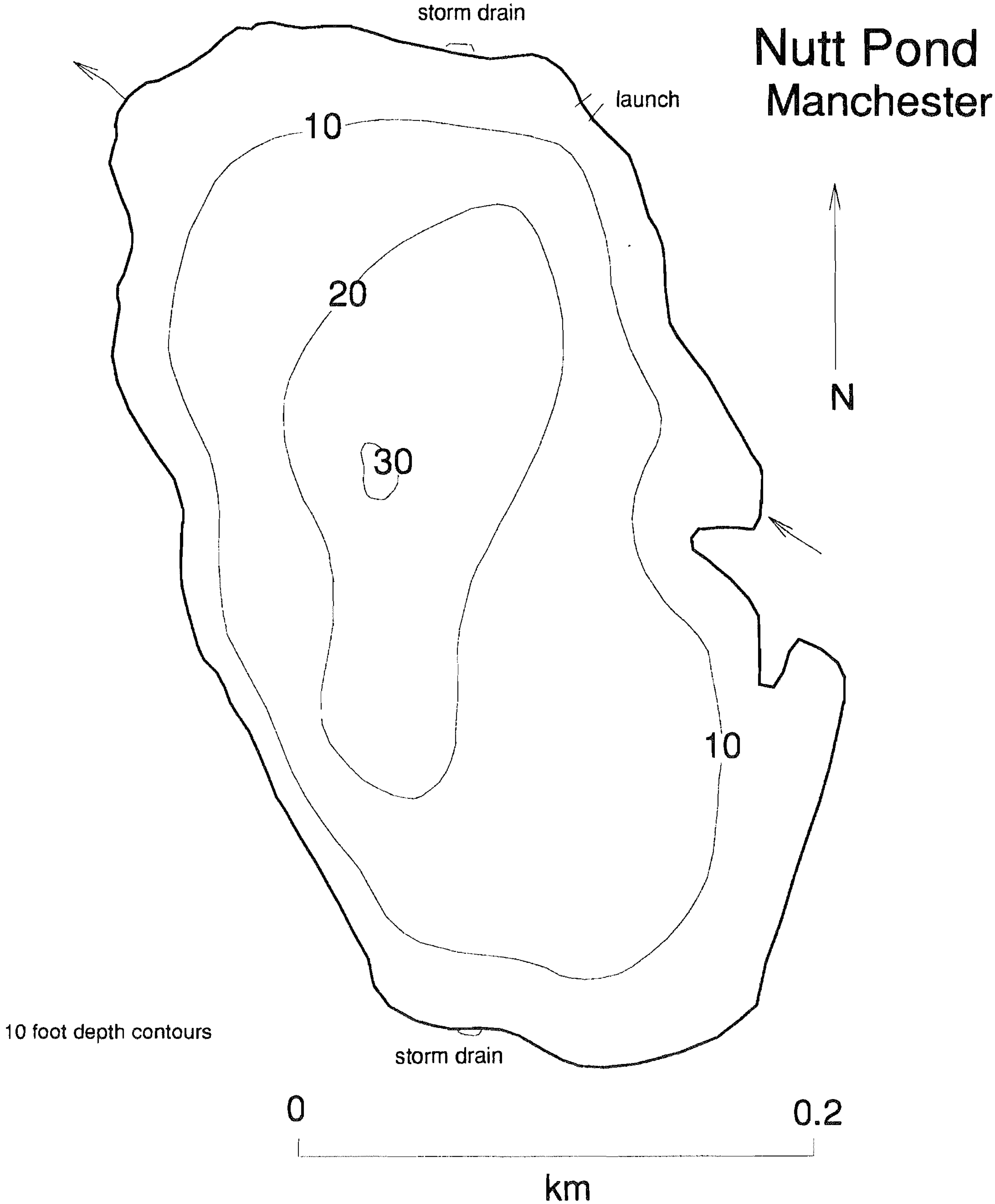
D.O.	S.D.	PLANT	CHL	TOTAL	CLASS
4	4	1	1	10	Meso.

COMMENTS:

1. This pond was previously surveyed and classified in 1981. The major trophic difference between the two years was in algal abundance: chlorophyll went from 39 mg/m^3 in 1981 to 6 mg/m^3 in 1995. Water clarity was also somewhat better in 1995. These changes resulted in a mesotrophic rating in 1995 compared to a eutrophic rating in 1981. More frequent sampling is needed to see if this is a real trend or a seasonal/yearly variation. Also, since there was no change in the epilimnetic phosphorus concentration between the two years, there is the question of other factors limiting algal growth in 1995 (zooplankton were very common). The blue-green algae *Oscillatoria* was dominant in 1981 while the dinoflagellate *Ceratium* was dominant in 1995.

2. This is a highly urbanized pond in Manchester that drains large impervious surfaces and highways. Sodium, chloride and conductivity values are extremely high for NH lakes.

3. Internal release of sediment phosphorus is very evident in the anoxic bottom waters.



Nutt Pond
Manchester
storm drain
launch
10
20
30
10
N
10 foot depth contours
storm drain
0
0.2
km

FIELD DATA SHEET

LAKE: NUTT POND
DATE: 07/06/95

TOWN: MANCHESTER
WEATHER: HOT & HAZY

	DEPTH (M)	TEMP (°C)	*DISSOLVED OXYGEN	OXYGEN SATURATION
	0.1	25.5	9.5	114 %
	1.0	25.5	9.5	114 %
	2.0	24.0	11.0	131 %
	3.0	18.0	4.9	51 %
	4.0	14.0	0.6	6 %
	5.0	11.0	0.1	1 %
	6.0	9.0	0.1	1 %
	7.0	7.2	0.1	1 %
	8.0	6.5	0.1	1 %
	9.0	6.5	0.2	2 %

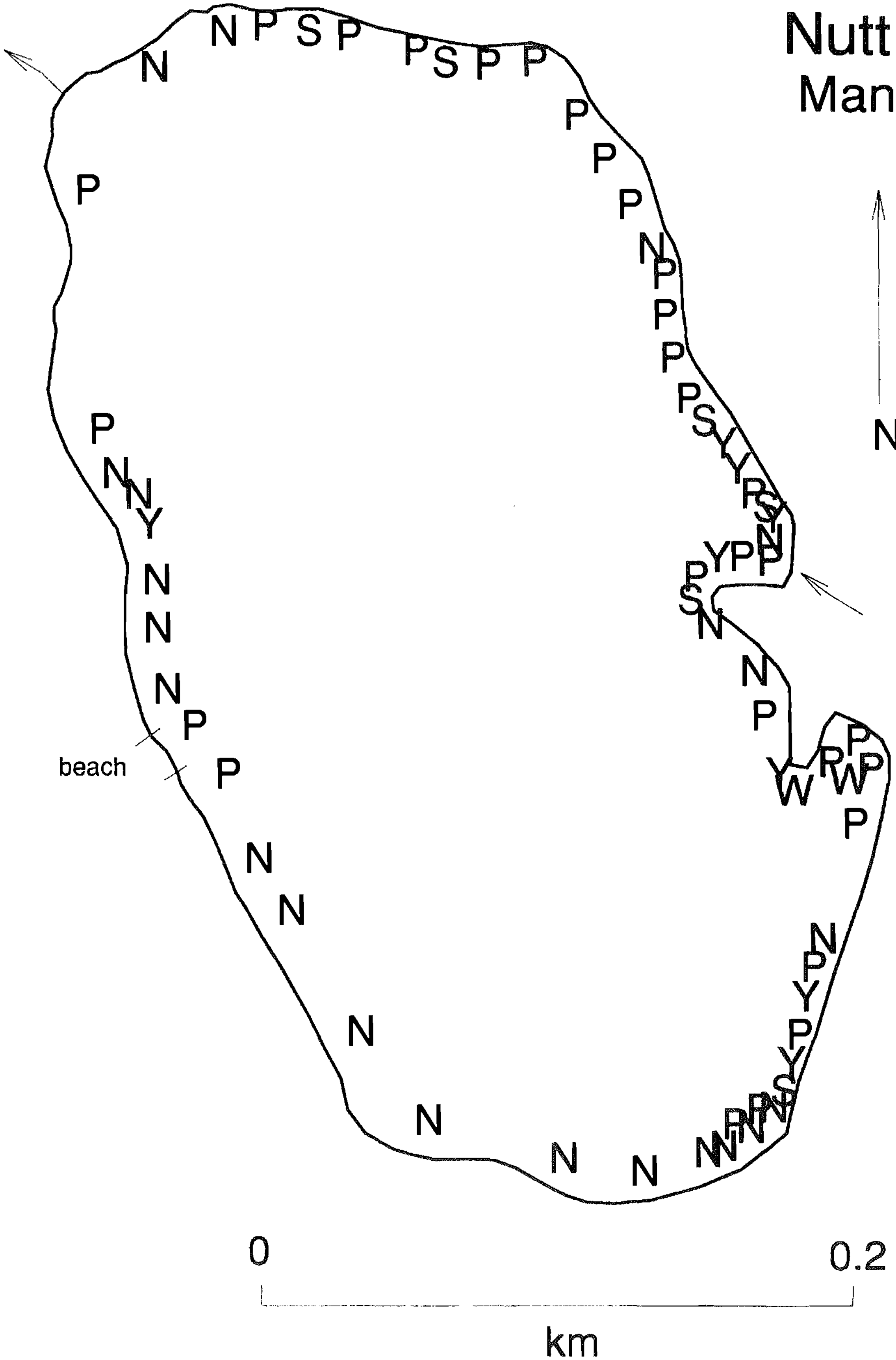
SECCHI DISK (m): 1.2
BOTTOM DEPTH (m): 9.2
TIME: 1030

COMMENTS:

The entire hypolimnion was devoid of oxygen. The extent of the dissolved oxygen depletion was greater than what occurred in 1981.

*Dissolved oxygen values are in mg/L

Nutt Pond
Manchester



AQUATIC PLANT SURVEY

LAKE: NUTT POND TOWN: MANCHESTER DATE: 07/06/95

Key	PLANT NAME		ABUNDANCE
	GENERIC	COMMON	
N	Nymphaea	White water lily	Scattered
Y	Nuphar	Yellow water lily	Sparse
P	Pontederia cordata	Pickerelweed	Scattered
S	Sparganium	Bur reed	Sparse
W	Potamogeton	Pondweed	Sparse

OVERALL ABUNDANCE: Scattered

GENERAL OBSERVATIONS:

1. At least two species of pondweed were present.
2. Observed a cormorant and two kingfishers; also a rat in the storm drain.

Appendix C
Site Evaluations

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 1 - Detention Pond at end of 60" Pipe at Weston Rd.	East	E2.2-E2.7	109.7	40050	60%	100%	24030	0.141	51.4	45%	100%	23.131	$26,750	$1	$1,156	1	1
Site 3 - Swirl Pond at end of Open Channel 2 - Near Dunkin Donuts	East	E1.6-E1.7 E2.1-E2.7	130.1	47503	60%	100%	28502	0.166	60.8	45%	100%	27.340	$50,000	$2	$1,829	2	2
Site 5 - Forebay located at end of Open Channel 1 - Near School	East	E1.6-E1.7 E2.1-E2.7	113.8	41553	60%	100%	24932	0.147	53.6	45%	100%	24.125	$56,250	$2	$2,332	3	3
Site 2 - East Inlet Energy Dissipation and Forebay at Home Depot Wetland	East	E1.1-E2.7	141.3	51581	85%	100%	43844	0.184	67.3	45%	100%	30.301	$71,875	$2	$2,372	4	4
Site 19 - 3 Rain Gardens (10'x20') located along Jobin Drive and Miami Court.	North	N8	12.8	4667	75%	50%	1750	0.015	5.6	60%	50%	1.681	$18,750	$11	$11,153	8	5
Site 16 - 5 Rain Gardens (10'x20') located along Jewett Street near Cilley Road.	East	E2.5	18.0	6582	75%	50%	2468	0.022	7.9	60%	50%	2.371	$31,250	$13	$13,181	10	6
Site 15 - 5 Rain Gardens (10'x20') located along Titus Ave. Subdivision.	West	W1	17.0	6190	75%	50%	2321	0.020	7.3	60%	50%	2.188	$31,250	$13	$14,281	13	7
Site 4 - Wetland Detention at Henry's Auto Repair.	South	S3-S15	26.7	9744	65%	100%	6334	0.042	15.2	45%	100%	6.839	$95,125	$15	$13,909	16	8
Site 20 - 10 Vegetated Swales (10'x20') located along Gabrielle Street near South Willow Street.	North	N7	9.9	3630	60%	50%	1089	0.012	4.5	25%	50%	0.568	$9,375	$9	$16,506	5	9
Site 22 - Detention Pond located between Rail Trail & Bradley Street on City property.	West	W1-W2	29.7	10845	65%	100%	7049	0.036	13.0	45%	100%	5.851	$100,000	$14	$17,090	14	10

			Land Use					Land Use						Land Use	Land Use	Land Use	Land Use
BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)	Price to Install	Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 14 - 5 Rain Gardens (10'x20') located along Beech Hill Drive near Bradley Street.	West	W2	12.8	4655	75%	50%	1746	0.016	5.7	60%	50%	1.713	$31,250	$18	$18,247	19	11
Site 18 -5 Rain Gardens (10'x20') located along South Porter Street near Maynard Ave.	East	E2.6	24.9	9081	75%	50%	3405	0.030	10.9	60%	50%	3.271	$62,500	$18	$19,107	18	12
Site 16 - 10 Vegetated Swales (10'x20') located along Jewett Street near Cilley Road.	East	E2.5	18.0	6582	60%	50%	1975	0.022	7.9	25%	50%	0.988	$18,750	$9	$18,980	6	13
Site 17 - 5 Rain Gardens (10'x20') located along Maynard Ave near South Porter Street.	East	E2.7	12.0	4398	75%	50%	1649	0.014	5.3	60%	50%	1.584	$31,250	$19	$19,727	21	14
Site 15 - 10 - Vegetated Swales (10'x20') located along Titus Ave. Subdivision.	West	W1	17.0	6190	60%	50%	1857	0.020	7.3	25%	50%	0.912	$18,750	$10	$20,564	7	15
Site 18 - 10 Vegetated Swales (10'x20') located along South Porter Street near Maynard Ave.	East	E2.6	24.9	9081	60%	50%	2724	0.030	10.9	25%	50%	1.363	$31,250	$11	$22,928	9	16
Site 20 - 5 Rain Gardens (10'x20') located along Gabrielle Street near South Willow Street.	North	N7	9.9	3630	75%	50%	1361	0.012	4.5	60%	50%	1.363	$31,250	$23	$22,926	23	17
Site 14 - 10 - Vegetated Swales (10'x20') located along Beech Hill Drive near Bradley Street.	West	W2	12.8	4655	60%	50%	1396	0.016	5.7	25%	50%	0.714	$18,750	$13	$26,275	12	18
Site 19 - 10 Vegetated Swales (10'x20') located along Jobin Drive and Miami Court.	North	N8	12.8	4667	60%	50%	1400	0.015	5.6	25%	50%	0.701	$18,750	$13	$26,766	11	19
Site 17 - 10 - Vegetated Swales (10'x20') located along Maynard Ave near South Porter Street.	East	E2.7	12.0	4398	60%	50%	1319	0.014	5.3	25%	50%	0.660	$18,750	$14	$28,407	15	20

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 8 -5 Rain Gardens (10'x50') located in Sam's Club Parking Lot Parking Lot.	South	S3	4.1	1501	75%	50%	563	0.007	2.4	60%	50%	0.725	$31,250	$56	$43,120	45	21
Site 21 - 5 Rain Gardens (10'x50') located in Sylvania Parking Lot.	North	N2	3.9	1428	75%	50%	536	0.006	2.3	60%	50%	0.689	$31,250	$58	$45,324	47	22
Site 9 - 5 Rain Gardens (10'x50') located in Tweeter & Pier 1 Parking Lot.	South	S12	3.5	1281	75%	50%	480	0.006	2.1	60%	50%	0.618	$31,250	$65	$50,538	48	23
Site 13 - 5 Rain Gardens (10'x50') located in RLR Trucking Parking Lot.	South	S1	3.4	1226	75%	50%	460	0.005	2.0	60%	50%	0.592	$31,250	$68	$52,810	49	24
Site 8 - 10 Vegetated Swales (10'x50') located in Sam's Club Parking Lot Parking Lot.	South	S3	4.1	1501	60%	50%	450	0.007	2.4	25%	50%	0.302	$18,750	$42	$62,093	36	25
Site 21 - 10 Vegetated Swales (10'x50') located in Sylvania Parking Lots.	North	N2	3.9	1428	60%	50%	429	0.006	2.3	25%	50%	0.287	$18,750	$44	$65,266	37	26
Site 9 - 10 Vegetated Swales (10'x50') located in Tweeter Music and Pier 1 Parking Lot.	South	S12	3.5	1281	60%	50%	384	0.006	2.1	25%	50%	0.258	$18,750	$49	$72,775	43	27
Site 13 - 10 Vegetated Swales (10'x50') located in RLR Trucking Parking Lot.	South	S1	3.4	1226	60%	50%	368	0.005	2.0	25%	50%	0.247	$18,750	$51	$76,046	44	28
Site 6 - 5 Rain Gardens (10'x50') located in Home Depot & Town Fair Tire Parking Lots.	North	N6	2.2	798	75%	50%	299	0.004	1.3	60%	50%	0.385	$31,250	$104	$81,176	52	29

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 18 - Baffle Units located on South Porter Street near Maynard Ave.	East	E2.6	24.9	9081	55%	50%	2497	0.030	10.9	9%	50%	0.491	$43,750	$18	$89,164	17	30
Site 7 - 10 Rain Gardens (10'x50') located in TJ Max and Lens-Crafters Parking Lot.	East	E1.3	3.4	1240	75%	50%	465	0.005	2.0	60%	50%	0.598	$62,500	$134	$104,446	59	31
Site 6 - 10 Vegetated Swales (10'x50') located in Home Depot & Town Fair Tire Parking Lots.	North	N6	2.2	798	60%	50%	239	0.004	1.3	25%	50%	0.160	$18,750	$78	$116,893	50	32
Site 16 - Baffle Units located on Jewett Street near Cilley Road.	East	E2.5	18.0	6582	55%	50%	1810	0.022	7.9	9%	50%	0.356	$43,750	$24	$123,021	24	33
Site 15 - Baffle Units located along Titus Ave. Subdivision.	West	W1	17.0	6190	55%	50%	1702	0.020	7.3	9%	50%	0.328	$43,750	$26	$133,288	25	34
Site 7 - 10 Vegetated Swales (10'x50') located in TJ Max and Lens-Crafters Parking Lot.	East	E1.3	3.4	1240	60%	50%	372	0.005	2.0	25%	50%	0.249	$37,500	$101	$150,402	51	35
Site 18 - Downstream Defender Unit located on South Porter Street near Maynard Ave.	East	E2.6	24.9	9081	85%	50%	3859	0.030	10.9	9%	50%	0.491	$75,000	$19	$152,852	20	36
Site 14 - Baffle Units located along Beech Hill Drive near Bradley Street.	West	W2	12.8	4655	55%	50%	1280	0.016	5.7	9%	50%	0.257	$43,750	$34	$170,301	31	37
Site 19 - Baffle Tank Units located on Jobin Drive and Miami Court.	North	N8	12.8	4667	55%	50%	1283	0.015	5.6	9%	50%	0.252	$43,750	$34	$173,485	29	38
Site 17 - Baffle Units located on Maynard Ave near South Porter Street.	East	E2.7	12.0	4398	55%	50%	1209	0.014	5.3	9%	50%	0.238	$43,750	$36	$184,121	32	39

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 10 - 5 Rain Gardens (10'x50') located in Four Points Sheraton Hotel Parking Lot.	South	S8	0.9	344	75%	50%	129	0.002	0.6	60%	50%	0.166	$31,250	$242	$188,003	74	40
Site 16 - Downstream Unit located on Jewett Street near Cilley Road.	East	E2.5	18.0	6582	85%	50%	2797	0.022	7.9	9%	50%	0.356	$75,000	$27	$210,893	26	41
Site 20 - Baffle Tanks located along Gabrielle Street near South Willow Street.	North	N7	9.9	3630	55%	50%	998	0.012	4.5	9%	50%	0.204	$43,750	$44	$213,972	38	42
Site 15 - Downstream Unit located along Titus Ave. Subdivision.	West	W1	17.0	6190	85%	50%	2631	0.020	7.3	9%	50%	0.328	$75,000	$29	$228,494	27	43
Site 18 - Hydroguard Unit Unit located on South Porter Street near Maynard Ave.	East	E2.6	24.9	9081	65%	50%	2951	0.030	10.9	5%	50%	0.273	$68,750	$23	$252,206	22	44
Site 12 - 10 Vegetated Swales (10'x50') located in Manchester Bingo Parking Lot.	South	S6	1.1	386	60%	50%	116	0.002	0.6	25%	50%	0.078	$18,750	$162	$241,718	67	45
Site 10 - 10 Vegetated Swales (10'x50') located in Four Points Sheraton Hotel Parking Lot.	South	S8	0.9	344	60%	50%	103	0.002	0.6	25%	50%	0.069	$18,750	$181	$270,724	70	46
Site 14 - Downstream Unit located along Beech Hill Drive near Bradley Street.	West	W2	12.8	4655	85%	50%	1978	0.016	5.7	9%	50%	0.257	$75,000	$38	$291,944	34	47
Site 11 - 10 Vegetated Swales (10'x50') located in front of Buell Harley Davidson Parking Lot.	South	S7	0.9	331	60%	50%	99	0.001	0.5	25%	50%	0.066	$18,750	$189	$282,004	71	48

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 19 - Downstream Defender located on Jobin Drive and Miami Court.	North	N8	12.8	4667	85%	50%	1984	0.015	5.6	9%	50%	0.252	$75,000	$38	$297,402	33	49
Site 17 - Downstream Unit located on Maynard Ave near South Porter Street.	East	E2.7	12.0	4398	85%	50%	1869	0.014	5.3	9%	50%	0.238	$75,000	$40	$315,636	35	50
Site 12 - 10 Rain Gardens (10'x50') located in Manchester Bingo Parking Lot.	South	S6	1.1	386	75%	50%	145	0.002	0.6	60%	50%	0.186	$62,500	$432	$335,719	77	51
Site 16 - Hydroguard Unit located on Jewett Street near Cilley Road.	East	E2.5	18.0	6582	65%	50%	2139	0.022	7.9	5%	50%	0.198	$68,750	$32	$347,973	28	52
Site 20 - Downstream Defender located along Gabrielle Street near South Willow Street.	North	N7	9.9	3630	85%	50%	1543	0.012	4.5	9%	50%	0.204	$75,000	$49	$366,809	42	53
Site 15 - Hydroguard Unit located along Titus Ave. Subdivision.	West	W1	17.0	6190	65%	50%	2012	0.020	7.3	5%	50%	0.182	$68,750	$34	$377,015	30	54
Site 11 - 10 Rain Gardens (10'x50') located in front of Buell Harley Davidson Parking Lot.	South	S7	0.9	331	75%	50%	124	0.001	0.5	60%	50%	0.160	$62,500	$504	$391,672	82	55
Site 8 - Baffle Tanks located in Sam's Club Parking Lot Parking Lot.	South	S3	4.1	1501	55%	50%	413	0.007	2.4	9%	50%	0.109	$43,750	$106	$402,452	53	56
Site 21 - Baffle Tanks located in Sylvania Parking Lots.	North	N2	3.9	1428	55%	50%	393	0.006	2.3	9%	50%	0.103	$43,750	$111	$423,021	54	57
Site 7 - Baffle Tanks located in TJ Max and Lens-Crafters Parking Lot.	East	E1.3	3.4	1240	55%	50%	341	0.005	2.0	9%	50%	0.090	$43,750	$128	$487,414	57	58

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 14 - Hydroguard Unit located along Beech Hill Drive near Bradley Street.	West	W2	12.8	4655	65%	50%	1513	0.016	5.7	5%	50%	0.143	$68,750	$45	$481,708	40	59
Site 9 - Baffle Tanks located in Tweeter & Pier 1 Parking Lot.	South	S12	3.5	1281	55%	50%	352	0.006	2.1	9%	50%	0.093	$43,750	$124	$471,691	58	60
Site 19 - Hydroguard located on Jobin Drive and Miami Court.	North	N8	12.8	4667	65%	50%	1517	0.015	5.6	5%	50%	0.140	$68,750	$45	$490,713	39	61
Site 13 - Baffle Tanks located in RLR Trucking Parking Lot.	South	S1	3.4	1226	55%	50%	337	0.005	2.0	9%	50%	0.089	$43,750	$130	$492,891	60	62
Site 17 - Hydroguard Unit located on Maynard Ave near South Porter Street.	East	E2.7	12.0	4398	65%	50%	1429	0.014	5.3	5%	50%	0.132	$68,750	$48	$520,800	41	63
Site 20 - Hydroguard located along Gabrielle Street near South Willow Street.	North	N7	9.9	3630	65%	50%	1180	0.012	4.5	5%	50%	0.114	$68,750	$58	$605,234	46	64
Site 8 - Downstream Defender Unit located in Sam's Club Parking Lot Parking Lot.	South	S3	4.1	1501	85%	50%	638	0.007	2.4	9%	50%	0.109	$75,000	$118	$689,918	55	65
Site 21 - Downstream Defender Unit located in Sylvania Parking Lots.	North	N2	3.9	1428	85%	50%	607	0.006	2.3	9%	50%	0.103	$75,000	$124	$725,179	56	66
Site 6 - Baffle Tanks located in Home Depot & Town Fair Tire Parking Lots.	North	N6	2.2	798	55%	50%	219	0.004	1.3	9%	50%	0.058	$43,750	$199	$757,639	72	67
Site 7 - Downstream Defender Unit located in TJ Max and Lens-Crafters Parking Lot.	East	E1.3	3.4	1240	85%	50%	527	0.005	2.0	9%	50%	0.090	$75,000	$142	$835,568	61	68

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 9 - Downstream Defender Unit located in Tweeter & Pier 1 Parking Lot.	South	S12	3.5	1281	85%	50%	544	0.006	2.1	9%	50%	0.093	$75,000	$138	$808,614	62	69
Site 13 - Downstream Defender located in RLR Trucking Parking Lot.	South	S1	3.4	1226	85%	50%	521	0.005	2.0	9%	50%	0.089	$75,000	$144	$844,956	65	70
Site 8 - Hydroguard Unit located in Sam's Club Parking Lot Parking Lot.	South	S3	4.1	1501	65%	50%	488	0.007	2.4	5%	50%	0.060	$68,750	$141	$1,138,365	63	71
Site 21 - Hydroguard Unit located in Sylvania Parking Lots.	North	N2	3.9	1428	65%	50%	464	0.006	2.3	5%	50%	0.057	$68,750	$148	$1,196,546	64	72
Site 6 - Downstream Defender Unit located in Home Depot & Town Fair Tire Parking Lots.	North	N6	2.2	798	85%	50%	339	0.004	1.3	9%	50%	0.058	$75,000	$221	$1,298,810	73	73
Site 7 - Hydroguard Unit located in TJ Max and Lens-Crafters Parking Lot.	East	E1.3	3.4	1240	65%	50%	403	0.005	2.0	5%	50%	0.050	$68,750	$171	$1,378,687	66	74
Site 9 - Hydroguard Unit located in Tweeter & Pier 1 Parking Lot.	South	S12	3.5	1281	65%	50%	416	0.006	2.1	5%	50%	0.052	$68,750	$165	$1,334,213	68	75
Site 13 - Hydroguard located in RLR Trucking Parking Lot.	South	S1	3.4	1226	65%	50%	398	0.005	2.0	5%	50%	0.049	$68,750	$173	$1,394,177	69	76
Site 12 - Baffle Tanks located in Manchester Bingo Parking Lot.	South	S6	1.1	386	55%	50%	106	0.002	0.6	9%	50%	0.028	$43,750	$412	$1,566,689	76	77

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 10 - Baffle Tanks located in Four Points Sheraton Hotel Parking Lot.	South	S8	0.9	344	55%	50%	95	0.002	0.6	9%	50%	0.025	$43,750	$462	$1,754,692	78	78
Site 11 - Baffle Tanks located in Buell Harley Davidson Parking Lot.	South	S7	0.9	331	55%	50%	91	0.001	0.5	9%	50%	0.024	$43,750	$481	$1,827,804	80	79
Site 6 - Hydroguard Unit located in Home Depot & Town Fair Tire Parking Lots.	North	N6	2.2	798	65%	50%	259	0.004	1.3	5%	50%	0.032	$68,750	$265	$2,143,036	75	80
Site 12 - Downstream Defender located in Manchester Bingo Parking Lot.	South	S6	1.1	386	85%	50%	164	0.002	0.6	9%	50%	0.028	$75,000	$458	$2,685,753	79	81
Site 10 - Downstream Defender located in Four Points Sheraton Hotel Parking Lot.	South	S8	0.9	344	85%	50%	146	0.002	0.6	9%	50%	0.025	$75,000	$512	$3,008,044	81	82
Site 11 - Downstream Defender located in front of Buell Harley Davidson Parking Lot.	South	S7	0.9	331	85%	50%	140	0.001	0.5	9%	50%	0.024	$75,000	$534	$3,133,379	83	83
Site 12 - Hydroguard located in Manchester Bingo Parking Lot.	South	S6	1.1	386	65%	50%	125	0.002	0.6	5%	50%	0.016	$68,750	$548	$4,431,493	84	84
Site 10 - Hydroguard Unit located in Four Points Sheraton Hotel Parking Lot.	South	S8	0.9	344	65%	50%	112	0.002	0.6	5%	50%	0.014	$68,750	$614	$4,963,272	85	85
Site 11 - Hydroguard located in front of Buell Harley Davidson Parking Lot.	South	S7	0.9	331	65%	50%	107	0.001	0.5	5%	50%	0.013	$68,750	$640	$5,170,075	86	86

BMP Description	Sub-Watershed	Associated Micro-Watershed ID	Land Use					Land Use					Price to Install	Land Use	Land Use	Land Use	Land Use
			Estimated Sediment Load (Land Use) (lbs/day)	Estimated Sediment Load (Land Use) (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Sediment Removal (lbs)	Estimated Phosphorus Load (lbs/day)	Estimated Phosphorus Load (lbs/yr)	BMP Removal Efficiency	Amount of Watershed Treated (%)	Phosphorus Removal (lbs)		Cost / Sediment Removed ($/lbs)	Cost / Phosphorus Removed ($/lb)	Cost / Sediment Removed Ranking	Cost / Phosphorus Removed Ranking
Site 10 - Hydroguard Unit located in Four Points Sheraton Hotel Parking Lot.	South	S8	0.9	344	65%	50%	112	0.002	0.6	5%	50%	0.014	$68,750	$614	$4,963,272	85	85
Site 11 - Hydroguard located in front of Buell Harley Davidson Parking Lot.	South	S7	0.9	331	65%	50%	107	0.001	0.5	5%	50%	0.013	$68,750	$640	$5,170,075	86	86

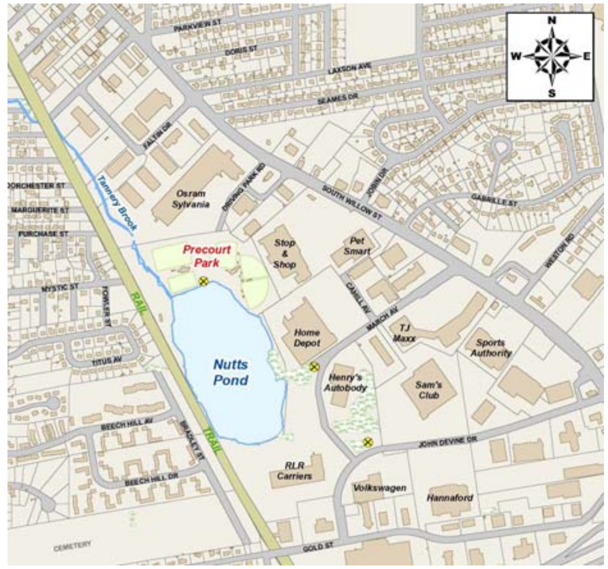
Appendix D
Public Education Sanding Brochure and Survey

Did You Know?

- ***A**nything you place in storm drains goes directly to a lake, pond or stream. In the Nutts Pond Watershed, everything eventually reaches Nutts Pond.*
- ***A** one acre parking lot produces 110 cubic feet of sand in an average year. This is equivalent to 1 to 2 dump trucks full of sand.*
- ***T**he Nutts Pond Watershed has about 135 acres of impervious parking lots and roadways. In an average year, winter sanding within the watershed could produce 14,580 cubic yards of sand. This is enough to cover a football field with 4 inches of sand.*

- ***S**ediment acts as a transport for other pollutants such as phosphorus, which leads to impaired waters.*
- ***S**ediment causes an inability for receiving waters to support aquatic life.*
- ***N**utts Pond is identified as an impaired water by the New Hampshire Department of Environmental Services (NH DES) due to an abundance of chlorophyll-a associated with excessive algae.*

Nutts Pond



Prepared by:

The CITY of MANCHESTER

NH Department of Environmental Services

Comprehensive Environmental, Inc.

Nutts Pond Watershed Sediment Loading Reduction

What Can You Do To Help?

Useful Ways To Reduce Sand and Grit Loadings on Nearby Nutts Pond

The CITY of MANCHESTER

If you have any questions or would like additional information contact::

City of Manchester, NH
Environmental Protection Division
300 Winston Street
1-603-624-6513

— Nutts Pond —

A Natural Resource

Have you ever noticed the pond next to Precourt Park? The pond is known as Nutts Pond and it is used by Manchester residents for boating, fishing and picnicking. The pond also offers an attractive view to the users of the nearby Rail Trail.

When precipitation in the Nutts Pond Watershed hits impervious surfaces such as buildings, parking lots and roads, it picks up pollutants such as sediments, nutrients and hydrocarbons and carries them into nearby catch basins, which ultimately drain to Nutts Pond. The sediment can fill in the pond and smother benthic organisms critical to habitat survival and the nutrients attached to these sediments can cause excessive algal blooms that use up the oxygen in the pond, leading to fish kills. The end result is a reduction in the water quality and recreational use of the pond.

What Can You Do?

Sediment Loadings in New England are worsened by the need for winter sanding, used to make roadways and parking lots safe for travel. Although catch basins provide some collection of sediment, they can only hold so much and, once full, sediment is easily transported to Nutts Pond. Some solutions to reduce the sediment loadings are offered below:

Routine Maintenance -

Routine street sweeping and catch basin cleaning can reduce sediment loadings to Nutts Pond.

Street sweeping before the spring thaw minimizes sediment from sanding operations from entering catch basins. Routine catch basin cleaning in the spring and fall, minimizes the amount of sediment that passes through the catch basins into Nutts Pond. Costs will vary based on the equipment used for maintenance and the type, size and number of structures.

Pavement Winter Management -

Properly managing paved surfaces during the winter months can help reduce the amount of spring cleaning & maintenance required. Carefully controlling the amount of sand used during sanding activities can help

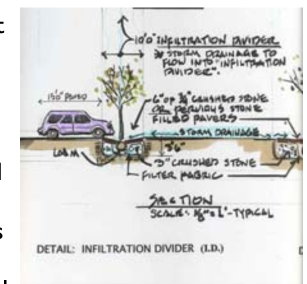
reduce loadings to the drainage system while still maintaining adequate levels of safety. Storing snow piles in designated areas away from catch basins and drainage systems or properly disposing of snow stockpiles are easy ways to prevent increased sand loadings during the spring thaw.

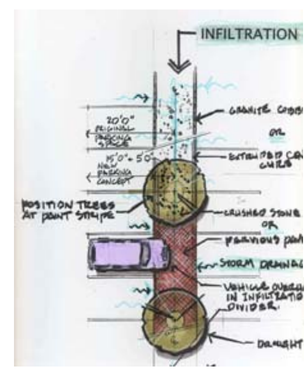
Catch Basin Inserts -

Inserts act as a filter to keep sediment behind while allowing stormwater to pass through. They are easy to install with costs averaging from $55 to $95 per structure. Cleaning can be performed by one person depending on the sediment loading.

Inverted Islands -

Inverted parking lot islands designed to collect and treat stormwater runoff offer an alternative to traditional raised and curved islands. Bioretention islands are often vegetated and include a special soil mix to remove pollutants. Surface runoff is typically infiltrated through the soils, minimizing the runoff volume and pollutant loading leaving the site in the drainage network. Inverted islands can be retrofitted into existing parking lots. Bioretention islands average from $6 to $12 per square foot.





City of Manchester Nutts Pond Sand Reduction Survey

1. Introduction

Thank you for taking the time to complete the Nutts Pond Sand Reduction Survey. This survey is an important part of a public education program funded by the NH Department of Environmental Services and the City of Manchester. Your participation will help the City determine how effective this program has been to make property owners/managers aware of the sedimentation issue in Nutts Pond and other local water resources in the South Willow Street area.

Last Winter, a brochure was distributed to commercial businesses located in the Nutts Pond watershed describing how winter sanding activities can impact local water resources and included maintenance alternatives for reducing this type of impact. This survey is being distributed to reinforce the need for owners/managers to participate in sand reduction maintenance programs and to assess how informative the educational brochure was and whether it influenced changes in property maintenance plans. Your answers will assist us in developing a successful program to help preserve and protect Nutts Pond and other local water resources.

There are 22 questions included in the survey which should take you approximately 10 minutes to complete. Please answer as many questions as possible to the best of your knowledge. We appreciate your time and look forward to your answers and opinions.

1. Please indicate if you are the property owner or manager.

- ◯ Property owner
- ◯ Property manager

2. Do you own or manage other businesses/properties in the South Willow Street area?

- ◯ Yes
- ◯ No

List All Properties

[ ]

3. How long have you owned or managed the business/property?

[ ]

4. Who is responsible for making property maintenance decisions?

- ◯ Property owner
- ◯ Property manager
- ◯ Partnership with other owner/manager

5. Do you follow an annual facility maintenance plan?

- ◯ Yes
- ◯ No

6. If yes, does the facility maintenance plan include parking lot and drainage system cleaning?

- ◯ Yes
- ◯ No

7. How often do the following serve as a main source of local news, daily information, and current city wide issues?

	Often	Sometimes	Never
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐

Other (please specify)

____

2. Parking Lot Sanding Practices

Please answer the following questions regarding parking lot maintenance and sanding activities.

8. Who maintains your parking lot during the winter?

- ◯ Property owner
- ◯ Property manager
- ◯ Plow/Sanding service company
- ◯ Other

9. What is the size of your parking lot? (Approximately 30 parking spaces per 1/4 acre)

- ◯ 1/4 acre or less
- ◯ 1/4-1/2 acre
- ◯ 1/2-1 acre
- ◯ 1-2 acres
- ◯ 2-3 acres
- ◯ More than 3 acres
- ◯ Not sure

10. Check the following products that are applied to your parking lot/sidewalk for winter safety. (Select all that apply)

- ☐ Sand
- ☐ Salt
- ☐ Sand/Salt Mix
- ☐ Other Deicers
- ☐ None
- ☐ Don't know

City of Manchester Nutts Pond Sand Reduction Survey

11. What types of parking lot and drainage system maintenance do you perform to remove sand from winter maintenance activities?
(Select all that apply)

☐ Sweeping or vacuuming Sand

☐ Catch Basin Cleaning

☐ Pipe Cleaning

☐ None

Other (please specify)

12. How often do you perform parking lot & drainage system maintenance?

	Once per year	Twice per year	More than twice per year	Don't know	Don't perform maintenance
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

13. When do you perform parking lot and drainage system maintenance?
(Select all that apply)

☐ January through March

☐ April through June

☐ July through September

☐ October through December

☐ Do not know

☐ Do not perform maintenance

3. Brochure follow up and Water Resource Information

The following information will help us assess the quality of our education efforts and help the City to further develop an effective sand reduction program to improve water quality in the Nutts Pond Watershed. We ask that you answer as many questions as you feel comfortable and simply skip those that you do not want to answer. If you are interested in obtaining more information about sand reduction techniques please provide your contact information where indicated at the bottom of this survey and you will be contacted shortly. You can also contact your local Conservation Commission or NH DES directly for more information.

14. Did you receive the Nutts Pond Watershed Sediment Loading Reduction brochure that was mailed out last winter?

○ Yes

○ No

○ Not sure/Do not remember

City of Manchester Nutts Pond Sand Reduction Survey

15. Are you aware of the water resources (e.g. stream, wetland, pond) located around your property/business?

- ◯ Yes
- ◯ No

16. How would you rate the quality of the water resources located In the South Willow Street area?

- ☐ Good water quality
- ☐ Somewhat good water quality
- ☐ Poor water quality
- ☐ Not Sure

17. Do you feel the educational brochure (provided with this questionnaire) clearly explained the Nutts Pond Sand Reduction Program.

- ◯ Yes
- ◯ No
- ◯ Somewhat

18. Do you feel the sediment reduction measures outlined in the brochure will help address the concern for sediment loading in Nutts Pond?

- ◯ Yes, routine maintenance and sediment removal from parking lots will effectively reduce sediment loading.
- ◯ No, parking lot sanding is not a major contributor of sediment in Nutts Pond.

19. Since receiving the education brochure, did you revise your facility's maintenance program to incorporate methods to further reduce sediment loading to local water resources?

	Yes	No	Planning to revise in the future
Reduce sanding application	◯	◯	◯
Increase frequency of parking lot sweeping	◯	◯	◯
Increase frequency of catch basin cleanings	◯	◯	◯
Installed sediment collection devices or equipment	◯	◯	◯
Installed bioretention islands or similar landscaping techniques to collect and and treat stormwater	◯	◯	◯

City of Manchester Nutts Pond Sand Reduction Survey

20. If your facility's parking lot maintenance was not revised, what prohibited you from taking measures to reduce sediment loading?
(Select all that apply)

- [ ] Increased cost for additional parking lot sweeping or catch basin cleaning.
- [ ] Initial cost of installing landscape features to collect and and treat stormwater.
- [ ] Insuffiecient space available for installing landscape stormwater treatment features.
- [ ] Current maintenance procedures provide adequate sediment removal from parking lot and drainage system.
- [ ] Not enough time to to make changes.

21. Do you have any suggestions for sediment removal techniques from parking lots that are not included in the educational brochure?

22. If you are interested in learning more about the Nutts Pond education grant or sand reduction techniques please provide the following contact information. This information is confidential and will only be used for matters relating to this project. You can also contact your local Conservation Commission for more information on water resources in your area.

Name:

Address:

Address 2:

City/Town:

ZIP/Postal Code:

Email Address:

Phone Number: