Total Phosphorus TMDL
for
Sands Pond, New Shoreham
(Block Island)
Rhode Island

Prepared By:

Office of Water Resources
Rhode Island Department of Environmental Management
235 Promenade St.
Providence, RI 02908

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LIST OF ACRONYMS

BIGIS = Block Island Geographic Information System

BIWC = Block Island Water Company

BMP = Best management practice, the schedule of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of and impacts upon waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Clean Water Act = the Federal Water Pollution Act (33 U.S.C. § 1251) et seq. and all amendments thereto.

Designated uses = those uses specified in water quality standards for each water body, whether or not they are being attained. In no case shall assimilation or transport of pollutants be considered a designated use.

DEM = Rhode Island Department of Environmental Management

DFW = Division of Fish and Wildlife

EPA = the United States Environmental Protection Agency.

ESS = Environmental Science Services, Inc.

Fecal coliform = bacteria found in the intestinal tracts of warm-blooded animals. Their presence in water or sludge is an indicator of pollution and possible contamination by pathogens, which are disease-causing organisms.

HEALTH = Rhode Island Department of Health

ISDS = Individual Sewage Disposal System

LA = Load Allocation, the portion of a receiving water's loading capacity that is allocated either to nonpoint sources of pollution or to natural background sources.

Loading capacity = the maximum pollutant loading that a surface water can receive without violating water quality standards.

MANAGE = A watershed pollutant loading model "Method for Assessment, Nutrient-loading and Geographic Evaluation of Watersheds".

MOS = Margin of safety. Because bacteria levels are variable, it is possible that the specified reductions may not be adequate to allow water quality to meet standards. To account for this uncertainty, an additional reduction in bacteria levels beyond the required numeric bacteria concentration is specified. This can be achieved by using conservative assumptions, an explicitly allocated reduction, such as a level 10% below the standard, or a combination of both techniques.

Natural Background = all prevailing dynamic environmental conditions in a waterbody or segment, other than those human-made or human-induced. Natural background bacteria concentrations include contributions from wildlife and/or waterfowl. However contribution from animals and waterfowl that exist in an area because of human activities (e.g. feeding of birds) are not considered as part of the natural background.

Nonpoint source = any discharge of pollutants that does not meet the definition of point source in section 502.(14) of the Clean Water Act. Such sources are diffuse, and often associated with land use practices that carry pollutants to the waters of the state. They include but are not limited to, non-channelized land runoff, drainage, or snowmelt; atmospheric deposition; precipitation; and seepage.

NTU = Nephelometric Turbidity Units, a standard measure of water turbidity.

Point source = any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation or vessel, or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture.

RIGIS = Rhode Island Geographic Information System

Runoff = water that drains from an area as surface flow.

RPD = Relative percent difference, expressed as the difference between observed and predicted values of a variable, divided by the observed value.

TMDL = Total Maximum Daily Load, the amount of a pollutant that may be discharged into a waterbody without violating water quality standards. The TMDL is the sum of wasteload allocations for point sources, load allocations for nonpoint sources, and natural background. Also included is a margin of safety.

TP = Total Phosphorus, the concentration of all forms of phosphorus in a water or sediment sample. Expressed as grams phosphorus per unit volume of sample.

μg/L = a concentration unit of micrograms (one-millionth of a gram) pollutant (e.g. total phosphorus) per liter solution. One μg/L is equal to one-thousandth of a milligram per liter (mg/l). Hence, the total phosphorus standard of 0.025 mg/l = 25 μg/L.

USGS = the United States Geological Survey

Water quality standard = provisions of state or federal law which consist of designated use and water quality criteria for the waters of the state. Water quality standards also consist of an antidegradation policy. Rhode Island’s water quality regulations may be found at www.state.ri.us/dem/pubs/regs/index.htm#WR.

WLA = Waste load allocation, the portion of a receiving water’s loading capacity that is allocated to point sources of pollution.

ABSTRACT

Sands Pond (waterbody ID number RI0010046L-01) is located on Block Island in the town of New Shoreham, Rhode Island (Figure 1.1). Sands Pond is a "kettle hole" pond, essentially a reflection of the island's groundwater. There are no channelized inflows or other discharges to the pond other than mechanical withdrawal for water supply or seepage through its bottom or sides. The pond is approximately 14.7 acres with its deepest depth, approximately 13.8 feet, in the northern portion of the pond in front of the water treatment plant intake. The average depth of the pond is approximately 7.1 feet. The relatively small watershed of approximately 74 acres is developed as open space, meadows, farmland, forestland or low-density single-family residential (120,000 sq. ft. minimum lots). In addition to the residential properties, the Block Island Water Company presently maintains a water treatment plant on the northern shore of the pond. There is a mix of sewered and non-sewered areas within the watershed, but all of the residential uses are currently serviced by individual sewage disposal systems (ISDSs). The water treatment plant discharges filter effluent to the town's sewer system, which is treated and discharged offsite. The treatment plant does not have sanitary facilities.

Under RIDEM's Water Quality Regulations (RIDEM, 1997), Sands Pond is designated as a Class AA waterbody, suitable as a source of public drinking water supply, for primary and secondary contact recreational activities and for fish and wildlife habitat. Because Sands Pond is designated as a public drinking supply water, it is also designated as a Special Resource Protection Water (SRPW).

Routine monitoring by the Block Island Water Company and their inability to meet treated drinking water standards led to the listing of this waterbody on Rhode Island's 303(d) List of Impaired Waters as being impaired by turbidity, excess algal growth/chlorophyll-a, taste and odor, and phosphorus. Sands Pond consistently failed to meet the Class AA water quality standard for turbidity (5.0 NTU over background, or 7.74 NTU). Additional monitoring by RIDEM in the summer of 2001 resulted in data representing exceedance of the Total Phosphorus (0.025 mg/l) Class AA water quality standard. Chlorophyll-a levels though not dictated by a specific numerical value indicated excessive algae growth in the pond, which is also a failure to meet Class AA water quality standards.

The objectives of the Sands Pond TMDL are to identify the measures needed to restore the pond to a condition that supports its designated uses and to protect the pond from future degradation. The objectives will be met by meeting the following water quality goals:

- Reduce algal abundance (chlorophyll-a) and turbidity concentrations to levels consistent with the use of the waterbody as a drinking water supply.
- Eliminate drinking water Taste and Odor problems by reducing algal abundance.
- Reduce the average Total Phosphorus concentration in the pond to 25 ug/l.

The current external phosphorus sources to Sands Pond are non-point in nature and include atmospheric deposition, groundwater, and waterfowl. These sources are balanced annually by the net settling of phosphorus to the sediments through death of water column algae. The settling term is a net value that reflects the balance between the sinking of detrital phytoplankton into the

bottom and the recycling of remineralized (inorganic) phosphorus back into the water column. Variations around the annual net rate are probably affected by bottom water anoxia, which occurs in the pond and the high phosphorus burden present in its sediments.

The numeric water quality standard for Total Phosphorus in Sands Pond is an annual mean concentration of 25 ug/l. The present annual mean growing season value is 35.5 ug/l. A 10% explicit margin of safety (MOS) is deducted from the allowable load to ensure that the water quality standard of 25 ug/l is met. The TMDL is an annual load of 3.9 kg/yr, which represents a 37% reduction of the existing load.

Remedial measures available to improve water quality in Sands Pond include management of the resident Canada Goose population and control of water column phosphorus by reducing phosphorus release from the sediments. Potential in-lake control measures include dredging, hypolimnetic aeration/oxygenation, capping or alum treatment. A reduction of Total Phosphorus concentrations in the water column will reduce water column chlorophyll-a levels, an indicator of algae biomass. A reduction in biomass will reduce turbidity to acceptable levels. The TMDL recommends consideration of these alternatives, as well as implementation of good housekeeping practices to reduce other nonpoint sources of phosphorus to the pond.

This TMDL will rely upon phased implementation to reach water quality goals. As the remedial measures are implemented, the corresponding response in total phosphorus, turbidity, chlorophyll-a and dissolved oxygen concentrations will be measured. Appropriate additional measures will be evaluated if standards are not met after implementation of the recommended remedial actions.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting water quality standards and thereby not meeting the designated uses. The goal of the TMDL process is to reduce loadings to a waterbody in order to improve water quality such that State Water Quality Standards are met and all designated uses are attained and maintained. A TMDL reflects the total pollutant loading of pollutant a waterbody can receive and still meet water quality standards. Rhode Island's 2006 303(d) list identifies Sands Pond as impaired by excess algae growth, turbidity, taste and odor and phosphorus.

1.1 Study Area

Sands Pond, water body ID# RI0010046L-01, is located on Block Island in the town of New Shoreham, Rhode Island and is designated as a drinking water supply. Figure 1.1 depicts the location and boundaries of the listed waterbody, along with the surface watershed contributing to this waterbody.

1.2 Pollutant(s) Of Concern

Sands Pond is listed on the RI 2006 303(d) List of Impaired Waters because it does not support the designated uses for Class AA waters. Current water quality data indicate that it is impaired for excess algal growth, turbidity, taste and odor and phosphorus.

1.3 Priority ranking

Sands Pond is on Group 1 of the state's 2006 303(d) List of Impaired Waters. TMDL development is currently underway for waters in this group.

1.4 Applicable Water Quality Standards

Under RIDEM's Water Quality Regulations (RIDEM, 2006), Sands Pond is designated as a source of drinking water supply and is classified as a Class AA waterbody. The following excerpt from Rule 8.B of the Regulations describes Class AA waters:

> *(a). Class AA – These waters are designated as a source of public drinking water supply (PDWS) or as tributary waters within a public drinking water supply watershed (the terminal reservoir of the PDWS are identified in Appendix A), for primary and secondary contact recreational activities and for fish and wildlife habitat. These waters shall have excellent aesthetic value.*

In addition, a footnote in the Regulations states that:

> Class AA waters used for public drinking water supply may be subject to restricted recreational use by State and local authorities.

Figure 1.1: Sands Pond Location Map and Watershed Boundaries

Rule 8.D of the Water Quality Regulations establishes physical, chemical, and biological criteria as parameters of minimum water quality necessary to support the water use classifications. In particular, Rule 8.D(2) establishes class specific criterion for freshwaters. For Class AA waters, the following criterion for Taste and Odor, excerpted from Table 1, apply:

> *None* [taste and odor] *other than of natural origin and none associated with nuisance algal species.*

For Class AA waters the following criterion for Color and Turbidity, excerpted from Table 1, apply:

> *None is such concentrations that would impair any usages specifically assigned to this class. Turbidity not to exceed 5 NTU over background.*

For Class AA waters the following criteria for Nutrients, excerpted from Table 1, apply to Sands Pond:

a. *Average Total phosphorus shall not exceed 0.025mg/l in any lake, pond, kettlehole or reservoir, and average Total P in tributaries at the point where they enter such bodies of water shall not cause exceedance of this phosphorus criteria, except as naturally occurs, unless the Director determines, on a site-specific basis, that a different value for phosphorus is necessary to prevent cultural eutrophication.*

b. *None [nutrients] in such concentration that would impair any usages specifically assigned to said Class, or cause undesirable or nuisance aquatic species associated with cultural eutrophication, nor cause exceedance of the criterion of 10(a) above in a downstream lake, pond, or reservoir. New discharges of wastes containing phosphates will not be permitted into or immediately upstream of lakes or ponds. Phosphates shall be removed from existing discharges to the extent that such removal is or may become technically and reasonably feasible.*

1.5 Antidegradation Policy

Due to its designation as a drinking water supply, Sands Pond is identified as a Special Resource Protection Water (SRPW) in the Water Quality Regulations. As an SRPW, Sands Pond is afforded special protections under Rule 18, *Antidegradation of Water Quality Standards.* Rhode Island's antidegradation policy requires that at the Tier 1 level any existing in-stream water uses and level of surface water quality necessary to protect existing uses, shall be maintained and protected. Additionally, Tier 2 of the antidegradation standards requires that in high quality waters where the existing water quality exceeds levels necessary to support propagation of fish and wildlife and recreation in and on the water, that quality shall be maintained and protected, except for insignificant changes in water quality as determined by the Director and in accordance with the Antidegradation Implementation Policy, as amended. Rule 18 protects Sands Pond from degradation by any new or increased discharge or activity unless the applicant provides adequate technical documentation and engineering plans to prove, to the satisfaction of the Director of RIDEM, that specific pollution controls and/or best management practices (BMPs) will completely eliminate any measurable impacts to water quality necessary to protect the characteristics upon which the SRPW designation is based. The following excerpt is taken from Rule 18.D:

> *D. Tier 2 ½ - Protection of Water Quality for SRPWs - Where high quality waters constitute a SRPW, there shall be no measurable degradation of the existing water quality necessary to protect the characteristic(s) which cause the waterbody to be designated as an SRPW. Notwithstanding that all public drinking water supplies are SRPWs, public drinking water suppliers may undertake temporary and short term activities within the boundary perimeter of a public drinking water supply impoundment for essential maintenance or to address emergency conditions in order to prevent adverse effects on public health or safety, provided that these activities comply with the requirements set forth in Rule 18.B (Tier 1 Protection of Existing Uses) and Rule 18.C. (Tier 2 Protection of Water Quality in High Quality Waters).*

1.6 TMDL Objectives

The objectives of the Sands Pond TMDL are to identify the measures needed to restore the pond to a condition that supports its designated uses and to protect the pond from future degradation. The objectives will be met by meeting the following water quality goals:

- Reduce algal abundance (chlorophyll-a) and turbidity concentrations to levels consistent with the use of the waterbody as a drinking water supply.
- Eliminate drinking water Taste and Odor problems by reducing algal abundance.
- Reduce the average Total Phosphorus concentration in the pond to 25 ug/l.

2.0 DESCRIPTION OF WATER BODY AND WATERSHED

Sands Pond is located in the southern portion of the town of New Shoreham, RI. New Shoreham encompasses the island of Block Island, located approximately 8 nautical miles south of the mainland of Rhode Island, in the eastern end of Long Island Sound. The pond has a surface area of approximately 14.7 acres in size with a mean depth of about 7.1 ft. (ESS, 2002); its maximum depth is about 13.8 feet. It has a surface drainage area of about 74 acres and a ground water recharge area of about 79 acres (USGS, 1996). Sands Pond is designated as a public drinking water supply, and the Block Island Water Company (BIWC) maintains a water treatment facility on the north shore of the pond. The BIWC supplies drinking water to approximately 220 customers in the Old Harbor area located on the eastern shore of Block Island.

The rights to the waters of Sands Pond were granted to the BIWC upon conveyance of the previously private water company to the now town owned and operated water company. The historic use of this water as a public water supply allows the BIWC to continue to designate and use this pond as a drinking water source.

Block Island was formed about 12,000 years ago when the glacier from the Ice Age finally subsided leaving the sandy moraine that now makes up Long Island, Block Island, Martha's Vineyard and Nantucket. Prehistoric Indians called the Manisses, hunted and gathered on this island as evidenced by the discovery of their shell heaps and fire pits that date back hundreds of years. European settlers in the 1600's discovered an island of gently rolling forested landscapes and hundreds of fresh water ponds. Farming and fishing communities were established which grew from an early population of 25 to about 1350 around the time of the American Civil War. In the nineteenth century an Island native, Nicholas Ball was instrumental in building the breakwater at Old Harbor to encourage steamboat traffic to visit the island. Victorian hotels soon followed suit, as the island became a vacation resort destination. As automobile travel transformed the transportation industry away from boat travel, the island began a shift back too primarily farming and fishing. The year round population declined and the hotel and resort industry fell vacant. In the 1960's the island began a resurgence of discovery as visitors were enchanted by the unspoiled nature of the landscape and the beautiful scenic beaches and bluffs that comprised the shoreline of this insulated but not isolated island. The hotels experienced a rebirth and restoration efforts and the upward trend in real estate in the 1980s fueled new development projects and proposals. A strong grass roots initiative by environmental and conservation groups and a town government unwilling to compromise on the importance of controlling development have been successful in limiting development on the island. Finite resources limit the island. The special character and importance of these resources is a recurrent theme for the control of growth and development of the island and its services.

2.1 Land Use

The Town of New Shoreham was originally incorporated in 1672 as the only town on the Island of Block Island. It is the smallest town in the smallest state in the United States. Today, the island is dotted with summer cottages; year round residences, hotels, restaurants and a well-preserved land bank of open space and conservation land. The island is approximately 9.73

square miles (6,230 acres) with a density of 80.8 persons per square mile (U.S. Census Bureau, 2000). The 2000 census reports a total population of 1010 persons. Less than half of the island is available for development. (New Shoreham, 1994). Of the approximate 2,710 acres available for development, 2,510 acres are currently zoned residential and 200 acres are zoned mixed business, coastal. There are a total of 1,606 housing units of which 1,134 were classified as vacant (1,109 seasonal or for recreational use). This indicates a significant transient population typical of a resort community. In the summer, the island's population balloons to up to 10,000, with an average additional influx of 3000 day-trippers visiting the island.

Figure 2.1 shows the various land uses within the watershed. The Sands Pond watershed is zoned Residential A, with a minimum lot size of 120,000 square feet. There are currently forty-eight (48) lots in the watershed. Thirty-two of the lots contain a dwelling unit, one lot houses the BIWC treatment facility, four lots are protected open space, three lots are right-of-ways, and seven lots are listed as vacant. Sixteen lots in the watershed exceed the 120,000-sq. ft. minimum. Twelve are currently occupied, two are open space and one is the pond itself. The remaining vacant large parcel (12.6 acres) has the potential of being developed into three or four house lots, depending upon the physical constraints of the land for Individual Sewage Disposal Systems (ISDS) development, frontage requirements, wetlands, etc. Multi-family dwelling units are not allowed without a special use permit.

There are currently four parcels within the immediate vicinity of the pond that are protected open space. Fourteen acres are in common ownership located along the southern shore of Sands Pond and are controlled by the homeowners of the Sands Pond Homeowners Association. An additional 1.38-acre parcel along the eastern shore is currently owned by the Nature Conservancy, a national private land trust organization. A homeowners association also has control of the other open space land.

2.2 Soils

The island soils are the result of the glacial terminal moraine and are comprised of mostly unconsolidated sediments. The soils present in the Sands Pond watershed all have moderate constraints to development as described in the Soil Survey of Rhode Island. Besides open water and wetlands, there are two predominant soil types in the watershed. The first series, RaB, Rainbow consists of coarse loamy mixed soils that are moderately well drained, percolate slowly and have a tendency to be wet. The other group consists of HkC, Hinckley, and GBC Gloucester soils. This latter group is made up of sandy, skeletal mixed soils that are excessively to somewhat excessively drained. Careful attention to septic system designs must be observed in order to avoid pollution of groundwater. The majority of the shoreline of the pond consists of the well drained, Hinckley and Gloucester series of soils. Figure 2.2 represents the distribution of soils throughout the watershed. The numbers as indicated on the map, are a representation of the development group these soils are classified by based on restrictions or constraints to residential or commercial construction. As is indicated in the table below the map, 54.31 of the total 88.34 acres of the watershed are in Group 1, which have few restrictions, but do contain moderate constraints to development (RIGIS, Soil Survey of Rhode Island). These restrictions are representative of the two soil types; one type is excessively permeable and steep sloped,

Figure 2.1: Land Use Map – Sands Pond Watershed

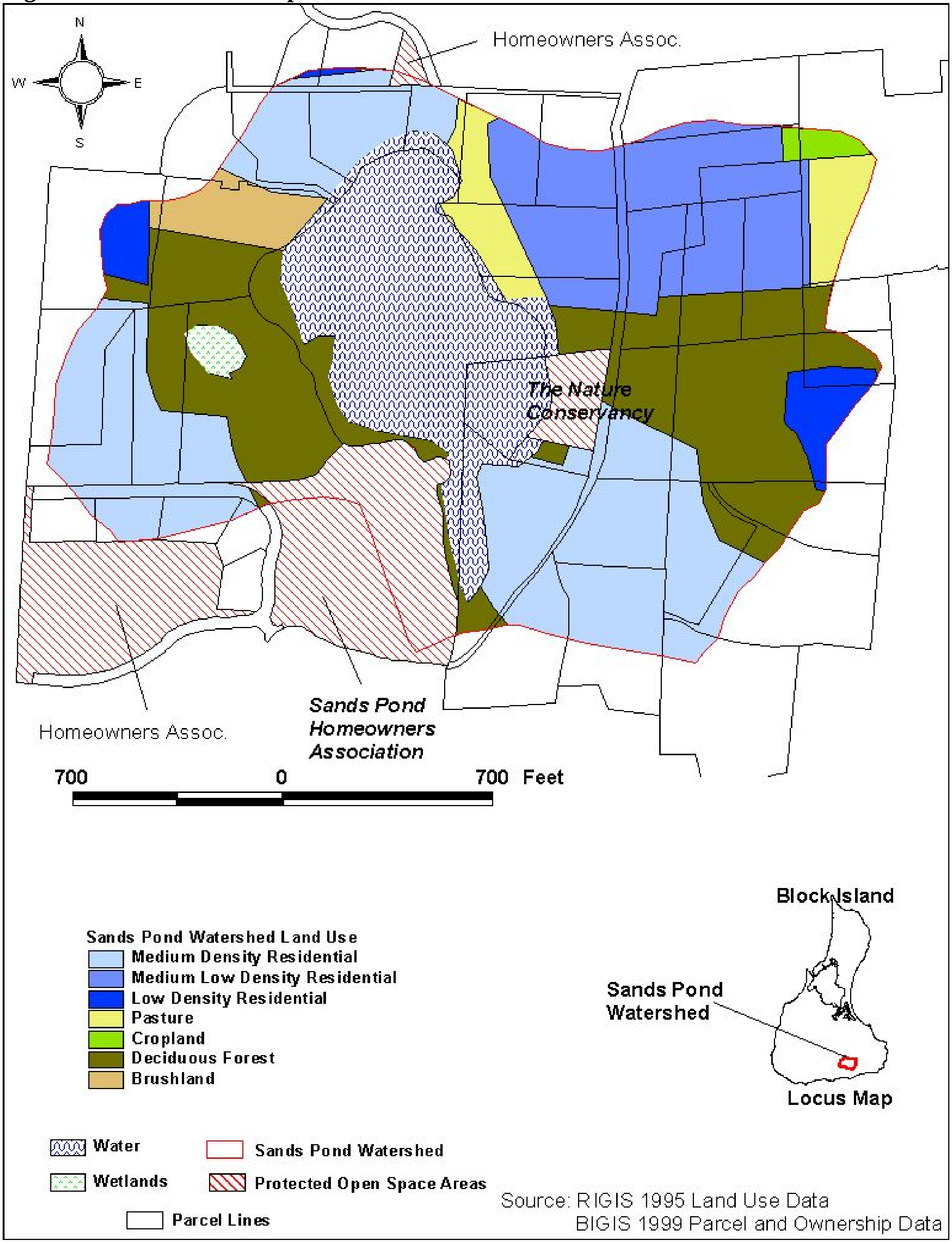
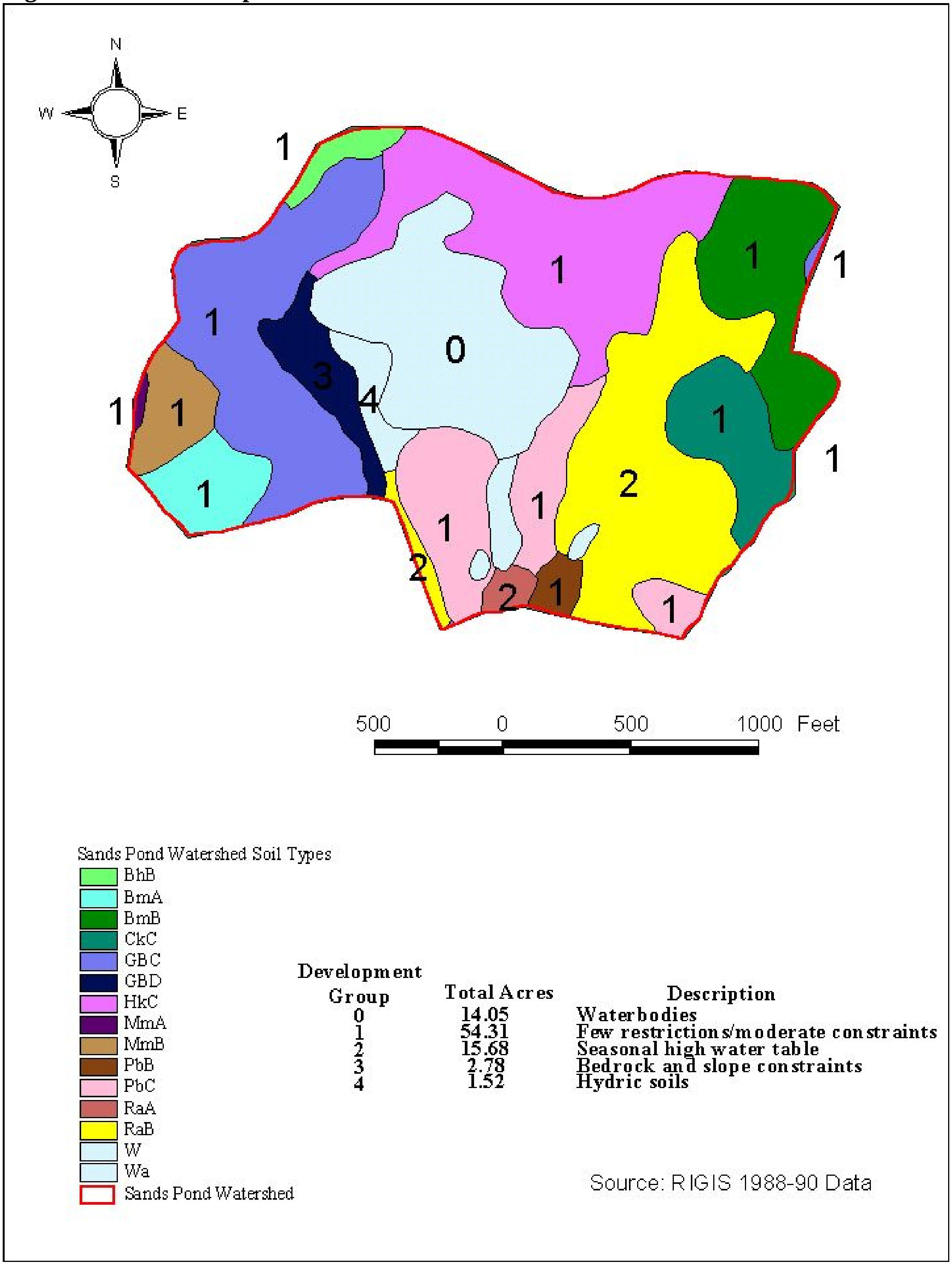


Figure 2.2: Soils Map – Sands Pond Watershed



while the other is slow to percolate. Figure 3.6 shows the locations of existing septic systems relative to soil types.

Surface drainage on Block Island is poorly developed, as is evident by the lack of well-developed stream channels.   Overland run-off on Block Island is considered to be a small fraction of average annual precipitation. Block Island is comprised of primarily permeable sandy soils, the island has numerous closed depressions, Sands Pond being one such depression; and there is an absence of visible runoff during most storms. In addition numerous studies indicate that in humid, vegetated areas, overland runoff is probably no more than 2 percent of average annual precipitation (USGS, 1996). No evidence of channelized flows to the pond was observed in the Sands Pond watershed. For this reason, overland stormwater runoff will not be considered as a source of nutrients to Sands Pond.

2.3 Hydrology

Block Island has a complex and delicate balance of a large variety of ponds, wetlands and groundwater resources. Sands Pond itself is a perched waterbody, extremely susceptible to climate changes, pollution due to subsurface leaching of contaminants, and iron enrichment. The pond is underlain by silt, clay or other low hydraulically conductive soils. Water levels appear to be an expression of the water table at an elevation of approximately 120’ above sea level (USGS, 1996). Water levels are affected by water table fluctuations, precipitation, evaporation, the historic addition of water pumped from a nearby supply well, and withdrawal by the BIWC through their intake pipe for public supply. During the period of 1985 – 1994, water from an adjacent supply well was pumped into the pond during periods of peak demand to maintain the pond level above the intake pipe. According to the BIWC, the pond is not currently being used as a water supply. All water presently supplied by the BIWC is from its system of wells. USGS (1996) states that the well contained excessively high concentrations of iron and that the chemical composition of the pond was changed as a result of inputs from this well. USGS does not, however, explicitly describe how these changes impact water column phosphorus.

3.0 PRESENT CONDITION OF WATERBODY

3.1 Existing Information

3.1.1 RI Department Of Health (RIDOH) Drinking Water Quality

The Rhode Island Department of Health (HEALTH), Drinking Water Quality Division currently maintains data regarding water quality for Sands Pond because it is a public water supply source. Water quality data dating back to July of 1988 were obtained from HEALTH for a variety of constituents. In earlier reports, the laboratory analyst assigned Turbidity and Taste and Odor to each sample. Turbidity was not expressed in NTU (Nephelometric turbidity units), but was expressed as slight, distinct or opaque resulting in very subjective reporting. Odors were described with nomenclature such as "swampy", "musky", "chlorine", and a number scale assigned for intensity. A number 1 was a weak sense of odor and a number 5 a strong sense of odor. This analysis of odor was also very subjective to the judgment of the analyst. (Clay Commons, personal communication, March 2001).

In the period between 1988 and 1992, the most recent reporting period of data, turbidity values ranged from a low of 0.7 to a high of 3.5. The average for the seven sampling results was 1.9. Odor descriptions were "swampy 1" to "swampy 3", "chlorine 2" and a report of "musty 1".

HEALTH does not require monitoring of this waterbody since the BIWC currently draws water from their sole source aquifer wells. Only finished water data is required; Sands Pond no longer serves as the water source.

3.1.2 Block Island Water Company data

Routine monitoring data collected by the BIWC for turbidity was sampled at the intake to the treatment center. Table 3.1 shows daily turbidity observations and monthly averages from March through October 2000. The monthly averages show that turbidity fluctuates seasonally, with lower values in the cooler months and higher values during the warm months of July through September. Monthly averages were lower from March through May, starting from a low value of 2.49 NTU in March. Turbidity increased significantly during June, reaching a maximum of 16.30 NTU in September. BIWC did not collect nutrient data. The BIWC has since discontinued using Sands Pond as a supply source, and daily sampling is no longer conducted on pond water.

There is documentation that the Town of New Shoreham and subsequently the BIWC were having difficulty providing the necessary treatment to Sands Pond water in order to comply with RIDOH drinking water standards. Review of the RIDOH files for the New Shoreham Water Company reveals that in several instances, drinking water standard violations required formal public notification. A Comprehensive Performance Evaluation of the BIWC completed in November 1993 indicates that the treatment plant was unable to meet turbidity standards for drinking water.

Table 3.1: Block Island Water Company Turbidity (NTU)

Day of Month	March, 2000	April, 2000	May, 2000	June, 2000	July, 2000	August, 2000	September, 2000	October, 2000
	Turbidity NTU	**Turbidity NTU**	**Turbidity NTU**	**Turbidity NTU**	**Turbidity NTU**	**Turbidity NTU**	**Turbidity NTU**	**Turbidity NTU**
1		3.02	3.14	4.07	12.00	14.60	19.50	12.20
2		2.87		4.51	11.00	13.20	18.30	
3		3.04	2.91	5.03	15.20	15.40	18.10	
4		6.45	2.60	6.91	14.50	17.90	28.20	
5		3.07	2.63	7.04	10.80	18.40	20.30	
6			2.59	6.82	12.30	16.20	16.80	11.60
7		3.69	2.71	6.17	13.40	16.60	15.50	13.10
8		3.26		6.11	14.30	8.35	7.81	13.20
9		2.39	2.60	5.56	18.60	24.90	15.00	11.30
10		1.86		6.01	13.20	14.40	14.90	
11		3.09		10.10	9.74	17.30	21.30	
12			2.71	13.20	26.00	16.50	14.10	12.30
13		3.90	2.56	9.60	14.00	14.30	12.40	11.40
14			3.38	8.96	13.60	16.30		10.60
15		3.49		7.76	11.80	12.40	13.30	10.40
16	2.84	3.84	2.96	8.91	9.60	11.20		14.70
17	2.85	3.57		13.70	9.08	9.56	13.90	
18		3.54	2.70	19.90	10.60	10.40	19.80	
19		3.56	2.94	16.30	11.30	7.94	18.50	
20	2.66	3.92	3.02	15.60	13.90	13.40	17.10	
21		4.13	4.14	10.10	13.20	13.10	12.60	14.00
22	2.55	4.21	3.98	10.30	13.40	13.00	15.70	14.00
23	2.34	3.86	3.79	10.60	16.80	13.70		
24	2.46	3.92	3.92	11.60	12.70	10.20	14.80	
25	2.34	3.76	3.37	13.90	16.90	16.30		
26	2.27		3.93	10.90	13.50	17.50		
27		4.39	3.86	9.50	12.80	15.20		
28	2.41	3.18	4.67	10.90	12.50	16.30		11.40
29	2.51	3.28	6.86	9.94	18.60	17.30	10.30	
30	2.19	3.22	5.56	9.97	16.10	14.00	16.80	
31			4.65		13.80	14.80		
Avg./ Month	**2.49**	**3.56**	**3.53**	**9.67**	**13.72**	**14.54**	**16.30**	**12.32**
Maximum	**2.85**	**6.45**	**6.86**	**19.90**	**26.00**	**24.90**	**28.20**	**14.70**
Minimum	**2.19**	**1.86**	**2.56**	**4.07**	**9.08**	**7.94**	**7.81**	**10.40**

In 1997, the Town hired Travassos-Geremia & Associates (TGA), a consulting environmental engineering firm, to investigate and recommend solutions to the algae growth in the pond. The pond had previously been treated with copper sulfate and was experiencing increased algae concentrations, indicating that it was recovering from those treatments. Other factors contributing to the rebound in algae concentrations were extremely high water levels in the pond, increased wildlife activity, and the influences of surrounding septic systems. TGA recommended treating the pond with potassium permanganate and/or providing permanent in-pond aeration. The town purchased and installed an Eco-Logic Pond and Lake System aeration and ozonation unit (Bob Pokraka, pers. comm). This system was installed in 1998, but has since become inoperable. To-date the town has been unsuccessful in repairing this unit. The pond was not treated with potassium permanganate.

3.1.3 Chandler, 2000-2001

On June 14, 2001, Mark Chandler a researcher at the New England Aquarium submitted to the town a summary report (Chandler, 2001) of investigative work performed on October 1, 2000 and May 20, 2001. Table 3.2 summarizes the Chandler study water quality data. Chandler's report concluded that the pond had in fact changed from a clear water pond to a turbid one sometime in the mid 1990s. He concluded that the cause of this degradation was not known, but suggested several possible causes. These include returning filter backwash into the pond, extreme draw downs of water, pumping well water from surrounding groundwater wells, large natural and manmade fluctuations of water levels, and copper sulfate treatments. Chandler did not conclude which single event or combination of events caused the algae blooms and disappearance of fish species. Regardless of the scenario causing the change, Sands Pond changed from a clear water pond to a pond with increased algae blooms and a decrease in water clarity beginning in the early 1990s, and that state continues today.

Table 3.2: Summary of Chandler water quality data

Water Quality Parameter	Result
PH	7.1
Turbidity (NTU) (October 1, 2000)	10.25
May 20, 2001	5.9
Secchi depth (cm)	80 (average of two samples)
Conductivity (um/S)	130 (average of two samples)
DO Surface (mg/l)	9.53
% saturation	96.7
DO 1.25 cm (mg/l)	9.31
% saturation	94.5
Color (PCU)	20
Temperature @ 50 cm below surface (C)	15.9

In addition to the water quality characteristics noted in the report, Chandler made observations on the habitat, wetland plant community, fish population and invertebrate diversity of the pond and surrounding watershed. As reported, the pond is typical of a true coastal pond with a relatively deep, sandy or rocky bottom, "likely fed to some extent by groundwater". The pond's buffer zone is mostly natural vegetation, with a mixture of trees and shrubs immediately adjacent to the pond. Noted however is the fact that the 2-5m vegetated perimeter (shrubs) immediately adjacent to the pond were dead; the cause of which is unknown but is most likely due to their submersion under high water level conditions. The pond substrate is diverse, made up of mostly sand, but contains some organic material found as either fine "mud" or coarse woody debris. There was very little vegetation observed within the pond, and only a few fragments of the plant *Myriophyllum* and *Juncas* were found.

Chandler also reported finding only two species of fish in Sands Pond. These two species, golden shiners (*Notemigonus chrysoleucas*) and brown bullheads (*Ameirus nebulosus*) are both highly tolerant of degraded conditions including low oxygen. Chandler concluded that the limited fish population was likely the result of some catastrophic water quality event. The loss of species such as pickerel, bass and sunfish previously observed in the pond could have occurred from copper sulfate poisoning or from decreased oxygen levels. The presence of the golden shiner in the pond suggested that the more likely impact was a low oxygen event because these minnows are relatively intolerant to copper sulfate, but are tolerant of low oxygen conditions.

A reduced diversity of macroinvertebrates was found during Chandler's October 1, 2000 survey. This lack of macroinvertebrates could be due to a reduced habitat quality, in this case aquatic plants and water quality, or due to some past management action taken on the pond. The application of copper sulfate could have been the cause of this reduced population since it is known to be highly toxic to aquatic organisms, and can kill not only the targeted algae, but also zooplankton, macroinvertebrates, fish and aquatic plants.

Chandler (2001) reports that Sands Pond is currently more turbid than it has been historically. It has a reduced diversity of fish, macroinvertebrates and plants. It could revert back to its clear state given enough time, or it is also possible that this might not happen, at least not in the near future. The nutrient recycling, or zooplankton communities, or some other property of the pond's natural ecosystem might reduce phytoplankton abundance, but given the fact that these conditions have remained since at least the mid 1990s it appears that this "turbid" state has some resilience.

3.1.4 DEM sampling, 2001

DEM staff sampled Sands Pond during six dry weather periods in the summer of 2001 for total phosphorus (TP), Dissolved orthophosphate, chlorophyll-a, Secchi depth, temperature, dissolved oxygen and turbidity. Wet weather data was not collected. The summer averages for each parameter are listed in Table 3.3. Narrative discussions of significant water quality parameters are contained in Section 3.2.

Table 3.3: DEM Sands Pond Summer 2001 Results

Parameter	Summer 2001 Average
Total Phosphorus	35.50 ug/l
Dissolved Orthophosphate	5.39 ug/l
Chlorophyll a	11.44 ug/l
Secchi Depth	0.93 Meters
Temperature	23.4^{o} C
Dissolved Oxygen	5.98 mg/l
Turbidity	6.54 NTU

3.2 Current Water Quality Summary

The information provided above describes the condition of the pond from a range of perspectives. It includes narrative accounts of attempts by water supply operators to improve its suitability as a drinking water source, taste and odor tests, and water quality data obtained during a spring-fall season. In this section, the data above will be synopsized to provide a summary of the present condition of the pond in the context of its water quality goals.

Turbidity

The 2001 DEM dry weather data for Sands Pond indicate that the turbidity standard of 5 NTU over background (7.74 NTU) was not exceeded as a summer average (6.54 NTU) but was exceeded at the surface for all stations during the late summer period between August 28 and September 13 (Figure 3.1). Turbidity levels were generally uniform at all stations and depths. Turbidity increased during the late summer months, reaching a maximum value that exceeded the standard at all stations on September 13. Turbidity had dropped to earlier season values by the time of the October 5 survey.

Figure 3.2 shows the monthly average turbidity data collected by the BIWC in 2000 against the monthly averages calculated from the data collected by RIDEM in 2001. Although trends in the two data sets are similar, the monthly means of the BIWC data are significantly higher, perhaps because of the different sampling location used for the BIWC data, or different laboratories conducting the analysis. The mean of the BIWC data, 10.0 NTU, does violate the turbidity standard of 7.74 NTU from June through October.

Total Phosphorus

Figure 3.3 shows total phosphorus by station and by depth in the pond during the summer of 2001. With the exception of one sample at the surface of SP-3 on July 13, Total Phosphorus concentrations exceeded the water quality standard of 25 ug/l during all sampling events and at all locations. The summer average of 35.5 ug/l is indicative of eutrophic conditions (USEPA, 1990).

Figure 3.1: 2001 DEM Turbidity data

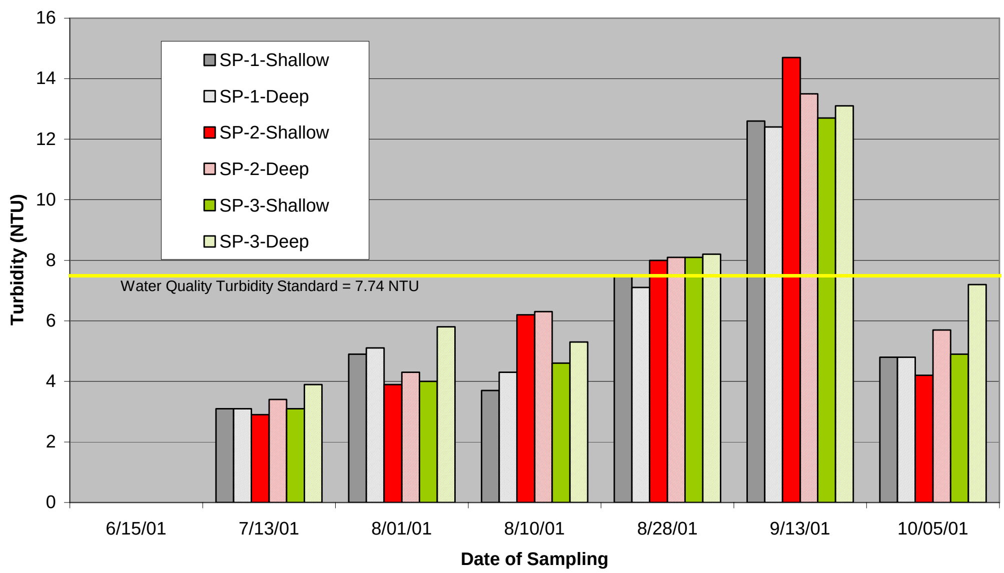


Figure 3.2: 2000-2001 Turbidity data for Sands Pond

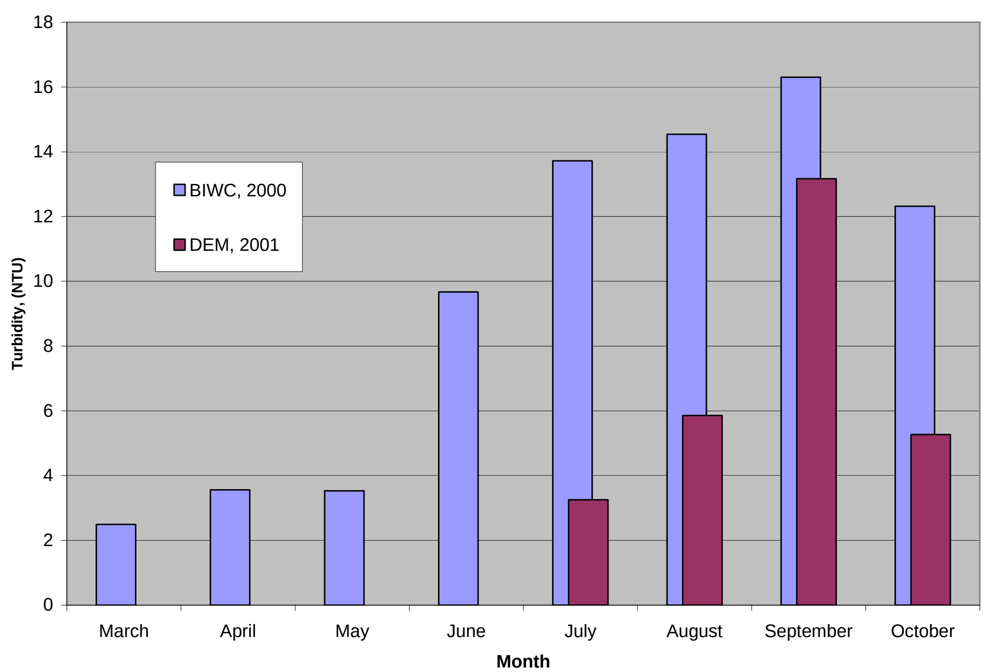
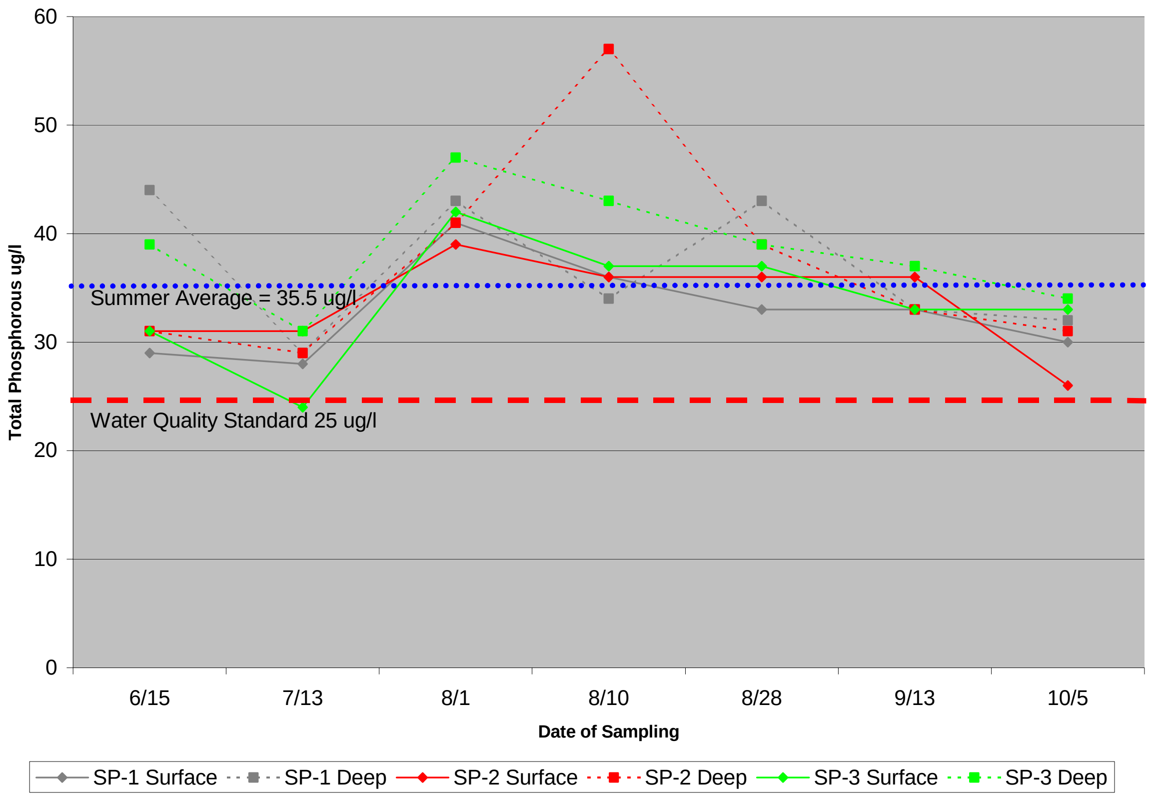


Figure 3.3: 2001 DEM Total Phosphorus data



Chlorophyll-a

Figure 3.4 shows the DEM chlorophyll-a data for 2001. Concentrations ranged from a low of 2.13 ug/l in June to a high of 20.83 ug/l in September. In October it appears that chlorophyll-a concentrations began to return to pre-summer levels, dropping below 9 ug/l. This again follows the same general trends as the turbidity. The chlorophyll-a goal of 10 ug/l is also shown in the figure. This goal was exceeded several times during the sampling period at the majority of the locations during the more critical months of August and September.

Dissolved Oxygen

The 2001 DEM dissolved oxygen data for Sands Pond are summarized in Figure 3.5. Summary tables of statistics by station and mean dissolved oxygen values for all stations by date are presented in Tables 3.2 and 3.3. Mean dissolved oxygen concentration by station ranged from 3.65 and 5.06 mg/l at SP-3 deep and SP-1 deep located in the deeper areas of the pond. Half of the observations at SP-3 deep and SP-1 deep were less than 5.0 mg/l. Mean concentrations at the surface stations ranged between 6.81 - 7.09 mg/l. None of the observations at the surface stations in the pond were less than 5 mg/l. These results suggest the periodic occurrence of low dissolved oxygen in the hypolimnion layer of Sands Pond.

Low dissolved oxygen conditions may naturally occur in the bottom waters of deeper ponds - where little to no mixing occurs. Evidence supporting that this condition may be a naturally occurring in Sands Pond are the facts that the pond has no inlet or outlet, its watershed is small and is largely undeveloped, and the only identified pollution sources are nonpoint in nature. Though the review of historic data by Chandler suggests the occurrence of an event(s) which has led to deterioration of the pond's water quality, there is insufficient data to determine to what extent the periodic low dissolved oxygen levels of the bottom waters are naturally occurring. Dissolved oxygen conditions are expected to improve with reduction of total phosphorus concentrations.

Figure 3.4: 2001 DEM Chlorophyll-a data

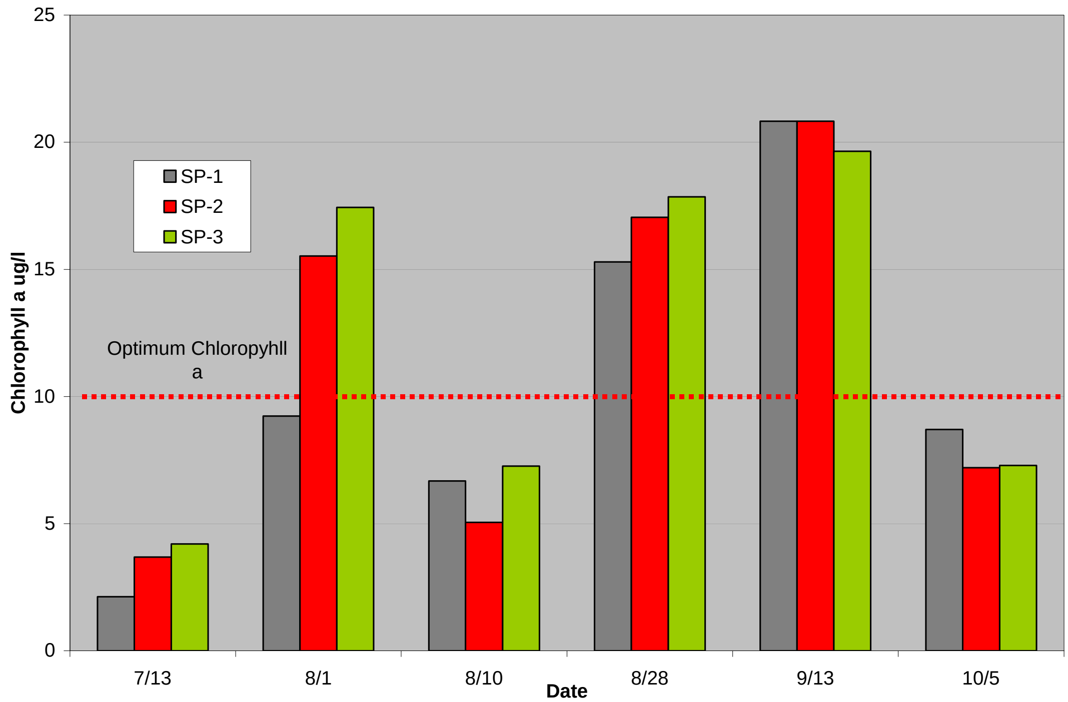


Figure 3.5: RIDEM 2001 Dissolved Oxygen data

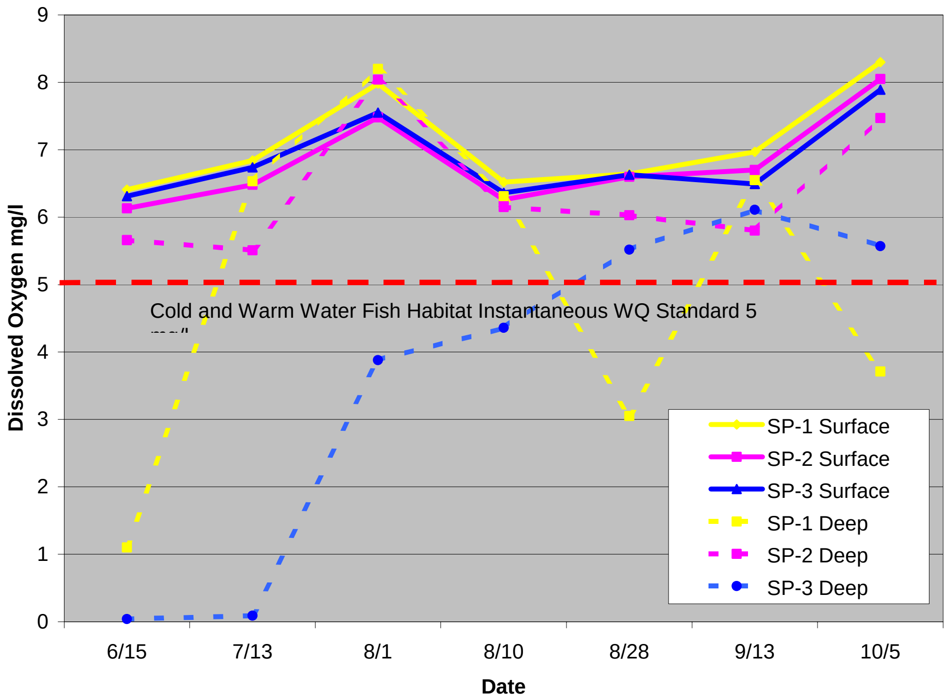


Table 3.4: Statistics of DEM dissolved oxygen (mg/L) by station for Sands Pond.

Station	SP-1 Surface	SP-2 Surface	SP-3 Surface	SP-1 Deep	SP-2 Deep	SP-3 Deep
Minimum	6.41	6.13	6.31	1.1	5.51	0.04
Mean	7.09	6.81	6.85	5.06	6.38	3.65
Maximum	8.3	8.05	7.89	8.2	8.04	6.11

Table 3.5: Mean dissolved oxygen (mg/L) for all stations by date in Sands Pond.

Date	6/15/01	7/13/01	8/1/01	8/10/01	8/28/01	9/13/01	10/5/01
Mean (mg/l)	4.28	5.37	7.19	5.99	5.75	6.44	6.83

3.3 Pollutant Sources and Loads

The basic mass balance for Total Phosphorus in Sands Pond may be expressed as:

$VdP/dt = W - K_sPV - QP$, (Thomann and Mueller, 1987)

and $K_s = \nu_s/H$

where:
K_s = net settling rate of phosphorus
ν_s = net settling speed
H = mean depth of pond (2.2 m)
V = Volume of the pond (1.3×10^5 m^3)
P = Annual average Total Phosphorus concentration in pond
Q = outflow
W = External source loading of phosphorus

Where the pond is in equilibrium and the change in the annual concentration goes to zero,

$W = K_sPV + QP$,

representing a balance between sources (e.g. point sources, atmospheric deposition, waterfowl) external sources and sink terms (losses to bottom settling and outflows) in the mass balance. In Sands Pond, outflows occur through groundwater and are assumed to be negligible. The net loading to the pond is the difference between the source term, W, and the loss to the sediments, K_sPV:

Net Load = [point source waste loads] + [stormwater loads] + [subsurface (groundwater) loads] + [atmospheric deposition] + [waterfowl loads] - [sediment losses].

The point source waste load term represents the load from pipes discharge or intake from the pond. This term is presently zero. The stormwater load term represents surface water inflows to the pond that accompany rainfall. USGS (1996) concluded, and site inspections by DEM confirm that no surface water inflows that would occur intermittently during and after storms exist to the pond. As was stated in section 2.2, surface drainage on Block Island is poorly developed due to the general land and soil characteristics. Overland run-off on Block Island is considered to be a small fraction of average annual precipitation. The surface water runoff is also assumed to be zero.

The remaining terms, subsurface (groundwater) loads, atmospheric deposition and waterfowl loads, and the sediment loss term are nonpoint in nature; their sum will be included in the load allocation (LA) for the pond. The groundwater loading is assumed to include inputs from septic systems. The net load term becomes:

Net Load = [groundwater loads] + [atmospheric deposition] + [waterfowl loads] - [settling loss to sediments]

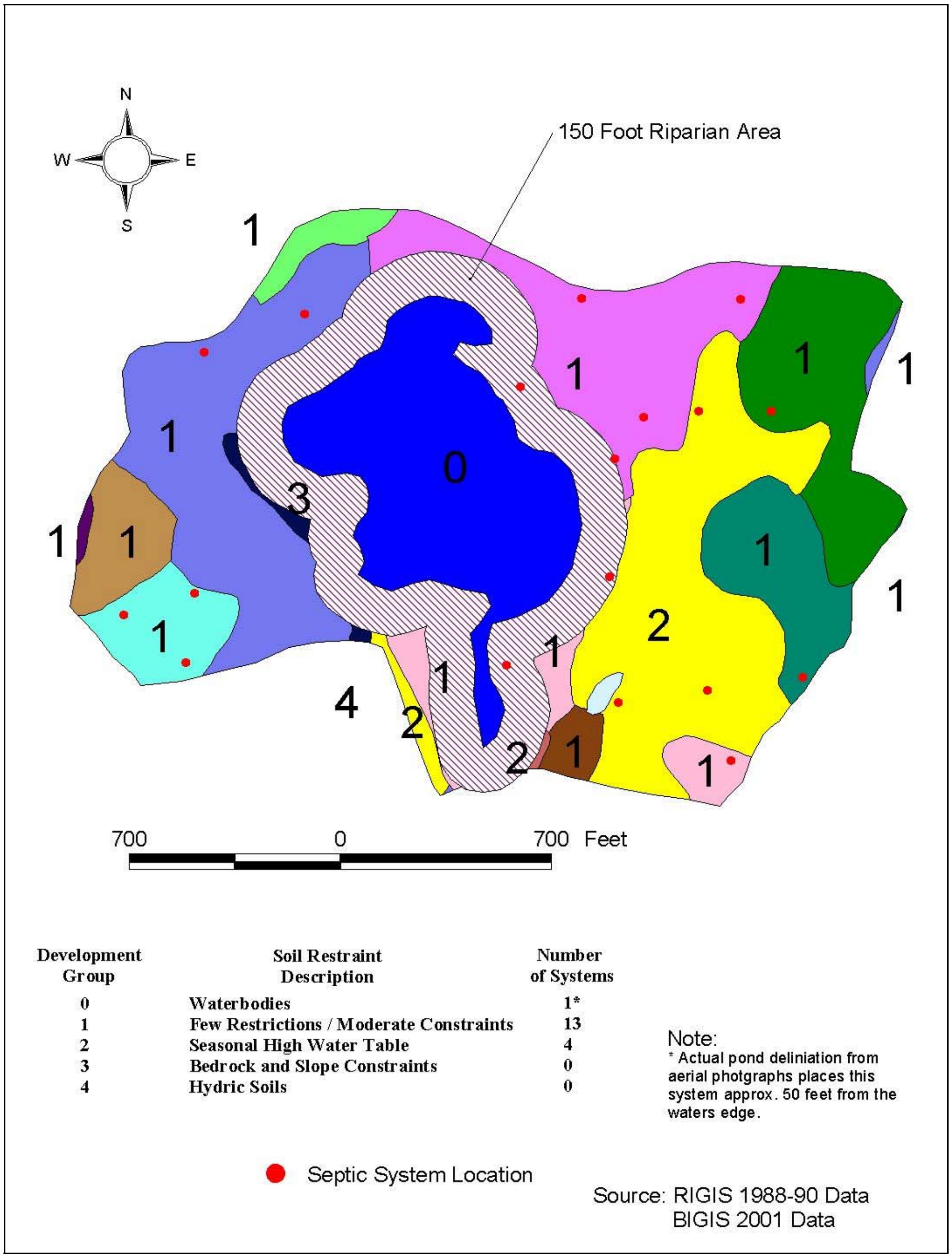
3.3.1 Groundwater loading

Orthophosphorus concentrations in groundwater from selected wells and springs on the island have been characterized by USGS (USGS, 1993). The average of all observations was 18.55 ug/l. The concentration of Total Phosphorus entering the pond in groundwater is therefore assumed to be 18.55 ug/l. The volume of ground water entering and leaving the pond (2.0×10^4 m^3/year) was estimated using Darcy's equation from USGS water table elevation and soils data.

The estimated annual groundwater load ($18.55\ mg/m^3 \times 2.00 \times 10^4\ m^3/yr$) is 0.38 kg/yr. This number is significantly lower than the assumed loading from septic systems adjacent to the pond, discussed below. To obtain a general agreement with the septic system loading estimate presented below, the groundwater loading estimate would need to be increased by a factor of 33. The groundwater loading term may also represent an overestimate of the groundwater contribution to the pond, because the phosphorus leaving the system through groundwater subsurface outflows is neglected.

Septic systems in the Sands Pond groundwater recharge area are contributors of phosphorus and nitrogen loadings to the groundwater and subsequently to Sands Pond. A report titled "Water Quality Impacts of Changing Land Use on Block Island, Rhode Island" (URI Cooperative Extension, 1996) states that malfunctioning septic systems located within 150 feet of a surface water body (riparian area), contribute 100% or 6.9 lb. P per unit annually to the water body. DEM considers this estimate to be a theoretical maximum value. Figure 3.6 shows the locations of the 18 septic systems in the Sands Pond watershed. Four of these systems are within the 150-foot riparian area of the pond and therefore could be considered as contributors. Following the URI study assumptions, the annual phosphorus loading to the pond from these four systems would be 12.5 kg. This estimate is considered to be unrealistic because phosphorus released by properly functioning septic systems typically absorbs to sediment particles and is not mobile in groundwater. To date, DEM has no information indicating that any of the septic systems within 150 feet of Sands Pond are not functioning properly (David Chopy, personal communication, July 12, 2006). Failing systems could transport phosphorus via overland flows, e.g. stormwater. DEM has seen no evidence of overland runoff to the pond. The septic system loading is included in the background groundwater loading term of 0.38 kg/yr.

Figure 3.6: Septic system locations in the Sands Pond watershed.



3.3.2 Atmospheric deposition

Phosphorus deposition to the surface of the pond was estimated for both dry and wet conditions. Average phosphorus concentrations in precipitation have been measured in the Sands Pond well field (USGS, 1993). The average concentration of dissolved phosphorus was 0.0073 mg/l. Average precipitation for Rhode Island is 1.09 m/yr (NCDC). National Weather Service data for Providence, RI indicates that there are 125 wet and 240 dry days per year. The surface area of Sands Pond is 5.9×10^4 m^2. The annual loading of phosphorus due to wet weather deposition is estimated as follows:

Wet deposition load = $(7.3 \times 10^{-7}\ kg/m^3)(1.09 m/yr)(5.9 \times 10^4\ m^2) = 4.7 \times 10^{-2} kg/year$

Tetra Tech (1998) reports measured atmospheric dry deposition rates of dissolved organic phosphorus of 5.4×10^{-5} g/m2/day for the nearby Peconic River estuary. The corresponding annual dry weather deposition to the surface of the pond is therefore:

Dry deposition load = $(5.4 \times 10^{-8} kg/m^2/day)(5.9 \times 10^4\ m^2)(240\ days/year) = 0.77\ kg/year$

The total annual atmospheric deposition load is the sum of the wet and dry terms, 0.82 kg/year.

3.3.3 Waterfowl, Wildlife and Domestic Animals

Observations of waterfowl activity on the pond were made during the summer of 2001 to establish the loading attributable to waterfowl activity on the pond. Waterfowl activity was limited to one or two “families” of Canada Geese, several smaller unidentified birds, and a few gulls. These families of geese consisted of two adults and several offspring. Gull activity appeared to be minimal, although BIWC personnel indicated that bird populations would increase significantly before storms, as the birds sought refuge in the protected waters of the pond. The presence of goose droppings along the shoreline in the small grassy area at the treatment plant indicated a fairly significant measure of waterfowl activity. These droppings fluctuated in quantity throughout the season and had diminished almost completely by the end of monitoring in early October.

A portion of the phosphorus loading can therefore be attributed to waterfowl. A literature value of 0.20 kg/bird-year unit load (RIDEM, 1998) was used to determine the total phosphorus load attributable to waterfowl. Based on observations, 25 bird-years (50 birds per day per season, season assumed to be ½ year) was used as a conservative estimate of the number of waterfowl contributing to the phosphorus load. The waterfowl load is estimated as follows:

Waterfowl load = (25 bird-years)(0.20 kg P/ bird-year) = 5.0 kg/year.

Although this estimate is approximate, waterfowl loadings are considered to represent a significant source to the pond.

The horses kept on the eastern shore of Sands Pond are a potential source of contamination to the pond. Contamination can result as stormwater flows along the ground surface and into the pond.

3.3.4 Internal cycling of phosphorus and the net settling term

A two-way exchange of phosphorus between sediments and the water column occurs at the bottom of the pond. Phosphorus in algae is lost from the water column as the algae die and sink to the bottom in organic form. In its organic form, phosphorus is relatively unavailable for uptake by phytoplankton and is considered to be "lost" to the water column. A portion of this organic phosphorus in the sediments is converted into a water-soluble inorganic form by bacterial decay and hydrolysis (remineralization), and re-enters the water column as orthophosphorus. This dissolved inorganic phosphorus is in a form that is readily taken up by the phytoplankton, and the cycle is repeated. The net of the settling and remineralization terms is a loss from the water column to the sediments. It may be calculated from the mass balance equation in section 3.3 where the annual mean Total Phosphorus concentration in the pond is at equilibrium ($dP/dt = 0$). In that case, the external loads are balanced by the net loss to sediments.

Vollenweider (1975) reports a typical settling rate (ν_s) of 10m/yr (0.0274 m/day) based on studies of northern temperate lakes. For Sands Pond, where the mean depth is 2.2 m (7.1 feet), the estimated net settling rate is 4.5 m/yr. Variations about this annual net rate are affected by sediment redox chemistry, which is affected by water column oxygen levels near the bottom (Figure 3.5). The potential for bottom phosphorus releases to significantly affect water column levels may scale with concentrations in bottom sediments. Total Phosphorus in a composite sediment sample collected by ESS (2002) in Sands Pond was 1300 mg/kg. ESS characterized this level as "severely polluted". So, the net annual loss of phosphorus is reflected in an apparently small average sinking rate, however, the large pool of phosphorus in the sediments may indicate that variations around this average value could be large.

As discussed in section 3.1.3, Chandler reported a few possibilities of how excess nutrients entered into Sands Pond causing a "severely polluted" level. In 1991 the Block Island Water Company stopped filtering properly and needed to backwash filters often. They started dumping the backwash water, containing potassium permanganate chlorine, iron, and alum, into Sands Pond. The BIWC also performed major water drawdown events replenishing the water with well water that contained a relatively high salt concentration. In 1997 the pond received copper sulfate treatments to reduce the noxious algal blooms that were appearing in the pond. These are all possible causes of the excess nutrient cycling that is occurring in Sands Pond.

Significant amounts of phosphorus in lake sediments may be bound to redox-sensitive iron compounds or fixed in more or less labile organic forms (Sondergaard, 2003). Iron does bind with phosphorus to create iron-phosphate. However, phosphorus can be re-released when the bottom waters are under anoxic conditions thereby unchanging the concentration of the phosphorus within the pond (Personal communication, Carl Nielson, August 23, 2006).

3.3.5 Load Summary

The basic mass balance equation for total phosphorus presented above will be used with the assumptions that the pond is completely mixed, and that sources and sinks are balanced on an annual basis.

Internal loss to the bottom = groundwater load + atmospheric deposition load + waterfowl load

$K_sPV = 0.38$ kg/yr + 0.82 kg/yr + 5.0 kg/yr = 6.2 kg/yr

The effective settling rate can be from the equation above for an external loading of 6.2 kg/yr and mean lake TP concentration of 35.5 ug/l. Solving the equation for sedimentation rate:

ν_s = 2.96 m/yr.

For the assumed annual phosphorus loading to the pond, the net settling rate is low relative to the value estimated from Vollenweider (1975), but is in the range of values reported by Thomann and Mueller (1987). Again, variations in sign and magnitude of phosphorus losses to the sediments associated with this sinking rate may be large and therefore could contribute to the algae blooms observed in the pond.

3.3.6 Natural Background Conditions

The natural background condition of Sands Pond is assumed to be represented by the existing loading and is not effected by any point sources of pollution. The natural background conditions are incorporated into the non-point source loading.

3.4 Water Quality Impairments

The study of previous reports and the results of 2001 monitoring document that the primary problem affecting Sands Pond is high turbidity due to an overabundance of algae, which in turn is caused by elevated levels of phosphorus. The results also suggest that there are periodic violations of the water quality criteria for dissolved oxygen in the bottom waters – though it has not been determined to what extent this may be naturally occurring. This section characterizes the water quality impairments in Sands Pond and describes specific violations of designated uses and water quality criteria found in the State's Water Quality Regulations.

3.5 Violations of Water Quality Criteria

The primary water quality criteria being addressed by this TMDL are minimum standards for turbidity, total phosphorus, chlorophyll a, and dissolved oxygen as they relate to excess algal biomass. The violations of these standards are outlined below

Turbidity. The State's Water Quality Regulations require that turbidity levels shall not exceed 5 NTU over background. The background has been established as 2.74 NTU, so the turbidity standard would be 7.74 NTU. Tables 3.1 and 3.2, and Figure 3.2 indicate that data collected by the BIWC and Chandler indicate that mean turbidity in the pond was greater than 7.74 NTU during 2000 – 2001. The DEM data for 2001 (Figure 3.1) show that turbidity levels did exceed the standard, primarily during the late summer months.

Total Phosphorus. The State's Water Quality Regulations state that "*Average Total Phosphorus shall not exceed 0.025mg/l in any lake, pond, kettlehole or reservoir, …*" The average summer Total Phosphorus concentration of the pond (Table 3.3) was 35.5 ug/l, which violates the 25 ug/l criterion.

Chlorophyll-a. The State's Water Quality Regulations do not include a numeric target for chlorophyll-a but rather a statement regarding nuisance algae that may cause any use impairment or cultural eutrophication associated species. A realistic goal of a mean chlorophyll-a concentration not to exceed 10 ug/l is a reasonable objective for a drinking water supply. The summer average chlorophyll-a concentration in the DEM data for 2001 was 11.44 ug/l (Table 3.3).

3.6 Designated Use Impairment

The water quality data for the pond and historical uses indicate that excessive turbidity and chlorophyll-a impair the pond for use as a drinking water supply. These impairments created problems in maintaining the use of the pond as a drinking water supply. As of 2002, the BIWC was no longer using the pond as a drinking water supply.

Other uses listed for Class AA waterbodies relate to recreation, habitat, and aesthetic enjoyment. RI state law allows the prohibition of contact recreation uses of a public drinking water supply, and these prohibitions apply to Sands Pond. The habitat use of the pond is impaired because the Total Phosphorus and Dissolved Oxygen levels impair the composition of fish, interfere with their propagation, and adversely alter their life cycle functions, uses, processes, and activities.

The remaining use of the pond is for aesthetic enjoyment. Aesthetic enjoyment and related passive uses are among those most impaired by summer algae blooms. Improvement of water quality for water supply purposes and aesthetic appeal are entirely consistent; no conflict between the two would exist.

4.0 TMDL ANALYSIS

4.1 Water Quality Targets

Sands Pond is a Class AA water body. The Turbidity standard for Class AA waters is not to exceed 5 NTU (nephelometric turbidity units) over background. DEM (2002) identifies the background turbidity level as 2.74 NTU. The numeric turbidity target is therefore 7.74 NTU. The Taste and Odor standard is none (i.e. taste and odor) other than from natural origin and none associated with nuisance algal species. There is no numeric standard for algal abundance, and the ideal level will vary depending upon the waterbody's management goals. A chlorophyll-a concentration of 10 ug/l is not perceived as a significant problem by water suppliers (ENSR, 1997) and is therefore set as the goal. The instantaneous minimum dissolved oxygen criteria for a cold or warm water fish habitat is 5 mg/l.

The algal abundance, turbidity, taste and odor and dissolved oxygen impairments in Sands Pond are assumed to be caused by an overabundance of phosphorus. The criterion for Total Phosphorus is an average concentration not to exceed 0.025 mg/l (25 ppb) and none [nutrients] in such concentration that would impair any usages.

The existing use of the pond as a drinking water supply is impaired due to high turbidity caused by excessive chlorophyll-a concentrations. The excessive chlorophyll concentrations also impair the use of the pond as fish habitat. The Department believes that when the Total Phosphorus standard is met in the pond, the use impairments related to chlorophyll-a, turbidity, and Dissolved Oxygen will be eliminated. Empirical relationships between chlorophyll-a and total phosphorus in lakes, summarized in Thomann and Mueller (1987), are presented below:

1) Bartsch and Gakstatter (1978):

$$\text{Log}_{10}(\text{chl a}) = 0.807 \log_{10}(\text{TP}) - 0.194$$

2) Rast and Lee (1978):

$$\text{Log}_{10}(\text{chl a}) = 0.76 \log_{10}(\text{TP}) - 0.259$$

3) Dillon and Rigler (1974):

$$\text{Log}_{10}(\text{chl a}) = 1.449 \log_{10}(\text{TP}) - 1.136$$

The numerical water quality target for this TMDL is an instream Total Phosphorus concentration standard of 0.025 mg/l (25 ppb).

When the Total Phosphorus criteria concentration of 25 ppb for is met in the pond, the three empirical relationships predict mean chlorophyll-a concentrations of 8.6 ug/l, 6.36 ug/l, and 7.76 ug/l, respectively. These levels are below the 10 ug/l chlorophyll-a goal established for the pond.

4.2 Margin of Safety

A margin of safety (MOS) must be included in each TMDL to account for uncertainties in the scientific and technical understanding of water quality in natural systems. The exact nature and magnitude of pollutant loads from various sources and the specific impacts these pollutants have on the chemical and biological quality of complex, natural waterbodies is incomplete. The

MOS is intended to account for these uncertainties in a manner that is conservative from the standpoint of protecting the environment. The existing EPA guidance allows for two approaches to achieve a margin of safety, implicit or explicit. Incorporating the MOS as part of conservative assumptions made in the development of source load allocations or reserving a portion of the loading capacity as a separate term in the TMDL equation.

An explicit MOS of 10% on TP load (hence the concentration) is assigned to the assimilative capacity of Sands Pond to ensure that the pond achieves its water quality standards.

4.3 Critical Conditions / Seasonal Variation

The turbidity and taste and odor problems in Sands Pond are attributed to excess algal abundance. The growing season for algae are the warm summer months between May and October. Monitoring was conducted during this time period and therefore the data is a representation of critical conditions. Setting load allocations based on critical conditions addresses the seasonal variation component and implies an additional margin of safety. If water quality standards are met under critical conditions, then they will be met during all seasons.

4.4 Allowable Loading

The existing external load to the pond (6.2 kg/yr) includes groundwater inputs (0.38 kg/yr), atmospheric deposition (0.82 kg/yr), and waterfowl (5.0 kg/yr), and is incorporated into the nonpoint source loadings. The balance between the current external loads and the net settling to the bottom results in an annual mean water column concentration of 35.5 ug/l. The TMDL objective is to reduce this concentration to less than 25 ug/l, with an explicit MOS corresponding to a 10% reduction of the allowable load incorporated. Given the linear relationship between loads and water column concentration, this corresponds to a mean TP concentration of 22.5 ug/l for the pond. The existing external load will need to decrease from 6.2 kg/yr to an annual load of 3.9 kg/yr to meet the TMDL objective of reducing the TP concentration to less than 22.5 ug/l.

4.5 Allocation of Allowable Loads

The TMDL equation establishes the allocation of phosphorus loadings from all sources and is expressed as:

$$TMDL = WLA + LA + AFG - MOS$$

Where:

TMDL	=	Assimilative capacity of the waterbody
WLA	=	Waste Load Allocation (Point source loads)
LA	=	Load Allocation (Nonpoint source loads)
AFG	=	Loading allowance for future growth
MOS	=	Margin of Safety

The TMDL allocation is presented in Table 4.1.

Table 4.1: Allocation of the TMDL

TMDL (kg/yr)	=	**WLA** (kg/yr)	+	**LA** kg/yr(kg/yr)	+	**AFG** (kg/yr)	-	**MOS** (kg/yr)
3.9		0	+	4.33	+	0	-	0.43

For Sands Pond, the WLA includes point discharges to the pond from pipes and from channelized storm runoff. No point sources exist, so the WLA is set to zero. The AFG is also set to zero because load increases due to additional septic systems are limited by the existing parcel development, town zoning ordinances, state and federal wetland regulations and various other development regulations currently in place, with the result that the AFG would not be considered to measurably increase under those constraints. The potential for future phosphorus load increases is further constrained by the limited subsurface mobility of phosphorus. The TMDL must therefore be achieved by a reduction in the Load Allocation (LA). DEM believes that the external loads are small, representative of the natural background loads to the pond, and cannot be further reduced by control actions.

To calculate the Load Allocation for a desired TMDL of 3.9 kg/yr where the MOS is equivalent to 10% of the Load Allocation and using the equation from Table 4.1:

TMDL = WLA + LA + AFG – MOS

3.9 kg/yr = 0 + LA + 0 – 0.10(LA)

3.9kg/yr = 0.9(LA) therefore LA = 4.33 kg/yr and MOS = 0.10(LA) = 0.43 kg/yr

Expressed as a daily load, TMDL = 0.01068 kg/day and LA = 0.01186 kg/day

In its assessment of sources, DEM has concluded that water column concentrations in the pond represent the balance between external sources and internal settling losses, both of which are nonpoint in nature. Assuming that Total Phosphorus concentrations are constant from year to year, the external sources are balanced by internal losses to the sediments. An increase in the phosphorus settling rate from 2.96 m/yr (Section 3.3.5) to 4.7 m/yr will reduce the water column Total Phosphorus concentration to a value corresponding with the TMDL (22.5 ug/l). Potential means for meeting this goal are outlined in Section 5.

4.6 Strengths and weaknesses in the analytical process

Strengths:

- The watershed is relatively simple. By inspecting the perimeter of the pond, DEM was able to determine that no point sources, in the form of pipes or channelized runoff exist.
- The pond has a relatively well-documented history. TMDL incorporates the findings of several studies and utilizes data collected over several years.
- The TMDL endpoints presented in the load allocation sections allow water quality standards to be met in critical conditions.
- The TMDL is based on actual data collected in the watershed.

Weaknesses:

- Because the pond is in a remote location, DEM was not able to undertake a wet weather study of the pond.
- DEM was not able to directly measure the external loading terms to the pond, and had to rely on literature values to estimate the largest external source term.
- The influence of septic systems was not directly measured. The URI Cooperative Extension Report (1996) estimate of phosphorus loading to the pond from septic systems in the watershed was considered to be a maximum theoretical value, rather than an actual value. Available literature indicates that phosphorus is generally bound to soil particles in the vicinity of the septic system and is not transported to nearby water bodies when the systems are properly designed and functioning.

4.7 Supporting documentation

Recent water quality studies considered significant to this TMDL are presented in Table 4.2. These references were used to characterize the present water quality conditions or identify water quality trends.

Table 4.2: Supporting documentation

Primary Organization or Authors	Title	Date of Report	Approximate Date of Study
DEM Office of Water Resources	Preliminary Data Report Sands Pond, New Shoreham Rhode Island	October 2001	2001
DEM Office of Water Resources	Final Data Report Sands Pond, New Shoreham Rhode Island	August 2002	June – October 2001
Block Island Water Company	Turbidity data	----	March – October 2000
URI Cooperative Extension	Water Quality Impacts of Changing Land Use on Block Island, Rhode Island	October 1996	1996
Mark Chandler	Report on Sands Pond	June 2001-	Fall 2000 – Spring 2001
Environmental Science Services	Sediment Quality Assessment ESS Job Number R297	April 2002	March 2002

5.0 IMPLEMENTATION

The source summary in section 3.3 identifies loadings from waterfowl as the probable largest phosphorus source, followed by atmospheric deposition and groundwater inputs. Because these sources are nonpoint in nature, none could be measured with any real degree of certainty, so the loadings are estimates based on data from other studies. The loading assessment exercise does provide useful information on expected magnitudes and upper limits of the existing loadings. For example, the magnitude of the current groundwater loading to the pond (0.38 kg.) is relatively small. A considerable increase in either the net groundwater flow rate through the pond or the Total Phosphorus concentration of groundwater entering the pond would be needed for groundwater to produce a significant increase in this component of the phosphorus budget of the pond. The estimate of waterfowl loading to the pond, based on an assumed year-round presence of 25 birds, is also liberal, even though considerable flocks may sometimes settle on the pond. The resident Canada Goose population has been increasing statewide and Sands Pond has become a refuge for the geese from inclement weather. Total Phosphorus concentrations in the pond sediments are high. These considerations have led DEM to conclude that the ambient concentration of phosphorus in the pond reflects a relatively low settling loss rate for phosphorus in the water column. Seasonal low dissolved oxygen levels at the bottom may also contribute to large fluctuations in the magnitude and sign of the sediment loss term. The external sources for the most part, are not related to human activities around the pond, and are considered to be due to natural background causes. The TMDL for the pond is therefore set at 63% of the present load. To meet the water quality goal, the mean Total Phosphorus concentration in the pond must be reduced by 37%. Given the information presently available, this goal can be accomplished by reducing the resident Canada Goose population and/or increasing the net settling rate of phosphorus from the water column by reducing the flux of phosphorus out of the sediment into the water column. The TMDL recommends that consideration be given to both alternatives, as well as to use of good housekeeping practices to reduce the loading of phosphorus to the pond.

5.1 Good Housekeeping Practices

To ensure that current loadings to the pond are not increased, this TMDL stipulates that the Town of New Shoreham and the BIWC ensure that non-structural Best Management Practices are practiced in the pond watershed. Human influences could potentially be attributed to septic systems, fertilizers, pet waste, storm runoff, and the operations of the water treatment plant. Under RIDEM's Rules Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Onsite Wastewater Treatment Systems (RIDEM 2008), a 200-foot setback from the drinking water supply is strictly enforced and includes requirements for the upgrading of septic systems and strict prohibition of new systems in this area. These regulations are in place in order to minimize these influences in the future.

General good housekeeping measures, which include minimizing fertilizer applications and policing pet waste, will also assist in mitigating phosphorus influxes through groundwater and runoff. Maintaining an uncut, vegetated buffer along the shore is also recommended as a means of discouraging waterfowl use of the pond, and to filter contaminants from any stormwater runoff. RIDEM also encourages all residents to use low or no phosphorus automatic dishwasher detergents. In New York, a legislative bill has been introduced allowing only trace amounts of phosphorus in dishwater detergents as a means of reducing the estimated 9-34% of phosphorus in municipal wastewater originating from automatic dishwashers. Use of low or no phosphorus detergents will help reduce phosphorus loads to Sands Pond.

As mentioned previously, the horses kept on the eastern shore of Sands Pond are a potential source of contamination to the pond. Contamination can result as stormwater flows along the ground surface and into the pond. A natural vegetation buffer should be created between the horses and Sands Pond to allow vegetative uptake and/or filtering of runoff. In addition, animal droppings should be cleaned up regularly and disposed of away from Sands Pond.

The role played by alterations to the pond by the Block Island Water Company in creating the current condition of the pond is not clear. Chandler (2001) suggests that manipulation of the pond by the BIWC, for example by the application of copper sulfate, may have contributed to the current state of the pond. The practices of excessively drawing down the pond, supplementing supplies by adding well or other pond water, and discharging filter backwash effluent should be reviewed or discontinued by the BIWC in the future.

5.2 Waterfowl Control

There are many ways to discourage waterfowl and especially geese from settling adjacent to a waterbody. No single technique is universally effective and feasible. Persistent application of a combination of methods is usually necessary and yields the best results. Some methods for controlling goose populations include the following: discontinuing feeding, modifying habitat, installing fencing, using visual scaring devices, applying repellents, using dogs to chase geese, and controlling goose nesting and capturing and removing geese (RIDEM Division of Fish & Wildlife and U.S. Department of Agriculture, written communication). Although the preceding methods pertain to the control of goose populations, many of the methods may also work for other waterfowl and gulls.

Although many people enjoy feeding waterfowl, feeding waterfowl is illegal in the state of Rhode Island and may cause large numbers of geese to congregate in unnatural concentrations. Well-fed domestic waterfowl, often act as decoys, attracting wild birds to the site. Geese that depend on supplemental feeding are also less likely to migrate when winter arrives. Some success in reducing goose feeding may be achieved through simple public education such as “Do not feed the geese” signs (the Division of Fish & Wildlife will provide examples on request). Further reduction of feeding may require the adoption and enforcement of local ordinances such as fines or community service (cleaning up droppings for example) for violations.

Geese are grazing birds that prefer short, green grass or other herbaceous vegetation for feeding. Well-manicured lawns adjacent to the shoreline provide excellent habitat for these grazing birds. Wherever possible, grass should be allowed to grow to its full height (10-14 in.) around waterbodies. Lawn areas immediately adjacent to the shoreline of the pond may be allowed to revegetate naturally to discourage the congregation of waterfowl. In addition to discontinuing mowing next to the pond, the installation of a buffer of native vegetation is recommended to further discourage waterfowl and to limit the establishment of invasive plant species.

Fencing or other physical barriers installed along the shoreline can be effective where geese tend to land on water and walk up to adjacent lawns to feed. Fencing works best when geese are in their summer molt and unable to fly. Fences must completely enclose a site to be effective. Goose fences should be at least 30 inches tall. Wire garden fencing will last for years. The installation of any fencing adjacent to a pond may require a permit from the Wetlands Permitting office of RIDEM.

Hunting is an option that can help slow the growth of resident goose flocks because it removes some birds and discourages others from returning to problem areas. It also increases the effectiveness of noisemakers, because geese will learn that loud noises may be a real threat to their survival. Canada goose hunting is permitted statewide in Rhode Island during a special September resident goose season, when very few migratory geese from Canada are present. Hunting is allowed also during a regulated fall-winter season but regulations tend to be more restrictive to protect migratory geese that may be in the state at that time. Landowners concerned about potential conflicts can easily limit the number of hunters and times they allow hunting on their property. For more information about goose hunting regulations or setting up a controlled hunt, contact DFW. (RIDEM 2007)

The control of goose nesting and the capture and removal of geese are two other methods that could be used to reduce excessive goose populations on lakes and ponds. Both activities require federal permits and may only be applied after it has been demonstrated that all non-lethal and long-term options are in place. Removal of wildlife should not be considered until every effort to deter use is made. The Division of Fish & Wildlife of RIDEM should be contacted if this method is being considered. Without efforts to reduce nuisance waterfowl populations, non-lethal methods of control may just shift the populations and their associated negative water quality impacts to other waterbodies. The involvement of the town working with property owners, and the Division of Fish & Wildlife and USDA Wildlife Services may be necessary to develop a more comprehensive and publicly acceptable strategy.

5.3 Internal Phosphorus Control

Consideration should be given to reducing the flux of phosphorus out of the sediment into the water column, particularly if the pond is to be used as a water supply in the future Three general approaches may be employed. Each has its advantages and drawbacks. Dredging the bottom of the pond would permanently remove the phosphorus-laden sediments and would increase the capacity of the pond to some extent. This method can be expensive considering the equipment needed, the remoteness of Block Island and the limited disposal options for the sediments. The next option, hypolimnetic aeration/oxygenation treats anoxic phosphorus release only and depends on iron availability to bind phosphorus and iron may not be inactivated itself in highly polluted sediments. Aeration techniques however have no lasting effect and once the source of air is shut off the internal loading will return. The last option is the application of a capping material that would prevent exposure of the existing, high phosphorus-laden sediments to anoxic conditions, and the ultimate release of phosphorus to the water column. The application of alum, which settles to the bottom, forming a layer over the contaminated sediments limiting their exposure, has been successful in other lakes and ponds that have exhibited similar eutrophic conditions (Cooke et al, 1986). Consideration of the pond's chemistry at the time of this application must be known to insure the proper application rate and chemistry. While first year costs for alum and aeration/oxygenation are similar (~$1,000-$3000/hectare), alum cost is only one-tenth as much when spread over ten years. The Block Island Water Company and the town should seek advice from a professional consultant with experience in the control of phosphorus release from pond sediments be hired to specifically address this source. The consultant should confirm the significance of internal cycling as a source of phosphorus to the pond, and secondly, evaluate the most effective and feasible BMPs to control phosphorus release from the sediment. Lastly, many BMPs used to control the release of internal phosphorus may have undesirable effects on the waterbody if not properly conducted and therefore the consultant should also be retained to oversee implementation of the selected BMPs. As part of this study, RIDEM hired Environmental Science Services, Inc. (ESS) to determine the quantity and quality of sediments in Sands Pond and to create an updated bathymetric map. All water and sediment sampling occurred on March 15, 2002. ESS found that the total Phosphorus and total Kjeldahl nitrogen values measured in Sands Pond sediment are both more than twice the upper threshold level as defined by the Great Lakes Sediment Quality Criteria and therefore indicate that these nutrients are present in concentrations that would characterize the sediments as "severely polluted". (ESS, 2002) ESS developed a few solutions to this problem such as dredging, pond bottom inversion, liner installation, or alum treatment. ESS suggests a whole pond alum treatment would be beneficial in reducing algal blooms and the formation of algal mats. The estimated total treatment cost is between $35,000 and $42,000, which would last at least five years. More information about the ESS study can be found in the Addendum.

The main concern of Block Island residents is the water level of Sands Pond. Since the New Shoreham Water District ceased using Sands Pond for water supply, the pond's water elevation has risen. To alleviate this issue, the town has applied for and received a permit to pump water from the pond and to discharge it off shore. To date, the Town has not pumped water from the pond – due to difficulties in meeting the treatment requirements imposed by RIDEM – with the pumping system as currently designed. Should the Town decide to pursue this option, consideration should be given to withdrawing from the pond's bottom waters to remove the higher phosphorus concentration waters from the pond.

6.0 PUBLIC PARTICIPATION

The public participation portion of this TMDL includes public meetings and a public review and comment period. Several preliminary meetings with town and water company personnel were conducted in order to obtain an understanding of the history of the pond and how the historical use of the pond has affected water quality. During the monitoring phase of the project, the local press published articles describing the process of the TMDL.

A public meeting was held on December 13, 2007, with the New Shoreham Water Board and Block Island Town Council at the Old Harbor Community Center. The Sands Pond TMDL was presented and all comments and concerns were incorporated into this TMDL. An article was also published in "The Block Island Times" to discuss the meeting.

Letters were sent to Sands Pond stakeholders informing them the draft TMDL was available for public review and comment. The document was made available at the Island Free Library on Dodge Street and at the New Shoreham Town Hall on Old Town Road. The document and the powerpoint presentation from the December 13, 2007 public meeting were also available online at the RIDEM website.

7.0 FOLLOW UP MONITORING

This TMDL relies upon phased implementation to reach water quality goals. As remedial measures are implemented, the corresponding response in total phosphorus concentrations will be measured. If standards are not met after the recommended remedial measures are implemented, the need for additional measures will be assessed, as appropriate.

Additional monitoring is required to ensure that water quality objectives are being met. Periodic monitoring of raw pond water by BIWC for compliance with applicable drinking water regulations is required. Monitoring will include ongoing monitoring of the pond at stations SP-1 and SP-3 for Secchi depth, and surface and bottom turbidity, temperature, dissolved oxygen, and Total Phosphorus. Shoreline surveys and similar capacity analysis by RIDOH personnel should also continue in order to maintain a continuity of monitoring results and provide additional data to assess the effectiveness of the recommendations contained in this TMDL.

The formation of a local watershed group is encouraged to develop a monitoring plan to supply long term data relating to turbidity, algae abundance and Secchi depth. These relatively simple tasks could provide valuable information to all parties for future study of the water quality conditions as the pond matures naturally and to how it responds to treatment.

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9.0 ADDENDUM

ESS Environmental Science Services, Inc.
Sediment Quality Assessment- Sands Pond, Block Island
ESS Job Number R297

ESS ENVIRONMENTAL SCIENCE SERVICES, INC.
ENVIRONMENTAL SCIENTISTS, ENGINEERS, AND PLANNERS

April 17, 2002

Ms. Cindy Hannus
State of Rhode Island
Department of Environmental Management
235 Promenade Street
Providence, Rhode Island 02908

Re: Sediment Quality Assessment - Sands Pond, Block Island
ESS Job Number R297

Dear Cindy:

Thank you for selecting Environmental Science Services, Inc. (ESS) to assist the Rhode Island Department of Environmental Management (RIDEM) with assessing the sediment quality of Sands Pond, Block Island. As you are aware, this assessment was initiated in order to determine the quantity and quality of sediments in Sands Pond and create an updated bathymetric map. Specifically, the ESS investigation was conducted in order to verify whether the internal cycling of nutrients (total phosphorus, total Kjeldahl nitrogen) trapped in the bottom sediments are contributing to the documented water quality problems of Sands Pond. This assessment provides RIDEM with general management recommendations along with associated cost estimates for improving conditions in the pond.

All water and sediment sampling occurred on March 15, 2002. Results of the sediment sampling and subsequent laboratory analysis are presented in Table 1. Area and volume calculations for water and sediments are summarized in Tables 2 and 3, respectively. A bathymetric map, sediment depth contour map, and sediment sampling location map are depicted in Figures 1, 2, and 3, respectively. In order to assess sediment quality, results from laboratory analyses (total phosphorus and total Kjeldahl nitrogen) were compared to applicable sediment quality guidelines (USEPA, 1977[1]). Sediment acquired from sampling sites was defined as impaired when any of the measured sediment quality parameters were found to exceed the guideline thresholds.

Physically, the sediments of Sands Pond are characteristic of many freshwater ponds throughout New England. That is, the sediments are very mucky (large % moisture values) and are composed primarily of inorganic fine sands and silts.

Total phosphorus and total Kjeldahl nitrogen were measured to assess the nutrient status of the pond sediment. Excessive levels of these nutrients often result in excessive aquatic plant growths or algal blooms, which are considered "classic" symptoms of cultural eutrophication. The total phosphorus and total Kjeldahl nitrogen values measured in the Sands Pond sediment are both more than twice the upper threshold level as defined by the Great Lakes Sediment

[1] USEPA, 1977. Guidelines for the pollution classification of Great Ponds harbor sediments. USEPA Region I. Chicago, IL.

888 Worcester Street, Suite 240
Wellesley, Massachusetts 02482
Telephone: (781) 431-0500 Facsimile: (781) 431-7434

401 Wampanoag Trail, Suite 400
East Providence, Rhode Island 02915
Telephone: (401) 434-5560 Facsimile: (401) 434-8158
www.essgroup.com

90 Route 6A, Unit 4B
Sandwich, Massachusetts 02563
Telephone: (508) 833-6226 Facsimile: (508) 833-9687

Quality Criteria (USEPA, 1977) and therefore indicate that these nutrients are present in concentrations that would characterize the sediments as "severely polluted."

Bathymetric measurements were performed using a combination of sonar and graduated peat probe. Measurements revealed a maximum water depth of 13.8 feet located in the northern portion of the pond basin and a mean depth of 7.1 feet. Depths of this magnitude, coupled with the absence of defined inlets and outlets to the pond, foster a setting, which would be sufficient to promote anoxic (oxygen-depleted) conditions in the hypolimnion (bottom waters) during the summer growing season (generally the time when oxygen demand is greatest).

Sediment depths were recorded through the use of the graduated peat probe at most locations in which water depth was recorded. In a few instances the depth of water plus sediment exceeded the length of the 16-foot probe, consequently, sediment depths were documented as minimum sediment depths at these locations.

Sediment area and volume calculations that were developed from the sediment depth contours (Table 3) revealed a maximum sediment depth of 8 feet and a mean sediment depth of 3.5 feet within the pond basin. Total volume of sediment in the pond was calculated to be in excess of 83,000 cubic yards. This estimate of sediment volume for Sands Pond is a conservative estimate due to the fact that in several locations sediment depth was greater than the maximum length of the sediment depth probe and therefore, could not be precisely determined.

Summary and Management Recommendations

Concentrations of both total phosphorus and total Kjeldahl nitrogen in the sediments represent a "severely polluted" condition (EPA, 1977). These data, in combination with the expected oxygen depletion in the hypolimnion, are likely to create conditions, which would promote the growth of nuisance aquatic vegetation. Under anoxic conditions, sediment bound nutrients may be liberated from the soil matrix and become distributed into the water column making them available for phytoplankton uptake. Under ideal growing conditions, it would be expected that the phytoplankton could develop into a nuisance algal bloom. It is also likely that the nutrient rich sediment could contribute to the formation of floating algal mats. Filamentous algae would be expected to grow along the pond's bottom, sequestering nutrients at the sediment-water interface until gas bubbles (generated during photosynthesis) become trapped among the filaments. Once enough bubbles become trapped, the entire mat then floats to the surface where it can impair water quality and result in foul odors as it begins to decay.

Solutions to this problem are somewhat limited, particularly for the Sands Pond system. Based on this preliminary survey, cost estimates for the dredging of Sands Pond would be expected to range between $1.5 million and $2 million for the entire sediment volume. Given other alternatives available, dredging would not be deemed the most economical or environmentally appropriate solution unless other management actions yield unsatisfactory results.

Currently, research is being conducted on an experimental process known as pond-bottom inversion in several New England ponds. Pond-bottom inversion is a technique by which cleaner material underlying the phosphorus rich upper sediment is brought up and spread over the upper material. This technique has yet to be proven effective and has not yet been shown to be more economical or less environmentally disruptive than hydraulic dredging.

A third possible alternative could be to cover the bottom sediments to sequester them from the water column. The addition of sand or clay or the installation of a liner would accomplish this. The addition of any bulky material would result in the loss of water depth, which is already a problem in the pond. Use of a synthetic liner would cost approximately $1.20/sq. ft., or more than $750,000 for Sands Pond. In addition to the financial implications, billowing gas build up could be a technical problem.

Finally, it may be possible to perform an alum treatment at the pond whereby an aluminum based compound is applied to the pond at a level that blankets the pond bottom. Alum binds to phosphorus and, if applied correctly, essentially seals the phosphorus rich sediments below it. Since the current rate of sediment deposition is expected to be relatively low and the pond's flushing rate is lower than that of a typical tributary fed system, it would be reasonable to expect the alum treatment to be an effective solution for at least five years, possibly longer, assuming that the filter backwash activity has ceased and that the pond has a detention time in excess of one year. It should also be noted that alum treatments are deemed to be safe and are regularly conducted in primary water supply systems without resulting in a disruption of service.

A whole pond alum treatment would be beneficial in reducing algal blooms and the formation of algal mats. Such a treatment could be performed at Sands Pond at a cost of between $2,500/acre to $3,000/acre resulting in a total treatment cost of between $35,000 and $42,000. Alum treatment should only be performed after a "jar" testing study has been completed using water from Sands Pond. The jar test is performed to determine the most appropriate aluminum compound to use and to determine the most appropriate dose and application rate. In addition, alum treatments must only be implemented with a comprehensive in-pond monitoring program on the day of treatment to ensure that the pH and alkalinity of the pond are maintained. A jar test study and the associated in-pond monitoring program could be performed for a cost of approximately $12,000.

If you should have any questions on this matter, please feel free to contact the undersigned at any time.

Sincerely,

ENVIRONMENTAL SCIENCE SERVICES, INC.

Carl D. Nielsen
Senior Water Resources Scientist

George B. Landman
Environmental Scientist

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Table 1. Laboratory sediment quality data for Sands Pond, Block Island.

Sediment samples collected on March 15, 2002.

Sampling locations are illustrated in Figure 3.

Parameter	Units	Results	Detection Limits
Total Solids	%	23.0	0.1
Total Phosphorus	mg/Kg	1300.0	28.0
Total Kjeldahl Nitrogen	mg/Kg	4200.0	260.0
Percent Water	%	77.0	0.1
Percent Organic Content	%	3.4	0.1

888 Worcester Street, Suite 240
Wellesley, Massachusetts 02482
Telephone: (781) 431-0500 Facsimile: (781) 431-7434

401 Wampanoag Trail, Suite 400
East Providence, Rhode Island 02915
Telephone: (401) 434-5560 Facsimile: (401) 434-8158

90 Route 6A, Unit 4B
Sandwich, Massachusetts 02563
Telephone: (508) 833-6226 Facsimile: (508) 833-9687

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Table 2. Area and volume calculations from bathymetric contours of Sands Pond, Block Island.

Bathymetry data was collected on March 15, 2002.

Depth Contour (feet below water level)	Area (sq. ft.)	Avg. Area (sq. ft.)	Incremental Volume (cu. ft.)	Cumulative Volume (cu. ft.)
13.8	0			
12.0	21,863	10,932	19,677	19,677
10.0	107,525	64,694	129,388	149,065
8.0	269,112	188,319	376,637	525,702
6.0	419,965	344,539	689,077	1,214,779
4.0	534,448	477,207	954,413	2,169,192
2.0	600,234	567,341	1,134,682	3,303,874
0.0	637,400	618,817	1,237,634	**4,541,508**

Total water volume in Sands Pond = 4,541,508 cu. ft.

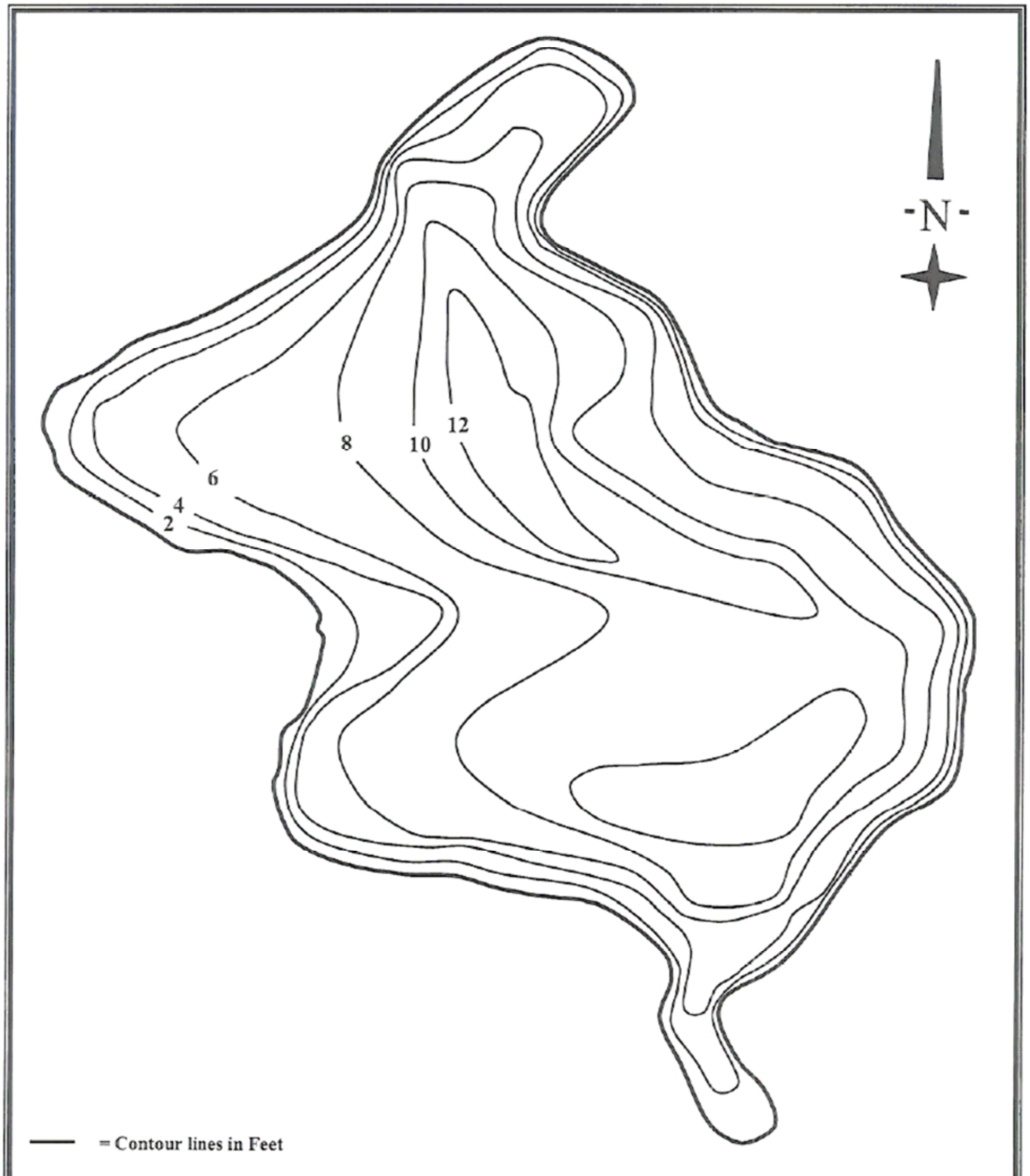
Mean Depth = 7.1 ft

888 Worcester Street, Suite 240
Wellesley, Massachusetts 02482
Telephone: (781) 431-0500 Facsimile: (781) 431-7434

401 Wampanoag Trail, Suite 400
East Providence, Rhode Island 02915
Telephone: (401) 434-5560 Facsimile: (401) 434-8158

90 Route 6A, Unit 4B
Sandwich, Massachusetts 02563
Telephone: (508) 833-6226 Facsimile: (508) 833-9687

www.essgroup.com



1" = 160 F:

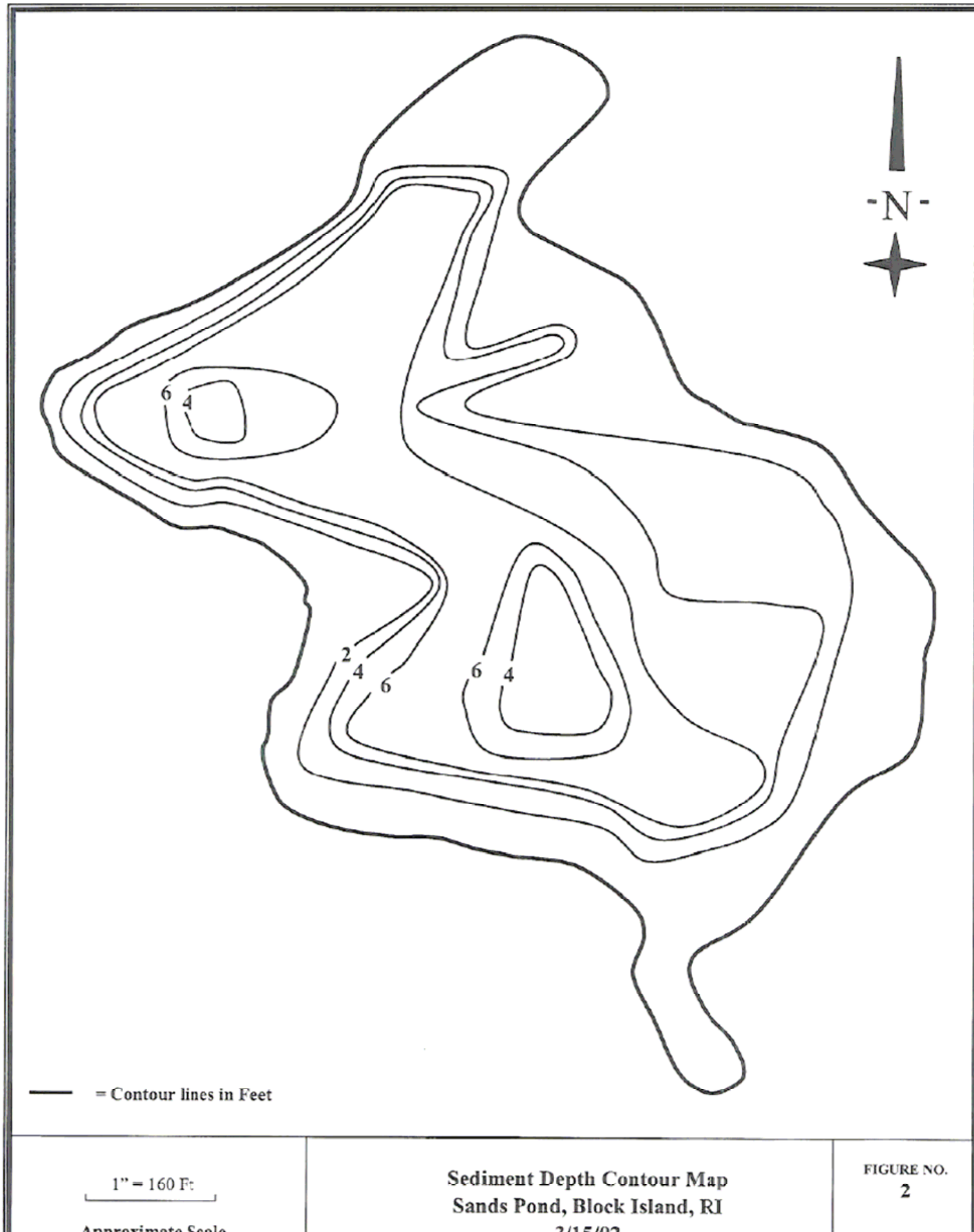
Approximate Scale

Bathymetric Map
Sands Pond, Block Island, RI
3/15/02

FIGURE NO.
1

PROJECT NO.
R297-000

ESS
J:\Sand Pond\Water bathymetry

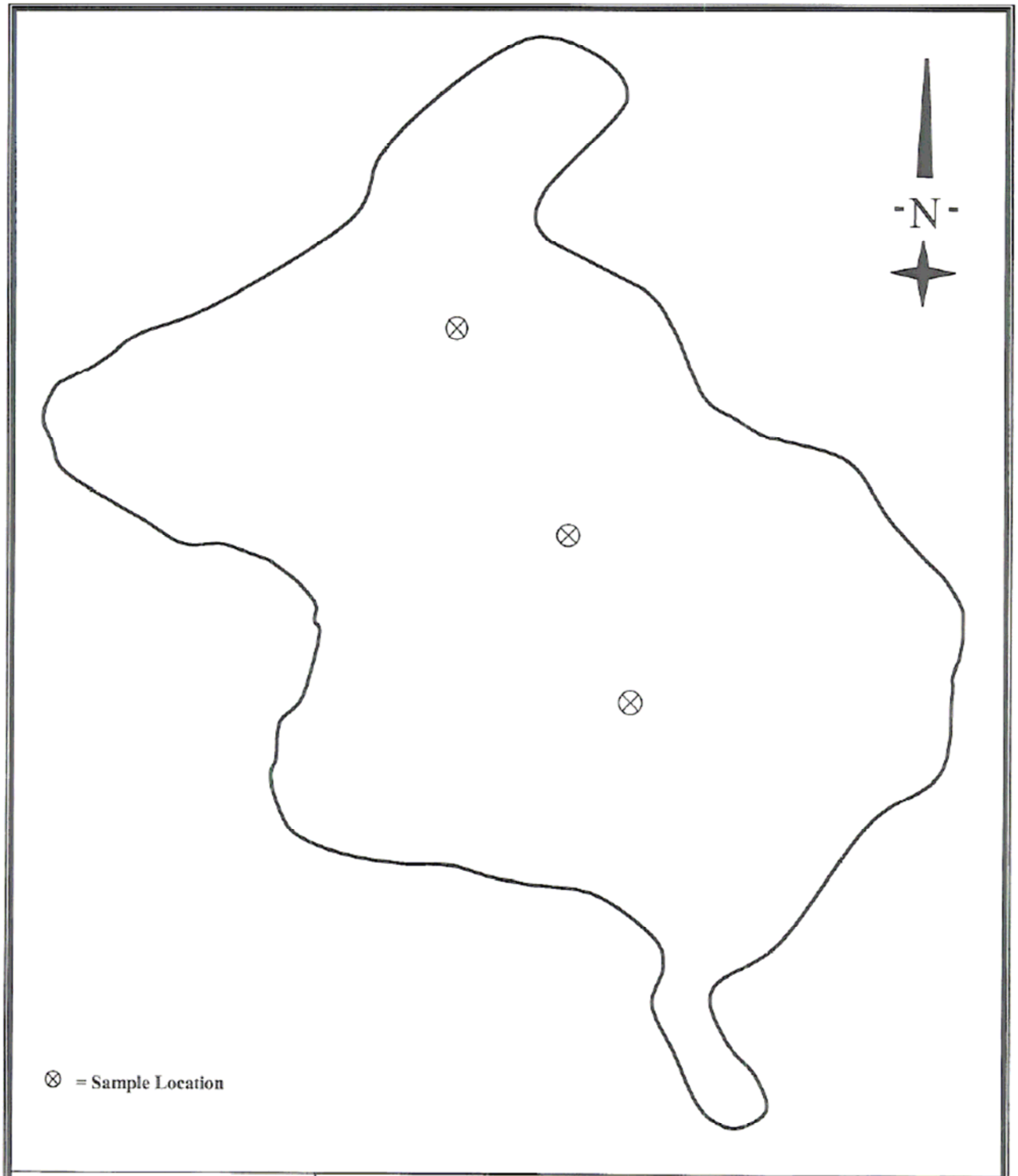


Sediment Depth Contour Map
Sands Pond, Block Island, RI
3/15/02

FIGURE NO.
2

PROJECT NO.
R297-000

ESS
J:\Sand Pond\Sediment bathymetry



1" = 160 Ft Approximate Scale	**Sediment Sampling Locations** **Sands Pond, Block Island, RI** **3/15/02**	**FIGURE NO.** **3** PROJECT NO. R297-000

ESS

J:\Sand pond\Sediment sampling locations

APPENDIX A

Response to Comment Documents

Comments from Steve Winnett, US EPA

Thank you for the opportunity to review and comment on the Department's DRAFT total phosphorus TMDL For Sands Pond, New Shoreham. Here are EPA Region 1's comments on it.

Major comment:

On page 24 of the text, at the bottom of the page, DEM references the presence of horses on the pond's shore, and that they are a potential source of contamination. EPA strongly agrees and suggests that leaving out a further characterization of this source (how many horses, how much of the year, how much manure disposed of how close to the pond, etc.) and the phosphorus source it represents may be underestimating the loading term for the pond. Horses can be a significant source of both nutrient and bacteria pollution. Considering the inclusion in the TMDL loading of relatively minor sources of phosphorus, such as atmospheric deposition and groundwater flow, and the significance of the other animal source (waterfowl) to the total load (81%), horses may be another important and significant source.

EPA suggests that this source be further investigated before the TMDL is finalized. If not, DEM should explain why this source is not being further investigated and characterized, and why RIDEM believes it is not a significant source. Currently, its exclusion stands out as a red flag.

RIDEM Response:
There are one to three horses located on a property on the eastern shore of Sands Pond. The horses are used during the tourist season for horse back riding. They are not on the property all the time nor are they stabled there all year round. The horses do not have direct access to the water, there is an approximate 10-foot buffer separating the horses from the pond. An investigation has found that there is no pile of manure being degraded on the property next to Sands Pond. The RIDEM does not believe the horses are a significant source of phosphorus to the pond.

Other comments:

* EPA notes that DEM is assuming that sources and sinks are balanced on an annual basis, and that the concentration of phosphorus is constant. Is there evidence or data to support that assumption, and that the concentration is not changing from year to year?

RIDEM Response:
The sample collection for Sands Pond occurred during one year, therefore there is no data to support the assumption that the sources and sinks are balanced on an annual basis. The RIDEM's assumption is based upon the following: There are no tributaries into or outlet from Sands Pond, and since the pond is no longer used as a source of drinking water, there is no withdrawal or return flow of filter backwash. The annual load of phosphorus to the pond is estimated to be relatively small and the sources, all nonpoint in nature, are attributable to groundwater inflow,

atmospheric deposition, and waterfowl. The phosphorus concentration is expected to fluctuate throughout the year depending upon loss to the sediment, algae/plant uptake, and internal mixing of the water column. Given that the annual load is so small, likely distributed throughout the year, and from diffuse sources, RIDEM believes the sources and the sinks are balanced annually.

* On page 32, RI DEM states, "…external sources for the most part are not related to human activities around the pond and are considered to be due to natural background causes." On page 26, RI DEM makes a similar statement in Section 3.3.6, Natural Background Condition. EPA suggests DEM reconsider or clarify this statement. Resident Canada geese populations are not natural background conditions, and are generally caused by human activities around water bodies, such as mowed lawns and the cutting of riparian vegetation, neither of which is a natural condition. Otherwise, the geese remain migratory. With longer grasses and vegetation, and tall riparian vegetation, colonization by Canada geese is very much reduced or eliminated. If the geese reside there despite more natural conditions, RI DEM should explain that. The septic systems which are the basis for the groundwater sources are also not a natural condition. EPA agrees that atmospheric deposition, while caused by human activity, is not caused by human activity around the pond.

RIDEM Response:
RIDEM has deleted the statement on page 26: "The non-point sources are those that occur naturally or are part of the existing background conditions."
And added the statement: "The natural background conditions are incorporated into the non-point source loading."

Although increases in the resident Canada geese population are generally attributable to human interference including the alteration of habitat associated with removal of riparian buffers, in the case of Sands Pond, the shoreline is mostly vegetated. The majority of the exposed shoreline exists at the Block Island Water Company property with approximately 75 feet exposed. The remainder of the pond is mostly protected with a substantial riparian buffer. RIDEM believes the increase in resident geese at Sands Pond coincides with the increased population statewide (and in the Northeast for that matter) and that Sands Pond is a refuge for the geese from inclement weather.

On page 32, the following statement has been added: **"**The resident Canada Goose population has been increasing statewide and Sands Pond has become a refuge for the geese from inclement weather."

* The derivation of the TMDL load of 3.9 kg/yr could be better explained. Specifically, the derivation of the LA of 4.34 kg/yr is not explained. One can surmise that the required reduction by 30% of the existing concentration 35.5 ug/l to the target of 25 ug/l was applied to the existing load of 6.2 kg/yr to get the LA of 4.34 kg/yr, but it should be laid out specifically for clarity. Also, should the MOS be 0.43, (rather than 0.44) as 10% of the LA? On a minor note, the LA is shown as 4.33 in the middle of page 30, and 4.34 elsewhere on the page.

RIDEM Response:
The paragraph from page 29 (see below) has been clarified to better explain the derivation of the TMDL load of 3.9 kg/yr and the LA of 4.33 kg/yr:

> The existing external load to the pond (6.2 kg/yr) includes groundwater inputs (0.38 kg/yr), atmospheric deposition (0.82 kg/yr), and waterfowl (5.0 kg/yr), and is incorporated into the nonpoint source loadings. The balance between the current external loads and the net settling to the bottom results in an annual mean water column concentration of 35.5 ug/l. The TMDL objective is to reduce this concentration to less than 25 ug/l, with an explicit MOS corresponding to a 10% reduction of the allowable load incorporated. Given the linear relationship between loads and water column concentration, this corresponds to a mean TP concentration of 22.5 ug/l for the pond. The existing external load will need to decrease from 6.2 kg/yr to an annual load of 3.9 kg/yr to meet the TMDL objective of reducing the TP concentration to less than 22.5 ug/l.

Also, the MOS should be 0.43 and this has been changed, the LA has also been changed to 4.33 consistently throughout the report.