Memorandum

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Subj: Clean Charles 2005 Progress Report

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To: Robert W. Varney, Regional Administrator
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I. Introduction

As you know, this year we will be conducting our Earth Day event as a briefing on a number of science developments on the Charles, including the publication of three studies on the Charles by the USGS, the completion of a second Gunderboom demonstration on the Charles, the first round of DNA based source tracking efforts in Laundry Brook and the development of a receiving water model. This model will serve as the basis for the Total Maximum Daily Loads (TMDLs) currently under development for bacteria and eutrophication in the Lower Charles and thus the underlying tool with which further decisions regarding restoration activities can be made. With respect to actual construction activities, 2002 was not an extraordinary year, as many of the illicit connection projects had been completed in prior years and major remaining CSO project--the Stony Brook separation project-- is not yet complete. [1]

The monthly data that is collected by Charles River Watershed Association and that serves as our measure of improved water quality shows no statistically significant progress between 2001 and 2002, which is consistent with the plateau in water quality levels we have witnessed for the last three years. We are reaching the point where additional improvements will depend increasingly on the municipalities' stormwater management including aggressive illicit connection investigation to ferret out both direct and indirect connections. This work will be guided by our developing scientific agenda, particularly the bacteria and nutrient TMDLs and the bacteria source tracking work.

The numbers below represent the percentage of time water quality standards for bacteria were met

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[1] As explained more completely below, there are several infrastructure improvements that have not yet been completed and that will have significant benefits. These include the separation of the Stony Brook, which currently discharges 45 million gallons/year of untreated sewerage to the lower basin and the elimination of illicit connections in Faneuil Brook. Stony Brook separation is scheduled for completion in 2006.

in the lower Charles, that is from Watertown Dam to the New Charles River Dam .

		1995	1996	1997	1998	1999	2000	2001	2002
overall									
	boating	39	57	70	83	90	92	82	91
	swimming	19	21	34	51	65	59	54	39
dry									
	boating		94	87	98	100	94	97	100
	swimming		40	56	85	71	82	80	71
wet									
	boating		45	61	74	85	91	74	86
	swimming		15	22	31	62	46	40	21

Based on this data, the case team recommends that we give the river the following grades this year: dry weather/B; wet weather/B-; and overall/B. These are identical to last three years,[2] but an improvement over all other previous years.

It is worth noting that while this initiative greatly benefits the Charles, it provides broader benefits by supplying a model for urban environmental restoration. The Mystic River Watershed Association has shaped an initiative that borrows many ideas from the Clean Charles 2005 initiative (including regular monitoring, coalition building with universities and government institutions and the removal of illicit connections). On a national level, the Clean Charles 2005 initiative serves as a model for the Administration's National Watershed Initiative for which grants are being announced very soon. This national initiative grew out of a visit by Administrator Whitman to the Charles for Earth Day 2001 at which she was briefed by the Clean Charles Task Force about the key principles of the initiative: the focus on a high value resource; an integration of a variety of federal, state and municipal tools, including enforcement, assistance, education, and permitting all directed at solving a clearly articulated problem and achieving a clearly articulated goal; measurement of progress in the metrics of actual

[2]While the data has gone up slightly in some categories and down in others comparative to last year, the differences are not, according to a careful analysis, statistically significant. Given the statical insignificance of the changes, we believe it is most reflective of actual river conditions to show the grades as unchanged.

environmental improvement; and working in partnership with the full range of institutions that are necessary for watershed restoration. After learning of the Charles initiative, Administrator Whitman secured an FY 03 budget allocation of $15 million to fund similar watershed initiatives across the nation.

The first phase of the Clean Charles 2005 effort saw the implementation of major projects that were obvious problems to water quality, most notably combined sewer overflows, illicit connections removal, and basic stormwater management. These were all significantly contributing to the bacterial problems in the lower Charles, and MWRA and the municipalities were under legal obligations to address these issues.

Now that these most obvious sources have been addressed, we will target less obvious sources using more complex regulatory and non-regulatory tools. With the completion of three USGS reports, the development of a receiving water model, and the development of a program for identifying the source of Bacterial contamination through source tracking, we are ready to move into a new and final phase for the Clean Charles 2005 effort.. In the year ahead we will be launching new efforts including: Total Maximum Daily Loads in the lower Charles for bacteria and nutrients; TMDLs for nutrients in the upper Charles; refinements to stormwater strategies based on the results of the DNA source tracking study; and increased recharge in the upper watershed through flow trading. Each of these is discussed below in greater detail in the section below on science.

The summary below provides an update on progress over the past year on the various elements of the Clean Charles initiative. It also provides an outline of some of the activities that are anticipated for the coming year.

II. Ongoing Cleanup Measures

A. Stormwater:

1.Municipal Stormwater Management Plans

Building on our earlier Memoranda of Agreement established with the Lower Charles municipalities requiring development of baseline stormwater management programs (SWMP), we established subsequent memoranda or agreements with many to upgrade and formalize their implementation. We provided advice on upgrading these their programs through our consultant, Center for Watershed Protection (CWP), the premier urban watershed consulting group in the country. The end result we sought was implementation of a SWMP for each community that represented state of the art for urban areas, that took into account the unique nature of each municipality, and that would meet the requirements of the NPDES Phase II Stormwater Program. As of March 2003[3], the Charles municipalities were required to seek coverage under EPA's General Permit for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (a.k.a. Small MS4 Permit). As a result of their prior planning and implementation efforts, the municipalities were well-positioned to comply with the Phase II Rule.

Several communities in particular should be recognized as leaders in the Clean Charles effort for their continued efforts in stormwater management:

Cambridge: The city has developed and implemented a very comprehensive SWMP with an aggressive schedule that incorporates most all of the CWP's recommendations. The city is well on its way to integrating storm and sanitary sewer infrastructure into their GIS, as well as mapping "hot spot" land uses. While in the process of drafting a new erosion and sediment control (ESC) ordinance, the city has developed an ESC standards/guidelines document for all major public projects. In addition, contractors working on large private development and utility projects must attend weekly construction/coordination meetings at the Cambridge DPW to discuss ESC issues among other things.

Dedham: Dedham has developed a very progressive SWMP that addresses virtually all the recommendations of CWP. Among the recommendations, Dedham passed a comprehensive yet balanced stormwater bylaw and is finalizing accompanying regulations that should represent a model for many other communities in the state.[4]

Wellesley: Wellesley continues to make steady progress at implementing its program in a prioritized fashion. In late 2002, the town signed a $190,000 contract with a consultant to prepare an update to its stormwater master plan. The town has implemented a computerized database of its catch basin cleaning program to refine cleaning and maintenance schedules. The town is currently implementing a wildlife management program at the Town Hall Duck Pond to abate the detrimental water quality impacts of large non-migratory waterfowl populations. In 2003, the DPW plans to construct a vehicle washing facility.

2. Outreach to Major Landholders

Our efforts to bring the major landholders along the Charles into the initiative provided modest returns over the past year. The Clean Charles Coalition now has a membership of 15 organizations. Among their general goals are to work within their member institutions to heighten appreciation for the

[3]Due to a delay in issuance of the Small MS4 Permit, regulated municipalities will not submit their applications and requisite storm water management plans until the Summer of 2003.

[4]MADEP's Stormwater Advisory Committee is in fact using the bylaw as a basis for developing a model bylaw.

Charles; to help bring public attention to the efforts of others in restoring the Charles; to participate in various small scale cleanup efforts; to promote better stormwater management by member institutions; and to educate smaller institutions in the watershed on stormwater management.

Thus far, the Coalition has established a webpage through which it has disseminated information on the Charles and a series of stormwater management best management practices that they have summarized. The address is http://www.cleancharles.org. They have also hosted a series of meetings through which they are developing stormwater management strategies for each of their facilities. They have also held a few workshops through which they reached out to the regulated community in the Charles watershed, including small businesses, to provide strategies for stormwater management.

On the cleanup front, the coalition has become an annual sponsor in the Earth Day cleanup of the lower Charles Reservation.

Finally, with the assistance of the Center for Watershed Protection, EPA provided the Coalition with a menu of activities related to stormwater management, and asked the coalition to commit to conducting those activities that would best match the expertise of their institutions. The Coalition is developing a voluntary pollution prevention program which will: target companies in the Lower Charles; provide technical assistance through workshops and instructional materials; encourage businesses to adopt specified water quality practices to improve pollution prevention abilities; and provide participants with public recognition for their participation through certificate and decals, website listing, a clean business directory and the like. In its first phase this program will focus on restaurants, as they are a business group that contributes significantly to bacterial contamination through improper waste management practices and oil and grease disposal practices. The Coalition is in the process of producing approximately 1,500 educational posters for distribution to local restaurants that reinforce appropriate practices for waste management and disposal.

3. Public Outreach on Stormwater

Beyond enhancing municipal and private stormwater management, raising public consciousness on and modifying behaviors to minimize pollution from stormwater is the next challenge. This is difficult in that public stormwater education efforts have largely been ineffective in the past, due to the dry nature of the topic and the routine approaches taken, such as inserts in utility mailings. Given the challenge, we have taken a multi-pronged approach:

> *a. Education through the public schools*: We have continued to fund the Urban Ecology Institute (UEI) as a conduit for information about stormwater management and the river generally. UEI's mission is to promote the stewardship of healthy urban ecosystems by improving science and civic education for middle and high school youth and by working with urban communities to protect and restore natural resources. The institute is now working with 12 public schools (five school systems) in the watershed. This comprises 22 classroom teachers and over 550 students. At eight field stations on the river and its tributaries, the

students monitor water quality and insect and bird biodiversity. Students are encouraged to think of themselves as working scientists and to discover the natural resources of their own neighborhoods. The students examine data from Charles River water quality studies and work with a watershed map that allows each student to identify the sub-basin of the Charles in which they live and attend school. They then can link their home and school to specific runoff problems and develop specialized remediation techniques. A goal of this effort is to train the future stewards of the Charles by educating them in a personal way about the fact that they live in a watershed (although many of its features are buried under the urban landscape), and that the water quality of the Charles is directly affected by contaminants that flow from their familiar localized environs. The results of the students' studies are presented at a year end conference in June to community groups and is posted monthly at www.bc.edu/bc_org/research/urbaneco/ . The UEI's program was enhanced over the last year as USGS provided education in stormwater field work and computer analysis as part of the *Charlescast* Project discussed below.

b. The EMPACT Charlescast Project: The *Charlescast* EMPACT Integration/Networking grant was implemented in 2002 by the USGS, CRWA, UEI, and the Boston Water and Sewer Commission. The project includes three major objectives, two of which support public outreach and education efforts:

> i. Since 1998 CRWA has implemented an EMPACT-funded real-time water quality monitoring and public notification project (a.k.a. the flagging program). The goal of the program is to provide daily water quality information to river users so that they can make informed decisions about how they choose to use the basin. The CharlesCast Project has enhanced the accuracy and timeliness of the existing program by utilizing a refined real-time data set and statistical models.
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> Based on various antecedent rainfall variables, CRWA (in collaboration with Tufts University) developed multivariate logistical regression models to predict the probabilities of exceeding the fecal coliform bacteria standard for secondary contact recreation at four bridge crossings. USGS collected rainfall data at their real-time monitoring gage at Watertown and extracted antecedent storm characteristics using SYNOP computer software.
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> Overall, the forecasting models were fairly accurate in predicting indicator bacteria levels based on confirmatory sampling that was done on approximately 25% of the days that flags were hoisted. Confirmatory sampling showed that the correct flag was hoisted 92% of the time (or 81 out of 88 flags).
> When the water quality was predicted to meet boating water quality standards a blue flag was flown at nine boating centers along the Charles; when predicted to violate, a red flag was flown. In addition, the bacteriological water quality predications were

published on CRWA's and the *Boston Globe's* web sites, the CRWA telephone hotline, the *Boston Globe*, and occasionally in local *Tab* and neighborhood newspapers. Results were made available by 11:00 am Monday - Saturday during July - October.

ii. Another objective of the Charlescast project is to build watershed literacy among 500,000 inhabitants of the Lower Charles watershed. Restoration of the river to fishable and swimmable standards cannot be accomplished without a major shift in public attitudes and behavior toward the watershed and implementation of Best Management Practices, including cleaning up pet waste, discouraging feeding of waterfowl, proper disposal of waste oil and household hazardous waste and the like. A key task in conducting this education is educating young people and homeowners that they have a "watershed address." This is a daunting task in a highly urbanized environment where three of the four largest tributaries to the Basin (Stony Brook-Boston, Laundry Brook-Newton, and Faneuil Brook-Brighton) and many subtributaries have been lost to public view due to extensive culverting.

Given the power of maps as educational tools, USGS will publish–on line, on CD and in hard copy format–a USGS atlas of the Lower Charles watershed. The atlas will be based on the GIS data compiled for the previous USGS EMPACT project and will contain both historic maps and photographs and the latest GIS coverages of the natural and built environment of the watershed (surficial geology , soils, shaded relief, sub-watershed boundaries, stormdrain infrastructure). All 20 major sub-watersheds of the Lower Charles River, many of them culverted and hence largely unknown to the public, will be depicted. The atlas will be geared to a lay person audience, and the on line version will be interactive allowing the user to click on a sub-basin and obtain spatial information and a sample storm hydrograph for that sub-basin. The Atlas will be distributed to public libraries, schools, local government officials and boards, and environmental organizations throughout the lower watershed, including the extensive CRWA membership.

Though contractual delays slowed the effort, USGS will soon begin the production of more than 1,000 copies of the Atlas for distribution.

c. *Mainstream Media Education Campaign*: EPA is assisting MIT, the Clean Charles Coalition, and other partners in the development and implementation of a mainstream media campaign in the Lower Charles River Basin to promote awareness to the general public regarding the impacts to the river of their daily activities and behaviors. The campaign envisions print, TV, and radio placements and public service announcements (PSAs) released in local media outlets. The initial phase of the campaign will the focus on lawn care practices and pet waste management, two behaviors of concern to water quality in the Lower Charles.

d. *Charles River Basin Documentary Film*: EPA plans to contract with the Boston University Film & TV Department later this year for the production of a documentary film that chronicles the ongoing 2005 Initiative and other key restoration efforts in the recent history of the Charles. The documentary would serve as an educational tool distributed to a wide audience, including commercial, public, and institutional outlets.

4. MIT Stormwater Competition

In March of 2002, EPA and MIT held the first annual stormwater design competition. Competitors were asked to provide innovative, cost effective designs at either of two sites. From the twenty odd entrants, a grand prize was selected that MIT will fund the implementation of up to ten thousand dollars. A first prize and honorable mention were also given in both the student and professional category. Judges assessed entries based on cost-effectiveness, innovativeness, aesthetics and, implementability and ease of replication. The winning design includes cisterns, porous pavers, rain chains and a rainwater garden. Most designs incorporated basic concepts like cisterns, efforts to enhance recharge to groundwater and plantings to absorb rainwater and keep it on site.

The goal of raising awareness of stormwater through the competition succeeded: it received broad press coverage and was the subject of a New England cable news spot. The designers recently met with contractors to begin the construction of the project. Once construction of the winning design is complete, we will conduct another round of publicity to continue to keep the public reminded of the importance of the issue.

5. Boston Stormwater Permit

a. Permit Requirements: EPA issued BWSC a stormwater permit on September 29, 1999 governing its 93 major and 102 non-major storm drain outfalls, many of which flow to the Charles. Under its permit, the Commission is required to implement a stormwater management program and a stormwater quality monitoring program, which includes:

- controlling Stormwater discharges from development projects;
- Identifying and remediating illegal sanitary sewer connections to storm drains;
- Requiring drainage discharge permits for non-stormwater discharges to the drainage system;
- Preventing unpermitted wet and dry weather overflows from the sanitary sewer system;
- Enforcing the Commission's prohibition on illegal dumping to the drainage system;
- Cooperating with federal, state and municipal agencies in preventing, containing and responding to spills; and
- Implementing a pollution prevention public education program.

In addition, Boston is conducting a stormwater quality monitoring program in five drainage areas representative of different land use, receiving water quality monitoring at four locations and a demonstration program to evaluate the effectiveness of non-structural controls

b. Accomplishments through 2002

Illegal Sanitary Connections (see also section B.1. below)

Between 1986 and 2001, BWSC's Illegal Sanitary Connection Remediation Program has corrected approximately 800 illegal connections resulting in removal of an estimated 500,000 gallons per day (gpd) of wastewater from the storm drain system. In 2002, BWSC spent $239,323 to correct 38 illegal connections representing approximately 13,500 gpd of wastewater; mostly from residential and multi-family connections. The average cost per correction, including paving costs was $6,300.

As of December 31, 2002, there are 68 outstanding illegal connections that require correction.

Cleaning of Storm Drains, Catch Basins, and Particle Separators

During 2002, BWSC responded to nearly 5,000 reports of blockages or breaks in sewers and drains and cleaned, flushed or rodded nearly 800,000 linear feet of pipe. In addition, 1,910 of 27,465 catch basins and 13 of 14 particle separators were cleaned. These cleanings resulted in the removal of approximately 5,000 yd^3 of material that otherwise could have been transported to receiving waters or occupied sediment deposition space for future storm flows. Catch basin materials are temporarily stored at the Calf Pasture Pumping Station and then transferred to a final disposal site, generally a landfill.

In September 2000, a three-year, city-wide catch basin inspection, cleaning and preventative maintenance program was initiated with an estimated cost of $5.3 million. In 2001, more than 90% of the Commission's catch basins were surveyed or inspected to collect pertinent data in electronic format, eventually allowing the data be integrated into BWSC's work order and GIS systems.

Since late 2001, BWSC has inspected 100 basins on a quarterly basis to better understand the factors governing the accumulation of materials and to help establish cleaning frequencies. During 2003, BWSC will develop a comprehensive city-wide catch basin preventative maintenance plan.

Particle Separators

BWSC is assisting the Boston Parks Department and the City of Brookline in conducting a program to evaluate the effectiveness of particle separators as part of the Muddy River Enhancement Program.

New Development and Construction Sites

During 2002, BWSC reviewed 373 Site Plans for conformance with BWSC's Sewer Use

B. Illicit Connections

1. Municipal Illicit Connections

Much of the work on illicit connections investigation work is complete as is a good portion of illicit connection removal, as least as it concerns the direct connection of sewer pipes to storm drains. While some municipalities continue to find fecal coliform above acceptable levels a variety of other sources could be contributing to this problem: animals, flow from other cities, or, most significantly, flow that seeps into storm drain systems through loose joints, accumulates there, and is then flushed out during wet weather events. The municipalities are sorting out some of these issues and and attempting to track down the final, direct illicit connections. Once complete this will be followed by compliance sampling to confirm that the identified direct illicit connections have been throughly remediated. Below is a summary of work conducted during 2002.

Community	Status of Investigation	Comments
Boston	Ongoing	Working on a number of areas in the watershed including the separated area of Stony Brook and Faneuil Brook. The neighborhoods covered are primarily Hyde Park, Jamaica Plain, W. Roxbury, and Roslindale with activity in Roxbury, Allston, and Brighton. BWSC corrected a total of 38 illicit connections in the City in 2002, removing an estimated 13,500 gallons per day of wastewater from the stormdrainage system. An additional 68 illicit connections are slated for removal in 2003. The Stony Brook separation project, estimated to be completed in September 2006, is currently 31% complete based on linear feet of storm sewer newly installed. Although the City has removed a large number of illicit connections from the Faneuil Brook basin, information from sampling done by USGS, CRWA, citizens, and EPA indicate that Faneuil Brook has significant remaining amounts of fecal loading. BWSC intends to focus on Faneuil Brook during 2003.
Brookline	On hold	Following elimination of known Boston sources in Village Brook, another sampling round on both sides of the Boston/Brookline boundary will be scheduled.
Cambridge	Ongoing	48common manholes were replaced in 2002 in Cambridge eliminating wastewater flows into the affected storm drains. An additional 34 are scheduled for removal in 2003. Cambridge removed 11 illicit connections during 2002 removing an estimated 4,400 gallons per day from the storm drainage system.
Newton	Ongoing	Data from recently collected DNA source tracking study indicates that there still remains some sanitary influence in Laundry Brook. In the first batch of dry weather samples analyzed, 45% was attributable to wildlife (90% of that 45% traced to water fowl); 23 % of bacteria was attributable to domestic animals (cats and dogs); 14% was attributable to human sources; 6% was undifferentiated animal species; and 12% was impossible to trace to any animal species.

The effort to eliminate illicit connections that commenced in January of 1995 has proven extremely effective and has eliminated over 1 million gallons of flow per day of sewage to the river. The illicit connections removed (mostly by the Boston Water and Sewer Commission and Cambridge) during 2002 represent a reduction in the volume of untreated wastes reaching the Charles River of roughly 18 million gallons per year. While this is represents less volume than prior years, it is still a significant bacterial load to the river. *For purposes of context, one should consider that this 18 million gallon per year reduction is equal to roughly one-third of the volume of the untreated combined sewer overflow, 58 million gallons per year, that currently flows to the lower Charles.*

With the exception of ongoing work in Boston, much of the illicit connection work that addresses sewer pipes tied directly into storm drains has been completed. Now that the systematic investigation of most stormdrains is near complete, municipalities will continue to investigate for new illicit connections as a matter of routine under stormwater management plans or stormwater permit in the case of Boston). Boston is not operating under an illicit connection order but continues to prioritize its investigation and removal of problem connections under its stormwater permit.

In addition, now that the most obvious illicit connections have been addressed, the less obvious sources of bacteria to stormwater will be investigated. As noted below in the discussion on the DNA study, we will attempt to identify the sources of remaining bacterial loads. Initially, this study has been focused on Laundry Brook in Newton, but to the extent it proves valuable, it will be more broadly utilized. Preliminary and partial data from recently collected DNA source tracking study indicates that wildlife, and waterfowl in particular, poses a significant bacterial load in the Laundry Brook sub basin. In the first batch of dry weather samples analyzed, 45% was attributable to wildlife (90% of that 45% traced to water fowl); 23 % of bacteria was attributable to domestic animals (cats and dogs); 14% was attributable to human sources; 6% was undifferentiated animal species; and 12% was impossible to trace to any animal species.

The great potential value that this technology promises is its ability to determine what next steps will be most effective in cleaning up the Charles. We know for instance that storm water coming from the major storm drains contribute greater than 50% of the bacterial load to the lower river. We do not yet know to what extent this is “pure” stormwater that is essentially street runoff or, alternatively, that it is runoff flow that becomes further contaminated by indirect cross connections to sewer lines. These indirect cross connections could take the form of loose jointed sewer lines running over or in the immediate vicinity of a loose jointed stormdrain, or could take the form of groundwater becoming contaminated with sewerage and infiltrating storm drains.

To the extent that additional results of DNA studies in other sub basins indicate that a high percentage of the bacterial contamination has a human source, then the cities will be requested to identify and correct the sources, to the extent feasible. If the sources are identified as being domestic animals, then public education on pet waste will need to be stepped up. Where data indicate that water fowl represent significant bacterial loading during dry weather, public education on feeding of ducks and other such birds is warranted.

C. CSO Improvements

Since 1988, MWRA has been working on a number of system improvements, including increased treatment capacity at Deer Island, that are resulting in a significant decrease in CSO discharges to the Charles. In addition, six CSOs to the lower Charles have already been eliminated. MWRA's 2002 Annual Report estimates that annual CSO discharge to the Charles River has been reduced from 1,742 million gallons/year in 1988 to 182 million gallons/year in 20002. MWRA's water quality sampling indicates that geometric mean bacteria counts in the Charles decreased nearly ten fold between 1989 and 2001. This data set is significant in that it spans a longer time frame than either the CRWA bacterial sampling on which the Report Card is based or the EPA Core Monitoring Program, which began in 1998.

MWRA's facility plan for the Charles required several major CSO projects affecting the lower Charles. Projects providing hydraulic relief at CAM 005 and BOS 017, upgrade of the Cottage Farm facility and implementation of floatable controls have been completed. The separation of Stony Brook, which was 13 % complete at this time last year is now 31% complete.

1. Cottage Farm Upgrade

In June 2001, MWRA completed acceptance testing at the upgraded Cottage Farm CSO facility and entered the period of start up and optimization. By September it had reached the same point with the Prison Point facility at the New Charles River Dam. The upgrades will enhance treatment system performance by improving the disinfection system and adding dechlorination capabilities to minimize potential harm to aquatic life posed by chlorinated discharges.

Since then, however, MWRA has made little progress in completing acceptance testing at Prison Point and start up and optimization monitoring at Cottage Farm because of the continued lack of significant rainfall events and facility activations.

2. CAM 005 Optimization

CAM 005 historically discharged to the Charles River near Mount Auburn Hospital about eight times a year. During 1999, MWRA constructed a new connection between the Cambridge system and MWRA's North Charles Metropolitan sewer. This project reduces the CSO annual discharge volume from CAM 005 by approximately 75% and drops the frequency of discharge to two per year. The physical improvements to the CSO at this location were completed ahead of schedule.

3. Stony Brook Separation

This project to separate sewer and storm lines is intended to minimize CSO discharges to the Stony Brook Conduit and to the Back Bay fens, both of which drain to the Charles. The work entails separating combined systems in parts of Roxbury and Jamaica Plain. Approximately 75,000 feet of new storm drains will be constructed by BWSC using MWRA funding.

In October of 1999, BWSC completed a preliminary design report and began the final design on the first of several planned construction contracts. Full implementation of the recommended sewer separation plan will reduce the number of overflows to the Stony Brook Conduit from as many as 22 per year to zero in a typical year. The USGS loads study indicated that Stony Brook currently comprises a major source of bacteria to the basin during wet weather and on an annual basis is responsible for nearly half of the bacterial load, and most of that from CSO influence on Stony Brook.

As of March 2003, construction of the project was about 31% complete as measured by linear feet of installed storm drain. The existing schedule requires construction progress at 15% per year, for a total of about 45% by July 2003. Contract 2, which includes 34% of the storm drain construction, commenced in March 2003. With the commencement of Contract 2, construction activity will soon reach a peak and actual progress is expected by MWRA to surpass court mandated progress by the end of this year. BWSC has advertised the paving and downspout disconnection contracts, which are expected to begin soon. The Stony Brook separation project is scheduled for completion in September of 2006.

4. Floatables Controls

The Facilities Plan calls for the control of floatable materials in all remaining CSO discharges in accordance with the National CSO policy. MWRA, BWSC and Cambridge are responsible for implementing these controls in their respective systems.

In 2002 BWSC, through an agreement with the Central Artery/Third Harbor Tunnel project, completed construction of underflow baffles at the last two regulators, discharging their floatable control obligations. Cambridge discovered structural problems with the four locations at which it was to construct floatables controls. Design work is currently about 80% complete and Cambridge expects to complete construction at all locations by June 2005.

With respect to MWRA, CSO outfalls MWR018, 019, 020, 021 and 022 conveyed overflows from MWRA's Boston Marginal Conduit to the Lower Charles in very large storms. MWRA closed MWR021 and 022 to CSO discharges in March 2000. During preliminary design of floatables controls at the seven remaining CSO regulators, it was determined that the installation of underflow baffles would be difficult and costly. After conducting analyses , MWRA raised the weirs at the three remaining outfalls and created a protocol by which the Prison Point system can relieve hydraulic flow to the Boston Marginal Conduit in large storms, thus minimizing discharges through MWR 018, 019 and 020. In addition, MWRA cleaned the conduit, optimizing the conveyance capacity of the pipe. MWRA is required to monitor the conditions int the Boston Marginal Conduit and report to EPA and DEP on the degree to which system changes have minimized CSO overflows into the lower Charles.

5. CSO Elimination

MWRA's plan calls for the elimination of a number of CSOs, many of which have been effected. The Authority completed construction work to permanently close CSO outfalls MWR 022 and MWR 021 on March 1 and March 13, 1999, respectively, well in advance of the May 2001 milestone. As of today, the lower Charles has a total of eleven remaining Combined Sewer Overflows. The expected annual volume and activation frequency of these remaining CSOs for a typical year at the conclusion of the Long Term Control Plan is as shown below.

CSO Discharge Frequency and Volume to Charles River Basin under Future Planned Conditions[5] and Existing Conditions

CSO Number	Location	Future Planned Conditions		Existing Conditions	
		Volume (mg/yr)	Activation Frequency (typical year)	Volume (mg/yr)	Activation Frequency (typical year)
MWR 018	Between Harvard Bridge and Longfellow Bridge [Boston Marginal Conduit]	0.45	2*	1.77	2
MWR 019		0.12	2*	0.52	2
MWR 020		0.05	1*	0.21	3
MWR 023	Stony Brook	0.13	2	45.23	24
MWR 201	Cottage Farm	26.68 (treated)	7	74.65 (treated)	13
BOS 046	Back Bay Fens	0	0	4.9	2
CAM 005	Mt. Auburn Hospital	0.78	2	0.78	2
CAM 007	Hawthorn Street	0.03	1	0.63	3

[5]Future Planned Conditions are those conditions predicted to exist when the Deer Island Treatment Plant is operating at full capacity and with Stony Brook conduit drainage area separation project completed. The Deer Island Treatment Plant is currently at full capacity.

*MWRA recently conducted additional evaluations on these CSO and implemented operations and maintenance procedures and structural modifications to eliminate CSO discharge in a typical year.

CAM 009	upstream of Anderson Bridge	0.08	1	0.32	5
CAM 011	upstream of Weeks Bridge	0	0	0.03	1
CAM 017	Cambridge Parkway	0.85	1	1.09	3
Total untreated		2.49		58.47	
Total treated		26.68		74.65	

As the numbers below reflect, significant reductions have already occurred in the volume of treated and untreated CSO discharges to the Lower Charles. Based on MWRA's extant plan, additional reductions are expected. These numbers are estimates based on MWRA's current long term control plan.

	treated CSO discharges	untreated CSO discharges
1988	1,500 MGY	?
2001	75 MGY	58 MGY
2006	27 MGY	2 MGY

6. Water Quality Variance

The Commonwealth with significant involvement of EPA on September 2, 1998 issued a variance in order to have the surface water quality designation of the Lower Charles reflect the fact that CSO discharges into this segment of the river will continue at a minimum until October 2003. This variance has been extended three times. In October DEP will make a final decision on the variance based on the USGS loads study, the USGS stormwater Best Management Practices analysis, receiving water modeling done by MWRA and the Cottage Farm storage evaluations. This short term modification of the standard in the variance is based on DEP's finding that during the term of the variance, more stringent controls would result in substantial and widespread economic impact. This variance temporarily changes the water quality classification of the River from B to B/CSO.

The conditions of the variance require MWRA, Cambridge and BWSC to implement the nine minimum controls, to provide CSO activation data, and (for MWRA) to evaluate Infiltration/Inflow controls in the North system. It also requires MWRA to provide member communities with technical assistance on some specific issues and to assess the feasibility of permanent storage at Cottage Farm, which will be the one major CSO discharge point at the completion of the current facilities plan. This variance also requires MWRA to collect data on the impacts of stormwater on water quality, to assist with the determination of whether additional CSO or stormwater controls will yield greater benefits for their relative costs and whether additional control of both CSOs and stormwater is appropriate. Much of MWRA's information gathering obligations has been satisfied by their funding contribution to the USGS Watershed Study.

The CSO Permit for Boston was issued on March 28, 2003. The CSO permit for Cambridge will be going to public hearing in late May of this year.

III. Enforcement and Assistance

A. Enforcement

i. June 1998 Inspections and Subsequent Cases

Following our March 1998 mailing to the 200 major facilities in the Charles Watershed holding or needing federal permits, OES and OSRR conducted inspections at roughly fifty facilities, including UST sites. All USTs with steel walls within 1000 feet of the river were inspected. As a general matter, the level of compliance was extremely high. Facility managers reported that EPA's March letter putting facilities on notice that inspections would commence in June provided them with the time and leverage to obtain necessary resources to review their facilities for compliance. OES Inspectors found only a handful of minor cases including four UST cases that were settled by field citations and only one significant case: MIT. The MIT inspection revealed hazardous waste emergency, storage, handling and labeling violations in 56 of 114 laboratories; a failure to keep an opacity monitor on its medial waste incinerator in working order; and a failure to have an adequate and fully implemented oil spill prevention plan. On April 18, 2001 a consent decree settling this case was filed in U.S. District Court. The settlement calls for MIT to pay $150,000 in penalties and to conduct Supplemental Environmental Projects worth more than $400,000.

Under the terms of the settlement, MIT has developed and is currently testing a computer-based 'virtual campus' compliance assistance tool to help universities and colleges all over the country comply with environmental laws. The virtual campus will address compliance with several environmental laws in eight featured areas, including a laboratory, an auto and grounds maintenance department and a 90-day hazardous waste storage area. When it is completed by 2004, the virtual campus will be posted on the Campus Consortium for Environmental Excellence web site.

MIT has also agreed to install at the campus's new Stata Center, a major research facility situated in an area of Cambridge prone to flooding, a state-of-the-art stormwater control and treatment system utilizing biofiltration. The project will reduce the rate of stormwater runoff from the area into the Charles River by 50 percent and reduce the amount of solids in stormwater runoff by 80 percent.

MIT also agreed to develop and implement three different environmental education projects with the Cambridge public school system. The projects, which bring Cambridge public school teachers into collaboration with MIT faculty, focus on water quality, pollution prevention, site cleanups or energy use - all with an urban theme. Each of the projects also will include a field activity to help improve the urban environment. Two of the three education programs have been completed, and the third is scheduled for the next academic year.

And, lastly, the settlement requires MIT to implement an Environmental Management System. As part of this effort, MIT must, among other things, identify key personnel at MIT responsible for environmental compliance issues, develop an inventory of materials used in laboratories, create a system of self inspection, improve its environmental training programs, and create a program for preventing, reducing, recycling and reusing wastes.

ii. Watershed Permitting/Flow Trading

EPA has provided roughly $100,000 in funding to CRWA and MADEP to undertake a watershed permitting exercise for an upper segment of the Charles River, including six communities. The goal is to develop a pilot project that focuses on a segment of the River with communities that are experiencing summer water shortages and have limited wastewater treatment capacity as a result of past growth. The segment of the upper Charles also suffers widespread elevations of nutrients and chlorophyll and localized elevations of bacteria levels. Sustained river flow during the summer is threatened by increases in water withdrawals from local wells; increases in impervious surfaces, which in turn decrease infiltration; and the short circuiting of water that is sewered from upstream sources to downstream wastewater treatment plants.

EPA and DEP launched the initial phase of this project during 2000 by reissuing six NPDES POTW permits[6] that specifically address the problems of excessive nutrients (primarily phosphorus and other organic enrichment) and low dissolved oxygen. All six permits were signed on September 29, 2000 and set a seasonal phosphorus limit of .2 mg/l from April 1 through October 31 and a reporting requirement for phosphorus from November 1 through March 31. Because these permitees are the dominant source of nutrients upstream of Watertown Dam during the dry summer months when algae blooms appear, our strategy calls for permitees to meet the highest and best practical treatment for total phosphorus, which is generally considered 0.2 mg/l. In addition, the permits hold permitees to their current design flow levels, unless they justify expansions after performing comprehensive wastewater management plans. These CWMPs would be expected to explore opportunities to increase groundwater recharge through de-centralized wastewater treatment with subsurface

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[6]These include four Publically Owned Treatment Works and two smaller facilities: Milford, Charles River Pollution Control District, Medfield, MCI Norfolk-Walpole, Southwood Community Hospital and the Wrentham Development Center.

discharges, stormwater infiltration basins and infiltration inflow control in wastewater collection systems. Communities wishing to increase flows are being encouraged to offset any new sanitary sewer connections through increased infiltration/inflow controls and/or stormwater recharge by a factor of 2:1.

CRWA is currently working on the development to of Total Daily Maximum Loads (TMDLs) for the upper Charles watershed for bacteria, phosphorus, and nitrogen. As part of the project, CRWA will investigate the feasibility of using river instream flow as a medium of exchange in trading. Increased river flow could increase the assimilative capacity of the river to accept pollutants while reducing stormwater loadings through infiltration. A flow based trading program, where regulated entities could enhance stormwater recharge as a substitute for increased end of pipe technologies, could achieve reductions in non-point loadings, enhance and restore riverine and wetland habitats, and improve water quality.

CRWA will assist EPA and DEP in working with the communities to optimize pollution trading between point and non-point sources and to provide the towns with the opportunity to share technical assistance and draw from each other's strengths. CRWA has developed a "Smart Storm" system, which includes a cistern attached to a dry well component. This system, which is intended to catch rain runoff from down spouts, allows for clean water to be captured before it becomes dirty, allows water to be recycled for irrigation or yard use, and, when cisterns are full, allows water to be recharged to the aquifer through the dry well system. This recharge, in turn, will raise base flow in the river.

CRWA's trading program hopes to facilitate construction of "Smart Storm" systems by parties such as POTWs who will attempt to increase baseflow and assimilative capacity of the river to compensate for the water quality impairments caused by their discharges.

IV. Science of the Charles

1. USGS Sediment Study

Published in March 2001, the USGS sediment study focused on the distribution and concentration of contaminants in sediments in the Charles basin. Through random sampling of surficial sediments throughout the basin and core sampling at proposed high use areas, the USGS study found that the Charles sediments are very contaminated, as one would expect in a basin that essentially has served as a settling pond for the Charles for the last century.[7] USGS compared the Charles sediments to those

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[7]The study finds that "the creation of the basin, combined with large sediment loading as a consequence of the ever-increasing urbanization of the watershed, has resulted in deposition and entrapment of more than 53 million cubic feet of sediment since 1908. In other words, more than 11

of other urban rivers in the U.S. and concluded that median concentrations of sediment contamination in the Charles ranged from 1.3 to 35 times higher. Several characteristics of the basin may explain the high concentrations of contaminants, according to USGS: low hydraulic gradients, a lack of flushing and a lack of natural uncontaminated sediment–from erosion of upstream uncontaminated soils–that typically dilute contaminated urban sediments. The salt wedge that creates an anoxic layer in the lower basin may also contribute to high sediment concentrations by sequestering metals in the sediments.

The concentration of both organic and inorganic elements are present at sufficiently high concentrations to cause potentially severe biological effects to benthic organisms living in and on the bottom sediment. USGS compared the concentrations of contaminants in surficial sediments to Probable Effect Levels (PELs), the concentration above which adverse effects frequently occur to benthos . The concentrations exceed PELS in about 77% of the inorganic elements tested; were above the Threshold Effect Level (TEL) but below the PEL in 15%, and were below the TEL in 8 %. The element with the largest percentage of PEL exceedences is mercury (94%); This is followed by lead (91%),cadmium (84%), zinc (83%) silver (75%), copper (73%), nickel (63%)m and chromium 53%). With respect to organic contaminants, the potential for adverse effects on benthic organisms was frequent for 63% of the compounds measured. PAHs, PCBs chlordane and DDT violate PELs in 100%, 89%, 49% and 14% of the samples taken, respectively. The reduction of a healthy benthic community also undoubtedly affects animal life higher on the food chain, such as fish. Despite the contaminant levels in sediment, the OEME fish study, discussed below found that there was still a varied and significant warm water fishery existing in the Charles.

With respect to human exposure, many individual polyaromatic hydrocarbons, total petroleum hydrocarbons, and lead measured in cores taken at four potential high use areas exceed exposure based soil concentration standards for direct contact and incidental ingestion. The core sampling occurred at four areas identified by MDC as potential future wading or swimming areas under their masterplan for the restored MDC reservation. These areas included Herter Park East in Brighton, the Esplanade Lagoons in Boston, Daley Field in Newton, and Magazine Beach in Cambridge. The areas with the highest concentrations of contaminants were depositional areas of the river–Daly Field and Herter Park East; the areas with lower concentrations were low depositional areas where fine grained sediment that contains contaminants apparently is resuspended and transported downstream (Magazine Beach) or is unable to be deposited due to physical barriers or flow regime (Esplanade Lagoons).

The concentrations were compared with the DEP epidermal and ingestion guidelines for soils. At Daly Field, where guidelines were most frequently violated, median concentrations of lead, TPHs and some PAHs violated the guidelines by factors of 2, 25 and 2-50, respectively.

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percent of the capacity of the basin has been filled with sediment over the ast 92 years. The thickness ranges from less than .5 feet near the Watertown Dam to greater than 5 feet near the Museum of Science.

At Magazine Beach PAH concentrations exceeded guidelines by 2 to 4 times, and the median TPH concentration exceeded the guidelines by 11 times.

The sediment information is relevant to the goal of a swimmable Charles in several respects: first, wherever beaches are constructed, sediment will need to be removed and replaced with a clean bottom such as sand[8]. Second, there are places on the river where depositional rates are relatively low, such as Magazine Beach, where bottom sand would take longer to become recontaminated.

While these data indicate that the areas originally targeted as potential swimming or wading areas contain problematic levels of bottom contaminants, water quality data collected over the years indicates that both clarity and bacteria levels are close to achieving swimming standards a significant amount of the time in the lower basin, particularly at EPA's monitoring station outboard of the lagoons in the mainstem of the Charles. This suggests that this area may be the most appropriate location for swimming, particularly if such an area were protected by a Gunderboom enclosure. (See section 4 below for a discussion of the 2002 Gunderboom demonstration.

2. The Salt Wedge Problem

A. USGS Salt Wedge Study

USGS published a second report in March 2001 entitled "Spatial Distribution, Temporal Variability, and Chemistry of the Salt Wedge in the Lower Charles River, Massachusetts, June 1998 to July 1999." This study details the effects that saltwater from Boston Harbor has on the lower Charles. The study found that the opening and closing of locks results in a significant saltwater wedge in the basin, particularly in the dry summer months when water flows from upstream are low and locks are open more often due to increased boating traffic. The effect of boat locking on the extent of the wedge in the lower basin is most dramatically portrayed by viewing the wedge before and after the July 4th Esplanade event. In high spring runoff period and during major storms, freshwater flows from the upstream River can flush the salt wedge completely out of the basin, as occurred during an eight inch rainstorm in mid-June 1998. This flushing is assisted by large capacity pumps which pump water from the basin over the MDC dam into Boston harbor, to avoid any flooding in the basin during rain storms.

The salt wedge appears to have both negative and positive effects. Because it forms an area of oxygen depleted zone on the river bottom, fish habitat in that area of the river is limited; however, it appears that the warm water fish that live in the basin are able to survive without resort to the bottom in this portion of the basin. One of the surprising positive benefits that the wedge may have is its apparent tendency to sequester metals in bottom sediments, that would otherwise be released to the water column.

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[8]One way of improving clarity in swimming areas would be to place white sand on the bottom, thereby increasing the amount of light reflected through the water column.

3. Mirant (Southern) NPDES Permit Application

The enhanced understanding of the salt wedge dynamic has been helpful to EPA in assessing proposed changes to the permit limits for the Kendall power plant. Mirant Corporation (formally Southern Energy) is proposing to upgrade the existing Kendall Square Station power generation facility located in Cambridge on the downstream side of the Longfellow Bridge. The proposed facility would upgrade existing generating facilities to increase power output while switching from oil as the primary fuel source to natural gas. Thus, the proposed plan would benefit local air quality as it would result in significant emission reductions of certain air pollutants. However, the proposed facility has implications on the water quality and fishery management goals of the Charles River as it would substantially increase both the quantity and temperature of once-through non-contact cooling water to the basin in order to dissipate waste heat.

EPA is currently working on a draft permit that will be published for public comment. Mirant's proposed discharge is significantly different from the existing discharges. First, there would be a substantial increase in thermal loading to the Charles River not only in terms of magnitude of heat load discharged but also in duration of peak heat loading to the river. The existing facility operates in a peaking manner with power output being very erratic. Thermal loading typically varies considerably over short periods of time and the river does not receive prolonged periods of peak thermal loading from the facility. Based on information provided by the project's proponent, the maximum daily thermal load to the Charles River during the past ten years was approximately 63% of the maximum daily permit limit. The proposed upgraded facility would be operated to produce a constant power output with thermal loading to the Charles River at or near permit limits for potentially long periods of time. Thus, under the proposed plan the Charles River would receive sustained periods of substantially increased thermal loading (57% higher than the maximum daily heat load during the past ten years).

Another significant difference between the proposed and the existing facility relates to the locations of the cooling water discharge to the Charles River. The existing facility discharges cooling water to the surface of the Charles via an outfall pipe located along the seawall in Cambridge. The proposed facility would continue to use the existing outfall; however, up to half of the cooling water flow (approximately 40 MGD) would be discharged through a diffusor in deep water in the middle of the Charles River. The intended purpose of the diffusor is twofold: (1) to more effectively distribute the heat load in the Charles River to avoid short-circuiting between the discharge at the seawall and the cooling water intakes located in Broad Canal (this would result in reduced efficiency); and (2) to increase mixing and prevent the onset of stratification caused by the influx of salt water from Boston Harbor. The goal of eliminating stratification is to improve dissolved oxygen levels in the bottom waters which are often anoxic because of the lack of vertical mixing. As a result of the increased mixing, it is anticipated that significantly higher river temperatures will occur throughout the water column and across the river below the Longfellow Bridge.

EPA along with several other federal and state agencies are evaluating the proposed project and assessing the impacts of increased thermal loading on fish populations and general water quality. The agencies are focused on ensuring that the cooling water discharge does not result in a thermal blockage that prevents the inward and outward migrations of anadromous fish species, nor result in excessive temperatures that would impair the Charles River as a nursery habitat for juvenile fish. Additionally, the impact of the increased thermal loading and the liberation of nutrients from bottom sediments as a result of the diffusers' mixing of basin waters, on eutrophication or excessive algal growth will be evaluated. An overabundance of algae which impairs recreational uses and contributes to low dissolved oxygen levels in bottom waters is frequently a problem during the summer in this portion of the basin and may be worsened by increased river temperatures and mixing of the basin.

As currently conceived, the permit would require the plant to operate with thermal discharge limits based on real-time monitoring probes placed in the water body. The thermal limits and locations established for the Charles would be based on the biological thresholds of the most sensitive life-stage of alewife and yellow perch throughout the year. The permit will also contain requirements to monitor for algal growth in the basin. In addition, operational limits will be placed on the power plant if algal blooms intensify in the lower Charles as a result of thermal discharges from the plant. A draft permit is expected to be issued in June.

4. USGS Findings on Clarity

Although not a formal part of either the Salinity or Sediment studies, USGS investigated the causes of impaired visibility in the lower Charles. Limited water clarity appears to be an impediment to swimming in the Charles, as the State's four foot visibility requirement is seldom met in the basin. MDC has long maintained that clarity is impaired due to tannins in the water, the result of water moving slowly through upriver marshy areas. The USGS data indicates that the highest contributor to this problem is TSS (42%) followed by phytoplankton (36%), and Dissolved Organic Matter (21%). In short, it appears that suspended solids and algae are major contributors to the water clarity problem and that dissolved organic matter or tannins plays a relatively minor role.

These results were borne out in additional color and visibility monitoring that was conducted during 2000 by OEME. This study conducted monthly sampling in March through September and attempted to find correlations between Secchi Disk transparency readings and other conditions. The study found the closest correlation between transparency trends and turbidity and TSS and found no correlation between soluble tannic acid and transparency. Both studies also suggest that it appears that it would be very difficult to control nutrients (and thus algae)to the extent necessary to improve water clarity to the state limit, notwithstanding the innovative permitting process discussed above. However aggressive stormwater management to reduce suspended solids in combination with reducing nutrients may have beneficial effects on the river's clarity.

Because the clarity issue appears related primarily to TSS, the use of filter booms around swimming areas may improve water clarity to an acceptable point. As discussed below, pilot studies during 2002 suggest that use of a barrier curtain in swimming areas could achieve the clarity requirements of

Massachusetts DPH.

5. Gunderboom Demonstration Project

Based on the USGS observation that TSS and algae are major contributors to the water clarity limitations in the lower Charles, we undertook a demonstration of the Gunderboom during the summer of 2000 to determine whether this technology could be used to develop a swimming area meeting the a 4 foot visibility measure[9]. A Gunderboom is a patented full water-depth filter curtain comprised of treated polypropylene/polyester fabric suspended by a floatation boom on the water's surface and secured to the bottom with anchors and sandbags. As water passes through the fine mesh curtain from the River into the enclosed area, bacteria and suspended solids are filtered out. Tests conducted by the manufacturer indicate that the curtain removes 99% of total suspended solids and 63% to 99% of fecal coliform.

We conducted the 2000 demonstration project by deploying a 150 foot section of the boom in the Magazine Beach area for a two day period first in June and then again in August, during which we sampled water inside and outside the boom for TSS, suspended solids and bacteria. This was intended to indicate whether a large scale boom would be effective in rendering the water clear enough to meet the state clarity standard and the extent to which the boom serves as a barrier to bacterial contamination, which will remain an impairment to swimming during wet weather. We chose to perform the test in June and August at Magazine Beach because our studies indicate that bacterial contamination and clarity impairment peak at Magazine Beach during the month of August and that June represents a month when dissolved organic matter most impairs water quality.

The results of the Gunderboom study bore out to some extent the expectations of the team. No conclusive improvements were obvious for fecal coliform and enterococcus bacteria, color and dissolved tannins or total organic carbon. Consistent with expectations, improvements were measured in TSS, Secchi Disk readings, turbidity and chlorophyll a, though the improvements were not as dramatic as had been hoped. The Gunderboom did improve water clarity so that it met the four foot standard, but was unable to maintain the visibility at that level due to disturbance of bottom sediment and leaks between the bottom of the boom and the river bottom.

During 2002 we conducted a second set of tests at two locations: at CRWA 8 off the Storrow lagoons, where water clarity in the basin is best, and at CRWA 8 near Magazine Beach, the site of an historic swimming beach. With respect to clarity, the CRBLA 8 station has met the clarity standard of 4 feet for public swimming beaches 60% of the time during the course of EPA's baseline study over the last four years. During the 2002 Gunderboom demonstration, the boom increased clarity at this

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[9]The four foot standard that existed until recently has been replaced by a more general standard prohibiting swimming at public beaches "lack[ing] water clarity. For purposes of judging the feasibility of swimming in the lower Charles, the four foot test is being assumed.

site by .24 meters, on average. If this average improvement is factored into the average water quality for this location, it appears that the Gunderboom would be able to achieve the four foot standard 100% of the time.

With respect to station CRBLA 06 near Magazine Beach, EPA baseline data shows that this area meets the state clarity standard approximately 10% of the time. Factoring in the .39 meter improvement in clarity that was demonstrated by the boom at this site, it appears that a system employing Gunderboom could assure the state standard would be achieved 75% of the time.

Sample results for bacteria levels were somewhat erratic, due in part to the low ambient levels during the test days, when concentrations did not violate the state swimming standard. Gunderboom systems in other settings, including salt water swimming beaches and drinking water Reservoirs, indicate that the boom can reduce fecal bacteria levels by up to 98%.

Given that Gunderboom has successfully developed systems for swimming areas at Sea Cliff Beach and Mamaroneck Beach, there is hope that this technology holds promise if the MDC or successor agency decides to create a swimming lagoon or pavilion in the basin. The MDC masterplan, released in 2002, includes a lagoon at Magazine Beach, where water would be diverted from the River into an engineered lagoon that would be dug from the existing parkland. Since water wold need to be filtered in such a diversion, it appears that the Gunderboom would be an appropriate technology. Magazine Beach was an area that was originally considered a promising swimming site, because it was historically used for swimming and because bottom conditions there were predicted to be better than further down in the basin. However, data collected over the last several years has conclusively shown that water quality, both in terms of bacterial counts and clarity, is much better in the lower basin, particularly off the lagoons. This would indicate that if swimming is reintroduced to the Charles, the lower basin would be preferable to Magazine Beach.

6. EPA Baseline Study

In 1998, EPA's Office of Environmental Measurement and Evaluation (OEME) initiated the Clean Charles 2005 Core Monitoring Program that will continue until 2005. The purpose of the program is to track water quality improvements in the lower Charles River and to identify where further pollution reductions or restoration actions are necessary to meet the Clean Charles 2005 Initiative goals. The program is designed to sample during the summer months that coincide with peak recreational uses.

The program monitors twelve "Core" stations. Ten stations are located in the Basin, one station is located on the upstream side of the Watertown Dam and another is located immediately downstream of the South Natick Dam (to establish upstream boundary conditions). Five of the ten sampling stations are located in priority resource areas which were earlier identified as potential wading and swimming locations. Six of the twelve stations are monitored during wet weather conditions.

In the year 2002, the following parameters were measured: dissolved oxygen, temperature, pH, specific conductance, turbidity, clarity, transmissivity, chlorophyll a, total organic carbon, total suspended solids apparent and true color, nutrients, bacteria, and dissolved metals. Also during 2002, modifications were made to the Program to support the development of a three-dimensional hydro-dynamic linked water quality model. The model will be used for the development of an eutrophication Total Maximum Daily Load (TMDL) to address low dissolved oxygen, numerous aesthetic impairments, algae blooms and pH violations in the Basin. Sampling stations, sampling parameters, and additional sampling dates were added to provide data for the model development. Seven additional TMDL stations were added between the BU Bridge and the Museum of Science. Total Kjeldahl Nitrogen (TKN) and algal analysis were added to the parameter list. Three additional TMDL sampling dates were added between June and September. Depth samples were collected at some stations to determine pollutant concentrations above and below the pycnocline (the interface between water of different densities). In addition to these modifications, the Core Monitoring station inside the pond at the Esplanade (CRBL08) was relocated to the main stem of the Charles and designated as CRBLA8.

In 2002, additional bacteria sampling was conducted during the Fourth of July and at selected "Hot Spot" locations. These data were summarized separately and are not included in this summary.

Conclusions of the 2002 Core Monitoring Program

The conclusions below summarize the 2002 Core Monitoring Program data and use these data to evaluate the water quality conditions from 1998 to 2002. No obvious short-term trends were observed from the past five years of data. Further statistical analysis of this data will be performed. Water quality was influenced by yearly fluctuations in weather and river flows, making short-term trends difficult to determine.

In 2002, from the middle of June through the first week in September, the flows at the Waltham gauging station were generally less than the flows recorded during 1998, 2000, and 2001. During this same time period, with the exception of some selected periods, the flows were greater than the low flows of 1999. The flow during 1998 and 1999 (from the middle of June through the first week in September) were generally the high and low flow years, respectively. In 1998, the summer conditions were generally wetter with correspondingly higher flows; in 1999, summer conditions were drier with correspondingly lower flows.

Six dry weather and three wet weather events were sampled from June through October. Comparing these data to the past four years' data revealed no definitive trends. However, the following conclusions can be made. The five years of data show that the section near the mouth of the River (Mass Ave. Bridge to the New Charles River Dam) met the swimming standards more often than any other part of the Basin. During lower flow years of 1999 and 2002, the mean clarity was the greatest at many of the stations in the lower part of the Basin. During 2002, elevated nutrient concentrations were measured in the water below the pycnocline.

Clarity, Color and Transmissivity

Water clarity was directly measured in the field using a Secchi disk. Mean Secchi disk readings downstream of Magazine Beach were greater than the means over the last two years and similar to the means from 1999. The greatest clarity was recorded between the Esplanade and the New Charles River Dam on July 9 and August 20. From Daly field to the BU Bridge, the mean Secchi disk value was 1.0 meters while the stations monitored between the Esplanade to the New Charles River Dam recorded a mean Secchi disk value of 1.5 meters.

True and apparent color were measured during the Core Monitoring sampling days which include July 9, August 6, September 10 and during the wet weather sampling events. These parameters were not measured during the TMDL sampling days of June 13, July 30, and August 20. The highest true and apparent color values were measured during July 9. Mean color values were generally lower than mean values measured during the previous years. As identified in a previous report (EPA 1999), it appears that part of the color was associated with particulate matter. This implies that controlling algae growth and preventing particulates from being discharged could enhance the clarity of the water and help achieve the bathing beach visibility criteria.

Transmissivity, a measurement of water clarity, was measured at selected stations. The greatest Transmissivity was recorded near the mouth of the Basin. The mean values from the two stations where Transmissivity was measured in 2001 and 2002, showed an average increase of 10% in 2002. The transmissivity measurements correlated well with Secchi disk measurements.

Bacteria

Fecal coliform concentrations were lower near the mouth of the Basin (Mass Ave. Bridge to the New Charles River Dam; CRBL07 - CRBL12), which was typical of the data collected during the previous four years. The dry weather samples collected at all stations from CRBL07 - CRBL12 were less than the swimming criterion[10], of less than 200 colonies/100ml, 95% of the time. The dry weather geometric means[11] were similar to those collected during previous years. During dry weather, approximately 31% of the core monitoring samples exceeded the fecal coliform swimming criterion (compared to 35%, 23%, 8%, and 17% in 2001, 2000, 1999and 1998, respectively). During wet weather, approximately 46% of the core monitoring samples exceeded the criterion[1] (compared to 44%, 63%, and 50% in 2001, 2000, and 1999, respectively). At station CRBL02, the geometric means have increased over the past three years (Figure 1a).

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[10]The Massachusetts fecal coliform swimming criterion of less than 200 colonies/100ml is actually based on a geometric mean of five samples or more. For this report, individual concentrations were compared to this criterion.

[11]Some of the dry weather geometric means were calculated from less than five data points; the actual criterion is based on a geometric mean of five samples or more.

E. coli bacteria was sampled during all sampling events. As observed with fecal coliform measurements, the E. coli concentrations were lower near the mouth of the Basin (Mass Ave. Bridge to the New Charles River Dam; CRBL07 - CRBL12). For these stations, all calculated geometric means met the Department of Public Health (DPH) Bathing Beach criterion[3] and one sample collected at station CRBL12 was greater than the DPH bathing Beach criterion for individual samples.

Fourteen or approximately 17% of the dry weather core monitoring samples exceeded this criterion, compared to 19% in 2001 and 35% in 1998 (Figure 2a). The fecal coliform and E. coli bacteria concentration from the six TMDL station between the Mass Ave. Bridge and the Museum of Science showed similar counts. The fecal coliform geometric means ranged from 7 to 10 and the E.coli geometric means ranged from 6 to 12.

Dissolved Oxygen (DO), pH and Temperature
Massachusetts has established DO criteria for class B waters. Two DO violations or approximately 1% of all the field measurements (compared to 0%, 0%, 3%, and 0% in 2001, 2000, 1999, and 1998, respectively) collected during the thirteen sampling events did not meet this criterion. Anoxia was measured at the bottom during the four sampling events in which depth profiles where conducted. All DO measurements below 4.5 meters were less than the MA DO criteria. These measurements were conducted at four stations downstream of the BU Bridge.

The data from all the dry and wet weather core monitoring surface measurements showed pH violated the criterion twenty times or approximately 22% of all field measurements (compared to18%, 20%, 8%, and 4% in 2001, 2000, 1999, and 1998). All surface violations were greater than 8.3 and occurred at or downstream of Herter East Park. Depth samples often had a lower pH than the surface measurements and were greater than or equal to 6.5.

The highest surface water temperature was recorded on August 20, between the Longfellow Bridge and the Museum of Science (CRBL11) at 29.2 ºC. (84.6ºF). There were ten recorded temperature measurements above the state criterion. These measurements occurred on August 6 and August 20, in the area of Longfellow Bridge and the Museum of Science.

Nutrients
Phosphorus was the most significant nutrient in this system. Elevated phosphorus concentrations at many of the sampling stations indicated highly eutrophic conditions. Each station recorded the highest concentration during the June or July sampling event. The dry weather means from eight stations were lower than any previous years' means. The additional TMDL sampling that was conducted during 2002 involved collecting samples above and below the pycnocline at three stations. This data revealed elevated concentrations of total phosphorus, ortho-phosphorous, total Kjeldahl nitrogen, and ammonia. The total phosphorus median concentration above the pycnocline was 57 ug/l and the median below the pycnocline was 484 ug/l. The highest concentrations for ammonia and nitrate from the surface samples were recorded during the June and July sampling event.

Metals

No measured metals exceeded the acute Ambient Water Quality Criteria (AWQC). Lead and selenium were the only metals that exceeded the chronic AWQC. The lead exceedances occurred only during the July 9 sampling event at the ten most downstream stations which was 21% of all dry weather metals samples (compared to 33%, 27%, and 8% in 2001, 2000,and 1999 respectively. No wet weather lead exceedances were measured (compared to 0%, 25%, and 72% in 2001, 2000, and 1999). Selenium exceeded the chronic AWQC twelve times during dry weather and fifteen times during wet weather. All exceedances occurred down stream of the Massachusetts Avenue Bridge. In past years, copper had exceeded the chronic AWQC but not selenium. The other measured priority pollutants metals (arsenic, cadmium, chromium, copper, mercury, nickel, silver, and zinc) did not exceed the AWQC. There were no identified reasons for these yearly changes.

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7. EPA Fish Study

During 1999, OEME conducted fish sampling to determine whether the lower Charles supported a balanced, indigenous population, whether that population was healthy and to determine health consequences associated with human consumption from it. The study followed 1985,1995 and 1997 DEP surveys. Those surveys prompted the Massachusetts Department of Public Health to issue a fish consumption advisory for PCBs in carp from Hemlock Gorge dam in Needham to the Museum of Science dam in Boston and a consumption advisory for large mouth bass caught upstream of the South Natick Dam for pregnant women and children under the age of twelve.

During 2000 OEME received and analyzed its fish data, which included weight/length and sex; age;%lipids;%solids; dioxin, PCB/pesticides; mercury; and metals. The primary findings from this data are as follows: Dioxins are evident, though low in fish. In some river segments, they were not found in sediment samples, but were evident in fish, probably because they bioaccumulate there. The dioxins were higher in offal than in fillets and higher in carp than other species. These findings are consistent with the fact that carp are bottom feeders whose digestive process leaves high levels of sediment in the fish gut. Carp offal also sequesters lipophilic contaminants such as dioxins.

With respect to pesticides, DDT showed up in only one carp sample at a concentration of 4 ppb. Its metabolites, DDE ad DDD, however, were present in all of the samples. DDE ranged from .01 to .25 ppm in fillets and .08 to 0.6 ppm in offal. DDD concentrations ranged from .01 to .11 ppm in fillets and .03 to 0.4 ppm in offal. All samples were well below the FDA action level of 5 ppm DDT for human consumption of edible fillets. Aldrin was not detected in any fish, but dieldrin was found in all samples. As with DDE and DDT, dieldren was below FDA action levels.

Analyses for total mercury was completed on all fish collected. All fish fillet samples were below the FDA action level of 1 ppm wet weight, ranging from .07 to .48 ppm. Largemouth bass showed slightly higher concentrations than the carp or perch, which appear to be quite similar in their body burdens. Mercury is known to bioaccumulate up the food chain, and largemouth bass are the dominant top level predator species in the lower Charles basin.

PCBs analyses indicated, as had the earlier DEP surveys, that the contaminant remains a human health concern. Some carp fillet samples exceed the FDA tolerance limit of 2.0 pp; Carp had the highest PCB concentrations in offal and fillets, followed by large mouth bass, yellow perch, anc calico bass, respectively. These concentrations appear to warrant the continuation of human health fish advisories and should raise some question as to the ecological health of the species surveyed.

Despite the fact that the EPA analyses supports the need for continued human health advisories, the study also suggests that based on the number and species of fish collected, there may be a respectable recreational fishery in the Lower Charles. This fishery includes Largemouth Bass, Carp and a variety of Pan Fish(Sunfish, Perch, Bluegill, Crappie). Smallmouth Bass and Chain Pickerel were also found, though not in abundance. The population of Largemouth Bass, a key recreational species, reflects a sustaining population with many of the fish between 12 and 16 inches.

EPA has forwarded the results of the fish study to the Massachusetts DPH, which will make decisions regarding health advisories based on it. While EPA cannot make any recommendations regarding fish consumption, the findings of this study indicate that a catch-and-release fishery that has recreational value to Boston may already exist and is likely to improve with water quality.

8. USGS Watershed Study: Stormwater and Mainstem Loads of Bacteria, Nutrients and Selected Metals, Lower Charles River Watershed

The U.S. Geological Survey (USGS) has published the results of a two year intensive study that focuses on assessing non-CSO pollutant loadings to the lower basin of the Charles River and that represents a cooperative effort by the USGS, the Massachusetts Water Resource Authority (MWRA), the Massachusetts Executive Office of Environmental Affairs (EOEA), and EPA New England: S*treamflow, Water quality, and Contaminant Loads in the Lower Charles River Watershed, Massachusetts, 1999-2000* Although the study has many facets, the primary objective is to characterize and quantify non-CSO pollutant loadings to the lower basin of the Charles River. The information generated from the project, together with other information being provided by the MWRA, EPA and others, will be used to determine the potential for additional water quality improvements from higher levels of CSO treatment, reductions in the number of overflows from additional storage, or remediation of storm water discharges. The information from these various sources has been incorporated into a receiving water model that estimates the effect of these sources on the Lower Charles during rain wet weather.

Background. This project began in 1999 and consisted of: (1) an extensive flow metering and monitoring program conducted during both dry and wet weather conditions; (2) development of a watershed model; (3) coordination with the MWRA on the development of a receiving water quality model; (4) a preliminary assessment of storm water management practices; and (5) providing the public with data and information compiled during the project in a time-relevant manner. Following is a brief description and status report of each project component.

(A) Continuous Flow Metering and Water Quality Monitoring. The dry and wet weather monitoring program was concluded in July 2000. Dry and wet weather samples were collected at nine (9) locations including two (2) mainstem stations in the Charles River at the Watertown Dam and the Museum of Science and four (4) tributary stations. Three (3) additional land use stations (with much smaller drainage areas than the four primary tributary stations) were monitored to evaluate the relationship between land-use type and storm water runoff quality. Eight of the monitoring stations were instrumented (all except the Museum of Science Station) to continuously measure flow during the monitoring program. Together the drainage areas tributary to the eight stations represents 96% of the entire drainage area to the lower basin of the Charles River, while the seven tributary stations represents 65% of the immediate drainage area below the Watertown Dam.

Dry Weather Sampling. Monthly grab samples were collected during dry weather starting in June 1999 and ending in late July 2000 at the nine locations. The samples were analyzed for indicator bacteria, nutrients, solids, and biochemical oxygen demand. Results of the dry weather sampling were used to estimate the pollutant load contributions from base-flow. All of the tributary stations, with the exception of the Muddy River station, were located within enclosed conduits. With the exception of the two largest basins metered, Stoney Brook and the Muddy River, the dry weather sampling results clearly indicate the presence of illicit sanitary connections to the upstream storm drainage systems. Follow-up investigations have been initiated by EPA. Although, indicator bacteria levels in the Stoney Brook Conduit and the Muddy River were generally low, the data are inconclusive for ruling out the presence of illicit connections due to the large size of the tributary drainage areas and the effects of long travel times and die-off, as well as, dilution.

Wet Weather Sampling. The wet weather sampling program consisted of two elements: (1) to measure flows and non-CSO pollutant loadings to the lower basin from the eight stations discussed above; and (2) to collect ambient water quality data at several locations within the lower basin of the Charles River during and after two storm events to support the development (by MWRA) and calibration of water quality model of the Charles River.

The first element involved storm event sampling at the seven tributary stations and one mainstem station (Watertown Dam). The Museum of Science station was sampled for only three events while no fewer than eight storms were sampled at the other eight locations. Composite samples intended to yield event mean concentrations were collected and analyzed for nutrients, selected trace metals, solids, and biochemical oxygen demand. Due to short holding time requirements, discreet indicator bacteria samples were collected during the storm event. The results of the bacteria sampling together with flow data were used to estimate event mean concentrations for bacteria. These data were used to characterize storm water quality and the quality of flow over the Watertown Dam. Ultimately, the flow metering data and the model will be used to estimate non-CSO loadings to the lower basin. The results of the wet weather sampling indicate pollutant concentrations that are typical of storm water that are reported in the literature.

The second element of the wet weather monitoring program involved sampling eight locations in the Charles River between the Museum of Science and the Watertown Dam during and after two storm events that occurred in July of 2000. The seven tributary stations (referred to above), and three additional tributary stations (for a total of 10 stations) were also sampled for the same two events. These data were used by the MWRA's consultant to develop a water quality model of the Charles River.

(B) Watershed Modeling. The USGS has completed the development and calibration of a lower basin watershed model using the Storm Water Management Model (SWMM). The results of this effort have been published in *Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999-September 2000, Water Resources Investigations Report 02-4129.* The USGS model represents areas served by separate storm water drainage systems that discharge to the lower basin and was calibrated using flow data from the tributary stations which collectively measured flow from 65% of the lower basin's drainage area. The MWRA will use its CSO model to predict CSO discharges from combined sewer service areas. The models will be used in combination with the pollutant data and flow data from the Watertown Dam site to estimate CSO and non-CSO pollutant loadings for the three month and one year design storms, as well as, on an annual basis. Also, the USGS model is being used to estimate flows and loads from ungaged areas for the two July 2000 storms, which will be used by the MWRA's consultant to calibrate the Charles River water quality model.

(C) Water Quality Model of the Charles River. The MWRA's consultant, Metcalf and Eddy, has developed a receiving water model that integrates the results of USGS's watershed model that measures runoff to the Lower Charles and the MWRA data regarading CSO loads to that body. The model has been used to simulate baseline and alternative conditions with varying levels of storm water and CSO abatement for the two design storms. This data will be added to USGS's assessment of stormwater loads to compare CSO and stormwater loads to the river under a variety of design storm conditions.

(D) Storm Water Management Assessment. In its third major publication on the Charles in 2002, USGS published the results of its assessment of various storm water best management practices (BMPs)to estimate the potential for reducing storm water pollutant loads to the lower basin. This publication is *Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts, Water Resources Investigations Report 02-4220*. Because the basin is highly urbanized, the assessment focussed on streetsweeping, as this is the most practical BMP in such an environment. The potential benefits associated with structural retrofit controls were also evaluated so as to be able to compare the relative advantages of structural and non-structural BMPs.

(E) Findings

The loads study reaches the following conclusions. These conclusions will be used to define the Clean Charles 2005 cleanup strategy in the years ahead:

-Annual contaminant loads from stormwater discharges directly to the Lower Charles River are large, but most dry weather and stormwater contaminant loads measured in the study originate from upstream of the Watertown Dam and are delivered to the Lower Charles River in mainstem flows. An exception to this is fecal coliform bacteria. Stony Brook, a large tributary influenced by CSOs contributed almost half of the annual fecal coliform load to the Lower Charles River for water year 2000, the year of the study.

-To achieve fishable and swimmable conditions will require further reductions in loads of contaminants from different sources. These include: sources upstream of the Watertown Dam under both dry and stormwater conditions; illicit discharges during all weather conditions to tributary streams; stormwater from tributary streams and storm drains that enter the River during rainstorms and snowmelt events; Boston and Cambridge area CSOs that affect the River during large rainstorms; and internal loading from bottom sediments.

-Fecal coliform bacterial densities measured in samples from the five mixed land use sites in the study area--Charles at Watertown, Laundry Book at Watertown, Faneuil Brook at Brighton, Muddy River, and Stony Brook--varied widely among subbasins and between dry weather and storm conditions. The highest mean dry weather fecal density (66,000 Colony Forming Units/100mL)was found at Faneuil Brook and indicates the likely presence of illicit sanitary cross connections. The lowest mean densities were at Stony Brook (47 CFU/100mL) and at the Museum of Science (33 CFU/100m/L). These low concentrations are perhaps attributable to the extensive illicit connection removal work already accomplished in the Stony Brook sub-basin and mainstem dilution and bacterial settling that occurs in the farthest reaches of the lower basin including near the Museum of Science.

-Among samples from the uniform land use sites–Laundry Brook at Newton Center (single family residential), Mount Auburn and Banks Street in Cambridge (commercial), Broadway and Prescott in Cambridge (multifamily), the relative coliform levels were as follows: Samples from Laundry Brook single family residential side had the highest mean stormwater densities (30,000 CFU/100mL) followed by 16,000 CFU from the multifamily site and commercial land use site (9,900CFU/ 100mL).

-The pattern of fecal coliform density exceedances of the swimming standard were almost identical to the pattern of Enterococcus exceedences of the proposed Enterococcus guideline of 61 CFU/100mL.

-The concentrations of phosphorus measured at Charles River at Watertown exceed the phosphorus guideline more than 44 percent of the time. Moreover, stormwater concentrations of phosphorus at the two largest tributaries–Stony Brook and Muddy River–were greater than the phosphorus guideline for every storm sampled. These data suggest that there is an ample supply of nutrients to cause the regular algae blooms and the eutrophication observed in the Lower Charles River during the summer months. In addition, these eutrophic conditions likely exacerbate low dissolved oxygen levels in the bottom waters as a result of organic loading and increased sediment oxygen demand as heterotrophic bacteria decompose the large sink of organic carbon.

-Stormwater event mean concentrations of this study were compared to concentrations from other studies collected in 23 cities between 1978 and 2000. While a host of factors could contribute to differences between the Charles findings and those of other studies, the following observations were made: In general the mean concentration of constituents in the Charles sub-basins studied were less than those measured in other studies with the exception of bacteria. Enterococcus mean concentrations were on average about 1.3 times greater in the samples from the Charles sub-basins and median concentrations of fecal coliform bacteria were about 7.3 times greater than those collected in other studies. These results indicate that stormwater quality in the study area is generally similar or better than that reported in studies of other areas. In spite of this, water quality in the lower Charles becomes impaired after rainstorms. This suggests that impaired water quality in the river after rainstorms may be more a function of the River's inability to assimilate large loads of contaminants relative to its size rather than the discharge of overly contaminated waters.

-Annually, about 44% of the total annual fecal coliform load is contributed to he Lower Charles River from Stony Brook, compared to 24% for upstream, which is the next highest contributor. Almost all of the annual Stony Brook fecal load (99.9%) is contributed by storms. (Thus, when MWRA completes the Stony Brook separation project in 2006, the fecal load to the lower basin will be substantially reduced.) The pattern of fecal coliform loading from upstream is different; more than 63% percent of the annual load occurs during dry weather.

-The annual Enterococcus bacterial load comes mostly from upstream (58%); the upstream load is more than three times greater than the next largest contributor of annual Enterococcus load, Stony Brook. Like fecal coliform, Enterococcus loading for the most part occurs during storms. Moreover, more than half of the total stormwater Enterococcus bacteria load comes from upstream. The difference between fecal coliform and Enterococcus loading patterns may be caused by different sources and survival characteristics of the bacteria. Enterococcus generally survive longer than fecal coliform once released by the host organism to a stream or river.

-To compare results among sub-basins different sizes and land use, it is useful to normalize load values to sub-basin are. Loads per unit area are know as yields. Looking at yields can give insight into whether a sub-basin is contributing a disproportionate amount of a particular constituent. Thus, it is not surprising that the upstream sub-basin contributes the largest proportion of the total annual load to the lower Charles for most of the studied constituents. The upstream basin is over 20 times larger than the largest tributary sub-basin–Stony Brook. In contrast, however, upstream yields were among the smallest for all of the water quality properties and constituents. In fact upstream yields for fecal coliform and Enterococci were the smallest compared with the sub-basin yields.

-The Muddy River sub-basin had among the highest yields of any of the study areas. This indicates that this sub-basin is contributing disproportionately large loads to the Lower Charles relative to its size, a conclusion that is not surprising because of the large amount of impervious surface in this sub-basin (42%), more than twice that of the next most impervious sub-basin, Laundry Brook (19%).

-MWRA has determined that CSOs tributary to Stony Brook activated 32 times during calendar year 2000 and that about 15 Mft3 CSO was discharged; MWRA has estimated that, after its sewer separation project is complete, there would be no activations during the 3 month design storm and only a small volume (4,000)ft3 discharged during the one year design storm.

-The loading estimates would appear to indicate that Stony Brook and Muddy River are most responsible for the numerous exceedences of the fecal coliform standard in the Lower Charles during storms. However, both the Stony and Muddy discharge downstream of the BU Bridge, where 99 percent of the volume of the water of the Lower Charles is found. Dilution of stormwater by cleaner water in the lower reaches of the Charles may explain why fecal coliform concentrations are often lower downstream than upstream, even though most of the bacteria enter the Lower Charles here during storms. In contrast, upstream reaches of the Lower Charles are much smaller in volume and, therefore, more affected by stormwater loading.

9. Science Program for 2003

During the 2003 calendar year, EPA intends to undertake several science efforts related to the Charles: continued identification of illicit connections and other hot spots in the river through municipal sampling, OEME sampling, and sampling conducted by citizen volunteer Roger Frymire. In addition, EPA will undertake major efforts to develop Total Maximum Daily Loads for bacteria and eutrophication in the lower Charles. Finally, the DNA work conducted in 2002 will be evaluated and, if funding allows, employed in other sub-basins.

Bacteria TMDL

The Lower Charles TMDL will integrate much of the data and analyses of recent years and, through use of a receiving water model, simulate the effects of the various dynamics of bacteria in the Lower Charles. This effort will integrate: information from the USGS sediment study which maps the lower Charles bathymetry; USGS monitoring of the various sub-basins in its Loads study; stormwater bacteria loads and stormwater hydrology from the USGS watershed model; and CSO loads and hydraulics from the MWRA model. All of these various data will be input into the MIKE 21 watershed model which will predict both spatially and temporally, the fate and transport of bacteria in the lower Charles. This information is valuable for a number of reasons.

First, it will assist the analysis necessary for the MWRA variance of the relative impacts of CSO and non-CSO loads on the river. During initial development of the MWRA facilities plan, it was argued by MWRA that any further CSO reductions beyond those contained in the plan would not be effective in reducing water quality impairments due to the perceived overwhelming influence of bacterial loads in stormwater. The receiving water model should be able to show the relative benefits of various additional CSO and non CSO controls to water quality for two scenarios: the 3 month storm and the one year storm. This should answer the question with respect to what additional CSO controls, beyond the existing facilities plan, are warranted.

With respect to non-CSO controls, once we understand what additional reduction of bacterial inputs are necessary to achieve water quality goals, we will estimate the amount of reductions that can be achieved through additional stormwater management such as streetsweeping or highly rigorous illicit connection detection and removal. This effort will be guided in part by an ongoing study being conducted by USGS with EPA ORD funds that assesses the effectiveness of the latest generation of street sweepers; and by the ongoing DNA bacteria source tracking study in Laundry Brook sub-basin that will tell us what the various sources of bacteria are. Based on all of this information, and an assessment of what is economically feasible, some reduction in stormwater bacterial loads will be identified as part of the TMDL. These reductions will then become enforceable through the various municipal stormwater management plans that exist.

With both CSO bacteria load reductions and stormwater CSO load reductions identified through this variance and TMDL process, a clear blueprint for the remaining bacterial cleanup efforts in the Lower Charles will exist as we approach 2005.

Eutrophication TMDL

As with the Bacteria TMDL, the eutrophication TMDL draws upon much of the scientific work that has been done in the lower Charles over the last several years. Data from the annual OEME lower Charles Baseline studies, supplemented by 2002 chlorophyll a data collection; the USGS Loads study and watershed model, the USGS sediment study, the MWRA regular monitoring data and CRWA nutrient data, are all being integrated through a receiving water model developed for EPA by TetraTech and Numeric to represent the physical and chemical dynamics of algal growth in the Lower Charles. A water quality goal can then be established, based most probably on a chlorophyll a concentration that satisfies the narrative eutrophication Massachusetts water quality standards.

Using the model, various reductions in the elements that cause or contribute to eutrophication–nutrients from upstream POTWs, nutrients in stormwater, and heat from power plants–can be simulated to determine how pollutant reductions should be allocated among these sources to achieve water quality goals. As with the bacteria TMDL, any later issued permits would need to comply with the eutrophication TMDL.

<u>IV. Miscellaneous</u>

A. Flagging Project

During the 2002 boating season, CRWA continued its sampling and flagging project at five basin boathouses, raising red warning flags where coliform levels exceed the safe boating standard. These activities will continue in FY 02 with additional funding from multiple sources. As discussed above, this effort was aided by the predictive model developed under the EMPACT grant.

B. Muddy River

1. In 1998, the Corps of Engineers conducted a study that looked at habitat restoration in the Muddy and that recommended constructing a recirculation/oxygenation project for low flow periods during the summer. We commented on this proposal, saying that it was a good idea but did not go far enough in restoring the river. This project probably will not be implemented until the much more significant dredging project (see c, below) is implemented.

2. The larger of the Muddy River efforts is the Emerald Necklace Environmental Improvements Master Plan, a major flood control/park restoration project that has been under development for several years. The flood control aspects of this project, which involves flow improvement in the lower Muddy near where it enters the Charles was commenced during 2002.

C. State SRF Funding

The MA DEP State Revolving Loan Fund (SRF), a successor to the construction grants program, is a mix of state and federal money that provides low/zero-interest loans on a competitive need basis to fund water pollution control projects. A summary of recent sewer and stormwater pollution abatement projects located in the Charles Basin are summarized below. (It should be noted that other municipalities have undertaken projects without SRF assistance).

Charles SRF Projects

Community	Project	Total Cost	SRF funding to date**	Benefit
Boston	Gardner St. Landfill Closure	$16,882,700	$13,401,790	Cap landfill
Cambridge	Common Manhole Rehab and Illicit Connection Removal	$14,050,864	$11,727,293	Eliminate sanitary sewer discharges to Charles River
Cambridge	Floatables and BMP Control Plan	$13,831,919	$3,562,000	control floatables and solids in CSO and separate stormwater discharges
Cambridge	Phase VI, Contract 3 Sewer Separation	$60,576,579	$22,490,000	separate combined sewer system eliminate CSO discharges to Charles River
Dedham	Stormwater Management Plan	$800,000	$800,000	Develop/Implement plan to minimize pollution from stormwater/NPS discharges
Dedham	Stormwater Study River St. area	$50,000	$50,000	
Dedham	Drainage Capacity Assessment	$30,000	$30,000	
Dedham	SSO Evaluation	$300,000	$300,000	
Needham	NPS Pollution Study	$628,000	$500,000	Develop/Implement plan to minimize pollution from stormwater/NPS discharges
Newton	Laundry Brook subarea illicit connection identification/removal	$117,000	$117,000	Eliminate sanitary sewer discharges to Charles River
Newton	Laundry Brook/Cheesecake Brook Underdrain Separation	$13,776,449	$14,638,000	Eliminate sewage pollution in drain system

Newton	Albermarle St./Concord St. I/I removal	$385,000	$385,000	Study to identify improvements eliminate overflows to Lyons field
Newton	Complete Laundry Brook Invest.	$126,000	$126,000	
	Total Charles CWSRF projects:	<u>$121,554,511</u>	<u>$68,127,083</u>	
	Total Stormwater Pollution Abatement Projects:	<u>$43,410,232</u>	<u>$30,688,742</u>	

* Boston Water & Sewer, Waltham, and Watertown were also eligible for SRF assistance but elected to proceed with local funding.

** Allotments through calendar year 2001 Intended Use Plan.