Stormwater Assessment and Assisted Remediation Program Guidebook

Produced by Charles River Watershed Association,
in collaboration with Mystic River Watershed Association
with funding from Massachusetts Environmental Trust

Forward

The Stormwater Assessment and Assisted Remediation Program (SAARP) Guidebook is an effort to impart institutional knowledge gained through a three year stormwater assessment and remediation project conducted by the Charles River Watershed Association (CRWA) and the Mystic River Watershed Association (MyRWA). Special thanks for all those who made this guidebook a reality, including CRWA staff members and volunteers Kate Bowditch, Anna Eleria, Dave Kaplan, Talia Chalew, Rebecca Scibek Wickham, Jackie O'Mara, Polly Dyer, and Anna Kissell; MyRWA staff and volunteers including Mary Beth Dechant and Stephen Murphy; and all our dedicated shoreline survey volunteers. Special thanks also to the Massachusetts Environmental Trust, who funded this Guidebook and the project on which it is based. CRWA and MyRWA hope this Guidebook finds a receptive audience with environmental and community organizations around the country. We are also interested in hearing your feedback and comments on this guidebook and how you are using it. Please contact me with any feedback or questions. Best of luck in your efforts to address stormwater pollution to your local waterways!

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Executive Summary

The Stormwater Assessment and Assisted Remediation Program (SAARP) Guidebook is intended to help environmental organizations and citizen groups address non-point source pollution to their local waterways. Non-point sources are the major cause of water quality impairment to most waterways throughout the country. From 2006 to 2008 the Charles River Watershed Association (CRWA) and the Mystic River Watershed Association (MyRWA) undertook a comprehensive effort to find sources of non-point source pollution in their respective watersheds and to work with municipal officials and the public to remediate these issues. Based on our experience in this multi-faceted project, CRWA and MyRWA developed a general methodology for others to implement such a program in their own watershed or area of concern. CRWA developed the term Stormwater Assessment and Assisted Remediation Program (SAARP) to refer to this program.

The SAARP has four major components: 1) visual shoreline surveys; 2) water quality monitoring; 3) working with municipal, state and federal officials; and 4) public education and outreach. This program is designed to be easily scaled up or down according to your organization's size, project budget, and geographical area.

Stormwater Assessment through Visual Monitoring

Walking or canoeing along the banks of a waterbody can offer many clues about the non-point source pollution problems of concern and this is a relatively easy place to begin. Visual shoreline surveys involve staff or volunteers observing and recording river conditions and common sources or effects of non-point source pollution. Shoreline surveys are useful in providing a summary of some of the most common problems observed in an area, as well as identifying the individual areas which are most severely impacted. Chapter 3 provides detailed instructions on conducting visual shoreline surveys.

Stormwater Assessment through Water Quality Monitoring

Measuring water parameters *in situ* or through collection and laboratory analysis of samples can greatly increase your understanding of the problems in your watershed and the severity of impairment. Water quality monitoring during various weather conditions can be particularly useful to assess the impacts of stormwater pollution. Chapter 4 offers instruction on designing water quality monitoring plans to assess the impact of stormwater runoff.

Assisted Remediation through Municipal Partnerships and Public Education

Data collection is useful but true success will be measured by how you parlay the results of your assessment into improvements in your watershed. Addressing non-point source pollution concerns will require the cooperation of government officials and watershed residents. Chapters 5 and 6 offer suggestions for working with local, state and federal officials as well as members of the public to remediate the problems you have worked to identify. Partnering with municipal officials and engaging the public in your efforts will provide you with further-reaching capabilities than would be possible on your own.

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Introduction

This guidebook is intended to help environmental organizations and citizen groups implement a Stormwater Assessment and Assisted Remediation Program (SAARP). Stormwater runoff has been identified as the primary source of pollution to Massachusetts waters. Reducing stormwater pollution is a high priority and will help protect drinking water supplies, recreational opportunities and ecosystem health. A SAARP is intended to identify and reduce stormwater pollution to surface water bodies primarily through visual shoreline survey monitoring, water quality sampling and partnerships with public and private organizations. Methods presented in this guidebook are based on a three-year stormwater mitigation program conducted by Charles River Watershed Association (CRWA) and Mystic River Watershed Association (MyRWA).

Who are CRWA and MyRWA?

The Charles River Watershed Association (CRWA) is a non-profit organization dedicated to protecting, preserving and enhancing the health, beauty and enjoyment of the Charles River and its watershed through the use of science, advocacy and law. CRWA was one of the nation's first watershed organizations and has been continually operating since 1965. The Charles River watershed, located in eastern Massachusetts, is 308 square miles, comprised of 35 cities and towns and home to nearly 1 million residents, or approximately 20% of the state's population.

The Mystic River Watershed Association (MyRWA) is a non-profit organization committed to protecting the water and related natural resources of the Mystic River watershed, through advocacy, outreach and water quality monitoring. The Mystic River watershed, located northeast of Boston, is approximately 76 square miles and encompasses portions of 21 cities and towns. It is home to over half a million people, or about 8% of the state's population.

With a combined 78 years of environmental science and advocacy experience, CRWA and MyRWA have well-established relationships with state and local government agencies. Additionally, both organizations have conducted extensive monitoring and research in their respective watersheds. Continuous efforts by both organizations and their volunteers to regularly monitor these rivers have led to the development of long-term water quality data sets, which have been integral to understanding and tracking the health of these rivers.

What is stormwater pollution?

Stormwater pollution is generated by rainwater washing over the land and picking up pollutants from roads, parking lots, rooftops, lawns, etc. Although rainwater is generally clean when it falls from the sky, as it flows over land it collects oil, grease, metals and tire wear from cars; fertilizers from lawns; salt and sand from road de-icing efforts; bacteria from pet and livestock waste; and numerous other pollutants. All of this pollution is washed into our waterways every time it rains. Stormwater pollution is considered non-point source pollution, unlike pollution from a factory or sewage treatement plant which is considered point source pollution. Stormwater pollution is in effect the most difficult type of pollution to mitigate because of its sources: it comes from everywhere!

Is stormwater pollution a significant problem in the Charles and Mystic Rivers?

Yes! In 1995, U.S. Environmental Protection Agency (EPA) Region 1 launched an ambitious effort based largely on CRWA's data collection and analyses, to restore the Charles River to fishable and swimmable conditions by 2005. EPA's work as well as that of many watershed

cities and towns, led to the elimination of many point source discharges into the river and a reduction in combined sewer overflows (CSOs) to the river (See: CSOs). These accomplishments led to drastic improvements in the river's water quality. Despite these efforts, however, water quality improvements have plateaued. Long-term monitoring conducted by CRWA shows that water quality in the river continues to suffer from pollutant-laden runoff that causes widespread violations of the Massachusetts Surface Water Quality Standards for Class B waterways (Figure 1).

The Mystic, like the Charles, is a highly urbanized watershed that is significantly impacted by stormwater runoff. Through a combination of government enforcement and the advocacy work of MyRWA and other citizen groups, many of the point sources of pollution to the Mystic, such as CSOs, have already been addressed. Nevertheless, much of the Mystic and its tributaries are plagued with problems from pollutants such as nutrients, metals, oil and grease, and pathogens. A walk along the Mystic River shoreline following a rainstorm will uncover many places where oil is washing into the river from nearby parking lots and roads.

Combined Sewer Overflows (CSOs)

Combined sewer systems are sewer systems in which wastewater and stormwater are both drained by a common system of pipes. Therefore, water flowing down the street and water flowing down your shower drain will be carried by the same pipe to a wastewater treatment facility to be treated and released into the environment. These outdated systems are equipped with overflow mechanisms. During periods of heavy rain, when the combined flow exceeds the capacity of the wastewater treatment system, these mechanisms overflow, dumping untreated sewage, industrial waste, toxic substances, stormwater and floating trash into nearby waterways. Overflow is necessary to prevent flooding in streets and sewage backups in homes, but has a detrimental effect on local water quality. Combined Sewer Overflows (CSOs) can be a significant source of pollution to a body of water.

Combined sewer systems were commonly constructed in the late 19th century, and Boston is one of over 700 cities in the U.S. that has a combined sewer system. Today, many cities have separate drainage systems for carrying sanitary (household) wastewater and stormwater. Sanitary waste is carried to a wastewater treatment plant, treated and then released into the environment, while stormwater is typically carried to the nearest surface water body.

EPA New England has worked to reduce the impact of CSO wastewater. In 2006, EPA and the US Justice Department reached an agreement with the Massachusetts Water Resources Authority (MWRA) to bring total annual CSO discharges to the Charles River down to 8 million gallons by 2013 from 1.7 billion gallons in 1988. This decrease has already begun to improve the water quality of the river environment and help to protect the health of the public living around the Charles.

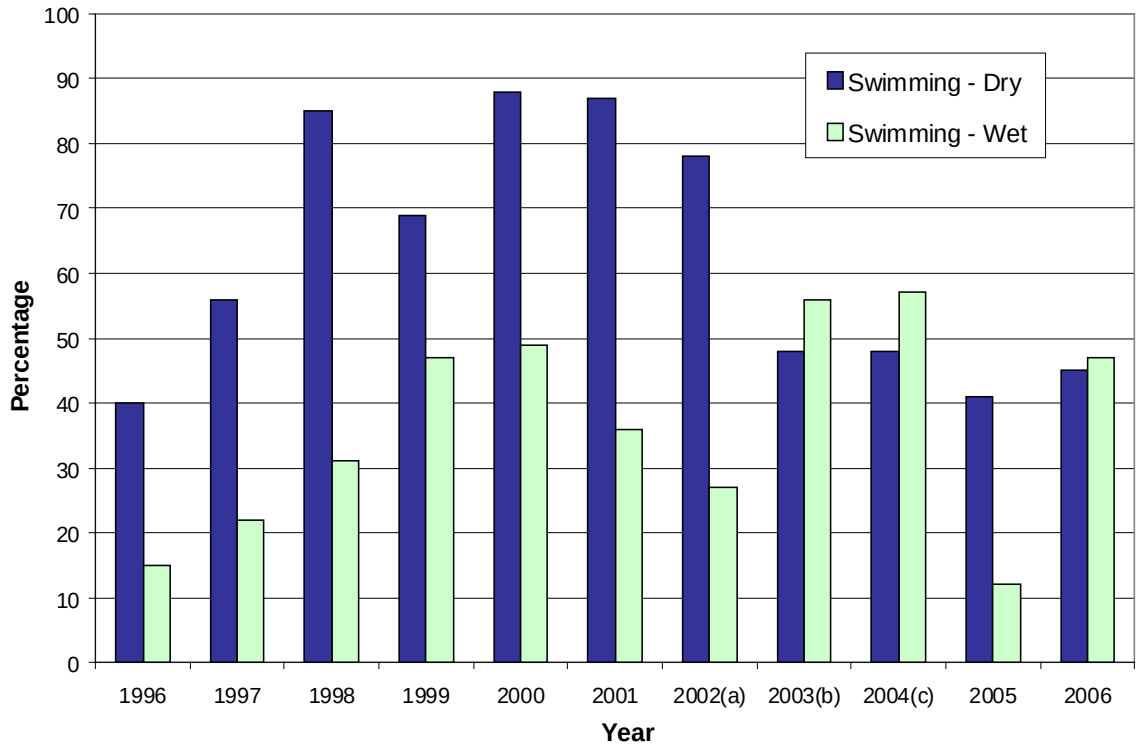
What are the stormwater pollutants of concern in the Charles and Mystic Rivers?

The pollutants of concern in the Charles and Mystic River watersheds are nutrients (primarily phosphorus), total suspended solids, bacterial and viral pathogens, sodium, chloride, metals, and petroleum hydrocarbons. In the Charles River, bacteria and nutrients impair the health of nearly the entire length of the 80-mile river and many of its tributaries. Nutrients and pathogens, as well as metals and oil and grease are particularly problematic in the Mystic River.

What are the sources of these pollutants?

Many activities add nutrients to the environment. Phosphorus is found in fertilizers, car exhaust, industrial and household cleaning products, and animal and human waste. Therefore, many common activities, such as driving, applying fertilizer to a lawn and not picking up after pets release nutrients into the environment that are washed into our waterways during rain events. New England's native soils are rich in phosphorus, so soil erosion can be another significant source of phosphorus. Phosphorus is ubiquitous in the environment therefore the

Figure 1: Percentage of Time the Charles River is Safe for Swimming in Wet and Dry Weather



(a)Only one dry weather event (rainfall of less than 0.1 inches in previous 72 hours) occurred in 2002. Rainfall data collected at Logan Airport in Boston. This may have skewed the percentages of the time the river met the modified swimming and boating standard as individual results were compared to geometric mean standards.
(b)In 2003, monthly water quality monitoring was conducted seven out of twelve months; of which only two occurred during wet weather. This may have skewed the percentages of the time the river met the modified swimming and boating standard as individual results were compared to geometric mean standards.
(c)Statistics from 1995 to 2003 are based on CRWA monthly fecal coliform testing in the Charles River Basin. In 2004, samples were analyzed for E. coli bacteria instead of fecal coliform bacteria and these results were compared to current MA surface water quality standards (126 cfu/100mL for swimming). For analysis and comparison purposes CRWA uses the geometric mean criteria established by the Massachusetts Department of Environmental Protection instead of the single sample criteria to be conservative and protective of the public's health.

Wet vs. Dry: The Effects of Stormwater Runoff on Bacterial Levels in the Charles River

The state of Massachusetts has designated the Charles River as a Class B waterway; therefore, its designated uses include swimming and boating. While the river is used extensively for boating, there are currently no official bathing beaches along the 80-mile river. Although in recent years the river has been safe for swimming nearly 90% of the time in dry weather, following rain events (and the occasional overflow of Boston's combined sewer system) stormwater runoff causes dangerously high bacteria levels in the river, making it unsafe for swimming (See Figure 1).

larger the volume of stormwater runoff entering the river, the larger the load of phosphorus it will carry.

Sources of bacterial contamination include pet, livestock and waterfowl waste, combined sewer overflows, sanitary sewer overflows, recreational boat sewage discharge, leaking sanitary sewer pipes, and illicit connections of sanitary sewer lines to stormwater drainage systems. Excessive amounts of sediment can come from poorly managed construction sites, road salt and sand used for snow and ice removal, and eroding river banks. Oil and grease can enter the environment through industrial or commercial activities and spills; however, leaking car and truck engines are also a major source of these pollutants.

Often, land use can be used to determine the likely types and sources of non-point source pollution in an area. The Charles and Mystic Rivers both flow through primarily suburban and urban areas. Land use in these watersheds is predominantly residential, with the upper parts of the watershed containing more low- and medium-density residential areas and the lower areas comprised of highly-urbanized, densely-populated cities (See Figure 2). Large areas of impervious surfaces in these regions mean a great deal of stormwater runoff, which is carried to the rivers through stormwater drainage systems.

Based on current literature, EPA was able to utilize land use to characterize the relative phosphorus load to the Charles River between 1998-2002 from a variety of land uses, CSOs and wastewater treatment facilities (WWTFs) (See Figure 3). These percentage estimates for contribution of the phosphorus load to the river are specific to the Charles River watershed; watersheds with larger areas of agricultural or industrial land use may find that those land uses are a more significant problem. Interestingly, the quantity of phosphorus coming from land uses with high percentages of impervious cover (commercial, industrial, institutional) actually contribute the largest amount of phosphorus to the Charles on a per acre basis.

How is stormwater regulated?

In 1987, the Clean Water Act was amended to include controls for reducing the impact of stormwater. US EPA promulgated Phase I and Phase II Stormwater Regulations in 1990 and 2003, respectively, under the National Pollutant Discharge Elimination System (NPDES) Program to control stormwater at the local level in urban areas and from certain industrial activities and construction sites. Phase I Stormwater Regulations control medium to large municipal separate storm sewer systems (MS4s) generally serving populations of 100,000 or greater, construction activities disturbing five or more acres of land, and ten categories of industrial activities. Phase II expanded

Figure 2: Land Use by Percentage
Source: EPA and MassDEP, Lower Charles River Nutrient TMDL

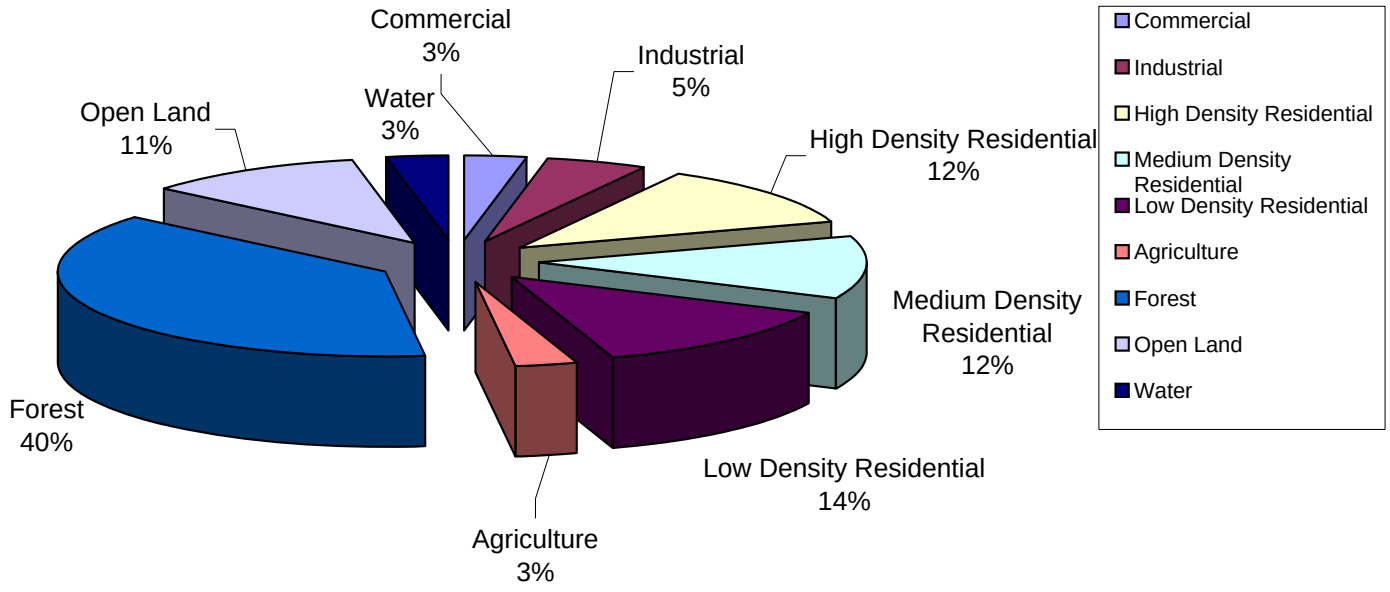
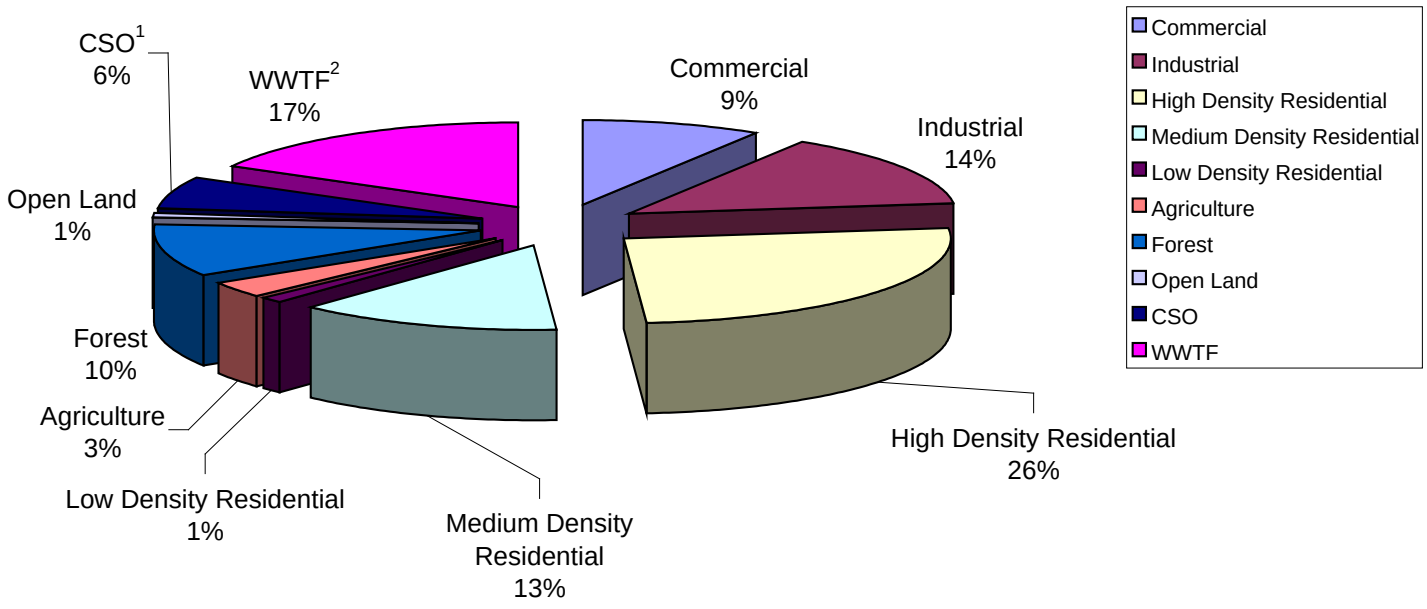


Figure 3: Distribution of Annual Phosphorus Load to the Charles River by Source Category (1998 – 2002) *Source: EPA and MassDEP, Lower Charles River Nutrient TMDL*



[1]Combined Sewer Overflow (CSO) is not a land use.
[2] Wastewater Treatment Facilities (WWTF) are not a land use.

the Phase I program to require operators of MS4s in urbanized areas with populations of less than 100,000, and construction activities disturbing between one and five acres of land to obtain a general NPDES permit for stormwater discharge into surface waterbodies. Municipalities and developments requiring a NPDES permit must develop, implement and enforce stormwater management programs that reduce the discharge of stormwater pollutants to the "maximum extent practicable" (US EPA, 2000).

How was the Stormwater Assessment and Assisted Remediation (SAARP) Program developed?

In order to identify potential non-point source pollution problems and to help remediate these problems, CRWA and MyRWA developed a joint project called Find It and Fix It (FIFI). FIFI was a comprehensive three-year project developed to help municipalities and land owners address non-point source pollution. The program had six major goals:

- Identify potential sources of non-point source pollution
- Track and monitor reported or suspected non-point source pollution "hot spots"
- Guide the remediation of non-point source pollution problems
- Guide enforcement of water quality standards (as needed)
- Engage and educate the public on non-point source pollution issues
- Transfer project knowledge to others

CRWA and MyRWA accomplished these goals through five key program elements:

- Visual Monitoring
- Water Quality Monitoring
- Promotion of Best Management Practices (BMPs) and Remediation Work
- Public Education and Outreach
- Writing and Publishing the SAARP Guidebook

Stormwater Assessment and Assisted Remediation Program (SAARP) methodology is based on the joint CRWA and MyRWA Find It and Fix It Project. This project was funded by the Massachusetts Environmental Trust (MET), a state environmental philanthropic organization, which provides grants to programs that protect and preserve Massachusetts' ecosystems and water resources. MET receives funds from the sale of special environmental license plates and environmental litigation settlements (MA EOEEA, 2008).

Chapter 1:
The Basics of the Stormwater Assessment and Assisted Remediation Program

The Stormwater Assessment and Assisted Remediation Program (SAARP) is designed to identify problems in surface waterways caused by non-point source pollution or stormwater runoff, guide the remediation of problems caused by stormwater runoff, and mitigate future effects of stormwater runoff. This program has four main components:

- Visual Shoreline Survey
- Water Quality Monitoring
- Working with Municipal Officials
- Public Education and Outreach

Table 1 explains how each component of the SAARP helps to address stormwater issues.

1.1 Visual Shoreline Survey

A visual shoreline survey involves staff or volunteers walking or canoeing along the river to look for signs of non-point source pollution or obvious problems resulting from non-point source pollution. Staff and volunteers, even those with little or no previous experience in river and riparian issues, can collect a wealth of valuable information just by walking or boating along the shore and recording their observations. Chapter 3 gives detailed instructions on organizing and conducting a visual shoreline survey.

1.2 Water Quality Monitoring

While the visual shoreline survey will identify many areas that may be impaired as well as areas that are likely sources of non-point source pollution, water quality monitoring is necessary to identify polluted areas and to begin tracking

Table 1: How the SAARP Helps in Addressing Stormwater Issues

Visual Shoreline Survey

- Identify most common problems occurring in the river and along its banks which are indicative of non-point source pollution
- Identify unusual conditions along the river bank
- Document pipes and outfalls carrying water to the river and its tributaries
- Assess the land uses directly abutting the river
- Identify locations for targeting remediation projects

Water Quality Monitoring

- Document the effects of non-point source pollution to a river or stream
- Document water quality violations in wet weather
- Discover previously unknown water quality problems in your watershed area

Working with Municipal Officials

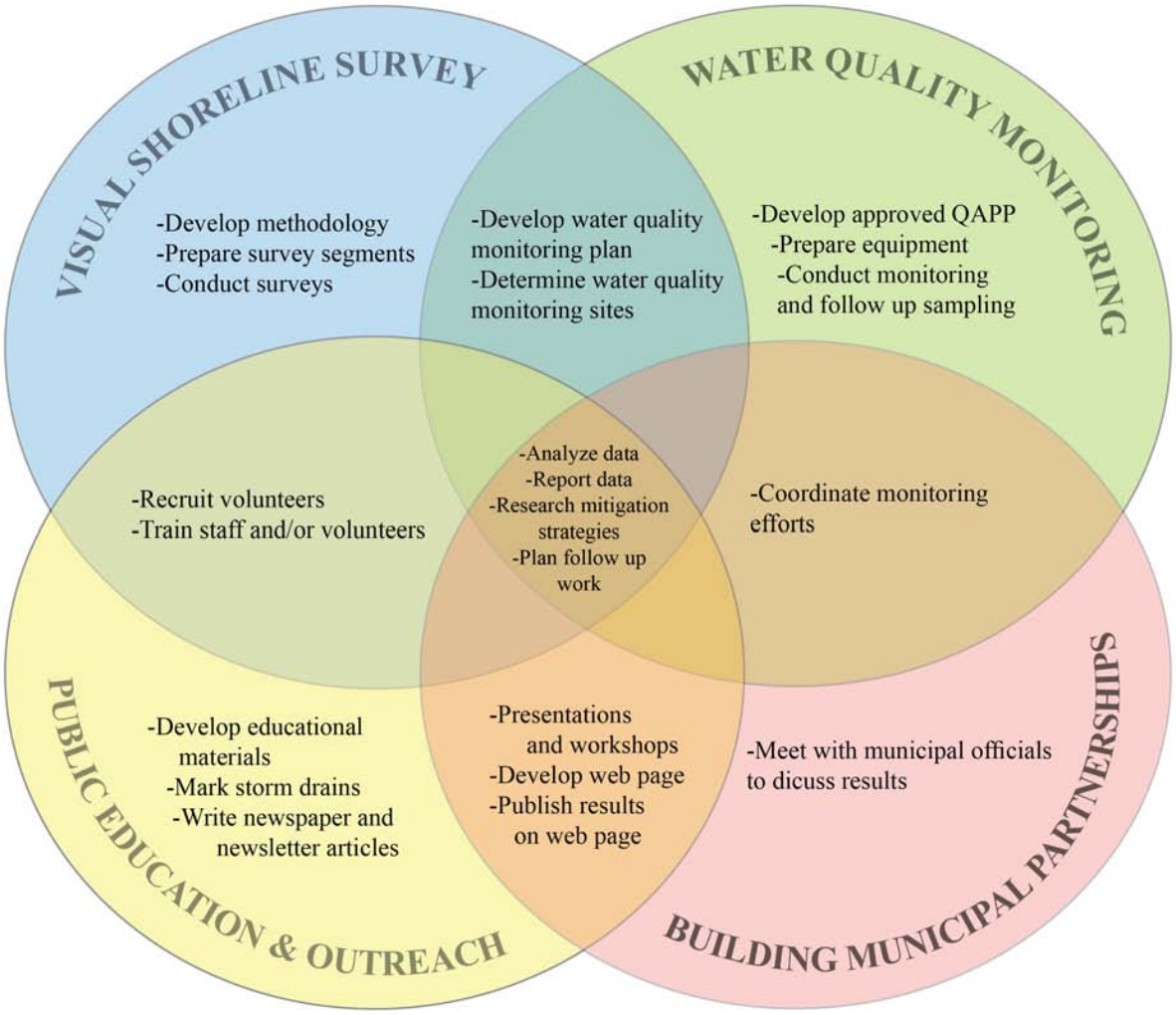
- Raise awareness of the issues in your watershed with those who have the ability to effect change
- Guide the remediation of stormwater problems using intelligent, long-term solutions
- Promote stormwater-friendly development and redevelopment in your area

Public Education and Outreach

- Raise awareness of the problems, their causes and effects, facing local waterways
- Promote awareness of daily activities that impact the river both positively and negatively to effect lifestyle changes in your watershed residents
- Train watershed stewards

pollution sources. Chapter 4 will discuss writing a water quality monitoring plan, including developing a QAPP and selecting water quality monitoring sites and parameters. To truly capture the effects of stormwater runoff, water quality monitoring should be done during both dry and wet weather; this is also discussed in Chapter 4. Please note that this section is not intended to guide organizations looking to develop a water quality monitoring program for the first time. Instead this section deals with issues specific to water quality monitoring conducted under a SAARP. If the SAARP will be your organization's first experience with water quality sampling, it is recommended you consult other sources.

Figure 4: Venn Diagram of Overlap Between Tasks



1.3 Working with Municipal Officials

The EPA's National Pollution Discharge Elimination System (NPDES) requires municipal officials to take some responsibility for reducing stormwater pollution to surface waterways. An essential aspect of the SAARP involves sharing data with municipal officials. Information collected and research conducted as part of a SAARP should be designed to be helpful for municipalities in their efforts to reduce stormwater pollution. Additionally, as part of a SAARP your organization should research and share information on stormwater best management practices (BMPs) that address the most prominent non-point source pollution issues in your locality and partner with municipalities to implement remediation projects. This task is discussed in Chapter 5.

1.4 Public Education and Outreach

Non-point source pollution comes from a variety of sources, many of them daily activities of your watershed residents. Reducing inputs of certain pollutants to the environment will require watershed-wide education campaigns. Chapter 5 discusses the many ways of reaching out to the public.

Chapter 2:
Getting Started: Steps to Starting a Stormwater Assessment and Assisted Remediation Program

To plan a successful SAARP, it is important to take certain steps to assess the capacity of your organization to accurately gauge the depth and breadth of the program you can undertake. Take the following steps to evaluate your capacity to successfully develop and plan the most effective stormwater assessment and assisted remediation program.

2.1 Identify Staff

Every organization has personnel with unique skills, proficiencies and expertise. It is important to ensure that your organization matches the components of your stormwater program with the abilities of your staff or volunteers. Secondly, it is important to assess the time staff and volunteers have to dedicate to the project, and not undertake more than you can legitimately accomplish. When seeking external funding sources it is essential to lay out a proposal that your organization can accomplish with the proposed time and money. Falling short of your projected deliverables and achievements can jeopardize future funding opportunities.

Lesson Learned

Many activities in the FIFI project proved to be far more time consuming than CRWA and MyRWA originally anticipated, and while we did not need to ask for more money, we did need to reallocate money between tasks. Where the information is available, we will report the amount of time spent on a project to help guide your planning timeline and staff time allocations.

2.2 Obtain Funding

The development of a SAARP requires resources in broad categories: staffing (including volunteer management); laboratory fees for water quality monitoring; printing expenses; and equipment. The effort can be undertaken as a discrete project, scaled appropriately to the capacity of your organization and the size of your volunteer force. Proposals for grant funds can be developed to support the entire project, one or a few component(s) of the project, one or a few category(ies) of expenses, or one or a few year(s) of a project. It may be possible to obtain in-kind support for laboratory expenses and donations or loans of equipment and supplies. If you plan on using volunteers, it is important to include funds or seek donations to support volunteers, to purchase items such as refreshments at training sessions or T-shirts. If you only obtain partial funding, be sure to re-scope the project in order to accomplish your goals. It may strengthen your project and thus your grant proposal, if you can demonstrate that your SAARP is building off of or expanding upon other projects within your organization, or is a component of a larger regional effort such as a watershed plan.

2.3 Gauge Volunteer Force

If you plan on relying heavily on volunteers for any of your project tasks, make sure you do not overestimate your potential volunteer work force. If your organization has previously relied upon volunteers to participate in projects, you will likely have a good idea of the number of individuals in your area willing to get involved. If your organization has never recruited volunteers for a task of this type, it is probably best to plan for a modest number of volunteers and be prepared to expand your project based on a positive response from your community. In an attempt to gauge your potential volunteer force, contact local volunteer clearing houses or local schools and universities to assess possible interest and availability.

Tip: Volunteers!

CRWA and MyRWA relied almost solely on volunteers to conduct our visual shoreline surveys. In our densely populated areas it was not difficult to recruit enough volunteers to survey our entire study areas. In fact, we were fortunate enough to have more interest than anticipated and ended up expanding our study area to include select tributaries. Finally, if this had not been the case, and volunteer response had been slim, CRWA planned to recruit summer college interns to complete portions of the visual shoreline survey.

2.4 Consider Field Equipment Needs

Visual field surveys and water quality monitoring require equipment (See Tables 5 and 13 in Chapter 3). Consider the following:

- Will you be able to accomplish your program goals using the equipment your organization currently has?
- What types of field equipment would you need to purchase to accomplish your goals?
- How much money will you need for field equipment?
- Will new equipment require staff training? Will it require a new or updated QAPP? If so, what are the associated costs?

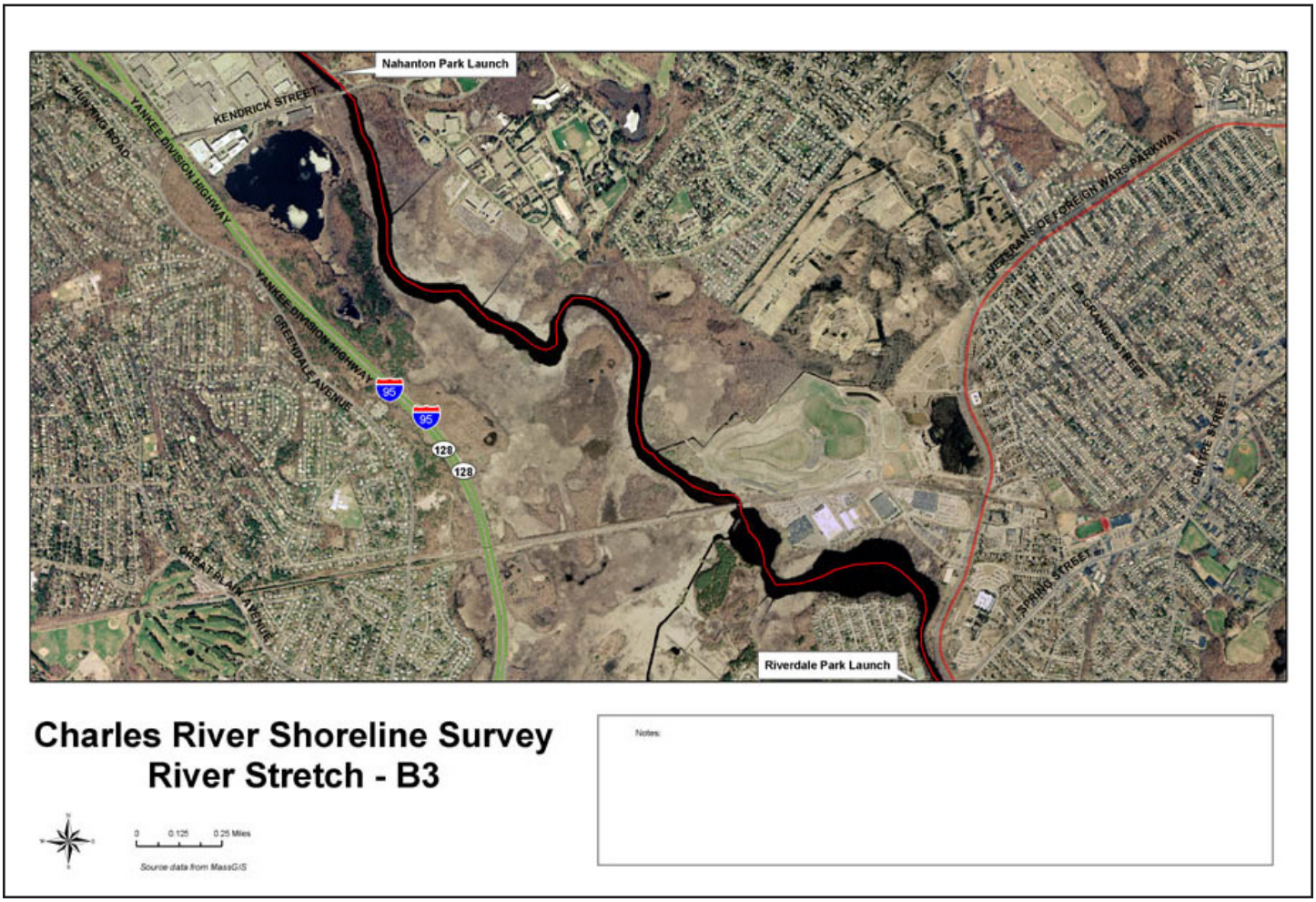
2.5 Assess Mapping Capabilities

Access to mapping software is a tremendous asset in most environmental studies. ESRI ArcGIS ® geographic informations systems (GIS) software is an invaluable tool when it comes to watershed delineation and visual display of geographical data. ArcGIS is useful in creating maps of visual stream survey segments for use by visual stream surveyors, creating maps of the issues stream surveyors identify, and creating maps of water quality monitoring sites (See Figure 5). ArcGIS ® software is particularly useful because of its widespread use. Utilizing this software may allow you to augment maps with existing GIS data layers such as stormwater outfall locations, town

Tip: Managing Shoreline Survey Data with Mapping Software

MyRWA stored visual river survey results in multiple formats to be able to effectively distribute it to various audiences. For municipal officials we hired a GIS consultant to develop GIS data layers of pipes and other observations using ESRI software. For outreach purposes we used Google Earth™ to make interactive maps for display on our website.

Figure 5: Aerial Map as Provided to Stream Survey Teams



boundaries and aerial photos, and to readily share your data in a convenient format with municipalities and agencies that also employ this software.

ArcGIS ® is expensive and generally requires training to utilize. If your organization does not have access to this software, consider hiring a GIS consultant to perform the mapping requirements of your SAARP or look into alternative mapping software. As geographic information systems are becoming so widely utilized, many programs are becoming readily available. Google Earth™ mapping service is a free program that allows you to create maps and display data geographically. Google Earth Pro™, available for a fee, is a more advanced version of Google Earth™, which allows you to create more involved maps using multiple layers. If you plan to purchase mapping software or hire a GIS consultant, make sure to include these expenses in your budget.

2.6 Foster Partnerships

Partnerships with like-minded organizations can greatly increase the effectiveness of a SAARP. Look for watershed, community, environmental, and research organizations in your community to partner with to expand your impact. Partnerships allow you to reach more potential volunteers and access more equipment and expertise than may be possible on your own. It may be particularly useful to determine if any other organizations, including state and federal agencies as well as municipalities in your area, are planning visual shoreline surveys

or water quality sampling events. You may be able to coordinate trainings and sampling outings and share data. While partnerships are not necessary for the development of a SAARP, taking advantage of these opportunities to share resources may be very helpful.

Partnerships

CRWA and MyRWA benefited from our partnership with each other as well as outside partnerships. We relied heavily on the expertise of the Massachusetts Riverways Program (Mass Riverways), a state agency working to promote the restoration, protection and ecological integrity of the state's streams, for assistance with our shoreline survey. CRWA and MyRWA modeled our Shoreline Survey Data Sheet (See Appendix) very closely after the Mass Riverways Adopt-A-Stream Program shoreline survey data sheet. Additionally, Mass Riverways provided staff to train shoreline surveyors.

Chapter 3:
Stormwater Assessment through Visual Monitoring

The first major element of a SAARP is the visual shoreline survey. Planning and conducting a shoreline survey can be a time consuming task, even if the river segment being surveyed is short. This section provides information on how to plan and conduct a visual shoreline survey, manage, analyze and present data. This chapter also discusses some of the first steps to following up on your stream survey results. Table 2 provides an overview of the shoreline survey task.

CRWA and MyRWA Shoreline Survey Methodology

The shoreline survey methodology presented here was developed by CRWA and MyRWA in cooperation with Mass Riverways. We were fortunate to be able to draw on the expertise of Mass Riverways in planning our shoreline survey as they have considerable experience in conducting shoreline surveys. Mass Riverways has continually managed a statewide "Adopt-A-Stream Program" since 1987. The Adopt-A-Stream program helps citizens form "Stream Teams" in their local communities to assess and protect local stream and river stretches. Through this program Mass Riverways has facilitated volunteer stream surveys of twenty-six rivers all across the state (MA DFG, 2008).

3.1 Shoreline Survey Methodology

The SAARP shoreline survey methodology requires the collection of data in multiple formats. As will be discussed below, surveyors will answer question about their shoreline section, take photographs of their observations, mark the location of photographs and other observations on a map, and write a narrative about their section. Each of these tasks helps to present a complete picture of each river segment. Additionally, prior to commencing surveys, your organization will have to make some overall decisions about how and when to conduct surveys. See Table 3 for an overview of the shoreline survey methodology.

3.1.1 Data Collection

Visual shoreline surveys are conducted for a variety of reasons. In a stormwater remediation program, surveyors will be looking for signs of non-point source pollution. Surveyors will observe every outfall pipe flowing into the river, riparian (area surrounding the river) land use, and any unusual river conditions. See Figure 6 for example observations. To capture all these aspects of the river segment, surveyors will need to:

- Complete a shoreline survey data sheet
- Take photographs of observations
- Mark the location of pipes and unusual circumstances on a map and/or record the geographic coordinates of each pipe and unusual situation using a handheld GPS units

Table 2: Shoreline Survey Tasks

When	Step	What
Pre-Survey	Develop Stream Survey Methodology	· Develop or adapt shoreline survey data sheet
		· Conduct field test of shoreline survey data sheet and adapt as needed
		· Plan survey dates and/or time frame
	Recruit Stream Survey Volunteers	· Contact current volunteers about survey opportunity
		· Contact other organizations and volunteer clearinghouses to recruit volunteers
		· Build database of potential volunteers
	Prepare Stream Survey Segments	· Divide the river into survey segments
		· Determine if each segment will be surveyed by foot, boat, or both
		· Conduct pre-survey site visits to check accessibility and distance of segments, revise as needed
		· Create aerial and USGS maps of each segment
	Train Staff or Volunteers	· Schedule adequate training sessions
		· Assign staff or volunteers to each stream survey segment
Survey	Conduct Visual Stream Surveys or Oversee Volunteers Conducting Stream Surveys	· Walk or canoe along river segments collecting data
		· Meet up with volunteers in the field to distribute and collect equipment
		· Follow up with volunteers to make sure surveys are being conducted in a timely manner
Post-Survey	Manage Data	· Track all incoming data, organizing data by stream survey section
		· Follow up with staff or volunteers regarding outstanding data
	Analyze Data	· Compile results into a central database or spreadsheet
		· Review common problems and unusual conditions
		· Develop action steps required to address the pressing issues
	Plan Short-term Follow-Up Work	· Schedule Action Planning meetings
		· Plan follow-up surveys
	Report Results	· Send results to municipal officials and private land owners
		· Publish results for general public

SAARP Shoreline Survey Data Sheet

The SAARP shoreline survey data sheet has three main sections (See Table 4). The first section consists of questions dealing with instream and water body conditions, non-point source pollution sources, and river wildlife and habitat. Naturally the questions focused on non-point source pollution sources will be of primary interest for the SAARP; however, while surveyors are in the field, it is useful to also collect additional information that may be of use to other organizations, for other projects or for future projects. These questions are in a multiple choice and short answer formats. This section also contains a key, providing codes for various conditions surveyors are likely to observe, so they can be easily marked on the map. (See Figure 7). This section of the data sheet asks specific questions about field conditions, therefore, in order to obtain the most accurate responses, surveyors should be instructed to complete it in the field during their stream survey.

The second section of the SAARP shoreline survey data sheet is a matrix in which volunteers enter information about each pipe they observe during the shoreline survey section (See Figure 8). In urbanized areas pipes typically convey a large percentage of the stormwater runoff entering the river; therefore, it is important for surveyors to make a detailed observation of each pipe and any problems in the pipe's vicinity that stormwater runoff may be causing. Surveyors should number pipes chronologically as they are

Table 3: Shoreline Survey Field Data Collection Methodology

Task	Description	Who Completes?	When Completed?
Complete shoreline survey data sheet	Complete the objective response and pipe survey sections in the field and open-ended sections following the survey.	Shoreline survey team	In field and following survey
Mark locations of observations on maps	Mark the location of every pipe, problem, and photograph taken on a USGS map using the key found on Page 2 of the shoreline survey data sheet.	Shoreline survey team	In field
Take GPS coordinates of pipes, problems and other observations	Using hand held GPS units, record latitude and longitude coordinates of every observation.	Shoreline survey team (if volunteers, staff may need to be present to pass out and collect GPS units)	In field
Photograph pipes and other observations	Take photographs of every pipe, problematic land use, problem, or interesting observation made during the survey.	Shoreline survey team (if volunteers, staff may need to be present to pass out and collect digital cameras)	In field
Label photographs	Label photographs so they clearly correspond to a mark on the map identifying where they were taken.	Stream survey team	Following survey

Figure 6: Example Photos of Observations. Clockwise from top right: oil sheen on water, trash along bank, pipe flowing in dry weather, minimal riparian buffer, erosion, algae in pipe.

observed, marking the location of each pipe on a map. Surveyors should also note the level of flow, any unusual color or odor of flow, whether algae is visible below the pipe and if there is evidence of erosion or sedimentation caused by the pipe's flow. Surveyors should rate each pipe to indicate the severity of any problems observed. A simple 0-2 rating system is used to distinguish between pipes with no issues (0), moderate or possible issues (1) and severe issues (2). Surveyors should also photograph each pipe they observe.

Finally, surveyors are provided two open-ended sections. The first asks surveyors to describe what they observe in their own words. The second asks surveyors to judge the most severe problems, best assets and priorities for action along their assigned river segment. These sections are very useful in collecting information

Figure 7: Key for River and Land Use Issues

INSTRUCTIONS

Please take photos of outfall pipes, eroding banks, polluted areas, poor drainage and other areas you deem noteworthy. Note on the map where the photo was taken and describe the location on the back of the photo or within the file name of a digital shot. Don't forget to include the date. Be specific (reference nearby road or house), so that people can compare later photos. Attached to the survey are aerial and USGS topographical maps for your reference. Please locate the following on the attached map using the following key.

KEY

PHOTOS
P1, P2, P3, … = photo location and number in order of photographs

OUTFALLS
1, 2, number in order of observation

EROSION *trace or delineate extent if practicable. Map scale may be too small.
E_1 = Severe erosion
E_2 = Moderate erosion
E_3 = Mild erosion

GARBAGE (by type?) *trace extent if practicable
G_1 = Toxic (oil cans, paint, antifreeze containers, etc.)
G_2 = Paper/Styrofoam
G_3 = Metals
G_4 = Other

OIL *trace extent if practicable
O_1 = Oil sheen visible
O_2 = Oily smell

FISH KILL = FSK

SEWAGE / BACTERIA SOURCES
S_1 = Presence of toilet paper, objectionable floatables
S_2 = Sewage smell, no visual signs
S_3 = Bird/waterfowl waste
S_4 = Pet waste

FOAM
F_1 = White foam (perfumey smell)
F_2 = "Natural" colored foam (earthy, fishy aroma)

INVASIVE SPECIES (See attached information for plant identification)
I_p = Phragmites
I_{pl} = Purple loosestrife
I_m = Milfoil
I_f = Fanwort
I_w = Water chestnut
I_{ww} = Waterweed

ACCESS POINTS
D = Docks
B = Boat Launch

ALGAE
A_1 = Filamentous algae (mats) *trace extent if practicable
A_2 = Green-colored water column

LAWNS
L_1 = Green, lush
L_2 = Mottled, color change

CONSTRUCTION SITE
CS_1 = Exposed, disturbed soils
CS_2 = Negligible sediment introduction

Figure 8: Pipe Survey Matrix

"Find it and Fix it" Pipe Survey of _____ River/Brook

Segment #_____ Segment Begins: _____
Date: _____ Segment Ends: _____
Names of observers: _____
Weather today: _____
Weather over past 24-48 hours: _____

Rating System
0 = No observed impairment (No dry weather flow, no solids, floatables or debris, no erosion or sediment. Pipe in good repair
1 = Needs rechecking (Some dry weather flow, moderate scouring or sediment deposition, some floatables or debris, odor, algae. Pipe in moderate condition
2 = Impairment – Needs investigation (Malodorous flow, foam, solids, turbidity or oily sheen, considerable sediment deposition, algae or debris, pipe in poor repair, blocked catch basins or drain.

Pipe# & Location (in stream, top of bank, in bank, under bridge, etc)	**Time**	**Pipe material and condition** (concrete, steel, PVC, clay, other)	**Flow level** (indicate on circle)**, flow rate and pipe size**	**Color, Odor** (clear, turbid, oily, foamy, colored)	**Algae below pipe?** Yes or No Describe extent	**Erosion, Sediment accumulation at outfall?**	**Pipe need to be rechecked? Describe geographic location**	**Rating (0-2)**	**Surrounding land use** (road, parking lot, farm, etc)
(Example) (1) in bank	9:33 AM	Concrete in good shape	Moderate 4" diameter	brown, turbid, faint sewage smell	Green growth coating rocks across the entire stream width and 100 yards upstream.	Sand accumulation at outfall	Should be rechecked. Downstream of Jones St. Bridge	1	Strip Mall, parking lot

Tip: Shoreline Survey Data Sheet

Starting with an existing, field-tested shoreline survey data sheet and adapting it to your program's needs is a great way to reduce labor. Additionally, starting with a survey that has been employed in the field can save you time and effort spent conducting multiple field tests. Many government agencies and organizations conduct periodic visual stream surveys. Contact organizations and agencies in your area which have previously conducted stream surveys to obtain copies of their stream survey data sheets, since it is likely that an existing data sheet can be modified to meet your needs. Using a tested data sheet may also allow the data to be used by others for a variety of projects, and can increase the credibility of your program.

that is not specifically asked for elsewhere on the data sheet and providing space for surveyors to further explain any situation they feel requires more description. By asking surveyors to prioritize problems, assets and action requirements, you will get a sense of the severity of the problems being observed in each section. Additionally, this instills a sense of ownership of the river in volunteers that will hopefully encourage stewardship extending beyond completion of the shoreline survey. As these sections do not require direct observation of river conditions and are aimed at getting a sense of the entire survey segment, surveyors can be instructed to complete these sections shortly after they have completed the field survey. (Data sheet is included in the Appendix.)

Modifying the SAARP Shoreline Survey Data Sheet

The shoreline survey data sheet should be designed to collect information relevant to your geographic region and common stormwater problems. The SAARP shoreline survey data sheet or another existing shoreline survey data sheet can serve as a good starting point to adapt to your needs. To determine if it meets your needs, conduct a field trial of the data sheet (discussed in the following section).

The first step to adapting or developing a shoreline survey data sheet is making a thorough list of the goals for the data you hope to obtain. For a SAARP this includes:

- River bank land use
- River and bank conditions (i.e. erosion, sedimentation, stability, condition of armored banks), especially surrounding stormwater outfall pipes
- Signs of non-point sources pollution, especially the pollutants of concern in your waterway (i.e. algae growth, oil sheens, odors)

Table 4: SAARP Shoreline Survey Data Sheet Sections

Section	Description
Objective Response	Short answer and multiple choice questions assessing instream and water body conditions, non-point source pollution sources, and river and wildlife habitat
	Key for marking common issues on the map (See Figure 7)
Pipe Survey	Table for listing each pipe observed by surveyors (See Figure 8)
Open-ended Response	Narrative description of the segment
	Priorities for Action: asks surveyors to prioritize problems, assets and priorities for remediation along the segment

Tip: Labor Hours

FIFI included shoreline surveys of over 90 miles of Charles River shoreline and 51 of Mystic River shoreline. The visual monitoring task took significant staff time. CRWA staff dedicated 433 hours to planning the visual shoreline survey; training and coordinating volunteers; and collecting, organizing and analyzing shoreline survey results. CRWA spent additional hours preparing the results for communication with municipal, state and federal officials although those hours were incorporated into Task 3: Promote BMPs (discussed in Chapter 5). MyRWA dedicated 850 hours to the shoreline survey of the Mystic River.

In addition to noting sources and effects of non-point source pollution, your organization may have secondary goals for your visual stream survey, for example, identifying potential sites for improving public access, or critical habitat areas in need of protection. Consider all the projects and objectives of your organization. By including the right questions on your shoreline survey data sheet, shoreline surveyors may be able to collect information that is useful to a variety of projects.

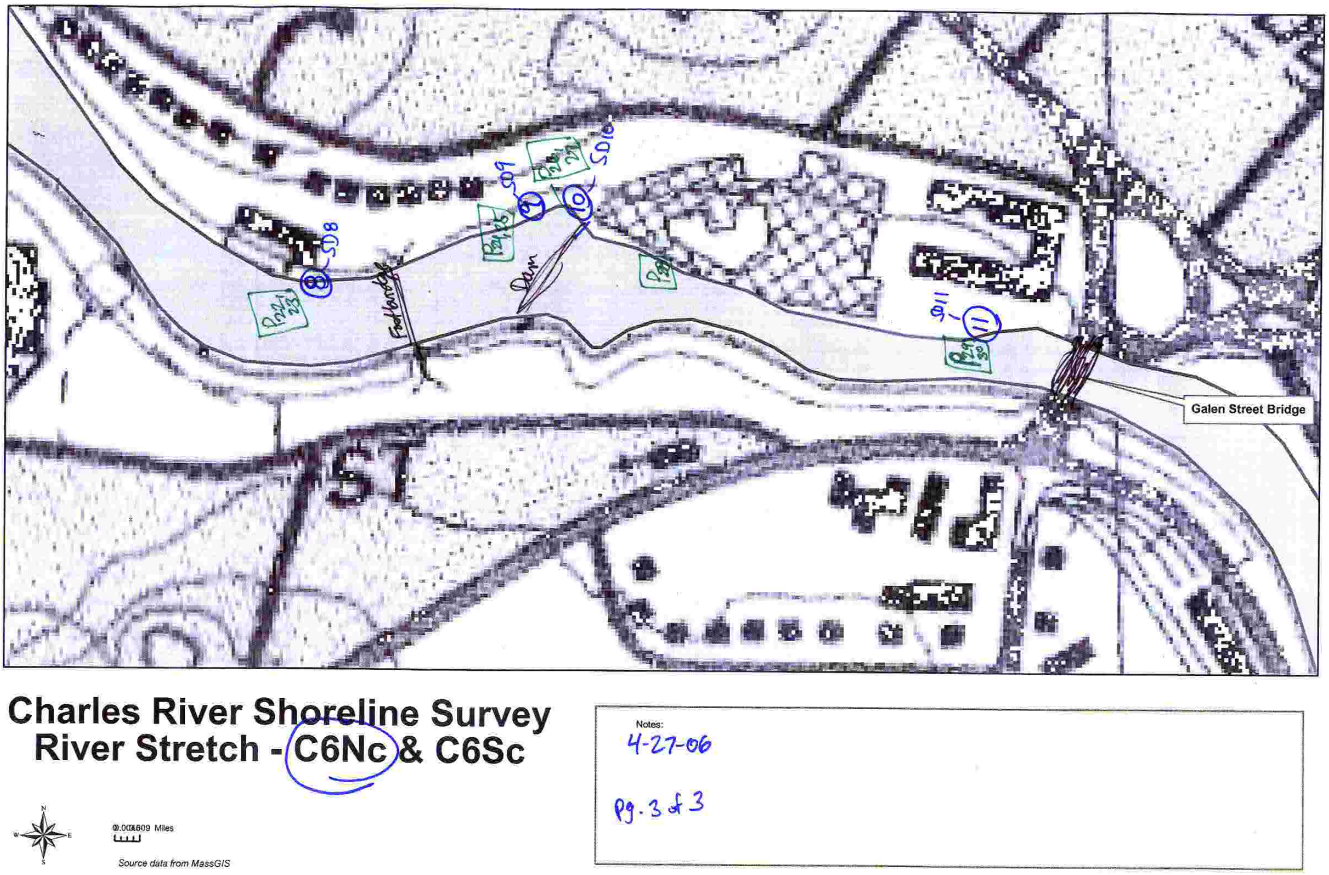
Consider also involving stakeholders outside of your organization to help develop secondary goals for your shoreline survey. If you plan to share shoreline survey results with local municipalities, state agencies or other environmental organizations, you may want to seek their input on the types of information they hope to obtain from the shoreline survey. For a municipality, it may be very important that surveyors note pipe size and signage so privately owned pipes can easily be distinguished from municipal pipes. Clearly describing each pipe observed may become a goal of the survey. Your organization will have to make the final determination of the goals for your survey, but stakeholder involvement can be effective in guiding the process and developing a shoreline survey data sheet that collects relevant and useful information.

After developing the goals of your shoreline survey, adapt or develop your shoreline survey data sheet to collect information relevant to your goals. Once you have developed a draft shoreline survey data sheet, conduct a field trial by sending staff or volunteers into the field to survey a stream segment using the draft shoreline survey data sheet. The field trial should be conducted by individuals who understand the goals of your visual shoreline survey. During the field trial, look for weaknesses in your shoreline survey data sheet. Is it asking the right questions to obtain information that meets your goals? Is it overly long and cumbersome? Is it laid out in a logical manner? Are the directions clear? (If you are

Table 5: Shoreline Survey Field Equipment List

- *Shoreline survey data sheet*
- *Aerial map of assigned river segment*
- *USGS map of assigned river segment (often at a very large scale) to mark the location of pipes and other observations*
- *Handheld GPS unit when available*
- *Copy of letter sent to river abutters*
- *Clip board*
- *Camera*
- *Insect repellent*
- *Sunscreen*
- *Cellular phone*

Figure 9: Marked-Up USGS Map of Shoreline Survey Segment



asking surveyors to distinguish between right bank and left bank, are the definitions of right and left included in the question?)

Maps

Provide maps to shoreline surveyors to mark the locations of their observations (Figure 5). Provide surveyors USGS topographic and aerial maps of their shoreline survey segment. The layout and coloring of USGS topographic maps make them ideal for legibly marking the location of pipes and river issues, while still providing landmarks to help determine location while in the field. For longer shoreline survey segments it is preferable to provide survey teams with multiple, large scale USGS maps of subsections of their shoreline survey segment, so every observation can be marked accurately and legibly (See Figure 9). Aerial maps are useful to orient the surveyors to their stream section and surroundings. These maps display landmarks which surveyors will be able to use to identify their location while in the field (See Figure 5). If recent aerial photographs are not available in your area, a road map may be used as a substitute.

Tip: Use the shoreline survey to collect data for complimentary programs!

In adapting the shoreline survey data sheet, CRWA added a question about garbage density to locate areas with large amounts of trash that could be targeted during our annual cleanup.

Tip: Budgeting

Although many volunteers will likely be able to provide their own digital camera for the survey, some surveyors may use film cameras, and some may need to borrow digital cameras. If your organization plans to provide reimbursement for developing expenses where film cameras are used, or to purchase additional digital or film cameras for surveyors, make sure to include this expense in the budget. Also consider waterproof cameras or cases if volunteers will be conducting surveys from boats or during wet weather conditions.

It is important to stress the importance of accurately marking the location of observations to all individuals conducting stream surveys. Many of the problems surveyors identify will need to be rechecked by someone in your organization or from a government agency; if the location of the problem is not marked accurately, it will be difficult for anyone to follow up. Additionally, shoreline surveys can provide evidence of when certain problems began; for example, volunteers might observe areas of minimal erosion that may evolve into severe erosion in a few months or years. If shoreline surveyors have accurately marked the location and photographed the minor erosion they observed, it provides evidence that this problem has been growing over time.

If available, shoreline survey volunteers should also be provided handheld GPS units to mark the precise location of anything notable they observe. This eliminates the error involved with surveyors trying to determine their exact location from a map and allows the data to be easily input into a GIS. As a precautionary measure volunteers should also be asked to mark locations on a map as the accuracy of GPS unit readings will vary by location, and there is a high probability of user error if volunteers are unfamiliar with handheld GPS units. When handheld GPS units are provided to volunteers, however, staff will likely have to meet volunteer surveyors in the field prior to surveys in order to distribute and collect the units. Although this requires staff to be present during surveys, it may ultimately save staff time, since results will not need to be digitized into a GIS.

Photographs

Surveyors should be encouraged to take lots of photographs while in the field, while always clearly indicating where each photograph was taken. Photographs allow experts on your staff to examine the issues identified to further understand the problems that are present and assess their severity. It will likely be impossible to recheck every issue identified; therefore, clear pictures of the issues observed are truly invaluable. Finally, make sure to ask surveyors to label photographs, whether hard copies or digital, so it is clear where each photograph was taken and what it is depicting.

3.1.2 Survey Teams

For both safety and data quality reasons, shoreline surveys should always be conducted by two or more people. Although many volunteers may regularly walk or run along the river alone, sending volunteers with variable amounts of experience into the field is generally inadvisable in the rare event of an injury or other problem (See Text Box: Safety First!). Additionally, multiple volunteers are preferable to one for observing issues and keeping track of data.

Safety First!

The safety of shoreline surveyors should be the primary objective of field outings. Here are some important safety tips to remember when performing a shoreline survey:

- *Always walk with someone else: never survey alone.*
- *Tell someone where you will be surveying and how long you expect to be. Make sure to let them know that you have returned safely!*
- *Carry a cell phone with you while you survey.*
- *Only survey during daylight hours.*
- *Dress appropriately for weather and terrain.*
- *Wear insect repellent and long-sleeved shirts and pants to protect against mosquitoes, poison ivy, and similar hazards.*
- *Wear sunscreen, even on cloudy days.*
- *Abandon survey and seek shelter if there are thunderstorms in the area.*
- *Do not enter posted areas without permission. Ask permission to cross private land, and use public access points whenever possible.*
- *Watch out for irate dogs and local wildlife.*
- *For your own safety, and to prevent erosion, do not walk on unstable river banks. If necessary observe the river from a short distance.*
- *Do not drink the river water.*
- *Avoid any contact with water flowing from pipes or other structures.*
- *By law, all canoe or kayak occupants must wear a U.S. Coast Guard Approved Personal Flotation Device.*
- *If at any time you feel unsafe, STOP your shoreline survey.*

3.1.3 Where, when and how to conduct surveys

Determining what time of year to conduct the survey is an important planning decision. In New England, conducting an outdoor survey is limited to three seasons out of the year. There are unique benefits to conducting surveys in spring, summer and fall, and the choice of season should result from careful consideration of the ultimate goals of your survey. A spring or summer survey may be ideal for identifying and locating certain plants, such as invasive species or aquatic vegetation. Summer may be ideal to assess the recreational use of the river. Additionally, in certain climates, volunteers may be able to complete the survey most expeditiously in the summer as there are fewer weather concerns. Finally, fall, especially after the leaves have fallen, may provide surveyors with the most advantageous view of the river and its banks.

In addition to seasonal consideration, it may be preferable to plan surveys during certain weather conditions. Signs of non-point source pollution may be more obvious during and following rain events; therefore, it may be most

desirable to have surveyors conduct the survey during or following a rain event. However, you should also consider that surveyors may rush in the rain, and the quality of data and photographs may suffer. Conversely, if a goal is to find illicit and illegal connections of sanitary sewer pipes to stormwater drainage systems; it may be preferable to conduct surveys following a period of dry weather as outfalls will not be carrying any stormwater.

Surveying the entire study area will likely require dividing the area into shorter segments, which will be surveyed on multiple days and possibly by multiple teams. Consider the timing of surveys along subsections. As shoreline surveys offer a snap shot of river and bank conditions, it is useful to have your entire study area surveyed in a relatively short time period. Determine the time period over which you hope to have surveys completed, ideally this should be less than one month. The time period may dictate your planning and training schedules.

Finally, surveyors should be asked to survey their river segments in a uniform manner, i.e. either upstream to downstream or downstream to upstream.

3.2 Shoreline Survey Segments

The visual shoreline survey will most likely take many weeks or even months to complete. To ensure that the entire study area is surveyed, you will need to divide the river into shorter segments and assign each segment to be surveyed by a staff or volunteer team. Dividing the river into segments can be challenging.

3.2.1 The Many Challenges of Dividing a River

If your visual stream survey study area is many miles long and traverses numerous municipalities, it is best to begin by dividing the river into large subsections, or stream teams.

Survey Season

CRWA and MyRWA conducted their initial shoreline surveys in the spring and summer. If surveys were scheduled on a specific date and time, volunteers met up with staff prior to and following completion of the survey. This method was employed primarily when surveyors were provided GPS units and/or digital cameras that were property of CRWA or MyRWA. If there was no scheduled day and time for a survey, surveyors along each Stream Team segment (See Figure 7) were asked to conduct their survey sometime within an assigned two week time span. After reviewing results for the initial surveys, follow up surveys were then scheduled for certain areas which sometimes required additional trainings.

Volunteers were asked to schedule surveys during or following rain events when possible, although because many volunteers had full time jobs, they often had limited availability. As many problems in the Charles and Mystic Rivers are the result of non-point sources, we believed asking surveyors to survey following rain events was most desirable for capturing the effects of stormwater runoff. Finally, all surveyors were asked to survey segments by walking or boating in the upstream to downstream direction.

Use municipal boundaries to delineate these sections as much as is feasible. Stream teams are useful in planning shoreline survey trainings, and organizing and distributing data.

If visual stream surveys are to be conducted by staff, some of the following discussion can be disregarded as less preparation will need to go into delineating stream survey segments. Nevertheless, it is imperative that a plan is developed prior to beginning the stream survey to ensure that the entire study area is surveyed and no sections are inadvertently overlooked.

If you plan to employ volunteers to conduct shoreline surveys, you will need to take great care in dividing the stream team sections into short segments for volunteers to safely make quality observations on foot or via canoe. The

Dividing the Charles

GIS software, recent aerial photos of the region, an intimate knowledge of the river, and a thorough pre-survey field outing all proved invaluable in dividing the river into shoreline survey segments. Beyond the challenge of dividing the river, we also faced the challenge of keeping track of the data collected for each segment. Shoreline surveys generate a large number of maps, data sheets and photos which can be overwhelming to track. CRWA assigned each segment a unique identifying number according to a standardized numbering system. Before being given to volunteers, each map and data sheet were labeled with this identifier to help keep track of the large number of maps, shoreline survey data sheets and photographs submitted by survey teams.

The Charles River survey area was initially divided into four main sections: Stream Teams A, B, C and D (See Figure 10). Subdividing the river into four large sections proved to be extremely useful throughout the entire visual surveying process. Stream Team sections were used to plan volunteer trainings and survey dates, and to process and report data. As Stream Team divisions were used in data reporting, we found it helpful to delineate these sections along municipal boundaries where possible.

Stream Team sections were then subdivided into shorter sections which were numbered from upstream to downstream. For example, the upstream-most section was assigned the identifier A1. Survey sections were initially delineated using maps and aerial photos and revised through a pre-survey field outing. These sub-sections were usually river stretches with clear start and end points, such as road crossings. Depending on the size and accessibility of this section, it would then be assigned to a survey team to observe on foot or via boat. CRWA used the notation N and S to articulate whether the survey was of the north or south bank and the notation C and W for canoers and walkers. Therefore, section D2CN denotes the north bank of the second most upstream section in the Stream Team D stretch which was surveyed by canoe.

ideal river segment for a walking survey:

- Is about 0.5 to 1.5 miles in length (can be surveyed in approximately 2 hours)
- Has clear start and end points (bridges work well)
- Has relatively uniform riparian land use and river conditions throughout (although this is not necessary).

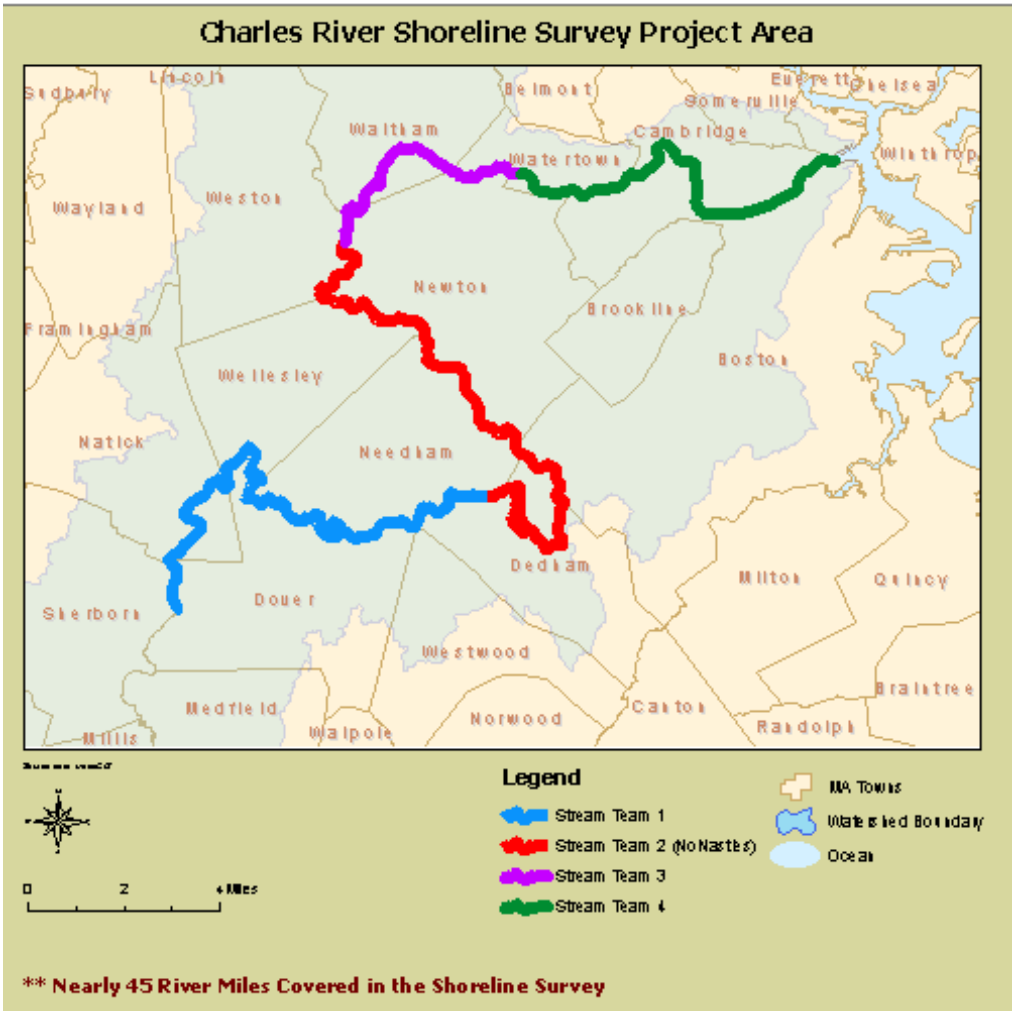
Shoreline surveys can also be conducted by canoe or kayak, these survey segments can range from 1 to 3.5 miles long. Additionally, private land ownership can cause additional problems if land owners object to surveyors walking along their land (contacting land owners is discussed in Section 3.2.3) and these sections may need to be surveyed by boat or excluded.

Using paper or electronic maps, you can begin dividing your project study area into segments of about 0.5 to 1.5 miles for foot surveys and 1 to 3.5 miles for canoe surveys. After roughly dividing the river, you will need to conduct pre-survey field outings to ensure that all segments are accessible (this is especially important for surveys which are to be conducted by boat) and can be safely walked or paddled in their entirety. Assign each section a unique identifier so data for each section can be easily identified and organized. Consider using letters for larger stream team sections and numbers for smaller subsections. Ask survey teams to label data sheets, photos and any other material with the segment's unique identifier. (See *Dividing the Charles* on previous page).

3.2.2 Pre-Survey Field Outing

If you are using volunteers to conduct the visual stream survey, conduct a pre-survey field outing of each segment, so you do not send a survey team through unsafe terrain. During a pre-survey field outing, staff should walk, canoe or drive along the entire project study area. In addition to ensuring that volunteers will be able to safely access and survey each segment, you will get a sense of how quickly volunteers will be able to survey each segment and will likely find that some segments need to be shortened and some can be lengthened. (Keep in mind that during the pre-survey assessment you will be able to walk these sites more quickly than the surveyors since you will not be stopping to make observations or collect data.) Areas

Figure 10: Map of CRWA's Stream Teams A-D



observed to have numerous outfall pipes or problems, or segments that are difficult to traverse for any reason should be divided into multiple segments of shorter lengths. Likewise, where land use or river conditions are rapidly and drastically changing, the river should be divided into shorter segments, so shoreline survey teams are not overwhelmed with the amount of data that needs to be recorded.

If either access to a boat or boat access to your river is limited, your pre-survey field assessment is the perfect time to prioritize segments that would benefit most from a boat survey including: stretches that are not easily accessible by foot; bordered solely by private land; stretches where bank steepness may make the vantage point of an observer on the bank significantly different from that of an observer on the river; and areas, such as those that are highly urbanized, where there is much to observe and two survey teams would be more desirable.

In addition, during your field assessment, observe the width of the river. Very narrow stretches can likely be observed by one volunteer team, however, when this is the case, make sure to remind the team to clearly indicate on which bank pipes or problems were observed. Wider stretches will require a volunteer team assigned to each bank. Finally, this field assessment is a good opportunity to take photographs of your area and river issues to be used during your shoreline survey training sessions.

Tip: Trespassing Issues

In areas where no public right of way, such as a road or walking path, ran along the river, CRWA conducted the surveys by boat.

Lesson Learned

CRWA and MyRWA always strove to make the best use of volunteer time. Through planning this extensive visual stream survey, we found two hours to be an adequate time for volunteers to feel a sense of worthwhile accomplishment and short enough not to exhaust or frustrate volunteers and provoke mid-survey abandonment. Following the field work, volunteers spent a variable amount of time completing their narrative and priorities for action section, and reviewing and labeling their photos.

Following your pre-survey assessment, review your study area divisions, making any necessary changes to the length of segments or method of survey; you may learn that some areas you previously thought were accessible by foot are not and therefore need to be surveyed by boat or vice versa.

3.2.3 Notifying Private Land Owners about Shoreline Surveys

In many areas shoreline survey teams will walk across private land during surveys. Trespassing and property laws differ by region, therefore it is advisable to review local laws and if necessary contact a lawyer for advice.

Regardless of local laws and regulations, you may wish to notify private land owners about the shoreline survey to raise awareness of your SAARP and stormwater runoff issues in your area. Contact information can usually be found in city and town assessor's databases. Some

cities allow you to search the database online by street. Once contacted, however, if private property owners object to surveyors walking on their land, you will have to consider this when planning stream survey subsections. A copy of the letter sent to river abutters along a portion of the Mystic River shoreline survey study area is included in the Appendix.

3.3 Shoreline Surveyors

Shoreline surveys can be conducted by staff, volunteers or some combination of the two. Stream surveys are a wonderful opportunity to engage volunteers in your organization and build river stewards. Planning for a survey conducted by volunteers may take more time than preparing for a survey that will conducted by staff; however, using volunteers as surveyors will drastically decrease the amount of staff time dedicated to surveying. Table 6 summarizes the different preparation tasks required when using staff and volunteers.

3.3.1 Recruiting Volunteers

Begin recruiting volunteers a few months prior to your survey. Table 7 provides a list of resources for reaching out to potential volunteers. Develop a system within your organization to track potential volunteers. Set up a centralized database where information on potential volunteers can be stored. Also, determine what types of information should be obtained from each potential volunteer. At a minimum you will need to collect volunteer

Table 6: Staff vs. Volunteer Stream Survey Teams

Stream Surveyors	Necessary Preparation Tasks	Recommended Preparation Tasks
Staff	· Subdivide study area into large stream team sections based on municipal boundaries	· Further subdivide river into survey section based on land use, distance and accessibility
	· Further subdivide river into survey sections to ensure entire river is surveyed	
	· Develop record keeping system to track who is surveying each section and when	
	· Conduct visual shoreline survey training	
Volunteers	· Subdivide study area into large stream team sections based on municipal boundaries	
	· Further subdivide river into survey section based on land use, distance and accessibility	
	· Track interested volunteers, including availability, geographic preferences, and boat access	
	· Conduct pre-survey field outing	
	· Develop record keeping system to track who is surveying each section and when	
	· Conduct (multiple) visual shoreline survey training(s)	

Tip: Tracking Volunteer Interest

CRWA developed an online survey to collect information about potential stream survey volunteers (See Figure 11). The survey was posted on our website and responses were e-mailed to us when an interested volunteer responded.

contact information; however, it may also be helpful to determine geographic preferences for survey locations, boat access, availability and previous experience.

3.3.2 Training Surveyors

Training does not need to be extensive, but should cover these main points:

- What is non-point source pollution?
- An overview of the SAARP
- Descriptions and example images of issues surveyors will be observing
- Review of safety precautions
- Detailed instructions of shoreline survey methodology

Surveyors, especially volunteers, will have varying backgrounds and familiarity with non-point source pollution and the problems it creates. Before going into the field, however, all surveyors should be presented with a brief introduction to the concept of non-point source pollution and the typical sources of non-point source pollution affecting your survey area. Additionally, volunteers should be informed about the larger project and how their role as shoreline surveyors will help achieve the ultimate goals of the SAARP.

Ensuring the safety of the volunteers should be of the highest priority. Before volunteers enter the field, ensure that they are aware of any potential safety hazards and all necessary precautions they should take. Take time during the training session to discuss safety precautions, no matter how basic, so surveyors will consider these when conducting their survey. See *Safety First!* for a complete discussion of safety precautions.
A large portion of the training session(s) should be dedicated to a thorough, clear explanation of the shoreline survey methodology, so all surveyors understand exactly what is expected of them in the field. Pictures, ideally from previous surveys or field outings in your survey area, are extremely effective in displaying the types of conditions volunteers should be noting. Take the time to review your shoreline survey data sheet with surveyors as some of the vocabulary may be new. Make sure to clearly distinguish between activities that must occur while in the field and those that can take place at a later date. Finally, ensure that all surveyors are provided with contact information and clear instructions for submitting their data.
Additionally, provide volunteers with their shoreline survey segment assignments and blank shoreline survey data sheets. Whether volunteers will conduct the survey at their own leisure or on an appointed day and time, it is useful to provide volunteers with information

Table 7: Resources for reaching potential stream survey volunteers

- *Volunteer clearinghouses*
- *Local schools and universities*
- *Local conservation corps, job corps, or City Year programs*
- *Girl Scout and Boy Scout Troops*
- *Your website*
- *Environmental fairs and/or events*
- *Partnership organizations*
- *Internet networking sites (Craigslist, MySpace, Facebook)*
- *Newspapers*

about their segment in advance, since they may wish to familiarize themselves with the area or plan their transportation and parking. Volunteers may also want to review the shoreline survey data sheet further and contact you with follow-up questions.

3.4 Data Management

Establish a protocol for receiving and organizing data prior to the commencement of the survey, as you will receive large amounts of data in a short period of time once surveys begin. Ideally, one person in the organization should be designated the responsibility of keeping track of the data as it is submitted, following up with surveyors to track down outstanding data in a timely manner, and clarifying any issues with surveyors concerning submitted data. Keep all data together, whether it is paper or electronic.

3.5 Data Analysis

Once a stream team section has been fully or almost fully surveyed, begin analyzing the data and preparing it for communication with municipalities, regulatory agencies, land owners, river stakeholders and the general public. This involves compiling results and communicating them in a clear and effective manner to individuals who are unfamiliar with your shoreline survey methodology. An effective way to accomplish this is by compiling and displaying the data in multiple formats such as: narrative memos or letters, summary tables, photographs and maps. See Appendix for an example of shoreline survey results maps and a summary tables sent to a municipal officials. Creating these multifaceted reports may require storing data in multiple formats or transferring data between formats.

3.5.1 Organizing Data with Microsoft Excel ©

A spreadsheet program such as Excel can be used to develop matrices which summarize the problems observed in each section (See Table 8). Summarizing data into a matrix requires a thorough reading of each shoreline survey data sheet but generally does not take many labor hours. In compiling this matrix, you will have a snapshot of the problems in each stream survey sub-section. This will be a useful tool in identifying problems which can be targeted for follow up actions under tasks two, three and four. It is likely that surveyors will have identified numerous locations, which would benefit from water quality monitoring, volunteer cleanups, invasive species removal, and/or further visual inspection. A summary matrix is a convenient way to review all the problems in an area in conjunction with one another and begin to determine and prioritize follow-up actions.

3.5.2 Organizing Data with ArcMap ©

Maps are an ideal way to display geographic data. ESRI ArcMap software is extremely helpful in generating maps of shoreline survey results. ArcMap can be used to display the locations of problems identified on survey maps (See Figure 12). It can also be useful to store much of the information collected and serve as a database for your results (See Figure 13). If volunteer teams do not have access to handheld GPS units, pipe and problem locates will need to be digitized from the survey maps. This process is time-consuming and leaves room for error but provides an excellent method for storing and visually displaying geographic data. Even when using GPS units, volunteers should record detailed information about locations in case GPS units fail or data is lost.

While maps can display locations and some details of problems, when being used to report data, they will need to be accompanied by tables

Figure 11: Shoreline Survey Online Volunteer Survey Form

Charles River Find-it & Fix-it Stormwater Program

If you are interested in participating in the Shoreline Survey (visual monitoring) effort and would like to speak to CRWA staff for more information, please fill out the questionnaire which will provide us initial background information and help us respond better to your inquiry. After review of your answers, CRWA staff will contact you either via phone or email.

Name

Street Address

City

State

Zip Code

Daytime Telephone Number

E-Mail Address

Do you have canoe experience and feel comfortable in a canoe?

- Yes
- No

Would you prefer to conduct the survey in a canoe or on foot (Survey lengths are between 1/2 and 1 1/2 miles)?

Canoe

The survey will be divided into four river sections covered by four "Stream Teams." Please rank your team preference from 1 (highest preference) to 4 (lowest preference).

1 Team 1: Farm Road in Dover to Rt. 128 in Dedham

1 Team 2: Rt. 128 in Dedham to Rt. 30 in Newton (Already primarily covered by existing "NoNasties" Stream Team, but may need additional support).

1 Team 3: Rt. 30 in Newton to Watertown Dam in Watertown

1 Team 4: Watertown Dam in Watertown to the New Charles River Dam in Boston

Can you attend an evening training session this spring?

- Yes
- No

Please provide us any additional questions or comments

Submit Reset

Training

CRWA and MyRWA's shoreline surveys were conducted solely by volunteers. Surveying all 90+ miles of the Charles River required the joint effort of over 100 volunteers. Prior to conducting shoreline surveys, volunteers were required to attend a two-hour training. All trainings were held in the evenings. CRWA initially held four separate trainings, one for Stream Teams A and B combined, one for Stream Team C and one for Stream Team D. Additional trainings were held for follow up and tributary surveys.

MyRWA typically scheduled stream surveys for a specific date and time, usually a Saturday or Sunday morning and held two identical evening training sessions in the week preceding the survey to accommodate the majority of the surveyors. In some cases, MyRWA also held training and surveys in one day. In these cases, volunteers would attend a training session from 9-11 a.m. and conduct surveys from 11 a.m. to 3 p.m. Holding multiple trainings for volunteers surveying along the same Stream Team section proved to be an effective strategy. Smaller groups made trainings more manageable and effective and provided an opportunity for volunteers to meet other like minded citizens in their area.

Shoreline survey trainings consisted of three brief presentations. The first was a brief introduction to non-point source pollution and Find It and Fix It (our SAARP) which was usually conducted by CRWA or MyRWA staff. The second was conducted by Mass Riverways and included a slideshow of photographs of issues surveyors would be observing and noting. The third presentation detailed shoreline survey methodology to ensure surveyors clearly understood what was required of them both in the field during the survey and following the survey, and what they were required to return to CRWA or MyRWA upon completion of the survey. Finally, volunteers were broken into teams of two and assigned shoreline survey segments. Ideally, these three presentations were concluded in an hour and a half in order to leave ample time for surveyors to ask questions. We strove to be clear with instructions, limiting the use of technical terms, and reiterating the most important points.

or narratives which provide as much detail as possible about each problem and, where available, pictures of the problem.

3.5.3 Assisted Remediation through Developing Action Steps

Once all the shoreline survey data has been reviewed, your project team should develop follow- up action steps to address the most common issues observed during stream surveys. This will likely take some research into

remediation strategies and can be considered part of the research and capacity building task discussed in section 5.1.

Action steps can include actions your organization will take, and actions you will recommend to municipalities or regulatory agencies. Action steps may include follow up shoreline surveys, continued visual monitoring of an issue, water quality monitoring, identifying the cause of an issue or owner of a specific pipe, public education campaigns and trash clean-ups. Develop both short term actions steps which should be taken immediately and long term action steps to help guide the remediation and ultimate solution of issues identified. It may be helpful to build a matrix which summarizes common observations, recommended short term and long-term actions steps, and potential responsible parties for each action (See Table 9 for an example). In this way you can also prioritize actions. Once this summary has been created, your organization can develop a clear plan for implementing action steps and building the partnerships necessary to implement changes. Implementing action steps will be discussed throughout this guidebook.

3.6 Visual Stream Survey Follow Up

After your stream survey study area has been completely surveyed and the data has been compiled, you can begin follow up work.

Figure 12: Map of Digitized Survey Results

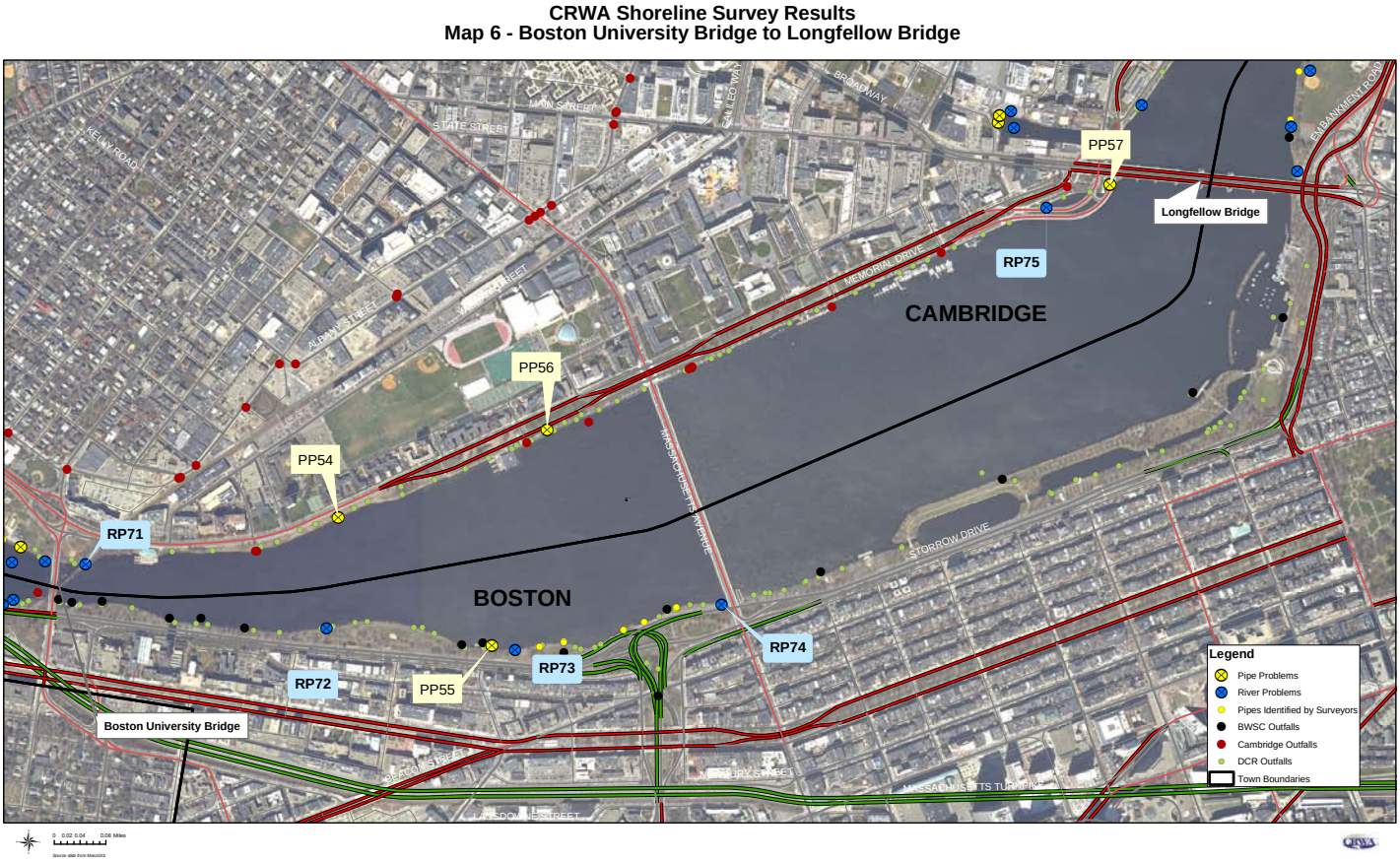


Table 8: Matrix of Stream Survey Results

River Stretch #	Start Point	End Point	Town/ City	Distance (Miles)	Volunteers	PROBLEMS						
						Water	Vegetation	Riparian Area	Land Use	Trash	Pipes	CRWA Next Steps
C1N	DCR Duck Feeding Launch, Norumbega Rd.	Woerd Ave. Boat Launch	Waltham	2.20	P. McHallam, M. Musen			Cemetery with no buffer	Sandpit with buffer, residential, parkland	Mostly in park areas	Pipes 2,3,4,8 need rechecking, rated '1', Pipe 5 collapsing	Recheck Pipes, discuss creation of buffer zone, action Steps
C1S	DCR Duck Feeding Launch, Norumbega Rd.	Woerd Ave. Boat Launch	Waltham	2.20	D. Latson, W. Aldrich		Water chestnut and milfoil	Trees and grass, lawns on river banks, residential construction	Residential, parking lots, roads, cemetery, unprotected land	High level of small trash, bottles, and cans, steel scrap-see map	Photo's indicate pipes with very brown water flow	Recheck pipes, action steps
C2N	Woerd Ave. Boat Launch	Moody Street Bridge	Waltham	0.95	C. Taplin, T. Miller	Around Nova Biomed, sewage smell and foam		Erosion near Moody St. bridge	Industrial, residential, parks, railroads, parking lots	Small trash, cans, and bottles	Pipes 4 and5 have loose stone banks with potential for collapse	Recheck pipes and Nova Biomed site, water quality monitoring around sewage smell, other action steps
C2S	Woerd Ave. Boat Launch	Moody Street Bridge	Waltham	0.95	K. Johnson, K. Fox	No water flow near impoundment	Milfoil (high amount)	Steep banks in residential areas, deteriorating stone walls	Industrial, residential, parking lots, bridges	5 gallon buckets, a/c unit, tires, shopping cart	Pipe 16 (GPS11) had algae growing in it	Restore stone walls, proceed to action steps
C2W	Woerd Ave. Boat Launch	Moody Street Bridge	Waltham	0.95	J. Boegal			Exposed dirt near buildings and lots, eroded asphalt	Industrial, commercial, residential, parking lots, roads, railroads, junkyards	Large amount of small trash (noted that it was done before CR cleanup)	Pipe 13 had orange brown sediment, tires (auto body shop nearby)	Contact auto-body shop, request reports, other action steps
C3	Moody Street Bridge/Dam	Newton Street Bridge	Waltham	0.46	J. Boegal	Musky smell, should be rechecked		Channelized, exposed roots, construction site	Industrial, commercial, parking lots, roads, railroads	Shopping cart just downstream of Elm st. bridge		Recheck section, other action steps (trash removal)
C4	Newton Street Bridge	Farwell Street Bridge	Waltham	0.74	D. Piscatelli, C. Hutchison	Oil at corner of Newton St. bridge*, foam by Shaws	Small amount of water chestnut	Erosion near benches on right bank	Industrial, commercial, residential, parking lots, roads, railroads, junkyards	High incidence of all types of trash, Farewell St. Bridge area	Pipes 5,31,32 made from old PVC piping needs to be rechecked, lots of outfall pipes	Recheck section and pipes, other action steps (water quality testing)
C5	Farwell Street Bridge	Bridge Street Bridge	Watertown	0.84	P. Romano, D. Coady	Small traces of oil, excessive trash in water		Heavy erosion across from pipe 3, exposed roots	Industrial, commercial, residential, parking lots, roads	High level of small trash, bottles, and cans	Pipe 3 buried, poor shape, near granite landmark, pipe 4,8 clogged industrial/ residential piping	Recheck section and pipes, other action steps (trash removal)
C5	Farwell Street Bridge	Bridge Street Bridge	Watertown	0.84	C. Austin, B. Austin	Little pieces of trash in water		Exposed roots	Industrial, commercial, residential, parking lots, roads, parks, lawns, construction site with uncovered dirt	Low level of small trash, bottles, and cans	Pipes 1 and 2 were blocked	Recheck section, contact construction site about BMPs, other action steps (trash removal)
C6N	Bridge Street Bridge	Galen Street Bridge	Watertown	1.17	V. Morrill, I. Ziza		Japanese bamboo plant as reported by passerby near the dam	Exposed roots, erosion near public access points and bike path	Light industry, commercial, residential, parking lots	High level of small trash, chain-link fence specifically notated	Pipes 1,3,5,6,8,9,10 and 11 light industry in fair-poor condition could use recheck	Recheck pipes, trash cleanup and other action steps
C6S	Bridge Street Bridge	Galen Street Bridge	Watertown	1.17	V. Morrill, M. Nogrady	Three oily locations, sewage smell at a pipe, white foam	Phragmites	Erosion near public access points (although these are a buffer)	Commercial, residential, parks, parking lots, roads	High level of small trash	Pipe 4 severe erosion, pipe 5 sewage odor, pipe 8 rust-colored, pipe 11 erosion	Recheck oily locations for sources, water quality monitoring of sewage smell at pipe, action steps

*C4 survey indicated they spoke to a policeman who has fished this stretch and found fish with tumors

Action Steps	1. Recheck pipes in wet weather C1N, pipes in C1S in bad shape as well 2. Address crumbling wall near industrial site (C2S) 3. Buffers between impervious parking lots and river 4. Target areas for trash clean-up (C6, C5, C4, C3, C2) 5.Remove shopping
Assets	Fishing and recreation, wildlife habitats, frogs, turtles, geese breeding area, swans, swallows, signs that say "Do Not Feed the Geese", mussells and clams

Lesson Learned

When data was received by CRWA, it was placed in a folder which was labeled with the identifier of the shoreline survey segment. Data was reviewed when it was submitted, but we did not have any established policy for keeping track of and following up with outstanding data. Our shoreline survey generated a large amount of data, and there was often a delay between when data was received and when staff had time to analyze it. In some cases this delay was many months, making it inappropriate to follow up on any missing or confusing data with surveyors after such a long delay.
CRWA recommends appointing one point person to review all incoming data to look for any missing components. Additionally, a protocol for tracking all data and following up on missing data should be establishing prior to beginning shoreline surveys.

Much of your follow up work will likely be incorporated into key program elements 2, 3 and 4, although some areas may also require follow up stream surveys.

3.6.1 Action Planning Meetings

Action planning meetings are a forum for bringing together your stream survey stakeholders, such as surveyors, municipal officials, other environmental groups and watershed residents. Ideally, action planning meetings should be scheduled after your organization has had an opportunity to review stream survey results but no more than a few months after the survey's completion. If your stream survey study area is large, it is advisable to schedule multiple action planning meetings focused on different river sections, to keep things localized. As action planning meetings will likely take place shortly after the survey is completed, it may be many months until you are able to compile all your data into maps and summarize the results for distribution or public presentation to municipalities.

At an action planning meeting, present the survey results. If survey volunteers are present, provide them the opportunity to present and further explain their observations. Seek surveyor's input into the types of follow up remediation work required in their segment. An action planning meeting provides an opportunity for municipal officials to get a sense of the types of observations made in their municipality and explain possible reasons for some of the observations. Finally, an action meeting can provide an opportunity to plan remediation work and recruit volunteers to help complete it. Stream survey volunteers may be anxious to begin fixing some of the issues they observed during their survey. Follow up actions for volunteers can be as simple continuing to visually monitor a certain area or distributing educational materials to their neighbors. Volunteers who are interested in becoming very involved may wish to organize a clean up or even assist in water quality monitoring.

3.6.2 Supplementary Stream Surveys

After reviewing the data from the initial stream survey, you may find that certain areas require follow up stream surveys. These may include those areas with inadequate data, unusual issues or problems requiring further monitoring and areas you wish to target during multiple seasons. Compile a list of segments requiring follow up stream surveys. Determine which area, if any, should be resurveyed by staff and

Figure 13: Pipe Layer Attribute Table

Attributes of Pipe Problems

FID	Shape *	OBJECTID	StrmSrvSec	PIPE_ID	Problem	MATERIAL	EROS_SEDAC	DIAMETER	DESCRIPTIO	SURVRATING	PipeSignag	Problem_ID	WebProbDes
0	Point	0	D3CN	D3CN_D	CLOGGED	CONCRETE	SEDIMENTATION	12	Clogged	2		PP36	
1	Point	0	D3CN	D3CN_F	CLOGGED	CONCRETE	SEDIMENTATION	12	Pipe Blocked	2		PP37	
2	Point	0	D3CN	D3CN_G	CLOGGED	CONCRETE	SEDIMENTATION	12	Pipe blocked	2		PP38	
3	Point	0	D3CN	D3CN_H	BROKEN PIPE	CLAY	NOT REPORTED	12	Pipe cracked	2		PP39	
4	Point	0	D3CN	D3CN_I	BROKEN PIPE	CONCRETE	NOT REPORTED	12	Bottom missing	2		PP40	
5	Point	0	D3CN	D3CN_2	CLOGGED	CONCRETE	NOT REPORTED	12	Pipe blocked	1		PP42	
6	Point	0	D3CN	D3CN_3	CLOGGED	IRON	NOT REPORTED	12	FRONT CRACKED &	2		PP43	
7	Point	0	D3CS	D3CS_1	CLOGGED	CONCRETE	EROSION	0	PIPE CRACKED	1		PP41	
8	Point	0	D3CS	D3CS_7	BROKEN PIPE	NOT REPORTED	NOT REPORTED	0		1		PP44	

Record: 1 Show: All Selected Records (0 out of 9 Selected) Options

Tip: A note of caution!

CRWA originally underestimated the time required to review, process and write data reports on shoreline survey data. As visual shoreline surveys were conducted entirely by volunteers, CRWA arranged to find shoreline survey segments for all interested volunteers, as engaging the community and building river stewards was a secondary goal of this project. Due to the large number of visual shoreline surveys conducted, data review and processing took much longer than originally anticipated. When scoping out your project study area and distributing shoreline survey segments, be sure to realistically assess the time your organization has available for data review and processing.

which can be resurveyed by volunteers. Once you have assessed your need for follow-up surveys, you can determine if you will need to recruit new volunteers and schedule additional training sessions, or if your current stream survey volunteer force will be willing and adequate to complete follow-up surveys. Be sure to update survey databases or matrices with data from follow up surveys.

3.7 Reporting Results

When it comes time to share results, a decision will have to be made about how and where to disseminate results. The manner in which data is presented will likely differ depending on the audience.

Table 9: Example of Matrix Summarizing Potential Action Steps, Implementation Partners and Priority Ratings for Common Shoreline Survey Observations

Observation	Recommended Next Step(s)	Potential Partners	Priority
Outfall pipe clogged with debris or sediment	1. Recheck and clean pipe	Municipal DPWs, State Agencies, Land Owners	Medium to high
Outfall pipe flowing in dry weather	1. Check source of pipe, using infrastructure maps	Your organization, municipal governments	High
	2. Check water quality of dry weather flow		
Sewage odor, oil sheens, discolored water	1. Conduct water quality monitoring to begin to assess the problem	Your organization, municipal governments, state agencies	High
Large trash items or area with many small trash items	1. Target during CRWA's Annual Earth Day Cleanup	Your organization, other environmental organizations, municipal governments, municipal DPWs, state agencies, watershed residents	Medium
	2. Removal of large items by town DPWs		
	3. Public education campaign about the non-point source issues and behavioral changes to protect the Charles River, with a focus on littering		
Excessive sedimentation and erosion	1. Review stormwater management for ways to reduce sediment load to the river	Your organization, municipal governments, state agencies, land owners	High
	2. Implement low impact development stormwater best management practices to slow and filter stormwater prior to discharge to the river		
Evidence of sediment washout from roadways	1. Review road sanding practices and address areas where its washing into the Charles River	Your organization, municipal governments, state agencies	High
Lawns abutting the river without a riparian buffer	1. Public education campaign about the non-point source issues and behavioral changes to protect the Charles River, with a focus on riparian buffer zones	Your organization, municipal governments, watershed residents	High

3.7.1 Municipal Officials

If many problems observed are within, around or as a direct result of stormwater or outfall pipes; results should be shared with directors of public works departments or relevant local agency that manages the stormwater drainage system. The relevant contact can be obtained from a city's or town's NPDES permit. Results should also be shared with local conservation commissions, your state environmental protection agencies,

and the U.S. Environmental Protection Agency. First, communicate your results via a written report. When sharing results with municipal officials it is important to fully describe all relevant problems observed and clearly indicate the location of each problem. Following the distribution of written reports, follow up with municipalities to schedule presentations and meetings.

In the written report introduce data by including a memo or letter which describes your SAARP and your shoreline survey protocol in particular. If your agency does not have a relationship with a municipality you may also need to describe your organization and its goals. The memo should describe common observation, suggest action steps and request a follow up meeting. To display specific problem include the maps of shoreline survey results you have generated and an accompanying table to describe each problem in more detail. Where available, also include photos. See Table 16 for a summary of what is included in the written report. Once written reports are sent out, contact officials to set up face to face meetings to discuss the results after they have had an opportunity to review the report. These meetings will be further discussed in Chapter 5.

3.7.2 Private Land Owners

If problems are observed on private land you may want to contact the landowner to advise them of the issue. If a certain problem exists throughout an entire neighborhood, it may be advisable to send the same letter or educational outreach brochure to every resident. When contacting private landowners it is also essential to clearly introduce your agency. If your agency has no regulatory authority, state this explicitly. Describe the SAARP and your shoreline survey protocol in particular. Make the landowner aware of the issue on his or her property and its potential effect on the river. Offer suggestions for the landowner on ways he or she can reduce negative impacts. Avoid threatening language and demanding tones. If the landowner chooses not to alter his or her behavior there is little you can do; therefore it is best to be clear and polite.

3.7.3 General Public

In addition to river abutters, municipal officials and regulatory agencies, you may want to share your stream survey results with the public. Most non-point source pollutants originate from the everyday actions of watershed residents, so sharing results can also be an opportunity to educate and inform individuals of steps they can take to reduce non-point source pollution.

There are multiple ways in which you can share stream survey results with the public: public

Analyzing Stream Survey Results

MyRWA found the "Priorities for Action" section of the shoreline survey data sheet to be the best place to start when reviewing shoreline survey data. From the trainings, the volunteers had a good sense of what in their segment was most important or required immediate action, and most volunteers highlighted these issues on the Priorities for Action page. This was a good way for our staff to quickly assess if there were any issues requiring immediate attention. After reviewing the "Priority for Action" sections, we went through the pipe surveys to determine locations to target for water quality sampling. Finally, we reviewed each data sheet more thoroughly to build our database of river issues.

presentation, a website, printed materials, newspaper articles, or e-mail newsletters.

Sharing your data with the public requires less detail about specific problems. Simply summarize common observations made along the river. Stress assets, such as recreational access, wildlife and river buffers, as well as problems. When describing a problem, clearly indicate why it is a problem, what are its likely causes and its potential effects on the river. Presenting results to the public is an opportunity to educate individuals who are unfamiliar with non-point source pollution issues. Do not alienate these individuals with scientific jargon or incomplete explanations.

Additionally, it is important to be cognizant of the fact that area residents may have a large amount of knowledge about or experience with specific areas along the river and throughout the watershed. The input of such individuals may be a valuable addition to your assessment process and may provide possible explanations for some of the observations your surveys have reported.

Tip: Working with Public Officials

When reporting to and meeting with public officials, remember that they probably share your concerns over the quality of local waterways but are working with limited resources and have competing priorities. Seek to build constructive partnerships and try to avoid a confrontational approach. Municipalities are key to improving conditions and solving problems. A personal introduction from a local resident may help to build a productive relationship.

Chapter 4:
Stormwater Assessment through Water Quality Monitoring

An important step in any effort to remediate pollution problems is to establish an ongoing water quality monitoring program in order to identify polluted areas and pollution sources, prioritize investments, monitor the effectiveness of past efforts and adopt management techniques for the future. Therefore, the second major element of a SAARP involves water quality analysis. Ensuring that data is reliable and adaptable for use by regulatory agencies requires a great deal of pre-planning prior to beginning the actual water quality sampling. Conducting monitoring events, managing, analyzing and reporting data will also require significant staff time. Table 10 summarizes the major tasks involved with water quality. Please note that this section is not intended to guide organizations looking to develop a water quality monitoring program for the first time. Instead this section deals with issues specific to water quality monitoring conducted under a SAARP. If the SAARP will be your organization's first experience with water quality sampling, it is recommended you consult other sources.

This key program element consists of three main tasks:

- Developing or expanding and updating a Quality Assurance Project Plan (QAPP) to incorporate water quality monitoring planned under the SAARP
- Planning and conducting water quality monitoring
- Managing, analyzing and reporting data.

4.1 Quality Assurance Project Plans (QAPPs)

The development of a Quality Assurance Project Plan (QAPP) is a crucial preliminary step for any water quality monitoring project. Data collected according to an approved QAPP has much further reaching implications than data collected without a QAPP. The EPA requires that all organizations conducting water quality monitoring using EPA funds or under a contract of agreement with the EPA, monitor according to a QAPP.

4.1.1 What is a QAPP?

A QAPP outlines field sampling design and methodology; laboratory procedures, including analysis and quality control; data management, including field recording, data storage, data analysis, quality assurance procedures for the data; and data reporting. In Massachusetts

Tip: QAPPs are essential!

Preparing and getting an approved QAPP is essential to conducting a water quality monitoring program. Data collected according to an approved QAPP has much further reaching capabilities than data collected with no plan or an unapproved plan. Government agencies and other groups may not consider your data valid if it is not collected according to a QAPP.

Table 10: Summary of Water Quality Monitoring Tasks

When	Step	Description
Pre-sampling	Develop QAPP	· Determine QAPP layout and content
		· Develop a work plan to write and assemble QAPP
		· Draft QAPP/assemble all required supporting documentation
		· Have QAPP approved by local regulatory authority
		· Revise QAPP and resubmit
	Develop a sampling plan	· Select monitoring locations
		· Select sampling parameters
		· Determine target number of monitoring events
		· Determine target monitoring conditions
		· Develop sampling procedures
		· Train all staff in sampling procedures
	Prepare equipment	· Obtain all necessary sampling equipment
		· Train staff on use of equipment
	Conduct pre-sampling site visits	· Asses or determine sampling site locations
		· Using GPS unit, maps or descriptions, clearly document sampling site locations
Sampling	Conduct dry weather monitoring	· Monitor weather to determine sampling dates and times
		· Target locations in accordance with your sampling plan
	Conduct wet weather monitoring	· Monitor weather to determine sampling dates and times, leave room for flexibility as weather changes
		· Target locations in accordance with your sampling plan
	Conduct non-weather dependant monitoring	· Target locations in accordance with your sampling plan
Post Sampling	Data management	· Review data as it comes in from the field and the laboratory
		· Enter data into spreadsheets or databases
	Data analysis	· Compare results to water quality standards and action limits
		· Compare wet and dry weather results
		· Compare results over time
		· Graph results
		· Perform statistical analysis on results if sample size is large enough
	Data reporting	· Share data with regulatory agencies and general public
	Follow-up sampling	· Depending on resources, plan follow up sampling

QAPPs are approved by the Massachusetts Department of Environmental Protection and the U.S. Environmental Protection Agency. Although QAPPs can take different forms you will typically want to include these four main sections: 1) project(s) overview, 2) sampling design and procedures, 3) data management, and 4) data verification. See Table 11 for a summary of what is included in each of these sections.

Lesson Learned

CRWA had previously developed QAPPs for our other water quality monitoring projects. The QAPP we created under the FIFI Project expanded upon and combined previous CRWA QAPPs. Despite this experience and the ability to draw upon prior QAPPs, we still faced many challenges in developing our water quality monitoring QAPP. This project alone took over 100 staff hours. The time and effort needed to develop a useful, high-quality QAPP should not be underestimated. If planning to develop a QAPP, ensure plenty of time is left to complete it prior to beginning water quality sampling. CRWA's QAPP required two rounds of submission prior to approval. Therefore, after completing our first draft, it was over four months before we had a finalized, approved QAPP.

4.1.2 Developing a QAPP

The development of a QAPP is a crucial preliminary step for any water quality monitoring project. If your organization does not have a water quality monitoring QAPP, it is highly advisable to develop one prior to conducting any water quality sampling. Even if your organization already has a QAPP, it still may need to be expanded to incorporate protocols for sampling conducted as part of your stormwater remediation plan. There are several very thorough and very useful guidance documents in publication that provide step by step instructions to developing a QAPP. This guidebook is not intended to provide detailed instruction on the development of a QAPP. Instead this section is intended to deal with some of the issues unique to developing a QAPP that encompasses protocols for water quality monitoring as part of a SAARP.

It is important to develop a QAPP that is useful and well adapted to your individual organization and your stormwater assessment program. Prior to beginning the QAPP, consider every type of sampling you may conduct throughout the SAARP. A program aimed primarily at identifying sources of non-point source pollution may require sampling methods

Tip: QAPP Resources

EPA has many documents available through their website that provide guidance on developing a QAPP, including:

- *EPA Requirements for Quality Assurance Project Plans*
- *Guidance for Quality Assurance Project Plans*
- *The Volunteer Monitor's Guide to Quality Assurance Project Plans*
- *EPA Guidance for Quality Assurance Project Plans*

The Kansas Department of Health and Environment provides a shorter guidance document for QAPP preparation. This document, entitled Preparing Quality Assurance Project Plans (QAPPs) For Stream Teams and Volunteer Monitoring Projects, describes the purpose of a QAPP and the necessary elements for each section, in only 6 pages!

Table 11: What's in a QAPP?

Section	Details
Project(s) Overview	· Overview and background of project(s) covered under the QAPP
	· Project management
	· Project quality assurance/quality control
	· Project task description
	· Problem definition, i.e. the water quality problems of your study area and motivation for the sampling
Sampling Design and Procedures	· Sampling process design
	· Sampling methods
	· Sample handling and custody
	· Analytical methods
	· Quality control
	· Quality objectives and criteria
	· Instrument/equipment testing, inspection and maintenance
	· Instrument/equipment calibration and frequency
	· Inspection/acceptance of supplies and consumables
Data Management	· Data reporting (inter- and intra-agency)
	· Data handling
	· Data tracking
	· Data assessment
Data Verification	· Data review
	· Data verification
	· Data validation

and protocols not typically conducted by your organization. For example, your program will likely require sampling from stormwater outfalls; rapid response monitoring (sampling locations that have not been sampled or scouted previously and are being sampled in response to shoreline survey results, or notification of the presence of an immediate pollution source or threat); wet weather monitoring, and overland stormwater runoff sampling.

Additionally, it is important for your QAPP to include standard procedures for collection and analysis of all water quality parameters for which you are likely to sample and in situ measurements you are likely to take (See Text Box: CRWA's QAPP Parameters). Include common pollutant parameters, such as nutrients, bacterial indicators, human waste indicators, metals, oil and grease, and pollutants of concern in your area. Parameter selection is discussed further in section 4.2.1.

If you employ external laboratories to provide analysis, researching and selecting laboratories will be an important step in your QAPP development. Selection of laboratories should be based upon the parameters the lab analyzes, method detection limits, analysis methodology, relevant certifications, cost, hours and proximity to sampling locations. If you anticipate after hours sampling will be necessary due to weather constraints, make sure to include a laboratory in your QAPP with evening and

weekend hours. Method detection limits (MDLs) can also be very important. A MDL is a laboratory's statistically derived detection limit or the laboratory's "best case" sensitivity for a particular analytical method. It is not effective to use a laboratory with MDLs above your state's water quality standards or your organization's action limits. Location will also be important to consider, since samples will need to be delivered to the laboratory within their holding periods. Working with external laboratories may require a great deal of coordination. This task in particular can be very time consuming. To include a laboratory in your QAPP, you will need to obtain their quality assurance paperwork to acquire an understanding of the methods used for each parameter and the associated method detection limits. Make sure you budget time for the laboratories to respond to your records requests.

If your organization has no existing QAPP or has not updated your QAPP recently, you may need to develop or revise your organization's action limits. The action limit for a parameter is the numerical value that would cause a decision maker to act. For many parameters, action limit can be based on a regulatory threshold such as surface water quality standards. In other cases, action limit will need to be developed from research and scientific literature. A chemistry background is helpful in this process. If you do not have such expertise in house, seek advice from other environmental organizations or the U.S. EPA.

Tip: Labor Hours

CRWA staff dedicated over 1,000 hours to water quality monitoring over the three years of our SAARP. MyRWA staff dedicated about 2,100 to water quality monitoring.

Lesson Learned

CRWA found the most significant delay was in working with external laboratories to obtain their quality assurance paperwork. Communicating and coordinating with external laboratories often proved to be rather challenging. Establishing a good relationship and a contact person at the laboratories was crucial to the success of obtaining the documentation required to develop our QAPP. Ideally, CRWA would have assembled a list of all materials we required from the laboratories prior to making requests. This includes determining all water quality parameters to be included in the QAPP and identifying all the required quality assurance paperwork. As the laboratories often took weeks or months to provide us with their materials, it significantly delayed the process when we had to make multiple requests to them. We learned it is better to request information on all parameters upfront instead of approaching the laboratories with multiple requests.

MyRWA found developing action limits to be the most difficult task in preparing our QAPP. MyRWA staff did not have the adequate chemistry background to feel confident in developing action limits on our own and therefore sought advice from the EPA, who we found to be very helpful.

QAPPs need to be reviewed and approved by state and federal agencies. Once a draft of a QAPP is complete, it is submitted for review to both your state environmental agency and US EPA. After a few weeks, these agencies will return the QAPP with comments. These comments will then need to be addressed and the QAPP resubmitted for review. This process can continue through multiple iterations. Take care to adequately address all comments that arise to expedite your approval process.

Tip: External Laboratories

When incorporating external laboratories into your QAPP, you will need to obtain multiple documents from each laboratory, including:

- *Laboratory SOP for each analyte you intend to incorporate*
- *Method detection limit (MDL) studies*
- *Quality control manual/plan for the laboratory*
- *Federal/State/Local laboratory certification*
- *Laboratory chain of custody form*

4.2 Planning and Conducting Water Quality Monitoring Events

Sampling for water quality indicators is an important tool to guide work to improve the health of a river and its tributaries.

4.2.1 Planning a Water Quality Monitoring Master Plan

Try to develop your sample plan simultaneously with your QAPP to ensure the QAPP covers all likely procedures and protocols. Issues that should be addressed in the planning phase include:

- Selection of monitoring locations
- Determination of the target number of monitoring events
- Determination of the target conditions for monitoring events
- Selection of sample parameters
- Develop protocol for rapid response monitoring

Tip: Action Limits

Even when water quality standards exist for a certain parameter, developing an action limit may require your organization to make a judgment call. The Massachusetts Surface Water Quality Standards for Class B waterways has two separate bacteria limits for primary contact: the first is based on a single sample, and the second is based on the geometric mean of five samples. CRWA selected the geometric mean criteria, which is lower than the limit for a single sample, to use as a conservative action limit for E. coli bacteria. MyRWA uses the single sample criteria as the action limit for E. coli bacteria when sampling events involve the collection of a single sample from a certain location, and the geometric mean criteria when collecting multiple samples from a single site.

Selection of Monitoring Locations

Selection of water quality sampling locations can be based on visual stream survey monitoring results, historic water quality data collected by your own agency or other trustworthy

agencies, and surrounding land use (See Text Box: Using Stream Survey Results to Select Sampling Locations). Possible sampling locations may include sensitive areas along the river's mainstem, river tributaries, outfall pipes and even areas of intense overland runoff flow. If possible, target areas surrounding redevelopment and development plans. For example, monitoring prior to and following a major development project or installation of a stormwater best management practice (BMP) could provide a very interesting case study.

Prior to determining individual sampling locations you may want to make some general rules regarding the selection and naming of sampling sites. See Table 12 for possible guidelines. Selecting ideal monitoring locations will likely require a pre-sampling site visit. Monitoring sites should be well documented, both so that sampling will occur at the exact same location during each outing, and monitoring results can be clearly linked to the location where samples were collected.

For certain monitoring locations, a pre-sampling site survey may not be possible. For example, in situations where your organization wishes to collect water samples in response to an unusual river condition, it is likely that samples will need to be collected immediately after a problem is observed. Document the exact location of 'hot

Using Stream Survey Results to Select Sampling Locations

The SAARP stream survey identifies areas where pollution is evident; water quality sampling is a good way of documenting pollution and assessing its severity. Surveyors will have identified areas where oil sheens are evident on the water, pipes are flowing in dry weather, algae is growing below pipes, bank erosion is severe, construction sites are unprotected, unnatural foam is floating on the water, and many other issues. To maximize use of your limited resources, you will likely want to prioritize the areas where you choose to conduct water quality monitoring. Select areas that are severely impaired and areas that show evidence of the most pressing issues in your watershed. For example, if erosion and sedimentation are not a major problem in your watershed, sample only areas where erosion is severe, such as downstream of a construction site, and have the sample analyzed for total suspended solids. Conversely, if nutrients are a major problem in your watershed, plan to sample at each location identified as having heavy algae growth, especially below outfalls. To prepare for your sampling outing, compile a list all possible sites you wish to target. Decide whether you with to sample during wet or dry weather. Plan your sampling outing by determining which site you will plan to target. Remember that sites may be difficult to find depending on the accuracy of the stream surveyors. Additionally, as the river is a dynamic environment, field conditions may have changed since the survey. Allow for extra time to find sites and assess the area. Be flexible; sites you originally planned to sample may show no evidence of a problem, but you may observe evidence of the same problem or a different problem nearby. Bring multiple sample bottles so you can collect samples for additional parameters if needed. If sample sites are changed in the field, make sure to clearly document the location of the new site.

spot' monitoring sites for potential follow-up and communication of results. Handheld GPS units and GIS software are extremely useful in mapping monitoring locations.

Table 12: Guidelines for Selecting and Naming Sampling Sites

Sample Site Considerations	· What is the maximum number of sites that can be sampled in one outing?
	· Should samples always be collected upstream or downstream of road crossings or vary by case?
	· When should you target outfall pipes and when should you target instream conditions?
	· When sampling tributaries, do you want to constantly target mainstem conditions upstream, downstream, or both, of the tributary's confluence with the river?
Nomenclature Considerations	· Are sampling sites identified with numbers, letter, descriptive words or both?
	· Is the name of the water body incorporated into the site name? If so, how?
	· If numbered, are sampling sites numbered upstream to downstream, or vice versa?
	· Should different types of sampling locations, such as outfall pipes, instream sites, tributary sites, and runoff sites have a distinguishing prefix or suffix?

Target Number of Monitoring Events

Municipalities, state, and federal agencies may have a minimum number of sampling events requirements for a particular site before that data can be considered in policy decisions. Review your state's surface water quality standards. Standards may be based on means, maximums or minimums of a certain number of samples. If you plan to compare your results directly with such standards to prove regulatory non-compliance, plan for the collection of an adequate number of samples. However, collecting the number of samples defined in the standards may not be necessary to get a sense of the water quality issues facing your study area. If a certain number of sampling events are required for each sampling location you target, you may have to limit your sampling locations to ensure you have adequate time and money to collect the adequate number of samples. If your organization also wishes to monitor 'hot spots', it is important to plan for time and money spent on this type of unplanned monitoring. Finally, consideration must be made for collection of quality assurance/quality control samples. If your QAPP dictates that a duplicate be collected for every 10 samples collected, factor analysis of these samples into your planning and budgeting.

Target Conditions of Monitoring Events

Plan to target most of your sampling locations in both wet and dry weather. It will be important for your organization to clearly define what is meant by wet and dry weather monitoring events (See Text Box: CRWA Water Quality Monitoring Plan). Samples collected during dry weather, following extended periods of dry weather, give an indication of the baseline quality of the river without the contribution of stormwater runoff pollution. Conversely, samples taken during rain events with rainfall amounts significant enough to cause stormwater runoff are indicative of the impact non-point source pollution has on a waterbody. When developing wet and dry weather definitions, seek guidance in the definitions of wet and dry weather in your state's water quality standards.

If you have more sites than are possible to monitor in both wet and dry weather, assess the water quality data available for each location.

"Find It and Fix It" Water Quality Monitoring Plan

Two major areas on which CRWA and MyRWA focused their initial water quality monitoring efforts conducted through the Find It and Fix It Program were tributaries and outfall pipes. Results of water quality sampling events were compiled and analyzed for trends in water quality impairment. Results were compared to state water quality standards and organizational action limits. In addition, results were compared between sites and in different weather conditions. We shared water quality results with municipal officials, property owners, CRWA and MyRWA members, the general public, and state and federal environmental agencies.

Tributary Monitoring

Many of the tributaries of the Charles River have been transformed over time as stormwater drainage areas, partially culverted or buried underground with numerous stormwater pipes discharging directly into them. Because of this, CRWA chose to focus some of our water quality monitoring efforts on these smaller streams. By monitoring tributaries, we hoped to gain insight into where the pollution in the Charles River is originating. CRWA targeted the tributaries found to be historically polluted, as determined by previous monitoring by CRWA and other agencies, and tributaries listed on the state's list of impaired waters (MassDEP, 2006b). Specific sample collection locations were determined on a case by case basis based on existing data, the extent of the reported pollution and accessibility.

Monitoring was conducted during dry weather to establish baseline conditions of previously unmonitored locations. As a follow up, CRWA conducted wet weather monitoring of these sites. Dry weather is defined by CRWA as less than 0.1 inches of precipitation within the past 72 hours. Wet weather is defined as a storm of at least 1 inch of precipitation after 72 hours antecedent dry conditions. Tributary sites were always analyzed for E. coli bacteria, total phosphorus and total suspended solids. In situations where there was evidence of other issues, additional sample parameters were also collected. For example, when oil sheens or gas odors were observed, oil and grease samples were added. In addition, in situ water quality parameters, such as pH, dissolved oxygen, salinity, conductivity and temperature were measured.

Outfall Monitoring

MyRWA sampled flow from outfall pipes in both wet and dry weather. We collected samples from every outfall pipe that was observed to be flowing in dry weather, either by stream survey volunteers or members of the public. Bacteria samples were always collected at these locations; additional parameters would be added if other suspicious conditions were observed, such as the smell of detergents, or heavy algae growth. Additionally, we targeted certain outfalls in wet weather. In areas along the river or streams previously observed to have high bacteria levels in wet weather, we targeted upstream pipes in an effort to determine the source of wet weather bacteria loading.

If an abundance of dry weather water quality data has been collected by other organizations, and includes the parameters you wish to target, your organization may be able to include this location by conducting only wet weather monitoring. Ensure their dry weather definition matches yours. Additionally, some sampling sites may be only wet weather sites, such as stormwater outfalls or areas where you are collecting stormwater runoff.

Selection of Sample Parameters

Sample parameters will depend on the pollutants of concern in your watershed, likely sources of non-point source pollution in your locality, state surface water quality standards and the laboratory analysis capabilities in your area. Again, previous water quality data is helpful in this process. Typical sources of non-point source pollution include pet waste; lawn fertilizers, herbicides and pesticides; road de-icing sand and salt; sediment from construction sites and other exposed or eroded areas; and vehicle exhaust and/or leaks. Numerous sample parameters may be appropriate to track these sources. Bacterial parameters (E. coli, fecal coliform and Enterococcus) can track problems with domestic pet waste, waterfowl waste and illegal connections of sanitary sewer lines to stormwater drainage systems. Other human waste or sewage tests, such as surfactants, fluoride, ammonia and potassium (a ratio of ammonia to potassium greater than 1 is indicative of a human source), and optical brighteners are useful in distinguishing human waste sources from animal sources. Sodium, TSS or chloride can be used to track the impact of road sanding or salting. Nutrient parameters, such as phosphorus and nitrogen, may be used to assess the impact of lawn fertilization, erosion or a high percentage of impervious area, as a parking lot with no stormwater controls.

It is also useful to target water quality testing to parameters for which local authorities have developed surface water quality standards. Evidence that surface water bodies are not in compliance with current standards is useful in effecting regulatory changes. Nevertheless, limiting your analysis to only sampling parameters for which surface water quality standards exist may not accurately capture the true effects of non-point source pollution in your region. When standards do not exist, review current research for recommended standards to develop action limits for these parameters.

Develop Protocol for Rapid Response Monitoring

Your staff cannot be in the field all hours of the day; however, your organization's volunteers, members and other stakeholders may advise you of potential problems they observe in your area of interest. A SAARP can provide the necessary funding to follow-up on these observations. Develop a protocol to follow when such a call is received, so that everyone in your office will know how to deal with these reports. Your protocol should include instructions for:

- Gathering information when a call is placed
- Procedure for follow-up observation or monitoring by staff
- Communicating potential hazards to environmental regulators or the public

Figure 14: Berm for Stormwater Sampling

4.2.2 Conducting Water Quality Monitoring

As mentioned above, conducting sampling to monitor specifically for the effects of non-point source pollution may differ from other types of water quality monitoring in sampling procedures, equipment needs and time commitment.

Sampling Procedures

Field work can be unpredictable and challenging. Prior to sending staff into the field to conduct water quality sampling, ensure that they are adequately trained in the sampling procedures defined in your QAPP. Also, make sure that staff is familiar with the sampling locations they will be targeting. If sampling locations are ambiguous, you will not be able to sample from the exactly the same location in future sampling events. Finally, make sure staff are aware of all necessary safety precautions they should take while conducting field work, and whom they should contact in the event of an emergency.

Throughout the SAARP, you will likely collect samples from multiple types of locations: centerline/in-stream, outfall pipe flow and overland stormwater runoff. Some sampling locations may be difficult to access from the bank without proper equipment. Basket sampling devises, extending sampling poles and hip waders are all useful equipment to help collect samples in difficult to access locations.

Collecting overland stormwater runoff in quantities required for laboratory analysis can also be a challenge. This may require some unique sampling techniques. Berms and funnels can be used to collect overland stormwater runoff into pools for sampling. Berms can be purchased or constructed by filling a length of PVC piping with sand or some other weighting material. During heavy rain events, berms can be placed on sloping surfaces to pool overland flow, so that samples can be collected. The height of the berms must be adequate to create a deep enough pool from which sample bottles can be filled. (See Figure 14).

Figure 15: Distilled Water Jug Funnel

Funnels can also be created by cutting off the bottom of a distilled water jug (See Figure 15). These can be used to scoop up stormwater runoff, which can then be poured into sampling bottles. Be advised that berms and funnels both have the potential to contaminate your sample and need to be washed with low-phosphate or phosphate free soap in the field between uses to prevent cross contamination. Proper techniques for use of this equipment should be in your QAPP.

Wet weather monitoring can be challenging. Waterproof paper is necessary to record data and observations. Sampling bottles may need to be pre-labeled in a dry environment, since wet bottles are difficult to label. Unlabeled bottles are of no use. Finally, if a certain tributary or river section has more sites than one sampling team can target during a sampling outing, especially if you are limited by weather conditions and laboratory closing times, it may be necessary to split up the sites and send multiple sampling teams into the field.

Equipment Needs

Conditions can change significantly in wet weather; therefore, despite having conducted pre-sampling site visits, your intended sampling methodology may not be appropriate. Field work requires flexibility and preparation for a myriad of contingencies. See Table 13 for a recommended list of field equipment for water quality sampling.

Table 13: Field Equipment Needs for Water Quality Monitoring

- *Directions to sampling sites*
- *Map of sampling sites*
- *Road map of area*
- *Camera*
- *Sampling bottles (enough for field duplicates and extras in case of loss or contamination)*
- *Latex gloves*
- *Waterproof field notebook*
- *Pencils/pens for data collection*
- *Sharpies for labeling sampling bottles*
- *Data sheets*
- *Waders*
- *Cooler with ice*
- *Weighted sample collection basket*
- *Extending sampling pole with fastener rings or duct tape*
- *Instrument to measure In situ parameters (YSI, pH meter, etc.)*
- *Bucket*
- *Instrument for measuring water depth*
- *Berms**
- *Funnels**
- *Phosphate-free soap and brush for washing berms and funnels in the field**
- *Laboratory chains of custody*
- *Hand sanitizer*
- *Calibration supplies if recalibration is necessary in the field*
- *Rain gear**

**Specific to wet weather events*

Follow-up Monitoring

As sampling events take place and you begin to review your data, it may be appropriate to revise your sampling master plan. If certain sites are showing minimal to no impact of stormwater pollution, and others are showing significant impacts, it may be appropriate to focus more thoroughly on sites where significant impact is occurring, especially if your resources are limited. Conversely, instead of abandoning sites with minimal stormwater impact, it may be more appropriate to retarget such sites during different weather conditions or different seasons. If wet weather monitoring events have primarily occurred during the falling limb of a storm, it may be preferable to plan the next wet weather monitoring during the first flush or peak of the storm, or both. Additionally, as problems associated with stormwater pollution can be seasonal, such as the effects of road de-icing materials or lawn fertilizers, it may be ideal to target certain areas for follow-up during particular seasons. Finally, consider changing sampling locations to attempt to track the source of a problem or add additional sampling parameters to learn more.

Time Commitment

Weather-dependent monitoring requires regular monitoring of the weather to plan sampling events accordingly. Additionally, this type of monitoring requires a considerable

amount of flexibility. Monitoring events will likely be scheduled and cancelled on very short notice as the weather changes. Depending on the climate in your area, if heavy rain events are rare, sampling may need to occur during early morning, evening or weekend hours. Make sure you know laboratory drop off hours to ensure that samples are delivered to the lab within the required holding time. If you anticipate after hours sampling will be necessary, make sure to include a laboratory in your QAPP with evening and weekend hours. Ensure that you have the staff time available to regularly check the weather, and the flexibility to monitor on short notice and outside of regular office hours. Finally, if samples are to be collected from overland runoff flow or directly from outfall pipes, timing the exact moment of sample collection, so that it coincides with a period of heavy downpours, may require a considerable amount of patience.

Bacteria Source Tracking

In response to high bacteria results from sampling conducted during the SAARP, MyRWA developed a bacteria source tracking program to determine the source of bacterial contamination to the surface water body. Fecal indicator bacteria can originate from wildlife waste as well as human waste, so additional monitoring is often required to determine whether or not the source is human. Additionally, it is helpful to have multiple types of evidence when presenting a problem to municipal representative or enforcement agencies.

The first step in our bacteria source tracking study was to attempt to determine where bacteria may be entering the river. To do this we conducted site visits and consulted maps of sanitary sewer and stormwater drainage systems. During site visits we would walk the area upstream of our sampling point, noting areas with sewage odors, pipes flowing in dry weather or other signs of contamination. Sewer and stormwater drainage system maps were useful in locating outfall pipes.

The second step was to develop the follow-up sampling plan for the area. Sampling sites were selected based on our review of sewer maps and the site visits. Additionally, we would determine which parameters to sample. This often meant adding parameters such as surfactants, fluoride, ammonia and potassium (a ratio of ammonia to potassium greater than 1 is indicative of a human source), and optical brighteners.

Using this technique, we were able to locate a culvert where a tributary emerged from underground with high levels of optical brighteners, a component of laundry detergents. We presented this data to municipal representatives to alert them of the problem and advocate for an investigation into the source of the contamination.

Figure 16: Excel Worksheet with Tributary Data

CRWA Water Quality Monitoring
Sawins Brook, Watertown
9-Nov-06, Wet Weather

Site	Date[1]	Time	*E. coli*	Total Suspended Solids	Total Phosphorus	Barometer[3]	Temperature	pH	Specific Conductivity	DO	DO	Salinity	Depth
		(HHMM)	(cfu/100mL)	(mg/L)	(mg/L)	(mmHg)	(°C)	(Units)	(µS/cm)	(mg/L)	(% Sat)	(ppt)	(ft)
SAW1	9-Nov-06	9:12	1600	<1	<0.01	750.5	13.50	6.80	847.7	7.69	75.3	0.44	0.85
SAW2B	9-Nov-06	9:28	1700	<1	<0.01	750.5	12.92	6.64	459.4	7.30	70.4	0.23	1.15
SAW3	9-Nov-06	9:50	1800	<1	<0.01	751.4	12.54	6.61	238.3	7.90	75.5	0.11	0.60
SAW4[2]	9-Nov-06	10:18	880	3.5	<0.01	751.7	12.47	6.65	408.6	5.89	56.2	0.20	1.30
SAW5	9-Nov-06	10:46	420	<1	<0.01	750.7	12.26	6.77	385.3	5.77	54.8	0.19	0.90
SAW6	9-Nov-06	8:45	720	3	<0.01	750.6	8.89	6.87	275.4	9.79	86.0	0.13	-

[1] This was a wet weather monitoring event, meaning greater than 1 inch of rain fell in the previous 24 hours at Logan Airport.
Total rainfall in the previous 24 hours at Logan Airport was 1.27in.
Total rainfall in the previous 48 hours at Logan Airport was 1.41in.
Before precipitation started, there were 5 days of dry weather.

4.3 Data Management, Analysis and Reporting

Managing, analyzing and reporting data are the final essential pieces of a water quality monitoring program. How to manage and present data and whom to present it to will be a direct result of your program's goals.

4.3.1 Data Management

Your QAPP should include clear procedures for data reporting, handling, management, tracking and control. Be sure to assign someone the task of obtaining the data from the laboratory, entering it, and filing it appropriately. Data needs to be stored accurately and in a clear, useful format. There should be no ambiguities in your data regarding when and where it was collected, what unit a value is in, and which parameter a value is measuring. Numerous databases provide means for clear, concise data storage; however, it can also easily be accomplished with Microsoft Excel (See Figure 16).

All data should be stored in multiple forms and backed up. Data collected in field notebooks should be transferred to standardized data sheets and filed by site. See Appendix for sample data sheet. If the field notebook is lost on a subsequent sampling outing, you will still have a hard copy of the data. Likewise, data stored electronically in a database or Excel spreadsheet should also be backed up. Unfortunately, copying data and entering data into an electronic format are both potential error introduction points. Your organization should designate a Quality Control Officer to review data after it is transcribed from field notebooks or external laboratory data reports to your own data sheets to ensure there are no transcription errors.

Another piece of data will be photographs taken in the field during sampling events. Photographs should be reviewed and labeled immediately following sampling events. If you wait days

or weeks before labeling photographs, it may be difficult to recall where each photograph was taken, and it is likely that some sampling sites may look similar. Organize photographs by the date of the sampling event, and label photographs with the sampling site where they were taken and any descriptive notes.
Data should be tracked through the collection, analysis, transmittal, and data entry phases. Field notebooks, data sheets, chains of custody, laboratory reports, printouts from data spreadsheet files, and the final report should be stored in the central files on your premises for the duration of your SAARP, and then archived indefinitely.

Data from sampling events that occur in response to notification of a problem, spill or unusual condition can present a special challenge if no protocol is set up in advance. Develop a protocol for tracking and storing data collected in these types of situations, including designating a centralized location where this data will be stored. Even if data is traditionally stored by location, consider storing all data from one time monitoring events in one location, so that results are easy to find. By storing results in a common location, when staff is notified of a problem, there is one place to look to see if your organization has previously been advised of, or responded to, the same issue.

4.3.2 Data Analysis

State and federal surface water quality standards are very useful benchmarks to compare your data against. Even in situations where an inadequate number of samples were collected to permit direct comparison (for example, when a standard is the mean of ten samples), these standards can still serve as a guide for high, moderate and low values of certain parameters. If your monitoring plan includes analysis of parameters for which your state has no surface water quality standard, compare results to your organization's action limit. Make sure to always document the source of your action limit.

Compare results from dry and wet weather outings to illustrate the impact of non-point source pollution. Compare results between sites and over time. Sites where parameters consistently measure much higher or lower than other sites in the area are likely indicative of a specific problem. In this situation consider adding sampling sites in the problem area to help determine the source of a problem. By comparing water quality data over time, it may be possible to quantify the effects of changes in your watershed, both improvements and declines. This will be especially relevant in situations where monitoring sites were chosen because of their proximity to development projects or BMP installations.

4.3.3 Preparing Data for Reporting and Distribution

Water quality data collected during the SAARP will likely be of interest to numerous agencies and organizations operating in your area, so sharing data should be an important goal of your project. Moreover, if your agency does not have regulatory authority, it is imperative to share data with local municipal governments, state agencies and your regional EPA office. See Chapters 5 and 6 for further discussion of distributing data and follow-up work.

Prior to reporting data, it is essential to perform quality control measures on your data. Review all data sheets, chains of custody, and data reports to ensure that the requirements for sample holding times, sample integrity, data quality assessments, and equipment calibration have been met. Re-examine field notebooks for any notes indicating that recorded values may be erroneous; for example, notes about instrument calibration or deviations from standard operating procedures. When recorded values are questionable, you will need to make a decision about whether or not to report them.

Figure 17: Excerpt from Data Quality Objectives Table as included in CRWA's QAPP

QC SAMPLE	FREQUENCY	ACCEPTANCE CRITERIA	DATA QUALITY INDICATORS	QC ACCESSES SAMPLING (S) and/ or ANALYTICAL (A) ERROR
Nitrate				
Field Duplicates	10% of samples	Within ±25% for values >0.5 mg/L; ±50% for values <0.5 mg/L	Precision	S & A
Laboratory Duplicates	10% of samples (min. of 1 per batch)	Within ±25% for values >0.5 mg/L; ±50% for values <0.5 mg/L	Precision- Lab	S & A
Laboratory Matrix Spike	10% of samples (min. of 1 per batch)	Between 80% and 120% recovery	Accuracy	A
Laboratory Blanks	1 per batch	< detection limit	Accuracy/bias Contamination	A
Equipment Blanks	5% of samples (if sampling equipment is used)	< detection limit	Accuracy/bias Contamination	S & A
Nitrite				
Field Duplicates	10% of samples	Within ±25% for values >0.5 mg/L; ±50% for values <0.5 mg/L	Precision	S & A
Laboratory Duplicates	10% of samples (min. of 1 per batch)	Within ±25% for values >0.5 mg/L; ±50% for values <0.5 mg/L	Precision- Lab	S & A
Laboratory Matrix Spike	10% of samples (min. of 1 per batch)	Between 80% and 120% recovery	Accuracy	A
Laboratory Blanks	1 per batch	< detection limit	Accuracy/bias Contamination	A
Equipment Blanks	5% of samples (if sampling equipment is used)	< detection limit	Accuracy/bias Contamination	S & A

Where field duplicates were collected, it is helpful to report the relative percent difference between a sample and a field duplicate. Review your data to ensure all data is meeting the quality objectives established in the QAPP (See Figure 17).

Your project will likely generate a large amount of data; it may not be appropriate to provide all your data to every local municipality, environmental agency or organization operating in your area of study. Instead, try to divide your data geographically by town, city, county or other relevant geographic area. In this way you can easily provide municipalities, agencies and organizations with only the data relevant to their jurisdiction or area of interest.

When sharing data, it is useful to present as complete a picture as possible. It is useful to include a narrative which briefly describes the goals and extent of your program; highlights the key points of the data being presented, details your organization's analysis of the data; and further describes any field conditions observed that are not obvious from the data. Such field conditions may include upstream conditions, water discolorations or odors. Finally, your narrative should provide recommendations for remediation plans. Naturally, any and all water quality parameters including in situ measurements should be shared. In addition to simply providing the data in numerical format, use graphs or charts to display the data visually, including state water quality standards or action limits set by your agency. This is useful to visually indicate where water quality violations are occurring (See Figure 18).

Maps and descriptions of sampling sites should also be included to provide a complete understanding of the data. Maps of water quality monitoring sites assist in visualizing where problems are occurring. Photographs taken while sampling should also be included to assist in displaying field conditions.

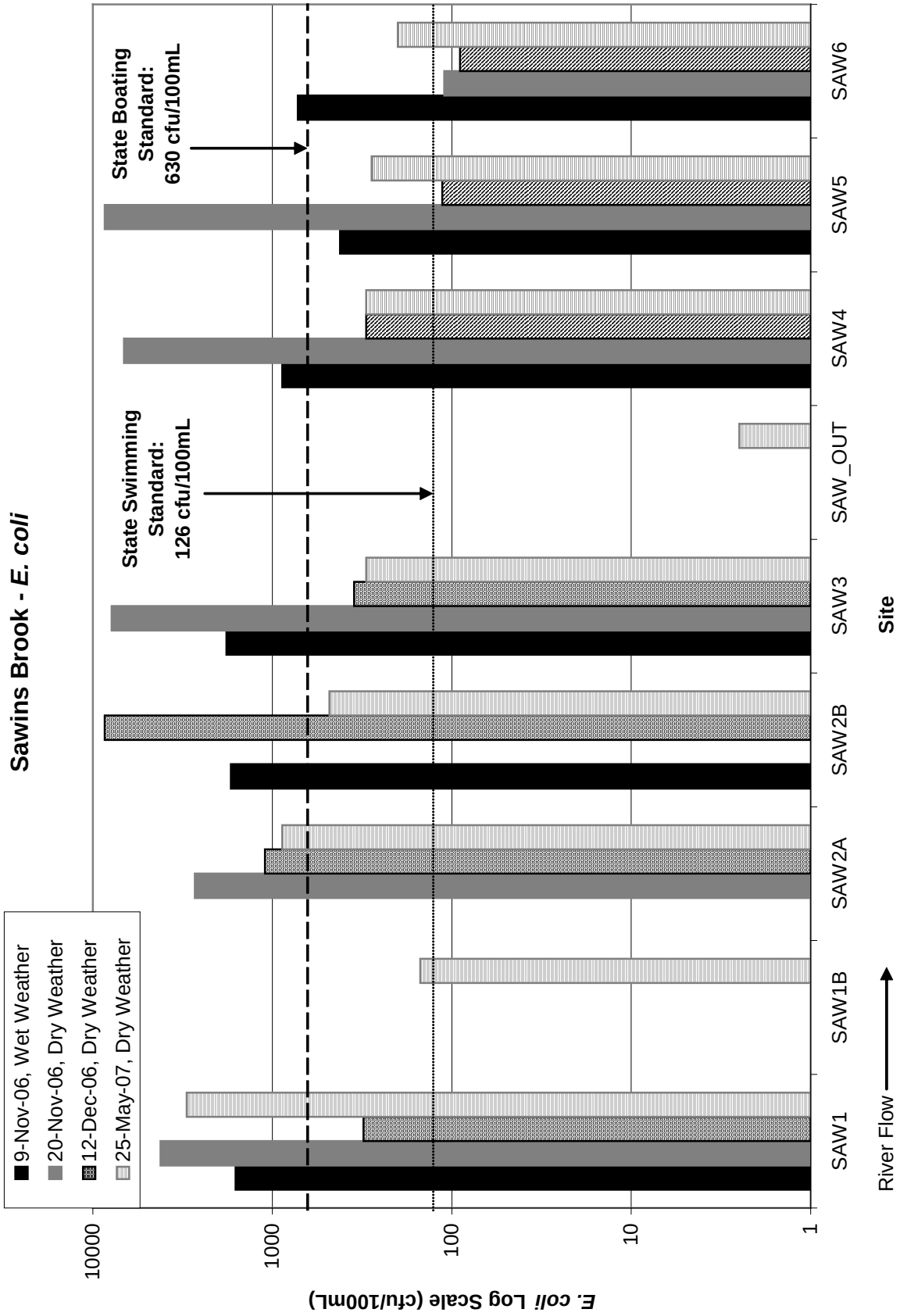
MyRWA's Data Reports

As part of the Find It and Fix It project, MyRWA developed a new data report format. We sought to develop a format which would:

- *Present data in multiple ways (i.e. graphs, maps, tables, narratives)*
- *Project a professional look and feel*
- *Provide a consistent and thorough analysis of the problems being explored*
- *Provide concrete action steps for follow up work*
- *Constitute a concise document which we could easily reference when presenting problems to appropriate stakeholders*
- *Present data in a format that could be shared with the general public through our website*

To develop this new data report format, we reviewed formats used by other watershed organizations and environmental groups. Based on these example reports and our established goals, MyRWA developed a standardized data report format. An example of MyRWA's Data Report format is included in the Appendix. Although we are very happy with this format, it takes many hours to prepare each report. In the future, we may move away from preparing a data report for each sampling event and instead establish a protocol for preparing reports after a certain number of sampling events.

Figure 18: Example of Graphed WQ data



Chapter 5:
Assisting Remediation through Municipal Partnerships

Through the shoreline survey and water quality monitoring elements of your program, it is likely that a large number of problems will have been identified throughout your watershed or area of concern. Despite the increased emphasis on stormwater pollution to our nation's waterways through regulation of some stormwater discharges, many surface waterbodies still suffer from pollutant-laden discharges. Many municipalities and other operators of stormwater drainage systems are struggling to meet these regulatory requirements. Municipal stormwater management programs designed to address these issues require capital improvement projects, operation and maintenance of stormwater drainage systems, pollution prevention measures, effective public education and outreach, and highly trained staff. Your organization can assist struggling municipalities not only by providing monitoring data but also in making decisions about the best way to address these problems by providing advice and assistance on remediation projects.

The ability to promote and conduct remediation work will likely vary depending on organizational capacity and funding. Nevertheless, many very simple steps can be taken to address issues or assist others in addressing them. Activities such as providing data to, meeting with, and planning educational opportunities for relevant regulatory officials can all be accomplished with a moderate amount of staff time. A central aspect of conducting and promoting remediation should be researching and promoting the use of low impact development stormwater best management practices (BMPs). Many of these practices are appropriate for retrofits of existing infrastructure and can be installed at similar or lower costs to traditional stormwater infrastructure.

Tip: Labor Hours

CRWA and MyRWA each dedicated approximately 1000 hours to working with municipal officials to promote intelligent remediation.

Tip: Assisted Remediation

Working with municipalities and other partners to leverage the remediation work of others will allow you to address multiple issues throughout your watershed areas without exhausting limited resources. CRWA and MyRWA primarily concentrated on this approach. Had our organizations attempted to plan and execute remediation of the issues we observed using solely our own resources, our accomplishments would have been limited.

There are many ways to remediate problems you have identified in your work. It may be helpful to develop a matrix of remediation projects you have identified, listing who might undertake the projects, how they might be funded, and how high a priority they are (Table 14). This can

Table 14: Sample Remediation Projects Summary Matrix for the "Beautiful River"

Project Description	Project Lead	Budget	Funding source	Start	Finish	Priority
Major Infrastructure Repairs						
Repair collapsed headwall and pipe at School Street	DPW	$5m	Capital budget			Medium
ID and remove suspected illicit connection to Chestnut Street drain	Sewer Department	$10k	Operating budget			High
Add hoods to catch basins in drain 5 tributary area to reduce oil and grease and other floatables in stormwater	DPW	$200k	Capital budget			Medium
Daylight 800 feet of Beautiful Brook currently in box culvert	Park and Rec Department		Grant from state plus capital budget			Low
Shoreline Improvements						
Stabilize eroding banks at Beautiful Road bridge	Beautiful river conservation organization	$75k	Grant from state program			High
Remove invasives and plant diverse native species at Beautiful Meadows wetland	Beautiful Garden society	$8k	Garden society funds and volunteer labor			Low
Plant trees to shade and cool river along shoreline in Beautiful Park	Beautiful Boy Scout troop, with Park and Rec leadership	$5k				Low
Clean up excessive litter, old tires, dumped materials along Beautiful River near highway	Town-wide volunteer day event	$4k	Volunteers w/ support from town DPW - trash pick-up, gloves, drinks			Medium
Site-specific improvements						
Plant biofiltration areas to reduce runoff and erosion from Beautiful market parking lot	Beautiful Market, as part of market expansion project	$25k	Beautiful Market			Medium
Move parking lot at Beautiful Mall 50 feet back from riverbank and plant native vegetation	Beautiful Mall	$70k	Beautiful Mall, with grant from state			Medium
Repair eroded footpath to shore and construct small dock at Beautiful Boat launch	Beautiful River Canoe Club	$6k	Donations			Medium

Table 14, continued: Sample of River Remediation Projects Summary Matrix

Project Description	Project Lead	Budget	Funding source	Start	Finish	Priority
Remove direct connection of runoff from Beautiful car wash	Beautiful river conservation organization		Grants from Rotary Club, Chamber of Commerce, Fishermen's group			High
Outreach and Education						
Better lawn care workshop	Beautiful Garden society	$800	Grant			High
Downspout disconnection program	DPW	$0	Staff time			Medium
Brochures about raingardens and other do-it-yourself techniques	Beautiful river conservation organization	$500	Grant			Medium
New Initiatives						
Pilot green street projects	DPW	$250k	Capital budget			Medium
Purchase Vacuum street sweeper	DPW	$175k	Capital budget			High
New stormwater bylaws	Town Conservation Department	$0	Staff time			Medium

help bring multiple partners together to help solve problems, and gives everyone a sense of ownership in the process, as well as developing a way to track progress. This matrix may be similar to the one you created when developing your Action Steps, however; this matrix should deal more specifically with individual problems in various locations and suggest an explicate action plan for each site.

Remember that different parties can undertake different projects. Some work can only be undertaken by Public Works Departments or regional Water and Sewer Commissions, such as repairing broken pipes. Some work can be undertaken by volunteers, such as cleaning up litter. Some work can be undertaken by a private property owner as part of a redevelopment project. River and conservation organizations can obtain grant funding to undertake some work themselves.

Remember that you can also make meaningful change through education, as many people will voluntarily change their behavior if they see it will make a difference and it is relatively easy.

5.1 Research Remediation Strategies

In planning your SAARP, make sure to dedicate labor hours to building organizational knowledge on remediation strategies. Once your visual stream survey and water quality monitoring have been partially or fully completed, identify the most common and most severe problems observed in your area. In preparation for communicating your results and beginning to advocate for change, it is effective to familiarize yourself with the most up to date information regarding stormwater remediation efforts to address the problems observed in your area. Research methods of

Table 15: Summary of Assisted Remediation through Working with Municipal Officials

Step	Description
Research stormwater remediation strategies	· Research what is being done in your area and around the country to address stormwater runoff
	· Become familiar with stormwater financing mechanisms
	· Become familiar with low impact development (LID) stormwater best management practices (BMPs)
	· Become familiar with pollution reduction strategies
Share stream survey results with municipal officials via written reports	· Determine to whom data should be sent
	· Create written reports by municipality, county or other relevant area
	· Schedule follow up meetings
Discuss stream survey results with municipal officials in person via public presentation or private meeting	· Detail specific problems
	· Show photographs of specific problems
	· Obtain information from officials regarding possible explanations for certain issues
	· Make remediation recommendations
	· Learn about the municipalities stormwater control program
	· Discuss follow-up actions
	· Discuss partnerships
Share water quality sampling results with municipal officials through written reports	· Perform all necessary quality control and quality assurance steps on data
	· Determine to whom data should be sent
	· Create written reports by municipality, county or other relevant area
	· Schedule follow-up meetings
Discuss water quality sampling results with municipal officials in person via public presentation or private meeting	· Summarize results
	· Obtain information from officials regarding possible explanations for the results observed
	· Learn about known water quality issues and their causes in the local community
	· Learn what, if anything, is being done to address water quality issues in the community
	· Discuss possible remediation projects
	· Discuss opportunities to partner on public outreach and education campaigns
Plan educational workshops and field trips	· Target relevant speakers or destinations
	· Invite municipal contacts

Tip: Stormwater Financing Mechanism Resource

In 2007, CRWA published a case study entitled Assessment of Stormwater Financing Mechanisms in New England. This report discusses the stormwater financing mechanisms in Newton and Reading, MA and South Burlington, VT. This report is available through our website: www.charlesriver.org. (Click on Projects/Stormwater Financing)

addressing these issues in order to learn what is being done; what is effective and what is not.

This task is as an opportunity to build a database of information on non-point source pollution remediation strategies. This database can take many forms, and you may actually prefer to develop multiple databases or develop the information into educational materials for distribution. In the early stages of your research, determine what format you want your research to take, since research may vary depending on whether or not you plan to develop material for distribution, or simply develop an information database for in-house use. This chapter and the next will discuss some specific remediation strategies; however, this guidebook is not intended as an exhaustive resource of remediation strategies.

5.1.1 Stormwater Financing Mechanisms

Familiarize yourself with strategies used to specifically fund stormwater remediation and control. If communities in your area have implemented a stormwater user fee or utility, contact individuals in that community to learn more about how their financing mechanism works and what the implementation process was like. First hand knowledge of developing and implementing these mechanisms, and the challenges involved in implementing them is useful to other communities considering a stormwater financing mechanism. Your organization can serve as a resource for these communities.

5.1.2 Low Impact Development Stormwater Best Management Practices

Presently there are numerous technologies available to help collect and treat stormwater runoff before it enters surface water bodies,

CRWA's LID BMP Matrices and Information Sheets

In conjunction with other projects, CRWA developed matrices and information sheets to relate information about LID BMPs. These technologies vary considerably in their cost, effectiveness and siting requirements. Because of this, we designed matrices to compile information on numerous BMP technologies. Matrices are designed to allow interested parties to easily compare these technologies across a variety of characteristics. The information sheets were developed for specific BMPs which we felt were particularly appropriate for use in our watershed. These full-color two-sided sheets provide a brief overview of the technology in an easy to read non-technical format. These info sheets were distributed to municipal officials with SAARP results when appropriate. See Appendix for Info Sheets.

or to filter and infiltrate it into the ground as groundwater. The SAARP is an opportunity to build a database of information on these technologies, so your organization can promote them. If communities in your area traditionally utilize traditional stormwater collection strategies to collect stormwater and funnel it to surface waters with little or no treatment, you may want to develop outreach materials built around some specific low impact development stormwater best management practices. See Appendix for information sheets developed by CRWA to highlight some of the BMPs particularly well suited to urban and suburban areas.

5.2 Data Distribution

As discussed above, shoreline survey and water quality data will be shared with local officials and other interested parties. Table 16 summarizes what the final data report formats discussed in Chapters 3 and 4.

Deciding exactly whom to distribute your data to may take some research and careful consideration. While reviewing and analyzing your data, you likely identified numerous problem areas. In some cases the source of the problem might be quite clear while in others, it will not be. Every effort should be made to distribute data to the agency or body that has the authority to address the issues you have identified. Recall that NPDES regulations require nearly every medium and large municipality to reduce the discharge of polluted stormwater into surface water bodies to the "maximum extent practicable" (US EPA, 2000). Your data may show that stormwater is carrying significant amounts of pollution into local waterbodies. Therefore, data should be shared with the local agency that manages the stormwater drainage system; this will likely vary by town and may be the Public Works Department, the Engineering Department or another agency all together. Data should also be shared with the state or federal agency that issues stormwater permits. Not all pipes flowing into a surface waterbody belong to municipalities. Private entities and state agencies also operate stormwater drainage systems. To ensure data is getting to the right party, review sewer and stormwater drainage maps, when available, to determine the owner of pipes. For stormwater drainage systems controlled under Phase I or Phase II of NPDES, the appropriate contact person can be found on the NPDES permit. This is usually accessible online. Additionally, there are likely to be

Tip: NPDES Permits

In some states stormwater permits are issued by the state; in Massachusetts permits are issued directly by the EPA.

Table 16: Data Reports for Visual Shoreline Surveys and Water Quality Monitoring

Results	Report
Visual Shoreline Survey	1. Written memo introducing your SAARP, summarizing results, suggesting action steps and requesting a follow up meeting
	2. Map showing location of specific problems
	3. Table describing specific problems to accompany map
	4. Photographs of problems
Water Quality Monitoring	1. Written memo reintroducing your SAARP, summarizing results, highlighting key issues and suggesting a follow up meeting
	2. Map of sampling sites
	3. Sampling results
	4. Graphs of sampling results with relevant water quality or action limit level noted
	5. Photograph taken during field outings

numerous environmental agencies that have jurisdiction in your area of study, including local or regional conservation commissions, state environmental and stormwater agencies and, of course, the EPA. Targeting agencies that are bound by regulations to address these problems is often a good way to see results.

Data should also be shared with land owners, especially those who own a significant amount of land or benefit directly from a healthy river. For example, if the river is abutted by a considerable amount of parkland or flows through a state park, forest or preserve, data should be shared with the management of these areas. Finally, agencies or organizations that have provided you with data, equipment, advice, training or funding may also be interested in the data you have generated. Sharing your data will only help to further encourage partnerships you have formed through the SAARP.

5.3 Meetings and Presentations

Beyond presenting data in paper format, it is also constructive to meet with regulatory officials to discuss results in person, learn more about what is being done to control stormwater and provide some guidance on implementing stormwater best management practices. After distributing data to municipal officials or private entities, make every effort to schedule one-on-one meetings with representatives from these parties. Individual municipalities may have specific externalities that affect the water quality in their area that you may or may not be aware of. Town or county officials may be able to offer explanations for some of the water quality results observed.

Additionally, meetings can be a good time to forge partnerships with municipalities and plan joint remediation work. If your organization has the expertise and the capacity, it may even

Tip: Meeting Minutes

Make sure to take notes at every meeting with municipal officials. These will be useful to review throughout your SAARP for items requiring follow-up actions.

MyRWA's Data Distribution Protocol

When distributing data that indicated infraction in water quality standards, MyRWA typically distributed water quality data in two rounds. First, we would share data with the relevant municipality, agency or private entity. Contacts for the first round of data distribution typically included Town Engineers, Department of Public Works Directors, Town and City Boards of Health, or for privately owned pipes, the contact listed on the National Pollutions Discharge Elimination System Permit (assuming we were able to correctly identify the pipe).

We would inform these parties that the data would be made public in 30 days. Following a 30 day period, we would commence the second round of data distribution, sending the data to regulatory agencies, Conservations Commissions and other stakeholder groups. We distributed data in this manner as a courtesy to the municipalities (or other party). This way the municipality could investigate the situation and be prepared to respond if they were contacted by regulatory agencies or outside entities.

Municipal Official Perspective
Contribution by Maria Rose, Newton, MA
Department of Public Works, Engineering Division

"The information provided by CRWA during their Find It and Fix It program has proved to be particularly useful to Newton because we have so many brooks to monitor, and hundreds of miles of drainage infrastructure to maintain. Thus, any data collected by CRWA helps us to focus an investigation within a manageable segment of our vast network of storm drains, main drainage pipes, culverts and open stream channels. Finding the problem can be more difficult than it seems because we have a lot of old infrastructure here in Newton; and the added challenge of addressing underdrain contamination. Underdrains are small, separate pipes located a foot or so beneath sanitary sewers in areas where high groundwater proved to be a challenge for construction – back in the first half of the last century. Over time, the deterioration of old clay sewer pipes has become a source of bacteria contamination (to our brooks) in areas where underdrains are co-located, this typically occurs seasonally when the groundwater level is high.

After reviewing the phosphorus data collected from Cheesecake Brook, I was inspired to host a lawn care workshop featuring ecological grasses that do not need fertilizers or much water to flourish into a beautiful landscape. The elevated phosphorus levels in Cheesecake Brook during a heavy rainfall event also led us to work with a group of high school students who have developed a flyer on the ill-effects of fertilizers. The flyer was distributed to Newton residents visiting our recycling center."

Newton has enjoyed working with CRWA on this and other related initiatives to further the health and sustainability of the Charles River."

be possible to partner with a municipality in the development and installation of stormwater BMPs. Conversely, you may wish to partner on lower budget solutions, such as developing education materials to distribute to residents. (See Appendix for examples). Regardless of how your organization moves forward, relationships with municipal officials are very valuable if your organization wishes to be a part of the remediation process.

In addition to one-on-one meetings with municipal officials, you may also want to present your data to the public at town or conservation commission meetings. Conservation commission members or private citizens can be powerful partners in conducting remediation work.

5.4 Workshops and Field Trips for Municipal Officials

Meeting with public works and other municipal officials may not lead directly to remediation. While your organization may not be able to convince local municipalities to address every issue you have identified, nor will municipalities

likely have money to do so, you can provide resources to educate officials about stormwater issues and long-term remediation strategies. A SAARP should include facilitation of field trips and workshops where these methods can be further explored by local municipal stormwater officials. Workshops can be an opportunity to inform as well as a time to forge new partnerships or strengthen existing ones. Table 17 provides a list of suggested topics for a stormwater workshop and field trips aimed at municipal officials.

Tip: Leaky Sewer Pipes

In many New England communities aging infrastructure, such as leaky sewer pipes, cause water quality problems. Town officials may be able to provide information about specific situations in their area, which cause problems, and what is being done to address these problems.

5.5 Conducting Remediation Work

A SAARP focuses on identifying problems and assisting in their solution. In some cases this may mean expanding your work beyond informing and educating to conducting actual remediation work or partnering with a local municipality or state agency to directly address some of the problems identified. Most non-point source pollution problems are large scale problems that cannot be solved by one organization, municipality or agency. For this reason this guidebook has stressed the importance of sharing data and partnering with other organizations and agencies, especially those best situated to effect large scale changes and advocate for intelligent, long-term solutions. Nevertheless, there are many actions your organization can take to begin to remediate the problems identified. In fact, many of the volunteers involved in your program may be eager to be involved in remediation efforts. If your organization has previous experience in planning volunteer work parties, consider planning a clean up, invasive plant removal or bank restoration work party.

Table 17: Workshops and Field Trips for Municipal Officials

Topic	Presenter	Field Trip
NPDES Phase II Permits	Representative from the permitting authority	
Targeting remediation projects from SAARP results	Representative from your organization	Remediation project conducted in response to SAARP results
Low Impact Development Stormwater Best Management Practices	Experts from local universities, state or federal environmental agencies, engineering/consulting firms or other non-governmental organizations	Low impact development best management practice research center or functioning low impact development best management practice
Grant funding for remediation opportunities	Representative from the funding agency	
Stormwater Financing Mechanisms	Representative from a community with stormwater financing mechanism	

Additionally, your organization may be able to play an active role in any remediation efforts planned by municipalities or stateag encies. After presenting your results to municipalities and regulatory agencies, keep communication lines open so that you are aware of

Remediation Work in Response to Find It and Fix It Program

MyRWA stream survey volunteers discovered a plume of sediment flowing from an outfall pipe into Spy Pond, a pond located in Arlington, MA which is used for boating and other secondary contact recreational activities. On further investigation, MyRWA determined flow from this pipe also had unacceptably high bacteria concentrations. After consulting a map of local outfall pipes, we determined that the pipe was owned by the Massachusetts Highway Department (MassHighway) and also collected stormwater runoff from the towns of Belmont and Arlington.

MyRWA organized a meeting of MassHighway officials, and town engineers, planners and DPW directors from Arlington and Belmont to discuss this issue. During the meeting, MyRWA presented our findings. Additionally, we advocated for MassHighway to implement BMPs along the highways being drained by this pipe in order to reduce sediment loading to the pond. We also assisted the three stakeholder groups in developing a plan for identifying the source of bacteria contamination to Spy Pond.

any remediation work planned in response to the information you present. Your organization may be able to be involved in guiding, supporting or publicizing the remediation. Regardless of your involvement in remediation, however, you will certainly want to follow up on the types of remediation being performed in response to your data. This will enable you to track the impact of your program.

Tip: How to Plan a Clean-up

CRWA developed a "Guide to Organizing a River Cleanup" which is available in the Appendix and through CRWA's website: www.charelesriver.org.

Funding for your stormwater program may be inadequate to fund actual remediation work or this may not be an original goal of your program. However, developing and implementing an implementation project may be an obvious next step to build upon your SAARP work, once your program is completed. In Massachusetts, the Department of Environmental Protection offers Section 319 grants solely to fund remediation work. By developing remediation plans and partnerships with public or private entities in your stormwater remediation program, it may be an easy and obvious next step to seek funding for such a project.

CRWA's University of New Hampshire Stormwater Center Field Trip

During the third year of the Find It and Fix It Program, CRWA led a field trip to the University of New Hampshire's (UNH) Stormwater Center. This field trip was targeted to municipal officials, and CRWA extended an invitation to every municipal official whom we had previously contacted throughout the course of our Find It and Fix It Program. Although there was a charge for individuals to attend, CRWA used FIFI funds to help keep the cost affordable. The attendance fee included breakfast, lunch, transportation to and from UNH and admission to the Stormwater Center.

The UNH Stormwater Center provides semi-controlled testing of stormwater management practices. The Center implements various stormwater management practices throughout their facility and tests their effectiveness. The facility provides visitors the opportunity to learn about various technologies, view stormwater technologies in action and see results of field tests. Field trip participants observed 15 different stormwater BMPs, varying from the conventional to the more innovative designs, and learned about their effectiveness in removing pollutants and reducing peak stormwater flows. In addition, presentations were made by the City of Newton on their stormwater user fee and by EPA on the upcoming revisions to the NPDES Phase II Stormwater Permits.

Chapter 6:
Assisting Remediation through Public Education and Outreach

Due to the nature of non-point source pollution, many problems will likely be best addressed through a combination of government action and lifestyle changes. Encouraging the residents of your watershed to alter their behavior can be very difficult. Additionally, communicating the results of your stormwater program with a general audience will certainly vary from the way you communicate them with stormwater officials or environmental regulatory agencies. Reaching your watershed residents can be accomplished in a number of ways such as educational brochures and handouts, storm drain markers, public presentations or workshops, appearances on local television programs, websites, and articles in newspapers or other publications.

6.1 Educational Materials

Publishing educational brochures and handouts can be an effective way to reach a large number of people. Educational materials can take many forms, and content will vary significantly depending on your intended audience. As mentioned above, municipalities may be interested in partnering with your organization to develop such materials targeted specifically at their residents, since public education and outreach are required by NPDES Phase II permits. When developing printed materials, it can be a challenge to simplify your message, so it is clearly understood by a general audience. Using pictures, diagrams and a minimal amount of text often captures people's attention better than long-winded explanations or complicated charts and graphs. If you live in a multi-cultural area, educational materials may need to be printed in multiple languages. Many organizations have published educational handouts and posters on non-points source pollution. See Appendix for examples of educational publications. If your organization plans to develop printed materials, make sure to include adequate funds in the budget for printing costs and to develop a plan for distributing these materials.

> ***Tip: Labor Hours***
>
> *CRWA dedicated over 2,000 labor hours to this task.*

6.2 Storm Drain Stenciling and Markers

Marking storm drains with messages such as "Do Not Dump" and "Drains to the Charles" can be an effective way of informing or reminding the public that storm drains are not garbage cans! (See Figure 19). Furthermore, this practice offers an opportunity for engaging community youth groups. By using members of the community to paint stenciled messages or place decals, you not only impart the message but you also educate local community advocates who can help further spread and explain the message communicated by the stencils. Storm drain stencils or decals can be effectively painted or placed by children 9 years of age or older, with adult supervision. Educating children about the problems associated with stormwater and allowing them to spread this message in their own neighborhood provides them with a sense of ownership over the storm drains they mark and will hopefully encourage them to live the message.

Table 18: Summary of Assisted Remediation through Public Outreach and Education Task

Step	Description
Develop Educational Materials	· Determine what topics you wish to develop materials on
	· Look for partners
	· Research topics
	· Draft materials
	· Translate materials into multiple languages if necessary
	· Develop plan for distributing materials
Mark Storm Drains	· Recruit community partners
	· Obtain necessary materials
	· Obtain necessary permits and/or permissions
Give Public Presentation	· Look for opportunities to present data publicly
	· Prepare presentations aimed at geographic area of presentation
Hold Public Workshops	· Determine topics for public workshops
	· Target potential presenters
	· Advertise workshop
Create SAARP web page	· Describe program
	· Display data
Publish newspaper and newsletter articles	· Describe program
	· Describe findings
	· Suggest action steps appropriate for a general audience

Additionally, it is important to acknowledge that stenciling or placing decals around storm drains effects a minor but permanent and noticeable change in a neighborhood. Some individuals may resent this change; therefore, it is advisable to have some community input and involvement when stenciling.

Stencils or decals can be custom ordered to communicate your message. Stenciling must be done with specific paint, specially designed for painting roadways. Contact your local transportation department, they may be able to donate some paint or refer you to a vendor. Stenciling will probably require permission from the local transportation or public works department. Be sure to obtain all relevant permits or permissions prior to commencing.

Figure 19: Storm Drain Marker

6.3 Public Presentation of Results

Some members of the public may be interested in learning the details of the results of your stormwater program. If the interest exists, consider planning evening presentations located in communities with significant non-point source problems at which you will present and explain your shoreline survey and water quality results. If such a presentation is unlikely to be well attended in your community, seek out opportunities to speak at meetings of local community groups such as land trusts, open space and conservation committees, "friends" groups, church groups and others.

6.4 Workshops

If a specific non-point source pollution issue is very problematic in your area, consider planning a workshop to educate community residents on ways to limit release of this pollutant into the environment. For example, in residential communities, landscaping practices can increase nutrient levels in local surface water bodies. Consider holding a workshop that provides alternative landscaping techniques which reduce nutrient runoff from residential lawns. If your organization does not have the expertise in-house to present such a workshop, make inquiries with other environmental groups and local environmental agencies as there may be someone in your community available to provide this type of presentation.

6.5 Website

Using your organization's website is a great way to reach a wide audience. Consider developing a web page dedicated solely to your SAARP. This provides an opportunity to share the details of your program with community residents and other interested individuals. Additionally, post shoreline survey and water quality results on your web page; these aspects of your program in particular are probably some of the most interesting to the local community. Finally, a website provides an easy and readily available forum for distribution of any educational materials your organization develops.

Displaying Data in Google Earth™

Both CRWA and MyRWA used Google Earth™ to display stream survey data. Google Earth™ is free to download and relatively easy to use, making it a readily available tool to display geographic data to a wide audience. Google Earth™ allows you to display data points accompanied by a photograph and description. If your data is stored in ArcMap©, you can download a free script created by the Portland Planning Department which transforms shapefiles into .kml files (files displayed by Google Earth™) from the ESRI website. If your organization does not have ArcMap©, but has considerable computer skills, it is also possible to write macros in Excel© to generate .kml files directly from Excel© spreadsheets.

6.6 Newspaper and Newsletter Articles

Newspapers and newsletters are another effective method of informing the public about your program, the problems associated with non-point source pollution, and what can be done to mitigate these problems. If your organization has the time and skill available, it may be possible to become a regular contributor to a local publication. Publishing articles in a widely read newspaper may provide an opportunity to reach an audience beyond those that might visit your website or attend a public presentation.

Healthy Lawns and Landscapes Workshop

The Charles River is heavily impacted by phosphorus loading. In 2007, the Massachusetts Department of Environmental Protection released a Total Maximum Daily Load (TMDL) report for the Lower Charles River, which found that overall phosphorus loads into the lower Charles need to be reduced by 54% in order to meet water quality standards. These findings were consistently reflected in our SAARP water quality monitoring results, where we repeatedly observed phosphorus concentrations well exceeding our organizational action limit.

Because lawn fertilizers are a non-point source of phosphorus to our waterways, we decided to hold a seminar on river friendly landscaping techniques. We scheduled three presenters for the seminar: CRWA Landscape Designer Viola Augustin, MA Department of Environmental Protection Consumer Waste Reduction Coordinator Ann McGovern, and Ken Dews of Rainstay. Augustin and Dews discussed Low Impact Development (LID) techniques to capture and treat or reuse stormwater runoff from residential properties, such as rain gardens, green roofs, porous pavers, rain barrels and cisterns. McGovern, a Northeast Organic Farmers Association (NOFA) Organic Landcare Professional and avid gardener, discussed reducing pesticide and synthetic fertilizer use, composting, and general lawn care.

The workshop was held in the evening, during the week, and light dinner was served. We advertised the workshop in local publications, online calendars, through flyers, and newsletters. We also sent invitations to our members. Finally, we taped the workshop so it could be aired on local cable access channels.

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