Clean Charles 2005 Initiative
Results of Color and Clarity Monitoring in the Charles River During Spring and Summer of 2000

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North Chelmsford, Massachusetts

December 2003

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1.0 EXECUTIVE SUMMARY

Clean Charles 2005 Initiative:
Results of Color and Clarity Monitoring in the Charles River During Spring and Summer of 2000.

The goals of the monitoring effort were to identify the main sources affecting impaired visibility in the Charles River and to identify temporal and spatial trends in the concentrations of those factors. Regardless of the bacteriological quality, if the water does not meet swimming standards for visibility, swimming may not be allowed in many sections of the river in the lower basin, including proposed bathing sites such as Magazine Beach in Cambridge. Identifying the main factors affecting visibility will help to determine if it will be possible to improve visibility through regulatory or pollution prevention strategies.

MONITORING DESIGN:
The Charles River was monitored at 13 sites along the entire length of the river once a month from March through September of 2000. *In situ* measurements for temperature, pH, specific conductivity, dissolved oxygen, turbidity, and secchi disk transparency were recorded. Samples were analyzed for nutrients (nitrate and nitrite, total phosphorus, orthophosphate), total suspended solids, mineral suspended solids, chlorophyll a, soluble tannic acid, apparent color, and true color. The EPA approved methods were used when applicable. Manufacturers' methods were used when EPA approved methods were not available.

CONCLUSION and RECOMMENDATIONS:
Total suspended solids greatly influence visibility in the lower basin as measured by secchi disk transparency. True and apparent color did not follow secchi disk transparency trends. Therefore, it may be possible to further improve the visibility in the lower Charles River basin through pollution prevention strategies. Further characterization of the suspended solids will be needed to determine sources and to target appropriate control strategies

RESULTS:

1) Secchi disk transparency trends followed most closely with trends in turbidity and total suspended solids. The greater the concentration of total suspended solids, the lower the visibility through the water column.

2) True and apparent color did not follow the secchi disk transparency in the lower basin. The apparent color of the water is the result of naturally occurring organic acids originating from the wetland areas of the watershed and total suspended solids. Color was most intense downstream of wetland areas during June. Trends in apparent and true color intensities followed with trends in soluble tannic acid and total organic carbon concentrations.

3) Nutrient levels remained relatively consistent over the sample period and did not follow secchi disk transparency trends. Nitrate and nitrite peaks were consistently observed at the Bellingham site. This is an artifact of the Milford Wastewater Treatment Plant and was diluted as water flowed downstream.

4) Temperature, pH, and specific conductivity did not correlate with SDT. They were relatively consistent with seasonal climactic trends and land use along the length of the river. There were some pH values that did exceed the Massachusetts water quality standards; however they did not correlate with color or visibility trends.

2.0 INTRODUCTION

In 1995, U.S. EPA - New England established the Clean Charles 2005 Initiative. This initiative aims to restore the Charles River to a condition safe for swimming and fishing by Earth Day 2005. The strategy for water quality improvement is based on the following; combine sewer overflow reduction, illicit sanitary connection removal, storm water management planning and implementation, public outreach, education, enforcement, technical assistance, and water quality monitoring and assessment.

At the time of this monitoring study, the Massachusetts Department of Public Health (MDPH) standard 105 CMR 445.000, "Minimum Standards for Bathing Beaches (State Sanitary Code, Chapter VII)," used both bacteriological and physical qualities to evaluate overall water quality. The standard required visibility through the water column to be a minimum of four feet. The standard has since been changed to a narrative standard (Appendix C). However, it remains that water must meet minimum standards for swimming to be allowed. The Charles River Watershed Association has demonstrated that nine sites downstream of the Watertown Dam met swimming and boating bacteriological standards as set by the Massachusetts Department of Environmental Protection 58% and 90% of the time overall in 2000, respectively. This was an improvement from 19% and 39% in 1995. Although Clean Charles 2005 strategies have been effective, many locations along the river still do not meet MDPH's swimming standard for visibility and it is unclear why. At many locations, the water of the Charles River is turbid with a yellow-brown tint.

3.0 PROGRAM DESCRIPTION

Teams from the Office of Environmental Measurement and Evaluation's (OEME) Ecosystem Assessment Unit (ECA) sampled 13 sites along the length of the Charles (Table 1 and Figure 1). Secchi disk transparency, pH, temperature, dissolved oxygen, specific conductivity, and turbidity were measured in the field. Laboratory analysis was conducted for true color, apparent color, total suspended solids, chlorophyll a, nitrite and nitrate, total phosphorus, orthophosphate as phosphorus, total organic carbon, and tannic acid.

Sample sites were selected based on potential relationships between land use and water quality. The three major causal agents thought to be associated with reduced visibility along the Charles River were suspended solids, algae (phytoplankton), and humic acids. Storm water runoff, nutrient loading, dissolved and suspended organic matter are factors that contribute to these causal agents. Therefore, the following potential sources were taken into consideration; wetlands, agriculture, residential development, transportation, wastewater treatment facilities, and major tributaries to the main stem of the Charles River.

Due to the distance between sampling sites it was necessary to have two sampling teams. ECA teams conducted all sampling for this project. Monthly sampling events were conducted between March 2000 and September 2000. One quality control (QC) duplicate sample was collected at a different location during each sampling event. The weather conditions were noted in the bound field notebook and field measurements were recorded.

3.1 SAMPLE SITE DESCRIPTIONS

Table 1. Sampling Site Descriptions

Site #	**Location Description**	**Latitude (N)**	**Longitude (W)**
1	Hopkinton. Echo Lake.	42°11'31.10"	71°30"28.41"
2	Bellingham. Hartford Avenue Bridge.	42°06"12.73"	71°29'58.92"
3	Franklin. Pond Street Bridge.	42°08'17.45"	71°25'51.66"
4	Medway. Mouth of Mine Brook, Shaw Street.	42°08'08.50"	71°25'04.10"
5	Millis. Myrtle Street.	42°08'03.49"	71°21'43.90"
6	Sherborn/Medfield. Upper Charles River Valley Storage, Route 27.	42°12'35.21"	71°21'05.93"
7	Natick. Downstream of South Natick Dam.	42°16'17.37"	71°18'55.90"
8	Needham. Cochrane Dam, South Street.	42°15'31.18"	71°15'46.04"
9	Newton. Charles River Watershed Association dock.	42°20'41.48"	71°15'35.79"
10	Waltham. Watertown Dam.	42°21'54.56"	71°11'22.49"
11	Downstream of Stoney Brook/Muddy River confluence	42°21'10.05"	71°05'15.81"
12	Cambridge. Magazine Beach.	42°21'13.42"	71°06'47.54"
13	Boston. Between Longfellow Bridge and Museum of Science.	42°21'54.77"	71°04'22.745"

3.2 WATER QUALITY MONITORING

Field measurements were collected using an YSI multi-parameter probe (sonde). The sonde was lowered to approximately 0.2 meters below the surface for all field measurements. The sonde recorded dissolved oxygen, temperature, pH, turbidity, and specific conductance. At the site where duplicate samples were taken, after the initial measurement, the sonde was moved a few feet while kept in the same horizontal plane and a duplicate set of measurements were taken. A secchi disk measurement was taken and used to indicate water clarity at locations where water depth was at least 4 feet (1.2 meters). All the samples for chemical analysis were collected as grab samples at approximately 0.2 meters below the water's surface. Chlorophyll a samples were stored in a black plastic bag to protect them from sunlight. All samples and analysis followed U.S. EPA approved or manufacturer methods and procedures as listed in Table 2.

Figure 1. Map of Charles River Watershed with Sample Locations

Table 2. Analytical Methods and SOP References

Parameter	Laboratory	Analytical Reference Method
Ph	EPA field measurement	YSI 6000 operation manual
Specific Conductivity	EPA field measurement	YSI 6000 operation manual
Temperature	EPA field measurement	YSI 6000 operation manual
Dissolved Oxygen (mg/L and % saturation)	EPA field measurement	YSI 6000 operation manual
Turbidity	EPA field measurement	YSI 6000 operation manual
Clarity	EPA field measurement	Secchi Disk
True Color	EPA laboratory	EPA 110.2 HACH manufacturer method 8025
Apparent Color	EPA laboratory	EPA 110.2 HACH manufacturer method 8025
Total Suspended Solids	EPA laboratory	EPA 160.2
Volatile Residues	EPA laboratory	EPA 160.4
Chlorophyll a	EPA laboratory	Standard Method 10200 H / EPA 446.0
Total Organic Carbon	EPA laboratory	Standard Method 5310B
Total Phosphorus	EPA laboratory	HACH manufacturer method 8190
Orthophosphate as Phosphorus	EPA laboratory	EPA 300.0 (modified)
Tannic Acid	EPA laboratory	HACH manufacturer method 8193
Nitrate + Nitrite, as Nitrogen	ALPHA Analytical Labs	EPA 300.0 (modified)

Note: The testing methods for Orthophosphate as P and for Nitrate-Nitrite as N were modified by the laboratory in order to achieve lower detection limits. Mineral suspended solids were measured as "volatile residues" following U.S. EPA method 160.4. The laboratory does not have an SOP, so the method instructions were followed exactly.

4.0 DATA QUALITY ASSURANCE

Data was reviewed to assure that it was within the ranges associated with the specific approved protocols. For example, if a probe did not meet the established QC goals, it was recalibrated and the pre-calibration value plus the date and time of correction was logged. If the calibration check showed that the inaccuracy was less than two times the accuracy range, the previously logged data was reported as "approximate" and flagged with a "J". Otherwise the data was rejected at the discretion of the project officer. At the end of each sampling run, a final calibration was made. Data was flagged as "est." for estimated if final calibration data was not available.

All data was reviewed by the project lead to assure that it was representative and complete, comparable, and usable. All reported data was accepted by the project lead if it met reporting limits and QA goals.

All data accepted by the project lead met reporting limits and quality assurance goals as stated in the QAPP (Table 3). All collected field duplicate data was reviewed by the project lead to determine if the data met the QC goals. All OEME chemical analytical results were reviewed by; the project QA officer, a second laboratory QC chemist, and the Chemistry Team Leader before results were released. For the data review process refer to OEME's Laboratory Quality Assurance Plan (EIA- QAP1 - 6/23/98).

Analytical results generated by an outside contract laboratory were certified in narrative form that the data submitted met the reporting and documentation requirements of the contract. Analytical results received by OEME were reviewed for acceptance by the designated Quality Assurance officer. The relevant analytical SOPs and QA manuals were requested and filed with the contract laboratory reports.

Table 3. Reporting Limits and Quality Assurance Goals

Parameter	Reporting Limits	Quality Assurance Goals		
		Precision	Accuracy	Completeness
PH	2 units	0.01 units	+/- 0.2 units	90%
Specific Conductance	0 mS/cm	0.01 or 0.1 mS/cm	+/-0.5% of reading + 0.001mS/cm	90%
Temperature	-5°C	0.01° C	+/- 0.15°C	90%
Dissolved Oxygen	0.2mg/l	0.01mg/l	0 to 20 mg/l:+/-0.2 mg/l	90%
Turbidity	0.01NTU	0.1NTU	+/- 5% or 2NTU which ever is greater	90%
Clarity	0.5 feet	N/A	N/A	90%
True Color (HACH)	5 units	Field Rep. RPD. 35%	N/A	90%
True Color (EPA method)	0 units	Field Rep. RPD. 35%	N/A	90%
Apparent Color (HACH)	5 units	Field Rep. RPD. 35%	N/A	90%
Apparent Color (EPA method)	0 units	Field Rep. RPD. 35%	N/A	90%
TSS/volatile residues	2 mg/l	Field Rep. RPD. 35%	+/- 30%	90%
Chlorophyll a	100 ppb	Field Rep. RPD. 35%	+/- 30%	90%
TOC	4 mg/l	Field Rep. RPD. 35%	+/- 25% of QC standard (62.4ppm)	90%
Total P	50 ug/l as P	Field Rep. RPD. 35%	MS 70-130% recovery	90%
Ortho-P	8.15 ug/l as P	Field Rep. RPD. 35%	MS 70-130% recovery	90%
Tannic acid	0 mg/L	Field Rep. RPD. 35%	+/- 0.08 mg/L	90%
NO2 + NO3 as N	NO3- 0.023 mg/L NO2- 0.030 mg/L	Field Rep. RPD. 35%	MS 80 - 120% recovery	90%
Ammonia as N	75 ug/l as N	Field Rep. RPD. 35%	MS 75 - 125% recovery	90%

Note: The methods for light penetration and tannic acid are manufacturer's methods. Determination of true and apparent color was conducted using both EPA and HACH manufacturer's methods

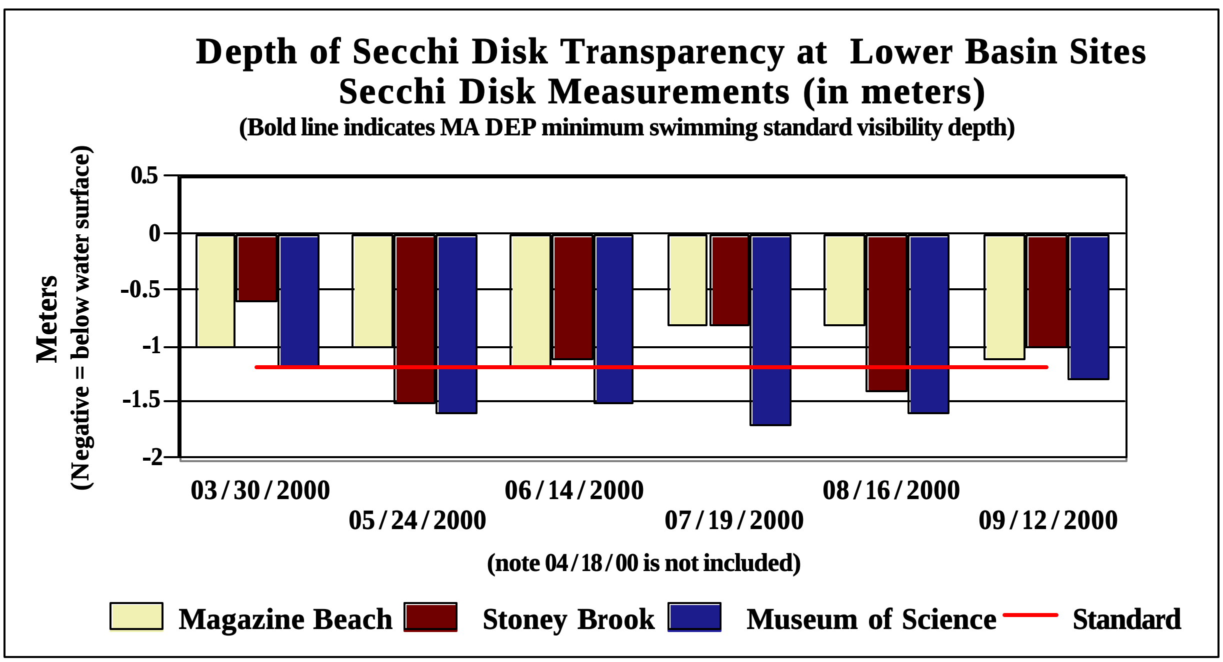
5.0 RESULTS AND DISCUSSION

At the time this study was conducted, the MADPH swimming standard required a secchi disk transparency of 1.2 meters. This has recently been changed to a narrative standard. Many factors can affect water transparency or clarity, these include: suspended matter (organic and mineral), algae or plankton, and color (dissolved organic matter such as tannins and lignin's). Establishing a monitoring program to assess potential causes of poor water transparency in the river, particularly the lower basin, was considered critical to interpreting data, and designing a plan to mitigate potential causes, thereby improving the prospects for a swimmable river. The goal was to measure chemical and physical parameters that potentially contribute to the water clarity problem. This would permit a basin-wide characterization and evaluation of the impact these parameters have on water quality. A total of 13 sample stations along the length of river were sampled during an index period extending from March to September. The locations were chosen to assess spatial and temporal trends in order to identify the main factors and locations affected by reduced water column visibility.

5.1 SECCHI DISK TRANSPARENCY

Figure 2 shows the secchi disk transparency for three locations in the Charles River Lower Basin for March to September 2000. Those depths less than 1.2 meters (above the red line), in place at the time of this investigation, were in violation of the MADPH standard. Magazine Beach targeted as a potential recreation resource for bathing and other activities met the standard only once. The Charles River at the Stoney Brook conduit met the standard twice, and the site between the Longfellow Bridge and the Museum of Science met the standards for all six months. These results are consistent with those results generated as part of the U.S. EPA's core monitoring program as documented in the "Clean Charles 2005 Water Quality Report 2001 Core Monitoring Program". SDT was not measured at the designated sampling stations upstream because the water depths were less than 4 feet. Secchi disk transparency was measured on two dates in the spring at Echo Lake in Hopkinton. Unsafe conditions did not permit SDT measurements on the remaining sampling dates.

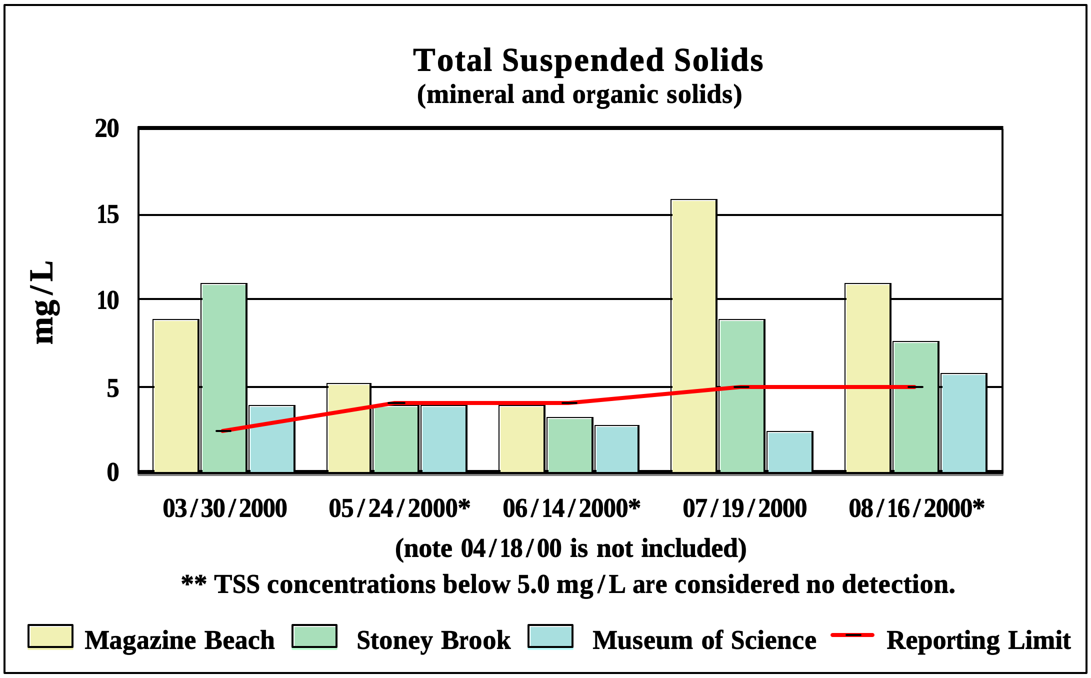
Figure 2. Secchi Disk Transparency for the Three Lower Basin Sites



5.2 TOTAL SUSPENDED SOLIDS AND TURBIDITY

An examination of the results for total suspended solids (Table 3, Appendix B) shows that TSS values in the upper basin above the South Natick Dam are generally in the range of the method reporting limit. Progressing downstream into the more densely populated and urbanized areas, TSS increases, with maximum values found in the lower basin during July and August. Figure 3 shows that TSS in the lower basin declines in May and June from the values reported in March, a period of increased runoff, and then increases again during July and August. Magazine Beach exhibited the highest TSS values followed by the Stoney Brook location. The site between the Longfellow Bridge and the Museum of Science apparently serves as a settling basin as demonstrated by the lower TSS values for each of the sampling dates.

Figure 3. Total Suspended Solids Measurements for the Three Lower Basin Sites

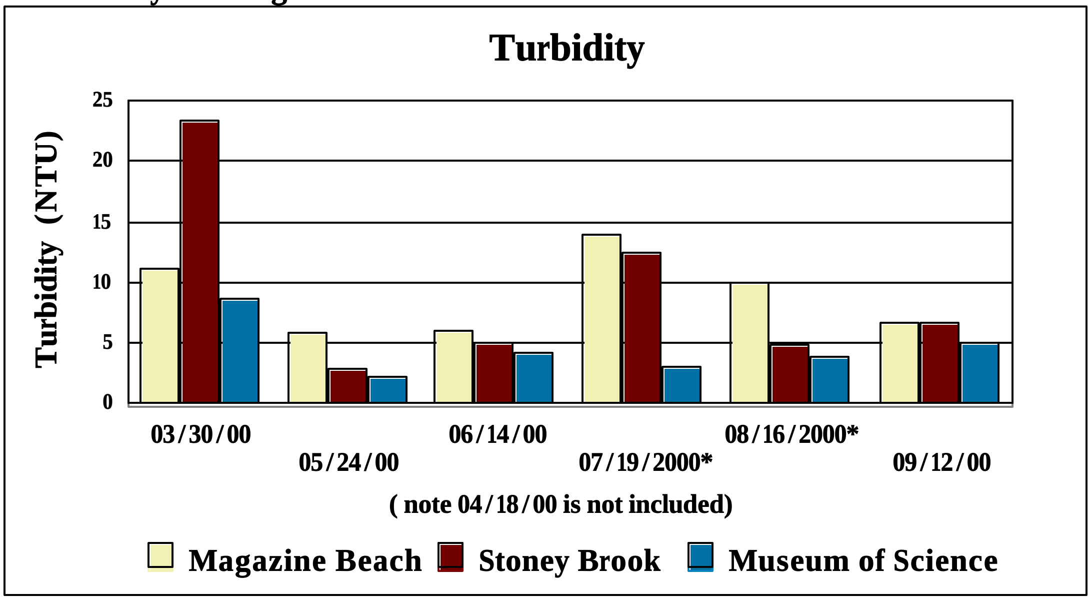


*Note: Data for dates 5/24, 6/14, and 8/16 - field replicate exceeds 35% and so did not meet the QA goal for precision.

Turbidity measurements are provided for the entire length of the Charles River in Table 2A, Appendix A. and in Figure 4 for the lower basin. In effect, turbidity is surrogate for TSS, and the upstream to downstream monthly trends closely track those for TSS. The turbidity information not only provides additional data, but also serves as a method validation procedure.

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the medium. Suspended solids in solution will increase the tendency for light to be scattered and absorbed rather than be transmitted through the water column, thus increasing the measurement of turbidity. Aqueous solutions have different physical and chemical properties than pure water; therefore they also have different optical properties. In this study, potential factors for diminished SDT were thought to be total suspended solids, dissolved organic acids (relatively measured as tannic acid), and algae expressed as chlorophyll a. Previous monitoring done by Robert Breault of the United States Geological Survey in the lower basin of the Charles River suggests the trend correlated with chlorophyll a (Breault, written communication 1999). When these graphs are compared to the graph for SDT, an inverse relationship is demonstrated. As total suspended solids (TSS) concentrations and turbidity increased, SDT decreased.

Figure 4. Turbidity Readings for the Three Lower Basin Sites

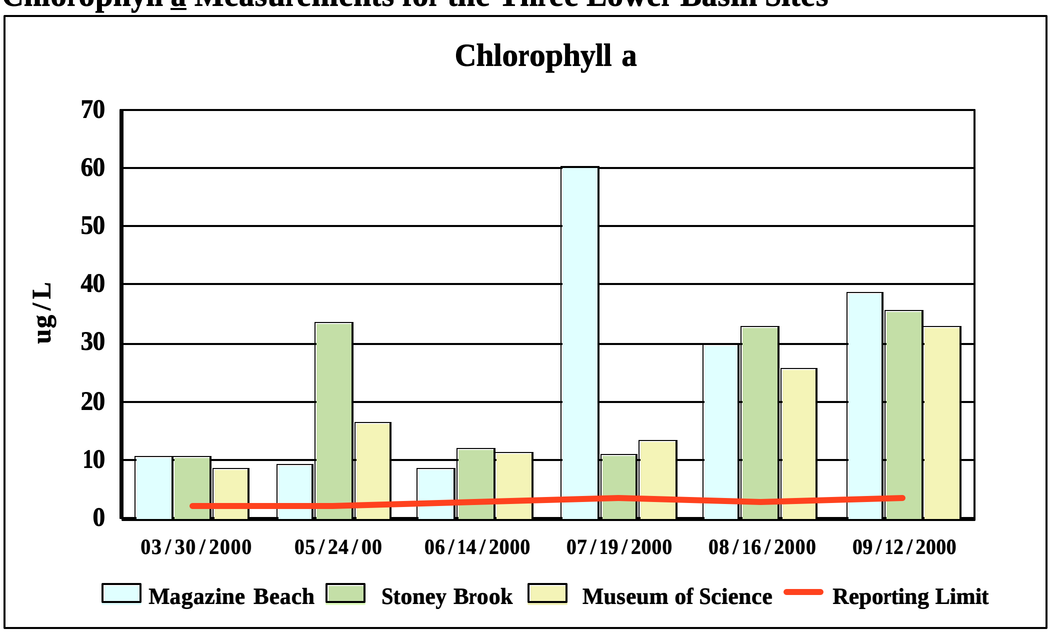


*Note: the reporting limit for data is 1.0 NTU

5.3 CHLOROPHYLL a

Chlorophyll a is a measure of algal biomass, and abundance. Table 9B, Appendix B, provides the chlorophyll a values measured for seven months beginning in March. From Echo Lake in Hopkinton downstream to Millis, the chlorophyll a values are in the low to moderate range. Beginning in Medfield and continuing downstream, the values increase with maximum values occurring in July, August, and September. A peak chlorophyll a value of 122 ug/L was recorded in Needham during July. Many of the values vary by station location and date, but generally were in excess of 30 ug/L at many locations. Chlorophyll a was notably abundant in the lower basin (Figure 5.) In general, chlorophyll a values measured during this study were consistent with values reported by others indicating eutrophic conditions. Although chlorophyll a was high at certain times in the Charles River, and comprised a fraction of the total suspended solids, it was not the only factor contributing to the increased turbidity and lower secchi disk transparency.

Figure 5. Chlorophyll a Measurements for the Three Lower Basin Sites



5.4 COLOR, TANNIC ACID, AND TOTAL ORGANIC CARBON

Apparent color, a measure of the intensity of light absorption by water, is a function of both the concentration of organic acids and total suspended solids, including all organic carbon forms and chlorophyll a. True color is a measure of the intensity of light absorption by water after removing solids by filtration or centrifugation. In this study, color was measured using two methods. The U.S. EPA approved method is a visual comparison method by which each sample is visually compared to standards of known color intensity. The HACH manufacturer method uses a spectrophotometer to measure the absorbency of light at 455 nm. All data was given in APHA units, which is a relative measure of color intensity. Greater color intensity indicates that more light is absorbed by the solution resulting in higher APHA unit measurements. The graphs and data included in this report were created from the data generated using the HACH manufacturer's method.

The U.S. EPA method and the HACH method are not comparable, but it was determined that both sets of data are usable. As shown by comparing the true and apparent color data, the water's color is greatly influenced by the presence of the organic acids.

The color of Charles River water downstream of Echo Lake has often been described as resembling strong tea due to its yellow-brown color. Generally speaking, color can be attributed to a variety of factors such as effluents, naturally occurring metals (iron and manganese), and natural products of decomposition (humic and tannic acids). Apparent color includes substances in solution and suspended matter, while true color is a measure with the suspended matter removed by filtration or centrifugation. Figure 6 provides the color results for all stations sampled during June when color reached its peak intensity. Moving downstream through the watershed, color increases in intensity in the upper watershed in the vicinity of Medway, Millis, and Medfield, plateaus, and then declines in the lower basin.

Results of tannic acid and total organic carbon (TOC) for June 14, 2002 are in Figure 7, (Table 4B and 8B, Appendix B). Organic acids give many natural waters a yellow-brown tint. Tannic acid is a component of naturally occurring organic acids, which result from the breakdown of organic matter. Measuring for tannic acid gives the relative amount of organic acids present in a water sample. The intensity of color varies with the concentration of those compounds present. TOC accounts for all organic carbon in the sample and therefore gave a benchmark for comparison. Moving downstream through the watershed, tannic acid and TOC concentrations increase in the upper watershed in the vicinity of Medway, Millis, and Medfield, plateaus, and then decline in the lower basin.

Looking at the data for the entire length of the river, there were several observations made. There were temporal trends in the color, TOC, and tannic acid data. This reflects the mineralization and breakdown of organic matter in wetlands and the leaching of the resultant organic acids into the river. Leaves fall in the autumn and plant matter dies. This material is not degraded during the winter. As temperatures rise in spring, microbes begin to go to work breaking down the material. The color intensity measurements follow this seasonal trend, with low measurements recorded in September and the peak measurements in June.

There were spatial trends in the color, TOC, and tannic acid data as well. It is noteworthy that in June, between the headwaters of Hopkinton's Echo Lake (site #1) to the Medway (site #3) sampling locations, the apparent color intensity increased from 35 APHA units to 145 APHA units after flowing through wetlands. The color intensity remained high until Waltham (site #10), what is considered to be the site of demarcation between the lower and upper basins of the watershed. Almost 6% of the land within the Charles River Watershed is delineated as wetland. Of that, 7.2% of the total land in the upper watershed is wetland, compared to 4.0% in the lower watershed. The lower watershed is recharged mainly by groundwater and municipal treatment plants, neither being a source of naturally occurring organic acids. The samples drawn from the lower watershed had decreasing color intensities due to the dilution effect of recharge.

There were no discernable similarities in patterns of concentrations between SDT and tannic acid or TOC data (the relative measure of tannic acid.). The patterns of TOC and tannic acid data were very similar for each sampling event.

Figure 8 (True and Apparent Color) and Figure 9 (TOC, TSS and Tannic Acid) for June 14, 2000 show that there are slight decreases for each of the parameters extending from Magazine Beach downstream to the Museum of Science. These observations tend to collaborate a similar trend in secchi disk transparency for the same date.

Figure 6. True and Apparent Color along the Charles River

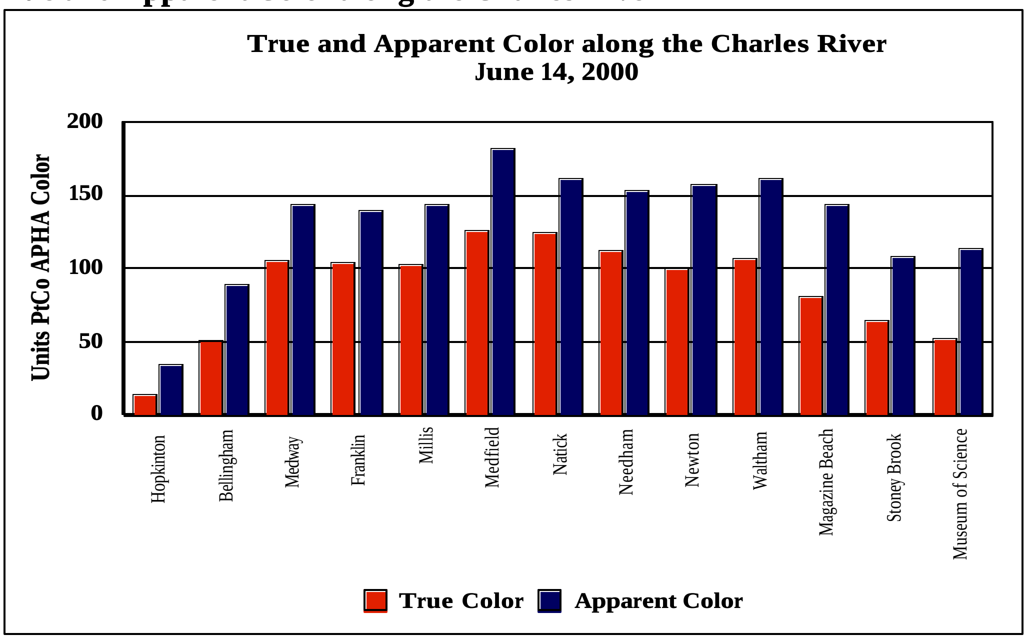


Figure 7. Total Organic Carbon, Total Suspended Solids, & Tannic Acid along the Charles River

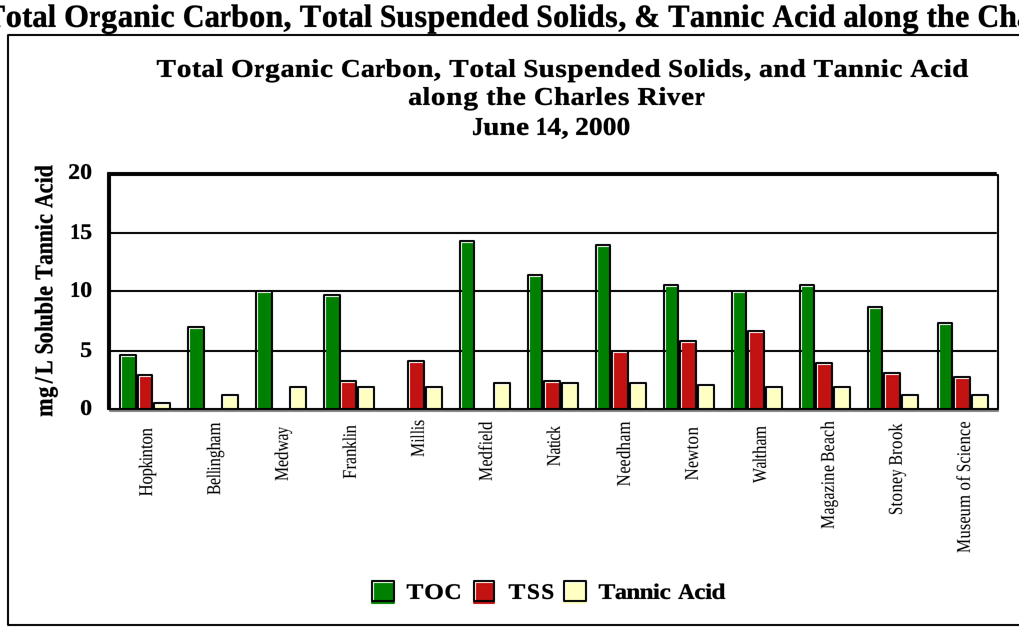


Figure 8. True and Apparent Color in the Lower Basin

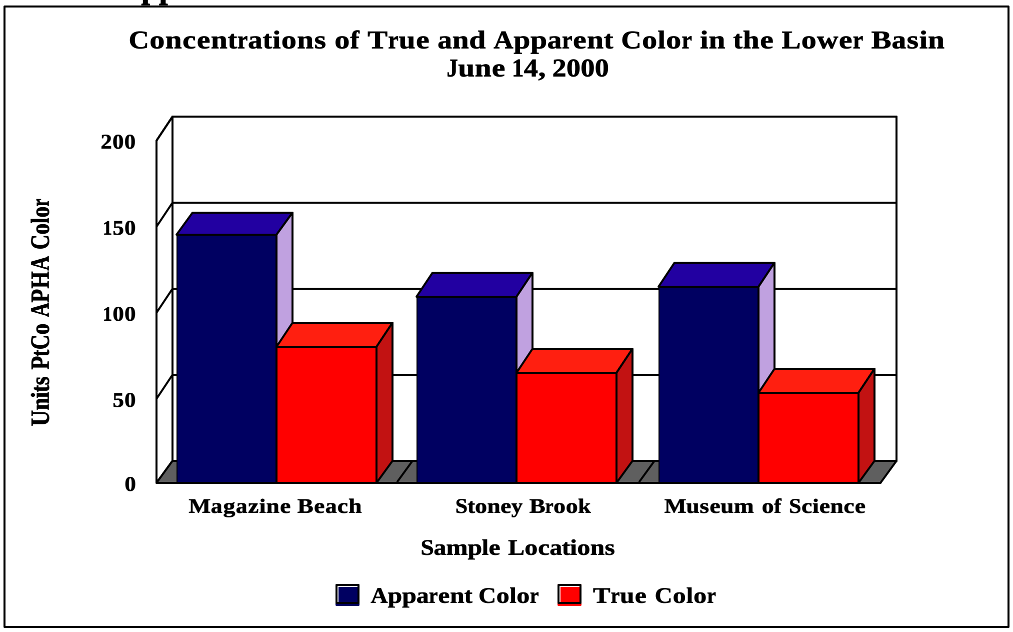
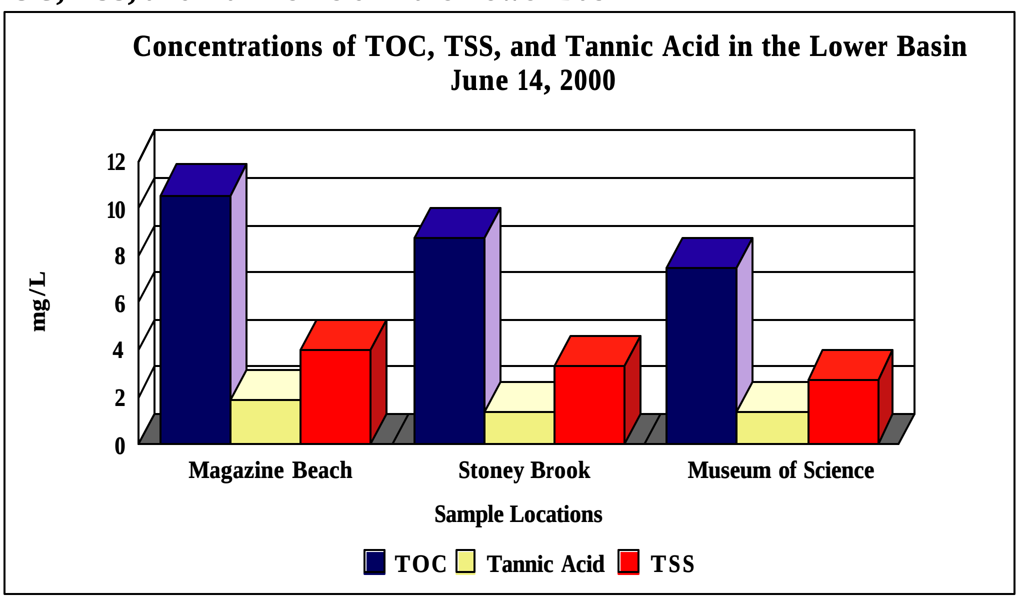


Figure 9. TOC, TSS, and Tannic Acid in the Lower Basin



6.0 CONCLUSION and RECOMMENDATIONS

- It may be possible to further improve the visibility in the lower Charles River basin through pollution prevention strategies. Further characterization of the suspended solids sources will be needed to target appropriate control strategies. Pollution prevention in combination with point and non-point control offers a possible means to improve water quality and water visibility in the Charles River Basin.

- Algae, measured from chlorophyll a, color, and total suspended solids (turbidity) together contribute to decreased clarity, however the phenomena appear to be most strongly linked to TSS as measured by SDT in the lower basin. Characterization of TSS, wet and dry weather loads, will be needed to determine appropriate control strategies and implementation of best management practices (BMPs).

- Nutrients are variable throughout the summer season. Phosphorus and algal blooms as indicated by abundant Chlorophyll a are high at times and locations throughout the Charles River Basin. Reductions of nutrients, particularly phosphorus, from point and non-point discharges need to be implemented to help reduce the stimulatory affects they have on algal abundance and the contribution to reduced water clarity.

- Nitrate and Nitrite concentrations peaked downstream of the Milford wastewater treatment plant at Station 2 in Bellingham. These values are generally a full magnitude greater than Echo Lake in Hopkinton, and substantially higher than any of the downstream stations including the lower basin.

- True and apparent color, tannic acid, and TOC intensify seasonally in the Upper Charles River basin where natural wetland drainage contributed to the tea-like water color throughout the watershed.

- Field physical-chemical water quality measurements appear to be within seasonal norms with the exception of a few water quality violations noted for pH. The only dissolved oxygen violation was detected in Bellingham downstream of the Milford waste water treatment plant during August 2000.

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Appendix A – Field Measurements

Table 1A – Secchi Disk Transparency (SDT)
Table 2A. Turbidity
Table 3A. Percent Dissolved Oxygen
Table 4A. Concentration Dissolved Oxygen
Table 5A. Temperature
Table 6A. pH
Table 7A. Specific Conductivity

Appendix A. Field Measurements

Table 1A. Secchi Disk Transparency (SDT)

Site#	Description	04/18/00	03/30/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	1.7	3.2	WOD	WOD	WOD	WOD	N/A
2	Bellingham	TS	TS	TS	TS	TS	TS	TS
3	Medway	TS	TS	TS	TS	TS	TS	TS
4	Franklin	TS	TS	TS	TS	TS	TS	TS
5	Millis	TS	TS	TS	TS	TS	TS	TS
6	Medfield	TS	TS	TS	TS	TS	TS	TS
7	Natick	TS	TS	TS	TS	TS	TS	TS
8	Needham	TS	TS	TS	TS	TS	TS	TS
9	Newton	TS	TS	TS	TS	TS	TS	TS
10	Waltham	TS	TS	TS	TS	TS	TS	TS
11	Magazine Beach	-0.6	-1	-1	-1.2	-0.8	-0.8	-1.1
12	Stoney Brook	N/A	-0.6	-1.5	-1.1	-0.8	-1.4	-1
13	Museum of Science	N/A	-1.2	-1.6	-1.5	-1.7	-1.6	-1.3

WOD = Water was flowing over the Echo Lake dam, so unable to sample with secchi disk.
TS = Water depth at sample site too shallow.
(Negative reading indicates depth below surface of water.)

Table 2A. Turbidity

		NTU						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/2000*	08/16/2000*	09/12/00
1	Hopkinton	1	0.2	0.3	NA	fc	0.8	-0.2
2	Bellingham	2.3	0.3	7.2	NA	fc	2.8	0.4
3	Medway	1.6	0.5	6.6	2.5	fc	2.8	-0.3
4	Franklin	3	1	6.5	3	fc	15.1	0.6
5	Millis	6	2.3	4.1	5.5	fc	3.7	6
6	Medfield	2.3	2.4	3.3	1.7	fc	5.9	4.9
7	Natick	5	2.3	4.2	6.2	fc	2.5	-0.3
8	Needham	2.8	2.2	4.1	21	fc	3.4	5
9	Newton	11.4	5.7	11.1	6.1	fc	4.9	4
10	Waltham	15	4.6	6.2	8.5	fc	15 J	16.9
11	Magazine Beach	11.3	12.06	5.9	6	14.1	10 J	6.7
12	Stoney Brook	23.4	N/A	2.9	5	12.5	4.95 J	6.6
13	Museum of Science	8.7	N/A	2.3	4.3	3	3.95 J	5

fc = calibration data indicates instrument not functioning correctly.
* = final calibration data not available.

Appendix A. Field Measurements

Table 3A. Percent Dissolved Oxygen

		03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
Site#	Description	% DO	% DO	% DO	% DO	% DO	% DO	% DO
1	Hopkinton	104.9	106.1	99.1	100.4	96.4	90.3	100.8
2	Bellingham	86.4	106.7	76.6	69.1	88.5	49.9	55.4
3	Medway	92.9	106.5	90.7	90.3	93	89.5	109.9
4	Franklin	95.4	109.2	92	94.2	89.2	88.8	100.4
5	Millis	93.3	100.4	87	90.7	87.3	80.7	119.6
6	Medfield	90.6	90.8	77.3	38	84.7	73.7	97.4
7	Natick	98.7	103.4	89.9	66.1	97.9	85.8	104.1
8	Needham	94.5	95	84.5	81.4	141	75	144.4
9	Newton	N/A	103.1	92.5	97.6	99.4	95.2	131
10	Waltham	99.3	107.4	98.2	95.4	86	77	97.4
11	Magazine Beach	93	98.5	76.9	90.5	96.7	79.9	89.9
12	Stoney Brook	87.8	N/A	80	****	60.2	90.9	126.9
13	Museum of Science	94.7	N/A	68.7	74.3	75.8	32	119.2

Table 4A. Concentration Dissolved Oxygen

		03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
Site#	Description	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	Hopkinton	12.18	11.71	9.83	9.39	8.07	7.82	8.72
2	Bellingham	9.46	12.09	7.77	6.86	7.87	4.55	4.99
3	Medway	10.51	12.04	9.37	9.17	8.23	8.22	10.12
4	Franklin	10.75	12.25	9.46	9.52	7.87	8.11	9.1
5	Millis	10.4	11.04	8.84	8.98	7.69	7.29	10.67
6	Medfield	9.9	9.93	7.83	3.66	7.23	6.58	7.96
7	Natick	10.8	11.24	9.02	6.37	8.36	7.57	9.01
8	Needham	10.41	10.29	8.48	7.63	11.96	6.61	12.74
9	Newton	N/A	11.21	9.08	9.14	8.43	8.33	11.16
10	Waltham	10.86	11.54	9.66	8.96	7.34	6.8	8.3
11	Magazine Beach	10.12	10.6	7.58	8.47	8.19	6.87	7.9
12	Stoney Brook	9.65	N/A	7.75	7.24	5.16	7.82	11.1
13	Museum of Science	10.48	N/A	6.76	6.9	6.38	7.02	10.29

Appendix A. Field Measurements

Table 5A. Temperature

		Degrees C						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	8.83	11	15.76	18.58	24.33	22.48	22.24
2	Bellingham	11.23	9.74	14.65	15.67	21.09	19.84	20.36
3	Medway	10.05	9.84	13.89	14.63	21.86	19.45	19.25
4	Franklin	10.08	10.2	14.07	14.8	21.64	19.79	20.13
5	Millis	10.59	11.05	14.61	15.86	21.65	20.3	20.87
6	Medfield	11.34	11.29	14.77	16.79	23.21	20.9	25.61
7	Natick	11.32	11.61	15.19	17.1	23.2	21.49	22.48
8	Needham	11.17	11.74	15.2	17.2	23.59	21.7	21.51
9	Newton	NA	11.55	16.2	18.54	23.43	22.09	23.23
10	Waltham	11.42	12.05	16.39	18.39	23.25	21.37	23.26
11	Magazine Beach	11.37	12.06	15.64	18.5	23.93	22.86	21.72
12	Stoney Brook	10.85	NA	16.47	18.6	23.01	22.81	21.86
13	Museum of Science	10.57	NA	16.05	19	23.92	23.13	22.54

Table 6A. pH

		pH						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	7.3	6.49	6.53	7.81	fc	6.8	7.59
2	Bellingham	7.05	6.54	6.62	7.02	fc	6.57	7.12
3	Medway	7.21	6.83	6.72	7.12	fc	7.06	7.63
4	Franklin	6.79	6.96	6.75	7.2	fc	6.98	7.47
5	Millis	7.16	7.02	6.74	7.23	fc	7.06	7.7
6	Medfield	6.97	6.86	6.78	6.84	fc	6.94	8.2
7	Natick	6.81	6.98	6.86	6.91	fc	7.02	7.73
8	Needham	6.91	6.95	6.87	7.06	fc	6.95	8.85
9	Newton	6.93	7.08	7.01	7.42	fc	7.11	8.03
10	Waltham	6.9	N/A	7.01	7.58	fc	7.17	7.53
11	Magazine Beach	7.16	7.19	7.1	fc	7.43	7.21	7.24
12	Stoney Brook	N/A	N/A	6.36	fc	7.13	7.52	8.66
13	Museum of Science	7	N/A	6.25	fc	7.37	7.38	8.58

fc = fail calibration check post sampling

Appendix A. Field Measurements

Table 7A. Specific Conductivity

		MS/CM						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	0.169	0.174	0.148	0.143	0.153	0.148	0.153
2	Bellingham	0.458	0.635	0.4	0.341	0.535	0.62	0.852
3	Medway	0.305	0.353	0.265	0.251	0.512	0.386	0.6
4	Franklin	0.268	0.323	0.258	0.234	0.434	0.316	0.531
5	Millis	0.243	0.293	0.262	0.226	0.381	0.373	0.447
6	Medfield	0.246	0.26	0.233	0.182	0.345	0.314	0.392
7	Natick	0.246	0.249	0.229	0.178	0.296	0.306	0.334
8	Needham	0.251	0.256	0.236	0.183	0.285	0.279	0.328
9	Newton	0.325	0.288	0.273	0.204	0.324	0.354	0.405
10	Waltham	0.357	0.335	0.266	0.211	0.35	0.35	0.391
11	Magazine Beach	0.38	0.346	0.3	0.234	0.39	0.382	0.45
12	Stoney Brook	0.443	N/A	0.344	0.266	0.49	0.539	0.737
13	Museum of Science	0.439	N/A	0.36	0.276	0.68	0.645	0.951

Appendix B – Laboratory Measurements

Table 1B. Total Suspended Solids (TSS)
Table 2B. Apparent Color
Table 3B. True Color
Table 4B. Tannic Acid
Table 5B. Nitrite and Nitrate as N
Table 6B. Orthophosphate as P
Table 7B. Total Phosphorus
Table 8B. Total Organic Carbon (TOC)
Table 9B. Chlorophyll a

Appendix B. Laboratory Measurements

Table 1B. Total Suspended Solids (TSS)

		TSS mg/L						
Site#	Description	03/30/00	04/18/00	05/24/2000*	06/14/2000*	07/19/00	08/16/2000*	09/12/00
1	Hopkinton	2.5 U	3.3 U	6.2	3	2.5 U	5	2.5
2	Bellingham	2.5 U	2.5U	7.8 J	2.5 U	5	5	2.5
3	Medway	2.5 U	3.5	6.4	2.5 U	6	9.2	2.5
4	Franklin	2.5 U	3.2U	4.4	2.5	2.5 U	5.8	2.5
5	Millis	3.8	4.5	6	4.2	2.5 U	8.5	5.2
6	Medfield	2.5 U	7	6.4	4 U	6.3	11	8
7	Natick	2.5 u	3.8	4 U	2.5	6.3	6.9	2.5
8	Needham	5.5	5	4.8	5	13	6.2	18
9	Newton	6.5	7.8	4.4	5.8	7.7	7.3	6
10	Waltham	9.3	8J	9.6	6.7	2.5 U	15	NA
11	Magazine Beach	9	5	5.3	4	16	11	NA
12	Stoney Brook	11 J	NA	4	3.3	9	7.7	NA
13	Museum of Science	4	NA	4 U	2.8	2.5 U	5.8	NA
Detection Limit		2.5	2.5 to 3.3	2.0 to 4.0	2.5 to 4.0	5.0	5.0	5.0

The reporting limit for this parameter was set at 2.5 mg/L in the original QAPP. Depending on the condition of the instrumentation on the day of analysis, the detection limit may have been higher than the reporting limit. Also, in July 2000 the OEME laboratory switched from requiring a reporting limit of 2.5 mg/L to 5.0 mg/L from the contract laboratory.
* = field RPD > 35%

Table 2B. Apparent Color

		units PtCo APHA color						
Site#	Description	03/31/00	04/18/88	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	24	25	40	35	27	24	14
2	Bellingham	53	36	101	91	58	63	28
3	Medway	94	87	159	145	63	102	29
4	Franklin	95	85	129	141	74	72	37
5	Millis	99	72	103	145	75	101	53
6	Medfield	90	92	115	183	103	117	75
7	Natick	79	92	122	163	82	70	41
8	Needham	80	91	124	154	139	73	108
9	Newton	100	105	128	159	100	79	64
10	Waltham	98	89	130	162	81	90	35
11	Magazine Beach	99	106	101	145	115	115	90
12	Stoney Brook	103	N/A	103	109	112	62	67
13	Museum of Science	90	N/A	95	115	92	53	61

Appendix B. Laboratory Measurements

Table 3B. True Color

		units PtCo APHA color						
Site#	Description	03/31/00	04/18/00	5/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	16	15	15	15	15	10	10
2	Bellingham	29	17	67	51	22	36	18
3	Medway	79	65	97	107	46	73	30
4	Franklin	84	60	84	106	51	43	32
5	Millis	81	46	66	103	40	59	33
6	Medfield	70	76	95	127	42	72	25
7	Natick	61	70	94	125	39	47	30
8	Needham	63	67	73	113	41	48	27
9	Newton	52	62	80	101	34	48	44
10	Waltham	52	56	73	108	41	33	39
11	Magazine Beach	52	57	74	81	38	33	31
12	Stoney Brook	41	NA	72	65	45	24	44
13	Museum of Science	37	NA	55	54	51	25	20

Table 4B. Tannic Acid

		mg/L soluble Tannic Acid						
Site#	Description	03/31/00	04/18/00	5/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	0.5	0.6	0.6	0.6	0.6	0.6	0.4
2	Bellingham	0.9	0.6	1.2	1.2	0.8	1.1	0.8
3	Medway	1.7	1.3	1.9	2	0.9	1.5	0.5
4	Franklin	1.7	1.3	1.6	2	0.9	0.9	0.6
5	Millis	1.6	1	1.5	2	0.9	1.2	0.6
6	Medfield	1.5	1.5	1.7	2.4	1	1.4	0.7
7	Natick	1.4	1.4	1.7	2.4	0.9	1.1	0.6
8	Needham	1.4	1.5	1.2	2.4	0.8	1.1	0.9
9	Newton	1.3	1.4	1.5	2.1	0.9	1	0.7
10	Waltham	1.1	1.3	1.5	2	0.9	0.8	0.6
11	Magazine Beach	1	1.3	1.3	1.9	0.9	0.8	0.7
12	Stoney Brook	0.9	N/A	1.4	1.4	0.9	0.6	0.6
13	Museum of Science	1.1	N/A	1.2	1.4	1	0.6	0.5

Appendix B. Laboratory Measurements

Table 5B. Nitrite and Nitrate as N

		NO3 + NO2 ug/L						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/2000**	09/12/00
1	Hopkinton	ND	ND	ND	ND	ND	ND	ND
2	Bellingham	ND	ND	11.3	10.6	ND	12	ND
3	Medway	ND	ND	9.2	9.2	ND	8.9	ND
4	Franklin	ND	ND	ND	ND	ND	17.4	ND
5	Millis	ND	ND	ND	ND	18	15	ND
6	Medfield	ND	ND	9.2	11.5	ND	ND	ND
7	Natick	14	ND	ND	11.5	ND	13.7	ND
8	Needham	ND	ND	ND	12.7	ND	8.9	ND
9	Newton	ND	ND	ND	12.6	ND	ND	ND
10	Waltham	ND	ND	ND	ND	ND	ND	ND
11	Magazine Beach	ND	ND	ND	ND	ND	ND	ND
12	Stoney Brook	ND	NA	ND	ND	ND	ND	ND
13	Museum of Science	ND	NA	ND	8.2	ND	ND	ND

* = field RDP > 35%

Table 6B. Orthophosphate as P

		ug/L						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/2000**	09/12/00
1	Hopkinton	ND	ND	ND	ND	ND	ND	ND
2	Bellingham	ND	ND	11.3	10.6	ND	12	ND
3	Medway	ND	ND	9.2	9.2	ND	8.9	ND
4	Franklin	ND	ND	ND	ND	ND	17.4	ND
5	Millis	ND	ND	ND	ND	18	15	ND
6	Medfield	ND	ND	9.2	11.5	ND	ND	ND
7	Natick	14	ND	ND	11.5	ND	13.7	ND
8	Needham	ND	ND	ND	12.7	ND	8.9	ND
9	Newton	ND	ND	ND	12.6	ND	ND	ND
10	Waltham	ND	ND	ND	ND	ND	ND	ND
11	Magazine Beach	ND	ND	ND	ND	ND	ND	ND
12	Stoney Brook	ND	NA	ND	ND	ND	ND	ND
13	Museum of Science	ND	NA	ND	8.2	ND	ND	ND

*field RPD > 35%

Appendix B. Laboratory Measurements

Table 7B. Total Phosphorus

		mg/L						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00**	08/16/00	09/12/00
1	Hopkinton	0.05U	0.05U	0.05U	0.05U	0.1U	0.025 ave U	NA
2	Bellingham	0.05U	0.05U	0.11	0.081	0.1U	0.062	NA
3	Medway	0.05U	0.05U	0.06	0.059	0.1U	0.065	NA
4	Franklin	0.2	0.05U	0.06	0.062	0.1U	0.091	NA
5	Millis	0.06	0.05U	0.07	0.086	0.1U	0.093	NA
6	Medfield	0.05U	0.05U	0.07	0.1	0.1U	0.086	NA
7	Natick	0.05U	0.05U	0.08	0.11	0.1U	0.065	NA
8	Needham	0.05U	0.05U	0.09	0.083	0.1U	0.025 U	NA
9	Newton	0.05U	0.05U	0.09	0.093	0.1U	0.094	NA
10	Waltham	0.05U	0.06	0.11	0.1	0.1U	0.063	NA
11	Magazine Beach	0.05U	0.06	0.13	0.083	0.1U	0.089	0.18
12	Stoney Brook	0.09	NA	0.07	0.1	0.1U	0.025U	0.11
13	Museum of Science	0.06	NA	0.05U	0.094	0.1U	0.025U	0.06

** = reporting limit from the contract lab for samples from 07/19/2002 was 0.10 mg/L

Table 8B. Total Organic Carbon (TOC)

		(mg/L)						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	4.0 U	4.11	N/A	4.62	4.2	3.8	3.6
2	Bellingham	5	6.84	6.85	7.16	5.3	6.2	6
3	Medway	7.9	7.6	9.68	10.2	6	7.4	4
4	Franklin	7.6	6.64	8.49	9.88	5.6	5.3	3.8
5	Millis	8.03	6.11	7.43	10.3 ave	5.1	6.1	4.1
6	Medfield	8	8.53	9.39	14.3	5.5	6.9	4.2
7	Natick	6.6	7.38	7.87	11.4	5.4	5.7	4.4
8	Needham	6	7.45	8.1 ave	14	5.7	5.7	5.1
9	Newton	7.1	7.57	7.23	10.7	5.8	5.7	4.6
10	Waltham	5.6	6.54	7.41	10.2	5.7	5.2	4.5
11	Magazine Beach	5.9	7.5 ave.	7.07	10.6	5.9	5.1	5
12	Stoney Brook	5.4	NA	6.54	8.72	5.6	4.3	4.8
13	Museum of Science	5.1	NA	6.79	7.46	5.9	4.3	4.6

Appendix B. Laboratory Measurements

Table 9B. Chlorophyll a

		ug/L						
Site#	Description	03/30/00	04/18/00	05/24/00	06/14/00	07/19/00	08/16/00	09/12/00
1	Hopkinton	3.1	5.1	14.7	9.2	3.5	5.3	4.7 ave
2	Bellingham	6.7 ave	5.6 ave	11.6	5.4 ave	8.3	4.7	1.65 U
3	Medway	5.3 J ave	5.3 ave	10.1	6.4	2.9	4.6	8.5
4	Franklin	5.8	6.4	5.9	5.4 ave	5	7.6	4.1
5	Millis	8.4	6.5	7.3 ave	9.1	17.5	12.3	22.3
6	Medfield	9.1	10.1	7.1	5.9	30.4	7.3	30.4
7	Natick	7	9.1	7.4	6.5	51.9	10.4	6.1
8	Needham	7.2	11.7	8.3	6.8	122	12.8	63.8
9	Newton	9.9	20.2	10.8	9.8	16.5	13	14.8
10	Waltham	11.6	14.1	12.1	8.9	9.7 ave	23.3	4.5
11	Magazine Beach	11	17.6	9.4	8.8	60.7	30.2	39
12	Stoney Brook	11.2	NA	33.8	12.3	11.4	33.3	36
13	Museum of Science	8.8	NA	16.7 ave	11.7	13.8	26	33.3
Detection Limit		2.0 to 2.2	2.0 to 2.5	2.0 to 2.4	2.4 to 3.0	2.4 to 3.7	2.4 to 2.8	3.0 to 3.7

The reporting limit for this parameter was set at 100 ppb in the original QAPP. Depending on the condition of the instrumentation on the day of analysis, the detection limit may have been higher than the reporting limit.

Appendix C – Massachusetts Department of Public Health 105 CMR 445.000

105 CMR 445.000
MINIMUM STANDARDS FOR BATHING BEACHES
STATE SANITARY CODE, CHAPTER VII

445.001: Purpose

The purpose of 105 CMR 445.000 is to protect the health, safety and well-being of the users of bathing beaches, to establish acceptable standards for the operation of bathing water and to establish a procedure for informing the public of any bathing water closures.

445.002: Authority

105 CMR 445.000 is adopted under the authority of M.G.L. c. 111, ss. 3, 5S and 127A.

445.003: Citation

105 CMR 445.000 shall be known and may be cited as 105 CMR 445.000: Minimum Standards for Bathing Beaches (State Sanitary Code, Chapter VII).

445.004: Scope

These regulations shall apply to all public and semi-public bathing beaches.

445.010: Definitions

The words, terms or phrases listed below, for the purpose of 105 CMR 445.000, shall be defined and interpreted as follows:

Bathing Beach means the land where access to the bathing water is provided. It shall not mean a swimming pool as defined in 105 CMR 435.000: Minimum Standards for Swimming Pools (State Sanitary Code, Chapter V).

Bathing Water means fresh or salt water adjacent to any public bathing beach or semipublic bathing beach at the location where it is used for bathing and swimming purposes.

Board of Health mean*s* the appropriate and legally designated health authority of the city, town, or other legally constituted governmental unit within the Commonwealth having the usual powers and duties of the board of health of a city or town, or its authorized agent or representative.

Department means the Department of Public Health.

Operator means any person who

(a) alone or jointly or severally with others has legal title to a bathing beach**,** whether or not that person has legal title or control of the bathing water**;** or
(b) has care, charge or control of such bathing beach as agent or lessee of the owner or an independent contractor.

Person means any individual or any partnership, corporation, firm, association or group, or the Commonwealth, or any of its agencies, authorities or departments or any political subdivisions of the Commonwealth, including municipalities or other legal entity.

Public Bathing Beach means any bathing beach open to the general public, whether or not any entry fee is charged, that permits access to bathing waters.

Semi-Public Bathing Beach means any bathing beach used in connection with a hotel, motel, a manufactured home park, campground, apartment house, condominium, country club, youth club, school, camp or other similar establishment where the primary purpose of the establishment is not the operation of the bathing beach, and where admission to the use of the bathing beach is included in the fee consideration paid or given for the primary use of the premises. **Semi-Public Bathing Beach** also means a bathing beach operated solely for the use of members and guests of an organization that maintains such a bathing beach.

Private Bathing Beach means any bathing beach not considered to be a public or semipublic bathing beach.

Sanitary Survey means a written report, conducted by a Massachusetts Registered Sanitary Engineer**,** Certified Health Officer or Registered Sanitarian, documenting an examination of the bathing water and contiguous land masses for the purpose of identifying actual or potential sources of microbiological or chemical contamination. The sanitary survey shall also include a description of the water circulation associated with the bathing area, the impact of bather load on the bathing beach area and any natural or artificial physical hazards.

445.020: Operation

No operator shall allow bathing or swimming in bathing water whenever in the opinion of the Board of Health or the Department the bathing water is or may be hazardous or unsafe for bathing or swimming. Bathing and swimming at public and semi-public beaches shall be limited to water areas that meet the requirements of 105 CMR 445.030. Any operator of a public or semi-public bathing beach shall comply with the requirements of 105 CMR 445.000.

445.030: Bathing Water Quality

Bathing or swimming shall not be permitted in any bathing water where the quality of the water does not meet the standards established in 105 CMR 445.030(A), 445.030(B), or 445.030(C), and no bathing or swimming shall be allowed when the bathing water is determined by the Board of Health or the Department to be unfit or so subject to contamination as to constitute a menace to health. Bathing or swimming shall not be permitted in bathing waters when:

(A) **Physical Quality.**

(1) Sludge deposits, solid refuse, floating waste solids, oils, grease or scum are present; or

(2) There are safety hazards including, but not limited to, fast currents, sharp drop-offs or an unstable bottom in the wading area(s) or lack of water clarity.

(B) **Bacteriological Quality.**

(1) The results of a sanitary survey or other information indicates that sewage or other hazardous substances may be discharged into the bathing water to a degree considered by the Board of Health or the Department to be of public health significance; or

(2) Epidemiological evidence discloses the prevalence of an infectious disease or other health condition which is considered to be related to the use of the bathing water and is considered by the Board of Health or the Department to be of public health significance; or

(3) The bacteriological quality of the bathing water is unacceptable as determined by laboratory analysis for the appropriate indicator organisms specified in 105 CMR 445.031 and exceeds the standards established therein.

(C) **Oil, Hazardous Materials, or Heavy Metals.**

(1) Oil, hazardous materials, or heavy metals are present in excess of surface water quality standards or guidelines established by the United States Environmental Protection Agency or the Massachusetts Department of Environmental Protection.

445.031: Indicator Organisms

(A) For marine water, the indicator organism shall be Enterococci.

(1) No single Enterococci sample shall exceed 104 colonies per 100 ml. and the geometric mean of the most recent five (5) Enterococci levels within the same bathing season shall not exceed 35 colonies per 100 ml.

(B) For fresh water, the indicator organisms shall be E. Coli or Enterococci.

(1) No single E. Coli sample shall exceed 235 colonies per 100 ml. and the geometric mean of the most recent five E. Coli samples within the same bathing season shall not exceed 126 colonies per 100 ml; or

(2) No single Enterococci sample shall exceed 61 colonies per 100 ml. and the geometric mean of the most recent five (5) Enterococci samples within the same bathing season shall not exceed 33 colonies per 100 ml.

445.032 Collection of Bathing Water Samples

(A) **Location.** The Board of Health, for public and semi-public bathing beaches that are not operated by the Commonwealth, and the Department, for bathing beaches that are operated by the Commonwealth, shall approve sampling locations at each bathing beach in its jurisdiction. Samples of bathing water shall be taken at locations within areas of greatest bather load. Additional samples shall also be obtained at any critical location subject to contamination from business developments, dwellings, streams, sewer outfall pipes or other sources. All required samples shall be obtained from these designated locations.

(B) **Sample Collection.** Samples shall be obtained in accordance with the procedures recommended by the most recent edition of the **Standard Methods for the Examination of Water and Waste Water** of the American Public Health Association or as approved by the United States Environmental Protection Agency.

(C) **Frequency.**

(1) The Board of Health, its agent, or any other authorized person shall collect the bacteriologic samples:

(a) Within five days of the opening of the bathing season; and
(b) At least weekly during the bathing season at a time and day approved by the Board of Health or the Department; and
(c) Prior to reopening a beach after closing for any reason.

(2) Testing for oil, hazardous materials, or heavy metals shall only be required if the operator, the Board of Health, or the Department has information indicating possible contamination of the bathing beach or bathing waters from oil, hazardous materials or heavy metals.

(D) **Field Data.** Physical conditions noted at the time of sampling shall be recorded on a form provided by the Department

(E) **Personnel. Samples** shall be taken by the Board of Health, the Department, their duly authorized representatives or other qualified persons as determined by the Board of Health or the Department.

445.033: Laboratory Analysis and Reporting

(A) **Laboratory Analysis**. Laboratory analysis of bathing water as required by 105 CMR 445.000 shall be conducted in accordance with the most recent edition of the **Standard Methods for Examination of Water and Waste Water** of the American Public Health Association or as approved by the United States Environmental Protection Agency.

(B) **Reporting.**

(1.) **Routine Reporting by Operators**. Any operator or authorized agent of a public bathing beach, except public bathing beaches operated by the Commonwealth, and any operator or authorized agent of a semi-public bathing beach shall report the certified results of all testing, monitoring and analysis of bathing water to the Board of Health within five (5) days of receipt of the results from the laboratory.

(2.) **Reporting by Operators of Levels Exceeding the Established Standards**.

Any operator or authorized agent of a public or semi-public bathing beach shall immediately report to the Board of Health the results of all testing, monitoring and analysis of bathing water found to exceed the standards established in 105 CMR 445.030.

(3.) **Reporting by the Board of Health.** The Board of Health or its authorized agent shall report the results of all testing, monitoring and analysis of bathing water to the Department no later than October 31 of each year.

445.034 Bathing Beaches Operated by the Commonwealth

State agencies that own or operate a bathing beach shall conduct or cause to be conducted all testing, monitoring, and analysis of bathing water at such bathing beach in accordance with these regulations. If the results of such testing, monitoring and analysis are found to exceed the standards established in 105 CMR 445.030, state agencies shall immediately, and in no event later than 24 hours, report the results of such testing, monitoring and analysis to the Department and the Board of Health in the city or town where the bathing beach is located. All other results shall be reported to the Department no later than October 31 of each year.

445.035: Sampling and Analysis at Semi-Public Beaches

(A) The operators of semi-public bathing beaches shall pay for the costs of testing, monitoring and analysis of bathing waters adjacent to such semi-public bathing beaches.

(B) Operators of semi-public bathing beaches may enter into contractual agreements with the Board of Health to have the testing, monitoring and analysis of bathing water conducted by the Board of Health, the Department or other qualified persons as determined by the Board of Health or the Department.

445.036: Public Request for Testing

Any person may request that the Board of Health, or in the case of a bathing beach operated by the Commonwealth, the state agency or the Department, conduct testing, monitoring, and analysis of public and semi-public bathing waters when there is reasonable basis to believe that an alleged violation of 105 CMR 445.000 has occurred. The Board of Health or the Department, as appropriate, shall promptly review such requests and determine whether any such testing, monitoring, and analysis is necessary to ensure the public health and safety of bathing waters.

445.040: Posting and Reopening Notifications

(A) **Posting.** Whenever the bathing water quality does not meet the requirements of 105 CMR 445.030 or after any significant rainstorm at a bathing beach where there has been a history of violations of the water quality requirements contained in 105 CMR 445.030, the Board of Health, its agent, or any other authorized person shall immediately, and in no event later than 24 hours, notify the Department, and post or cause to be posted, a sign, or signs, at the entrance to each parking lot and each entrance to the beach stating:

WARNING! NO SWIMMING
SWIMMING MAY CAUSE ILLNESS

and a graphic depiction of a swimmer in a red circle with a diagonal hatch mark. The sign shall also contain the reason for the warning, the date of the posting and the name and telephone number of the board of health.

(B) **Reopening.** Prior to reopening bathing water posted due to a violation of the standards established in 105 CMR 445.030, the Board of Health, its agent, or any other authorized person shall verify that the certified results of the laboratory analysis are less than the standard specified in 105 CMR 445.031. The operator of any state operated bathing beach shall notify the Department and the Board of Health within 24 hours, or the next business day, of the reopening of the bathing water.

445.100: Variance

(A) The Board of Health may grant a variance from the provisions of 105 CMR 445.000 for any public or semi-public bathing beach not operated by the Commonwealth. The Department may grant a variance for any bathing beach operated by the Commonwealth. In granting a variance, the Board of Health and the Department shall review available epidemiological data and a written sanitary survey of the bathing beach, as provided by the operator. The survey shall include:

(1) All possible sources of contamination, both bacterial and chemical on the watershed tributary to the bathing beach including the location and volume of:

(a) sewage and industrial waste water discharges;
(b) storm water overflows;
(c) bird and animal populations; and
(d) commercial and agricultural drainage.

(2) The volume and quality of the diluting water, water depth, water surface area, tides and confluence of tributaries, water currents and prevailing winds.

(B) Any variance granted by the Board of Health shall specify the required bacteriological testing schedule, provided that the frequency of bacteriological testing shall not be less than once prior to the bathing season and at least every 30 days thereafter throughout the duration of the bathing season.

(C) Any variance granted by a Board of Health or the Department shall expire*:*

(1) at any time as determined by the Board of Health, but in no instance greater than four years, at which time the operator may apply for an extension, or
(2) at any time the results of bacterial test exceed the levels at 105 CMR 445.031.

(D) No variance from the requirement of weekly testing shall be granted until the applicant provides the Board of Health or the Department with water quality data collected for at least two complete and consecutive bathing seasons.

(E) In granting a variance, the Board of Health or the Department must determine that the enforcement of 105 CMR 445.000 would not serve a significant public health purpose and that the granting of the variance will not conflict with the intent and spirit of these minimum standards. Any variance or other modification authorized to be made by these regulations may be subject to such qualification, revocation, suspension, or other expiration as the Board of Health or the Department expresses in its grant. A variance or other modification authorized to be made by this regulation may otherwise be revoked, modified, or suspended in whole or in part, only after the holder thereof has been notified in writing and has been given the opportunity to be heard.

445.101: Variance to be in Writing

(A) Any variance granted by the Board of Health or the Department shall be in writing. Any denial for a variance shall also be in writing and shall contain a brief statement of the reasons for denial. A copy of each variance shall be conspicuously posted for 30 days following its issuance and shall, while it is in effect, be available to the public at all reasonable hours in the office of the clerk of the city or town, or in the office of the Board of Health and in the case of a variance by the Department, at the Department.

(B) The Board of Health shall submit to the Department a notice of the intent to grant a variance. The Department shall approve, disapprove, or modify the variance within 45 days from receipt thereof. If the Department fails to comment within 45 days, its approval shall be presumed. No alteration of any requirement in these regulations shall be made under any variance until the Department approves it or 45 days has elapsed without comment, unless the Board of Health certifies in writing to the Department that an emergency exists.

445.300: Severability

In the event that any section of 105 CMR 445.000 is found to be invalid or unconstitutional, the remaining sections shall not be affected and shall remain in full force and effect. To this end, the provisions of this regulation are hereby declared severable.

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