PLANNING ASSISTANCE TO STATES

TURNER RESERVOIR STUDY
EAST PROVIDENCE, RHODE ISLAND

February 2001

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The U.S. Army Corps of Engineers conducted an investigation of Turner Reservoir in East Providence, Rhode Island in order to determine its potential as a recreational area and a back-up water supply for the City of East Providence. In addition, the Corps of Engineers performed a preliminary groundwater investigation to determine the feasibility of potentially using the now abandoned Central Pond well field as a back-up water supply. Our preliminary investigation found that the Turner Reservoir and Central Pond Well fields may be suitable for a back-up water supply; however, both water supply alternatives will require thorough treatment of the water. Based on the Corps preliminary findings, treatment of water for the Turner Reservoir or Central Pond Well Fields could be an expensive procedure. Comprehensive treatment of the Turner Reservoir will be required for the following reasons: the presence of heavy aquatic plant growth, potential for coliform bacteria and elevated levels of contaminants, particularly cadmium in sediments. Similarly, to improve the esthetic qualities of the groundwater from the Central Pond well fields will require the use of water treatment methods. In particular, besides improving the taste and odor, treatment will remove the high levels of iron and manganese present in the water. Although the water's appearance is not attractive, the Corps of Engineers' investigation did not find any water quality problems that would prohibit using the Turner Reservoir for recreation use, such as swimming. Turner Reservoir appears to support a good largemouth bass population, which could provide a recreational warmwater fishery.

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Executive Summary

The U.S. Army Corps of Engineers conducted an investigation of Turner Reservoir in East Providence, Rhode Island in order to determine its potential as a recreational area and a back-up water supply for the City of East Providence. In addition, the Corps of Engineers performed a preliminary groundwater investigation to determine the feasibility of potentially using the now abandoned Central Pond well field as a back-up water supply. Prior to 1969, East Providence obtained its municipal water supply from the Turner Reservoir and from four groundwater wells located in the Ten Mile River Aquifer. In 1982, a proposal to utilize the Turner Reservoir as a water supply was rejected because Turner Reservoir was considered an unsafe water supply due to upstream discharges into the Ten Mile River that flow into Turner Reservoir. The present investigation focuses on providing a preliminary determination of the suitability of Turner Reservoir and the Central Pond Well Fields based on the following criteria: Water Quality, Fisheries and Fish Tissue Analyses, Sediment Analyses and Groundwater analyses for the Central Pond Well Fields.

Based on the above criteria, the Corps of Engineers recommends that if the City seeks to pursue the potential use of the Turner Reservoir or the Central Pond Well Field as a backup water supply, further studies should be undertaken. Our preliminary investigation found that the Turner Reservoir and Central Pond Well fields may be suitable for a back-up water supply; however, both water supply alternatives will require thorough treatment of the water. The City of East Providence will need to gather additional sampling data and conduct further investigation to determine the level of required treatment and the resulting costs. Based on the Corps preliminary findings, treatment of water for the Turner Reservoir or Central Pond Well Fields could be an expensive procedure. Comprehensive treatment of the Turner Reservoir will be required for the following reasons: the presence of heavy aquatic plant growth, potential for coliform bacteria and elevated levels of contaminants, particularly cadmium in sediments. Similarly, to improve the esthetic qualities of the groundwater from the Central Pond well fields will require the use of water treatment methods. In particular, besides improving the taste and odor, treatment will remove the high levels of iron and manganese present in the water.

Although the water's appearance is not attractive, the Corps of Engineers' investigation did not find any water quality problems that would prohibit using the Turner Reservoir for recreation use, such as swimming. Turner Reservoir appears to support a good largemouth bass population, which will provide a recreational warmwater fishery. The Corps of Engineers found concentrations of methyl mercury in largemouth bass tissue composites that were below Food and Drug Administration (FDA) action levels, but above some of the United States Environmental Protection Agency (EPA) health risk levels for consumption. Consequently, it behooves the City of East Providence to have the results of the fish tissue data reviewed by the State Department of Health in order to determine if further study and/or health advisories should be initiated. The Corps of Engineers also found concentrations of most metals from sediment samples exceeded state cleanup levels. The City of East Providence should forward the metal concentration data to the Rhode Island Department of Environmental Management (RIDEM) for further evaluation.

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Planning Assistance to States
Turner Reservoir Study
East Providence, Rhode Island

I. Introduction

A. Background

Prior to 1969, the city of East Providence obtained its municipal water supply from the Turner Reservoir and from four groundwater wells located in the vicinity of Central Pond on the Ten Mile River. In order to protect this water supply, the City acquired approximately 270 acres of land in the surrounding watershed. The City's landholdings are located within East Providence, and also in the city of Pawtucket, Rhode Island and the town of Seekonk, Massachusetts. The surface area of the Turner Reservoir comprises approximately 225 acres. The City currently purchases water from the Providence Water supply Board; however, the City's Water Supply Management Plan indicated the City's commitment to looking at the economic feasibility of using the Turner Reservoir and the Central Pond wellfield as alternative sources of water supply.

The Turner Reservoir/Central Pond complex has been identified as a critical area of concern and is addressed in the City's 1992 Comprehensive Plan. The City's plan outlines conservation strategies to preserve open space adjacent to the water bodies and to open the area to passive recreation through the development of the Ten Mile River Greenway. The plan also identifies strategies to minimize the environmental impact of non-residential development and redevelopment within the area.

The purpose of this Planning Assistance to States study is to provide an analysis which will assist in the evaluation of Turner Reservoir and the Central Pond wellfields as the City's long term back-up water supply. The study will also discuss the suitability of permitting recreation use at Turner Reservoir.

B. Authority

The study was conducted by the New England District (NAE), U.S. Army Corps of Engineers, Engineering/Planning Division, Planning Branch, Special Studies Section for the city of East Providence, Rhode Island. The study was funded under the authority provided by the Corps of Engineers Planning Assistance to States (PAS) program (Section 22, WRDA 1974, Public Law 93-251). Under the PAS program, the study is cost shared 50/50 between the local sponsor, the city of East Providence, and the Federal government, the U.S. Army Corps of Engineers. A cost sharing agreement was executed on April 16, 1999.

C. Project Study Area and History

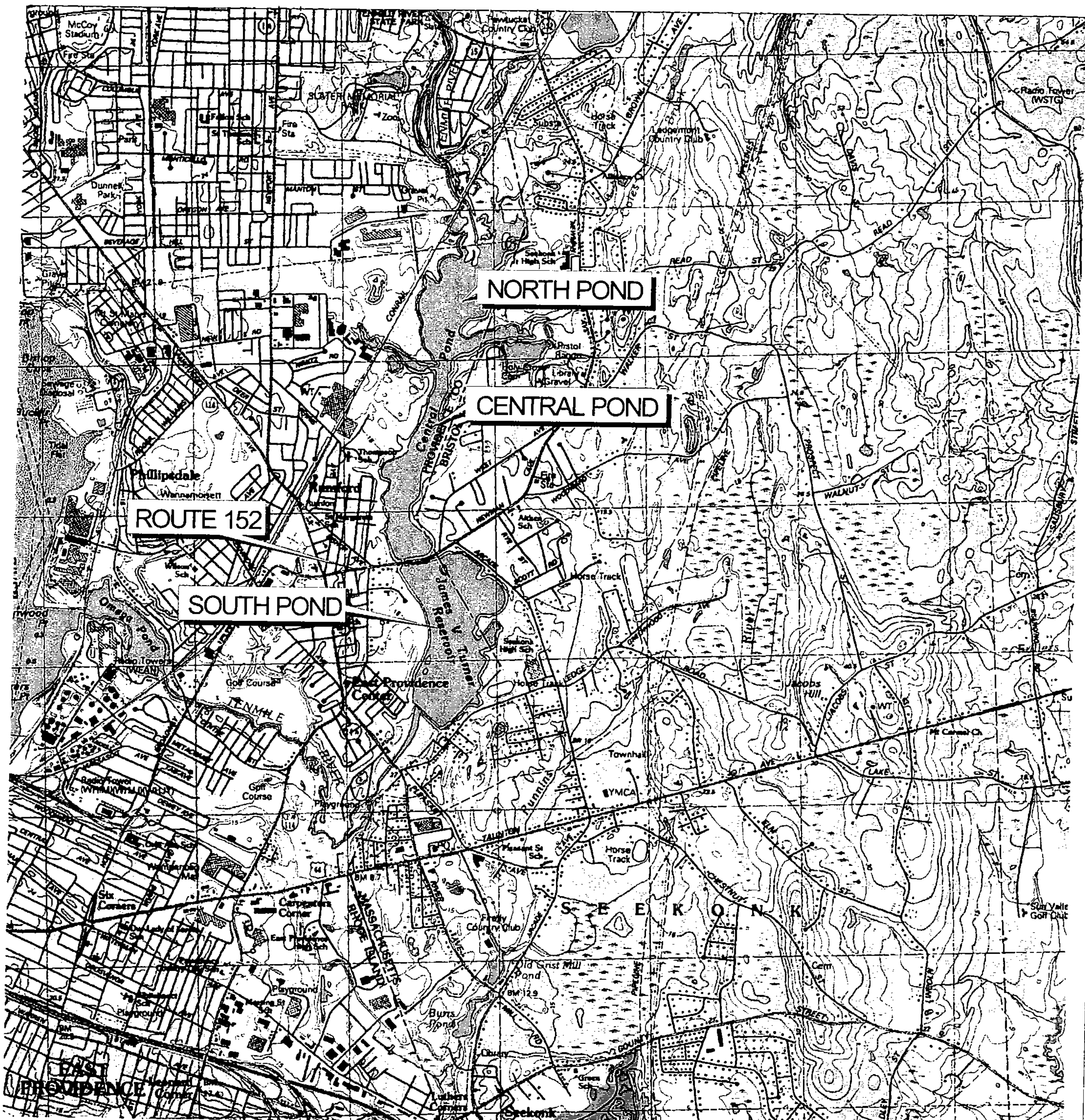
The study area is located in the city of East Providence on the Massachusetts-Rhode Island border with parts of the reservoir area extending into Seekonk, Massachusetts (see Figure 1). The James V. Turner Reservoir consists of a series of three (3) ponds with a combined surface area of 225 acres and is located at the end of the freshwater section of the Ten Mile River. The three ponds are individually named North, Central, and South Pond, but collectively known as Turner Reservoir. Below Turner Dam, at the south end of South Pond, the Ten Mile River flows about two miles to the Providence River. Total drainage area at the dam is 52.1 square miles.

Between 50 years and 100 years ago, a dam was constructed on the Ten-Mile River approximately 100 feet upstream from what is now Route 152 presumably to provide waterpower for a local mill. The resulting one-mile long impoundment is the area now known as Central and North Ponds, and consisted of approximately 100 acres of artificial lake. In 1930, another dam was constructed approximately 0.75 miles downstream from the original milldam as a water supply for the city of East Providence. The weir elevation of this new dam (Turner Reservoir Dam) was approximately 5 feet higher than that of the milldam upstream. The resulting impoundment was known as Turner Reservoir, and consisted primarily of the flooded pasture/wetland immediately downstream from the milldam (i.e. Route 152). It also included the upstream areas of Central and North Ponds, due to the higher weir elevation of the new dam, which raised the impoundment surface elevation above the previous level of Central/North Pond (i.e. overtopping the milldam). This formed the existing Turner Reservoir Central/North Pond complex. The remains of the mill dam (i.e. the water control structures) can be seen upstream from Route 152, and the weir still stands approximately 5 feet below the existing water surface.

During the period following the construction of the dam to 1969, Turner Reservoir was used as a water supply for the City of East Providence. It was discontinued due to odor and other aesthetic water quality problems. It is currently used for recreational fishing and boating.

D. Study Objectives

This study investigates the potential of Turner Reservoir to serve as a future back up water supply for the City of East Providence, Rhode Island. Turner Reservoir was used as a water supply up until 1969. In 1982, Turner Reservoir was identified as a proposed water supply; however, the proposal was rejected because Turner Reservoir was considered unsafe due to upstream industrial discharges into the Ten Mile River that flow into the Turner Reservoir. This study provides a preliminary investigation into the suitability of Turner Reservoir and the Central Pond Well field as a back-up water supply. In addition, this study discusses the suitability of Turner Reservoir for recreational purposes.



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VICINITY MAP

Section 22 Planning Assistance to States
Turner Reservoir Study
East Providence, Rhode Island

January 2001 | FIGURE 1

II. Methodology

The Corps of Engineers and city of East Providence agreed at the beginning of the investigation that evaluating the suitability of Turner Reservoir and the Central Pond Well field as a water supply source would require a phased approach. The present investigation focuses on the preliminary phase of determining the suitability of Turner Reservoir, using the following information:

- Determine the water quality of Turner Reservoir.

- Perform a fisheries investigation of the Turner Reservoir, which consists of collecting fish samples and analyzing a representative sampling of fish tissue.

- Collect and analyze sediment samples for Turner Reservoir.

- Collect groundwater data for Central Pond Well field.

- Discuss the suitability for recreational purposes.

The study will recommend any further testing that may be needed. The City will use the information and recommendations developed in their subsequent evaluation of these sites as back-up water supplies.

III. Findings

A. Water Quality Analysis

1. <u>Summary of Findings for Water Quality Analysis</u>. Although the water's appearance is not attractive, with large amounts of aquatic weeds and a number of waterfowl present at the site, Corps investigations did not find any water quality problems that would prohibit using Turner Reservoir for recreation, including swimming, or for public water supply. Before being used for water supply; however, the water would have to be thoroughly treated, and this could be expensive.

2. <u>Background</u>. Prior to 1969, the city of East Providence obtained its municipal water supply from Turner Reservoir and four groundwater wells in the vicinity of Central Pond on the Ten Mile River. Although East Providence currently gets its water from Scituate Reservoir, the city's Water Supply Management Plan includes investigating the economic feasibility of using Turner Reservoir and the Central Pond well field as alternative water supply sources. The purpose of this Planning Assistance to States study was to provide analysis that will assist in the evaluation of Turner Reservoir and the Central Pond well field for use as long-term backup water supply. The study also looked at the suitability of recreation at Turner Reservoir.

3. Reservoir Description. James V. Turner Reservoir is located in East Providence on the Massachusetts-Rhode Island line, with parts of the reservoir extending into Seekonk, Massachusetts (See Figure 1). It consists of a series of 3 ponds with a combined surface area of 225 acres, located at the end of the freshwater section of the Ten Mile River. The route 152 causeway separates North and Central Ponds from South Pond. On some maps, North and Central Ponds are collectively labeled "Central Pond," and South Pond is labeled "Turner Reservoir." To avoid confusion, "Turner Reservoir" is used in this report to refer to all three ponds, which are individually referred to as "North," "Central," and "South" Ponds.

4. Reservoir Use. East Providence used Turner Reservoir as a public water supply source until 1969, when treatment with sand filtration followed by chlorination was no longer able to keep coliforms out of the treated water. The source of these bacteria was probably upstream wastewater discharges. Turner Reservoir is currently used for limited recreation, mainly fishing and non-motorized boating.

5. Land Use. Sections of the Ten Mile River watershed are heavily urbanized, including parts of East Providence, Pawtucket, Attleboro, and all of the urbanized area of North Attleboro. Other sections are still undeveloped, and much of this land is covered with wetlands including swamps, marshes, and open bodies of water. In additional to municipal wastewater treatment plants discharges, the Ten Mile River receives runoff from golf courses, including Slater Park, which is just upstream from Turner Reservoir's North Pond. In the past, the river also received industrial discharges including metal wastes from jewelry manufacturing. The main effects of municipal wastewater discharges and runoff from urban areas and golf courses would be to add nutrients to the river, leading to eutrophication in downstream impoundments. Urban runoff, and to a lesser extent municipal discharges, will also add coliform bacteria, metals, and organic chemicals to the river. The extensive areas of wetlands in the watershed will not remove these contaminants because the wetlands are upstream of the sources. The main effect of the wetlands in the upper watershed is to moderate flows in the river by storing and releasing runoff.

6. Reservoir Yield. Only a cursory analysis of potential water supply yield for Turner Reservoir is included in this study. The reservoir volume is not known, because siltation has undoubtedly reduced it since it was last used for water supply. However, the reservoir has a surface area of 225 acres, and very rough measurements during water quality sampling indicate it may have an average depth of 4 to 5 feet, which would give it an estimated volume of around 350 million gallons. Average daily flow can be calculated from the record at the USGS gage about 1.2 miles downstream from the dam. Using the 11-year record at the gage, from 1986 through 1997, and adjusting flows by drainage area, the average daily flow at the dam is 103 cfs (66 million gallons per day). Using a spread-sheet analysis of flow for each day of the eleven-year period of record at the gage, storage of 350 million gallons would have provided a safe yield of 16 million gallons per day. If used as a backup water supply, the reservoir could provide greater yields for shorter periods of time; however, during a serious drought the yield could be less.

7. Water Quality Classification. The Rhode Island Department of Environmental Management (RIDEM), Division of Water Resources, has assigned the waters of the Ten Mile River from the Newman Avenue Dam, including Turner Reservoir, to the confluence with the Seekonk River below Omega Pond to Class B. Such waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. They should be suitable for certain industrial processes and cooling, hydropower, aquaculture, navigation, irrigation, and other agricultural uses. These waters should have good aesthetic value. Should the reservoir be used for public water supply, it would become designated as Class A. Whether designated Class A or B, a water quality classification is a goal and not necessarily a description of actual conditions.

(a) General Criteria. Water quality criteria are set to protect the most sensitive designated water use in each class. Surface waters may be suitable for other beneficial uses, but will be regulated to protect and enhance the designated uses. The following minimum criteria are applicable to all waters of the State, unless criteria specified for individual classes are more stringent. All waters should be free of pollutants in concentrations or combinations or from anthropogenic activities subject to these regulations that adversely affect fish and wildlife or human health. There should be no pollutants in concentrations or combinations that form unsightly deposits, or change the color or physical, chemical or biological conditions to such a degree as to create a nuisance or interfere with the existing or designated uses.

(b) Specific Criteria for Class B Waters. Dissolved oxygen (DO) should not be less than 60 percent of saturation, based on a daily average, and an instantaneous minimum DO concentration of 5.0 mg/l should be maintained. The 7-day mean water column DO concentration should not be less than 6 mg/l. There should be no color or turbidity in such concentrations that would impair any usage specifically assigned to this class. Turbidity levels should not exceed 10 NTU over natural background conditions. Total coliform bacteria should not exceed a geometric mean value of 1,000 and not more than 20 percent of the samples should exceed a value of 2,400 per 100 ml. Fecal coliform bacteria should not exceed a geometric mean value of 200 and not more than 20 percent of the samples should exceed a value of 500 per 100 ml. The pH should be in the range of 6.5 - 9.0 or as naturally occurs. Concentrations of algal nutrients should not cause undesirable or nuisance aquatic species associated with cultural eutrophication to develop, impair any usage assigned to a class, or cause exceedance of criteria in a downstream lake or pond. Average total phosphorus should not exceed 0.025 mg/l in any lake or pond, but more stringent site-specific limits may be necessary to prevent or minimize accelerated or cultural eutrophication. Ambient concentrations of pollutants should not exceed the RIDEM Ambient Water Quality Criteria and Guidelines, for the protection of aquatic organisms from acute or chronic effects. These criteria may be modified based on results of approved bioassay tests.

(c) Specific Criteria for Class A Waters. Criteria for class A waters are mostly the same as those for Class B except for coliform bacteria. Total coliform bacteria in Class A waters should not exceed a geometric mean of 100 and not more than 10 percent of the samples should exceed 500 per 100 ml. Fecal coliform bacteria waters should not exceed a geometric mean of 20 and not more than 10 percent of the samples should exceed 200 per 100 ml. The drinking water standard is less than 1 total coliforms per 100 ml, but that applies to treated waters.

8. Rhode Island Public Health Requirements. The Rhode Island Department of Health approves water supplies for public consumption. Discussions with them indicated that there are no water quality conditions that would automatically prevent a raw water source from being used for public water supply. However, treatment to deal with whatever was found would have to be designed before the Department of Health would issue a permit.

9. Historical Water Quality Information. Only a limited amount of historical water quality information was found for the Ten Mile River in Rhode Island. These studies have shown a general improvement in the river's water quality as municipal and industrial discharges have been cleaned up; however, they also found the river still had problems, especially with elevated levels of nutrients and metals.

(a) Rumford River Laboratories Study. *"Toward a Cleaner Ten Mile River"*, a report prepared by Rumford River Laboratories in September 1985 discusses a 1984 river survey. It found that, "The overall condition of the river had improved markedly in the last decade due to better treatment of industrial and municipal wastewaters. However, problems remained with two major aspects: metal contamination by copper, lead and nickel, and over-fertilization of aquatic vegetation by phosphate nutrients. There were abnormally high concentrations of metals in the river and large residuals of metals in the sediments of the impoundments, eliminating normal bottom organisms. The adverse impacts of these metals were seen at all levels in the aquatic food chain in 1984, limiting the numbers and species of algae, small aquatic organisms and fish. Copper and nickel in the river system came from industrial discharges, while lead came from industries, roadways and other sources. There were also problems with ammonia, excess chlorine, and other chemicals lethal to aquatic life, from some of the wastewater treatment plants."

(b) USGS Study. The USGS did a trophic evaluation of Turner Reservoir in 1988 and found high nutrients and physical habitat impairment, according to RIDEM. However, little other information is available on that study.

(c) RIDEM Monitoring. RIDEM has collected very limited information on water quality at Turner Reservoir. About every two years, RIDEM takes a single grab sample from the Ten Mile River near Turner Reservoir during the September low-flow period. Data from these grab samples have shown that Turner Reservoir has high ammonia, BOD, chloride, turbidity, nutrients, coliform bacteria, and possibly lead. RIDEM suspects high coliform counts may come from waterfowl. Dissolved copper and lead still exceed chronic aquatic life criteria. There are high metals in the sediment, but that is a problem of uncertain dimensions.

10. Corps Site Visit. On June 24, 1999, the Corps visited the site. The general impression was that Turner Reservoir did not look very appealing as a public water supply (see Figure 2). There were thick mats of aquatic weeds and algae lining most of the shoreline and extending out for a dozen yards or more in many places. There were also a lot of waterfowl, especially Canada geese, and their droppings were heavy along parts of the shoreline.

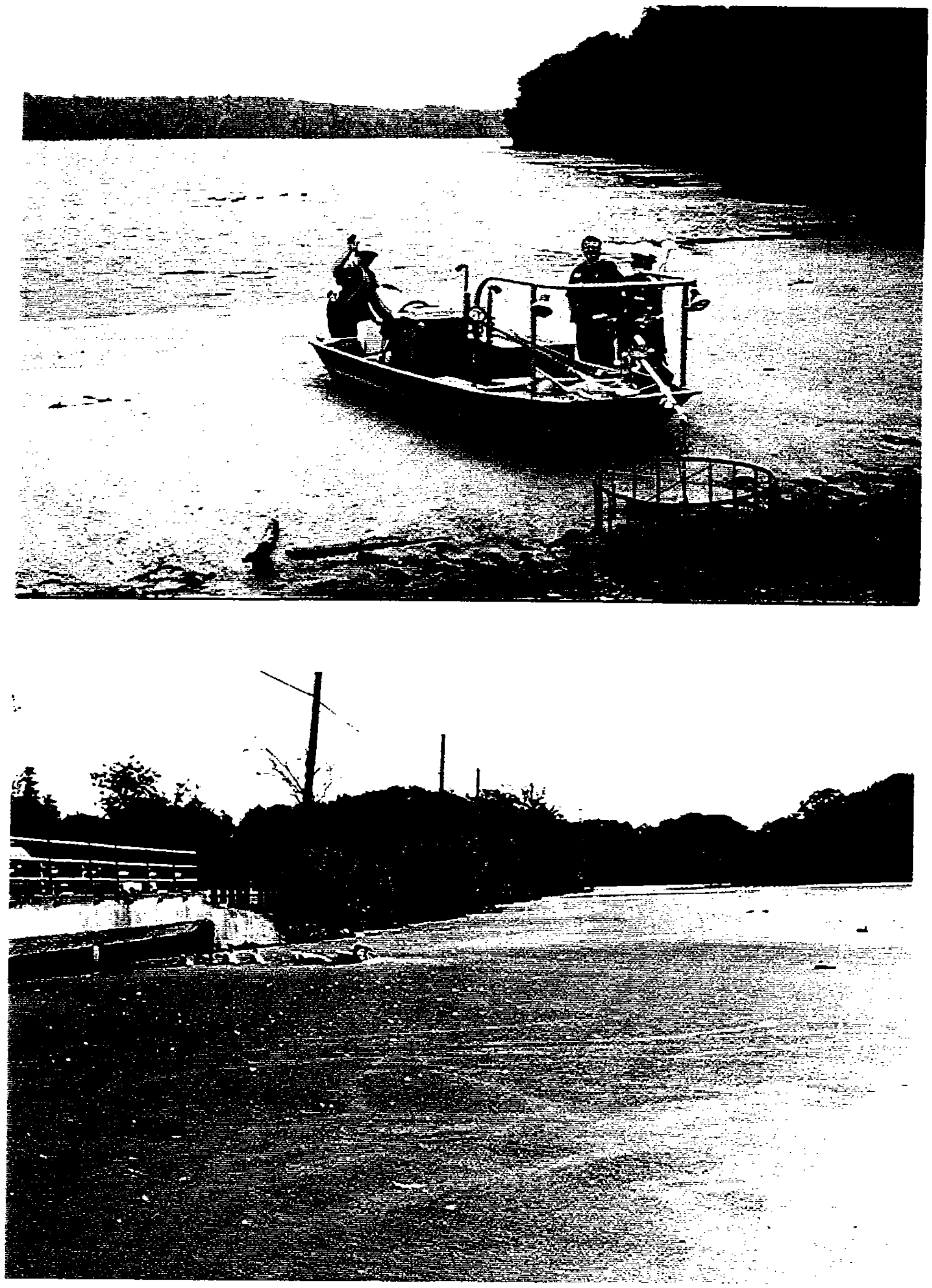

Figure 2. - Photographs illustrating the presence of duckweed at Turner Reservoir in the vicinity of the small beach area and adjacent to Route 152.

11. Corps Water Quality Data. The Corps sampled water quality parameters at 4 stations at Turner Reservoir on September 3, 1999. The station locations were in the Ten Mile River at the railroad crossing just upstream of where it enters North Pond, at the Route 152 culvert between Central and South Ponds, in the approximate center of South Pond, and in the discharge immediately below the James V. Turner Reservoir dam (see Figure 3). Parameters measured at these stations included temperature, DO, pH, nitrogen, phosphorus, and total and fecal coliform bacteria. The sample from the central South Pond station was also analyzed for VOCs, SVOCs, and heavy metals. In addition, at the South Pond station, two locations in Central Pond, and one in North Pond, profiles of temperature, DO, and pH were collected. Tables 1 through 4 show the collected data.

(a) DO and pH. DO and pH levels showed the effects of the heavy aquatic plant growth. DO levels were high, generally supersaturated at the surface and with good levels extending down towards the bottom of the reservoir. Samples taken 1 to 2 feet below the surface had 8.9 to 11 mg/l of DO, and DO saturation levels ranging from 100 to 126 per cent. At a depth of 9 feet, in an area where the water was 10 feet deep, the DO was 5.1 mg/l and equal to 56 percent of saturation. The pH levels also showed the effects of aquatic plant activity. At the surface, pH levels ranged from 8.8 to 9.3 SU, which is consistent with photosynthetic activity which raises the pH by using up dissolved carbon dioxide. The pH levels decreased with depth, but even at a depth of 9 feet the pH was 8.2; well into the alkaline range. There were no significant differences in DO or pH among the three ponds.

TABLE 1
FIELD DATA AT TURNER RESERVOIR
COLLECTED ON 9 SEPTEMBER 1999

Station	Depth* (feet)	Temp. (°C)	DO (mg/l)	DO % Sat	pH (SU)	Cond. (uS/cm)
Ten Mile River Inlet	2	19.3	6.1	66	7.5	865
North Pond	1	21.2	8.9	100	9.0	683
	3	21.0	7.5	84	8.9	673
Central Pond 1	1	22.2	10.9	125	8.9	674
	5	21.9	11.6	127	8.9	680
Central Pond 2	2	22.1	9.6	110	8.8	659
	7	21.8	6.0	66	8.6	672
Route 152	2.5	22.2	10.5	121	8.9	636
South Pond	2	22.5	11.0	126	9.3	609
	5.5	22.0	9.4	108	9.1	603
	9	21.8	5.1	56	8.2	633
Reservoir Discharge	1	21.7	10.3	117	9.3	553

*Depth below water surface

(b) Nutrients. Analyses of nutrients showed a sharp decrease in nitrogen from the Ten Mile River through the reservoir and a gradual increase in phosphorus. Total nitrogen, consisting mostly of nitrate, was 6.9 mg/l in the Ten Mile River where it enters North Pond. This decreased to 0.97 mg/l at Route 152 between Central Pond and South Pond, to 0.52 mg/l in the middle of South Pond, and to 0.49 mg/l in the reservoir dis-

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New England District

WATER QUALITY SAMPLING LOCATIONS

Section 22 Planning Assistance to States
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East Providence, Rhode Island

January 2001 | FIGURE 3

charge. Total phosphorus levels gradually increased from 0.16 mg/l where Ten Mile River enters North Pond to 0.34 mg/l where it leaves South Pond.

TABLE 2
NUTRIENT DATA, TURNER RESERVOIR
COLLECTED 3 SEPTEMBER 1999

Station	NH3-N (mg/l)	NO2-N (mg/l)	NO3-N (mg/l)	Total N (mg/l)	Total P (mg/l)
Ten Mile River Inlet	0.29	0.17	6.4	6.86	0.16
Route 152	0.08	0.17	0.72	0.97	0.28
Central South Pond	<0.075	0.15	0.29	0.52	0.31
Reservoir Discharge	0.25	0.12	0.12	0.49	0.34

(c) Phosphorus. One set of samples cannot define conditions, but these measurements indicate there may be an excess of phosphorus in the sediments in Turner Reservoir. Phosphorus behaved quite differently from nitrogen: high levels of nitrogen entering from the Ten Mile River were quickly taken up by aquatic plants, causing nitrogen levels to drop across the two ponds. When the Ten Mile River enters North Pond it had enough phosphorus to stimulate nuisance aquatic plant growth, but phosphorus levels still rose between inflow and outflow. A possible explanation for this rise is that there is so much phosphorus in the sediments that sediment releases to the overlying water exceed plant uptake. At all stations, phosphorus concentrations were many times higher than the 0.025 mg/l level set by Rhode Island Water Quality Standards.

(d) VOCs, SVOCs, and Metals. A single sample from the central part of South Pond was analyzed for VOCs, SVOCs, pesticides and PCBs. All contaminant levels were below method detection limits. This sample was also analyzed for a number of heavy metals. All except barium were below method detection limits, and the barium level of 0.2 mg/l was well below drinking water standard of 2 mg/l. Method detection limits for the other metals were all below applicable drinking water criteria except for lead. The maximum contaminant level goal for lead is 0 ppm. There is no acceptable level of lead in drinking water, and systems should be operated to minimize lead levels, but the action limit of 0.015 mg/l is a default standard of sorts. If the lead level is below the action limit of 0.015 ppm, it is assumed the system is operated well. The detection limit for the analytical method used to analyze lead at Turner Reservoir was 0.05 mg/l, which is greater than the 0.015 mg/l action limit. Consequently, it cannot be shown that the lead level is not a concern. However, because of the low solubility of lead in natural waters and that it is no longer entering the environment from gasoline, it is unlikely that lead in Turner Reservoir would exceed the 0.015 mg/l action limit. Furthermore, the action limit of 0.015 mg/l applies to treated waters. Even if the lead level in Turner Reservoir exceeded 0.015 mg/l, it would mean the water would have to be treated to remove lead; not that the water couldn't be safely used for water supply.

TABLE 3
METALS DATA AT CENTRAL POND, TURNER RESERVOIR
COLLECTED 9 SEPTEMBER 1999

Metal	Measurement (mg/l)	MCLG (mg/l)	MCL (mg/l)	SCL (mg/l)	Freshwater Acute Criteria (mg/l)	Freshwater Chronic Criteria (mg/l)
Arsenic	<0.005	NA	0.05		0.34	0.15
Barium	0.2	2	2		NA	NA
Cadmium	<0.005	0.005	0.005		0.0043	0.0022
Chromium	<0.01	0.1	0.1		0.57	0.074
Lead	<0.05	0	0.015*		0.065	0.0025
Mercury	<0.0005	0.002	0.002		0.0014	0.00077
Selenium	<0.01	0.05	0.05		NA	0.005
Silver	<0.01			0.1	0.0034	NA

*Action level – not an actual MCL.

(e) Coliform Bacteria. Total and fecal coliform bacteria showed dramatic drops from the inflow through the reservoir discharge. Total coliform levels were 400 per 100 ml in the Ten Mile River before it entered North Pond, 130 at Route 152 between Central and South Ponds, 55 in the center of South Pond, and 8 per 100 ml in the discharge from Turner Reservoir. Fecal coliforms went from 220 at the inlet to 9 per 100 ml in the discharge. Total coliform bacteria include organisms that originate in animal intestines but also bacteria that naturally occur in the ground. Fecal coliforms originate only in the intestines of warm-blooded animals, making them a more certain sign of contamination. Because of the large numbers of waterfowl, especially Canada geese, that use the reservoir, it is surprising that coliform levels decreased in this manner.

TABLE 4
COLIFORM DATA, TURNER RESERVOIR
COLLECTED 3 SEPTEMBER 1999

Station	Total Coliforms (per 100 ml)	Fecal Coliforms (per 100 ml)
Ten Mile River Inlet	400	220
Route 152	130	110
Central South Pond	55	5
Reservoir Discharge	8	9
Geometric Mean	69	32

(f) Comparison with State Standards. The measured DO levels generally met Class A and B criteria for concentrations and percent saturation. The pH was also generally within the 6.5 to 9.0 range, although this was exceeded by readings of 9.1 and 9.3 SU. However, it is likely that diurnal analyses would show greater exceedences of standards, with the DO and pH peaking in the afternoon, and then dropping to low levels by early morning, due to aquatic plant activity. Rhode Island Water Quality Standards call for average total phosphorus not to exceed 0.025 mg/l; a level exceeded at all stations generally by at least an order of magnitude. With a geometric mean of 69 and a maximum of 400 per 100 ml, the total coliform samples meet Class A and B criteria. However, the fecal coliform counts had a geometric mean of 32 and a maximum of 220 per 100 ml, which meets Class B criteria but exceeds those for Class A waters. High levels of coliform bacteria do not in themselves make a water unacceptable as a raw water supply, but do mean that higher levels of treatment will be necessary before the water can be used, and that there is a greater risk of potential problems to humans.

12. Treatment for Water Supply. Before Turner Reservoir could be used for public water supply, the water would have to be thoroughly treated. Although not nearly enough data have been collected to design a treatment system, there is sufficient information to discuss the types of treatment that would likely be required. The major concerns in designing this system would be the bacteria load to the watershed from urban runoff and wastewater treatment plant discharges, and the effects of algal blooms.

(a) Required Treatment. Filtration would be required to remove turbidity and suspended solids. Algal blooms could complicate this filtration by producing large amounts of material that could clog the filters, and by producing a fluctuating load that could be more difficult to deal with than even a constant heavy load. Because of the developed nature of the watershed, filtration would also be required to remove organisms such as *Giardia* that are not reliably killed by chlorination. A two-stage filtration system might be required with a coarser filter to remove the total solids load caused by algal blooms, and a finer filter to remove *Giardia*. Disinfection would be required, and because of the urban runoff and municipal wastewater discharges in the watershed, the disinfection system would have to be extensive. Chlorination, ozonation, or ultra-violet light treatment are systems that might be used, singularly or in combination. The addition of alum as a method of reducing the phosphorus has been used in other reservoirs; however, the use of alum may not be acceptable here because it changes the chemical characteristics of the water.

(b) Additional Treatment. Metals removal, probably through flocculation and precipitation, might be required. Although the Corps data showed only low levels of barium, past studies found high levels of metals in the sediments, and additional sampling may show higher concentrations requiring removal. Algal blooms and the resulting fluctuations in pH and DO could complicate metals removal processes. Activated carbon treatment will likely be required to remove taste and odor producing compounds introduced by algal blooms and urban runoff. Although the disinfection system will also destroy, or at least greatly reduce, tastes and odors, using chlorination or ozonation for such purposes can leave undesirable byproducts in the water.

13. Recreation Water Quality. Results from Corps sampling indicate that most of the reservoir meets water quality standards for recreation, including swimming. The biggest identified problem is the excessive aquatic plant growth that reduces the lake's aesthetic appeal and physically obstructs boats and swimmers. It is very likely that runoff from urban areas causes high coliform levels after rainstorms, which would require

temporary closing of beaches for health and safety reasons; however, in most cases that would not last more than a day or two.

14. Conclusions. Although the water's appearance is not attractive, with large amounts of aquatic weeds and a number of waterfowl present at the site, Corps investigations did not find any water quality problems that would prohibit using Turner Reservoir for recreation, including swimming, or for public water supply. Before being used for water supply; however, the water would have to be thoroughly treated; i.e. filtration, disinfection, etc. and this could be expensive.

(a) Major Problems. Excessive nutrient enrichment leading to heavy aquatic plant growth is the biggest identified problem. In addition to making the water unappealing for most uses, it complicates and increases the costs of treatment for water supply, and physically interferes with recreation uses. Coliform bacteria are the next most serious concern. Although the few samples taken by the Corps did not find very high levels, it is likely that counts increase dramatically following rainstorms. Counts also increase, at least in sections of the reservoir, after visits by large numbers of waterfowl, especially Canada geese. If the ponds were opened to swimming, a program of regular and possibly intensive bacteria monitoring would be important.

(b) Dredging Benefits. Selective dredging would likely improve the reservoir by removing contaminated sediments and increasing the water's depth. The sediments contain high levels of algal nutrients, and Corps sampling indicates they may be a source of phosphorus to the overlying waters and therefore contribute to the algae problem. Removing these sediments may reduce the level of aquatic weed and algae growth; however, there are still enough nutrients in the Ten Mile River to cause eutrophication problems. Dredging would also remove accumulated heavy metals that might bioaccumulate in fish; although, Corps sampling found no evidence that heavy metals were a problem for use of the reservoir for water supply or recreation, including swimming. Finally, dredging would increase the volume available for water supply storage and an increased depth might benefit potential boaters and swimmers.

(c) Watershed Controls. Ultimately, controlling the reservoir's eutrophication problem will require controls on upstream sources. This could include upgrading waste-water treatment plants to include nutrient and phosphorus removal, and will require best management practices in the watershed to control runoff quality, especially from urban areas and golf courses.

(d) Additional Sampling. Additional sampling is required to confirm the Corps findings. Sampling following rainstorms is particularly important because pollutant loads generally increase at such times, often dramatically.

B. Fisheries and Sediment Investigation

1. Summary of Findings for Fisheries Investigation. Turner Reservoir supports a warm water fish assemblage consisting of bluegill, pumpkinseed, yellow perch, white perch, white sucker, yellow bullhead, largemouth bass, and black crappie (one specimen collected). In addition, representatives of the catadromous American eel were collected. South Pond yielded a more diverse distribution of species and sizes of individual fish, than Central/North Pond. This is most likely a function of habitat, since the southern pond had more diverse aquatic habitat.

Largemouth bass were the most abundant species collected from the entire study area; comprising approximately 41% of the species collected. The largemouth bass length frequency distribution indicates the presence of a good population, with several age classes represented, including fish that could be up to 7 –10 years old. The most abundant year class represented was Year Class 1+ (i.e. fish that were approximately one year old). This is unusual, since length frequency distributions generally show that age class 0+ (young of year) as the most abundant. The fact that one year old fish were the most abundant, and not young of year, indicates that habitat conditions in the lake are suitable for good over-winter survival for young of year largemouth bass. It could also be partly due to sampling bias, since the extremely shallow near shore areas (nursery areas), were not easily accessed by the sampling boat, due to the overabundance of duckweed.

Mean Condition Factors (K values) of largemouth bass, a measure of weight/length relationship and a general indicator of environmental conditions, were slightly lower than those calculated for largemouth bass from other lakes in New England. However, this could be due to the low values of a few of the smaller individuals sampled. Generally, the abundance and size distribution indicate a good largemouth bass fishery with habitat/food requirements being met.

Primary forage species (prey species) for the largemouth bass in Turner Reservoir appear to be bluegill and pumpkinseed sunfish as well as the young of year of other species (white sucker). Golden shiner, a common forage species in many lakes, and historically present in Turner Reservoir, were not collected in the 1999 sampling.

2. Summary of Findings for Fish Tissue Analysis. Concentrations of methyl mercury in largemouth bass (0.146 ppm) were approximately two times higher than those found in white sucker and yellow bullhead. This is expected since these are a predator species at the top of the food chain. Although these concentrations of methyl mercury are below the action level of 1 ppm established by the FDA, they are above some risk criteria established by the EPA for consumption. EPA risk criteria are not enforceable, but do provide approximate health risks for specific populations and levels of consumption. The concentrations of methyl mercury found in the largemouth bass are above the risk levels for children (0.1 ppm) consuming these fish.

Concentrations of PCBs were detected for all three composite fish samples. The highest concentration of 0.12 ppm was found in the white sucker composite (from Central Pond). White sucker is a bottom dwelling fish exposed to the sediment. These concentrations are below the FDA action level of 2 ppm, but they are above the levels where specific health risks could occur from consumption (0.016 ppm). It should be noted that concentrations in largemouth bass and yellow bullhead (0.02 ppm) exceeded this threshold as well.

Concentrations of polycyclic aromatic hydrocarbons (PAHs) were detected from all three composite fish tissue samples. These were highest in the yellow bullhead composite sample (0.023 ppm) from South Pond. These levels of PAHs are above the EPA risk levels established for 17 target PAHs of most concern to human health. Therefore, there may be health risks associated with consumption of yellow bullhead from Turner Reservoir, based upon these levels of polycyclic aromatic hydrocarbons.

Concentrations of the pesticide, DDT and its degradation products (DDE and DDD), as well as total Chlordane, Dieldren, Endrin, Heptachlor Epoxide, Hexachlorobenzene, and Mirex, from the composite fish tissue samples were below EPA risk levels presented in the publication "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume II, Risk Assessment and Fish Consumption Limits, Second Edition, 1997".

3. Summary of Findings for Sediment Analysis. High concentrations of metals were detected in the sediments of Turner Reservoir. Concentrations of all metals analyzed, with the exception of arsenic were above the Long and Morgan Biological effects levels (ER-L and ER-M), where effects upon sensitive aquatic life can be expected. Concentrations of all metals (including arsenic) were also above the Ontario Ministry of the Environment (OME) guidelines Low Effects Levels (LEL) where effects upon aquatic life can be expected. Concentrations of zinc, arsenic, lead, and mercury in some samples did not exceed the OME's Severe Effects Levels (SEL). Metals in the highest concentrations were copper, nickel and zinc. In addition, levels of cadmium (157 ppm from site TR#2)(see Figure 3) were not only above the biological effect levels, but also above the cleanup levels established by some states (i.e. the State of Washington).

Concentrations of Total PCBs were highest in the sediments from site TR#3 (321.19 ppb), the most downstream site of Turner Reservoir. This is below the Long and Morgan Biological effects level where biological effects would be expected to occur in most forms of aquatic life (ER-M), but above the level where they would be likely to effect sensitive aquatic life forms (ER-L).

Concentrations of pesticides were detected in the sediments from all three stations. Concentrations of 4'4' DDE were 11.94 ppb at site TR#2, 25.89 ppb at site CP#1, and 60.50 ppb at site TR#3, the most downstream site. All of these samples (except the TR#2 site) exceeded the Long and Morgan biological effects levels for both the ER-L (2 ppb) and the ER-M (15 ppb). Therefore, these concentrations are at levels where biological effects would be expected to occur in most organisms.

Concentrations of 23 Polycyclic Aromatic Hydrocarbons were detected in the sediments from Turner Reservoir, and were highest at site TR#3 (the most downstream site in South Pond). The compounds detected in the highest concentrations were Fluoranthene and Pyrene, which were above the ER-L levels, but below the ER-M levels, indicating that biological effects may be predicted to begin among sensitive life states and/or species of aquatic organisms.

4. Investigation. Although there is no formal boat access, small non-motorized watercraft are launched from the shore adjacent to Route 152 on both the upstream and downstream sides. The area is also fished from the extensive shoreline well as from the Route 152 causeway. The Rhode Island Department of Environmental Management (RIDEM) conducted fisheries sampling in 1965; however, minimal fisheries data has been collected since that time. This has partly been due to the reservoir's inaccessibility to larger motorized watercraft (from the lack of a definite boat launch) which are necessary for effective fish sampling by RIDEM.

A fisheries investigation was conducted at Turner Reservoir during September 1999. This study included sampling of the fish population to determine species composition and population structures, as well as analysis of fish tissue for the presence of contaminants (from selected target species) in order to determine possible ecological and/or human health risks. In addition to the fish tissue analysis, sediments from selected locations in the reservoir were collected and analyzed for contaminants.

5. Corps Site Visit and Methods.

(a) Fish Sampling. On September 9, 23, and 24, 1999, representatives from the New England District sampled selected locations of Turner Reservoir for resident fish species. A map of the locations of these sampling areas is presented in Figure 4. With the exception of the deployment of one gillnet for a short period, sampling was accomplished by boat electroshocking using a Coffelt Industries, Mark 22 Electrofishing unit with Pulsed Direct Current, mounted on a 14 foot aluminum Jon-boat. Selected sections of the near shore area on both the East Providence and Seekonk sides (from both Turner Reservoir and Central Pond) were sampled during the daylight hours, by either slowly navigating the boat parallel to the shore (approximately 20 to 50 feet off shore) and intermittently energizing the electrodes of the sampler; or by systematically passing from approximately forty feet offshore shoreward (ending at the shore itself). Generally, the abundance of floating duckweed along much of the shoreline precluded the use of successive passes (the latter method) in much of the reservoir. In addition to the boat shocking, a 5-foot wide x 125-foot long variable mesh experimental gillnet was set for 2 hours approximately parallel to shore (Site GN1) extending from a small island adjacent to Route 152. This sampling was primarily designed to capture target species (i.e. bullhead and/or sucker) for tissue analysis.

Upon collection (by electrofishing), fish were placed into an aerated live-well, weighed to the nearest gram (or 0.25 ounce for fish weighing greater than 200 grams requiring a larger scale), measured to the nearest 0.25 centimeter and, with the exception of those taken for tissue analysis, released. Fish collected from the gillnet were identified and counted. Target species that were retained for tisssue analysis were also weighed and measured. Non-target species surviving gillnet deployment were released back into the reservoir, and non-surviving fish were removed and disposed off site.

(b) Condition Factors. Condition factors (K) (a measure of robustness) of selected sport fish was calculated using total length according to the formula $\mathbf{K = W \times 10^5/L^3}$ where

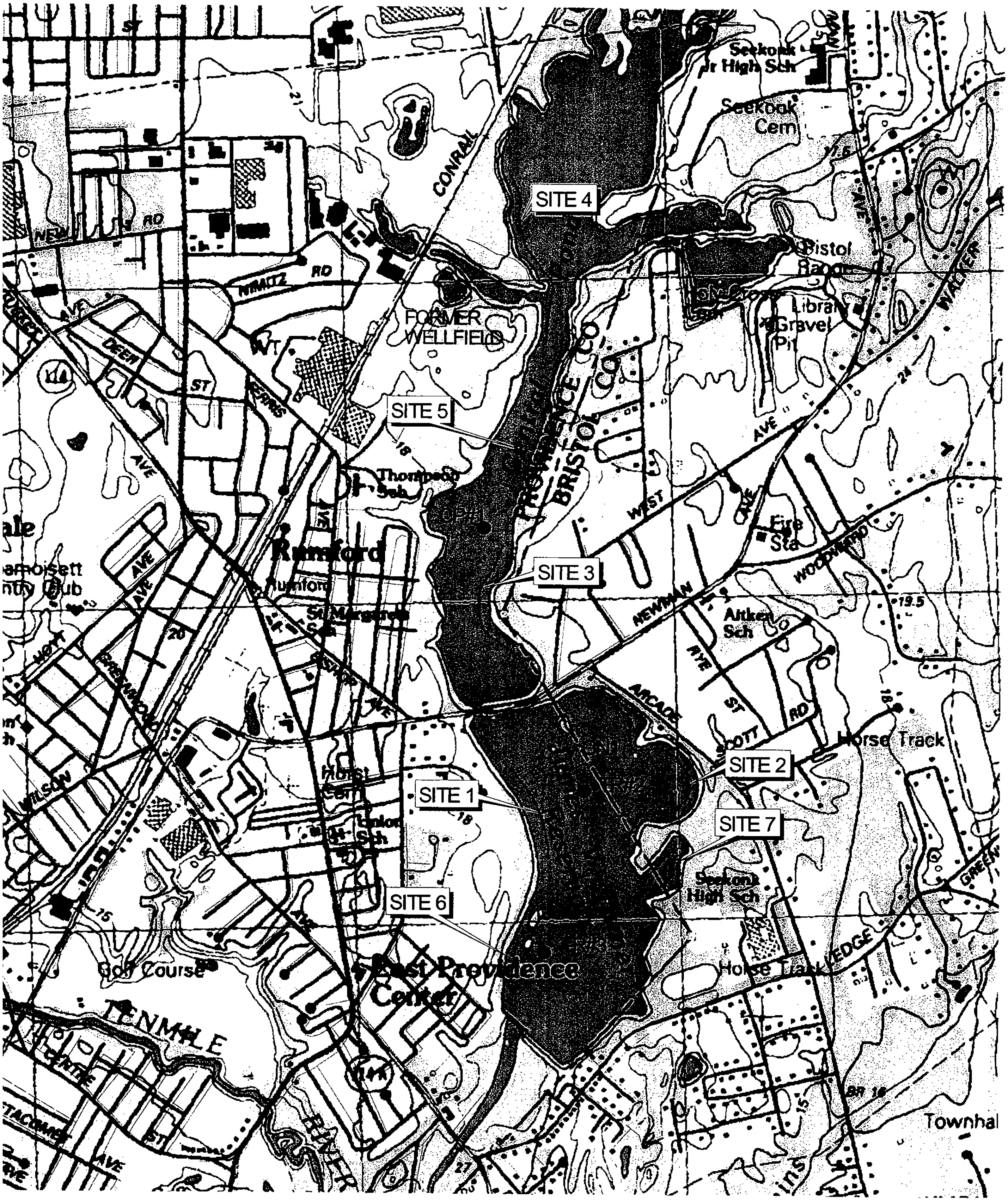
K = condition factor
W = weight (grams)
L = length (mm)

Selected fish specimens (from both sampling methods) taken for tissue analysis were prepared according to the methods outlined in the EPA document "Guidance For Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1; Fish Sampling and Analysis, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, Washington, D.C., 1993." where each fish was individually wrapped in foil, immediately frozen on dry ice, and stored frozen until delivery to the laboratory (approximately six weeks later) for processing and analysis.

In addition to the fisheries sampling noted above, sediment samples were collected on November 10, 1999, from station CP #1 in Central Pond, and stations TR#2 and TR#3 in South Pond (see Figure 4). Sediment was collected using a Petite Ponar grab sampler, pre-rinsed with reagent grade isopropanol and deionized water. Approximately three grabs were collected from each site and composited. Composite samples from each site were placed on ice, and stored frozen or at 4° C (depending upon type of analysis), until they were analyzed for bulk chemistry, metals, total organic carbon, and grain size.

(c) Fisheries.

Species Distribution - Data collected during this 1999 fisheries sampling, indicated that Turner Reservoir supports a freshwater fish assemblage consisting of bluegill, pumpkinseed, yellow perch, white perch, white sucker, yellow bullhead, and largemouth bass. In addition, two individual specimens of American eel (*Anguilla rostrata*) were collected as well as one specimen of black crappie. These data are generally in agreement with historical data, which were collected from the Turner Reservoir complex by RIDEM in 1965. Exceptions were Black Crappie and American eel which were not found in 1965 but were collected during 1999; and Golden shiner and chain pickerel which were found in 1965, but were not found in 1999. A listing of all



LEGEND

FISH AND SEDIMENT SAMPLING LOCATIONS

● Sediment Sample Points — Fish Sample Location

N

US Army Corps of Engineers
New England District

FISH & SEDIMENT SAMPLING LOCATIONS

Section 22 Planning Assistance to States
Turner Reservoir Study
East Providence, Rhode Island

January 2001 | FIGURE 4.1

species collected from the Turner Reservoir complex with their relative percentages (percent capture) by number and by weight is presented in Table 5.

TABLE 5
LISTING OF ALL FISH SPECIES CAPTURED AT TURNER RESERVOIR (INCLUDING CENTRAL AND NORTH PONDS) DURING THE SUMMER OF 1999 (BY ELECTROFISHING)[1]

Species	Scientific Name	Total Collected	Percent Catch	Percent Weight
Bluegill	*Lepomis macrochirus*	41	14.39	7.52
Eel	*Anguilla rostrata*	2	0.70	
Largemouth Bass	*Micropterus salmoides*	118	41.40	52.21
Pumpkinseed	*Lepomis gibbosus*	52	18.25	10.78
White Perch	*Morone americana*	7	2.46	4.50
White Sucker	*Catostomus commersoni*	4	1.40	12.37
Yellow Bullhead	*Ameiurus natalis*	2	0.70	2.36
Yellow Perch	*Perca flavescens*	58	20.35	9.30
Black Crappie	*Pomoxis nigromaculatus*	1	0.35	0.97

[1]An additional 46 white perch were also collected by gillnet, not included in above table.

Although the primary sampling method utilized in this study was electrofishing, a single gillnet was deployed for a short period of time. This gillnet captured an additional 46 adult white perch (ranging between 12 and 24 centimeters) as well as a single pumpkinseed and a single yellow bullhead. Since these fish were generally not individually weighed and measured; they were not incorporated into the species percentages calculated for the fish sampled by electrofishing. Therefore, the total percentage of white perch noted in the following figures are slightly higher, due to the additional fish captured in the gillnet.

The 1999 fisheries survey indicated differences in species distribution and fish sizes (i.e. ages) between specimens collected from South Pond and those collected from Central/North Pond. South Pond contained a greater number of species than Central/ North Pond; although the mean lengths of the individual fishes were generally less. A total of eight fish species were collected from South Pond (American eel, bluegill, black crappie, largemouth bass, pumpkinseed, white perch, and yellow bullhead), whereas only four species (bluegill, largemouth bass, white sucker, and yellow perch) were collected in Central/North pond. In addition, the largemouth bass collected from the South Pond were generally smaller in both size and weight than those collected from Central/North Pond. Respective lengths and weights of South Pond fish averaged 12.9 cm and 51.7 grams, compared to those from Central/North Pond which averaged 15.01 centimeters and 130.6 grams (length and weight respectively). Also, yellow bullhead and American eel were collected in South Pond, but not in Central/North Pond, while white sucker were collected in Central/North Pond and not in South Pond.

These differences in species composition and size are most likely related to differences in habitat between the two areas. Generally, South Pond contained more diverse aquatic habitat than Central/North Pond. Consequently, it produced greater species and/or size diversity. Much of Central/Northern Pond was characterized by steep bank topography, leading to a sharp drop off to deeper water, whereas South Pond included areas of shallower water with emergent vegetation and cover, as well as deeper areas with submerged cover. Generally, deeper water containing submerged cover (characteristic of the habitat of Central/North Pond) is preferred by larger fish (i.e. adults and/or larger predator fish) that rest and/or feed in covered areas of deeper water. Smaller fish species, including fry and juveniles of predator species, are generally found in shallower areas where there is a greater percentage of rooted submerged and emergent aquatic vegetation and quieter water. This is characteristic of some of the areas of South Pond. Therefore, it would be expected that the deeper areas of Central/North Pond that were sampled would yield a greater percentage of adults and larger fish species than would areas of South Pond that contained shallower habitat. Although most of Central/North Pond was characterized by steeply sloping shoreline (as noted above), the upstream portion of the Ten Mile River contained an extensive area of wetlands, with presumably shallower habitat which may provide additional spawning and nursery area for the resident fish species. However, this area was not sampled, due to its extreme location upstream, and the fact that the primary focus of the study was the more downstream area of Turner Reservoir.

While most of the habitat in Central/North Pond was uniformly characterized by the steep sides and deeper water near shore, at least two locations in South Pond were shallow and could be considered as nursery areas for fry and juvenile fish species. These included a small inlet (cove) on the Seekonk side of the reservoir (Site 7) as well as the near shore area along the East Providence side (Site 6) (see Figure 4). Fish collected from Site 7 had the smallest mean lengths in the entire reservoir complex for all species found in that location with the exception of white perch, indicating that this area is preferred habitat for many of these smaller individuals. Many small fish were also collected at Sites 1 and 6, which are both located on the East Providence side of the reservoir. Generally, these areas were also characterized by more gradually sloping shorelines, with emergent vegetation, similar to that in the cove of Site 7.

In addition to differences in habitat between Central/North Pond and South Pond, which appears to determine the species and size distributions of the two areas, it is possible that the remaining structure of the former Central Pond Dam acts as a physical barrier between the two areas. Although the crest of the dam is submerged several feet below the surface of the water, allowing the movement of pelagic (water column) dwelling species over it, the existing structure may limit the movement of bottom dwelling (demersal) species between Central/North pond and South Pond. The presence of the structure could explain why yellow bullhead and white sucker (two bottom dwelling species) were not collected in both places (i.e. white sucker were found only in Central/North Pond, and yellow bullhead were found only in South Pond).

Dominant Species - A listing of all species collected in Turner Reservoir is presented in Table 5. In addition, these data are displayed graphically in Figures 5, 6, and 7. It can be seen that largemouth bass was the most abundant species collected in Turner

Reservoir, both numerically and by weight. They comprised approximately 30 percent of the total fish collected in South Pond and 78 percent of the total fish collected in Central/North Pond. For the combined area of both South Pond and North/Central Pond largemouth bass were also the most abundant species, comprising approximately 41 percent of the total number of fish collected (Figure 7).

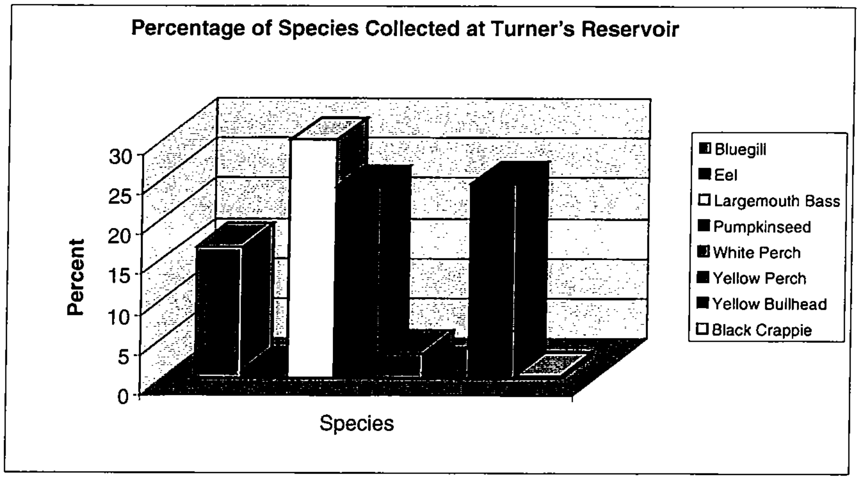


Figure 5. Percentages of Species collected at South Pond of Turner Reservoir during the summer of 1999.

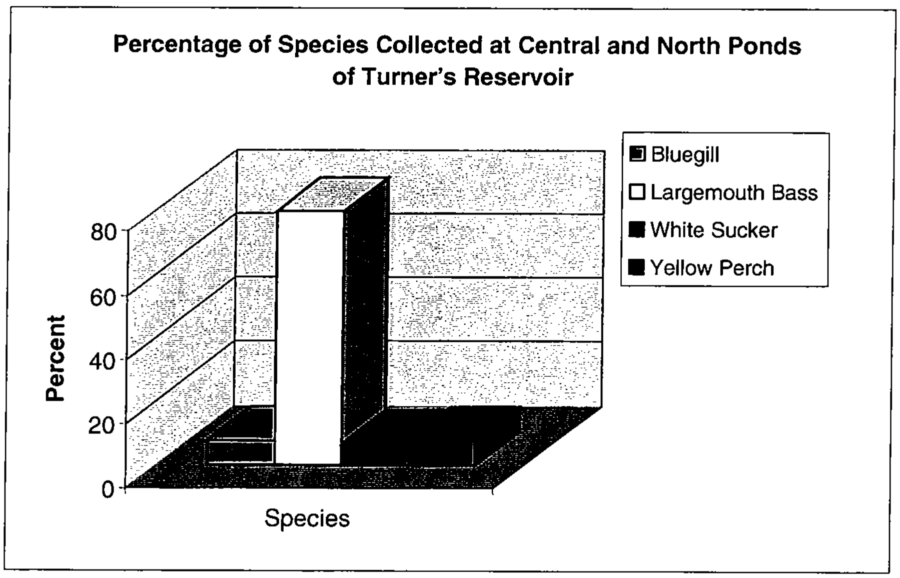


Figure 6. Percentages of Species collected at Central/North Pond of Turner Reservoir during the summer of 1999.

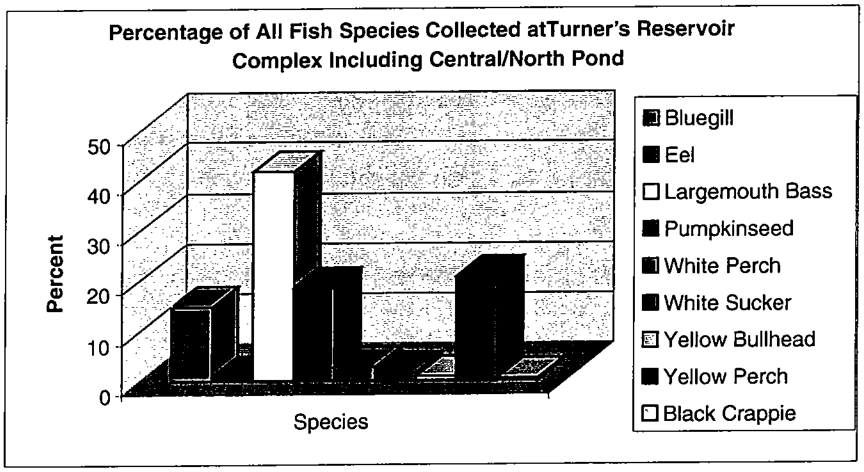


Figure 7. Percentage of Species Collected from all Locations in Turner Reservoir.

Large Mouth Bass Length Frequency Distribution - A length frequency distribution of all of the largemouth bass collected in the Turner Reservoir was calculated and is presented below in Figure 8. As noted previously, although the former mill dam in Central Pond may be acting as a barrier to the movement of bottom dwelling fish, water column dwelling fish such as largemouth bass would still be allowed to move freely between the two areas. Since there is less largemouth bass spawning habitat available in the Central/North Pond area than in South Pond, Central Pond fish may spawn in the shallow areas of South Pond. Therefore, fish collected from the entire reservoir were used in compiling the length frequency distribution for largemouth bass.

Based upon this length frequency distribution, there appears to be a well represented largemouth bass population present in Turner Reservoir. These include fish that were hatched in 1999 from that year's spawning (i.e. young of year, represented as 0+) as well as fish that had resulted from the previous year's spawning (i.e. age class 1+, 1998). The largest fish collected (49 centimeters) is within the size class of fish that could range from approximately 7 to 10 years old in temperate climates (Carlander, 1977). Referring to this distribution, ages of fish can be approximated based upon published age and size data, although precise determination of age classes generally requires the use of other methods in addition to length frequency determination (such as scale and/or otolith examination). However, the distribution of Turner Reservoir's largemouth bass population presented below does show that several year classes of largemouth bass are present in the reservoir, particularly young fish, ranging from one to three years old as well as older fish. This indicates that a reproducing population is present in the reservoir.

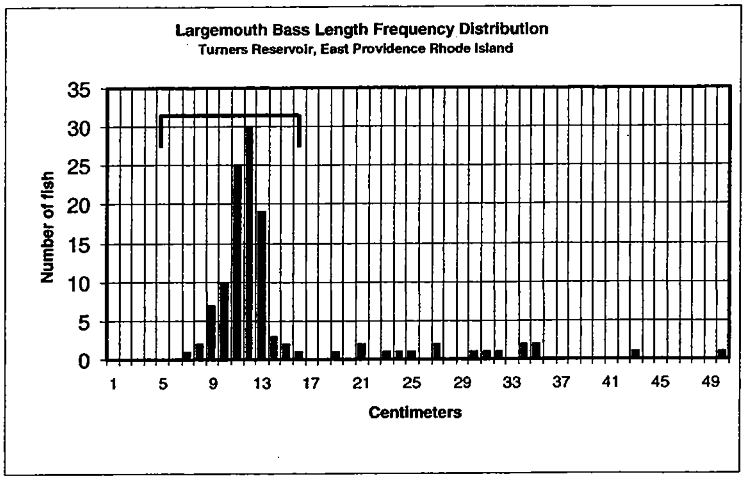


Figure 8. Length Frequency Distribution of Largemouth Bass in Turner Reservoir.

This largemouth bass length frequency distribution from Turner Reservoir is unusual when compared to other New England lakes, because it shows a continuous grouping of smaller fish ranging from approximately 7 centimeters to 16 centimeters, with the most abundant size class collected being approximately 12 centimeters. Largemouth bass length frequency data collected from many other New England lakes (including many man made lakes similar to Turner Reservoir) indicate that this size range generally corresponds to two age classes; young of year, and 1+. Generally in these lakes, the most abundant fish are the young of year (age class 0+) with lengths ranging from 3 to 8 centimeters, with a mean of approximately 5–6 centimeters. However, at Turner Reservoir the most abundant largemouth bass size class was 12 centimeters, which when compared to other similar New England locations corresponds to fish at least one year old. Although fish corresponding to the sizes of young of year were collected, they were at the upper size ranges, with the smallest fish being 6.5 centimeters (as noted earlier young of year generally range between 3 – 8 centimeters). In addition, there were fewer of these fish than the older age 1+ fish.

It is likely that this unique size distribution of largemouth bass at Turner Reservoir is the result of sampling bias. Much of the shallow nearshore area of the south pond (where most of the young of year are found) was inaccessible to the sampling boat by excessive growth of duckweed. Consequently, the deeper sections, which provide habitat for older fish were sampled more intensely than the shallower areas. The result is the disproportionate collection of fish larger than young of year. The fact that young of year were collected; however, indicates the presence of a reproducing largemouth bass population in the reservoir. In addition, the large number of year old fish (age 1+) indicates that not only was there successful largemouth bass spawning in the previous year (1998), but that these fish were able to successfully overwinter and survived in large numbers. Therefore, this indicates the presence of not only largemouth bass spawning habitat, but nursery, and overwintering habitat as well.

Condition Factors of Largemouth Bass - Condition factor (K value) is a coefficient that measures the general "plumpness" or "robustness" of a fish by calculating the relationship between weight and length (see methods section above). Generally, this K value can be an indicator of overall environmental conditions, in that the greater the amount of body weight of a fish relative to its length, the better the food supply and habitat requisites for growth and survival. This coefficient was calculated for each of the largemouth bass collected. The mean (K) of all largemouth bass collected from Turner Reservoir was approximately 1.32. Condition factors of largemouth bass collected from other man made reservoirs similar to Turner Reservoir in New England (including Corps of Engineers Flood Control Projects) have ranged from 1.39 for Elm Brook Pool in New Hampshire, to 1.55 from Hancock Brook Lake in Plymouth Connecticut. Of these two locations, Elm Brook Pool generally had the better (more evenly distributed) largemouth bass population; however, the overall condition factors were lower than the one in Connecticut.

Although the overall condition factor for all of the largemouth bass collected from Turner Reservoir appears slightly lower that from largemouth bass collected from some other New England locations, it may be due to relatively low values of some individual year classes. It appears that the largemouth bass from Turner Reservoir from the younger age classes, (0+ and 1+) have lower values than those fish older than age class 1+. The mean K value calculated from fish less than 18.5 centimeters in length from Turner Reservoir was approximately 1.29, whereas the mean K value from fish that were greater than age 1+ is approximately 1.47. Therefore, although the younger age classes appear to have lower K values than those calculated for largemouth bass from various other man made lakes in New England, the K values of the older fish are within the middle of the range of those collected from other areas. Therefore, it could be assumed that there is adequate food and water quality (i.e. habitat requisites) present in Turner Reservoir for largemouth bass survival and reproduction (at least for the older fish). Although the K values from the younger age classes are slightly lower than some other New England locations, the fact that so many of these fish were collected (particularly age class 1+) suggests that favorable nursery conditions exist to allow growth and winter survival. Therefore, based on the higher condition factors of the older largemouth bass, and the fact that so many younger largemouth bass were collected (although their condition factors were slightly lower than those from other New England locations), Turner Reservoir appears to have suitable food availability (forage) as well as other habitat requisites (i.e. suitable water quality and basin morphology) to sustain a self reproducing largemouth bass population.

In many lakes, largemouth bass (as well as other predator species) feed (forage) upon smaller and/or non-predatory species such as golden shiner and young of white sucker, as well as young of year of other predatory and non-predatory (i.e. bluegill and pumpkinseed sunfish). White sucker were found in Central and North ponds but they

Table 6. Metal Concentrations in Fish Tissue Collected from Turner Reservoir/Central Pond, East Providence Rhode Island[1]

Turner Reservoir Fish Tissue Results

Metals	(ppm) ug/g	Dry wt							
Sample	**Cr**	**Ni**	**Cu**	**Zn**	**As**	**Cd**	**Pb**	**Hg**	**MeHg**
LMB	1	1	1	34.8	0.5	0.1	1	0.567	0.635
llow Bullhead	1	1	1.03	17	0.5	0.125	1	0.403	0.386
Vhite Sucker	1	1	1.43	56.7	0.5	0.1	1	0.179	0.196
Metals	**ug/g**	**Wet Wt**							
Sample	**Cr**	**Ni**	**Cu**	**Zn**	**As**	**Cd**	**Pb**	**Hg**	**MeHg**
LMB	0.229	0.229	0.229	7.983	0.115	0.023	0.229	0.130	0.146
llow Bullhead	0.175	0.175	0.181	2.980	0.088	0.022	0.175	0.071	0.068
Vhite Sucker	0.248	0.248	0.355	14.062	0.124	0.025	0.248	0.044	0.049

[1] Holding times between collection and analysis were exceeded for Hg and Methyl Hg, however, discussion with representatives from Batelle indicated that data would still be reliable. Please note that although the concentration of methyl mercury is greater than total mercury, these results are within the margin of error.

Table 7.

PCB and Pesticide Concentrations in Fish Tissue

Turner Reservoir, Central/North Pond
East Providence Rhode Island

	Largemouth Bass	Yellow Bullhead	White Sucker
	Composite Fillet	Composite Fillet	Composite Fillet
Sample Wet	15.11	6.74	18.16
Sample Dry	3.39	1.31	3.68
Moisture (%)	77.57	80.50	77.22
% Lipid (wet)	0.40	0.68	2.95
Units:	ug/kg, dry wt.	ug/kg, dry wt.	kg, dry wt.

Compound	Largemouth Bass Result ug/kg, dry wt.		Result ug/kg, wet wt. (ppb)	Total PCBs ug/kg Wet Wt	Total PCB's ug/g Wet Wt	Yellow Bullhead ug/kg, dry wt.		ug/kg, wet wt. (ppb)	Total PCB's ug/kg Wet Wt	Total PCB's ug/g Wet Wt	White Sucker ug/kg, dry wt.		ug/kg, wet wt.	Total PCB's ug/kg Wet Wt	Total PCB's ug/g Wet Wt
* Cl2(08)/Cl2(05)	0.72	U	0.00			1.85	U	0.00			0.66	U	0.00		
* Cl3(18)	0.28	U	0.00			0.72	U	0.00			1.67		0.38		
* Cl3(28)	0.32	U	0.00			0.82	U	0.00			9.89		2.25		
* Cl4(44)	0.34	U	0.00			0.87	U	0.00			8.11		1.85		
* Cl4(52)	1.49		0.33			0.91	U	0.00			6.53		1.49		
* Cl4(66)	1.46		0.33			2.52		0.49			13.20		3.01		
* Cl5(101)	3.84		0.86			5.61		1.09			25.75		5.87		
* Cl5(105)	1.44		0.32			2.59		0.50			9.10		2.07		
* Cl5(118)	3.99		0.89			1.62	U	0.00			31.29		7.13		
* Cl6(128)	0.80		0.18			1.53	J	0.30			5.14		1.17		
* Cl6(138)	7.55		1.69			11.83		2.31			65.77		14.98		
* Cl6(153)	4.92		1.10			8.15		1.59			32.17		7.33		
* Cl7(170)	1.06		0.24			2.64		0.51			5.03		1.15		
* Cl7(180)	4.52		1.01			7.50		1.46			35.90		8.18		
* Cl7(187)	1.80		0.40			4.04		0.79			12.15		2.77		
* Cl8(195)	0.28	U	0.00			0.73	U	0.00			4.39		1.00		
* Cl9(206)	1.73		0.39			4.33		0.84			4.27		0.97		
Cl10(209)	0.90		0.20	15.93	0.02	2.12		0.41	20.61	0.02	1.90		0.43	124.05	0.12
Cl3(17)/Cl2(15)	0.26	U	0.06			0.66	U	0.13			0.24	U	0.05		
Cl3(24)/Cl3(27)	0.44	U	0.10			1.14	U	0.22			0.41	U	0.09		
Cl4(49)	0.73		0.16			0.94	U	0.18			10.77		2.45		
Cl4(77)	0.67	U	0.15			1.73	U	0.34			0.62	U	0.14		
Cl5(87)	1.34		0.30			2.06		0.40			11.70		2.67		
Cl5(110)	2.54		0.57			1.30	U	0.25			0.48	U	0.11		
Cl5(126)	0.37	U	0.08			0.95	U	0.19			0.34	U	0.08		
Cl6(129)	0.32	U	0.07			0.82	U	0.16			1.13		0.26		
Cl6(169)	0.27	U	0.06			0.70	U	0.14			0.25	U	0.06		
Cl7(183)	0.96		0.22			1.83		0.36			4.87		1.11		
Cl7(184)	0.40	U	0.09			1.04	U	0.20			0.37	U	0.08		
Cl8(201)/Cl6(157)	0.18	U	0.04			0.47	U	0.09			0.17	U	0.04		
Aldrin	0.27	U	0.06			0.69	U	0.13			0.25	U	0.06		
a-BHC	0.33	U	0.07			0.85	U	0.17			0.30	U	0.07		
b-BHC	0.18	U	0.04			0.47	U	0.09			0.17	U	0.04		
d-BHC	0.20	U	0.04			0.51	U	0.10			0.18	U	0.04		
g-BHC	0.26	U	0.06			0.68	U	0.13			0.86		0.20		
a Chlordane	2.07		0.46			3.82		0.74			31.99		7.29		
g-Chlordane	0.60		0.13			1.83		0.36			0.28	U	0.06		
2,4 DDE	0.70	U	0.16			1.81	U	0.35			0.65	U	0.15		
4,4 DDE	17.45		3.91			29.75		5.80			144.75		32.97		
2,4 DDD	0.60		0.13			0.71	U	0.14			6.34		1.44		
4,4 DDD	3.82		0.86			5.90		1.15			33.73		7.68		
2,4 DDT	0.76	U	0.17			1.95	U	0.38			0.70	U	0.16		
4,4 DDT	0.44	J	0.10			1.15	U	0.22			4.67		1.06		
Dieldrin	1.74		0.39			2.78		0.54			16.73		3.81		
Endosulfan I	0.45	U	0.10			1.16	U	0.23			0.41	U	0.09		
Endosulfan II	0.37	U	0.08			0.95	U	0.19			0.34	U	0.08		
Endosulfan sulfate	0.40	U	0.09			1.04	U	0.20			0.37	U	0.08		
Endrin	0.51	U	0.11			1.31	U	0.25			0.47	U	0.11		
Endrin aldehyde	0.37	U	0.08			0.95	U	0.18			0.34	U	0.08		
Endrin ketone	0.39	U	0.09			1.01	U	0.20			0.36	U	0.08		
Heptachlor	0.48	U	0.11			1.24	U	0.24			0.44	U	0.10		
Heptachlor epoxide	0.47		0.11			0.85	U	0.17			3.35		0.76		
Hexachlorobenzene	0.22	U	0.05			0.57	U	0.11			1.23		0.28		
4,4-DDMU	1.06		0.24			2.27		0.44			12.83		2.92		
a-chlordene	0.80	U	0.18			2.06	U	0.40			0.74	U	0.17		
trans Nonachlor	4.27		0.96			5.31		1.04			27.89		6.35		
cis Nonachlor	1.83		0.41			1.97		0.38			11.45		2.61		
Methoxychlor	0.41	U	0.09				U	0.00			0.37	U	0.09		
Mirex	0.31	U	0.07		0.0000		U	0.00			0.30		0.07		
Surrogate Recoveries:															
Cl3(34)	65										71				

Field Sample Data

Table 8.

Concentrations of Polycyclic Aromatic Hydrocarbons in Fish Tissue
Turner Reservoir, East Providence Rhode Island

	Largemouth Bass Composite			Yellow Bullhead Composite			White Sucker Composite
	Turner and Central Pond			Turner			Centr
	Fillet			Fillet			
Matrix:	Tissue			Tissue			
Collection Date:	09-Sep-99 and 23-Sep-99			09-Sep-99 and 24-Sep-99			23-
Extraction Date:	27-Dec-99			27-Dec-99			27-
Analysis Date:	12-Jan-00			12-Jan-00			12-
Sample Wet Wt. (g):	15.11			6.74			
Sample Dry Wt. (g):	3.39			1.31			
Moisture (%):	77.57			80.50			
% Lipid (wet):	0.40			0.68			
Units:	**ug/kg, dry wt.**		**ug/kg, wet wt** (ppb)	**ug/kg, dry wt.**		**ug/kg, wet wt** (ppb)	**ug/kg,**
Benzo(b)thiophene	0.93	U	0.21	2.41	U	0.47	
Naphthalene	6.73		1.51	11.61		2.26	
2-Methylnaphthalene	3.00		0.67	4.29		0.84	
1-Methylnaphthalene	1.73		0.39	2.46		0.48	
2,6-Dimethylnaphthalene	0.40	U	0.09	1.04	U	0.20	
2,3,5-Trimethylnaphthale	0.66	U	0.15	1.69	U	0.33	
Biphenyl	0.26	U	0.06	0.68	U	0.13	
Acenaphthylene	0.32	U	0.07	0.82	U	0.16	
Acenaphthene	0.20	U	0.05	0.53	U	0.10	
Dibenzofuran	0.30	U	0.07	0.78	U	0.15	
Fluorene	1.45		0.33	1.15	U	0.22	
Phenanthrene	3.38		0.76	5.29		1.03	
Anthracene	0.35	U	0.08	0.91	U	0.18	
1-Methylphenanthrenes	0.47	U	0.10	1.21	U	0.24	
Dibenzothiophene	0.68	U	0.15	1.76	U	0.34	
Fluoranthene	0.46	U	0.10	3.05		0.59	
Pyrene	1.51	U	0.34	3.89	U	0.76	
Benzo(a)anthracene	0.31	U	0.07	0.81	U	0.16	
Chrysene	0.34	U	0.08	0.87	U	0.17	
Benzo(b)fluoranthene	0.33	U	0.07	0.86	U	0.17	
Benzo(k)fluoranthene	0.24	U	0.05	0.61	U	0.12	
Benzo(e)pyrene	0.21	U	0.05	0.54	U	0.11	
Benzo(a)pyrene	0.50	U	0.11	1.28	U	0.25	
Perylene	1.54		0.35	3.71	U	0.72	
Indeno(1,2,3-c,d)pyrene	0.94	U	0.21	2.43	U	0.47	
Dibenz(a,h)anthracene	0.72	U	0.16	1.85	U	0.36	
Benzo(g,h,i)perylene	1.49	U	0.33	3.83	U	0.75	
						11.77	
Surrogate Recoveries:							
Naphthalene-d8	62			57			
Phenanthrene-d10	61			60			
Chrysene-d12	61			60			
ME - Estimate, significant matrix interference.							

were not found in South Pond . Golden shiner, although historically found in Turner Reservoir, were not collected in the 1999 sampling. Therefore, it appears that the largemouth bass in Turner Reservoir are feeding primarily on other species such as the abundant young of pumpkinseed and bluegill, rather than on white sucker (for the fish in the southern pond) or golden shiner.

It is possible that the absence of golden shiner in the sampling from Turner Reservoir could be partially due to sampling bias. Electrofishing, which was the primary method of sampling conducted in Turner Reservoir generally collects fish from the near shore areas, and the deeper areas adjacent to shore. Golden shiners are a pelaegic schooling species found more in open water areas than in close near shore areas. Therefore, electrofishing of the nearer shore areas is less likely to collect golden shiner than sampling of the open water areas. However, it should be mentioned that the single gillnet which was set in the deeper area of South Pond did not collect golden shiner, but did collect white perch, which are another schooling fish species. Generally, in lakes where golden shiner are extremely abundant, at least some are collected in gillnets. The fact that none were collected at all by either gillnetting or electrofishing suggests that these are not abundant in Turner Reservoir. Therefore, it would appear that these species are not the primary forage species for the largemouth bass in Turner Reservoir, but other species (i.e. bluegill, pumpkinseed) are.

(d) Contaminant Levels in Fish. In order to determine if chemical contaminants were present in fish from Turner Reservoir, three samples each of largemouth bass, white sucker, and yellow bullhead were collected/analyzed. Tissue from these species was composited to create three composites, one for each target species. These composite samples were analyzed for metals, polycyclic aromatic hydrocarbons (PAH), PCBs and Pesticides. Largemouth bass were selected because they are considered popular gamefish, as well as predators, susceptible to bio-accumulation and concentration of metals and other contaminants. Yellow bullhead was selected as it is a popular bottom dwelling gamefish and because it is exposed to bottom sediments. White sucker, while not necessarily a popular gamefish, are also bottom dwelling species, exposed to the sediment, feeding along the bottom and ingesting detritus and other material.

Attempts were made to use individual fish specimens from various sampling locations within the Turner Reservoir complex in order to determine an overall value for the entire area (i.e. presence or absence). However, largemouth bass were the only species that were found throughout Turner Reservoir. White sucker was found only in Central Pond, and Yellow bullhead was found only in South Pond. Therefore, the composites of white sucker and yellow bullhead are representative of Central/North Pond and South Pond respectively, rather than the entire complex as are for largemouth bass from at least one of the three composite tissue samples (of each of the three species). Although these tissue samples were also tested for chromium, arsenic, nickel, and lead these metals were not detected at the method detection levels used. High concentrations of some of these metals in fish tissue can adversely affect the health of individuals consuming these fish. Of these metals, the Food and Drug Administration (FDA) and U.S. Environmental Protection Agency (EPA) have established health criteria for levels in fish tissue for only mercury and cadmium, respectively. The FDA establishes action levels for certain contaminants, which are considered to be the maximum concentrations of that contaminant in fish before issuing specific health advisories, while the EPA uses risk analysis. Risk analyses determines the percentage of risk associated with fish consumption based upon the amount of fish consumed and the concentration of the target contaminant. These risk analyses have been published in the EPA publication "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume II, Risk Assessment and Fish Consumption Limits, Second Edition, 1997". The FDA has established an action level of 1 ppm (wet weight) for methyl mercury in fish tissue, and the EPA, has calculated risks associated with consumption of fish with cadmium concentrations exceeding excess of 0.06 ppm.

Mercury levels (both of total and of methyl-mercury) found from all three species composites were considerably less than the FDA action level of 1 ppm. Total mercury concentrations in Turner Reservoir fish were 0.044 ppm, 0.071 ppm and 0.130 ppm for the white sucker, yellow bullhead and largemouth bass composites respectively. It should be mentioned that these are levels of total mercury, which would include methyl-mercury as well. Most mercury found in tissue is in the form of methyl mercury, which is highly toxic (i.e. much more than elemental mercury). These fish from Turner Reservoir were also tested for methyl mercury. As would be expected, the concentrations of methyl-mercury were very close to the concentrations of total mercury, indicating that most of the total mercury found was in the form of methyl mercury. The methyl-mercury concentrations for the above fish tissue composite samples were 0.049 ppm, 0.068 ppm, and 0.146 ppm for white sucker, yellow bullhead and largemouth bass respectively. The EPA risk assessments consider 0.1 ppm in fish tissue as the highest concentration allowable for children before there is considerable risk of health effects. The above data indicate that the largemouth bass collected from Turner Reservoir exceed that level. Therefore, according to the EPA risk assessment, levels of methylmercury in largemouth bass may pose a health risk to children consuming these fish. It should also be noted that largemouth bass (a predator) had the highest mercury concentrations compared to the yellow bullhead and white sucker. This is expected, due to the bio-accumulation/concentration that occurs up the food chain, since these appear to be the top predators in the reservoir.

Although FDA action limits have not been established for the other metalsdetected in the fish tissue, the U.S. Environmental Protection Agency calculated risk analyses for some of them. Risk analyses have been calculated for cadmium, as well as some of the other organic contaminants that were analyzed in the fish at Turner Reservoir. For cadmium, risk associated with consumption of fish containing this metal (for the general public) begins at fish tissue concentrations in excess of 0.3 mg/kg (or ppm). For children it begins at concentrations greater than 0.06 mg/kg. Based upon these data, the levels of cadmium found in the fish samples from Turner Reservoir, (all of which were below 0.03 mg/L (or ppm)) are not high enough to present a risk to human health.

Other metals that can have adverse health effects to humans include arsenic (As), lead (Pb), and chromium, however, concentrations of these three metals in the fish tissue analyzed (for all three species) were below the detection limits of 0.5, 1.0, and 1.0 ppm for arsenic, lead and chromium respectively. Although FDA action levels for these metals in fish tissue have not been established, comparison can be made with other countries, that have established legal limits. Legal limits for arsenic in fish tissue vary from 0.1 to 10 ppm (NED 1995) and for lead, the legal limits vary from 0.5 ppm to 10 ppm. It should be noted that the lowest level in some of these ranges is actually below the detection limits used in this study. Therefore, harmful levels of these metals could still exist in the fish tissue from Turner Reservoir, but were not detected by the method used in this study. Only one foreign country had an established legal limit for chromium which was 1 ppm. However, all of the fish tissue samples analyzed from the Turner Reservoir had concentrations below 1ppm.

Results of the PCB analysis are presented in Table 7. Levels of total PCB's recovered from all of the tissue composite samples ranged from 0.02 ppm (wet weight) for largemouth bass and yellow bullhead, to 0.12 ppm for white sucker. These are below the FDA action level of 2 ppm (wet weight) for PCB's. However, EPA has established monthly fish consumption limits for PCB's (EPA, Fact Sheet, September 1999, Polychlorinated Biphenyls (PCBs) Update; Impact on Fish Advisories), which are much more conservative. These limit the consumption of fish with concentrations greater than 0.016 ppm to only two meals a month (for cancer health endpoints), and for levels greater than 0.097 ppm (which would apply to white sucker) no consumption is recommended at all. Therefore although the PCB levels in fish tissue from Turner Reservoir are lower than the FDA action levels, health risks may still exist, particularly for white sucker consumption.

Pesticide results from the three tissue composite samples are presented in Table 7. Specific EPA risk assessment concentrations have been calculated for the DDT and its degradation products (DDE and DDD), as well as total Chlordane, Dieldrin, Endrin, Heptachlor Epoxide, Hexachlorobenzene and Mirex. For the tissue samples analyzed, the concentrations of these contaminants were all below the EPA risk published in the 1997 publication noted above.

Concentrations of Polycyclic Aromatic Hydrocarbons (PAH) from the three composite fish tissue samples from Turner Reservoir are presented in Table 8. Total PAH concentrations ranged from 0.005 ppm (wet weight) for the largemouth bass composite, to 0.008 ppm for the Yellow Bullhead composite, and 0.023 ppm for the white sucker composite. These concentrations are for the 27 PAHs listed in Table 8. Of these 27 PAHs listed, the EPA has identified 17 target PAHs as being of the greatest concern to human health. Risks are associated with consumption of fish containing total concentrations of these 17 target PAHs greater 0.0001 ppm. It is obvious that the concentrations of these target PAHs in fish tissue from Turner Reservoir exceed this, particularly, those from the white sucker collected from Central Pond. It should be noted that the PAHs that were highest in all three species were Napthalene, 2-Methylnapthalene, and Phenanthrene. Phenanthrene is the only target analyte of most concern to human health.

Recommendations for health advisories are generally determined by the state departments of health, and depend upon a variety of factors, primarily how the fish is prepared, as well as numbers of meals consumed. Therefore, it is not in the scope of this study to determine whether or not health advisories should be established, but rather to indicate the potential of a health problem based upon the presence of various contaminants in fish tissue. Therefore, it is recommended that these results be sent to the Rhode Island Department of Health for further evaluation, to determine if any type of fish consumption advisories should be implemented.

(e) Sediment Chemistry. Sediment samples were collected from two locations in South Pond (TR#2 and TR#3) and one location in Central Pond (CP#1). These were analyzed for the same compounds as the tissue samples, with the addition of total organic carbon and grain size. Generally, all of the sediments had detectable levels of the metals tested for, with the sample from TR#2, the center of South Pond having the highest concentrations. Detectable levels of PCBs, Pesticides, and PAHs were also recovered from each of the sediment samples, with site TR#3 (the most downstream) having the highest concentrations of all of these.

Concentrations of metals in the Turner Reservoir/Central Pond Sediments are presented in Table 9. Metals in the highest concentrations were copper, nickel and zinc. All concentrations of each metal analyzed with the exception of arsenic, were above the Long and Morgan Biological effects levels (1990, from NED, 1994) for both Low levels (ER-L) and Median levels (ER-M) as well as the Ontario Ministry of the Environment Low Effects Levels (LEL). Concentrations of zinc, arsenic, lead and mercury in some samples did not exceed the Ontario Ministry's Severe Effects Levels (SEL). The Long and Morgan Biological effects levels are statistically derived measures of sediment pollutant concentrations having effects on sensitive aquatic life. The ER-L is a concentration at the low end of the range in which effects were observed; the ER-M is a concentration approximately midway in the range of reported values associated with biological effects. Accordingly, the ER-L value indicates the low end of the range of concentrations in which effects were observed or predicted. They were considered (in the published document) as the concentrations above where adverse affects may begin or are predicted among sensitive life states and/or species as determined in sublethal tests. The ER-M values were considered the concentrations above where effects were frequently always observed or predicted among most species.

Table 9.

Concentrations of Metals in Sediments
Turner Reservoir, East Providence Rhode Island

(ppm)

(concentrations in µg/g dry weight - not blan

Client ID	Client Description	Matrix	Sample Wet Wt. (g)	Sample Dry [a] Wt. (g)	Moisture (%)	Cr ICP-MS	Ni ICP-MS	Cu ICP-MS	Zn ICP-MS		As ICP/MS
SAMPLE RESULTS											
CP#1	Central Pond	Sediment	94.26	12.704	86.52	407	564	1350	731	B	11.3
TR#3	Turner Reservoir Site 3	Sediment	105.77	28.269	73.27	350	1050	1400	678	B	6.54
TR#2	Turner Reservoir Site 2	Sediment	88.46	12.395	85.99	897	1750	2710	1500	B	13.5
Long and Morgan											
Biological Effects Levels											
ER-L						**80.0**	**30.0**	**70.0**	**120**		**33.0**
ER-M						**145.0**	**50.0**	**390.0**	**270**		**85.0**
Ontario Guidelines (OME)											
Effects Levels											
LEL						**26.0**	**16.0**	**16.0**	**120.0**		**6.0**
SEL						**110.0**	**75.0**	**110.0**	**820.0**		**33.0**

[a] Approximately 0.25-g aliquots of homogenous sample were digested and analyzed.

The Ontario Ministry of the Environment (OME) Sediment Quality Guidelines have also been developed to protect aquatic life. The OME Severe Effects Levels are applied to sediment containing concentrations of contaminants where a pronounced disturbance of the sediment-dwelling community can be expected. This is considered the concentration of a compound in the sediment that would be detrimental to the majority of benthic species, and the sediment would be classified as heavily polluted. While the Long and Morgan Biological Effects levels have been derived largely from a database of primarily marine and estuarine studies, the OME values were derived largely using data from the Great Lakes and other freshwater bodies, and are therefore more applicable to freshwater aquatic life. However, the Long and Morgan Biological Effects Levels are also recognized as applicable for evaluating effects for freshwater aquatic life in lieu of other criteria. (NED, 2000). As noted, most of the concentrations of the above metals in Turner Reservoir sediment exceeded the concentrations where biological effects would be expected to occur in aquatic life, according to both the Long and Morgan Biological Effects Levels, and the OME Sediment Quality Guidelines.

The ER-L and ER-M concentrations for each of the metals tested for are presented in Table 9. The concentrations of metals in Turner Reservoir sediments ranged from over 30 times the ER-M for nickel from site TR#2 (1750 ppm) to approximately 3 times the ER-M level for Lead (Pb). Therefore, based upon these criteria, biological effects from these elevated metals concentrations could be expected or observed among most species in Turner Reservoir exposed to Turner Reservoir sediment. In addition, some of these metals were in concentrations above some state clean-up standards and/or above levels in sediments from other locations considered to be highly polluted. For cadmium, the sediment clean-up standard for the State of Washington is 6.7 ppm, and the concentration of cadmium detected in the sediment from site TR #2 was 157 ppm, with levels from the other two locations averaging approximately 75 ppm. Also for Zinc, the level of 1500 ppm detected in the sediment from site TR#2, exceeds the State of Washington Sediment Cleanup Standard of 960 ppm, as well as the Great Lakes Sediment Guideline of greater than 200 ppm for heavily polluted sediment. Also, although concentrations of arsenic (which ranged from 6.54 to 13.5) were less than the ER-L and ER-M levels, they exceeded the OME Low Effects Level (LEL) level of 6 ppm as well as the Great Lakes Sediment Guidelines of greater than 8 ppm for heavily polluted sediment. It should be noted that although these elevated concentrations of metals are present in the sediments of Turner Reservoir, they may not be bound-up in the sediments. In order to determine bioavailability, Acid Volatile Sulfides - Simultaneously Extracted Metals Analysis would be required, which was not part of the scope of this study. Therefore, it is recommended that the metals data be forwarded to the State of Rhode Island DEM for further evaluation in order to determine if any clean-up actions need to be implemented.

ER-M level of 400 ppb, (i.e. the concentration above where effects were frequently always observed or predicted among most species), they were above the ER-L level of 50 ppb (i.e.the concentrations above where adverse affects may begin or are predicted among sensitive life states and/or species as determined in sublethal tests).

Sediment concentrations of pesticides determined from the three sites in Turner Reservoir/Central Pond are presented in Table 10. Generally, these were highest at site TR#3, (the most downstream site in Turner Reservoir). Out of a total of 23 different pesticides that were analyzed, detectable levels of total chlordane, total DDT, Dieldren, Endosulfan II, were recovered from all three locations; and detectable levels of methoxychlor were recovered from the Central Pond site (CP-#1). Concentrations of some of these pesticides exceeded the biological effect levels. Highest pesticide concentrations were those of 4'4 DDE, which was 11.94 ppb at site TR#2, (the center of South Pond), 25.89 ppb at site CP#1 (Central Pond) and 60.50 ppb at site TR#3, the most downstream site. All of these concentrations exceeded both the ER-L (2 ppb) and the ER-M level (15 ppb), with the exception of site TR#2 which exceeded only the ER-L. In addition, other DDT related compounds, (4'4' DDT and 4'4' DDD) were found in concentrations higher than ER-L's but lower than the ER-M's at each of the three Turner Reservoir sites. The other pesticides noted, were recovered from the sediments in lower concentrations, and therefore will not be discussed. However, this does not mean that they are at concentrations that do not effect sensitive aquatic life, but rather that it is beyond the scope of this study to investigate each one individually.

Detectable levels of 23 PAHs were recovered from all three of the Turner Reservoir sampling sites. Theses results are presented in Table 11. Highest concentrations (calculated by summing the total from each location) were found in site TR#3, (the most downstream site). The individual compounds recovered in the highest concentrations were fluoranthene and pyrene. Fluoranthene had a maximum concentration of 662.24 ppb at site TR#3, and Pyrene, which had a maximum concentration of 632.73 ppb at the same site. The concentrations of fluoranthene were all below the ER-M of 3.6 ppm (3600 ppb) however slightly above the ER-L level of 0.6 ppm (600 ppb). Concentrations of pyrene were also above the ER-L level of 0.35 ppm, (350 ppb) but below the ER-M level of 2.2 ppm (2200 ppb). Other compounds that were recovered in high concentrations were benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(e)pyrene and benzo(a) pyrene. Levels of benzo(a)pyrene from all the collection sites were at or below the ER-L level of 0.4 ppm, and all below the ER-M level of 2.5 ppm. ER-L and ER-M levels were not applicable to the total concentration of both benzo(b)fluoranthene and benzo(k)fluoranthene; however, the highest total concentration of these two compounds of 1073.3 ppb (1.073 ppm) from site TR#3 was below various other sediment criteria.

The U.S. EPA has proposed some sediment criteria to various PAHs (US EPA, 1993) to protect benthic organisms. For fluoranthene, the level is 600 ppm normalized to total organic carbon (TOC). It should be noted, that the total concentrations of all of the PAHs summed together (at each site) are below this value for

Table 10.
Concentrations of PCBs and Pesticides in Sediment
Turner Reservoir, East Providence Rhode Island

	CP#1				TR#3				TR#2			
Client ID:	CP#1				TR#3				TR#2			
Client Description:	Central Pond				Turner Reservoir Site 3				Turner Reservoir Site 2			
Matrix:	Sediment				Sediment				Sediment			
Collection Date:	10-Nov-99				10-Nov-99				10-Nov-99			
Extraction Date:	06-Dec-99				06-Dec-99				06-Dec-99			
Analysis Date:	06-Jan-00				06-Jan-00				06-Jan-00			
Sample Wet Wt. (g):	30.74				30.47				29.16			
Sample Dry Wt. (g):	10.41				6.87				6.50			
Moisture (%)	66.13				77.44				77.70			
Units:	ug/kg, dry wt.			Total PCB's	ug/kg, dry wt. (ppb)			Total PCB's				Total PCB's
			(ppb)				(ppb)				(ppb)	
* Cl10(209)	2.17		2.17		4.40		4.40		2.85		2.85	
* Cl2(08)/Cl2(05)	1.18	U	0.00		1.79	U	0.00		1.89	U	0.00	
* Cl3(18)	2.74		2.74		5.40		5.40		1.04		1.04	
* Cl3(28)	7.01		7.01		11.23		11.23		3.26		3.26	
* Cl4(44)	5.72		5.72		10.34		10.34		3.07		3.07	
* Cl4(52)	7.54		7.54		14.14		14.14		2.92		2.92	
* Cl4(66)	6.77		6.77		12.51		12.51		2.84		2.84	
* Cl5(101)	11.55		11.55		20.57		20.57		4.39		4.39	
* Cl5(105)	2.92		2.92		5.77		5.77		1.51		1.51	
* Cl5(118)	7.39		7.39		12.99		12.99		3.01		3.01	
* Cl6(128)	1.68		1.68		3.28		3.28		0.89		0.89	
* Cl6(138)	8.46		8.46		14.91		14.91		5.07		5.07	
* Cl6(153)	10.82		10.82		19.15		19.15		5.68		5.68	
* Cl7(170)	8.05		8.05		11.29		11.29		15.75		15.75	
* Cl7(180)	2.41		2.41		4.61		4.61		2.10		2.10	
* Cl7(187)	3.53		3.53		5.38		5.38		3.56		3.56	
* Cl8(195)	0.13	U	0.00		0.20	U	0.00		0.21	U	0.00	
* Cl9(206)	1.98		1.98	181.46	4.63		4.63	321.19	2.59		2.59	121.08
2,4 DDD	1.08				2.81				0.64			
2,4 DDE	2.08				4.48				1.05			
2,4 DDT	0.64	U			0.98	U			1.03	U		
4,4 DDD	5.76				13.30				4.33			
4,4 DDE	25.89				60.50				11.94			
4,4 DDT	3.19				4.85				3.61			
a-BHC	0.43	U			0.65	U			0.68	U		
Aldrin	0.12	U			0.19	U			0.20	U		
b-BHC	0.12	U			0.18	U			0.19	U		
cis Chlordane	5.68				5.22				3.51			
Cl4(49)	2.69				5.39				1.00			
Cl5(87)	4.25				7.88				1.89			
Cl7(183)	1.24				2.42				0.81			
Cl7(184)	0.17	U			0.26	U			0.27	U		
d-BHC	0.12	U			0.18	U			0.19	U		
Dieldrin	1.47				1.97				0.91			
Endosulfan I	0.28	U			0.42	U			0.45	U		
Endosulfan II	2.08				3.27				1.38			
Endosulfan sulfate	0.11	U			0.16	U			0.17	U		
Endrin	0.45	U			0.68	U			0.72	U		
Endrin aldehyde	0.45	U			0.68	U			0.72	U		
g-BHC	0.15	U			0.22	U			0.23	U		
g-Chlordane	3.46				4.09				2.54			
Heptachlor	0.13	U			0.19	U			0.20	U		
Heptachlor epoxide	0.13	U			0.20	U			0.21	U		
Methoxychlor	1.03				0.44	U			0.47	U		
Surrogate Recoveries:												
Toxaphene	16.70	U			16.70	U			16.70	U		
Cl3(34)	90				73				79			
Cl5(112)	50				43				71			

ME - Estimate, significant matrix interference.
B - Analyte detected at >5X the MDL.
U - Not detected; sample specific MDL reported.
& - QC value outside the accuracy or precision criteria goal.
J - Detected, but below the sample specific MDL.

* - NS&T Congener - should be included in summation for total PCB, where Total PCB = (Sum of detected NS&T congeners) x 2
In case of ND, use a value of 0.0 in summation

Field Sample Data

Table 11.

Concentrations of Polycyclic Aromatic Hydrocarbons in Sediment
Turner Reservoir, East Providence Rhode Island

Client ID:	**CP#1**		**TR#3**		**TR#2**	
Client Description	**Central Pond**		**Turner Reservoir Site 3**		**Turner Reservoir Site 2**	
Collection Date	11/10/99		11/10/99		11/10/99	
Extraction Date	12/06/99		12/06/99		12/06/99	
Analysis Date	01/07/00		01/07/00		01/07/00	
Sample Wet Wt. (g):	30.74		30.47		29.16	
Sample Dry Wt. (g):	10.41		6.87		6.50	
Moisture (%)	66.13		77.44		77.70	
Units:	**ug/kg, dry wt.**	**Total**	**ug/kg, dry wt.**	**Total**	**ug/kg, dry wt.**	**Total**
	(ppb)		(ppb)		(ppb)	
Naphthalene	43.30		41.99		24.90	
2-Methylnaphthalene	24.10		28.53		12.72	
1-Methylnaphthalene	13.54		15.25		7.33	
2,6-Dimethylnaphthalene	28.55		31.74		11.77	
Biphenyl	208.77		199.73		59.63	
Acenaphthylene	56.83		84.78		39.56	
Acenaphthene	19.04		27.01		11.47	
Fluorene	36.26		64.60		24.96	
Phenanthrene	237.46		325.33		176.22	
Anthracene	68.85		89.06		44.15	
1-Methylphenanthrene	37.66		52.30		29.46	
Fluoranthene	618.24		662.24		521.41	
Pyrene	576.03		632.73		466.05	
Benz(a)anthracene	267.29		278.23		211.26	
Chrysene	479.30		544.59		350.99	
Benzo(b)fluoranthene	527.47		569.07		360.17	
Benzo(k)fluoranthene	452.66		504.10		325.69	
Benzo(e)pyrene	452.23		510.86		308.29	
Benzo(a)pyrene	395.65		434.94		288.64	
Perylene	239.24		607.39		138.09	
Indeno(1,2,3-c,d)pyrene	425.20		484.56		286.80	
Dibenz(a,h)anthracene	94.66		109.64		62.23	
Benzo(g,h,i)perylene	422.85		481.59		284.90	
		#####		6780.28		4046.67
Surrogate Recovery (%)						
Naphthalene-d8	60		53		58	
Phenanthrene-d10	71		63		73	
Chrysene-d12	68		59		75	

U, not detected; sample-specific MDL reported.
J, detected, but below the sample-specific MDL.
& = QC data outside of Data Quality Objectives.
NA = Not Applicable.

one individual compound (particularly when normalized to Total Organic Carbon). Therefore, it appears that although some individual PAHs may be above the biological effect levels for sensitive organisms, generally, the concentrations of PAHs in the Turner Reservoir sediment are below the levels where biological effects would be expected in all organisms exposed to the sediment.

6. Conclusions. Turner Reservoir appears to support a good largemouth bass population, which will provide a good recreational warm water fishery. Other species present include white sucker, yellow bullhead, perch, yellow perch, bluegill and pumpkinseed. Although the concentrations of methyl mercury in the largemouth bass tissue composite were below the FDA action level, they were above some of the concentrations calculated by the EPA for consumption. Therefore, it is recommended that the results of the fish tissue data be reviewed by the State DOH in order to determine if further study and/or health advisories should be initiated.

If it is determined that the existing health risk for consumption of largemouth bass is not acceptable, a catch and release recreational fishery could be established. The abundance of larger/older largemouth bass present in this reservoir would be a strong attraction to sportfishermen.

Concentrations of PCB's were below the FDA action level (2 ppm) for all three composite fish tissue samples. The white sucker composite sample had the highest concentration of PCB's (0.12 ppm). Although this is below the FDA action level, it is above the EPA risk criteria of 0.016 ppm for (cancer health endpoints) where consumption would be limited. Concentrations (0.02 ppm) for largemouth bass and yellow bullhead exceeded this threshold as well. Although white sucker is not necessarily a popular gamefish, it is often caught as food supplement by subsistence fishermen. Therefore, it is recommended that the Rhode Island DOH review these data in order to determine if further study and/or health advisories should be initiated.

Concentrations of PAHs in the fish tissue were also above some EPA health risk criteria for some of the compounds detected. These data should also be reviewed by the State DOH in order to determine if fish health advisories should be implemented.

Trace metals, total PCB's, pesticides, and PAHs were all detected in the sediment from Turner Reservoir. Many of these compounds were detected in concentrations above criteria where adverse effects could be expected to occur in aquatic life forms exposed to this sediment. Sediment concentrations of some metals (i.e. cadmium) were not only above biological effect levels, but also above clean-up standards established by some states (i.e.Washington). Rain events, resulting high flows in the Ten Mile River, seasonal turnover and mixing by wind can stir up and re-suspend sediments in Turner Reservoir. Therefore, it is not recommended that Turner Reservoir be used as a water supply, given the elevated concentrations of various contaminants in the sediment, and the potential for sediment re-suspension, unless a filtration system could be implemented that would adequately remove them.

General observations indicate a nutrient enriched water body. Large amounts of floating duckweed covered much of the shoreline during the summer months, making sampling difficult. In addition, large populations of ducks, domestic/wild geese, and swans inhabit the reservoir. Resulting fecal contamination of the shoreline was noted from these waterfowl, and it is very likely that this contributes to much of the nutrient enrichment in the Reservoir.

C. Wetlands and Habitat

1. Habitat Description. The Turner Reservoir Complex is approximately two miles long as measured from the dam at the outlet to the inflow of the Ten Mile River on its north end. It consists of a series of three ponds with a combined surface area of 225 acres. Route 152 crosses the reservoir approximately 0.75 miles upstream from the outlet dam, and separates the southern pond, referred to as Turner Reservoir from Central Pond immediately upstream. Central Pond is long and narrow, and extends upstream (from the Route 152) causeway an approximate distance of 0.7 miles, to a wider area near the inflow which on some maps is referred to as North Pond, although it is often not distinguished from Central Pond. North Pond continues for approximately 0.5 miles to the inflow of the Ten-Mile River. As noted previously, in this study the entire complex was considered as Turner Reservoir. Widths of the various ponds in the reservoir complex vary, ranging from approximately 2000 feet maximum in the southern section (Turner Reservoir Proper) downstream from Route 152, narrowing to approximately 500 feet in Central Pond, and widening again in the Northern section (North Pond) to approximately 2000 feet. Maximum depths range from 9-11 feet in the centers of both Turner Reservoir and Central Pond.

Generally, the banks are steeply sloped throughout most of the entire complex, dropping off rapidly from the shoreline to depths of approximately two feet close to the water's edge. Exceptions to this are found in the northern upstream sections of Central/North Pond, parts of the western shore of the southern pond (Turner Reservoir) and a small cove on the eastern side of Turner Reservoir. Most of the perimeter of the reservoir is well vegetated and/or wooded residential property, although a small wooded park is located along the eastern shore (Seekonk side) of the southern pond (Turner Reservoir) abutting the dam at the outflow. In some areas of Central Pond, on the eastern side, overhanging trees have fallen into the water, creating cover for resident fishes. The shoreline immediately upstream from the dam itself is rock rip-rapped on both sides.

2. Wetlands. The relatively steep topography of the shoreline perimeter of the Turner Reservoir complex precludes the existence of extensive wetlands (i.e. other than open water) within its immediate boundaries. In Turner Reservoir proper (i.e. the southern pond) wetland habitat other than open water is limited primarily to the margins of the impoundment along the western shore (East Providence side), as well as the edges of a shallow cove on the eastern shore (Seekonk side). In addition, a large area of wetland exists near the inflow of the Ten-Mile River at North/Central Pond. The small

cove in the southern pond located on the Seekonk side of Turner Reservoir is characterized by a wide area of emergent and floating aquatic vegetation along the near shore area, while the area of the northern pond contained a combination of scrub shrub, floating and emergent aquatic vegetation.

Classification of these two wetland habitats according to Cowardin et al, (1988) would be Lacustrine Aquatic Bed, and Lacustrine Emergent for the area in the southern pond, and Palustrine Scrub Shrub (primarily) for the areas near the inflow of the Ten Mile River. In addition, most of the shore on the East Providence side of the southern section of Turner Reservoir contains rooted floating aquatic bed vegetation (water lily) as well as emergent aquatic vegetation (pickerel weed). During the time of sampling, extensive mats of duckweed covered the shore along most of the perimeter of the entire Turner Reservoir Central/North Pond complex. This duckweed produced a foul septic odor, which permeated the air in the immediate vicinity of the shoreline.

D. Suitability of Central Pond Well field

1. Summary of Findings for Groundwater Quality. The Corps of Engineers was tasked by the City of East Providence to perform an investigation of the current groundwater quality conditions for consideration of the ground water as a potential long-term, back-up water supply for the City. Groundwater samples collected from three locations indicate that high levels of iron and manganese are still a problem as well as the presence of low levels of volatile organic contamination. Further groundwater investigation to determine the nature and extent of the volatile organic contamination would have to be undertaken prior to the development of the groundwater as a drinking water source. The treatment of the groundwater for volatile organic contamination, iron, and manganese prior to distribution to the community could have the potential to be an expensive procedure for the City.

2. Background and Purpose. Prior to 1969, East Providence obtained its municipal water supply from the Turner Reservoir and from four groundwater wells located in the Ten Mile River Aquifer. The high levels of dissolved iron and manganese in the groundwater ultimately caused the City to abandon the wellfield around 1970 and seek water from an alternative source. The City currently obtains its water from the City of Providence. This preliminary groundwater investigation examines the feasibility of potentially using the now abandoned Central Pond well field as a back-up water supply and examines the groundwater quality at three locations within the Turner Reservoir area.

3. Investigation. On November 10, 1999, three groundwater monitoring points were installed at three locations in the Turner Reservoir and Central Pond areas (see Figure 9). One monitoring point was located within the abandoned wellfield and the other two monitoring points were located near the Bridgham Farm area and the dam. The locations were selected primarily based on access for the drill rig and were spaced around Turner Reservoir and Central Pond so as to give a cursory representation of the current

groundwater quality conditions in the area. These monitoring points consisted of three one-inch diameter wells, two of which are flush mounted with the ground surface and one where the casing sticks up above the ground surface. The monitoring points are outfitted with a 10 foot slotted well screen. One groundwater sample from each monitoring point plus a quality control sample were collected to evaluate the subsurface water quality. No soil samples were collected.

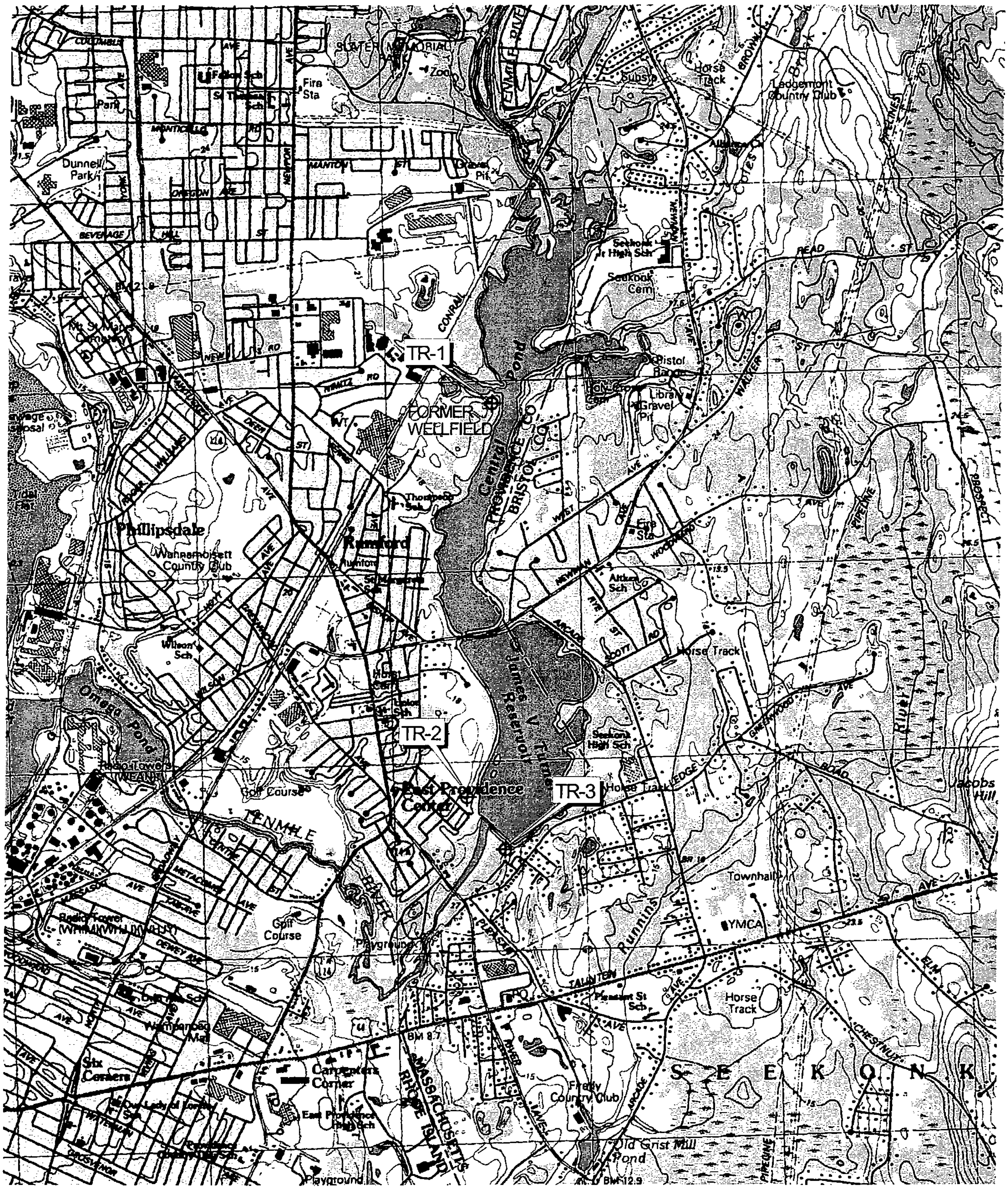
In addition to the collection of groundwater samples, real-time field data was collected as the groundwater was withdrawn from the ground. The field data consisted of temperature (^{o} Celsius), pH, Oxidation/Reduction Potential (ORP), and the percentage of Dissolved Oxygen/Dissolved Oxygen . Ferrous iron concentrations were determined in the field using a field test kit. See Appendix B for analytical data, Appendix C for well logs for TR-1, TR-2, and TR-3, and Appendix D for additional site investigation information and field data for Monitoring Points TR-1, TR-2, and TR-3.

(a) Monitoring Point TR-1. Monitoring point TR-1 is located in the area of the abandoned wellfield near former water supply well #76 (see Figure 9). The monitoring point was advanced without problem to a depth of 73.2 feet below ground surface (bgs). Groundwater sample TR-1 was collected from a screened interval of 62.7 feet to 72.7 feet bgs. A quality control duplicate sample (TR-1D) was also collected from this location.

(b) Monitoring Point TR-2. Monitoring point TR-2 was installed between the rip-rap and gate to the Bridgham Farm Conservation Area on the west side of the dam at the southern end of Turner Reservoir. The monitoring point was relocated three times due to refusal at depths that ranged from 9 feet to 15 feet bgs. At the fourth location, the monitoring point was advanced to a refusal depth of 17 feet bgs. Groundwater sample TR-2 was collected from a well screen interval of 6.5 feet to 16.5 feet bgs.

(c) Monitoring Point TR-3. Monitoring point TR-3 was installed on the east side of the dam located at the southern end of Turner Reservoir. The monitoring point was advanced to a refusal depth of 27.8 feet. Sample TR-3 was collected from a well screen interval of 17.3 feet to 27.3 feet bgs.

4. Field Readings. Table 12 presents the final field readings for the parameters shown. The ORP (Oxidation Reduction Potential) values in the high, negative range, and the DO (Dissolved Oxygen) with values less than 1 mg/L, indicate that conditions are favorable for an anaerobic and reducing environment. The groundwater quality conditions are ideal for the dissolution of iron (as shown by the high ferrous iron readings) and manganese from the groundwater. The ferrous iron field readings are real time data collected as soon as the water is removed from the ground with minimal contact with the air and indicate that high levels of dissolved iron are present in the groundwater. The manganese levels were analyzed by the analytical laboratory and indicate high dissolved levels of manganese. When the groundwater is exposed to oxygen, as it is when removed from the ground to the pumping station and distributed to the community, the iron and manganese will precipitate out of solution, thereby causing taste, odor, and



LEGEND

groundwater monitoring points

⊕

N

US Army Corps of Engineers
New England District

GROUNDWATER MONITORING LOCATIONS

Section 22 Planning Assistance to States
Turner Reservoir Study
East Providence, Rhode Island

January 2001 | FIGURE 9

staining on clothing and ceramic materials. This has been an historical problem with the groundwater. A complete set of field readings for all three monitoring points can be found in Appendix D.

Table 12
Final Field Readings For Groundwater Monitoring Points

Mon. Point Loc.	Temp (°C)	pH	ORP	DO(mg/L) /DO%	Ferrous Iron (mg/L)
TR-1	12.81	6.28	-471.3	0.17/1.6	13.6
TR-2	15.73	6.81	-371.4	0.08/0.8	3.3
TR-3	15.52	6.67	-267.8	0.08/0.8	2.11

5. Analytical Results. Samples were analyzed by Environmental Health Laboratories of South Bend, Indiana for the following drinking water parameters: antimony, arsenic, barium, beryllium, cadmium, total chromium, manganese, mercury, nickel, selenium, thallium; Phase I, II & V Regulated and Unregulated Volatiles; Phase II & V 525; Phase II & V PCB/Toxaphene/Chlordane. Complete analytical results are presented in Appendix B. Compounds and elements detected in the groundwater samples are shown in bold type in Appendix B.

(a) Monitoring Point TR-1: Samples TR-1 and TR-1D (duplicate):

Sample TR-1- Eleven volatile compounds were detected in concentrations ranging from 0.2 micrograms per liter (ug/L) for chloroform to 2.5 ug/L 1,1-dichloroethane. Ethylbenzene (0.2 ug/l), 1,2,4-trimethylbenzene (0.3 ug/l), and methyl-t-butyl ether (MTBE) (0.9 ug/l) were detected at very low concentrations and are components of gasoline, as are total xylenes (0.9 ug/l). Trichloroethylene (0.4 ug/l) and its degradation products cis-1,2-dichloroethylene (1.4 ug/l), and 1,1-dichloroethylene (0.8 ug/l) were also detected. Toluene and 1,1,1-trichloroethane were detected at concentrations of 0.8 ug/L and 1.8 ug/L, respectively. The above volatile organic compounds are regulated via Maximum Contaminant Level (MCLs) with the exception of 1,1-dichloroethane, 1,2,4-trimethylbenzene, and MTBE which are unregulated. None of the regulated volatile compounds detected exceeded their applicable MCLs. Chlorinated solvents such as 1,1-dichloroethane, trichloroethylene, cis-1,2-dichloroethylene, 1,1-dichloroethylene, and 1,1,1-trichloroethane have many uses in chemical and manufacturing processes, some of which are metal degreasers, cleaners, adhesives, insecticides, etc. Toluene and chloroform may possibly be contaminant related, but may also be laboratory generated as they are common laboratory contaminants. The only semivolatile compound detected in this sample was di(2-ethylhexyl) phthalate at a concentration of 1.3 ug/L which is below the current Maximum Contaminant Level (MCL) of 6.0 ug/L. Hydrocarbon oil was tentatively identified in sample TR-1 at a concentration of approximately 720 ug/L. The metals barium, beryllium, chromium, and nickel were detected in concentrations ranging from 0.4 ug/L to 9.7 ug/L but were below the current MCLs for those particular elements. Manganese was detected at a concentration of 210 ug/L which exceeds the current Secondary MCL (SMCL) of 50 ug/L. No pesticides or PCBs were detected.

Sample TR-1D - Eleven volatile organic compounds were detected at concentrations ranging from 0.2 ug/L for chloroform and 2.4 ug/L of 1,1-dichloroethane. Ethylbenzene (0.2 ug/L), 1,2,4-trimethylbenzene (0.3 ug/L), and methyl-t-butyl ether (MTBE) (0.9 ug/L) were detected at very low concentrations and are components of gasoline, as are total xylenes (1.0 ug/L). Trichloroethylene (0.4 ug/L) and its degradation products cis-1,2-dichloroethylene (1.3 ug/L), and 1,1-dichloroethylene (0.8 ug/l) were also detected. Toluene and 1,1,1-trichloroethane were detected at concentrations of 0.7 ug/L and 1.8 ug/L, respectively. The above volatile organic compounds are regulated via MCLs with the exception of 1,1-dichloroethane, 1,2,4-trimethylbenzene, and MTBE which are unregulated. None of the regulated volatile compounds detected exceeded their applicable MCLs. Chlorinated solvents such as 1,1-dichloroethane, trichloroethylene, cis-1,2-dichloroethylene, 1,1-dichloroethylene, and 1,1,1-trichloroethane have many uses in chemical and manufacturing processes, some of which are metal degreasers, cleaners, adhesives, insecticides, etc. Toluene and chloroform may possibly be contaminant related, but may also be laboratory generated as they are common laboratory contaminants. The only semivolatile compound detected in this sample was di(2-ethylhexyl) phthalate at a concentration of 1.0 ug/L which is below the current MCL of 6.0 ug/L. Phthalates are found in plastic compounds, are the products of combustion, and are very common in the environment. Hydrocarbon oil was tentatively identified in sample TR-1D at a concentration of approximately 420 ug/L. The metals arsenic, barium, chromium, and nickel were detected in concentrations ranging from 0.6 ug/L to 9.5 ug/L but were below the current MCLs for those particular elements. Manganese was detected at a concentration of 190 ug/L which exceeds the current Secondary MCL (SMCL) of 50 ug/L. No pesticides or PCB's were detected.

Ferrous iron concentrations which were collected via a field test kit ranged from 13.6 mg/L to 25.8 mg/L which exceed the recommended EPA maximum of 0.3 mg/L.

(b) Monitoring Point TR-2: Sample TR-2 - No semivolatile or volatile organic compounds were detected in this sample. The metals antimony, arsenic, barium, chromium, and nickel were detected at concentrations ranging from 0.2 ug/L to 18 ug/L and are below the current MCLs for those particular elements. Manganese was detected at a concentration of 800 ug/L which exceeds the current SMCL of 50 ug/L. Ferrous iron concentrations ranged from 3.0 mg/L to 5.10 mg/L which exceed the recommended EPA maximum of 0.3 mg/L. No pesticides or PCB's were detected.

(c) Monitoring Point TR-3: Sample TR-3 - Methyl-t-butyl-ether (MTBE) (0.5 ug/L) and 1,2,4-trimethylbenzene (0.2 ug/L), and total xylenes (0.4 ug/L) which are components of gasoline were detected. One other volatile organic compound, cis-1,2-dichloroethylene (0.1 ug/L) was detected. Total xylenes and cis-1,2-dichloroethylene did not exceed the MCLs established for those compounds. The other two compounds MTBE and 1,2,4-trimethylbenzene are not regulated. No semivolatile compounds were detected in this sample. The metals antimony, arsenic, barium, chromium, and nickel were detected at concentrations ranging from 0.2 ug/L to 26 ug/L and are below the current MCLs for those particular elements. Manganese was detected at a concentration of 1900 ug/L which exceeds the current SMCL of 50 ug/L. Ferrous iron concentrations ranged from 2.11 mg/L to 7.6 mg/L which exceed the recommended EPA maximum of 0.3 mg/L. No pesticides or PCB's were detected.

6. Conclusions. Field data, specifically the negative ORP (Oxidation Reduction Potential) values and the low concentrations of dissolved oxygen (less than 1 mg/L), indicate that anaerobic and reducing conditions are present in the ground water at all of the monitoring point sample locations. These anaerobic and reducing conditions cause dissolution of iron and manganese in the groundwater and will precipitate out upon contact with oxygen. Manganese levels ranged from 190 ug/L to 1,900 ug/L which exceed the SMCL of 50 ug/L and ferrous iron levels ranged from 2.11 mg/L to 25.8 mg/L which exceed the recommended EPA maximum of 0.3 mg/L. High iron and manganese levels in the ground water have been an historic problem in this area and based on the field and laboratory data, still appear to be so. The ground water would be usable but would have to be chemically treated to improve the esthetic qualities of the water (taste, odor, staining of ceramic fixtures and laundry). Water treatment methods would have to be implemented prior to distribution of the groundwater to the community system.

Low levels (below current MCLs) of volatile organic contaminants are present in samples from monitoring point locations TR-1, and TR-3. Three of these compounds, methyl-t-butyl-ether, 1,2,4-trimethylbenzene, and total xylenes are found as components of gasoline. The other compounds are chlorinated solvents and are commonly used in the chemical and manufacturing industries. Eleven volatile organic compounds in samples from these two monitoring point locations ranged in concentrations from 0.1 ug/L to 2.5 ug/L Eight of these compounds fall under regulatory guidance (MCLs). The levels of these compounds do not exceed any Federal and State water quality guidelines.

The source(s) of the volatile organic contaminants is not known but contamination was found at monitoring point TR-1 at a depth of 62.7 to 72.7 feet and at monitoring point TR-3 at a depth of 17.3 feet to 27.3 feet. This indicates that a potential widespread problem may exist especially since the distance between TR-1 and TR-3 is approximately 1.25 miles and the area is heavily urbanized. However, no volatile organic contaminants were detected in the upper portion of the water table from monitoring point TR-2. There could and may be more than one source area and the only way to determine that is with further investigation.

Hydrocarbon oil was tentatively identified from samples TR-1 and TR-1D at a concentration of approximately 720 ug/L and 420 ug/L, respectively. The source for the hydrocarbon oil is not known. No volatile organic compounds were detected in samples from monitoring point location TR-2. Metals were detected in all the ground water samples but are below the MCLs established for those elements.

Removal of the iron, manganese and volatile organic contaminant components from the ground water supply could potentially be a substantial financial burden to the city of East Providence. Historical information for the area indicates that the ground water in the overburden and bedrock is "generally of good quality and is soft but locally may contain excessive iron". The USEPA recommends that the dissolved iron content in groundwater should not be greater than 0.3mg/L as iron levels above that concentration have a tendency to stain plumbing fixtures, stain clothes during laundering, etc., and manganese levels should not be greater than 0.05 mg/L. If the city of East Providence moves forward with their plan to reuse the wellfield as a potential long-term back up supply, then additional investigation is warranted to determine the nature and extent and possible source(s) of the volatile organic contamination. The additional investigation may include: the sampling of the groundwater at various depths through the installation of shallow, medium, and deep monitoring wells; and laboratory analysis of groundwater samples for VOCs, SVOCs, metals (including iron and manganese), pesticides and PCBs. The costs for this type of investigation could be substantial.

IV. Conclusions

A. Determination of the Suitability for Back-Up Water Supply

The present investigation focused on providing a preliminary determination of the suitability of Turner Reservoir and the Central Pond well field as back-up water supplies based on the following: Water Quality, Fisheries and Fish Tissue, Sediment, and Groundwater analyses. Our preliminary investigation found that the Turner Reservoir and Central Pond Well fields may be suitable for a back-up water supply; however, both water supply alternatives will require thorough treatment of the water.

The Corps investigation did not find any water quality problems that would prohibit using the Turner Reservoir as a public water supply; however, it should be noted that the water's appearance is not attractive. Excessive nutrient enrichment leading to heavy aquatic plant growth seems to be the major identified problem followed by coliform bacteria.

The groundwater investigation of the Central Pond Well fields confirmed the presence of high levels of iron and manganese identified as a historic problem. In addition, the groundwater investigation of the well field revealed the presence of low levels (below current MCLs) of volatile organic contaminants in samples from monitoring point TR-1.

B. Determination of the Suitability for Recreational Purposes

Although the water's appearance is not attractive, with large amounts of aquatic weeds and a number of waterfowl present at the site, Corps investigation did not find any water quality problems that would prohibit using the Turner Reservoir for recreation use such as swimming.

Turner Reservoir area may not be ideal as a water supply; however, it still can be managed as a recreation area. Turner Reservoir appears to support a good largemouth bass population, which will provide a recreational warm water fishery. Other species present include white perch, yellow perch, bluegill and pumpkinseed. Although the concentrations of methyl mercury in the largemouth bass tissue composite were below the FDA action level, they were above some of the EPA health risk levels for consumption

V. Recommendations

A comprehensive system for treatment of the water from Turner Reservoir and the Central Pond Well fields would be required to remove the high nutrient content in the water, the potential for coliform bacteria, elevated levels of contaminants, and improve the taste and odor of the water.

The Rhode Island Department of Health should review the results of the fish tissue data in order to determine if further study and/or health advisories should be initiated. If it is determined that the existing health risk for consumption of largemouth bass is not acceptable, a catch and release recreational fishery could be established.

In addition, because of a potential problem with coliform bacteria, if Turner Reservoir was open to swimming, the City of East Providence should adopt a regular and possibly intensive bacteria monitoring program.

The Corps of Engineers also found concentrations of most metals from sediment samples exceeded state cleanup levels. The city of East Providence should forward the metal concentration data to RIDEM for further evaluation. The city of East Providence should perform additional sampling in order to determine sources of contamination and determine the type of water treatment system required.

If the city of East Providence moves forward with their plan to reuse the Central Pond Well Field as a potential long-term back-up supply then additional investigation is warranted to determine the nature and extent and possible source(s) of the volatile organic contamination. The additional investigation may include: the sampling of the groundwater at various depths through the installation of shallow, medium, and deep monitoring wells; and laboratory analysis of groundwater samples for VOCs, SVOCs, metals (including iron and manganese), pesticides and PCBs.

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APPENDIX A

FINAL DATA REPORT FOR LABORATORY TESTING FOR FISH TISSUE AND SEDIMENTS SAMPLES AT TURNER RESERVOIR, EAST PROVIDENCE, RHODE ISLAND BY BATTELLE

FINAL DATA REPORT

For

LABORATORY TESTING FOR FISH TISSUE AND SEDIMENT SAMPLES AT TURNER'S RESERVOIR, EAST PROVIDENCE, RHODE ISLAND

Submitted to

Department of the Army
U.S. Army Corps of Engineers
North Atlantic Division
New England District

Contract No. DACW33-96-D-0005
Delivery Order No. 45

August 2, 2000

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Attachment 1. Custody Records
Attachment 2. Grain Size Results and Plots
Attachment 3. TOC Results
Attachment 4. Metals Results
Attachment 5. PCB/Pesticide Results
Attachment 6. PAH Results

1. Introduction

On November 10, 1999 NAE collected sediment grab samples at three locations at Turner's Reservoir in East Providence, RI. NAE also collected fish samples at Turner's and Central Pond on September 9, 23 and 24, 1999. A representative from Battelle (Karen Foster) retrieved custody of the sediment and tissue samples on November 19, 1999. All samples, with the exception of sediment samples for grain size and TOC analysis, were stored frozen over the weekend and logged into the laboratory on November 22, 1999. Sediment samples for grain size and TOC analyses were stored refrigerated.

Sediment samples were analyzed at the instruction of NAE for grain size and chemical analyses as shown in Table 1. Fish samples were processed and analyzed at the instruction of NAE for chemical analyses as shown in Table 2. This report presents the results of the physical and chemical analyses performed. Custody records for all samples collected are provided in Attachment 1. All final data and associated quality control results for grain size, TOC, Metals, PCB/Pest, and PAH analyses are provided as attachments to this report. Data qualifiers applied to the chemistry results are defined on the final data tables.

Table 1 Summary of Sediment Samples Collected at Turner's Reservoir, RI.

Sample ID	Collection Date	Field Samples and Laboratory ID Correlations		
		Grain Size/TOC Analysis	Metals Analysis	PAH/Pest/PCB Analysis
CP#1	11/10/99	X3032	1427*1	X3030
TR#2	11/10/99	X3038	1427*3	X3036
TR#3	11/10/99	X3035	1427*2	X3033

Table 2 Summary of Fish Samples Collected and Compositing Scheme.

Composite No.	Samples in Composite	Collection Date	Mass (wet) of Fillet Tissue Used to Form Composite	Field Samples and Laboratory ID Correlations	
				Metals Analysis	PAH/Pest/ PCB Analysis
1[a]	LMB-01-001	9/09/99	45.174 g	1427*4	X3726
	LMB-01-002	9/09/99	45.190 g		
	LMB-004-001	9/23/99	45.240 g		
2[b]	YB-002-001	9/09/99	6.065 g	1427*5	X3727
	YB-007-001	9/24/99	6.253 g		
	YB-007-002	9/24/99	6.153 g		
3[a]	WS-004-001	9/23/99	38.468 g	1427*6	X3728
	WS-004-002	9/23/99	38.160 g		
	WS-004-003	9/23/99	38.664 g		

[a] Fillets with skin on
[b] Fillets with skin off

2. Methods

2.1. Grain Size Analyses

Water content and grain size distributions were determined by ASTM D-422. Grain size analyses were performed at Applied Marine Sciences (AMS) of League City, Texas.

2.2. Total Organic Carbon Analyses

Total Organic Carbon (TOC) was analyzed according to EPA Method 9060. All samples were analyzed in duplicate and results are reported in % dry wt. TOC analyses were performed at Applied Marine Sciences.

2.3. Metals Analyses

Sediment samples were analyzed for eight metals: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn). To prepare the samples for analysis, they were first freeze-dried then blended in a Spex mixer-mill. Approximately 0.25-g aliquots of dried, homogeneous sediment sample were digested using a mixture of nitric and hydrofluoric acids in a nitrogen vented system. This method was employed to allow volatilization of SiF_4, removing a significant amount of matrix interference from the digestate and allowing quantitative recovery of the crustal elements. The digestion method used follows a modified version of EPA Method 200.2 (EPA 1991). The modification involved precluding the addition of hydrochloric acid and inclusion of the hydrofluoric acid to achieve a total digestion. Mercury was analyzed using cold-vapor atomic absorption spectrometry (CVAA) following EPA Method 245.5 (EPA 1991). The remaining metals were analyzed by inductively coupled plasma mass spectrometry (ICP/MS) following a modified version of EPA Method 200.8 (EPA 1991).

Tissue samples were analyzed for nine metals: As, Cd, Cr, Cu, Pb, Hg, methyl mercury (MeHg), Ni, and Zn. To prepare the samples for analysis, they were first freeze-dried then blended in a Spex mixer-mill. Approximately 0.2- to 0.5-g aliquots of homogeneous sample were digested using a mixture of nitric and hydrofluoric following a modified version of EPA Method 200.2 (EPA 1991). Mercury was analyzed using CVAA following EPA Method 245.5 (EPA 1991). Methyl mercury was analyzed using cold-vapor atomic fluorescence (CVAF) according to Battelle Method MSL I-015-03. The remaining metals were analyzed by ICP/MS following a modified version of EPA Method 200.8 (EPA 1991).

2.4. PCB/Pesticide Analyses

Individual PCB congeners and pesticides were extracted using methylene chloride. Sediment samples were extracted three times with methylene chloride using shaker techniques. Tissue samples were also extracted three times with methylene chloride using maceration techniques. Sample extracts were reduced in volume and cleaned using alumina column chromatography and HPLC. A portion of the extract was exchanged into hexane and analyzed for PCBs and chlorinated pesticides using gas chromatography/electron capture detection (GC/ECD) following a modified EPA method 8081. Dual column confirmation was performed for all analytes.

2.5. PAH Analyses

PAHs were extracted along with PCB/Pests as described above. Extracts were reduced, cleaned using alumina column chromatography and HPLC, and a portion of the extract analyzed in the selected ion monitoring (SIM) mode using gas chromatography/mass spectrometry (GC/MS) following a modified EPA method 8270.

3. Results

3.1. Grain Size Results

Grain size analysis results including water content and plots were furnished by Applied Marine Sciences, Inc. from League City, Texas, and are provided in Attachment 2 along with quality control results. Sediments were generally characterized as black sandy organic silt (CP#1) and black organic clay (TR#2, TR#3). Table 3 summarizes the grain size distributions.

QC Results – Results from all QC samples (*i.e.*, sample replicate) were within the control limits specified by the method. For further information regarding results from the QC samples please see the QA/QC narrative provided in Attachment 2.

Table 3 Summary of Grain Size Results

Sample ID	Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)
CP#1	0.00	0.00	1.52	35.06	34.17	29.25
TR#2	0.00	0.00	1.33	23.71	29.46	45.50
TR#3	0.00	0.00	0.72	4.76	44.52	50.00

3.2. Total Organic Carbon Results

TOC results for sediment samples are provided in Attachment 3 and summarized in Table 4.

QC Results – Results from all QC samples (*i.e.*, blank, sample replicate, SRM) were within the control limits specified by the method. For further information regarding results from the QC samples please see the QA/QC narrative provided in Attachment 3.

Table 4 Summary of TOC Results

Sample ID	TOC [1] (% Dry Wt.)
CP#1	6.35
TR#2	8.97
TR#3	12.94

[1] All TOC analyses were performed in duplicate and these results are provided in Attachment 3.

3.3. Metals Results

Metals results for all field and quality control samples are provided in Attachment 4.

Sediment – Metals were detected in all of the sediment samples. Concentrations of metals detected in sediment collected at TR#2 were generally 2x higher than concentrations measured in sediment collected at CP#1 and TR#3.

Fish – Copper, zinc, mercury and methyl mercury were detected in the fish samples. The white sucker fish collected at Central Pond contained higher levels of Cu and Zn compared to the levels detected in the largemouth bass and yellow bullhead fish samples. The largemouth bass fish samples collected at Turners and Central Pond contained higher concentrations of Hg and MeHg compared to the yellow bullhead and white sucker fish samples.

QC Results – With few exceptions, results from QC samples were generally within the control limits specified by the method. Exceptions included:

- Zn was detected in the method blank prepared with the sediment samples at approximately 20× the detection limit. However, concentrations of Zn in the associated field samples were 30 to 70× blank levels. The contamination appears to be isolated to the method blank and samples appear unaffected. Results for Zn have been flagged with a "B" qualifier to indicate that the blank result was greater than 5× the detection limit.
- Cr, Cu, Ni, and Zn were under-recovered in the matrix spike sample prepared with the sediment samples. However, native concentrations of these metals in the background sample (CP#1) used to prepare the matrix spike were greater than the spike level, thereby masking the recovery of these metals in the matrix spike sample.
- Tissue samples were received outside the 28-day holding time for Hg and MeHg and samples were digested 75-days past the holding time. Even so, the samples were stored frozen upon collection (Chris High, per personal communication; documentation of storage conditions at NAE not provided with samples) and the Hg and MeHg analyses should not be compromised.
- Zn was under-recovered in the matrix spike sample prepared with the tissue samples. However, native concentrations of Zn in the background sample (Turners and Central Pond, Fillet) used to prepare the matrix spike were greater than the spike level, thereby masking the recovery of Zn in the matrix spike sample.

For further information regarding results from the QC samples please see the QA/QC narratives provided in Attachment 4.

3.4. PCB/Pest Results

Results of PCB and chlorinated pesticide analyses for all field and quality control samples are provided in Attachment 5.

Sediment – Samples contained high levels of DDTs, chlordane and PCBs. Sediment collected at TR#3 contained the highest concentrations of pesticides and PCBs.

Fish – Largemouth bass and yellow bullhead fish samples contained low levels of PCBs (<10x laboratory MDL). The highest concentrations of pesticides and PCBs were detected in the white sucker fish samples collected at Central Pond. DDTs were detected in all the fish samples with 4,4'-DDE as the predominant isomer.

QC Results – With some exceptions, results from QC samples were generally within the control limits specified by the method. Exceptions included:

- Target PCB congeners and pesticides, as well as the surrogate compounds, were under-recovered in the laboratory control sample (LCS) prepared with the sediment samples. The chromatogram and peak integrations were reviewed and it appears that 60 to 75% of the LCS was lost during sample preparation. Recoveries of target PCB and pesticides were very good in the matrix spike samples, indicating that the method is in control. Poor recovery of target PCB congeners and pesticides appears to be isolated to the LCS.
- Endrin aldehyde was poorly recovered in the LCS and matrix spike/spike duplicate (MS/MSD) QC samples prepared with the sediment and tissue samples. Endrin aldehyde is a problematic compound that has irreproducible recovery from the alumina cleanup column. We suspect that the recovery of Endrin aldehyde would improve if the alumina column had been eluted with a larger volume of methylene chloride. Endrin aldehyde was not detected in the sediment or fish tissue samples.
- Measured concentrations of PCB congeners $Cl_5(87)$, $Cl_7(170)$, $Cl_7(180)$, and $Cl_9(206)$ in the SRM (NIST 1941a), prepared with the sediment samples, did not agree well with certified values resulting in elevated percent differences (PDs). PCB congeners $Cl_7(170)$, $Cl_7(190)$, and $Cl_9(206)$ have historically had elevated PDs that have been attributed to potential phthalate contamination. Recoveries of PCB congeners $Cl_5(87)$, $Cl_7(170)$, $Cl_7(180)$, and $Cl_9(206)$ in the MS/MSD were within the control limits specified by the method.
- The recovery of the surrogate compound $Cl_5(112)$ was elevated in the sample duplicate of the White Sucker (tissue fillet) from Central Pond. The chromatogram and peak integrations were reviewed and the cause of the elevated recovery was not apparent.
- The relative percent difference (RPD) between concentrations of PCB congeners and pesticides in the tissue replicate samples (White Sucker from Central Pond) exceeded the upper control limit (30% RPD) for $Cl_5(118)$, $Cl_6(138)$, 4,4'-DDE, 2,4'-DDD, and

Dieldrin. The chromatogram and peak integrations were reviewed and no apparent cause, other than sample non-homogeneity, was apparent.

- An SRM was inadvertently not prepared with the tissue samples. The SRM is used to assess data quality in terms of accuracy. Results from the LCS and MS/MSD analyses are also used to assess data quality in terms of accuracy. Percent recoveries of PCB congeners and pesticides in the LCS and MS/MSD prepared with the tissue samples were within the control limits specified by the method, with the exception of Endrin aldehyde and Methoxychlor.

For further information regarding results from the QC samples please see the QA/QC narratives provided in Attachment 5.

3.5. PAH Results

Results of PAH analyses for all field and quality control samples are provided in Attachment 6.

Sediment – PAHs were detected in all of the sediment samples. Sediment samples had similar PAH distribution patterns dominated by 4-, 5- and 6-ring PAH compounds. Sediment collected at TR#3 contained the highest concentrations of PAHs.

Fish –Largemouth bass and yellow bullhead fish samples contained low levels of PAHs (<10x laboratory MDL). The highest concentrations of PAHs (predominantly 2- and 3-ring PAH) were detected in the white sucker fish samples collected from Central Pond.

QC Results – With some exceptions, results from QC samples were generally within the control limits specified by the method. Exceptions included:

- The procedural blank prepared with the sediment samples contained several PAHs at levels greater than 5× the detection limits. With the exception 2,6-Dimethylnaphthalene, concentrations of PAHs in the associated field samples were generally 10 to 250× blank levels. Concentrations of 2,6-Dimethylnaphthalene in the associated sediment samples were 2 to 6× blank levels and concentrations detected may be somewhat attributed to blank contamination. Procedural blank results for 2,6-Dimethylnaphthalene have been flagged with a "B" qualifier. Concentrations of PAHs in the blank are well below the target detection limits specified by NAE (20 µg/kg dry weight).
- Target PAHs, as well as the surrogate compounds, were under-recovered in the LCS prepared with the sediment samples. The chromatogram and peak integrations were reviewed and it appears that 60 to 75% of the LCS was lost during sample preparation. Recoveries of target PAHs were very good in the matrix spike samples, indicating that the method is in control. Poor recovery of target PAH appears to be isolated to the LCS.
- Measured concentrations of Fluorene and Perylene in the SRM (NIST 1941a) prepared with the sediment samples did not agree well with certified values resulting in somewhat elevated PDs. Fluorene has historically had elevated PDs. Whereas, the

PD value for Perylene (31%) was slightly outside the upper control limit (≤30%). Recoveries of Fluorene and Perylene in the MS/MSD were within the control limits specified by the method.

- The RPD between concentrations of Phenanthrene and Anthracene in the tissue replicate samples exceeded the upper control limit (30% RPD). Surrogate recoveries for one of the replicate samples was generally 20% lower than the duplicate sample, resulting in higher variability between replicate PAH measurements.
- An SRM was inadvertently not prepared with the tissue samples. The SRM is used to assess data quality in terms of accuracy. Results from the LCS and MS/MSD analyses are also used to assess data quality in terms of accuracy. Percent recoveries of PAHs in the LCS and MS/MSD prepared with the tissue samples were within the control limits specified by the method.

For further information regarding results from the QC samples please see the QA/QC narratives provided in Attachment 6.

4. References

Battelle 1999. Draft Report for Turner's Reservoir. Compilation of sediment grain size and TOC results. December 10, 1999.

EPA. 1991. Methods for the Determination of Metals in Environmental Samples. EPA-600/4-91-010.)

Attachment 1

Custody Records

ATTACHMENT 3
Batteile Duxbury Operations
Sample Receipt Form

Project Number G339645-0001 Client USACE

No. of Shipping Containers — Date/Time Received 11/22/99 0950

SHIPMENT

Method of Delivery: ______ Commercial Carrier (Air bill No. ______)
✓ Hand Delivered
______ US Mail (RPS No. ______)

COC Forms: ✓ Shipped with samples ______ No forms

Cooler(s)\Box(es) were sealed with: ______ Tape ______ Custody Seals NONE (Other specify)
Were the seals intact for each shipping container ______ Yes ______ No
If seals were broken (list impacted samples):

SAMPLES

Sample Labels: ✓ Sample labels agree with COC forms ______ Discrepancies (see COC forms)

Container Seals: ______ Tape ______ Custody Seals NONE (Other specify)
______ Seals intact for each shipping container
______ Seal broken (list impacted samples):

Condition of Samples: ✓ Sample containers intact
______ Sample containers broken/leaking (see COC forms)

Temperature upon receipt (°C): unknown
(Note: If temperature upon receipt differs from required conditions, list impacted samples):

Initial pH (water): NA pH adjusted: ______ Final pH ______ Volume HCl/ NaOH added ______
Initial Total Residual Chlorine (water): NA Adjusted: ______ Final TRC ______
Sample Containers:
Samples returned in PC-grade sampling jars unknown (Yes/No). Lot No. ______

All but the following samples were returned in Battelle-prepped bottles:

Storage Location: GS/TOC - walk in ref; all others - walk in freezer **BDO IDs Assigned:** X3030 - X3050

* Additional Comments: Samples put in refrigerator over weekend Received by custodian on Mon morning 11/22/99 jma

Samples logged in by: [illegible signature] Date/Time: 11/22/99 1135

Fish were received wrapped in Aluminum Foil

STA #	Analysis	BOS ID
P#1	• Bulk Chem	X3030
P#1	• Metals	X3031
P#1	• TOC/GS	X3032
R#3	• Bulk Chem	X3033
TR#3	• Metals	X3034
TR#3	• TOC/GS	X3035
TR#2	• Bulk Chem	X3036
TR#2	• Metals	X3037
R#2	• GS	X3038

G-30

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME
	Tonnes Reservoir [illegible]

SAMPLERS: *(Signature)* [signature]

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS	ANALYSIS	Bulk Chem	Metals	TOC	Grain size		
[illegible]	11/6	1500	[illegible]	✓	Cutter Reef	3		✓	✓	✓	✓		composite [illegible]
TR-3	11/6	1600	✓		Tonnes Reservoir site 3	3		✓	✓	✓	✓		"
TR-2	11/6	1635	-		Tonnes Reservoir site 2	3		✓	✓	✓	✓		"
Sta													Sample[illegible]
													Bulk
													metals
													Cu [illegible]
													Sampl[illegible]
													Grain[illegible]
													[illegible]
													"

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time
[signature]	11/19/96 1400	[signature]		

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time
		Arsenault 11/22/96		

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

G-30

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME
	[illegible]

SAMPLERS: *(Signature)* [illegible]

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS	ANALYSIS			BOS ID		REMARKS
1	[illegible]	[illegible]			LMB-01-001	1 Fish			X	3009		Largemouth Bass - Tumors
1	[illegible]	[illegible]			LMB-01-002	1 Fish			X	3010		Largemouth Bass - Tumors
1	[illegible]	[illegible]			[illegible]	1 Fish			X	3011		White Perch - Tumors
1	[illegible]	[illegible]			[illegible]	1 Fish			X	3012		White Perch - Tumors
2	[illegible]	[illegible]			YB-002-001	1 Fish			X	3013		Yellow Bullhead - Tumors
4	[illegible]	[illegible]			LMB-004-001	1 Fish			X	3014		Largemouth Bass Control/Ref
4	[illegible]	[illegible]			[illegible]-004-001	1 Fish			X	3015		White Sucker Control/Ref
4	[illegible]	[illegible]			[illegible]-004-002	1 Fish			X	3016		White Sucker Control/Ref
4	[illegible]	[illegible]			[illegible]-004-003	1 Fish			X	3017		White Sucker - Control/Ref
5	[illegible]	[illegible]			LMB-05-001	1 Fish			X	3018		Largemouth Bass - Control/Ref
7	[illegible]	[illegible]			YB-007-001	1 Fish			X	3019		Yellow Bullhead - Tumors
7	[illegible]	[illegible]			YB-007-002	1 Fish			X	3020		Yellow Bullhead - Tumors.
												Please call Ron [illegible]
												([illegible]) for Fish Histopathology
												on Processing/[illegible]

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
[illegible]	[illegible] 1400	[illegible]			
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)* 11/22/89 [illegible]	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

BATTELLE Laboratory Sample Login Report

Project # : G339645-0001

Client : USACE

Receive Date : 11/22/1999 10:00:00 AM

Logged in By : JOANNE

Collection Date	Login Date	Lab ID	Client Sample ID	Type	Matrix	Preservative	Storage Location	Login Comments
11/10/1999 3:00:00 P	11/22/1999 9:59:59 A	X3030	CP#1 BULK CHEM	SA	SED	NONE	WALK IN FREEZER	
11/10/1999 3:00:00 P	11/22/1999 10:08:55	X3031	CP#1 METALS	SA	SED	NONE	WALK IN FREEZER	
11/10/1999 3:00:00 P	11/22/1999 10:09:29	X3032	CP#1 TOC/GS	SA	SED	NONE	WALK IN REF	
11/10/1999 4:06:00 P	11/22/1999 10:10:05	X3033	TR#3 BULK CHEM	SA	SED	NONE	WALK IN FREEZER	
11/10/1999 4:06:00 P	11/22/1999 10:10:54	X3034	TR#3 METALS	SA	SED	NONE	WALK IN FREEZER	
11/10/1999 4:06:00 P	11/22/1999 10:11:21	X3035	TR#3 TOC/GS	SA	SED	NONE	WALK IN REF	
11/10/1999 4:35:00 P	11/22/1999 10:12:01	X3036	TR#2 BULK CHEM	SA	SED	NONE	WALK IN FREEZER	
11/10/1999 4:35:00 P	11/22/1999 10:12:45	X3037	TR#2 METALS	SA	SED	NONE	WALK IN FREEZER	
11/10/1999 4:35:00 P	11/22/1999 10:13:15	X3038	TR#2 GS	SA	SED	NONE	WALK IN REF	
09/09/1999 11:52:00	11/22/1999 10:13:42	X3039	LMB-01-001	SA	FISH	NONE	WALK IN FREEZER	
09/09/1999 11:52:00	11/22/1999 10:16:06	X3040	LMB-01-002	SA	FISH	NONE	WALK IN FREEZER	
09/09/1999 11:52:00	11/22/1999 10:16:30	X3041	WP-001-001	SA	FISH	NONE	WALK IN FREEZER	
09/09/1999 11:52:00	11/22/1999 10:16:56	X3042	WP-001-002	SA	FISH	NONE	WALK IN FREEZER	
09/09/1999 6:30:00 P	11/22/1999 10:17:20	X3043	YB-002-001	SA	FISH	NONE	WALK IN FREEZER	
09/09/1999 12:30:00	11/22/1999 10:18:04	X3044	LMB-004-001	SA	FISH	NONE	WALK IN FREEZER	
09/23/1999 2:00:00 A	11/22/1999 10:18:53	X3045	WS-004-001	SA	FISH	NONE	WALK IN FREEZER	
09/23/1999 2:00:00 A	11/22/1999 10:41:36	X3046	WS-004-002	SA	FISH	NONE	WALK IN FREEZER	
09/23/1999 2:00:00 A	11/22/1999 10:42:27	X3047	WS-004-003	SA	FISH	NONE	WALK IN FREEZER	
09/23/1999 4:30:00 A	11/22/1999 10:42:53	X3048	LMB-05-001	SA	FISH	NONE	WALK IN FREEZER	
09/24/1999 10:00:00	11/22/1999 10:43:15	X3049	XB-007-001	SA	FISH	NONE	WALK IN FREEZER	

ATTACHMENT 3
Battelle Duxbury Operations
Sample Receipt Form

Project Number ________ Client Blackstone - Turners

No. of Shipping Containers 1 Date/Time Received 12/17/98 10:30

SHIPMENT

Method of Delivery: ✓ Commercial Carrier (Air bill No. 4270 1903 7025) FED EX
____ Hand Delivered
____ US Mail (RPS No. ________)

COC Forms: ✓ Shipped with samples ____ No forms

Cooler(s)\Box(es) were sealed with: ✓ Tape ____ Custody Seals ____ (Other specify)
Were the seals intact for each shipping container ✓ Yes ____ No
If seals were broken (list impacted samples):

SAMPLES

Sample Labels: ✓ Sample labels agree with COC forms ____ Discrepancies (see COC forms)

Container Seals: ____ Tape ____ Custody Seals NO SEALS (Other specify)
____ Seals intact for each shipping container
____ Seal broken (list impacted samples):

Condition of Samples: ✓ Sample containers intact
____ Sample containers broken/leaking (see COC forms)

Temperature upon receipt (°C): 2.2°C
(Note: If temperature upon receipt differs from required conditions, list impacted samples):

Initial pH (water): NA pH adjusted: NA Final pH NA Volume HCl/ NaOH added NA
Initial Total Residual Chlorine (water): NA Adjusted: NA Final TRC NA
Sample Containers:
Samples returned in PC-grade sampling jars UNKNOWN (Yes/No). Lot No. ________

All but the following samples were returned in Battelle-prepped bottles:

Battelle

Pacific Northwest Division
Marine Sciences Laboratory
1529 West Sequim Bay Road
Sequim, Washington 98382

AMPLE CUSTODY RECORD

Date 12/16/99 Page 1 of 1

oject No. 1415 + 1427
oject Name Blackstone + Turners
oject Manager Cecelius + Bigler Phone 360 681-3627

Lab ______
Address ______
Attention ______

Lab No.	Sample No.	BD Collection Date	Matrix	Testing Parameters: Bigler						No. of Containers	Observations, Instructions
415*60	X3295	X3717	tiss.	X						1	NED Blackstone
15*58	X3293, X3294	X3718	comp.	X						1	
15*64	X3284, X3285, X3286	X3719	comp.	X						1	
415*62	X3287, X3288	X3720	comp.	X						1	
15*68	X3297, X3298	X3721	comp.	X						1	
15*63	X3282, X3283	X3722	comp.	X						1	
15*56	X3291, X3292	X3723	comp.	X						1	
15*54	X3289 X3290	X3724	comp.	X						1	
15*65	X3296	X3725	tiss.	X						1	
27*4	X3039, X3040, X3044	X3726	comp.	X						1	NED Turners
27*5	X3043, X3049 X3050	X3727	comp.	X						1	
27*6	X3045, X3046, X3047	X3728	comp.	X						1	

inquished by: Linda S. Bigler 12/16/99 130
gnature Date Time
Linda S. Bigler
inted Name
Battelle
ompany

Received by: Michael Mearn 12/17/99 10:30A
Signature Date Time
Michael Mearn
Printed Name
Battelle Duxbury
Company

Total No. of Containers 12

Shipment Method:

Special Requirements or Comments:

inquished by:
gnature Date Time
inted Name
ompany

Received by:
Signature Date Time
Printed Name
Company

DISTRIBUTION:

1. Provide white and yellow copies to the Laboratory
2. Return pink copy to Project file or to project manager.
3. Laboratory to return signed white copy to Battelle for project files

BATTELLE Laboratory Sample Login Report

Project # :

Receive Date : 12/17/1999 10:30:00 AM

Client : BLACKSTONE AND TURNERS

Logged in By : MEARAM

Collection Date	Login Date	Lab ID	Client Sample ID	Type	Matrix	Preservative	Storage Location	Login Comments
	12/17/1999 10:59:28	X3717	1415*60	SA	TISSUE	NONE	WALK IN FREEZER	x3295
	12/17/1999 11:13:46	X3718	1415*58	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3293,x32
	12/17/1999 11:14:25	X3719	1415*64	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3284,x32
	12/17/1999 11:15:01	X3720	1415*62	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3287,x32
	12/17/1999 11:15:31	X3721	1415*68	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3297,x32
	12/17/1999 11:16:02	X3722	1415*63	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3282,x32
	12/17/1999 11:16:33	X3723	1415*56	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3291,x32
	12/17/1999 11:17:06	X3724	1415*54	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3289,x32
	12/17/1999 11:17:36	X3725	1415*65	SA	TISSUE	NONE	WALK IN FREEZER	x3296
	12/17/1999 11:18:02	X3726	1427*4	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3039,x30
	12/17/1999 11:18:47	X3727	1427*4	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3043,x30
	12/17/1999 11:19:24	X3728	1427*6	SA	TISSUE	NONE	WALK IN FREEZER	comp of x3045,x30

Battelle
. . . Putting Technology To Work

Sample Split and Transfer Log

Project Number	G339645-0001	Date of Work	11/23/99
Project Title	Fine Pond		
Analysis Type(s)	Grain Size + TOC		
Splitting Procedure	Split cores into TOP (1of2) and BOTTOM (2of2) horizons; homogenized; removed ~300+g for analysis		
	(include description of amount or weight of split, packaging, storage)		
Name	Charles H. Lyman	Date	11/23/99

Sample ID	Sample ID	Sample ID	Sample ID	Sample ID	Sample ID
X3074-TOP					
X3074-BOT					
X3076-TOP					
X3076-BOT					
X3078-TOP					
X3078-BOT					
X3035					
X3032					
X3038					

...se ...iples ...n Turners – Split to ...val at ...telle

Released	Received
Signature/Date: Charles H. Lyman 11/23/99	Signature/Date: [signature] 11/23/99
Storage Location/Conditions:	Storage Location/Conditions:

Attachment 2

Grain Size Results and Plots

GRAIN SIZE – SEDIMENT QA/QC SUMMARY

PROJECT: Turner's Reservoir

PARAMETER: Grain Size

LABORATORY: Applied Marine Sciences, Inc.

MATRIX: Sediment

SAMPLE CUSTODY: A representative from Battelle Duxbury retrieved a total of three (3) sediment samples on 11/19/1999 from NAE. Samples were received chilled, transported to the laboratory, and stored in the Walk-in-Refrigerator over the weekend until they could be logged into the laboratory's tracking system on 11/22/1999. Samples were received chilled and in good condition. The cooler temperature on arrival was not recorded. Samples were stored refrigerated until analysis.

Battelle shipped sediment samples to Applied Marine Sciences, Inc. (AMS) on 11/23/1999. Samples were received at AMS on 11/24/1999. All samples were received in good condition and were stored at 4°C until analysis.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Method Blank	SRM % Diff.	Relative Precision	Achieved Detection Limit (% DW)	Target Detection Limit (% DW)
Grain Size	ASTM D-422	NA	NA	≤25%	NA	NA

METHOD: Sediment samples were analyzed for water content and grain size distributions following ASTM D-422.

HOLDING TIMES: Samples were prepared for GS determination within holding time.

Collection Date	11/10/1999
GS Analysis Date	12/08/1999

DETECTION LIMITS: Not applicable

BLANKS: Not applicable

REPLICATES: RPDs were within the control limits specified by the method, as follows:

% Gravel – NA
% Coarse Sand – NA
% Medium Sand – 3.8 %RPD
% Fine Sand – 0.85 %RPD
% Silt – 1.2 %RPD
% Clay – 0.22 %RPD

SRM: Not applicable

Applied Marine Sciences, Inc.

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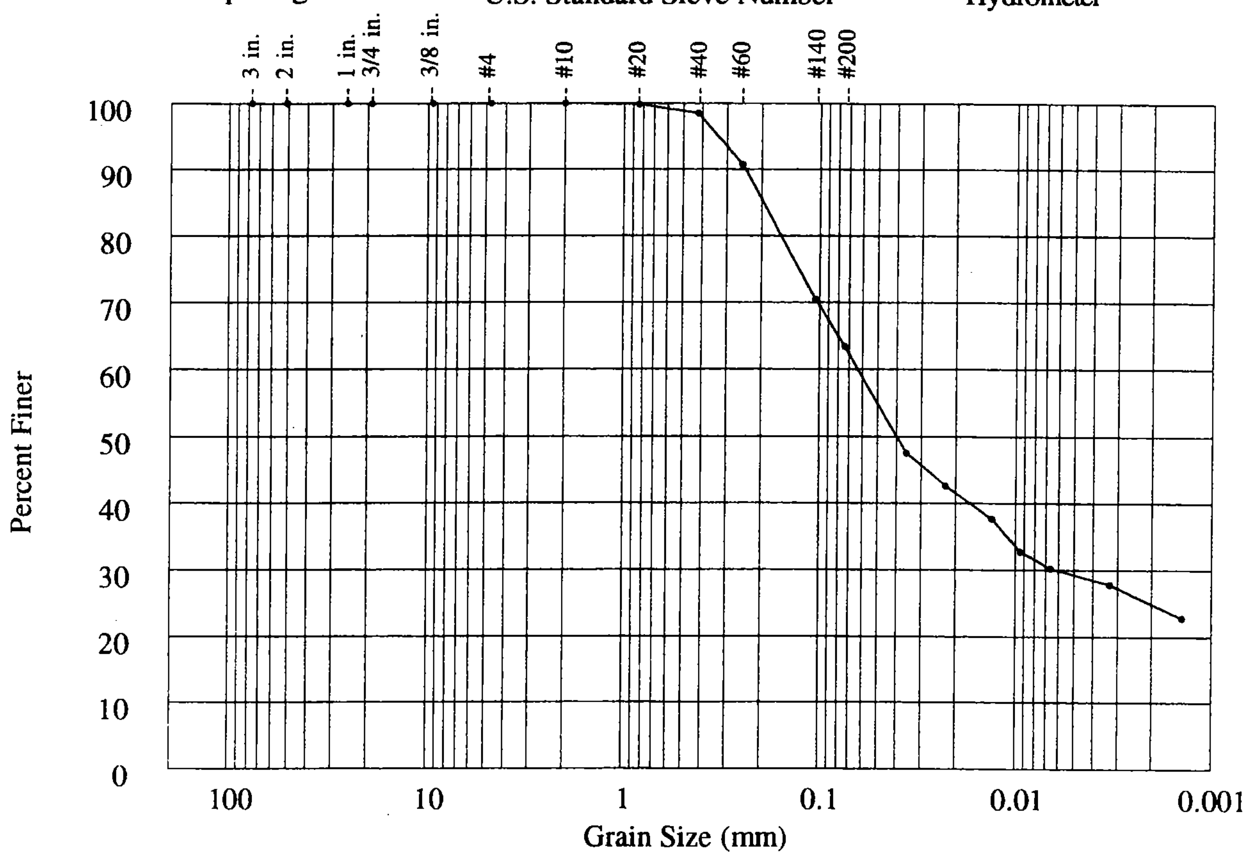
Grain Size Distribution Test Report



% Cobble >3"	% Gravel <3" - #4	% Sand: Coarse #6-#10	% Sand: Medium #16-#40	% Sand: Fine #50-#200	% Fines: % Silt 0.074-0.005 mm	% Fines: % Clay <0.005 mm
0.00	0.00	0.00	1.52	35.06	34.17	29.25

Nat. Water (%)	LL	PI	D85	D60	D50	D30	D15	D10	Cc	Cu
308.96										

Material Description	USCS
Black Sandy Organic Silt	OL/OH

Project Description		
USACE-New England District, O&M Projects	Client P/N:	G339645-0001
Turner's Reservoir	AMS P/N:	9903-34
	Client ID:	CP#1
	Battelle ID:	X3032
	AMS ID:	5059
	Date:	12/8/99

Applied Marine Sciences, Inc.

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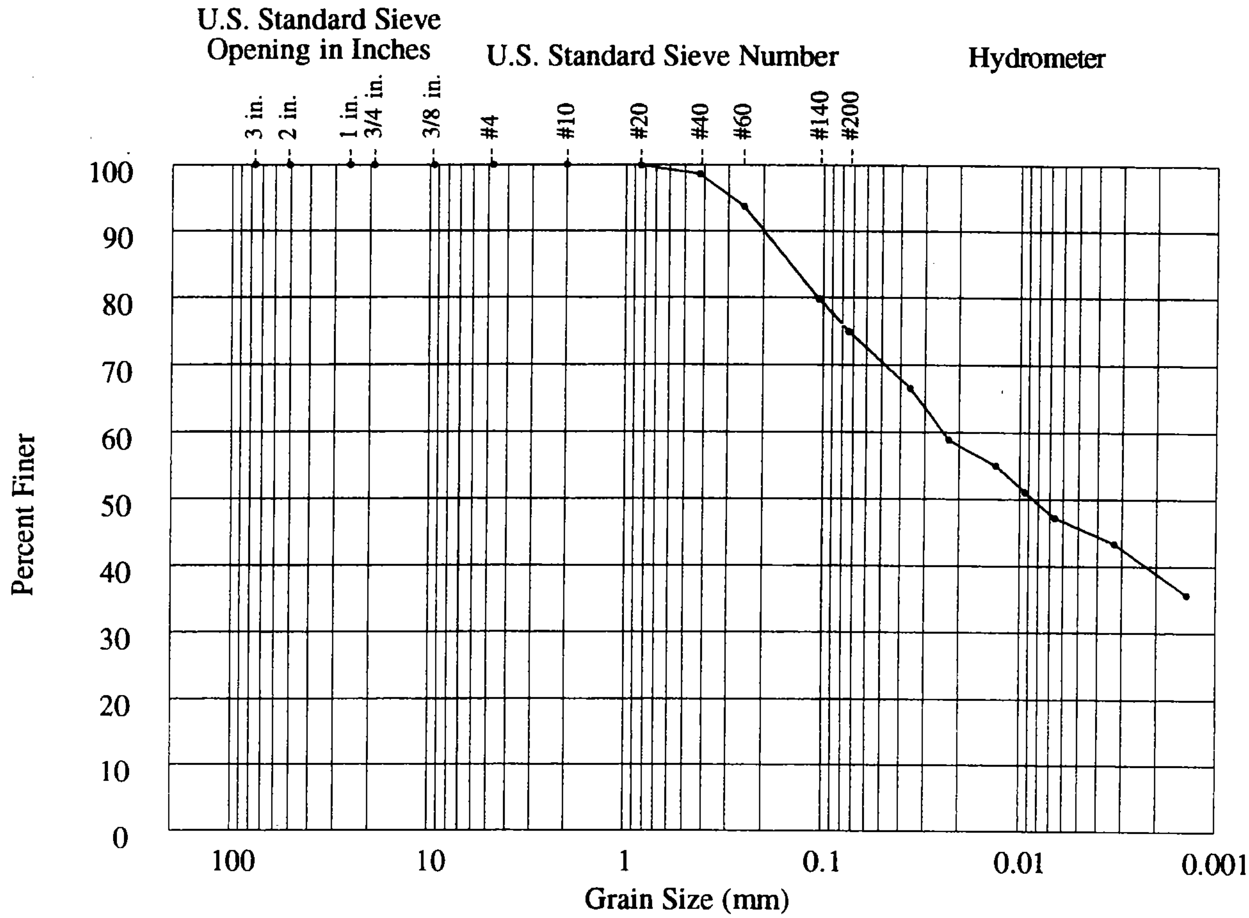
Grain Size Distribution Test Report



% Cobble	% Gravel	% Sand			% Fines	
		Coarse	Medium	Fine	% Silt	% Clay
>3"	<3" - #4	#6-#10	#16-#40	#50-#200	0.074-0.005 mm	<0.005 mm
0.00	0.00	0.00	1.33	23.71	29.46	45.50

Nat. Water (%)	LL	PI	D85	D60	D50	D30	D15	D10	Cc	Cu
627.64										

Material Description	USCS
Black Organic Clay with Sand	OL/OH

Project Description		
USACE-New England District, O&M Projects	Client P/N:	G339645-0001
Turner's Reservoir	AMS P/N:	9903-34
	Client ID:	TR#2
	Battelle ID:	X3038
	AMS ID:	5061
	Date:	12/8/99

Applied Marine Sciences, Inc.

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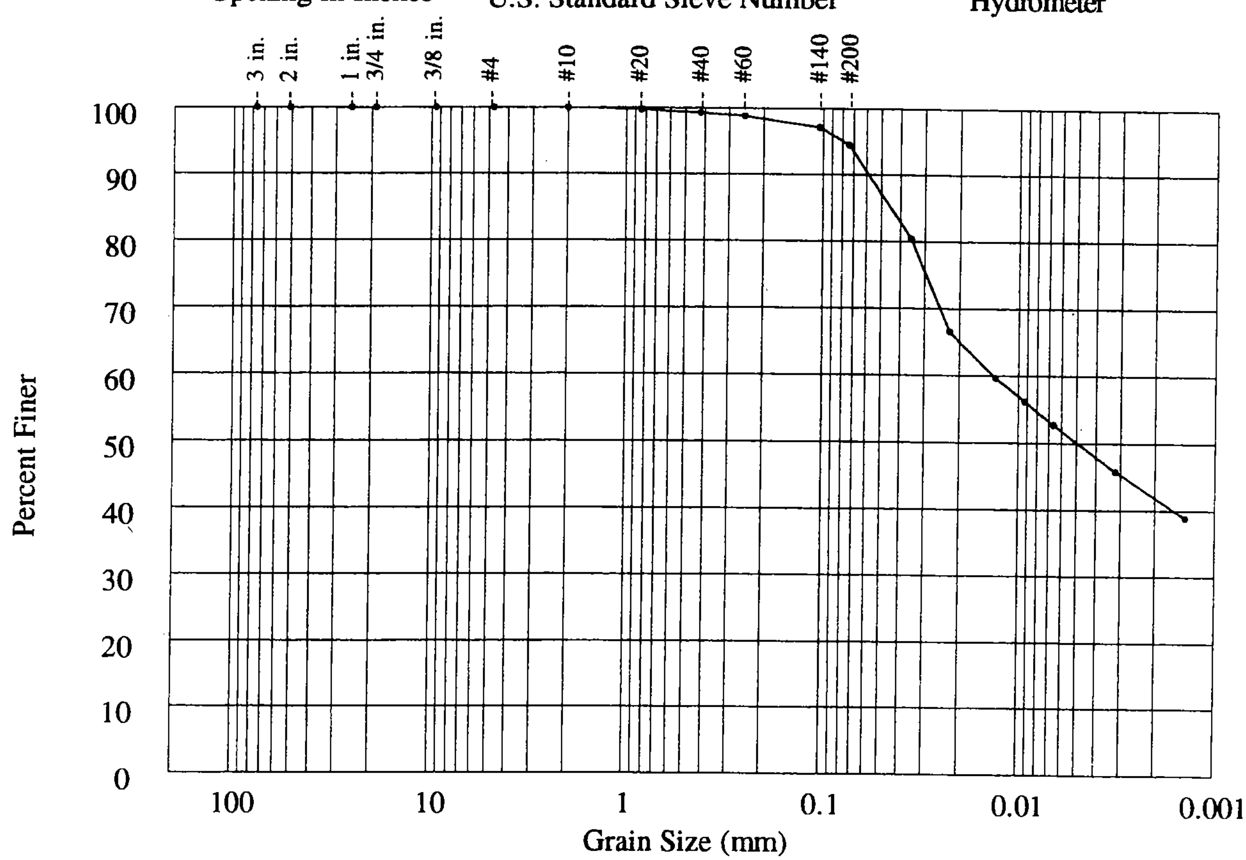
Grain Size Distribution Test Report



% Cobble	% Gravel	% Sand			% Fines	
		Coarse	Medium	Fine	% Silt	% Clay
>3"	<3" - #4	#6-#10	#16-#40	#50-#200	0.074-0.005 mm	<0.005 mm
0.00	0.00	0.00	0.72	4.76	44.52	50.00

Nat. Water (%)	LL	PI	D85	D60	D50	D30	D15	D10	Cc	Cu
645.07										

Material Description	USCS
Black Organic Clay	OL/OH

Project Description		
USACE-New England District, O&M Projects	Client P/N:	G339645-0001
Turner's Reservoir	AMS P/N:	9903-34
	Client ID:	TR#3
	Battelle ID:	X3035
	AMS ID:	5060
	Date:	12/8/99

Applied Marine Sciences, Inc.

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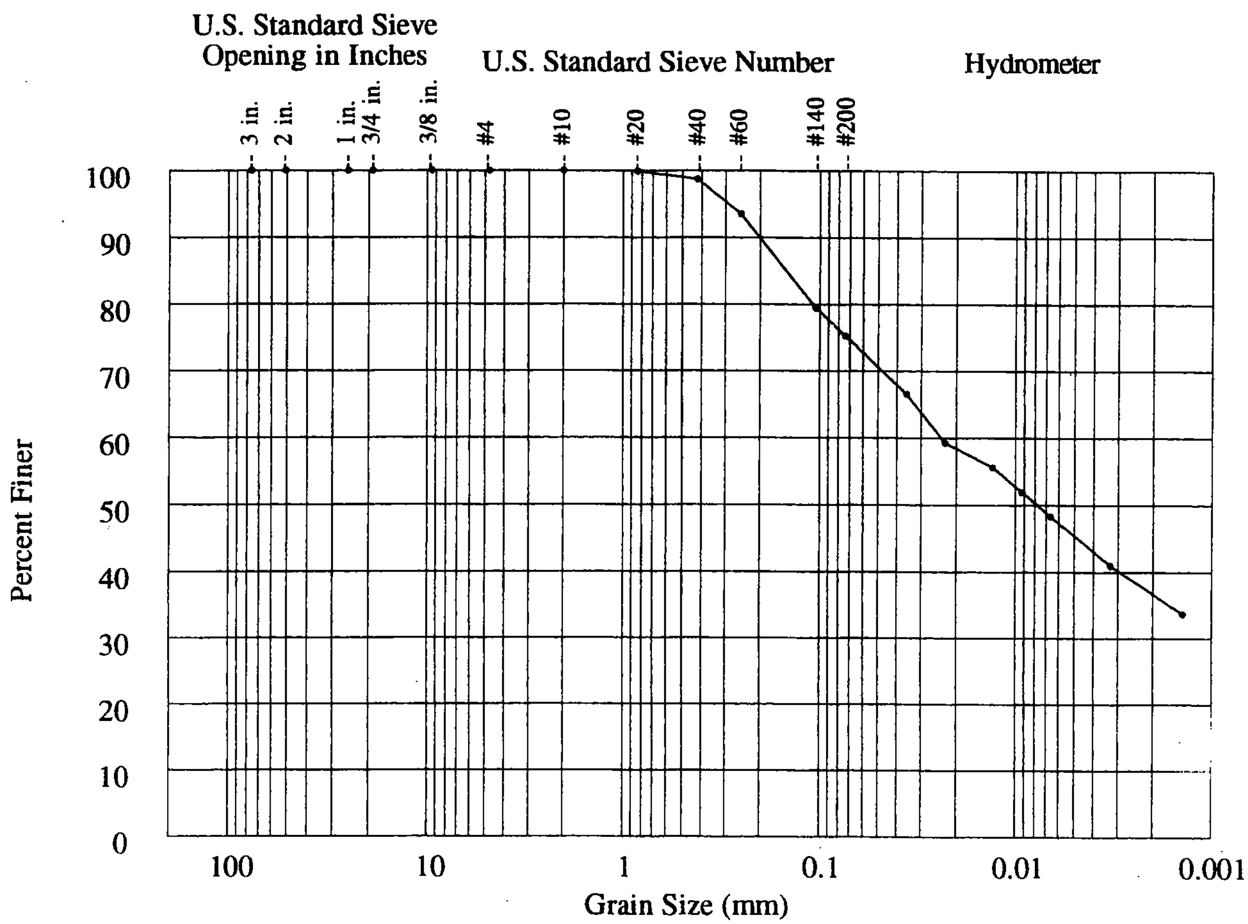
Grain Size Distribution Test Report



% Cobble	% Gravel	% Sand			% Fines	
		Coarse	Medium	Fine	% Silt	% Clay
>3"	<3" - #4	#6-#10	#16-#40	#50-#200	0.074-0.005 mm	<0.005 mm
0.00	0.00	0.00	1.28	23.51	29.81	45.40

Nat. Water (%)	LL	PI	D85	D60	D50	D30	D15	D10	Cc	Cu
629.54										

Material Description	USCS
Black Organic Clay with Sand	OL/OH

Project Description		
USACE-New England District, O&M Projects	Client P/N:	G339645-0001
Turner's Reservoir	AMS P/N:	9903-34
	Client ID:	TR#2
	Battelle ID:	X3038
	AMS ID:	5061-2
	Date:	12/8/99

Attachment 3

Total Organic Carbon Results

TOC – SEDIMENT QA/QC SUMMARY

PROJECT: Turner's Reservoir
PARAMETER: Total Organic Carbon (TOC)
LABORATORY: Applied Marine Sciences, Inc.
MATRIX: Sediment
SAMPLE CUSTODY: A representative from Battelle Duxbury retrieved a total of three (3) sediment samples on 11/19/1999 from NAE. Samples were received chilled, transported to the laboratory, and stored in the Walk-in-Refrigerator over the weekend until they could be logged into the laboratory's tracking system on 11/22/1999. Samples were received chilled and in good condition. The cooler temperature on arrival was not recorded. Samples were stored refrigerated until analysis.

Battelle shipped sediment samples to Applied Marine Sciences, Inc. (AMS) on 11/23/1999. Samples were received at AMS on 11/24/1999. All samples were received in good condition and were stored at 4°C until analysis.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Method Blank	SRM % Diff.	Relative Precision	Achieved Detection Limit (% DW)	Target Detection Limit (% DW)
TOC	EPA Method 9060	<5x DL	≤5%	≤25%	0.01	0.01

METHOD: Sediment samples were analyzed for TOC content following EPA Method 9060.

HOLDING TIMES: Samples were prepared for TOC analysis within holding time.

Collection Date 11/10/1999
TOC Analysis Date 12/06/1999

DETECTION LIMITS: Achieved detection limits met the target detection limits suggested in the project scope of work.

BLANKS: A method blank was prepared with sediment samples. TOC was undetected in the method blank.

REPLICATES: Each sediment sample was analyzed in duplicate. RPDs were within the control limits specified by the method.

SRM: An SRM was analyzed as a continuing calibration. The RPD between the measured and true values was within the control limits specified by the method.

Applied Marine Sciences, Inc.

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Project Number: G339645-0001
Project Title: USACE O&M NAE
Turner's Reservoir
Client: Battelle-Duxbury Operations

AMS Project Number: 9903-34
Date Sampled: N/A
Date Received: 11/24/99
Matrix: Soil

Total Organic Carbon (EPA SW9060)

Field Sample ID	Battelle Sample ID	AMS Sample ID	TOC-Replicate 1 (%)	TOC-Replicate 2 (%)	MDL (%)	Date Analyzed
CP#1	X3032	5059	6.35	5.88	0.01	12/6/99
TR#3	X3035	5060	12.94	12.46	0.01	12/6/99
TR#2	X3038	5061	8.97	9.02	0.01	12/6/99

Quality Assurance: These analyses were performed in accordance with EPA guidelines for quality assurance.

KSD

AMS, Inc. Project Manager

Applied Marine Sciences, Inc.

502 N. Highway 3, Suite B • League City, TX 77573 • (281) 554-7272 • Fax (281) 554-6356

Project Number: G339645-0001
Project Title: USACE O&M NAE
Turner's Reservoir
Client: Battelle-Duxbury Operations
Battelle Samp ID X3032
Field Samp ID: CP#1
AMS Samp ID: 5059

AMS Project Number: 9903-34
Date Sampled: N/A
Date Received: 11/24/99
Matrix: Soil

Total Organic Carbon (EPA SW9060)

Result	Duplicate	RPD	MDL	Unit	Date Analyzed
6.35	5.88	7.69	0.01	%	12/6/99

Quality Assurance: These analyses were performed in accordance with EPA guidelines for quality assurance.

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Project Number: G339645-0001
Project Title: USACE O&M NAE
Turner's Reservoir
Client: Battelle-Duxbury Operations
Battelle Samp ID X3035
Field Samp ID: TR#3
AMS Samp ID: 5060

AMS Project Number: 9903-34
Date Sampled: N/A
Date Received: 11/24/99
Matrix: Soil

Total Organic Carbon (EPA SW9060)

Result	Duplicate	RPD	MDL	Unit	Date Analyzed
12.94	12.46	3.78	0.01	%	12/6/99

Quality Assurance: These analyses were performed in accordance with EPA guidelines for quality assurance.

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Project Number: G339645-0001
Project Title: USACE O&M NAE
Turner's Reservoir
Client: Battelle-Duxbury Operations
Battelle Samp ID X3038
Field Samp ID: TR#2
AMS Samp ID: 5061

AMS Project Number: 9903-34
Date Sampled: N/A
Date Received: 11/24/99
Matrix: Soil

Total Organic Carbon (EPA SW9060)

Result	Duplicate	RPD	MDL	Unit	Date Analyzed
8.97	9.02	0.56	0.01	%	12/6/99

Quality Assurance: These analyses were performed in accordance with EPA guidelines for quality assurance.

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