SHEEPSCOT RIVER
WATER QUALITY MONITORING
STRATEGIC PLAN

A
Guide for
Coordinated
Water Quality Monitoring Efforts
in an
Atlantic Salmon Watershed
in Maine

May 2004

Project SHARE
Research and Management Committee

SHEEPSCOT RIVER
WATER QUALITY MONITORING
STRATEGIC PLAN

A
Guide for Coordinated
Water Quality Monitoring Efforts
on an
Atlantic Salmon Watershed
in Maine

May 2004

Prepared
for the
Project SHARE
Research and Management Committee

Prepared
by
Barbara S. Arter
BSA Environmental Consulting

Funded
by
National Fish and Wildlife Foundation

SHEEPSCOT RIVER
WATER QUALITY MONITORING
STRATEGIC PLAN

Preface

In an effort to enhance water quality monitoring (WQM) coordination among agencies and conservation organizations, the Project SHARE Research and Management Committee initiated a program whereby river-specific WQM Plans are developed for each of the eight Atlantic salmon rivers currently listed in the Endangered Species Act. The Sheepscot River WQM Plan is the first plan to be developed under this initiative. It was developed between May 2003 and April 2004.

The Sheepscot River WQM Plan was produced by a workgroup comprised of representatives from both state and federal government agencies and several conservation organizations (see credits below). The purpose of this plan is to characterize current WQM activities, describe current water quality trends, identify the role of each monitoring agency, and make recommendations for future monitoring. The project was funded by the National Fish and Wildlife Foundation.

Credits

The following individuals have contributed to the development of this plan:

Denise Buckley	US Fish and Wildlife Service
Paul Christman	Maine Atlantic Salmon Commission
Robert Dudley	US Geological Survey
Melissa Evers	Maine Department of Environmental Protection
Stacy Gambrel	Sheepscot Valley Conservation Association
Bob Goldstein	US Geological Survey
Melissa Halsted	Kennebec County Soil and Water Conservation District
Sherry Hanson	Maine Department of Marine Resources
Mike Herz	Sheepscot Valley Conservation Association
Maureen Hoffman	Sheepscot Valley Conservation Association
George Maendel	Sheepscot Wellspring Land Alliance
Susanne Meidel	Maine Department of Environmental Protection
Dana Murch	Maine Department of Environmental Protection
Lili Pugh	Sheepscot Valley Conservation Association
Alex Pugh	Sheepscot Valley Conservation Association
Greg Stewart	US Geological Survey
Robert Stratton	Maine Department of Environmental Protection
Mark Whiting	Maine Department of Environmental Protection
Scott Williams	Volunteer Lakes Monitoring Program

Special thanks to Maureen Hoffman, SVCA, for producing the maps in the Plan.

SHEEPSCOT RIVER
WATER QUALITY MONITORING
STRATEGIC PLAN

Table of Contents

List of Acronyms

AS	Atlantic Salmon
ASC	Atlantic Salmon Commission
BMP	Best Management Practices
BOD	Biological Oxygen Demand
DO	Dissolved Oxygen
DPS	Distinct Population Segment
E. coli	*Escherichia coli*
IF&W	(Maine Department) Inland Fish and Wildlife
KRIS	Klamath Resource Information System
MASTF	Maine Atlantic Salmon Task Force
MDEP	Maine Department of Environmental Protection
MS	Mainstem (of the Sheepscot River)
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source (Pollution)
PEARL	Public Educational Access to Environmental Information in Maine
SVCA	Sheepscot Valley Conservation Association
SWLA	Sheepscot Wellspring Land Alliance
SWCD	Soil and Water Conservation District
TAC	(Maine Atlantic Salmon) Technical Advisory Committee
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TP	Total Phosphorus

UMSGMC	University of Maine Senator George Mitchell Center
USFW	US Fish and Wildlife
USGS	US Geological Survey
WB	West Branch (of the Sheepscot River)
WC	Water Chemistry
WQ	Water Quality
WQM	Water Quality Monitoring

EXECUTIVE SUMMARY

The Project SHARE Research and Management Committee initiated the development of the Sheepscot River Water Quality Management Plan as an effort to enhance water quality monitoring (WQM) coordination among agencies and conservation organizations within the rivers comprising the Maine Distinct Population Segment of Atlantic salmon. The goal of this plan is to characterize current WQM activities, describe current water quality trends, identify the role of each monitoring agency, and make future monitoring recommendations.

The Plan and its recommendations were created by the Sheepscot River WQM Plan workgroup which was comprised of representatives from all of the state and federal agencies and conservation organizations monitoring in the watershed. While the Plan suggests numerous river reach, WQ parameter, and study site recommendations, the success of the plan relies on the ability of the workgroup to identify a lead agency or task force to ensure that all monitoring parties are on task and that recommendations are being successfully implemented.

The Sheepscot River Watershed is currently, or has recently been, monitored by at least twelve different agencies and organizations at over 40 different monitoring locations. The Plan reviews the activities of each monitoring agency/organization, including objective, history, monitoring parameters, and locations, and provides a summary of their results. The monitoring agencies reviewed in the Plan include the Sheepscot Valley Conservation Association (SVCA), Sheepscot Wellspring Land Alliance, MDEP Salmon Program, MDEP TMDL Program, MDEP Hatchery Licensing Program, MDEP Dam Regulation Program, DMR, ASC, NOAA, USFWS, and USGS. The review indicates that SVCA and the USGS have the longest records of monitoring and the largest datasets.

The Plan reviews each WQM parameter trend and provides locations of poor WQ by parameter. The parameters include: DO, bacteria, temperature, pH, nutrients, biomonitoring, and flow. The data indicate that the sites with overall poor water quality (low DO, high bacteria, high summer temperatures, high nutrient levels) include the reach below Sheepscot Pond, the West Branch, Dyer River below Rt. 215, Chamberlain Brook, the mainstem at the gage in Whitefield, below Coopers Mills Dam, and the mainstem above Sheepscot Pond.

Based on the review of the WQM history, data, and trends, the Plan provides Coordination Strategies to refocus and/or support conservation, restoration, and management efforts. The Plan provides strategies for coordinating WQM information and activities with administrative activities, NPS restoration, land-use management, channel restoration, dam regulation, water classification, outreach activities, and fish stocking practices. In addition, the Plan divides the watershed into 28 sections: 9 sections of the MS and WB, 7 lakes and ponds, 11 tributaries, and the estuary. Each section or waterbody is characterized according to Atlantic salmon habitat, class, attainment status,

and general WQ condition. From this information, a reach-specific recommendation is provided.

The Plan provides recommendations using a variety of approaches: by program, by indicator, by reach, and in summary. Given the overwhelming nature and complexity of the subject, these different “menus” are provided in an attempt to simplify the available action items and to allow the user to view the plan from different perspectives. The final chapter lists all of the recommendations suggested in the Plan and provides a list of potential partners for each recommendation.

Chapter One INTRODUCTION

1

Understanding water quality status and trends in Maine's Atlantic salmon rivers is essential to the success of state and federal recovery plans and activities. Currently, water quality data is collected on Maine's eight salmon rivers by a variety of agencies and organizations with different goals. Within any one watershed, data and information may be collected by as many as ten different agencies or organizations, including:

- Maine Department of Environmental Protection
- Maine Atlantic Salmon Commission
- Maine Department of Marine Resources
- National Oceanic & Atmospheric Administration
- Maine Inland Fish and Wildlife
- US Fish &Wildlife
- University of Maine
- US Geological Survey
- Watershed Councils/Conservation Organizations

To date, there is no coordinated storage, maintenance, review, or distribution of water quality monitoring information or data gathered by these agencies and organizations. As a result, data collection may be inadequate or redundant, and inappropriate decisions may be made due to a lack of coordination. The lack of a standard tool that helps agencies and organizations determine water quality trends and conditions in a consistent, credible, and coordinated manner may hinder effective restoration efforts.

Enhanced WQM, data sharing, and management activity-WQM coordination are identified as significant salmon restoration strategies in the recently published National Academy of Sciences 2004 Report, *Maine Atlantic Salmon*:

> "The monitoring of water quality and gauging of streams should be augmented. A network of meteorological-monitoring, stream-gauging, water-quality-monitoring, and biological-monitoring sites should be linked to a geographic information system and an online database within 2 years."

1.1 Project Goal and Objectives

The goal and objectives of this project were established by the Project SHARE Research and Management Committee and the Sheepscot River WQM Plan Workgroup. The following chapters in this document address each of the objectives. The Goal and Objectives are as follows:

GOAL
Improve coordination of water quality monitoring activities among governmental agencies and conservation organizations within the rivers comprising the Maine Distinct Population Segment (DPS) of Atlantic salmon.
OBJECTIVES
1. Summarize current monitoring efforts: collecting agency, parameters, and locations. 2. Characterize current water quality trends: DO, temperature, bacteria, pH, nutrients. 3. Identify gaps in current monitoring efforts and water quality information. 4. Determine the role of each monitoring agency: the type, location, and outcome of monitoring and data. 5. Identify those locations and activities that require targeted monitoring, such as priority habitat or restoration sites. 6. Make recommendations for future monitoring and data storage and dissemination.

1.2 Selecting the Sheepscot River

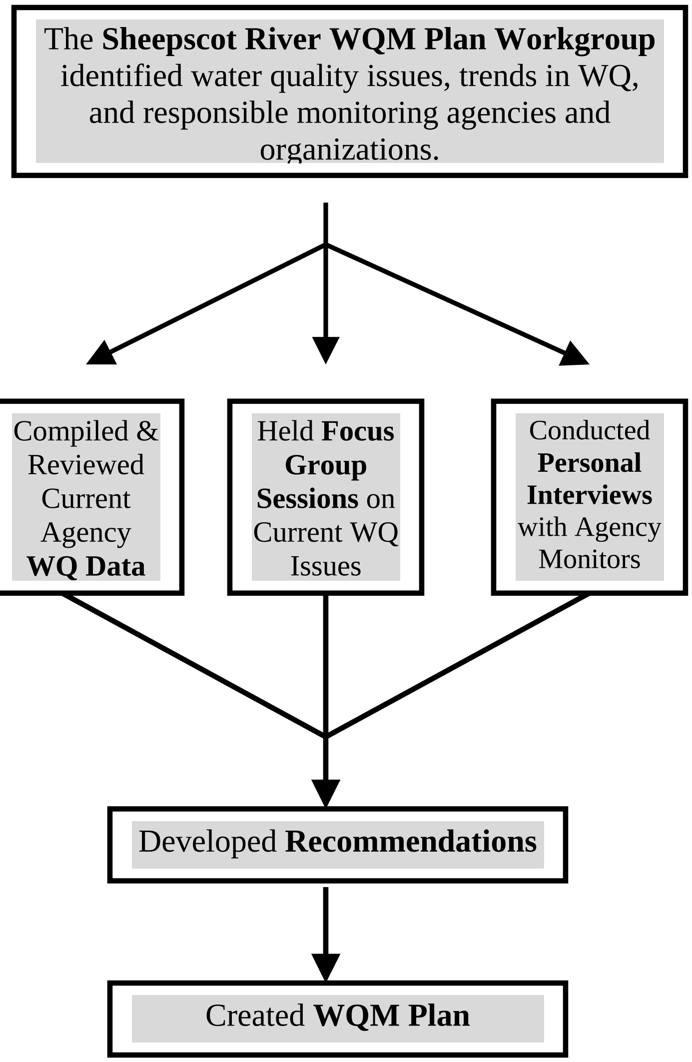
The Sheepscot River was selected as the first river for the Project SHARE River-Specific WQM Plan Initiative for several reasons:

- The Sheepscot River has more WQ data than any other salmon river. The Sheepscot Valley Conservation Association and several governmental agencies have been collecting data on the river for over ten years.
- All of the participating agencies and organizations working in the watershed expressed a strong need and desire to coordinate data.
- The Sheepscot River is a priority watershed that appears on several priority water quality or NPS listings:
    1) Protection under the Maine Atlantic Salmon Conservation Plan and the Federal Endangered Species Listing.
    2) MDEP Nonpoint Source Priority Watershed List.
    3) MDEP Biomonitoring Retrospective, 1999. Aquatic Life Criteria Attainment.
    4) MDEP Aquatic Life Classification Attainment Report 2003. Non-attainment at site below Palermo fish hatchery.
    5) MDEP Maine Salmon Rivers Water Quality Monitoring Program (1999-2001)
    6) MDEP Section 303d Waters (TMDL) 1998 (EPA Approved) for the West Branch and Dyer River.
    7) MDEP Section 305(b) Waters (TMDL) 2002 for seven freshwater sites.
    8) MDMR Shellfish Sanitation Program. Several shellfish area closures.

1.3 Plan Development Methodology

Information for the development of this plan was gathered between May 2003 and February 2004 using the methodology described in Figure 1.3.1. During that time, nine facilitated focus-group sessions were held for the purpose of discussing WQ issues, characterizing WQ trends, identifying agency roles, and establishing recommendations for future monitoring. Data from the various monitoring agencies and organizations was compiled and reviewed, and several personal interviews were conducted to clarify data results.

Figure 1.3.1. Sheepscot River WQM Plan Development Methodology



1.4 Recommendation for Use of this Plan

General Recommendations

By following the recommendations in Chapter 6 of this document, WQM agencies and organizations can better coordinate their efforts. This can be done in a few simple steps:

1. This Plan is designed to be used as a springboard for the development of agency-specific work plans that:
   a. incorporate the agency-specific recommendations from this Plan,
   b. assign staff, funding, equipment, and time to specific action items
   c. coordinate WQM activities with other agencies' activities
   d. develop new studies that are consistent with the findings in this Plan
2. This Plan presents a large volume of water quality information and recommendations representing the diligent efforts of the Workgroup. However, the success of this Plan depends on the willingness of each agency to follow through with the recommendations and to communicate, coordinate and collaborate with each other. It may be necessary for one coordinating body, such as the Maine Atlantic Salmon Technical Advisory Committee (TAC), to take the lead and ensure that agencies are on task.
3. Several recommendations are umbrella action items that will apply to all agencies. In this case, one agency or task force will be needed to take the lead in order to achieve the recommendation. One important example is the creation of data storage and dissemination mechanism. Several web-based options are available including KRIS and PEARL. In either case, direction will be required to meet recommendation goals.
4. All monitoring agencies and organizations should consult this plan for guidance:
   a. before beginning or continuing any future monitoring effort; monitoring agencies are advised to consult this document for monitoring guidance, and
   b. agencies should refer to this plan annually as a measure of outcome success.

Watershed-Specific Recommendations

This plan presents recommendations developed by the workgroup and the consultant. These recommendations are presented in the document using a variety of approaches: by program, by indicator, by reach, and in summary. Given the overwhelming nature and complexity of the subject, these different "menus" are provided in an attempt to simplify the available action items and to allow the user to view the plan from different perspectives.

Recommendations for each monitoring agency	Chapter 3
Recommendations for specific WQ Trends	Chapter 4
Recommendations for specific river reaches	Chapter 5
Summary of all recommendations by topic	Chapter 6

Chapter Two
The Sheepscot River Watershed

2

2.1 Physical Description

The following information has been summarized from "The Sheepscot River: An Atlantic Salmon River Management Report*," by Alfred Meister Atlantic Sea Run Salmon Commission, 1982.*

The Sheepscot River drainage area (including the estuary) is approximately 320 square miles. The river originates out of the hills of Montville at an elevation of 600 feet, approximately 26 miles northeast of Augusta. It runs southwest through the towns of Palermo, Somerville, and Whitefield where it joins the West Branch. The West Branch originates in Palermo at an elevation of 800 feet above Branch Pond and flows southwest for approximately 17 miles through China and Windsor before joining the mainstem above North Whitefield. The mainstem reaches tidewater in the town of Alna. The total length of the mainstem to tidewater is approximately 34 miles. The Sheepscot tidal waters continue for another 20 miles before emptying into Sheepscot Bay just east of the mouth of the Kennebec River. The watershed contains 57 lakes and ponds, 24 of which drain to the freshwater portion of the river; the remaining drain to the estuary (see Appendix, Map 1).

The Dyer River is a major tributary draining to the Sheepscot estuary, originating in Jefferson at an elevation of 290 feet. It has a stream length of 17 miles and drains approximately 30 square miles. There are several areas of long shallow deadwater above the estuary and a run of riffles in the section below Dyer Long Pond.

The dominant soils of the drainage are brown podzolics of the Scantic-Merrimac-Hollis types derived from glacial parent material. Typical forest soils overlay glacial sand and gravels. Boulders and rubbles in the riffles of the river originate from glacial material.

For the purpose of this document, the river is divided into four river sections:

1. **Mainstem (MS) –** the mainstem and its tributaries above and below the confluence with the West Branch to head of tide at Head Tide Village in Alna.
2. **Dyer River –** the Dyer River drainage.
3. **West Branch (WB) -** the West Branch of the Sheepscot River and its tributaries.
4. **Estuary –** the mainstem of the Sheepscot River occurring below head of tide in Alna and extending to Sheepscot Bay.

2.2 Flow

There is a USGS gage on the river at North Whitefield that has been recording discharge since 1939. The average annual discharge is 248 cfs. The annual peak streamflow for that time (64 years) ranged from 6,420 cfs in December 1973 to 1,010 cfs in January 1957 (USGS, 2004). Peak flows in most years were below 2000 cfs.

Average monthly stream flow records indicate that high flow typically occurs during April (739 cfs) and low flows generally occur during August (46.6 cfs) and September (51 cfs). The lowest flow on record occurred in October 1941 (6.75 cfs).

2.3 Atlantic Salmon Habitat

According to the *Atlantic Salmon Conservation Plan* (MASTF, 1997), the Sheepscot River contains 2,845 units of habitat (one unit equals 100 m^2), a smolt production goal of 8,535, and a minimum total run of 215 adults.

Atlantic salmon spawning and rearing habitat has been mapped for most of the mainstem, the West Branch, and four tributaries: Dyer River, and Ben, Trout, and Choate brooks. This habitat has been prioritized by quality and quantity into subwatersheds (See Appendix, Map 2):

Subwatershed #1	MS from Head Tide to Coopers Mills
Subwatershed #2	WB from the confluence to the outlet of Branch Pond
Subwatershed #3	MS from Coopers Mills to the inlet of Sheepscot Pond
Subwatershed #4	MS above Sheepscot Pond; WB above Branch Pond, MS below Head Tide

2.4 Water Classification

The state's Water Classification Program has established four classes of fresh surface waters with different levels of environmental protection (Table 2.4.1). The class definitions include narrative criteria of aquatic life and habitat and numeric criteria for dissolved oxygen and bacteria (*E. coli*). A waterbody must meet the requirements of all four criteria to be in attainment of its designated use.

The Sheepscot River has segments which are Class AA, A, and B (Table 2.4.2), and all of the lakes are Class GPA. These river segments will be discussed in more detail in subsequent chapters.

Table 2.4.1. Maine Water Quality Criteria for Classification of Fresh Surface Waters (38 MRSA §465, MDEP 2001)

Class	Dissolved Oxygen Numeric Criteria	Bacteria (*E. coli*) Numeric Criteria	Habitat Narrative Criteria	Aquatic Life (Biological) Narrative Criteria
Class AA	as naturally occurs	as naturally occurs	free flowing and natural	No direct discharge of pollutants; as naturally occurs
Class A	7 ppm; 75% saturation	as naturally occurs	natural	as naturally occurs
Class B	7 ppm; 75% saturation	64/100 ml (g.m.*) or 427/100 ml (inst.*)	unimpaired	Discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community.
Class C	5 ppm; 60% saturation	142/100 ml (g.m.*) or 949/100 ml (inst.*)	habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

* g.m., geometric mean; inst., instantaneous level

Table 2.4.2. Sheepscot River Classification (MDEP Water Classification Program, 2004)

CLASS	LOCATION	COMMENT
C	• No waters are classified as C	N/A
B	• Mainstem from Sheepscot Lake to Route 17 • All other tributaries which are not Class A	Irreplaceable social and economic benefits and this use must be maintained
A	• Mainstem from its origins in Montville to Sheepscot Lake • Trout, Choate, Weaver, Ben, Finn, Hewitt, Dearborn, and Culvert Pond Brooks	Upgraded classification for both the Montville section and these tributaries
AA	• Mainstem from Route 17 to tidewater • West Branch from Branch Pond outlet to confluence with mainstem	West Branch is listed as TMDL and is currently being monitored

Chapter Three
Water Quality Monitoring History

3

3.1 Overview

The Sheepscot River Watershed is currently, or has recently been, monitored by at least ten different agencies and organizations at over 40 different locations (see Map 3, Appendix A). Table 3.1.1 is an overview of each agency's monitoring objective and history.

This chapter will review the activities of each monitoring agency/organization and provide a summary of their results. Every attempt has been made to present each agency's data set and information in a consistent manner. However, due to different levels of data analysis and variation in monitoring objectives, some descriptions are more detailed than others. For details about specific monitoring programs and data, the reader is advised to contact individual agencies.

Within each of the following sections, the reader will find program-specific recommendations developed by the Workgroup. A comprehensive list of all watershed WQM recommendations is found in Chapter 6.

Table 3.1.1. Overview of WQ Monitoring History in the Sheepscot River Watershed.

Agency	Objective	History	Parameters	Locations
SVCA & SWLA	Habitat Protection/ Recreational Value	10+ years	DO, Bacteria, Salinity, Temperature	WB, Upper MS, MS, Estuary
MDEP: Salmon Program	Salmon Restoration	5	DO, TSS, pH, Turb, Temperature, Anions, Nutrients, Cations	MS below Sheepscot P, WB, WB Tribs, Lower MS
MDEP: TMDL Program	Clean Water Act	5+	DO, *E. coli*, Macroinvertebrates	3 sites on the WB; 3 on the MS, 1 on Dyer R.
MDEP/IFW: Hatchery Prog.	Fish Hatchery Licensing	3	Flow, BOD, TSS, Total P, N, Ammonia	Below Sheepscot Pond @ hatchery outlet
VLMP/MDEP: Lakes Program	Lake Productivity	20+	Transparency, DO, pH, TP, Chl a	6+ lakes
MDEP Dam Regulation	Dam Regulation	10+	Dam Ownership	Throughout watershed: WB, MS, & tribs
DMR	Shellfish Sanitation	10+	Bacteria, Temp.	Estuary only
ASC	Salmon Restoration	3 10+	Temperature, pH, Population, Habitat	Lower WB, MS below Sheepscot P, Lower MS
NOAA	Salmon Restoration	4	Temperature, pH, Conductivity	Lower MS above Head Tide
USFWS	Salmon Restoration	6	Temperature	Both WB & MS
USGS	Water Resources Monitoring	65	Flow statistics, Temperature	Gage at Whitefield

3.2 Sheepscot Valley Conservation Association (SVCA)

Objective:	Salmon habitat, NPS, and recreational quality
Monitoring History:	10 years: Continuously since 1994.
Database Storage:	In house
Parameters:	DO, Temperature, Bacteria
Location:	West Branch, Upper Mainstem, Mainstem, and Estuary
Identified Trends:	High temperatures in lower MS
	Low DO in Upper MS, Chamberlain Bk, WB
	High *E. coli* in Upper and Lower MS, Chamberlain Bk, WB

Monitoring Background

The Sheepscot Valley Conservation Association (SVCA) has been collecting WQ data since 1994 with the goal of protecting salmon habitat and evaluating WQ for overall recreational value. The nongovernmental organization monitors over 25 sites, which were selected based on proximity to sensitive and recreational (swimming) areas, as well as access and landowner permission. The sites are located throughout the watershed:

3 in the Upper MS (above the confluence with the WB),
13 in the MS (below the confluence with the WB) and its tributaries,
12 in the West Branch and its tributaries, and
2 in the Estuary and its tributaries

Parameters

Temperature, DO, and bacteria samples are collected at most of the sites. DO is monitored using the Winkler Titration Method, temperature is monitored using a thermometer, and grab samples are sent to the Maine Department of Human Services Health and Environmental Testing Laboratory for *Escherichia coli* (*E. coli*), *Enterococcus*, and fecal coliform testing.

Results

The data was analyzed to determine how often the site was in violation of the Maine State Water Classification Program (MDEP, 2001). According to the 2002 SVCA Report (Pugh, 2002), the data was analyzed for the number of days/year in which conditions were below Class AA, A, B, SA (estuary) classification standards:

AA: DO ≥ 7mg/L; *E. coli* geomean ≤ 32 colonies/mL; Instantaneous E. ≤ 214 col/mL
A: Same as AA
B: DO ≥ 7mg/L; *E. coli* geomean ≤ 64 colonies/mL; Instantaneous E. ≤ 427 col/mL
SA: DO ≥ 7mg/L; *E. coli* geomean ≤ 8 colonies/mL; Instantaneous E. ≤ 54 col/mL
For all sites: Temperature ≤ 22.5° C

Results from the violation analysis indicate four general areas of concern: Upper MS, Chamberlain Brook, Lower MS, and the West Branch. Table 3.2.1 describes the locations and associated parameters with the greatest number of violations, as well as suggestions for possible cause.

Table 3.2.1. Results of SVCA WQM Program (Pugh, 2002).

Location	Site Numbers	WQ Summary	Comment
Upper MS (Headwaters in Palermo)	S015	Low DO; High Bacteria	At 15 yrs, conduct trend analysis; site is improving; site has lowest temperature in WS
Chamberlain Brook	CHABK001, 002, 003	Low DO and High Bacteria	Need to locate bacterial source; conduct survey
Lower MS above Head Tide	S010	High temperatures	Need to evaluate cause of high temperatures (i.e., flow, lack of buffer, etc)
Puddle Dock to Head Tide	S005, S006, S007	High Bacteria	Need to locate bacterial source; conduct survey
West Branch	WB001.5, 002, 003, 005	Low DO	Most sites are in violation of bacteria standard; continue monitoring for trend
West Branch @ Weeks Mills	WB004	High Bacteria during low flow	Probably not run off (NPS) but point source

A DO measurement of at least 7 mg/L is thought to be necessary to support healthy populations of salmon or other coldwater fishes. The *E. coli* thresholds are thought to represent cultural enrichment by human activities. However, a body of water may still meet state water classification if the *E. coli* enrichment is shown to be from natural sources. A temperature of 22.5 C is the point at which young salmon are stressed to the point that they stop feeding and where body condition begins to deteriorate.

General WQ trends are summarized as follows:

- The tributaries had significantly lower mean DO than the MS, possibly due to lower flow.
- The tributaries overall had lower mean temperatures than the MS possibly due to the presence of groundwater inputs (springs).
- The WB had significantly lower DO than other reaches and was in violation over 40% of the time in most years.
- The Upper MS had significantly lower temperatures than the other reaches.
- Chamberlain Brook and Upper MS (S015) had a higher number of DO and bacteria violations than other reaches.
- Seventy percent of samples collected near Head Tide (S005, S006, S007) were in violation of *Enterocooccus* standards for all years monitored.

Recommendations:

1. Continue to monitor sites and reassess the data in five years. Analysis of fifteen years of data may yield trends not apparent in just ten years of data.

2. Intensify sampling at Chamberlain Brook in order to locate source of bacteria. Conduct Bacterial Source Tracking (BST) analysis to identify whether bacteria are of human or wildlife origin.
3. Add additional sites to the Dyer River in order to locate the source of the recent higher-than-normal bacteria counts. Also, conduct a synoptic survey of the entire river.
4. Continue monitoring SO15 and WB004 to determine if trends of high *E. coli* levels continue.
5. Conduct NPS Survey in order to determine location/cause of bacteria at all sites. Coordinate monitoring with survey results.
6. Lengthen sampling season to include mid April and early October in order to capture spring and fall precipitation events.
7. Install flow meters in order to correlate DO, temperature, and bacteria with flow.
8. Use drainage-specific approach to monitoring. Focus monitoring on small drainage areas to pinpoint cause of poor WQ.
9. Work with MDEP Stream Team Program to establish Stream Walk Team to conduct Habitat Walks on tributaries.
10. For river sections which have poor WQ associated with low flow, the following parameters should be added:
    - USGS gages
    - Hand-held flow meters
    - Turbidity
    - Total Phosphorus
11. Since the goal of the SVCA is to establish a monitoring/WQ trend history, no sites should be removed from the program. Several new sites, however, should be added in order to obtain a better understanding of the smaller drainages. New sites may include:
    - **Ben Brook –** contains priority salmon habitat but has not been monitored for over 5 years.
    - **MS above Sheepscot Pond –** there is only one site in this reach; add additional sites because of salmon habitat; protect good WQ from recent development pressure.
    - **Lovejoy Stream and Turner Branch –** these are tributaries to Turner Pond and Long Pond, contain potential salmon habitat, and drain large watershed.

3.3 Sheepscot Wellspring Land Alliance (SWLA)

Objective:	Protection of Headwaters in Upper MS
Monitoring History:	10 years: Continuously since 1994.
Database Storage:	In house: stored with SVCA data
Parameters:	DO, Temperature, *E. coli*
Location:	Mainstem Headwaters above Sheepscot Pond
Identified Trends:	High turbidity, sedimentation, and *E. coli* in this river section

Monitoring Background
Sheepscot Wellspring Land Alliance (SWLA) was formed in 1990 with the specific goal of protecting a 47-acre parcel of land adjacent to a unique freshwater marsh in Montville. SWLA's work focuses on Sheepscot Pond, the MS above the pond and the WB above Branch Pond. Their work focuses on land conservation and NPS pollution from road runoff, bank erosion, and agriculture/forestry.

SWLA water quality monitoring efforts are part of the SVCA WQM program. SWLA Volunteers monitor at SVCA site S015F, which is approximately 3 miles above Sheepscot Pond.

Parameters
Parameters monitored by SWLA at SVCA site S015F are DO, temperature, and *E. coli*. The data is managed by SVCA (see Section 3.2).

Results
Results of recent monitoring at this headwater site indicate:

- the development of silt deltas
- increased turbidity
- high bacteria counts

Recommendations
1. TSS and turbidity, which are currently not monitored, should be measured especially in areas of known NPS pollution (crossings, runoff, agricultural practices).
2. Use TSS/turbidity information to improve roads and other NPS sites.
3. Conduct shoreline surveys in areas of known bacterial contamination in order to identify contamination source. Once bacterial source is identified, conduct Bacterial Source Tracking (BST) analysis, which separates human bacteria from other warm-blooded animals for identification.
4. Conduct WQM in conjunction with riparian buffer analysis and flow information.

3.4 Maine Department of Environmental Protection Salmon River WQM Program

Objective:	Salmon Restoration
Monitoring History:	5 years: continuously from 1999 – 2004
Database Storage:	In house
Parameters:	DO, Temperature, Nutrients, TSS, Turbidity, pH, Cations, Anions
Location:	West Branch, Mainstem, Estuary
Identified Trends:	TSS and turbidity are high in WB and MS during the high flow; cations are greater in the WB than in the MS; phosphorus is higher on the MS than on the WB; daytime summer temperatures were below the level considered stressful to cold-water fish; nitrates are higher in both the WB and MS than other salmon rivers.

Monitoring Background
The MDEP Salmon River WQM Program has collected WQ data on the Sheepscot River annually since 1999. The program collaborates with the Sheepscot River Watershed Council and the Kennebec SWCD to collect samples for lab analysis and to conduct field monitoring. Sampling to date includes baseflow sampling for 1999, 2000, and 2001 and stormwater or snowmelt sampling for 2000, 2001, and 2002. The purpose of the MDEP Maine Salmon River WQM Program is to provide a broad-based water chemistry profile of the rivers to (1) provide a baseline for the detection of trends, and (2) to help identify water chemistry factors that might be limiting salmon recovery (Whiting, 2003).

Monitoring sites for this program are:

- 1 site on the MS above Long Pond
- 2 sites on the Lower MS
- 5 sites on the WB
- 1 site on Meadow Brook (WB Tributary)
- 1 site on Dearborn Brook (WB Tributary)

Parameters
Temperature, pH, and DO are measured in the field. From 1999 to 2002 samples were taken to the UM George Mitchell Center for lab analysis. The lab analysis included pH, alkalinity, specific conductivity, turbidity, total suspended solids (TSS), dissolved organic carbon (DOC), total phosphorus (TP), and major cations (Na, Ca, K, and Mg) and anions (Cl, SO_4). Carbonate was not measured directly, but virtually all of the

alkalinity is assumed to be from carbonate. Nutrients (NO_3 and total phosphorus, TP) were also generally measured. TSS and turbidity were generally measured in stormwater samples or whenever the river appeared to be milky. Due to a lack of funding, the lab analyses were discontinued in 2003 and field measurements were expanded to include turbidity. Turbidity is currently measured with a small portable turbidity meter.

Results

The following results are from 2000-2002 data (Whiting, 2003):

Baseflow Sampling General Trends

- **Cations** (Ca, K, Mg, and Na) are generally much greater in the WB than in the MS. For example, WB 1999 Ca levels ranged from 6.94 – 15.90 mg/L whereas MS 1999 Ca levels ranged from 2.96 – 7.21 mg/L. The level of calcium at which salmon would experience a nutrient deficiency is 2.5 mg/L. Often the concentration of Ca in the Sheepscot is greater than 5 mg/L which is considered ideal for salmon.
- In both the WB and MS, **cations** exhibit a seasonal pattern. Nutrients are generally greater in the fall. For example,TP generally ranges from 0 – 26 µg/L in baseflow conditions. However, the concentration of TP in stormwater can be as high as 160 µg/L. In general, TP is associated with the movement of small suspended particles.
- **Total phosphorus** (TP) is both soil P and P dissolved in water. Phosphorus is generally higher on the MS (1999: 6.3 -160 µ g/L with an average of 36.44 µg/L) than on the WB (1999: 4.2 – 96 µg/L with an average of 26.3 µg/L). Although the TP levels found in the MS are considered low when compared to other waters in the in the United States, the levels are considered high for Maine. In a study by the USGS, the background concentration for TP in streams in the glaciated upper Midwest and New England is about 13 µg/L for the median and 18 µg/L for the 90th percentile (Smith, et al, 2003). Phosphorus generally does not accumulate in rivers as is does in lakes, but high levels (> 20 µg/L) may yield periphyton blooms and such sites should be closely monitored. Rivers with more than 50 µg/L TP are often negatively impacted. High TP in September is associated with rain events.
- **Dissolved Organic Carbon** (DOC) levels in the MS and the WB were similar and ranged from 3.73 – 15.8 ppm. These values are typical for a Maine river. These levels are similar to DOC levels found in Downeast rivers.
- **Dissolved Oxygen** levels in summer months are 7 – 8 ppm with a low of 6.7 ppm. Most of these values represent morning samples when DO is generally lower as compared to the afternoon when photosynthesis has enriched oxygen levels.
- **Daytime summer temperature** measurements range from 13.9 – 21.9˚ C and were below the level considered stressful to cold-water fish (22.5˚ C). Salmon generally stop feeding at this temperature. It should be noted that the samples were measured throughout the day and therefore are not representative of the daily extremes. This data is used primarily to calculate oxygen saturation.

Storm Event General Trends

- **Calcium** appears to be similar in the WB (3.84 – 4.78 mg/L) and MS (3.78 – 4.21 mg/L) during winter and spring storm and snowmelt events. However, during fall storm events calcium increases in both streams but is three times greater in the WB: WB (16.3 – 17 mg/L) and MS (5.3 – 6.08 mg/L)
- **Nitrates** are generally higher in both the WB and MS than other salmon rivers. The Sheepscot ranges from < 1.0 µeq/L (essentially zero) to 29.9 µeq/L whereas the Narraguagus ranges from < 1.0 to 5.6 µeq/L. Nitrates in water generally originate from precipitation, human and animal waste, residential and agricultural fertilizers, and bedrock.
- **Phosphorus** does not differ greatly between the WB and MS during storm or snowmelt events. TP in the WB ranges from 20 – 91 µg/L while TP in the MS range from 14 – 70 µg/L. The highest Total P concentrations occur during storm events, with short-term concentrations as high as 160 µg/L
- **Total Suspended Solids (TSS) and Turbidity** are moderate (1-3 NTU) and occur in both the WB and MS during the high flow period in February through May. River water during this period appears "milky." Even though fall flows can be as high as spring flows, neither the MS nor WB had noticeable turbidity in the fall. Winter freezing (frost heave) and winter road maintenance (salt sand spreading) may contribute to spring turbidity. Even moderate turbidity may affect a fish's ability to find food. Impaired visibility for an extended period ($\geq$ 2 weeks in the 1-3 NTU range) may be moderately stressful to juvenile and adult salmon (Newcombe & Jensen, 1996).

Recommendations

1. Restore lab analysis funding to the MDEP Salmon River Program so that nutrient and TSS monitoring can continue. Funding provided data for 1999 through 2002 but not for 2003. Funding should be restored to the program so that data from the "drier years" (2000 – 2002) can be compared to that from "wetter years."
2. Correlate temperature, turbidity, and nutrient monitoring with NPS sites.
3. At this time, the MDEP Salmon River Program Sheepscot River lab analysis data has not been completely analyzed. The ASC, MDEP, and NOAA should work together to see that the data is analyzed by site, by event, by nutrient, and over time.

3.5 Maine Department of Environmental Protection TMDL Program

Objective:	Determine TMDL for waters not attaining class standards
Monitoring History:	5 years: Program began 1998
Database Storage:	In house & http://www.state.me.us/dep/blwq/monitoring
Parameters:	Dissolved Oxygen, *E. coli*, Aquatic Life (macroinvertebrates)
Location:	West Branch, Mainstem
Identified Trends:	Seven sites do not attain class standards

Monitoring Background
Section 303(d) of the Clean Water Act requires the Maine Department of Environmental Protection to identify waterbody segments that do not attain water quality standards or are imminently threatened and are not expected to meet state water quality standards even after the implementation of technology-based controls for both point and nonpoint sources of pollution. In the development of the 303(d) list (TMDL List), the MDEP considers results from the Biological Monitoring Unit predictive models (macroinvertebrate monitoring) and WQ data or reports from local, state, federal or nongovernmental conservation organizations. In addition, MDEP consults the 305 (b) Water Quality Assessment Report, which is an inventory of impaired waters statewide. The 303(d) process subsequently requires the establishment of Total Maximum Daily Loads (TMDLs) or other control methods in order to assure the attainment of water quality standards (MDEP, 1998). Two sections on the Sheepscot River appeared on the 1998 303(d) list and seven river sections will appear on the 2002 305(b) list (MDEP, 2004).

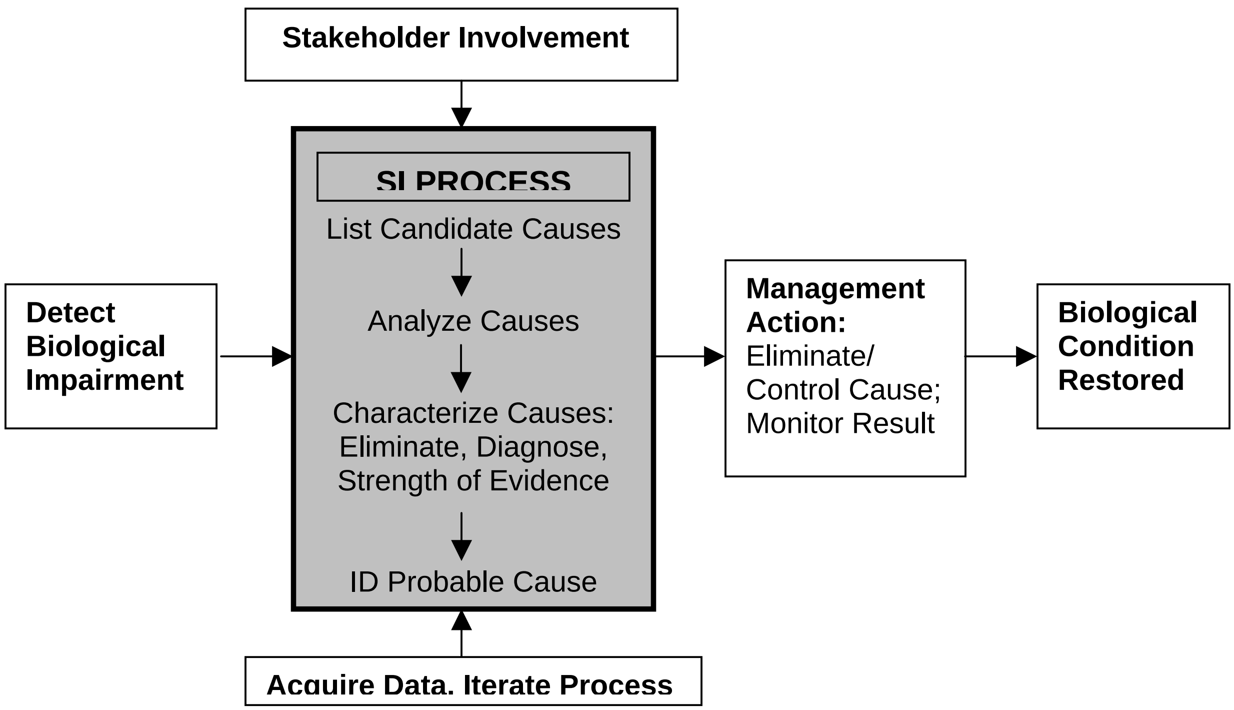
The standards used to determine attainment include aquatic life (generally macroinvertebrates), dissolved oxygen, bacteria, swimmability and fishability, metals, pesticides, salts, algal growth, fish kills, and contaminants. For waters that are not meeting standards, MDEP is required to determine the amount of pollutant that the waterbody can receive and still meet water quality standards. This amount of pollution is referred to as the Total Maximum Daily Load or TMDL. The process involves characterizing impairment and includes analysis of DO, metal, TSS, flow, P, N, temperature, and conductivity.

Once developed, the TMDLs are then used as guidance tools. At this time, however, there is not an implementation plan for NPS-related TMDLs, except on a volunteer basis. The MDEP will encourage communities to remediate sites using 319 NPS Abatement Program Funding.

Stressor Identification

In addition to developing a TMDL for each of the seven impaired sites in the Sheepscot drainage, MDEP will also use the "Stressor Identification" (SI) process on the impaired section of the West Branch. The SI process (Figure 3.5.1) identifies "stressors causing biological impairment in aquatic ecosystems, and provides a structure for organizing the scientific evidence supporting the conclusions" (USEPA, 2000). The process allows the researcher to determine the probable cause of impairment based on analysis and characterization of the indicators and strength of evidence.

Figure 3.5.1. The Management Context of the SI Process (USEPA, 2000)



Parameters

For the 2002 TMDL list of the Sheepscot River, the MDEP used:

1. data from the SVCA WQM Program (EPA-certified QAPP)
2. results from MDEP Biomonitoring Program (macroinvertebrate and temperature monitoring)

Result

Biological monitoring for macroinvertebrates has been conducted on the Sheepscot River since 1984. Eight sites were originally established but six of the sites are considered low risk and are no longer monitored. In 2002, the remaining two sites, Station #S74 on the MS in N. Whitefield at the USGS gage and Station #S268 on the WB in China at Weeks Mills were monitored and both sites attained Class AA/A standards. However, in 1999, an additional site, Station #S393 on the MS below the IF&W Fish Hatchery in Palermo, did not attain its Class B status. Using the MDEP Biocriteria Protocol Model, the site only attained Class C standards. Because of nonattainment at this site, the section was placed on the 2002 TMDL List.

In addition to macroinvertebrate monitoring, the MDEP Biomonitoring Unit deployed temperature loggers at the USGS gage in Whitefield, on the WB in Weeks Mills (Dirigo Rd.), and the WB in Whitefield (Howe Rd.) from 2001-2003. This data indicates that summer water temperatures rose above 25°C frequently in 2001 and 2002 at all 3 sites. Data from 2003 indicates that temperatures rose above 25°C in early July but were between 20-25°C for the remainder of the summer.

There are currently seven sites in the Sheepscot River Watershed listed on the 2002 TMDL List as not attaining their class due to low DO and/or high bacteria (see Table 3.5.1). These sites include WB below Halls Corner, Dyer River below Rt. 215, MS below the Palermo Hatchery, and Choate, Carlton, Trout, and Meadow brooks.

Table 3.5.1. Rivers and Streams Impaired by Pollutants. TMDL Required (MDEP 305(b), 2004).

SEGMENT NAME	SEGMENT SIZE (mi)	SEGMENT CLASS	MONITORED DATE	IMPAIRED USE	CAUSE(S)	POTENTIAL SOURCE(S)
West Branch below Halls Corner	4.0	Class AA	2000	Aquatic life Recreation	Dissolved oxygen; Bacteria	Agric NPS
MS below Sheepscot P	4.0	Class B	2000	Aquatic life	Dissolved Oxygen	Aquaculture PS
Dyer River below Rt 215	5.0	Class B	2000	Aquatic life Recreation	Dissolved oxygen; Bacteria	Agric NPS
Trout Brook (Alna)	2.3	Class A	2000	Aquatic life	Dissolved oxygen	NPS (unspecified)
Meadow Brk (China)	5.0	Class B	2000	Aquatic life	Dissolved oxygen	NPS (unspecified)
Carlton Brk (Whitefield)	2.8	Class B	2000	Aquatic life	Dissolved oxygen	NPS (unspecified)
Choate Brk (Windsor)	1.3	Class A	2000	Aquatic life	Dissolved oxygen	NPS (unspecified)

Rivers with high bacteria are considered lower priority because there are no bacteria BMPs and it is unknown if the bacteria contamination is of human or wildlife origin. Sites with bacterial contamination from wildlife cannot be remediated. Therefore, sites with bacterial contamination will only be placed on the 303(d) or 305(b) list if the bacteria are proven to be of human origin.

Both point source and nonpoint source pollution sites are listed on the TMDL List. Currently 43% of all state sites are NPS pollution related, 10% are point source related and 47% are a combination of point and nonpoint source pollution. While point source pollution has permit requirements for remediation, nonpoint sources have no requirement for remediation.

Recommendations:

1. SVCA data has been instrumental in putting several sites on the TMDL List. This action, in turn, will protect these listed waters in the future. MDEP and SVCA should continue to collaborate in WQM especially at those sites that are currently not receiving adequate monitoring (See Section 3.2). Intensified monitoring may reveal new TMDL locations that can be remediated.
2. For those sites where bacteria may be linked to livestock, WQM should be coordinated with agricultural BMPs. Pre- and post-remediation monitoring should be conducted at these agricultural sites.
3. Currently, MDEP has WQ data and information stored in a variety of MDEP divisions (e.g., Hatchery Licensing Program, Lakes Division, Salmon Program, Biomonitoring Program, etc). Public and interagency access to that data currently requires tracking down the data from each separate division. The USEPA will soon require that MDEP place their data on the EPA website using "STORET." The MDEP should work with PEARL to ensure that data from each division is either directly housed on the PEARL site or linked to the EPA site or both. The Biomonitoring unit of the MDEP is currently developing the Bio IMP Project, Biomonitoring Internet Mapping Project, which will be linked to the PEARL website.
4. The SVCA and cooperating agencies have recently begun the process of gathering GIS and other data relevant to Atlantic salmon and/or water quality and storing it in a centralized database (SVCA KRIS Project). Ultimately, this information will be analyzed to 1) determine those factors most limiting to salmon and 2) direct the focus of future salmon studies and restoration efforts. The Stressor Identification Process should be the mechanism of choice when making this limiting-factor determination since it provides an organized, logical method for weighing evidence and eliminating and diagnosing potential stressors.

3.6 Maine Department of Environmental Protection Pollutant Discharge Elimination Program: IF&W Fish Hatchery

Objective:	Hatchery Licensing
Monitoring History:	MDEP review of recent data: 3 years (1999 – 2002)
E-Database Storage:	In house: MDEP
Parameters:	Flow, Biomass, BOD, TSS, Total P, N, Ammonia, and macroinvertebrates
Location:	IF&W Fish Hatchery Outlet in Palermo
Identified Trends:	Site does not attain Class B standards Highly enriched

Monitoring Background

The IF&W Fish Rearing Facility in Palermo was built in the 1950s and currently raises brown trout and splake (lake trout/salmon hybrid). It is located near the outlet of Sheepscot Pond, which was chosen for its excellent source of coldwater. The hatchery maintains consistent coldwater temperatures (approximately 14°C) by withdrawing and mixing both lake-surface and lake-bottom water.

There are two major sources of poor-quality water from the Palermo Hatchery:

1. The settling basin at the eastern raceway is rarely cleaned out so that overflow water enters the river untreated and with poor water quality: high BOD, high TSS, and high P, N, and ammonia (and possibly formalin, which is used as a disinfectant).
2. Water which drains directly from the last six chambers of the western raceway undergoes no settling and enters the river untreated and with poor water quality and high nutrients.

The effluent has a 3:1 dilution ratio, which means that there are three parts receiving water to one part effluent. The dilution ratio is based on 7Q10, which is determined by taking the average flow for a seven-day period during a ten-day period. The period is generally in late summer.

IF&W is responsible for monitoring WQ of the effluent and receiving waters. MDEP regulates the discharge of pollutants to waters and is mandated with ensuring that facility effluent discharges do not cause non-attainment of classification standards. The MDEP issued waste discharge licenses for the Palermo hatchery and monitoring requirements in July 2000 (MDEP, 2002).

Parameters
Current monitoring of effluent includes flow, biomass, BOD, TSS, TP, N, and ammonia. Samples are collected and measurements are recorded by IF&W Hatchery biologists. The monitoring results are sent to MDEP for licensing purposes. In addition, the site was part of the MDEP 1999 Biomonitoring Program for Classification Attainment in which macroinvertebrates are monitored.

Results
The section of the Sheepscot River receiving effluent from the hatchery is classified as Class B. However, recent biological monitoring indicates that the section is only attaining Class C standards. MDEP biologists suggest that observed conditions indicate a highly enriched and unbalanced macroinvertebrate community (MDEP, 2002). Furthermore, MDEP Hatchery Licensing Program reviewed hatchery procedures and found poor or inconsistent QA/QC, water treatment, monitoring, and reporting (Stratton, MDEP, Personal Communication, 2003).

In addition to the substandard water quality of the receiving waters in this portion of the Sheepscot River, there is also concern that excessive water withdrawal from Sheepscot Pond necessary for maintaining the raceways may be negatively affecting flow in the portion of the river above the hatchery and below the pond outlet. The area just below the pond contains high priority salmon habitat and in many years, the summer pond level has been withdrawn so low that flow from the outlet has been negligible. Therefore, in many years, the hatchery outflow, in effect, controls the flow and water quality regime of the entire river below the hatchery.

Recommendations:

1. SVCA has two current monitoring stations in the area: SO14.5F, just below the hatchery and SO14F above the inlet of Long Pond. Local WQM organizations should increase monitoring in the following ways:
    a. maintain the two current sites and add one additional site above the hatchery as a control,
    b. increase the monitoring occurrences at all three sites to include those times when the hatchery is being cleaned and effluent is entering the receiving waters, and
    c. add an additional site midway between SO14.5F and SO14F to determine distance-effects of effluent.
2. Under new licensing in 2005, operations and monitoring should include:
    a. standards for bringing receiving waters into attainment,
    b. standards for upgrading the water quality of the effluent (sludge removal, microfiltration, oxygenation),
    c. a plan for cost-effective effluent treatment, and
    d. regulation on the mass and concentration limit on all pollutants.
3. Prior to relicensing in 2005, a study should be conducted which compares water quality and flow above (control) and below the hatchery (point source) in order to establish a permitting model for dilution, water quality standards, mass limits, and

water treatment design. This study could be a cooperative effort between USGS, MDEP, and possibly the UM Senator George Mitchell Center.

4. Conduct a flow study to determine the effects of hatchery withdrawal and dam operation on mainstem flow.

3.7 Volunteer Lakes Monitoring Program & Maine Department of Environmental Protection Lakes Program

Objective:	Monitoring Cultural Eutrophication,
Monitoring History:	20+ years: varies with individual lake
Database Storage:	http://www.pearl.maine.edu/
Parameters:	Transparency, DO, pH, Alkalinity, Total P, Chlorophyll a
Location:	Lakes
Identified Trends:	Branch P, Clary L, Long P, and Dyer Long P. are identified as having "Below Average" WQ

Monitoring Background

The MDEP and the Volunteer Lakes Monitoring Program (VLMP) collaborate in the collection of lake data to evaluate water quality, track algal blooms, and determine water quality trends. The VLMP has been collecting WQ data on Maine lakes since the 1970s. The primary focus of their monitoring program is cultural eutrophication, or nutrification, as a result of human activity.

Although there are over 40 lakes and ponds in the Sheepscot Drainage, ten lakes have been identified as having the greatest influence on Sheepscot River freshwater WQ. Lakes such as Sheepscot Pond, Long Pond, Branch Pond, Clary Lake, and Savade Pond drain directly to AS habitat and may require special attention and monitoring.

Several of the Sheepscot River lakes have a long history of WQM and have active monitoring programs (Sheepscot, Branch, Dyer Long, and Clary). Some lakes, however, do not have an active monitoring program and therefore, have little available data (see Table 3.7.1).

Lakes and ponds may influence river WQ in a variety of ways (VLMP, 2004):

- Lakes and ponds in the river watershed may be viewed as pollutant "traps."
- However, as nutrients, sediment, and algae concentrations rise in these waterbodies, there is a proportional export of pollutants to the river downstream. "Lake outlet effect" occurs when poor-quality lake water enters the river and subsequently diminishes river water quality.
- Salmon often pass through in-stream lakes in order to access upstream habitat. Poor lake WQ could act as an obstacle to passage. The use of these lakes by Atlantic salmon is not fully understood.

Table 3.7.1. History of Volunteer Lake Monitoring in the Sheepscot River Watershed (VLMP, 2004).

Lake	Yrs of Data	Active Monitoring
Sheepscot Pond	23	Yes
Long Pond	6	No
Branch Pond	15	Yes
Turner Pond	3	No
Dyer Long Pond	7	Yes
Clary Lake	28	Yes
Beech Pond	0	No
Savade Pond	0	No
Three Corner Pond	1	No
Little Dyer Pond	0	No

Parameters

MDEP and VLMP measure the following productivity indicators: transparency, DO, pH, alkalinity, TP, and chlorophyll a (chl a). Transparency, TP, and chl a are sometimes referred to as "trophic state" indicators (VLMP, 2004). Transparency, DO, and pH are performed in the field, while TP and chl a are analyzed at the MDEP lab.

Results

In addition to understanding productivity indicators and overall water quality, the size of the lake, its drainage area, and its flushing rate (Table 3.7.2) should also be considered. Sheepscot Pond is the largest and deepest of the lakes and drains the largest area but has a flushing rate of one flush/year. Conversely, Turner Pond is the shallowest and smallest lake but has a flushing rate of 26.12 flushes/year.

Because several of the lakes have little or no available WQ data, only five of the ten significant lakes have been classified by MDEP/VLMP using five of the productivity indicators (Table 3.7.3). The MDEP and VLMP use these five indicators to determine the "Water Quality Status" and "Potential Blooms" of each lake. As illustrated in Table 3.7.4, no lake is classified as "Above Average," two (Sheepscot and Branch) are classified as "Average," two (Long and Dyer Long) as "Slightly Below Average," and one, Clary Lake, is classified as "Below Average." Clary Lake, Dyer Long Pond, and Long Pond are classified as below average due to a combination of low transparency, higher than average TP, and/or higher than average chlorophyll a values. These values and classifications indicate that these three lakes are somewhat productive and require monitoring and possibly protection. It should be noted that Dyer Long Pond is not currently being monitored (VLMP, 2004).

In addition to productivity indicators, DO is measured as an indicator of survivability. Sheepscot, Clary, Long, and Dyer Long Pond all show low DO depletion (moderate to high amounts of measured DO) in deep areas of the lake. Recent DO profiles show moderate DO depletion (low amounts of DO) in deep areas of Branch Pond. Although not unusual for late summer, it could be a concern for coldwater fish species.

Table 3.7.2. Morphometry of Sheepscot River Watershed Lakes (VLMP, 2004).

Lake	**Depth**	**Surf. Acres**	**Flush/Yr**	**Watershed Mi²**
Sheepscot P.	132	1203	1.0	33.
Long P.	16	484	18.1	8.8
Branch P.	38	306	5.5	8.3
Turner P.	7	195	26.12	8.1
Dyer Long P.	16	351	6.5	10.3
Clary Lake	22	667	1.8	7.52
Beech P.	N/A	N/A	N/A	N/A
Savade P.	N/A	N/A	N/A	N/A
3 Corner P.	35	69	1.13	0.82
Little Dyer P.	N/A	N/A	N/A	N/A

Table 3.7.3. Water Quality Indicator Averages for Sheepscot River Watershed Lakes (VLMP, 2004).

Lake	**Secchi Mtrs Ave = 4.8 m**	**TP ppb Ave= 12 ppb**	**CHL ppb Ave= 4.7ppb**	**Color SPU Ave =27SPU**	**D.O. Loss**
Sheepscot P	4.9	7	2.6	39	OK
Long P	3.4	10	3.7	37	OK
Branch P	4.2	12	3.9	30	Moderate
Turner P	2.2	19	5.7	80	OK
Dyer Long P	3.0	11	6.3	43	OK
Clary L	3.7	16	8.5	28	OK?
Beech P	N/A				
Savade P	N/A				
3 Corner P	5.1				
Little Dyer P	N/A				

Table 3.7.4. MDEP Water Quality Summary for Lakes in the Sheepscot River Watershed (VLMP 2004).

Lake	Water Quality Status/ Potential for Blooms
Sheepscot P	Average/ Average
Long P	Slightly Below Average/Low to Moderate
Branch P	Average, but Low DO in deep areas/ Average
Turner P	Insufficient Data
Dyer Long P	Slightly Below Average / Low
Clary L	Below Average / Average
Beech P	No Data
Savade P	No Data
3 Corner P	Insufficient Data
Little Dyer P	No Data

The MDEP also characterizes lakes using a rating system called the Water Quality Category (Table 3.7.5), which rates the WQ level as well as the lake's vulnerability to change. The categories and descriptions are as follows (see *Phosphorus Control in Lake Watersheds*, MDEP, 1992 for full description):

Outstanding: very clear, very low algae, very low TP; rare and unique
Good: clear, low algae, low TP; common
Moderate/Stable: less clear, no summer blooms, moderate algae and phosphorus; does not appear to be at risk for developing blooms.
Moderate/Sensitive: less clear, moderate algae and phosphorus: has high potential for developing blooms because of DO depletion in metalimnion; rating is given to lakes with no data
Poor/Restorable: supports obnoxious summer algal blooms and are candidates for restoration

Of the six lakes for which there is data, four are classified as "Moderate/Stable." Branch Pond and Clary Lake are classified as "Moderate/Sensitive." Branch Pond is sensitive due to DO depletion at deep levels; Clary Lake is sensitive due to high TP and Chlorophyll a. The lakes, for which there is no data, are classified as "Moderate/Sensitive" as a precautionary measure.

Table 3.7.5. MDEP Water Quality Categories for Lakes in the Sheepscot River Watershed (VLMP 2004).

Lake	**Water Quality Category**
Sheepscot P	Moderate/Stable
Long P	Moderate/Stable
Branch P	Moderate/Sensitive due to DO depletion
Turner P	Moderate/Stable
Dyer Long P	Moderate/Stable
Clary L	Moderate/Sensitive due to high TP & Chla
Beech P	Moderate/Sensitive
Savade P	Moderate/Sensitive
3 Corner P	Moderate/Sensitive
Little Dyer P	Moderate/Sensitive

Recommendations

1. Increase the dialogue between the VLMP and the river-monitoring agencies to ensure that both groups are informed of sensitive areas or sudden trends of poor water quality. Encourage the use of a centralized database for data storage and internal and public outreach programs that stimulate collaboration.
2. Solicit and train community volunteers to monitor those lakes and ponds that do not have an active monitoring program.
3. Sheepscot Pond, Long Pond, Branch Pond, Clary Lake, and Savade Pond drain directly to AS habitat. New WQM sites should be established at the outlet of these lakes and correlated with lake data in order to document and manage for any lake outlet effect, which may affect aquatic life and classification attainment status.
4. Intensify lake monitoring efforts with increased development pressure, especially in lakes draining to AS habitat or Class AA/A waters. This could be accomplished with more monitoring sites and monitoring days.
5. Lakes which are classified as “Moderate/Sensitive” or “Below/Slightly Below Average” should receive increased monitoring efforts. This would include Dyer Long, Long, Clary, and Branch Ponds.
6. Lakes with large drainage areas may require increased monitoring and protection. For instance, Sheepscot Pond drains a 33 square mile watershed. Although this section of the watershed (the headwaters) is currently underdeveloped, it is also under the greatest development pressure from Route 3 and sprawl from Augusta.

3.8 Maine Department of Environmental Protection Dam Licensing

Objective:	Dam Regulation
Monitoring History:	10+ years
Database Storage:	In house
Parameters:	No WQ data;
	Only Dam Ownership and Regulation
Location:	Throughout Watershed: WB and MS
Identified Trends:	N/A

Monitoring Background
The MDEP Dam Regulation Division does not gather or store any WQ data or information. The following information is included in this section because the topic was identified as having a direct effect on flow, WQ, and WQM decisions.

There are nine dams in the freshwater portion of the Sheepscot River watershed which may have a significant effect on river WQ and fish habitat. None of these dams, however, create impoundments which serve as reservoirs. Most of the dams are "run of the river" in which headpond input equals output (except for evaporative losses). In this case, the natural flow downstream is generally not affected; the flow increases during rain events and decreases during dry periods. (Personal Communication, Dana Murch, MDEP, September 2003). Table 3.8.1 summarizes attributes of several dams in the watershed.

Water Quality and Aquatic Habitat
(Personal Communication, Dana Murch, MDEP, September 2003)
In general, dams diminish water quality and aquatic habitat in the following ways:

- Dams reduce the natural reaeration process, increase time of travel, and thereby lower dissolved oxygen content and raise temperatures.
- Dams cause an increase in the settling of sediments and nutrients on the upstream side.
- In some cases, dams may alter flow downstream; in general, water is released and flow is high in the spring, and water is withheld and flow is low in summer.
- Dams change upstream aquatic ecosystems from lotic (fast moving) to lentic (slow moving).
- Dams may obstruct fish passage during low flow and, in some cases, year round.
- Dams may cause increased erosion downstream.

Dam Regulation
Currently there are no laws regulating dam registry, dam removal, dam maintenance, or gate operation. Prior to 1993, dam owners were required to register their dams with MDEP; however due to budgetary constraints, the costly registry process was discontinued. Today dam owners are not required to register their dams. In some cases, MDEP can be petitioned to issue an order requiring the operator to maintain flow downstream. (Personal Communication, Dana Murch, MDEP, September 2003).

Table 3.8.1. Dams in the Sheepscot River Watershed

Dam	Dam Location	Owner	Function	WQ or Passage Issue?
Head Tide Dam	Alna	Town of Alna	Instream; swimming; social value	Passage is issue at low and high flow.
Dyer Long Pond	Jefferson	Privately Owned	Impounds Dyer Long Pond	Condition/passage unknown
Clary Lake Pond	Whitefield	Privately Owned	Impounds Clary Lake; social value	Lake level held unnaturally high; downstream often dry; alewife passage obstructed
Three Corner Pond Dam	Jefferson	Deering Lumber	Impounds Three Corner Pond	Condition/passage unknown
Coopers Mills Dam	Whitefield	Town of Whitefield	Instream; alewife & eel fisheries; fire pond	Dam leakage; salmon passage obstructed; need to keep lamprey out
Turner Pond Dam	Somerville	Privately Owned	Impounds Turner Pond; social value	Condition/passage unknown
Sheepscot Pond Dam	Palermo	IF&W	Impounds Sheepscot P.; supplies hatchery water intake	Hatchery pumps cold water from pond; controls flow of SR
Branch Pond Dam	China	Privately Owned	Impounds Brach Pond; grist mill	No fishway has been proposed. Fishway request may be needed.
Eastman Mill Dam	Palermo	Privately Owned	Impounds Chisholm P.	Condition/passage unknown

Specific Dam Issues
1. Clary Lake Dam: the gate is opened in spring and water is released in order to allow lake residents to install their docks. The release provides ample flow in the river during spring but flow diminishes during the summer.
2. Branch Mills: No fishway has been planned for proposed mill.
3. There are 7 dams maintaining impoundments and 2 dams that are run-of-the-river. Coopers Mills and Head of Tide Dams are run of the river dams and may be altering salmon habitat significantly.

Recommendations
1. Sheepscot River Watershed Council should conduct a survey of the dams to ascertain:

a. Current ownership
b. Current operation
c. Current condition and structural composition
d. Water level maintenance and flow data

Operation and construction will indicate WQ issue and dictate WQM as well as management decisions. Also, SRWC should inventory remnant dams that may also be altering flow.

2. Determine which dams are currently causing flow problems and meet with owners to discuss possible operation alternatives.
3. WQM Recommendations:
    a. Monitor WQ above and below dam to determine true effect of dam.
    b. Correlate WQ data with flow data – when flow is low, is WQ also low?
4. Although there are no laws requiring dam permitting or removal, the Federal Endangered Species Act (ESA) protects salmon. If a dam obstructs salmon passage or diminishes habitat, the ESA could require dam removal. The SVCA should petition the MDEP to remove such dams or require improved fish passage and flow.

3.9 Maine Department of Marine Resources Shellfish Sanitation Program

Objective:	Shellfish Sanitation
Monitoring History:	10+ years: continuously from 1990-2004
Database Storage:	In house
Parameters:	Fecal coliform, Temperature, Salinity,
Location:	Estuary
Identified Trends:	Shellfish Area Closures due to high fecal coliform from OBD septic system discharge

Monitoring Background

The goal of the DMR Shellfish Sanitation Program is to protect public health by ensuring that shellfish are harvested from pollution-free areas and are processed and transported under sanitary conditions.

This goal is accomplished by monitoring waters in shellfish growing areas for fecal coliform and red tide. In addition to classification of the shellfish areas, the DMR also conducts a shoreline survey to inspect properties for faulty septic system, improper ditching, and potential NPS before a shore is classified.

DMR maintains approximately 45 sites in the estuary extending from Head Tide in Alna to Newagen on Southport Island (east) and Outer Head on Georgetown Island (west) in Sheepscot Bay.

Parameters

The fecal coliform multiple tube fermentation method is used as the pollution indicator of waste from warm-blooded animals. It is an easy, reliable, and inexpensive analysis that has a long history of use and data for comparison. Temperature and salinity is also measured.

A random sampling method is used in order to obtain an understanding of WQ in varying conditions such as, seasonal variation, tides, and weather changes. Sites are sampled a minimum of six times per year to maintain open approved status.

Classification: Classification of a site is based on the statistical average of the 30 most recent samples, the "90th percentile" (P90), or the number of colonies per 100 ml sample. Table 3.9.1 summarizes the classification standards of the shellfish sanitation program.

Table 3.9.1. DMR Water Quality Classification

Classification	**P90**	**Definition**
Approved	<49	Open. No sewage pollution or red tide
Conditionally Approved	<49	Open unless there is > 1 inch rainfall in 24 hour period. Examples include sewage treatment plant or marina.
Restricted	>49 and <300	Depuration harvest only. Slightly polluted area; harvest under strictly regulated conditions by licensed operation that purifies shellfish before sale.
Prohibited	>300	Closed. Actual or potential sewage or red tide or lack of sufficient data.

Results

Overall, estuarine WQ is considered quite good: 88% of the sites meet approved standards. Primary sources of poor WQ in the estuary include overboard discharge septic systems (< 100 systems), a sewage treatment plant, and at least two marinas. Out of 43 sites:

- 21 sites are Approved
- 4 sites are Prohibited due to poor WQ/pollution
- 15 sites are Prohibited due to pollution threats, such as overboard discharge septic systems.
- 3 sites are Restricted

Ten-year trends in the data indicate that WQ in:

- 70% of the sites remained constant
  - 65% had good WQ
  - 5% had poor WQ
- 21% of the sites improved
- 9% of the sites declined
- 7% of the sites had inconsistent or poor WQ

In summary, the DMR considers the estuarine WQ very good and the data indicates some improvements in the past ten years. The primary reason for closures in the estuary is the large number of overboard discharge septic systems (OBD). Although several OBD sites generally meet the water standards, they are classified as Prohibited due to the potential of pollution, such as when they are not properly maintained. There has been little interest from the local community to remove the systems and upgrade the shellfish areas.

Recommendations

1. Although DMR data indicates improving conditions with regards to bacteria, the fresh water areas are showing diminished WQ and increased bacteria. DMR should train volunteers to conduct a shoreline survey to determine the origin of bacterial inputs.

2. Encourage communities to remove OBDs and replace with a less-contaminating system.
3. Compare DMR marine temperature and bacteria data with freshwater temperature and bacteria data to determine trends.
4. The effects of high levels of bacteria on coldwater fish are currently unknown. A study that investigates the effects of fecal bacteria on overall WS productivity (plant and animal communities) as well as coldwater fish species, such as salmon and trout, should be conducted, and the results from the study should be used to guide management activities.

3.10 Maine Atlantic Salmon Commission

Objective:	Salmon Restoration
Monitoring History:	10+ years for population data; 3 years for WQ data
Database Storage:	In house
Parameters:	Temperature, pH, population estimates, and habitat mapping
Location:	West Branch, Mainstem, and some tributaries
Identified Trends:	Lake warmwater influences river; pH values are considerably higher than the Downeast rivers; Salmon may be lost in the fry and parr stage

Monitoring Background
The charge of the Atlantic Salmon Commission is to determine best salmon stocking practices based on salmon habitat, population estimates, and water quality. The ASC has collected population and habitat data and information for over ten years. Water Quality data has been collected for only 3 years and in some cases only 1 year. The objective is to correlate WQ with known fish habitat, survival, and population information (parr numbers, redd counts, etc) so that better decisions about stocking programs can be made.

Parameters
The ASC maintains an internal database of mapped spawning and juvenile rearing salmon habitat, redd counts, electrofishing data, pH, and overwinter temperature. Temperature is measured using temperature loggers and pH is determined using the closed cell method.

Results
Habitat
The ASC, in collaboration with the USFWS, has surveyed AS habitat throughout the watershed for approximately 6 years. This information is currently in GIS format and is regularly updated as new information develops. In addition to describing the substrate and amount of runs and riffles, the habitat surveys also record any noticeable inputs of coldwater, such as springs, using temperature measurements. All sections of the Sheepscot River have been surveyed except for the following:

MS from Coopers Mills Dam to Long Pond
WB above Branch Pond
All tributaries except: Trout, Choate, Ben, and Dyer

The habitat is classified into two types:

> **Juvenile rearing habitat** is generally composed of runs and riffles with some gradient. Substrate consists of gravel, cobbles, and small boulders. Juvenile habitat contains no glides (calm, smooth-flowing stretch) or soft bottom.
> **Spawning habitat** is generally composed of glide tails and pool tails. Substrate consists mainly of gravel or rubble that is 2-10 cm in diameter. Water level is generally less than three feet in depth and higher velocity than juvenile habitat.

The habitat inventory and mapping suggest that the following areas have the best habitat:

1. **Below Sheepscot Pond and Palermo Hatchery**. This portion is somewhat unnatural due to inputs of hatchery nutrients and cold water (cool in summer, warm in winter).
2. **West Branch**: This entire portion has juvenile rearing habitat scattered evenly throughout.
3. **Mainstem Below the Confluence**. This area is evenly scattered with spawning habitat and there are large quantities of spawning and rearing habitat in the MS above head of tide in Alna and in Trout Brook which enters below head of tide in Alna

pH Survey

The ASC in conjunction with the University of Maine Senator George Mitchell Center is conducting a synoptic survey of pH conditions in the eight Atlantic salmon rivers. Samples were collected and tested for closed cell pH in May, July, and October, 2003 and April, 2004. Closed cell pH is a measurement of pH in a sample of water sealed from atmospheric contact and chilled to prevent respiration. The sample is measured in the lab, but is considered a measure of *in situ* conditions. The pH is thought to represent the pH of the water without the influence of respiration and photosynthesis. Sheepscot River pH ranged between 6.32 – 7.67 during these collection dates. This range of pH values is considerably higher than other DPS rivers (4.68 – 7.44) and is not considered a threat to salmon.

Overwinter Temperature Logger

The ASC installed 6 loggers (2 on the WB and 4 on the MS) during winter 2001-2002 in an effort to gain a better understanding of overwinter temperatures and warmwater influences from lakes and ponds:

- Reaches directly below Branch, Sheepscot, Long, and James ponds did not freeze (go below zero), possibly due to warmwater input from ponds.
- The section approximately 1 mile below Branch Pond outlet did freeze- confirming lake effect on above portion.
- King Mills and Head of Tide did freeze possibly due to calm water with no warm water inputs.

Population Studies

Electrofishing

In an effort to determine the number of parr in the river, 26 sites (7 on the WB and 19 on the MS) are sampled via electrofishing each fall. Parr estimates determine at what life stage (fry, parr, or smolt stage) fish are lost in the system. In the Sheepscot River Watershed, Atlantic salmon fry are released in the spring. In the fall, researchers return to count how many have successfully survived and matured to the parr stage.

Although the actual numbers of fish/location vary from year to year and season to season, the data does indicate some very strong trends:

- Young-of-the-year (YOY) prefer smaller streams and survival is better in the upper portions of the watershed. There is more fry habitat in the smaller parts of the river and in the upper portion of the watershed.
- Although parr are found throughout the MS, more parr are found in the upper portions of the watershed than in other areas.
- Larger fry and parr are found in the MS, specifically near Coopers Mills and the Howe Road crossing.
- The number of fry and parr decrease below Coopers Mills where the river widens. This may be related to elevated temperatures and substrate differences in this river section.
- While similar electrofishing data suggest that salmon are lost in the smolt stage in other DPS rivers, Sheepscot electrofishing data suggest that salmon may be lost at the fry and parr stage. The reasons, though unclear, may be related to fry/parr habitat and temperature.

Redd Counts

Redd count surveys have been conducted by the ASC since 1999 and the data indicate that redd development is declining:

Year	# of Redds
1999	21
2000	16
2001	18
2002	4

Recommendations

1. Temperature monitoring is important as both fry and parr are sensitive to high summer temperatures. Also at higher temperatures, oxygen demand is greater due to respiration while oxygen solubility is lower. High summer temperatures are a particular problem on the West Branch. Conduct a temperature study in which
    - lethal temperatures in nature are determined,
    - the duration of high water temperatures, and
    - temperature is correlated with stream profile and flow.
2. Currently, the choice of stocking locations is based primarily on access and the number of habitat units per reach. Furthermore, there is little to no research suggesting the best time and conditions needed to ensure stock survival. In an effort to increase fry survival at stocking sites, ASC and USFW should:
    - review reach-specific historical WQ data to determine best sites and times for stocking and
    - monitor each stocking site for temperature, DO, turbidity, TSS, and flow at the time of stocking in order to ensure stock survival.

3. There is anecdotal evidence to suggest that salmon may experience temperature shock during the stocking process. Salmon are kept at warmer temperatures in the hatchery but are exposed to cooler temperatures when entering the river. The USFW and ASC should consider an experimental "stream-side incubation" in which salmon become acclimated to the ambient stream temperature, and the shock of the hatchery-river temperature differential is reduced.
4. Correlate fish population data with WQ and flow data (e.g., using electrofishing, determine the number of fish finding refuge in spring holes during low flow period).
5. Within the watershed, there are sites with good habitat characteristics and sites without. Anecdotally, the good sites appear to have high nutrients, adequate buffer, high number of habitat units, good temperature regime. A more specific study that compares the WQ of productive sites with that of unproductive sites should be conducted for the purpose of restoring poorer sites.

3.11 NOAA National Marine Fisheries

Objective:	Salmon Restoration
Monitoring History:	4 years: continuously from 2001 – 2004
Database Storage:	In house
Parameters:	Temperature, pH, and Conductivity
Location:	Lower Mainstem above Head Tide
Identified Trends:	Daytime summer water temperatures were above lethal limit for an extended time period; pH ranges were normal

Monitoring Background
In an effort to assess Atlantic salmon smolt production, NOAA has maintained a YSI water quality data logger in the MS of the Sheepscot River just above head of tide since June 20, 2001.

NOAA Fisheries biologists are particularly interested in recently observed extreme temperatures, which may be potentially lethal to salmon. Studies indicate that temperatures of 22.5° C are stressful, and temperatures of 29.5° C for 1000 minutes or 32.9° C for 100 minutes are lethal to juvenile salmon (Elliotte, 1991).

Parameters
The logger is placed downstream from the majority of the basin's juvenile rearing habitat and records temperature, pH, and conductivity hourly, with point calibrations occurring monthly. Conductivity is not correlated with the Atlantic salmon life cycle at this time.

Results
Temperature
Temperature data from the YSI data logger indicate that potentially lethal temperatures occurred in all years (2001-2003) between mid-June and early August:

- Water temperatures were above 27° C on at least 7 days during this period in each year.
- Several days during this period experienced temperatures above 30° C.
- All nighttime, or minimum, temperatures during this period each year were between 20 and 25° C.
- On at least one occasion each year, the nighttime, or minimum, temperature remained at or near 25° C.
- Late August temperatures are generally lower, clustering at 25° C during the day and at 20° C during the night.

pH

YSI logger data indicate that, in general, pH in the Sheepscot River is well within healthy levels for salmon smolt production:

- Overall, the pH range of the Sheepscot River (6.0 – 8.5) is higher than that of the Downeast salmon rivers (4.5 – 7.0).
- Daytime, or diurnal, pH is higher than nighttime, or nocturnal, pH, possibly due to differences in photosynthetic activity. The largest diurnal difference occurred on the same day (June 30) in both 2002 and 2003. The daytime high pH was approximately 8.5 and the nighttime low pH was approximately 7.0. This is a difference of 1.5 units and is most likely associated with higher temperatures and an increase in the daily fluctuations of respiration and photosynthesis. .
- Summer pH is higher than winter pH, possibly due to summer photosynthesis and the influence of runoff during the winter months. During the growing season (June through October), pH for all three years (2001-2003) ranged between 6.0 and 8.5. During winter months (November through May), pH ranged between 5.7 to 6.7 in 2001/2002 and 6.7 to 7.0 in 2002/2003.
- The lowest pH values recorded was in March 2002 (pH 5.7-6.0) and may be associated with rain events and spring runoff.

Recommendations

1. All data, information, and activities should be correlated with continuous data (i.e., USGS gage and long term data loggers):
    a. Plot discharge with temperature, nutrient, habitat, electrofishing, telemetry, and pH data to determine relationship with flow.
    b. Correlate point sample data upstream and in tributaries with continuous data collected downstream (e.g., Compare 3:00 pm grab sample upstream with 3:00 pm continuous logger data downstream)
2. Develop flow discharge profile and correlate points with temperature and other WQ information. Determine cross-sectional and longitudinal profiles for other WQ parameters and compare.
3. Investigate the effects of the late winter/early spring low pH readings on parr/smolt populations and smolt migration.
4. Correlate stocking with cool temperature sites (i.e., sites with historically high temperatures should not be stocked).
5. Because temperatures during June and July are high, there is a need to determine the duration of the high temperatures and if water cools enough in evening and early morning to provide refuge for fish.
6. The data logger is currently stationary, and the data only reflects the temperature of the one location in the lower basin. Conduct a study that identifies areas of refugia possibly using USGS infrared technologies.

3.12 U.S. Fish and Wildlife Service

Objective:	Salmon Restoration: Stocking Management
Monitoring History:	5 years: continuously from 1999 – 2004
Database Storage:	In house
Parameters:	Temperature
Location:	West Branch, Mainstem, Estuary
Identified Trends:	Areas experiencing high summer temperatures include Coopers Mills, Kings Mills, Long Rips, and Choate Brook

Monitoring Background

The primary mission of the U.S. Fish and Wildlife Service (USFWS) is to enhance populations of Atlantic salmon within the Maine DPS. Between 1994 and 1997, the USFWS deployed loggers at juvenile population index sites where the USFWS and ASC conduct annual electrofishing surveys to assess the population of parr in the river. At the same time, loggers were placed at the temporary adult trapping facility in Alna. From 1998 through 2000, the agency expanded their monitoring to include a variety of sites throughout the drainage. These sites were selected either based on high populations of salmon parr or sites where the habitat appeared productive but had poor parr survival. In particular, the agency wanted to develop a better understanding of Long Rips, an area of seemingly good habitat, but few salmon (Denise Buckley, USFWS, Personal Communication, 2004).

1994 - 2000 USFW temperature monitoring sites included:

Weeks Mills	Kings Mills
Windsor Station	Howe Road
Coopers Mills	Rt 126
Trout Brook	Alna
Upper Deer Hill Rd	

The data from the 1994-2000 monitoring has not been fully analyzed, and results from monitoring efforts are still unclear. In 2001, the agency ceased monitoring until a clearer monitoring plan was developed. The loggers were permanently loaned to the SRWC in 2001 to continue monitoring.

Parameters

The USFW Service deployed temperature loggers. The temperature data is stored in the ASC temperature database.

Results

The primary objective of the USFWS temperature monitoring was to determine the lethal temperature limit for salmon and how specific reaches of the river varied. At extreme temperatures, salmon are increasingly stressed and more susceptible to disease, predation, and feeding problems. The temperature data collected between 1994 and 2000 indicate the following:

- During the period that the temporary adult trap operated in Alna, temperatures frequently reached extreme limits. In at least one instance (1994), the temperature reached 31.1°C, which is considered sublethal. Following that episode, three dead adult Atlantic salmon were observed upstream of the trapping facility
- Long Rips is an area that also reaches temperatures that may limit production of salmon. This is a very straight, over-widened area of south-facing habitat.
- Two other areas of concern are immediately below the Coopers Mills dam and the Kings Mills index site. Both of these sites regularly experience temperatures that can affect growth and normal feeding behavior of salmon parr. In 1994, 1995, and 1997 both sites experience particularly long stretches of time (several consecutive days) where minimum daily water temperatures never dropped below 22.5°C.
- Tributary temperature readings from 2000 indicate that Ben, Dyer, Trout, and Choate brooks all exceeded 22.5 °C during the summer months. The highest tributary temperature reading was 25.56°C on Choate Brook.

Recommendations

1. Data from 1994-2000 should be analyzed, summarized, and presented to the scientific community for review as soon as possible so that decisions can be made regarding the placement of loggers in the 2004 season.
2. In addition to understanding where high temperatures occur, areas of low-temperature refugia need to be identified. Once a river temperature profile is developed, restoration efforts can ensure that there is passage to coldwater refuge areas.
    a. Deploy loggers in known or suspect areas of groundwater input
    b. Conduct an infrared imaging study of the watershed to determine locations of groundwater inputs.
3. Temperature monitoring using loggers should continue but sites should be evaluated. Agencies should determine which sites are representative of the river and consolidate monitoring efforts by reducing the number of overall sites and adding sites where there is currently no known data.
4. Stocking efforts should be reevaluated and subsequently coordinated with WQ information. For example,
    - Long Rips is currently stocked with fry, which may not survive if exposed to lethal temperatures. The agencies should consider stocking 0+ parr rather than fry in this stretch to avoid possible loss of fry.
    - Sites, such as the Upper Deer Hill Road on the WB, contain excellent parr habitat. It is unclear, however, if the site can support smolt. The development

of stocking location requirements should include an evaluation of smolt production as well as parr especially as related to temperature.

5. High summer temperatures have been anecdotally associated with low flow. A study should be conducted that correlates temperature and flow in order to determine the potential cause of reoccurring high summer temperatures.

3.13 U.S. Geological Survey

Objective:	Monitor Water Resources
Monitoring History:	65 years**:** continuously from 1938 – 2004
E-Database Storage:	In house and at http://me.watger.usgs.gov
Parameters:	Flow statistics and fluvial geomorphology reports
Location:	Gage at Whitefield
Identified Trends:	Bankfull flow conditions occur more frequently in Maine; little to no change in bankfull flow geometry; annual spring runoff has increased during February and March but has decreased during May and June

Monitoring Background
The US Geological Survey's (USGS) primary mission is to monitor water resources in the watershed. In addition to flow, stage record, and discharge statistics, they also conduct fluvial geomorphology studies. Flow data has been collected at the North Whitefield Gaging Station since 1938.

Fluvial Geomorphology Studies
The fluvial geomorphology studies have attempted to understand the ability of water to move materials and shape the stream channel over time. Channel Evolution Models describe how streams change from stable, in which there is a floodplain, to incised or entrenched, where the channel is both deep and wide, and water and its energy cannot disperse on to the floodplain

Maine rivers generally do not function like typical alluvial river ecosystem models as cited in the literature because they generally do not flow through fine-grained material but rather through coarse gravel, boulders, and exposed bedrock. As a result, new models were developed to better understand Maine river systems.

Regional hydrologic geometry curves for bankfull flow have been developed for several regions of North America using measurements of stream width, stream depth, and water velocity during bankfull conditions (Dudley, 2004).

Results
A recent cooperative study between the USGS Maine District, ASC, and USFWS entitled, "Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine" (Dudley, 2004), found that Maine's unique geology, climate, and hydrology result in regional geometry curves that differ from the established curves for other regions of North America. The study indicates that:

- Bankfull flow conditions occur more frequently in Maine's central and coastal rivers. On a flow-duration basis, bankfull streamflow for rivers in coastal and central Maine is equaled or exceeded about 30 days a year. Bankfull streamflow is roughly three times that of the mean annual streamflow for the sites investigated in this study. Regional climate, snowmelt hydrology, and glacial geology may play important roles in dictating the magnitude and frequency of occurrence of bankfull streamflows observed for rivers in coastal and central Maine.
- Maine's flow pattern differs from other areas of the country, which generally experience bankfull flow as distinct flood events that occur once every 1-2 years, or about 1.5-years on average.

The data and hydrologic geometry curves also indicate that:

- little to no change in bankfull flow geometry occurred at the gaging station between 1938 and 2002.
- as velocity at the site increases, depth increases and width increases only slightly. It is suggested that the increase in depth is due to steep banks at the gaging site. Some areas of the Sheepscot River are composed of ledge and remain stable over time, such as the gaging station. Anecdotal observations suggest that other areas tend to be more alluvial and the banks appear to be widening over time.

Flow information recorded at the gage for this same period indicates that:

- average annual discharge for the Sheepscot is 248 cfs,
- while stream geomorphology and channel geometry has remained constant, total annual runoff has increased.
- annual spring runoff has increased during February and March but has decreased during May and June (Dudley and Hodgkins, 2002). The early spring increase and early summer decrease in runoff is attributed to earlier snowmelt runoff. Annual runoff is determined by subtracting evapotranspiration and contribution to groundwater from annual precipitation. Increased annual runoff may be the result of a decline in evaporation, an increase in the amount of impervious surfaces, an increase in precipitation, a decline in groundwater contributions, or a combination of all factors. It has been suggested that increased runoff is the result of an increase in spring precipitation since there has not been enough development to significantly change evapotranspiration, groundwater contributions, or impervious surfaces. In order to confirm precipitation increases, flow data should be correlated with USHCN data (US Historical Climatology Network).

Recommendations:

1. Water quality monitoring data and anecdotal observations suggest that flow and fluvial geomorphology patterns may be contributing to poor water quality. The following are river reach characteristics which should be investigated:
    - reaches that appear to have lower than normal flow, such as Howe Rd.

- reaches in which high temperature, low dissolved oxygen, and high *E. coli* are associated with low flow,
- reaches that appear to be over widened, and
- reaches that do not have enough cold water fish habitat (i.e., riffles)

2. Rivers may also be affected by anthropogenic activities such as: agriculture, road structures (bridges, culverts, etc), dams, and development. Restoration efforts and WQM should focus on areas where there is historic proof of anthropogenic influences.
3. In order to confirm precipitation increases, flow data should be correlated with USHCN (US Historical Climatology Network) data.
4. Evidence suggests that compared to other salmon rivers, the Sheepscot may have more water quality issues associated with flow. Therefore, the following studies should be initiated by the ASC and USGS.
    - Conduct Fluvial Geomorphology Study of the WB and of the MS.
    - Develop Groundwater Contribution Model using infrared imaging (similar to Acadia National Park).
    - Develop Overall Water Budget for River Basin (similar to Water Use Management Plans in the DE Rivers)
    - Develop Low Flow Model and Dam Study
    - Install a gage on the WB to assess continuous flow.
5. WQ trends are generally related to flow/discharge. While analyzing long-term data for trends may provide some information, it is probably more fruitful to compare WQ for only those years with similar flow. For example, a study should be done to compare DO and temperature across all low flow or dry years or compare nutrients across all high flow, wet years then comparing the same for dry years.
6. Conduct a watershed-wide flow and temperature study to determine if flow and temperature are related.

Chapter Four
Water Quality Trends

4

4.1 Overview

Chapter Three reviewed the monitoring objectives, history, and results of each of the WQM agencies and organizations involved on the Sheepscot River. This chapter will review each parameter trend and the locations of poor water quality by parameter. The parameters include: DO, bacteria, temperature, pH, nutrients, biomonitoring, and flow.

Recommendations will not be made for each WQ parameter but rather will be made by river reach or waterbody in Chapter 5 and in summary in Chapter 6.

Please note that some of the information given below is similar to the results found in Chapter 3. This information is repeated here for quick reference. Please consult Chapter 3 for details.

4.2 Dissolved Oxygen

Dissolved oxygen has been monitored by the SVCA, MDEP/SRWC, DMR (Estuary), the IF&W Hatchery, and the VLMP (Lakes). In addition, the data is utilized by the MDEP TMDL Program for determination of TMDLs. DO is monitored using either DO Kit (Winkler Titration) or a DO meter.

Sites where below normal DO levels have been observed:

Upper MS above Sheepscot Pond	Trout Brook
Dyer River below Rt 15	Carlton Brook
West Branch below Halls Corner and Maxcys Mills	Choate Brook
Chamberlain Brook	Meadow Brook
Branch Pond	Hewitt Brook

Explanation
Levels of DO in the WB and MS during summer months of 2000 ranged from 6.7-8.8 ppm with a low occurring at the outlet of Sheepscot Pond in September 2000. Most of these values represent morning samples when DO is generally lower as compared to the afternoon when DO is higher due to photosynthesis (Whiting, 2003).

SVCA data indicate that the WB has significantly lower DO than other reaches (in violation over 40% of the time in most years) and that the tributaries have significantly lower mean DO than the MS, possibly due to lower flow (Pugh, 2003). Two locations that are of particular concern are Chamberlain Brook and Upper MS (S015) which both had a higher number of DO and bacteria violations than other reaches.

The MDEP have found that DO at seven sites was impaired enough to place them on the TMDL list. These sites include WB below Halls Corner, Dyer River below Rt. 215, MS below Sheepscot P, and Trout, Choate, Meadow, and Carlton brooks.

While most of the lakes (Sheepscot, Clary, Long, and Dyer Long) in the watershed show little DO depletion (moderate to high amounts of DO), in deep areas of the lake, recent DO profiles show moderate DO depletion (lower amounts of DO) in deep areas of Branch Pond. Although not unusual for late summer, it could be a concern for fish species.

4.3 Bacteria

Bacteria levels have been monitored by the SVCA, MDEP/SRWC, and DMR (Estuary). In addition, the data is utilized by the MDEP TMDL Program. In most cases, bacteria are determined using the fecal coliform multiple tube fermentation method.

Sites where above normal bacteria levels are observed:

Upper MS above Sheepscot Pond	Dyer River below Rt 215
WB below Halls Corner, Maxcys Mills, Meeks Mills, & Howe Road	Estuary below Sheepscot Village
Head Tide	Chamberlain Brook
Meadow Brook	Hewitt Brook

Explanation
SVCA data indicate that Chamberlain Brook and Upper MS (S015) had a higher number of bacteria violations than other reaches and that 70% of samples collected near Head Tide (S005, S006, S007) were in violation of Enterocoocci standards for all years monitored. Furthermore, both Dyer River below Rt. 215 and the WB below Halls Corner are cited on the TMDL list for impairment due to bacteria.

DMR data indicate that the estuary at Sheepscot Village and below is restricted to depuration shellfish harvest. While some areas of the estuary are approved for shellfish harvesting, approximately 75% of the estuary shoreline below Wiscasset is classified as prohibited, or closed to shellfish harvesting. Primary sources of poor WQ in the estuary include overboard discharge septic systems (< 100 systems), a sewage treatment plant, and at least two marinas.

4.4 Temperature

Temperature has been monitored by NOAA, ASC, USGS, and USFW using electronic loggers and by the SVCA, MDEP/SRWC, and DMR using digital or mercury thermometers. In addition, the MDEP TMDL Program utilizes the data.

Sites where stressful summer temperature levels have been observed:

MS at Kings Mills	Dyer River
MS at Long Rips	Ben Brook
Coopers Mills below dam	Trout Brook
MS at USGS gage in Whitefield	WB at Howe Rd, Whitefield
WB at Dirigo Rd, China	Choate Brook
Above Head Tide	

Sites where low summer temperature levels have been observed:

Upper MS above Sheepscot Pond	All secondary tributaries – not the WB

Sites where above freezing winter temperature levels have been observed:

Below Branch Pond	Below Sheepscot Pond
Below Long Pond	Below James Pond

Explanation

Both NOAA and USFW summer temperature logger data indicate several reaches in the lower MS that experience stressful, or sublethal, temperatures. NOAA data indicates that the MS at Head Tide reached temperatures that are considered stressful for salmon. During a period between late June and early August the temperature exceeded 27° C on at least 7 days and on four days, the temperature exceeded 30° C. Furthermore, nighttime temperatures during this same period remained between 20 and 25° C.

The USFWS data indicates that temperatures on the MS at Alna reached 31.1° C on at least one occasion. This high-temperature incident was followed by a fish kill upstream from the logger site. In addition, Long Rips also reaches temperatures that may limit production of salmon. Lastly, the reach below the Coopers Mills dam regularly experiences temperatures that may affect growth and normal feeding behavior of salmon parr. In 1994 and 1995, the site experienced particularly long stretches of time (several consecutive days) where water temperatures never dropped below 22.5°C.

Data from SVCA, MDEP/SRWC, and USFWS suggest that the tributaries do not regularly reach stressful or sublethal temperatures and they have lower mean temperatures than the MS possibly due to the presence of groundwater inputs (springs). These locations could serve as possible refugia for coldwater species trying to escape high summer temperatures in the MS. The highest tributary temperature reading was 25.6°C on Choate Brook. The river section with the lowest regular summer temperatures is the Upper MS above Sheepscot Pond.

Winter temperature logger data from the ASC suggest that the run-of-the-river lakes and ponds may have a warming effect on river sections just below their outlets during winter months. Data indicate that the river sections below Sheepscot Pond, Branch Pond, Jamesville Pond, and Long Pond did not freeze possibly due to warmwater input from the lakes. Conversely, areas of calm water, such as Kings Mills, Head of Tide, and one mile below Branch Pond did freeze. The effects of warm winter temperatures on salmon are still unclear.

4.5 pH

The UMSGMC (for the ASC) measures pH using the closed cell and the air equilibrated methods, MDEP and Kennebec County SWCD/SRWC uses handheld units, and NOAA uses YSI temperature/pH loggers.

Sites where stressful pH levels have been observed:

In general, the Sheepscot River and its tributaries do not experience pH levels considered stressful to aquatic life.

Explanation
All three pH data sets indicate that the Sheepscot River and its tributaries do not experience pH levels that are stressful to aquatic life. The ASC/UM pH values ranged from 6.32 to 7.67 and the NOAA pH values ranged from 6.0 to 8.5. This range of pH values is considerably higher than the DE rivers (4.68 – 7.44) and is not considered a threat to salmon.

Regarding seasonal and diurnal trends, the NOAA data suggests that daytime pH is higher than nighttime pH, possibly due to photosynthesis during the day and respiration during the night. The daytime high pH was approximately 8.5 and the nighttime low pH was approximately 7.0. In addition, summer pH is higher than winter pH, possibly due to summer photosynthesis and the influence of runoff during the winter months. Lastly, the lowest pH values recorded was in March 2002 (pH 5.7-6.0) and may be associated with rain events and spring runoff, or may have been due to equipment malfunction.

4.6 Nutrients, Cations, & Anions

Nutrient levels have been monitored by the MDEP/SRWC and the VLMP using lab analysis. In addition, the data is utilized by the MDEP TMDL Program.

Sites where high nutrient levels are observed:

Clary Lake	MS at the USGS gage
Dyer Long Pond	MS at Long Rips
Long Pond	MS at Head Tide
West Branch at Howe Rd.	

Explanation
VLMP data indicate that Clary Lake, Dyer Long Pond, and Long Pond are moderately productive based on a combination of low transparency, higher than average TP, and/or higher than average chlorophyll a values. Other lakes in the system are above average in terms of productivity but are generally stable with regard to algal blooms and influences from phosphorus.

The MDEP Salmon River Program nutrient data results are still unclear and due to the complexity of nutrient cycling, require further, more advanced analysis. In general, the lower portions of the MS (USGS gage, Long Rips, Head Tide) and the WB (Howe Rd) experience higher levels of TP during both baseflow (up to 160 μg/L) and storm events (up to 91 μg/L) than the upper portions. These high TP values in the lower portions of the river may be due to an accumulation, or downstream, effect. Furthermore, TP was somewhat higher on the MS than on the WB during baseflow possibly due to a greater amount of NPS pollution.

Nitrates are generally higher in both the WB and MS than other salmon rivers. The Sheepscot ranges from < 1.0 μeq/L (essentially zero) to 29.9 μeq/L whereas the Narraguagus ranges from < 1.0 to 5.6 μeq/L. Nitrates in water generally originate from precipitation, human, and animal waste, residential and agricultural fertilizers and bedrock.

Dissolved organic carbon (DOC) levels in the MS and the WB were similar and range from 3.73 ppm to 15.8 ppm. These values are typical for a Maine river and are similar to DOC levels found in Downeast rivers.

Cations (Ca, K, Mg, and Na) are generally much greater in the WB than in the MS. For example, WB 1999 Ca levels range from 6.94 - 15.90 mg/L whereas MS 1999 Ca levels range from 2.96 - 7.21 mg/L. These ranges are within the acceptable limit for fish growth. The level of calcium at which salmon would experience a nutrient deficiency is 2.5 mg/L. Often the concentration of Ca in the Sheepscot is greater than 5 mg/L which is considered ideal for salmon.

4.7 Turbidity

Turbidity has been monitored by the MDEP/SRWC using lab analysis or hand held turbidity meters.

Sites where high turbidity levels have been observed:

WB at Howe Rd	In association with NPS sites
MS at USGS gage	Upper MS above Sheepscot Pond

Explanation

Turbidity and storm-event total suspended solids were measured by one WQM program, the MDEP/SRWC Salmon River Program. Three years of data suggest that both the WB and MS generally experience moderate turbidity (1-3 NTU) during the high flow period in February through May. Levels greater than 2 NTU may alter fish feeding. Snow melt values have been recorded as high as 17 NTU on the WB at Howe Rd and 13 NTU on the MS at the USGS gage in Whitefield.

There is also anecdotal evidence that high levels of turbidity and TSS may be occurring at sites in the headwaters above Sheepscot Pond (SWLA) and at several sites associated with documented NPS sites (Halsted, M. KCS&WD, Personal Communication, 2003).

4.8 Biomonitoring

Biological monitoring for macroinvertebrates is conducted by the MDEP Biomonitoring Program using the Biocriteria methodology and predictive models.

Sites not attaining class standards:

MS below IF&W Hatchery

Explanation
Biological Monitoring for macroinvertebrates has been conducted on the Sheepscot River since 1984. Eight sites were originally established but six of the sites are no longer monitored because they are considered low risk. Recent monitoring suggests that two sites may be improving while one site is in nonattainment. Two sites, which appear to be improving include the MS at the USGS gage and the WB at Weeks Mills, which were monitored in 2002 and found to be attaining their Class AA/A.

The area below the IF&W Hatchery and Sheepscot Pond (Class B) was monitored in 1999 and found to be in nonattainment (Class C) due to enrichment from hatchery effluent.

4.9 Flow

Discharge, or flow, is monitored by the USGS using a water-stage recorder (gage) located upstream from the Rt. 126 crossing in North Whitefield. The gage has monitored continuously since 1938.

Sites with anecdotally observed low flow:

MS above Head Tide	Some tributaries
Below Clary Lake	Below Coopers Mills Dam
Most of the WB	

Explanation
USGS Water Resource Data from 2002 indicate that the peak above base discharge of 1,100 ft^3/s, was exceeded once in water-year 2002 (Oct. 1, 2001 to Sept. 30, 2002), with a maximum discharge of 1,420 ft^3/s occurring in March and a minimum discharge of 11 ft^3/s occurring in August. The average annual discharge for the Sheepscot River is 248 cfs.

Recent fluvial geomorphology studies indicate that little to no change in bankfull flow geometry has occurred at the gaging station between 1938 and 2002. However, while stream geomorphology and channel geometry have remained constant, total annual runoff has increased. Annual spring runoff has increased during February and March but has decreased during May and June possibly due to an increase in spring precipitation.

At least ten dams within the upper watershed may have a potential impact on flow. Three dams are of particular interest. Clary Lake dam is opened in the spring providing increased flow to the river but is closed during the summer months when increased flow could be beneficial to coldwater fish. Two dams occur in run-of-the-river impoundments, Coopers Mills and Head of Tide, and may be altering salmon habitat.

There have been anecdotal reports of low flow especially associated with high temperatures and low DO. These areas include the MS above Head Tide, the West Branch, and some of the tributaries. These sites should be investigated using hand-held flow meters.

Chapter Five
Water Quality Monitoring Strategies

5

5.1 Introduction

The results from a water quality monitoring program have the potential to steer, refocus, support, and justify conservation and management initiatives and efforts. The data can facilitate work between agency personnel and land and dam owners. It can make changes in river segment classification and TMDL listings. It can direct land and water conservation, restoration, and protection efforts. Lastly, the data and information can be used to find funding for all of these efforts.

The key to effective WQM is not in the collecting, compiling, or storing of data but rather in its use. The ultimate goal in monitoring water quality is to work with other agencies to achieve management goals and ensure better water quality. The success of the strategies and recommendations in this plan will depend on all agencies' ability to improve WQM planning and to quickly analyze and utilize results and conclusions for better management decisions.

5.2 Coordinating WQM with Management and Administrative Activities

5.2.1 Coordinating with Administrative Activities

- Establish a well-constructed, easy-to-access, web-based database of WQM data from all agencies that contains very specific and detailed metadata describing monitoring agency objective, protocol, and analysis.
- Use guidance from Maine Atlantic Salmon Commission GIS Needs Assessment (Champlain Institute, 2002), PEARL, and KRIS GIS TAC to make decisions about database storage and data sharing.
- The MDEP should ensure that data from each division is user friendly and centrally located to ensure both public and interagency personnel access. This could be achieved using PEARL website.
- Each WQM agency and organization should use this plan as a springboard for the development of agency-specific work plans that:
  a. incorporate the agency-specific recommendations from this Plan,
  b. assign staff, funding sources, equipment, and time to specific action items
  c. coordinate WQM activities with other agencies' activities
  d. develop new studies that are consistent with the findings in this Plan
- All monitoring agencies and organizations should consult this plan for guidance:

a. before beginning or continuing any future monitoring effort, monitoring agencies are advised to consult this document for guidance.
b. annually as a measure of outcome success.

5.2.2 Coordinating with NPS Restoration Efforts and Land Use Management

- Correlate land use practices, such as new development, timber harvesting, and agriculture with existing WQ data for better planning. For example, towns could establish a Phosphorus Ordinance in areas that are adjacent to sensitive lakes and ponds.
- Use freshwater bacteria and temperature data to supplement DMR efforts to regulate shellfish growing areas. Data could be used to open or close particular shellfish areas or to identify the source of contamination.
- Use bacteria, DO, nutrient, and temperature data to help towns identify and remove OBD sites in the estuary, especially Head Tide village. Conduct BST analysis to determine origin of bacteria.
- Use turbidity and TSS data as evidence of NPS inputs and justification for NPS mitigation.

5.2.3 Coordinating with Channel Restoration

- Use temperature and flow data as evidence for channel over widening. Long-term data may help to determine historic flow and/or channel shape.
- Use turbidity and TSS data, NPS surveys, and stream walks to indicate locations of bank destabilization and subsequent bank restoration efforts.
- Use data to coordinate riparian buffer survey and result analysis.

5.2.4 Coordinating with Dam Regulation

- Use low flow data from downstream of dam sites to work with dam owners in releasing water during summer months.
- Use WQ data from downstream of dam sites to petition MDEP to regulate dam and allow water to be released during summer low flow

5.2.5 Coordinating with the Water Classification Program

- Use DO and bacteria data to determine TMDL specifications for contaminated sites.
- Use data to upgrade the class of river sections in the Water Classification Program.

5.2.6 Coordinating with Outreach Activities

- Use WQ results to educate the public about NPS pollution, and land and water conservation and protection
- Use WQ results to solicit and train potential WQM volunteers.

5.2.7 Coordinating with Salmon Stocking Practices

- Correlate stocking locations with cool temperature sites. Review ASC groundwater inventory database for cool-temperature sites and stock accordingly.

- Avoid stocking at sites that experience high summer temperatures, such as Kings Mills, Long Rips, below Coopers Mills dam, above Head Tide and some sites on Dyer River.
- Stocking agencies should consider stocking parr or smolts rather than fry in order to increase survival.

5.3 Sampling Strategies and New Studies

Although there are a large number of sites monitored by several agencies and organizations, there appears to be no evidence for eliminating any site locations. Therefore, in order to meet management goals and recommendations (especially those listed in Section 5.4 below) within reasonable budgets, sampling efforts may need redesign.

- Several sites are monitored by several different agencies/organizations. Reducing the number of agencies/organizations collecting data at each site would reduce redundancy. Encourage labor and data sharing.
- Most bacteria testing sites are scattered throughout the watershed. Design a WQM regime based on smaller drainages such as tributaries. For instance, focus efforts on one tributary or river section, identify the boundaries, increase the sites within the boundaries, and collect samples within a short time interval in order to identify the source within the smaller drainage. Follow up with a remediation plan for the small drainage.
- Several water quality indicators are monitored as grab samples and only reflect the water quality condition at one time and in only one place in the water column and in the river reach. Future monitoring should include the establishment of cross sectional and longitudinal WQ profiles in order to determine variability between microhabitats. This strategy should be used primarily for temperature but DO may also be a candidate.
- Use continuous data such as flow or temperature logger data to correlate 1) bacteria and DO levels with flow and temperature, 2) temperature levels with flow and electrofishing data with flow.
- Although raw flow and temperature data are currently available for the Sheepscot River, both of these data sets are not summarized and as a result are not being utilized to their fullest potential. For example, two other salmon rivers, the Pleasant and the Narraguagus, have had this statistical summary completed (Nielsen, 1999; Dudley and Nielsen, 2000); the Sheepscot River should also have the temperature and flow data analyzed since these factors have been recognized as a source of potential impairment.
- Prior to the relicensing of the IF&W Hatchery in Palermo, a study should be conducted which compares water quality and flow above and below the hatchery point source in order to establish a permitting model for dilution, water quality standards, mass limits, and water treatment design.

- Since the levels of bacteria are high enough in the watershed as to be considered impaired (TMDL), a study should be conducted which observes the effects of *E. coli* on Atlantic salmon.
- Within the watershed, some sites are more preferred than others by salmon, especially during stress. In order to gain a better understanding of preferred habitat, a study should be conducted which identifies areas of high quality habitat refuge, characterizes the WQ/WC of the habitat, then seeks to mitigate sites of poorer habitat.
- Conduct more flow enhancement studies and/or next steps to implementation of flow enhancement projects.
- Consider petitioning DEP and DIFW to improve water level management at dams and fish passage to improve salmon and alewife fisheries.

5.4 WQM by River Reach and Waterbody

Table 5.4.1 divides the watershed into 28 sections including 9 sections of the MS and WB, 7 lakes and ponds, 11 tributaries, and the estuary. Each section or waterbody is characterized according to AS habitat, class, attainment status, and general WQ condition. From this information, a reach-specific recommendation is provided. Program administrators can use the specific recommendations to design agency-specific workplans (see Appendix, Maps 3 and 4).

Figure 5.4.1. WQM Recommendations for Specific River Reaches and Waterbodies. (See Appendix, Maps 3 and 4.)

Waterbody or River Section	**Subwatershed/ AS Habitat**	**River Classifi-cation**	**Attaining Class/ TMDL ?**	**Primary Condition/Impairment**	**Comment/Recommendation: Parameters, Sites, Studies**
Upper MS above Sheepscot Pond	Priority 4 No	A	Yes/None	Primarily pristine with little development, cold water; low DO, high bacteria, anecdotal high turbidity	In six years conduct 15 year analysis; increase the number of sites; conduct turbidity monitoring ASAP; monitor for bacteria and DO to determine trend and source; area may need protection from development
Sheepscot Pond	Priority 3 Drains to AS habitat	GPA	Yes/None	Average WQ; average potential for bloom; moderate/stable for vulnerability to change	Intensify present monitoring; protect lake from development.
MS between Sheepscot P & Long P	Priority 3 Yes	B	No/ Yes	Low DO, nutrient enrichment from hatchery; winter warm water input	SVCA should continue to work with MDEP to monitor the site; add additional site above hatchery to serve as control; add an additional site midway between S014 and S014.5 to determine distance-effect of effluent; prior to relicense, conduct study to compare WQ/flow above and below hatchery point source
Lovejoy Str. & Turner Branch	Priority 3 Unknown	B	Yes/None	Unknown	Develop WQM program and encourage ASC to survey for AS habitat.
Turner Pond	Priority 3 Unknown	GPA	Yes/None	Unknown	There is no VLMP currently on this lake; establish volunteer WQM program. Monitor and protect from sedimentation and nutrient input.
Long Pond	Priority 3 Drains to AS habitat	GPA	Yes/None	Below average WQ (some productivity); low potential for bloom; moderate/stable for vulnerability to change	There is no VLMP currently on this lake; establish volunteer WQM program. Monitor and protect from sedimentation and nutrient input.
MS @ Coopers Mills to Long Pond	Priority 3 Unknown	B	Yes/None	High summer temperatures, winter warmwater input; anecdotal low flow	Monitor for lake-outlet effect; initiate use of flow meters; reinstate summer temperature loggers; avoid stocking; encourage ASC habitat survey and mapping.
MS below Rt 17 to Kings	Priority 1 Yes	AA	Yes/None	Primarily good quality; possibly some high	Reinstate summer temperature loggers; initiate the use of flow meters; correlate WQ data with

Mills				temperatures, high nutrients	precipitation/discharge data; monitor for TP, nutrients, and turbidity
Clary Lake	Priority 1 Drains to AS habitat	GPA	Yes/None	Below average WQ (some productivity); low potential for bloom; Sensitive to change (high TP and chl a)	Intensify present monitoring; protect lake from sediment and nutrient input.
MS below Kings Mills to Head Tide	Priority 1 Yes	AA	Yes/None	High bacteria; high summer temperature; high TP and nutrients; anecdotal low flow	Conduct shoreline survey to ID bacteria source; reinstate summer temperature loggers; reconsider stocking in areas of high temperatures; initiate the use of flow meters; monitor for lake-outlet effect; correlate WQ with continuous data from NOAA temperature logger and USGS gage; monitor for TP, nutrients, and turbidity; site appropriate for channel restoration.
Carlton Brook	Priority 1 Unknown	B	No/Yes	Low DO	Establish a WQM program for this tributary and work with MDEP to identify/mitigate TMDL/NPS (if it is not natural); encourage ASC habitat survey and mapping
Chamberlain Brook	Priority 1 Unknown	B	Yes/No	High bacteria	Use Drainage Approach to identify source of bacteria; conduct Shoreline Survey; intensify bacteria sampling; Encourage ASC habitat survey and mapping
Trout Brook	Priority 1 Yes	A	No/Yes	Low DO	Continue monitoring and work with MDEP to identify/mitigate cause of low DO – if not natural
Ben Brook	Priority 1 Yes	A	Yes/None	Unknown	There is currently no monitoring on this section. Begin a monitoring program; protect high WQ
Dyer River above Dyer Long P.	Priority 1 No	B	Yes/None	Unknown	There is currently no monitoring on this section; investigate need and feasibility of future monitoring.
Dyer Long Pond	Priority 1 Drains to AS habitat	GPA	Yes/None	Below average WQ (some productivity); low potential for bloom; moderate/stable for vulnerability to change	Continue present monitoring; protect lake from nutrient input.
Dyer River Below Rt 215	Priority 1 Yes	B	No/Yes	Low DO and high bacteria; contains priority AS habitat	There are currently no monitoring sites on the Dyer River; create a monitoring plan for the river which focuses on the source of bacterial input; conduct

					shoreline survey; monitor for lake-outlet effect; reinstate summer temperature loggers.
WB above Branch Pond	Priority 4 No	B	Yes/None	Unknown	There is currently no monitoring on this section; investigate need and feasibility of future monitoring.
Branch Pond	Priority 4 Drains to AS habitat	GPA	Yes/None	Low DO; sensitive for vulnerability to change	Intensify present monitoring; protect lake from sediment and nutrient input.
WB below Branch P. to Weeks Mills	Priority 2 Yes	AA	Yes/None	Winter warmwater input; high summer temperature; low DO	Monitor for lake-outlet effect Reinstate temperature loggers.
WB at Weeks Mills to Halls Corner	Priority 2 Yes	AA	Yes/None	Low DO and high bacteria	Continue monitoring
Meadow Brook	Priority 2 Unknown	B	No/Yes	Low DO; high bacteria	There is currently only one upstream sites on the brook; create a monitoring plan which focuses on flow, cause of low DO; encourage ASC habitat survey and mapping.
Hewitt Brook	Priority 2 Unknown	A	Yes/None	Occasional high bacteria; low DO	Intensify monitoring; encourage ASC habitat survey and mapping.
Dearborn Brook	Priority 2 Unknown	A	Yes/None	High bacteria; low DO	Continue monitoring, possibly increase sites as needed upstream; encourage ASC habitat survey and mapping.
Savade Pond	Priority 2 Drains to AS habitat	GPA	Yes/None	Unknown	There is no VLMP currently on this lake; establish volunteer WQM program; monitor and protect from sediment & nutrient input; monitor for lake-outlet effect.
Choate Brook	Priority 2 Yes	A	No/Yes	Low DO; priority AS habitat; some high summer temperatures	There are currently no sites on the brook; create a monitoring plan that focuses on flow, cause of low DO, and temperature. Potential logger site.
WB below Halls Corner (Rt 17)	Priority 2 Yes	AA	No/Yes	Low DO, high TP, nutrients, turbidity	Conduct Shoreline Survey; intensify monitoring to ID source and work with MDEP to identify/mitigate TMDL/NPS. Monitor for nutrients, turbidity.
Estuary	N/A	SA	Yes/None	High bacteria	Conduct Shoreline Survey; intensify monitoring to ID source; coordinate the removal of OBDs with WQM; conduct study to compare estuary temperature/bacteria with freshwater data.

Chapter Six
Recommendations

6

The following table summarizes all of the recommendations provided in this document. The recommendations are grouped by topi, and several potential partners are listed for each recommendation:

1. **ADMINISTRATION:**
   a. Strengthen Coordination among Water Quality Monitoring Agencies
   b. Encourage Dissemination of Data and Related Information

2. **WATER QUALITY PARAMETERS:**
   a. Identify Gaps in WQ Indicators and Add New Parameters to Fill Gaps
   b. Research Current WQ Standards in Order to Create and Lobby for New State Standards

3. **WATER QUALITY MONITORING STATIONS AND TIMING**:
   a. Identify Gaps in Spatial and Temporal Information and Add New Monitoring Sites and Regimes to Fill Gaps

5. **WATER QUALITY MONITORING STUDIES AND DATA ANALYSIS:**
   a. Identify Gaps in Knowledge and Develop Studies that Fill Those Gaps

6. **MANAGEMENT AND RESTORATION ACTIVITIES:**
   a. Coordinate Fish Stocking Programs with WQ Information
   b. Coordinate NPS Restoration with WQ Information
   c. Coordinate Dam/Flow Regulation with WQ Information
   d. Coordinate Water Classification with WQ Information
   e. Coordinate Outreach with WQ Information
   f. Coordinate Salmon Habitat Enhancement Projects with WQ Information

Table 6.1. A Summary of Recommendations for Water Quality Monitoring in the Sheepscot River

ADMINISTRATION	
OBJECTIVE #1: Strengthen Coordination among Water Quality Monitoring Agencies	
Recommendation	**Partners**
Each WQM agency and organization should use this plan as a springboard for the development of agency-specific work plans that: • incorporate the agency-specific recommendations from this Plan, • assign staff, funding sources, equipment, and time to specific action items • coordinate WQM activities with other agencies' activities • develop new studies that are consistent with the findings of this plan	All Stakeholders
The success of this Plan depends on the willingness of each agency to follow through with the recommendations and to communicate, coordinate and collaborate with each other in achieving goal and objectives of improving water quality.	All Stakeholders
Several recommendations are umbrella action items that will apply to all agencies. In this case, one agency will be needed to take the lead in order to achieve the recommendation.	All Stakeholders
Before beginning or continuing any future monitoring effort, monitoring agencies are advised to consult this document for monitoring guidance	All Stakeholders
Agencies should refer to this plan annually as a measure of outcome success and to plan for upcoming monitoring and when developing their own agency plan.	All Stakeholders
Increase the dialogue between the VLMP and the river-monitoring agencies to ensure that both groups are informed of sensitive areas or sudden trends of poor water quality.	SVCA, SRWC, MDEP, VLMP, PEARL, ASC, NOAA, USFWS
OBJECTIVE #2: Encourage Dissemination of Data and Related Information	
Establish a well-constructed, easy-to-access, web-based database of WQM data from all agencies that contains very specific and detailed metadata describing monitoring agency, protocol, and analysis.	PEARL Committee, KRIS TAC, All Stakeholders

Use guidance from Maine Atlantic Salmon Commission GIS Needs Assessment (Champlain Institute, 2002) and KRIS GIS database to make decisions about database storage and data sharing.	All Stakeholders
Currently, MDEP has WQ data and information stored in a variety of MDEP divisions (e.g., Hatchery Licensing Program, Lakes Division, Salmon Program, Biomonitoring Program, etc). Public and interagency access to that data currently requires tracking down the data from each separate division. The USEPA will soon require that MDEP place their data on the EPA website using "STORET." The MDEP should work with PEARL to ensure that data from each division is either directly housed on the PEARL site or at least linked to the EPA site or both.	MDEP, PEARL, KRIS TAC
Several agency WQM datasets have not been fully analyzed (see below) nor have reports been submitted. Each agency should require that yearly reports and final study reports be submitted and distributed to partnering agencies for review in a timely fashion.	All Stakeholders
WATER QUALITY PARAMETERS	
OBJECTIVE: Identify Gaps in WQ Indicators and Add New Parameters to Fill Gaps	
Recommendation	**Partners**
Install flow meters throughout watershed, especially in WB, in order to correlate DO, temperature, and bacteria with flow.	SVCA, USGS, KSWCD
Lengthen sampling season to include mid-April and early October to capture spring and fall precipitation events.	SVCA
TSS and turbidity are not currently being measured in the watershed. TSS and turbidity should be measured in this area especially in areas of known NPS (crossings, runoff, ag practices)	SVCA, SWLA, MDEP, SRWC, KCSWCD
Deploy loggers in known or suspect areas of groundwater input	USFW, ASC, NOAA, USGS
WATER QUALITY MONITORING STATIONS AND TIMING	
OBJECTIVE: Identify Gaps in Spatial and Temporal Information and Add New Monitoring Sites and Regimes to Fill Gaps	

Recommendation	Partners
Intensify sampling at Chamberlain Brook in order to locate source of bacteria.	SVCA
Add additional sites to the Dyer River in order to locate the source of the recent higher than normal bacteria counts. Also, conduct a synoptic survey of the entire river.	SVCA, MDEP
Closely monitor SO15 and WB004 to see if trends of high *E. coli* levels continue.	SVCA, MDEP
Change monitoring focus from broad-base approach to drainage-specific or concentrated approach.	SVCA, All Stakeholders
Design a WQM plan for Ben Brook that has priority salmon habitat but has not been monitored for over 5 years.	SVCA, All Stakeholders
Design a WQM plan for MS above Sheepscot Pond because there is only one site in this reach, it has good WQ, and it may need protection from recent development pressure.	SVCA, SWLA, All Stakeholders
Design a WQM plan for Lovejoy Stream and Turner Branch which are tributaries to Turner Pond and Long Pond, may contain potential salmon habitat, and drain a large WS.	SVCA, All Stakeholders
MDEP and SVCA should continue to partner in WQM in the watershed, especially those sites which are currently not receiving adequate monitoring. Intensified monitoring may reveal new TMDL locations that can be remediated.	MDEP, SVCA
Intensify monitoring in the area above and below the IF&W hatchery: a. maintain the two current sites (SO14.5F, just below the hatchery and SO14F above the inlet of Long Pond) and add one additional site above the hatchery as a control, b. increase the monitoring occurrences at all three sites to include those times when the hatchery is being cleaned and effluent is entering the receiving waters, and c. add an additional site midway between SO14.5F and SO14F to determine distance-effects of effluent.	SVCA, SRWC, MDEP, IF&W
Solicit and train community volunteers to monitor those lakes and ponds that do not have an active monitoring program.	VLMP, SRWC, MDEP
WQM sites should be established at the outlet of all lakes and correlated with lake data in order to document and manage for any lake-outlet effect, which may affect aquatic life and classification attainment status.	VLMP, SRWC, MDEP
Lake monitoring efforts should intensify with increased development pressure, especially in those lakes draining to AS habitat or Class AA or A waters.	VLMP, SRWC, MDEP

Lakes that are classified as "Moderate/Sensitive" or "Below/Slightly Below Average" should receive increased monitoring efforts. This would include Dyer Long, Long, Clary, and Branch Ponds.	VLMP, SRWC, MDEP, Lake Associations
Lakes with large drainage areas may require increased monitoring and protection.	VLMP, SRWC, MDEP
Temperature monitoring using loggers should continue but sites should be evaluated. Agencies should determine which sites are representative of the river and consolidate monitoring efforts by reducing the number of overall sites and adding sites where there is currently no known data.	USFW, NOAA, ASC, USGS, SVCA
Water quality monitoring data and anecdotal observations suggest that flow and fluvial geomorphology patterns may be contributing to poor water quality. The following are river reach characteristics which should be investigated: a. reaches that appear to have lower than normal flow, such as West Branch. b. reaches in which high temperature, low dissolved oxygen, and high *E. coli* are associated with low flow, c. reaches which appear to be over widened, and d. .reaches which do not have enough cold water fish habitat (i.e., riffles)	USGS, SVCA, S&W CD, SRWC, USFW
Rivers may also be affected by anthropogenic activities such as: agriculture, road structures (bridges, culverts, etc), dams, and development. Restoration efforts and WQM should focus on areas where there is historic proof of anthropogenic influences.	USGS, SVCA, S&W CD, SRWC, USFW
WATER QUALITY MONITORING STUDIES AND DATA ANALYSIS	
OBJECTIVE: Identify Gaps In Knowledge and Develop Studies that Fill Those Gaps	
Recommendation	**Partners**
Continue to monitor SVCA sites and reassess the data in six years. Analysis of fifteen years of data may yield trends not apparent in just nine years of data.	SVCA
The ASC, MDEP, and NOAA should work together to see that the MDEP lab analysis data is analyzed by site, by event, by nutrient, and over time.	ASC, MDEP, NOAA
The Stressor Identification Process should be the mechanism of choice when making determination regarding factors limiting salmon survival since it provides an organized, logical method for weighing evidence and eliminating and diagnosing potential stressors.	All Stakeholders

Prior to IF&W Hatchery relicensing in 2005, a study should be conducted which compares water quality and flow above (control) and below the hatchery (point source) in order to establish a permitting model for dilution, water quality standards, mass limits, and water treatment design.	USGS, MDEP, UMGMC, IF&W
Monitor WQ above and below each in-stream dam to determine true effect of dam and correlate WQ data with flow data – when flow is low, WQ is low.	USGS, SVCA, SRWC, MDEP
A flow study should be conducted to determine the effects of hatchery withdrawal and dam operation on mainstem flow.	USGS, SVCA, SRWC, MDEP
Compare DMR marine temperature and bacteria data with freshwater temperature and bacteria data to determine trends.	DMR, SVCA, SRWC, MDEP
The effects of high levels of bacteria on coldwater fish are currently unknown. A study that investigates the effects of fecal bacteria on overall WS productivity (plant and animal communities) as well as coldwater fish species, such as salmon and trout, should be conducted, and the results from the study should be used to guide management activities.	USFW, NOAA, ASC, IF&W, DMR
Conduct a temperature study which investigates high temperature effects on salmon, specifically: a. the lethal temperatures as they occur in nature, b. the duration of high water temps, and c. temperature as correlated with stream profile and flow	ASC, NOAA, USFWS, USGS, IF&W
In order to determine what is responsible for the good habitat, the ASC and the stakeholders should conduct a study which identifies the WQ/WC characteristics of the preferred sites and compare those characteristics with the unpreferred sites.	ASC, NOAA, USFW, USGS
There currently are continuous data sets for temperature, pH, and flow. All data, information, activities should be correlated with sites with continuous data (i.e., USGS gage and long term data loggers). Correlate point sample data upstream and in tributaries with continuous data collected downstream (e.g., Compare 3:00 pm grab sample upstream with 3:00 pm continuous logger data downstream.)	NOAA, ASC, USGS, USFW
Develop flow discharge profile and correlate points with temperature and other WQ information. Determine cross-sectional and longitudinal profiles for other WQ parameters and compare.	NOAA, ASC, USGS, USFW
Investigate the effects of the late winter/early spring low pH readings on parr/smolt populations and smolt migration.	NOAA, ASC, USGS, USFW
The data logger is currently stationary, and the data only reflects the temperature of the one location in the lower basin. Need to find areas of refugia possibly using USGS infrared technologies.	NOAA, ASC, USGS, UFWS

The temperature data sets from the USFW 1994-2000 monitoring effort and the SRWC 2001 monitoring effort have not been completely analyzed to date.	USFW, ASC, USGS, NOAA
High summer temperatures have been anecdotally associated with low flow. A study should be conducted that correlates temperature and flow in order to determine the potential cause of reoccurring high summer temperatures.	USFW, ASC, USGS, NOAA
WQ Trends are directly related to flow/discharge. While analyzing long-term data for trends may provide some information it is probably more fruitful to compare WQ for only those years with similar flow. For example, a study should be done to compare DO and temperature across all low flow or dry years. Or compare nutrients across all high flow, wet years then comparing the same for dry years.	USGS, SVCA, SRWC, ASC, NOAA,
Several datasets have not been fully analyzed (USFW temperature, MDEP nutrients and cations, USGS discharge). These datasets should be analyzed as soon as possible for the purpose of directing monitoring efforts and facilitating appropriate decision-making.	All Stakeholders
Evidence suggests that compared to other salmon rivers, the Sheepscot may have more water quality issues associated with flow. Therefore, the following studies should be initiated by the ASC and USGS. a. Conduct Fluvial Geomorphology Study of the WB and of the Mainstem. b. Develop Groundwater Contribution Model using infrared imaging (similar to Acadia NP). c. Develop Overall Water Budget for River Basin (similar to WUMPs in the DE Rivers) d. Develop Low Flow Model and Dam Study e. Conduct Flow Study of the WB	USGS, SVCA, SRWC, ASC, NOAA,

MANAGEMENT AND RESTORATION ACTIVITIES

OBJECTIVE #1: Coordinate Fish Stocking Programs with WQ Information

Recommendation	**Partners**
In an effort to increase fry survival at stocking sites, ASC and USFW should: a. review reach-specific historical WQ data to determine best sites and times for stocking and b. monitor each stocking site for temperature, DO, turbidity, TSS, and flow at the time of stocking in order to ensure stock survival.	ASC, NOAA, USFW, USGS

Correlate stocking with cool temperature sites. (i.e., sites with historically high temperatures should not be stocked)	ASC, NOAA, USFW, USGS
Stocking efforts should be reevaluated and subsequently coordinated with WQ information. For example, a. Long Rips is currently stocked with fry, which may not survive if exposed to lethal temperatures. The agencies should consider stocking 0+ parr rather than fry in this stretch to avoid possible loss of fry. b. Sites, such as the Upper Deer Hill Road on the WB, contain excellent parr habitat. It is unclear, however, if the site can support smolt. The development of stocking location requirements should include an evaluation of smolt production as well as parr especially as related to temperature.	ASC, USFW
The USFW and ASC should consider an experimental "stream-side incubation" in which salmon may become acclimated to the ambient stream temperature and reduce the shock of the hatchery-river temperature differential. A second possibility would include raising salmon at the Palermo Rearing Station.	ASC, NOAA, USFW, USGS, IF&W
OBJECTIVE #2: Coordinate NPS and Channel Restoration with WQ Information	
Recommendation	**Partners**
Conduct Septic System Survey in order to determine location/cause of bacteria at all sites. Coordinate monitoring with survey results.	DMR, MDEP, SVCA, SRWC
Conduct WQM in conjunction with riparian buffer analysis.	SRWC, SWLA, SWCD
Coordinate temperature, turbidity, and nutrient monitoring to capture effects of NPS sites and develop mitigation plan to respond to WQ results.	SVCA, SWLA, MDEP, SRWC
DMR will train SR volunteers in order to help them conduct a shoreline survey to determine the origin of bacteria inputs.	DMR, SVCA, SRWC, VLMP
Encourage communities to remove OBDs and replace with a less-contaminating system.	DMR, SVCA, SRWC, VLMP
Use temperature and flow data as evidence for channel over widening. Long-term data may help to determine historic flow and/or channel shape.	USGS, SVCA, SRWC, SWCD
Use turbidity and TSS data to indicate locations of bank destabilization and subsequent bank restoration efforts.	USGS, SVCA, SRWC, SWCD

For those sites where bacteria can be linked to livestock, WQM should be coordinated with agricultural BMPs.	SVCA, SWLA, MDEP, SRWC, SWCD
OBJECTIVE #3: Coordinate Dam/Flow Regulation with WQ Information	
Recommendation	**Partners**
Sheepscot Watershed Council will conduct a survey of the dams to ascertain current ownership, operation, condition, and water level maintenance. The information can be used to regulate dam operation and to focus WQM.	SRWC, SVCA, MDEP
OBJECTIVE #4: Coordinate Water Classification with WQ Information	
Recommendation	**Partners**
Use DO and bacteria data to determine TMDL specifications for contaminated sites.	SRWC, SVCA, MDEP
Use data to upgrade the class of river sections in the Water Classification Program.	SRWC, SVCA, MDEP
OBJECTIVE #5: Coordinate Outreach with WQ Information	
Recommendation	**Partners**
Use WQ results to educate the public about NPS pollution, and land and water conservation and protection	SRWC, SVCA, MDEP
Use WQ results to solicit and train potential WQM volunteers.	SRWC, SVCA, MDEP
OBJECTIVE #6: Coordinate Salmon Habitat Enhancement Projects with WQ Information	
Recommendation	**Partners**
Use more flow enhancement studies and/or next steps to implementation of flow enhancement projects to improve fish habitat.	ASC, USFW, NOAA

Consider petitioning DEP and DIFW to improve water level management at dams and fish passage to improve salmon and alewife fisheries.	ASC, USFW, NOAA
Use WQ and fish habitat quality studies information to enhance fish habitat	ASC, USFW, NOAA

LITERATURE CITED

Buckley, D. 2004. Personal Communication. US Fish and Wildlife Services, Orland, ME.

Champlain Institute. 2002. "Maine Atlantic Salmon Commission GIS Needs Assessment." Dartmouth, NS, CA.

Dudley. R.W., 2004, Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine: US Geological Survey Scientific Investigations Report 2004-5042, [in press]

Dudley R. W., and G. A. Hodgkins. 2002, Trends in Streamflow, River Ice, and Snowpack for Coastal River Basins in Maine During the 20th Century: U.S. Geological Survey Water-Resources Investigations Report 02-4245, 26 p.

Dudley, R. W. and J. P. Nielsen. 2000, Streamflow Statistics for the Narraguagus River at Cherryfield, Maine: U.S. Geological Survey Open-File Report 00-95, 18 p.

Elliotte, J.M. 1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon . Freshwater Biology. 25:61-70.

Maine Atlantic Salmon Task Force. 1997. Atlantic Salmon Conservation Plan for Seven Maine Rivers. Augusta, ME.

Maine Department of Environmental Protection. 1992. Phosphorus Control in Lake Watersheds. Augusta, ME.

Maine Department of Environmental Protection. 1996. Section 305(b) Report: Water Quality Assessment. Augusta, ME.

Maine Department of Environmental Protection. 1999. Biomonitoring Retrospective: Fifteen-Year Summary for Maine Rivers and Streams. Augusta, ME.

Maine Department of Environmental Protection. 2001. Water Classification Program. Augusta, ME.

Maine Department of Environmental Protection. 2002. Water quality concerns and effects from state fish hatchery discharges. Unpublished Report. Augusta, ME.

Maine Department of Environmental Protection. 2004. 2002 Section 303(d) Report: Total Maximum Daily Load (TMDL) Waters. Augusta, ME.

Maine Department of Environmental Protection. 2004. Water Classification Program. Augusta, ME.

Meister, A. 1982. The Sheepscot River: An Atlantic Salmon River Management Report. Maine Atlantic Sea Run Salmon Commission. Bangor, ME.

Murch, D. 2003. Personal Communication. Maine Department of Environmental Protection. Augusta, ME.

Nielsen, J.P., 1999, Record Extension and Streamflow Statistics for the Pleasant River Maine: U.S. Geological Survey Water-Resources Investigations Report 99-4078, 22 p.

Newcombe, C. P. and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. No Amer. Fisheries Man 16 (4):693-719).

Pugh, L. 2002. Sheepscot Valley Conservation Association Water Quality Monitoring Report. Alna, ME.

Smith, R., R. Alexander, and G. Schwarz. 2003. Natural background concentrations of nutrients in streams and rivers of the conterminous United States. Environ. Science & Technology 37 (14): 3039-3047.

Stratton, R. 2003. Personal Communication. Maine Department of Environmental Protection. Augusta, ME.

U.S. Environmental Protection Agency (USEPA). 2000. Stressor Identification Guidance Document. EP 822-B-00-025. Washington, DC.

U.S. Geological Survey. 2004. Water Resources Data. http://nwis.waterdata.usgs.gov/me/ nwis/monthly/?site_no=01038000

Whiting, M. C. 2002. Maine Salmon Rivers Water Quality Monitoring Data. Unpublished. Maine Department of Environmental Protection. Augusta, ME.

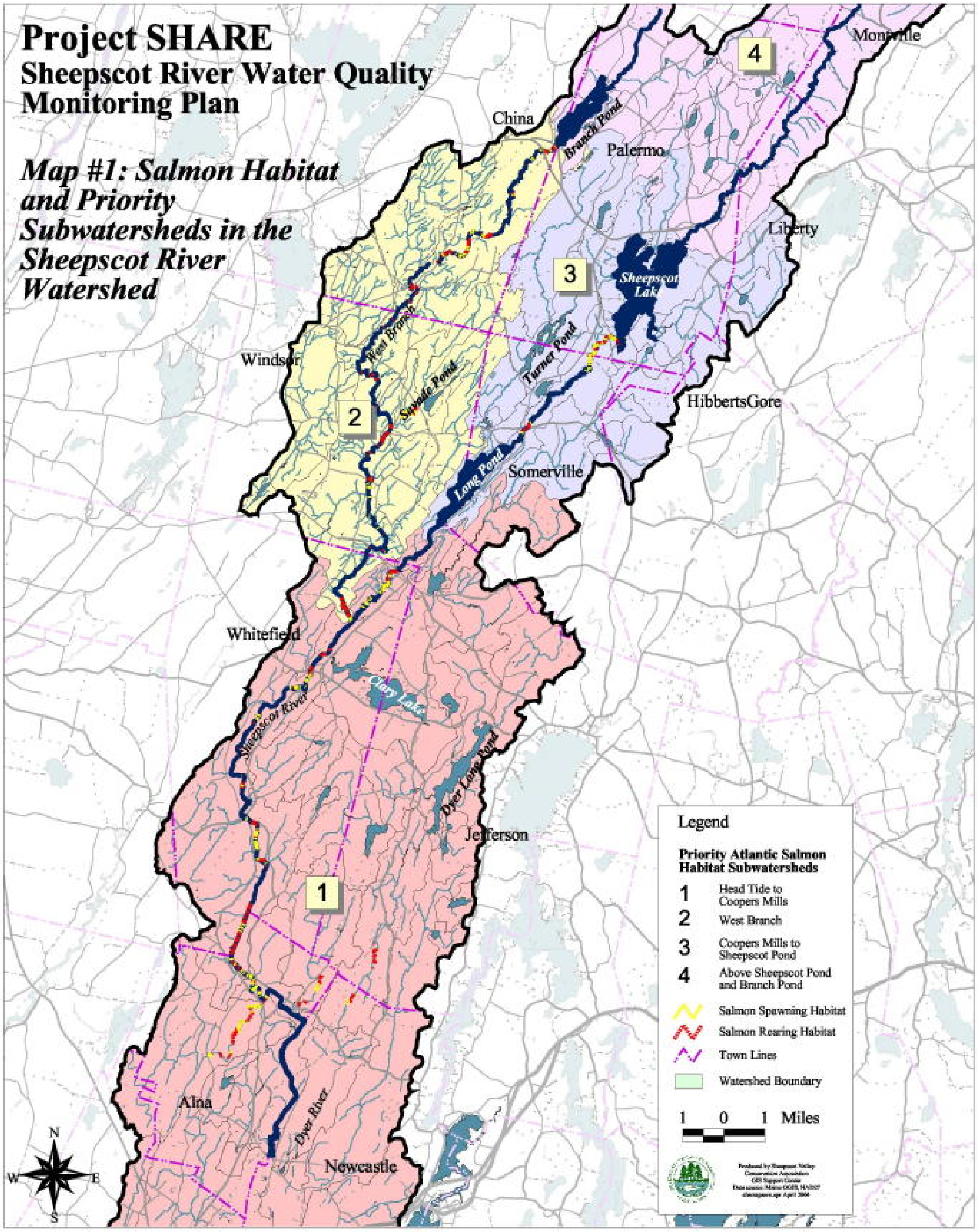
APPENDIX

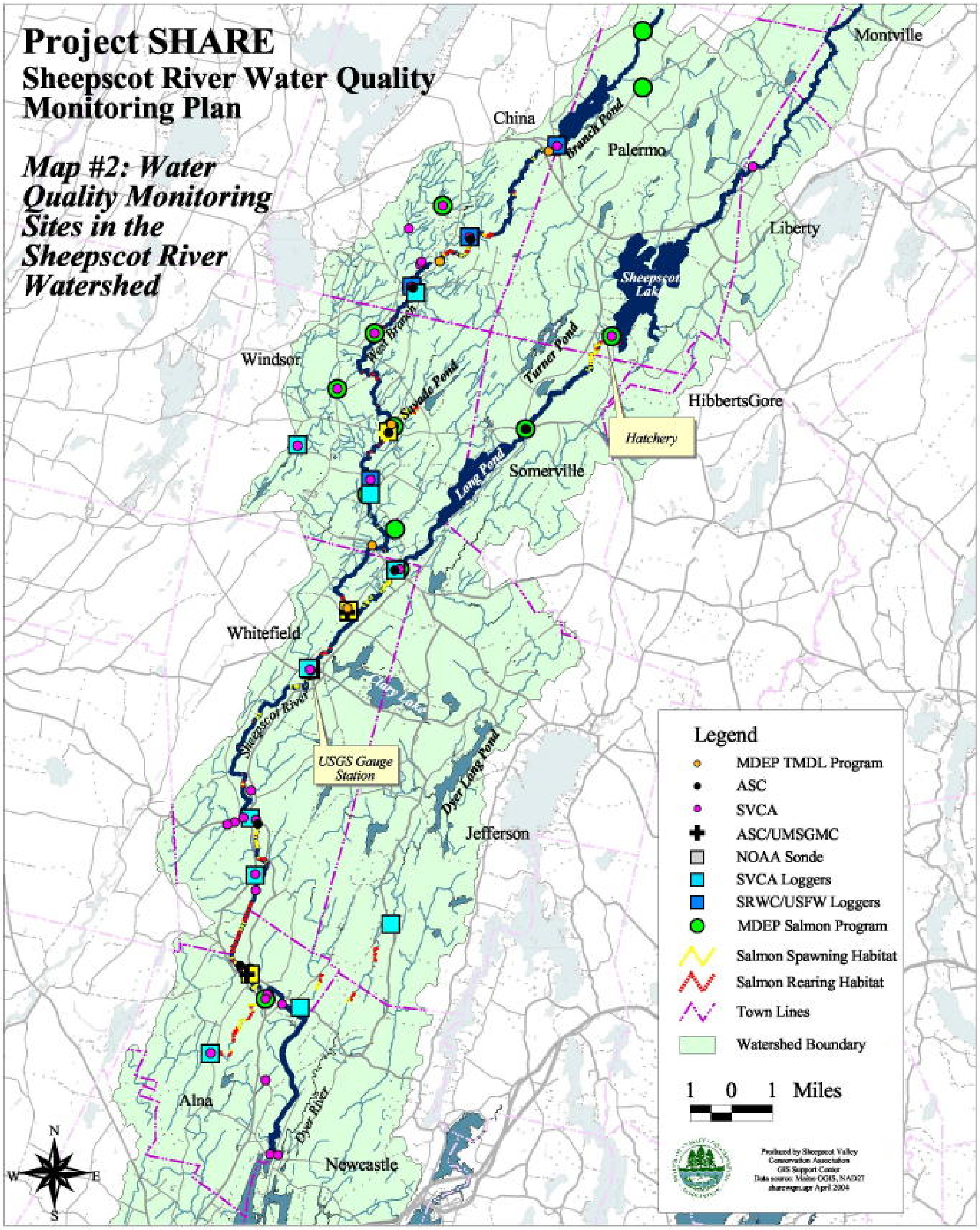
MAPS

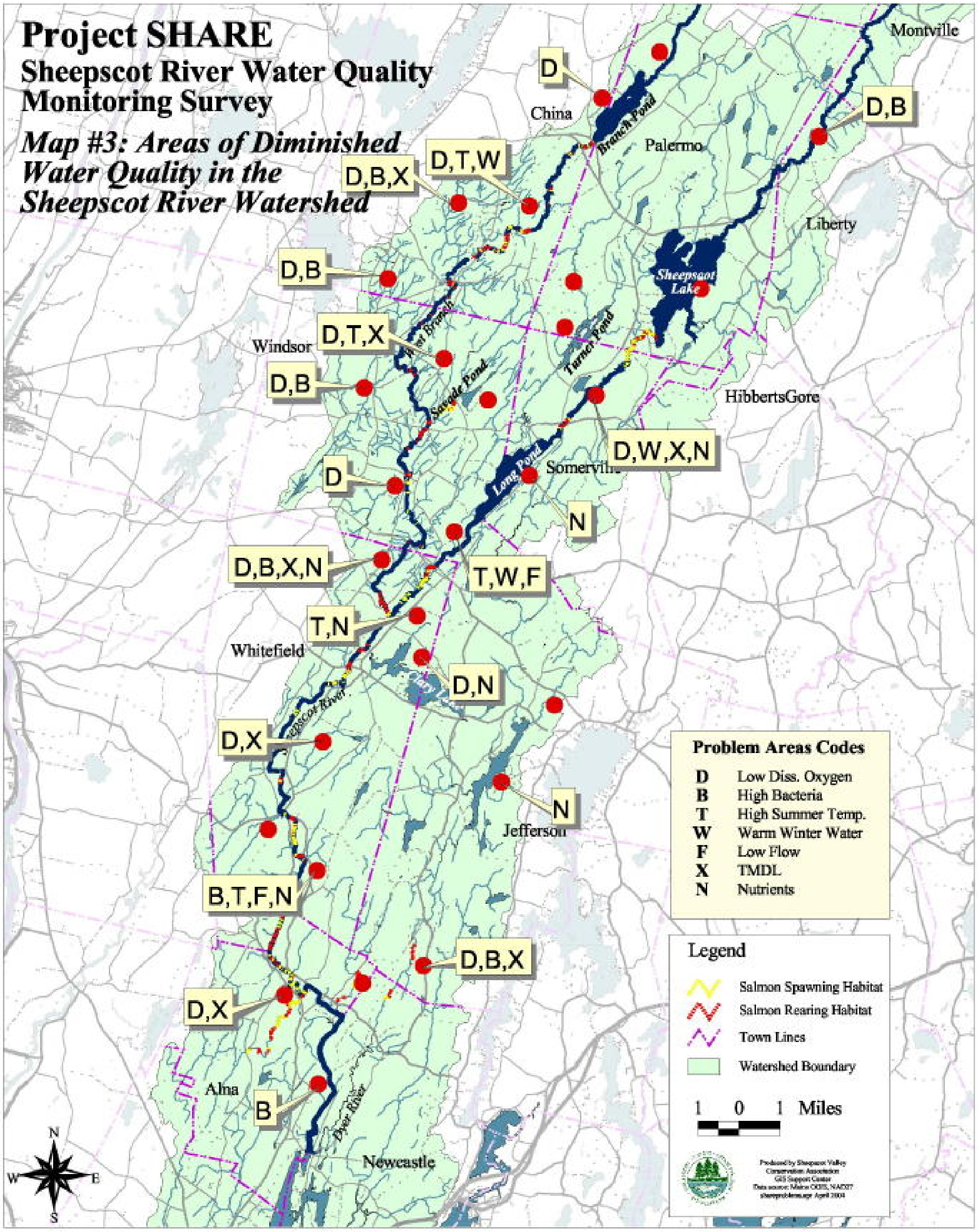
OF

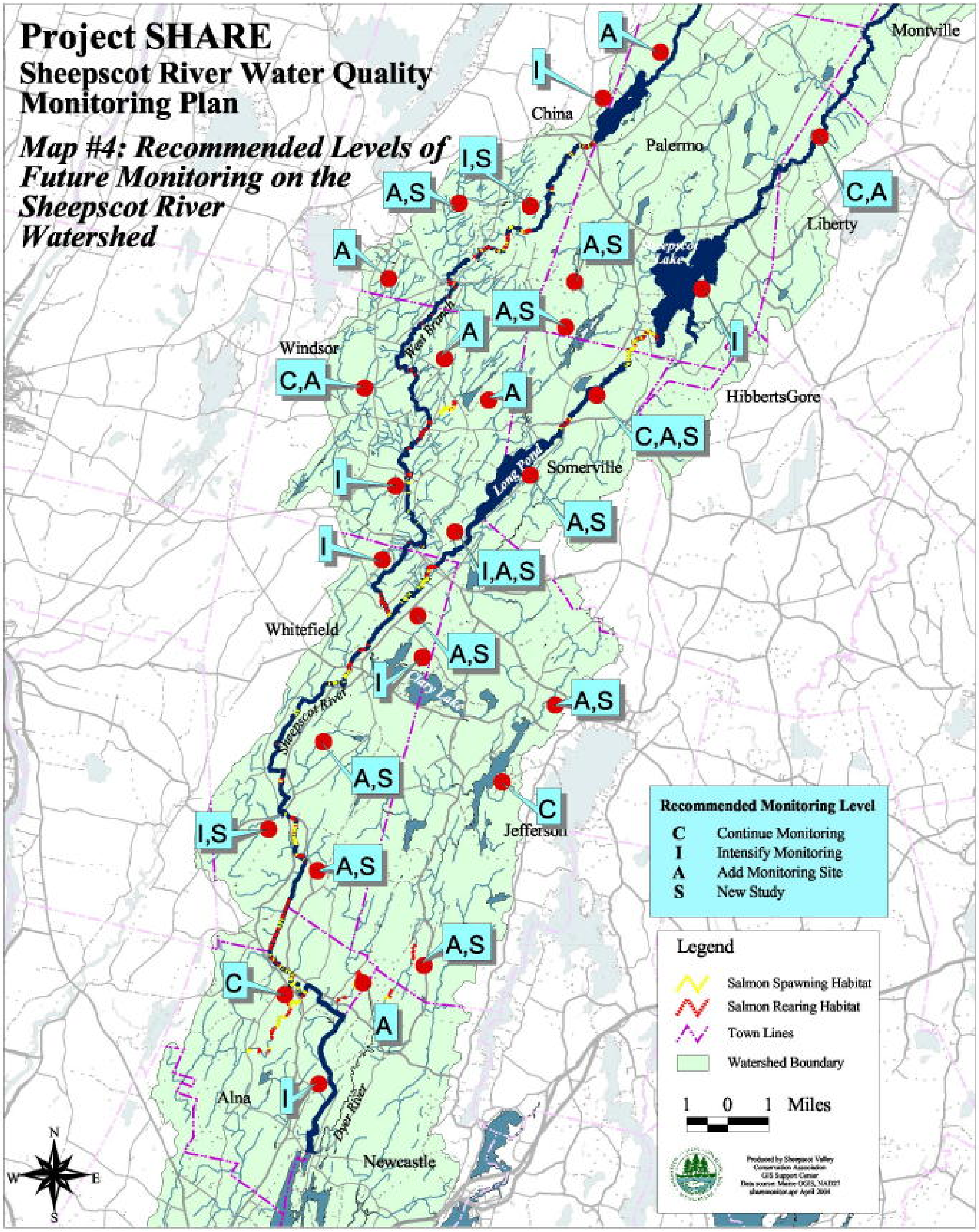
THE

SHEEPSCOT RIVER WATERSHED


Project SHARE
Sheepscot River Water Quality Monitoring Plan
Map #1: Salmon Habitat and Priority Subwatersheds in the Sheepscot River Watershed
Montville
4
China
Branch Pond
Palermo
Liberty
3
Sheepscot Lake
Windsor
West Branch
Turner Pond
Savade Pond
2
HibbertsGore
Long Pond
Somerville
Whitefield
Clary Lake
Sheepscot River
Dyer Long Pond
Jefferson
1
Alna
Dyer River
Newcastle
N
W
E
S
Legend
Priority Atlantic Salmon Habitat Subwatersheds
1 Head Tide to Coopers Mills
2 West Branch
3 Coopers Mills to Sheepscot Pond
4 Above Sheepscot Pond and Branch Pond
Salmon Spawning Habitat
Salmon Rearing Habitat
Town Lines
Watershed Boundary
1 0 1 Miles


Project SHARE
Sheepscot River Water Quality Monitoring Plan
Map #2: Water Quality Monitoring Sites in the Sheepscot River Watershed
Montville
China
Branch Pond
Palermo
Liberty
Sheepscot Lake
Windsor
West Branch
Savade Pond
Turner Pond
HibbertsGore
Hatchery
Somerville
Long Pond
Whitefield
Clary Lake
Sheepscot River
USGS Gauge Station
Dyer Long Pond
Jefferson
Alna
Dyer River
Newcastle
Legend
MDEP TMDL Program
ASC
SVCA
ASC/UMSGMC
NOAA Sonde
SVCA Loggers
SRWC/USFW Loggers
MDEP Salmon Program
Salmon Spawning Habitat
Salmon Rearing Habitat
Town Lines
Watershed Boundary
1 0 1 Miles
N
W E
S


Project SHARE
Sheepscot River Water Quality Monitoring Survey
Map #3: Areas of Diminished Water Quality in the Sheepscot River Watershed
D
D,B
D,T,W
D,B,X
D,B
D,T,X
D,B
D,W,X,N
D
N
D,B,X,N
T,W,F
T,N
D,N
D,X
N
B,T,F,N
D,B,X
D,X
B
China
Palermo
Montville
Liberty
Windsor
HibbertsGore
Somerville
Whitefield
Jefferson
Alna
Newcastle
Branch Pond
Sheepscot Lake
Turner Pond
Savade Pond
Long Pond
Dyer River
Problem Areas Codes
D Low Diss. Oxygen
B High Bacteria
T High Summer Temp.
W Warm Winter Water
F Low Flow
X TMDL
N Nutrients
Legend
Salmon Spawning Habitat
Salmon Rearing Habitat
Town Lines
Watershed Boundary
1 0 1 Miles
N
S
E
W


Project SHARE
Sheepscot River Water Quality Monitoring Plan
Map #4: Recommended Levels of Future Monitoring on the Sheepscot River Watershed
China
Palermo
Montville
Liberty
Windsor
HibbertsGore
Somerville
Whitefield
Jefferson
Alna
Newcastle
West Branch
Long Pond
Sheepscot River
Dyer River
A
I
I,S
A,S
C,A
A,S
A
A,S
A
I
C,A
A
C,A,S
I
A,S
I
I,A,S
A,S
I
A,S
A,S
C
I,S
A,S
A,S
C
A
I
Recommended Monitoring Level
C Continue Monitoring
I Intensify Monitoring
A Add Monitoring Site
S New Study
Legend
Salmon Spawning Habitat
Salmon Rearing Habitat
Town Lines
Watershed Boundary
1 0 1 Miles
N
W
E
S