Final Report

State of the New Meadows River

A report on the current environmental and resource status of the New Meadows River and surrounding watershed

Prepared for

New Meadows River Watershed Project
Steering Committee

Prepared by

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Acknowledgment

This project would not have succeeded had it not been for the dedicated participation of the members of the New Meadows River Watershed Project Steering Committee. Over the course of this project the Committee included: Theo Holtwijk (Chairman), *Director of Planning and Development, Town of Brunswick*, Michael Feldman, *Brunswick Town Councilor*, Ralph Merry, *Town of West Bath Selectman*, David Chipman, *Town of Harpswell Selectman*, Robert Cummings, *Town of Phippsburg*, Dr. Walter Rosen, *Brunswick Conservation Commission*, Elsa Martz, *Representative for the Town Harpswell*, Eric Butler, *Brunswick Marine Resources Committee*, Roger McNelley and James Hennessey, *West Bath Marine Resources Committee*, Arthur Dodge, *Harpswell Marine Resources Committee*, James Upham, *City of Bath Planner*, George Pollard, *City of Bath Planning Board*, Edward Benedikt and Anne Hammond, *New Meadows Lakes Association*, Diane Gould, *U.S. Environmental Protection Agency (EPA)*, Katherine Groves, *Casco Bay Estuary Project (CBEP)*, Todd Janeski, *Maine State Planning Office (SPO)*, Sherry Hanson and Laura Livingston, *Maine Department of Marine Resources (DMR)*, Lee Doggett and Donald Kale, *Maine Department of Environmental Protection (DEP)*, Dr. Edward Laine, and Cathryn Field *Bowdoin College*, Alan Houston and Steve Walker, *Town of Brunswick Natural Resources Planners*, Michael Doan and Peter Milholland, *Friends of Casco Bay (FOCB)*, Jon Hentz, *Town of West Bath Shellfish Warden*.

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Executive Summary

The New Meadows River Watershed Project (NMRWP) is a collaborative effort of the municipalities of Brunswick, West Bath, Harpswell, Phippsburg, and Bath, the Maine State Planning Office, the Maine Departments of Marine Resources and Environmental Protection, the U.S. Environmental Protection Agency, Casco Bay Estuary Project, Friends of Casco Bay, New Meadows Lake Association, Bowdoin College and MER Assessment Corporation

This report, prepared under a Non-point Source Pollution 319(b) Program grant from the Maine Department of Environmental Protection, serves as a compilation and summary of currently available information on the present status of the marine environment and resources of the New Meadows River. As such, it is intended to provide a comprehensive, point-in-time baseline picture to assist in the determination and identification of existing and potential problems along the river, as well as a guide for future studies. To this end, this document covers a wide range of information from water and sediment quality to population demographics and current land use within the river's watershed.

The New Meadows River is located in the northeastern corner of Casco Bay in southwestern Maine. Its northern extreme is at 43^0 56' 08" N Lat., 69^0 51' 36" W Long., and its southern extreme at 43^0 46' 42" N Lat., 69^0 53' 20" W Long. Its watershed, estimated at approximately 23 square miles, falls within two counties, the western shore being in Cumberland County, the eastern shore in Sagadahoc County. The watershed covers areas in five municipalities, the City of Bath to the north, Brunswick and Harpswell to the west, and West Bath and Phippsburg to the east. All but the City of Bath have shoreline on the River.

Geologically, the New Meadows River, as the other embayments of Casco Bay, originated from volcanic activity. Glaciation during more recent geological history is responsible for the varied surficial sediments found today. This varied geology provides a wide range of habitats and ecological niches, all of which combine to make the New Meadows River highly diverse and productive.

Historically, the New Meadows River area was first inhabited by Native Americans of the Pejepscot and Kennebec tribes. Evidence exists that suggests that an early European fishing outpost in the southernmost area of the New Meadows River may have been established as early as 1018. This was followed by a transient colonial settlement established around 1607, but permanent settlement of the upper New Meadows River first occurred around the mid-1600s. Since that time, the population of the area has increased steadily as more and more people have sought to exploit the areas natural resources, both terrestrial and marine, and more recently, to enjoy its natural beauty, way-of-life, and the recreational opportunities the river offers. Indeed, the population has grown over 12-fold since the late-eighteenth century, and has more than doubled just within the past fifty years. As along much of the coast of Maine, this population expansion has caused a shift in land use from agriculture and resource exploitation to industrial-commercial and residential uses, particularly over the past ten to twenty years. This trend is expected to continue for the foreseeable future and will undoubtedly have some degree of impact on the New Meadows River.

Fortunately, due to its nature, as of now, the New Meadows River appears generally to have suffered little as a result of development along its shores and within its watershed. Water quality testing results indicate that the New Meadows River functions more as an embayment than a true estuary, since there is no substantial surface freshwater input other than local run-off. However, subsurface groundwater discharge from the bottom and Kennebec River flow from the south around Small Point may have a significant influence on the river's circulation and rate of exchange.

Dissolved oxygen and nutrient levels show water quality to be good to excellent throughout most of river. Similarly, toxic metals and chemicals testing of lobsters, mussels, and sediments also show that, with only a few exceptions, levels of these contaminants in the New Meadows River are generally low, similar to other areas of Casco Bay, and are not a matter of immediate concern.

Despite these generally good conditions, there are certain areas of the river that have proven susceptible to low oxygen events. Testing in the upper reaches of the river and in the New Meadows Lakes has shown that these areas occasionally experience low dissolved oxygen episodes during warmer months, a condition that can be exacerbated by, and perhaps even cause, periodic fish kills such as the pogie kills of the early 1990's. Nutrient levels in these areas, particularly in the Lakes, are also higher than normal and are likely the cause of the extensive algal blooms experienced annually in this section of the river. Testing results have revealed a possible internal source of nutrient generation, specifically in a deep hole in the Lower Lake, the bottom of which routinely becomes totally oxygen depleted during summer months.

Testing by the Maine Department of Marine Resources reveals much of the river and its shellfish growing areas to be clean and safe for shellfish harvesting and consumption. However, actual and potential sources of bacterial contamination are currently causing a substantial portion of the shoreline to be closed to the harvesting of shellfish. These closures are a matter of considerable concern, for the New Meadows River supports a significant soft-shell clam resource that, in turn, is the base of a shellfish industry important to the local economies of the surrounding communities. Although the New Meadows River shellfish growing areas represent a relatively small portion of Maine's total shellfish growing area, production from its shellfish flats over the past four years has accounted for an estimated 7.5% of Maine's total soft-shell clam production, indicating the exceptional productivity of the this area. In 2000 it was estimated that the 2001 New Meadows River harvest of soft-shell clams could be as high as 16,735 bushels resulting in direct income to the harvesters of approximately $1.3 million and extended economic activity in the order of $3-$4 million. Substantial effort has therefore been made to identify and correct the existing sources of contamination to insure continued access to the resource, but much remains to be done.

The shellfish of the New Meadows River represent but a small fraction of the combined value of its exploitable resources, not to mention its intangible values of aesthetics and as a place to live and recreate. All of these values depend on high environmental quality. Yet the very environmental quality and natural beauty that attract so many people to the area risk being diminished by the inevitable development that will occur to accommodate them; only proper planning will avoid, or at least limit, environmental degradation..

To minimize future environmental impacts to the river, the New Meadows River Watershed Project is considering the development of a watershed management plan for the New Meadows River that would involve all five municipalities within the watershed. However, before such a plan can be prepared the New Meadows River Watershed Project should consider the following recommendations:

- Complete and implement the NMRWP Strategic Plan;
- Form a Subcommittee of the NMRWP to guide and oversee municipal data collection and reporting;
- Promote and coordinate studies to improve our understanding of the New Meadows River system;
- Promote and coordinate the collection of information on the marine resources of the New Meadows River;
- Coordinate and facilitate reclassification of closed shellfish areas.
- Investigate options to develop a functional circulation model for the New Meadows River.

Introduction

The New Meadows River Watershed Project (NMRWP) is a collaborative effort of the municipalities of Brunswick, West Bath, Harpswell, Phippsburg, and Bath, the Maine State Planning Office, the Maine Departments of Marine Resources and Environmental Protection, the U.S. Environmental Protection Agency, Casco Bay Estuary Project, Friends of Casco Bay, New Meadows Lake Association, Bowdoin College and MER Assessment Corporation.

The activities of the NMRWP are guided and coordinated by a Steering Committee that includes representatives from the Town Council or Board of Selectmen of Brunswick, Bath, West Bath, Phippsburg, and Harpswell, as well as representatives from each of the Federal and State agencies and other organizations. The Project Coordinator is Christopher Heinig of MER Assessment Corporation, working for the NMRWP under contract to the Town of Brunswick. Two Bowdoin College seniors, Adrienne Oakley and Abir Biswas served as Project Assistants.

The goals of the New Meadows River Watershed Steering Committee are to:

- expand local awareness of connections between local land uses and water quality through citizen involvement in surveys in priority shellfish beds and the Lake
- locate and prioritize sources of bacteria, sediment, PAH's (polycyclic aromatic hydrocarbons) and storm water in a cost-effective manner
- make recommendations to landowners for mitigating or removing these sources
- develop a cadre of trained and motivated citizens who can carry out local surveys and share their skills with other volunteers
- build local support for a comprehensive watershed action plan and inter-local cooperation
- continue integrating these activities with the Casco Bay Estuary Project.

In January 2001 the Maine Department of Environmental Protection (DEP) awarded the Town of Brunswick, serving as agent for the NMRWP, a $30,000 grant under its Non-point Source Pollution 319(b) Program to assist the NMRWP in achieving these goals, specifically through the preparation of a report of the state of the New Meadows River, the report presented here.

We have collected, compiled and summarized as much information as possible on the current status of the marine environment and resources of the New Meadows River. We have tried to provide a comprehensive, point-in-time baseline picture to assist in the determination and identification of existing and potential problems along the river, as well as a guide for future studies. To this end, this document covers a wide range of information from water and sediment quality to population demographics and current land use within the river's watershed. While some of the information presented is rather technical in nature, the casual reader is encouraged to pursue this information; such readers should not be intimidated by technical data.

This document is, by design, a compilation of baseline information that will serve as the starting point against which future, similar efforts can be compared to establish trends within specific parameters over the long term. However, some of the information collected, compiled and analyzed during the project, as well as the process of information collection, already reveals certain areas of concern that should be addressed and corrected over the short-term. Recommendations for measures to address these concerns are included here.

The ultimate objective of the New Meadows River Project is to protect, and where necessary, to restore or repair, the biological health of the river, thereby protecting its commercial, recreational and esthetic value. Our success in this endeavor will depend upon the cooperation of the residents and business owners operating in the river's watershed, as well as vacationers and other transients.

The Steering Committee did not wait for the completion of this report before undertaking actions to inform the public about its work. The first educational outreach effort was the development of a web site http://academic.bowdoin.edu/new_meadows that is hosted by Bowdoin College.

In the spring of 1999 we contacted by letter the homeowners in the watershed to inform them of our existence and to advise them of some of our activities and to invite them to a "Chowdah festival" and briefing session. That event was held at the New Meadows Inn in August of 1999. About 60 people attended. Over chowder made from clams donated by a local digger the group heard presentations by Bowdoin College students working on the New Meadows River.

The Brunswick Conservation Commission held a workshop on environmentally sound gardening practices in Spring 2001. Panelists included Commission members and a rep from the Maine DEP. The workshop was televised on the Brunswick Community Cable channel.

In May of 2001 the Committee, assisted by an AmeriCorps team, staged a community day at the West Bath Middle School. There we provided short "field trips" along the water's edge. Displays and literature were provided by the U.S. Environmental Protection Agency, the Casco Bay Estuary Project, MER Assessment Corporation, Bowdoin College (Geology student project), Friends of Casco Bay, the Maine Department of Marine Resources, the New Meadows Lake Association, and the Maine Department of Environmental Protection. Regrettably, attendance was light. The Steering Committee is considering another field day, this time at a more central location, possibly at the Cooks Corner Mall.

The SC envisages this State of the River report as providing material for a variety of educational activities.

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Location

The New Meadows River is located in the northeastern corner of Casco Bay in southwestern Maine. Its northern extreme is at 43^0 56' 08" N Lat., 69^0 51' 36" W Long., and its southern extreme at 43^0 46' 42" N Lat., 69^0 53' 20" W Long. Its watershed, estimated at approximately 23 square miles, falls within two counties, the western shore being in Cumberland Country, the eastern shore in Sagadahoc County. The watershed covers areas in five municipalities, the City of Bath to the north, Brunswick and Harpswell to the west, and West Bath and Phippsburg to the east. All but the City of Bath have shoreline on the River proper (Figure 1).

Although named a "River", technically it is not, since no river actually flows into or down the New Meadows. In fact, since there is no river flow, the New Meadows does not even meet the definition of an estuary, for there is normally only a relatively small drop in salinity between the mouth at Bear Island and the Lakes at the north. Indeed, as the data discussed later in this report show, the New Meadows "Lakes", both upper and lower, are usually close to full salinity. The New Meadows River, therefore, is simply an embayment... but a very interesting one.

Geology and Geological History

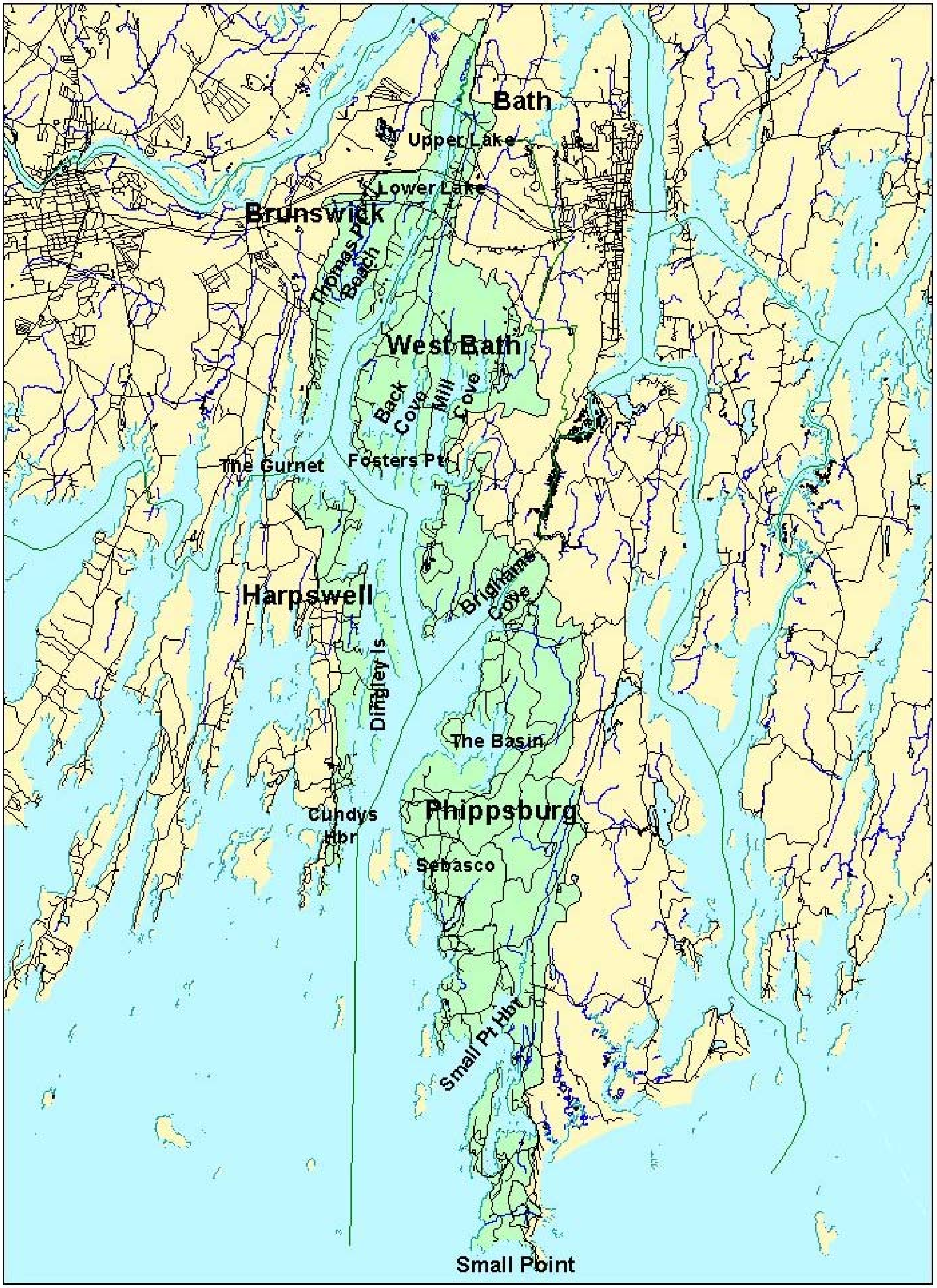
The New Meadows River, along with the other embayments of Casco Bay, originated from volcanic activity. The resulting volcanic formations subsequently underwent substantial deformation approximately 350 million years ago that caused linear folding of the bedrock which resulted in a northeast-southwest alignment of the bedrock, evident today in the northeast-southwest orientation of the peninsulas, islands, and ledges of the area. Erosion and scouring during glaciation slowly removed softer portions of the bedrock leaving only the harder layers which ultimately formed the foundation for the bays, necks, and other geological features of today's coastline (Duffy, 1989).

Glaciation during more recent geological history is responsible for the surficial sediments found today. Approximately 20,000 years before present (BP) glacial ice, a lobe of the Wisconsinan ice sheet covered all of Maine and most of the Gulf of Maine and the massive weight of the ice sheet caused the bedrock layer to be depressed. When the glacier began to recede approximately 14,000 years BP, the sea began to move landward, eventually flooding the coast to a depth of nearly 70 meters effectively submerging most of the coastal area that exists today. As the glacier continued its retreat inland, sediment-laden meltwater from the retreating glacier deposited a layer of fine sediment, referred to in geological terms as glaciomarine mud or Presumpscot Formation, over the bedrock.

Approximately 13,000 years BP, the loss of the weight of the ice sheet allowed the depressed bedrock to rebound, exposing the soft sediments to the elements. Subsequent erosion removed this soft layer, again exposing much of the underlying bedrock. A maximum height of almost 60 meters above present sea level was reached approximately 10,500 years BP when the rate of sea level rise equaled the rate of bedrock rebound. As the rate of rebound continued to slow while the rate of sea level rise remained relatively unchanged, the sea continued to move inland until reaching close to its present level approximately 2,000 to 1,500 years BP (Oakley, 2001).

The geology of the present-day New Meadows River includes a wide variety of formations from exposed and thinly covered bedrock on the terrestrial side to thick layers of glaciomarine mud deposits below the water. The interface between the land and the sea, or intertidal area, varies similarly from highly exposed, vertical bedrock walls to very soft mud in sheltered bays and coves. This varied geology provides a wide range of habitats and ecological niches, all of which combine to make the New Meadows River highly diverse and productive.

Figure 1. New Meadows River watershed



Human History - adapted from *Meadowsweet": Its Rich Historical Environment* by William C. Purington

At the time the first colonists arrived in the of the New Meadows River area, it was already being hunted and fished by native Americans of the Pejepscot and Kennebec tribes. These natives frequented the upper reaches of the New Meadows River, using the short section of land between Merrymeeting Bay, the Androscoggin and Kennebec Rivers, and the Upper New Meadows as a shortcut into eastern Casco Bay, thereby saving them having to navigate the length of the Kennebec and around Small Point.

Foreign influences in the area may have started as early as the eleventh century. The carved inscription of "1018" on a rock found at Popham Beach has been attributed to Norse Vikings, known to frequent the North Atlantic coast of America during that time. The first true attempt to establish a settlement in the area was made at Popham in 1607, the same year Jamestown, Virginia was established. This settlement was abandoned just a year later due to the harsh weather. It wasn't until over 100 years after the first settlers departed that Small Point was successfully colonized beginning in 1716.

The first European colonist known to have settled in the upper New Meadows River area was Thomas Purchase, a farmer, trapper and fisherman, originally of Devonshire, England, who arrived around 1628. The exact location of his first home is not known, but he is known to have built several houses in the Brunswick area along the Androscoggin, including the Fair Stone House, believed by some to have been built on "Fish House Hill" on a site on Water Street where the Narcissa Stone House was later built. Although Purchase appears to have traded extensively with the Indians, he also endured numerous attacks by them on his dwellings. Purchase's expansion of the Pejepscot Proprietorship granted to him in 1632, and the exploitation of the land that followed, undoubtedly precipitated these attacks, which along with others that followed, eventually led to the French and Indian Wars of 1689 to 1763.

By all accounts, Purchase was very successful at exploiting the then abundant salmon and sturgeon of the Androscoggin River. He reportedly caught, dried and salt-cured enough fish to export "thirty-nine barrels of salmon" and sturgeon to foreign markets every three weeks, including a London-based company allegedly established for the primary purpose of importing fish from this area. Indeed, this company is reported to have stationed an agent on the Androscoggin River at the Pejepscot Falls to transact its business. Purchase died in 1675 at the age of 101 in Lynn, Mass.

The second memorable person to settle in the area was Thomas Stevens who moved to the New Meadows River from North Yarmouth in 1675. Stevens' prominence in the community is evidenced by the fact that several areas along the New Meadows River, including the upper section of the river itself and the "carrying place" between the then Whiskeag River (Kennebec River) and the Stevens River, today's New Meadows River, were named after him.

The next person mentioned in historical accounts is Captain James Thompson who moved his family to the New Meadows around 1739 after his father and his family had arrived in the area in 1727. Thompson appears to have been principally a dealer of general merchandise, although he was also a cobbler, a farmer, a scow operator on the New Meadows River, and an innkeeper as of 1750.

Another important figure in the area's history is Samuel Hinkley who purchased 200 acres at the New Meadows River in 1742, having previously moved to Brunswick in 1739, the year Brunswick was incorporated as a Town. Hinkley was highly respected and served as one of the town's first selectmen, represented the Town at the General Court of Massachusetts, was Brunswick's first Town Clerk, and moderated Brunswick's first town meeting. By this time Brunswick had grown substantially and it is reported that by 1765 there were 173 families residing in the town whose population had risen to about 500. Most of the population lived along the Twelve-rod Road (now Maine Street and along the New Meadows. By this time the New Meadows area had become economically self-sufficient and no longer dependent on Brunswick. However, a 1762 petition by the people of the New Meadows Rive area to separate from the Town to form their own town was rejected.

Captain John Peterson moved into the area around 1783. Captain Peterson was very industrious and established several enterprises along the New Meadows. A stone dam he built on the west side of Howard Point cove included a gristmill and a double sawmill, the latter built and operated by Joseph Berry and a man named Sears. Captain Peterson also established two shipyards on the New Meadows to build the ships needed to supply the two general stores he ran in the area. One of these shipyards was located in Howard's Point cove just below the dam on the west side of the cove, the other near the Brown's Ferry site. These shipyards were very successful, continuing to build ships through the 1807 shipping embargo, up to 1809.

By this point in time, considerable shipping was taking place along the New Meadows River in and out of Cushman's and Brown's wharves. According to some accounts, by the mid-1800s almost twenty shipping vessels sailed the New Meadows each year. Packet sailing vessels reportedly sailed routinely between the New Meadows River and Portland and Boston, bringing in merchandise for the traders in Brunswick and Topsham and carrying away the lumber and cotton produced by the various mills, granite from a quarry (opened by Rev. Samuel Woodward in 1799 near the New Meadows Church), and ice. Fish and shellfish were still abundant and very cheap. Large quantities were being exported by the early 1800s.

Captain Peterson was also a driving force behind the construction of a canal through the Stevens' Carrying Place to link the Kennebec and the head of the New Meadows Rivers, primarily for the transport of logs and lumber. Although completed by 1793, the canal never proved practical due to the two-hour difference in the time of the tide between the heads of the New Meadows and Kennebec Rivers that severely limited its use. Indeed, according to Captain Peterson's granddaughter, the only logs ever to have been floated down the canal were those sent through by her grandfather at the time of the canal's completion.

Transport and travel by land across the New Meadows River was limited through most of the 1700s. The first "roads" between Bath and Brunswick appear to have been built sometime between 1718 and 1740 and were mere foot or horse paths. To facilitate transport between Brunswick and West Bath, Benjamin Brown began operating a ferry across the New Meadows around 1760, substantially reducing the transit time between West Bath and Brunswick. The ferry continued in operation until about 1792. Captain Peterson continued operating a ferry until 1796 when a toll bridge was built across the river near Brown's Ferry landing. This, and subsequent bridges, were often lost to ice or inclement weather. Nevertheless, the bridge was maintained for about 50 years. After the revolution, however, the economy of the area began to shift from farming, fishing and logging to manufacturing. With this shift towards an industrial economy came the need for greater land-based transportation. Governor King's Road, so named after William King, first governor of the newly formed State of Maine in 1820, was built between 1805 and 1806 and is considered to have been the best road between Brunswick and Bath prior to modern highways.

The first railroad bridge across the New Meadows River was built in 1849, four years after the Maine Legislature allowed West Bath to incorporate as a separate town. The railroad provided regular passenger service between Bath and Brunswick, then on to Yarmouth and Portland. The trolley remained a popular form of transportation for both passengers and freight until Route 1, originally Governor King's Road, now referred to as the Old Bath Road, was built in 1937. Shortly after, the trolley service was discontinued. When Route 1 was built, the bridge that crossed the New Meadows River was replaced with the existing causeway and culvert, thereby creating the New Meadows Lakes. While the tidal range on the south side of the causeway is around nine feet, the tidal amplitude of the Lakes is measured in inches.

Population Growth

The populations of the four New Meadows River shoreline municipalities has fluctuated over the course of the past 200 years. Generally speaking, and as Table 1 below shows, the population of the area rose steadily from 1790 through 1850. Between 1850 and 1870 the population declined in all but Harpswell where the population continued its steady increase. Following a brief increase in the general population between 1870 and 1880, the population again generally declined from 1880 through 1930. However, the population began to increase in 1940 and has continued to increase steadily in all of the municipalities ever since, as shown in Figure 2 (note that the right, blue numbered Y-axis for the Brunswick population is 4-fold that on the left for Harpswell, West Bath and Phippsburg).

Table 1.
Population change in Brunswick, Harpswell, West Bath and Phippsburg over the period 1790-2000

Town	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890
Brunswick	1,357	1,809	2,682	2,931	3,547	4,259	4,977	4,723	4,687	5,384	6,012
Harpswell	1,071	1,049	1,190	1,253	1,352	1,448	1,534	1,603	1,749	1,773	1,766
West Bath							603	400	373	315	307
Phippsburg				1,119	1,311	1,657	1,805	1,770	1,344	1,497	1,396

Town	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Brunswick	6,806	6,621	7,261	7,604	8,658	10,996	15,797	16,195	17,366	20,906	21,172
Harpswell	1,750	1,650	1,242	1,364	1,305	1,644	2,032	2,552	3,796	5,012	5,239
West Bath	291	230	313	277	353	578	766	836	1,309	1,716	1,798
Phippsburg	1,254	1,079	872	801	1,020	1,134	1,121	1,229	1,527	1,815	2,106

Source: Fogler Library, Maine Census Data: Population Totals - http://library.umaine.edu/census/townsearch.htm

Figure 2.
Population change in Brunswick, Harpswell, West Bath and Phippsburg over the period 1790-2000
(Note: the right, blue numbered Y-axis for the Brunswick population is 4-fold that on the left for Harpswell, West Bath and Phippsburg).

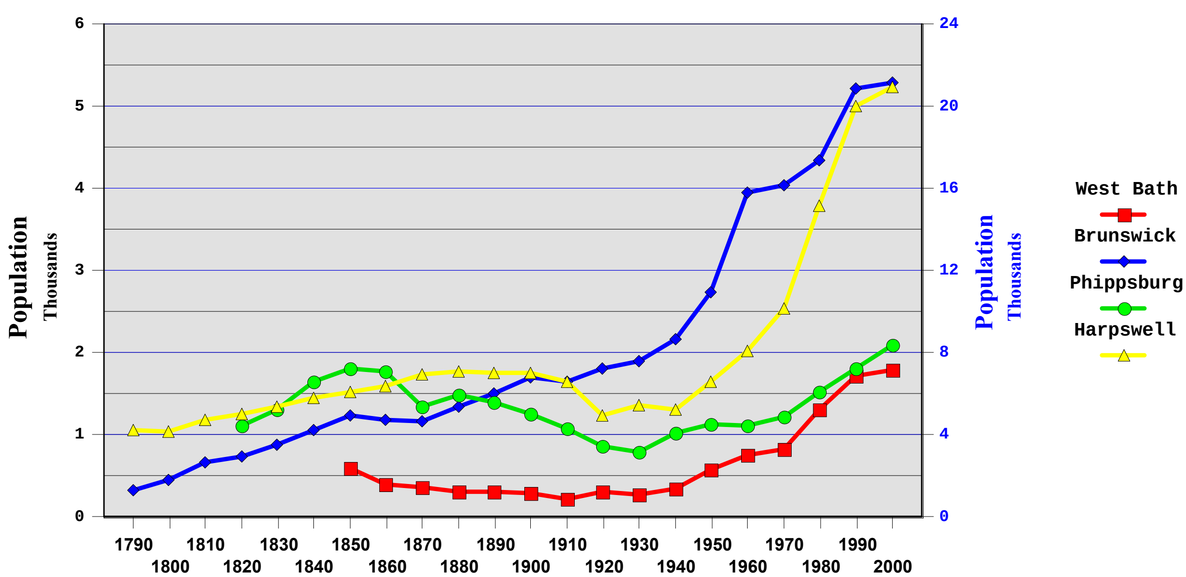


Table 2, below, shows the rate of population change, as percent change, for the period 1790-2000 based on the values in Table 1. These rates fluctuated dramatically as a result of population shifts in response to events of the times. Particularly interesting is the unusually fast rate of growth during the 40-year period 1950-1990 that peaked during the prosperous late 1970s and early 1980s. Within the last 10 years the rate of growth has leveled off sharply. The trends over the 50-year period 1950-2000 are shown graphically in Figure 3.

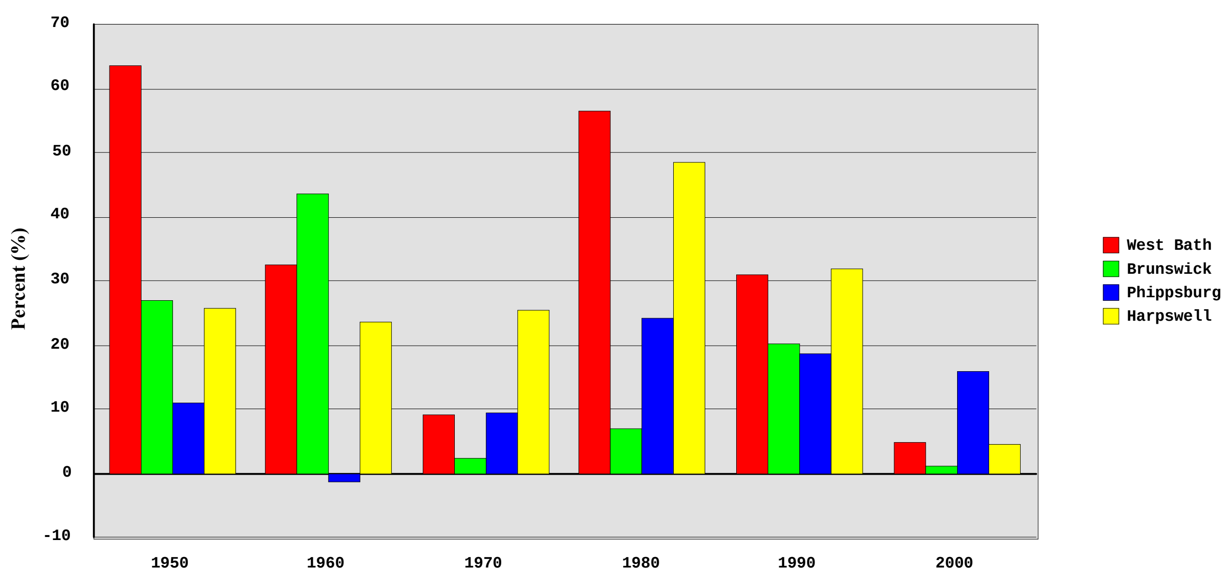
Table 2.
Rate of population change in Brunswick, Harpswell, West Bath and Phippsburg over the period 1790-2000, as percent change

Town	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890
Brunswick		33.3%	48.3%	9.3%	21.0%	20.1%	16.9%	-5.1%	-0.8%	14.9%	11.7%
Harpswell		-2.1%	13.4%	5.3%	7.9%	7.1%	5.9%	4.5%	9.1%	1.4%	-0.4%
West Bath								-33.7%	-6.8%	-15.5%	-2.5%
Phippsburg					17.2%	26.4%	8.9%	-1.9%	-24.1%	11.4%	-6.7%

Town	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Brunswick	13.2%	-2.7%	9.7%	4.7%	13.9%	27.0%	43.7%	2.5%	7.2%	20.4%	1.3%
Harpswell	-0.9%	-5.7%	-24.7%	9.8%	-4.3%	26.0%	23.6%	25.6%	48.7%	32.0%	4.5%
West Bath	-5.2%	-21.0%	36.1%	-11.5%	27.4%	63.7%	32.5%	9.1%	56.6%	31.1%	4.8%
Phippsburg	-10.2%	-14.0%	-19.2%	-8.1%	27.3%	11.2%	-1.1%	9.6%	24.2%	18.9%	16.0%

Source: Fogler Library, Maine Census Data: Population Totals - http://library.umaine.edu/census/townsearch.htm

Figure 3.
Rate of population change in Brunswick, Harpswell, West Bath and Phippsburg over the period 1950-2000, as a ten-year interval percent change



The trend in population growth for each community over the past 50 years is summarized below in Table 3. as the actual and relative growth, shown as actual population and percent increase, respectively, for each ten-year period.

Table 3.
Actual and relative population change in Brunswick, Harpswell, West Bath and Phippsburg for each ten-year period 1950-2000

Town	1950-1960		1960-1970		1970-1980		1980-90		1990-2000	
	Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Brunswick	4,801	43.7%	398	2.5%	1,171	7.2%	3,540	20.4%	266	1.3%
Harpswell	388	23.6%	520	25.6%	1,244	48.7%	1,216	32.0%	227	4.5%
West Bath	188	32.5%	70	9.1%	473	56.6%	407	31.1%	82	4.8%
Phippsburg	-13	-1.1%	108	9.6%	298	24.2%	288	18.9%	291	16.0%

Source: Fogler Library, Maine Census Data: Population Totals - http://library.umaine.edu/census/townsearch.htm

Figure 4.
Population change in Brunswick, Harpswell, West Bath and Phippsburg over the period 1950-2000
(Note: as in Figure 2, the right, blue numbered Y-axis for the Brunswick population is 4-fold that on the left for Harpswell, West Bath and Phippsburg).

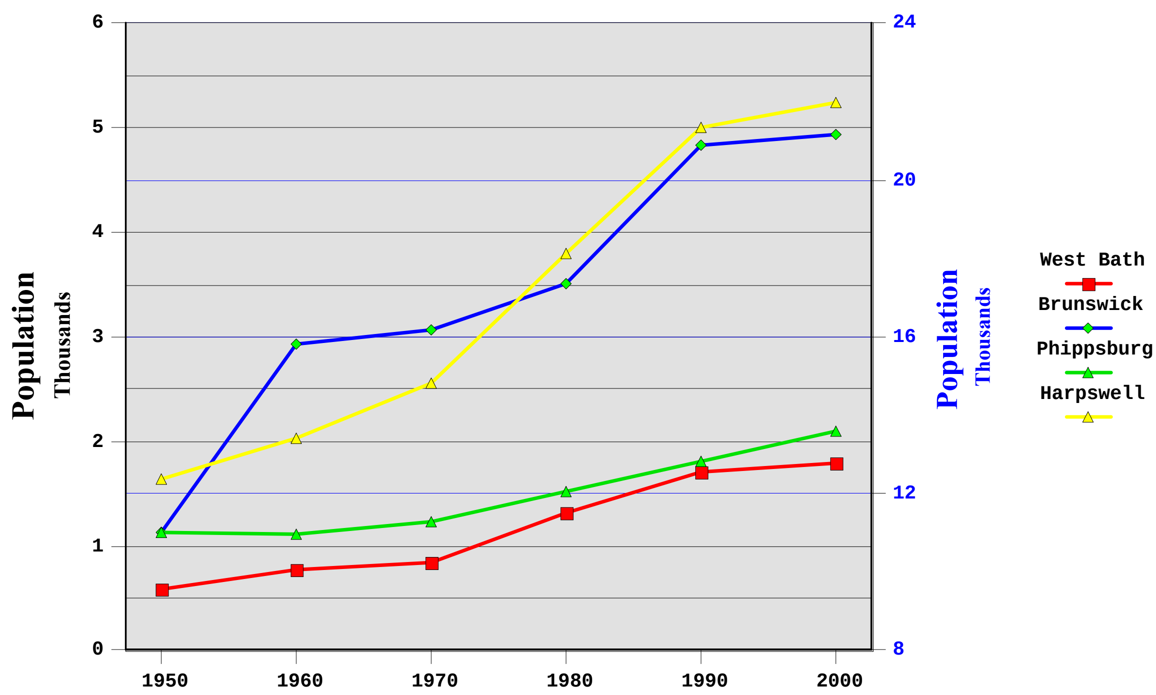


Table 4., below, presents the projected population in each of the four NMR shoreline towns based on the population growth rates of the past 50-year and the assumption that these will be sustained for the next 50 years.

Table 4. Population Projection 2050

Town	Pop. increase 1950-2000	% Pop. increase	Projected Pop. increase	Population 2050
Brunswick	10,176	92.3%	19,593	**40,765**
Harpswell	3,595	218.7%	11,456	**16,695**
West Bath	1,220	211.1%	3,795	**5,593**
Phippsburg	972	85.7%	1,805	**3,911**
Total	**15,963**	**152.0%**	**36,650**	**66,964**

There is little doubt that such an increase in population will have a significant impact on the general Eastern Casco Bay region, overall, and the New Meadows River area specifically, as it has over the past 50 years. Indeed, recent demographic changes within the towns, and projections based on those changes, indicate that a substantial part of the development that will be required to accommodate this increase in population will occur within the New Meadows River watershed.

Recent Demographics

The New Meadows River is at the eastern end of the most populated area in Maine. Approximately 10% of the State's 1.25 million people live in its towns surrounding Casco Bay. According to the State Planning Office almost 80% of the total growth during the period 1970-1990 took place in towns such as Brunswick and Harpswell, a fact clearly evident from the data presented in the previous section.

All four towns report that development to accommodate these increases in population has occurred on the shoreline. In the case of Brunswick, West Bath and Harpswell, the New Meadows River area either has been, or is anticipated to be, the most intensively developed sections in all three towns.

According to a Planning Decisions report to the Town of Brunswick, the Town's household population growth grew the fastest along the New Meadows River shore between 1990 and 2001 (est.), with an 8.4% increase in housing units, 22.6% of relative growth (highest among the areas) and nearly 41% growth in residents (~230 new residents). Furthermore, …"The change from 1990-2001 has been greatest along the New Meadows River at 64.3% growth of the household population being under the age of 18." (Source: Table G – Estimated Household Population Growth by Geography Brunswick 1990-2001; also see Table H). Regarding future development, the report states:

> "Rural areas of town are projected to drive Brunswick's growth through 2020…Areas that are projected to receive most of Brunswick's future population growth include West Brunswick, Pleasant Hill, and the ***New Meadows Shore***. These areas both contain large undeveloped parcels that have good environmental conditions for development (soils and slopes). Growth in the ***New Meadows Shore*** and ***East Brunswick*** will be stronger if the Cooks Corner Master Plan is successful in its attempt to reorient development around pedestrians." - excerpt from Projected Household and Population Growth by Region, 2001-2020 (page 12).

The increase in the number and size of large retail stores, such as WalMart, in the Cook's Corner area, suggests that such projections are correct. In addition, the recent move by MidCoast Hospital to its new facilities off the Bath Road just east of Cook's Corner will likely serve as a focus for development, particularly for the older segments of the population seeking proximity to medical facilities. This, in turn, will increase the demand for local services, thus prompting development within the commercial/retail sector.

In Harpswell, between 1995 and1999 nearly 60% of the 62 lots subdivided during the period were within the Shoreland Zone; 42, or 76%, of these were in the Shoreland Residential Zone. The largest developments were located on Great Island, primarily on the north end; all of Harpswell's shoreline on the New Meadows River is along Great Island. During the same period, of the 282 new dwellings built in the town, 149, or ~53%, were built on Great Island, again, primarily within the shoreland zone although not along the immediate shoreline. Additionally, Cundy's Harbor, on Great Island, is one of the five most densely populated areas in the town of Harpswell.

West Bath also reports that the largest growth in the Town has been along the New Meadows River shoreline. Indeed, the highest development density in the Town is found at Bull Rock, Kings Point, Rockhaven, Fosters Point, Sabino, Birch Point, and Brigham/Shoal Cove, all along the New Meadows River.

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Land Use and Zoning

This section briefly summarizes the existing land uses and zoning in the New Meadows River watershed by municipality as well as speculation on the likely direction development might take in the near future based on recent development trends.

Town of Brunswick

Current Land Use

The Brunswick portion of the NMR watershed is primarily residential with several large mobile home parks, but also includes the Cook's Corner retail center, an industrial zone centered around the Bath Iron Works Harding Plant, and a Medical Use Zone that encompasses land around the recently completed Mid Coast Hospital Complex. Some farms, fields and wooded areas are also present, as well as a commercial marina and restaurant adjacent to the river. Recent subdivisions have been relatively small, less than 10 lots typically.

Existing Zoning

The Brunswick portion of the NMR watershed includes six zoning districts and three overlay districts. Zoning requirements are as follows:

	Max. density	Minimum lot area	Max. impervious surface coverage
Growth Area			
Cook's Corner	15 units/acre	15,000 sf	80%
Residential 6	8 units/acre	12,000 sf	45%
Industrial 3	12 units/acre	20,000 sf	80%
Rural Area			
Country Residential 2	1 unit/1.5 acres	1.5 acres	20%
Mixed Use 1	1 unit/1.5 acres	1.5 acres	20%
Farm and Forest 3	1 unit/ 2 acres	2 acres	25%

The three overlay zones are as follows:

1. Along the New Meadows River is the Natural Resource Protection Zone (NRPZ). This zone requires that buildings be setback 250 feet from the water in high/moderate value areas (as rated by Maine IFW), 125 feet in all other areas.

2. The Medical Use Zone (MUZ) around the Mid Coast Hospital is in the I-3 and FF-3 zones. Impervious area limits have been set for 50%.

3. The Mobile Home Park Zone includes and is limited to the existing mobile home parks in this area.

Future Growth

This area is expected to see continued moderate growth, stimulated by the new presence of the Mid Coast Hospital. This growth may be medical use related, commercial, and residential.

Town of West Bath

Current Land Use

The West Bath portion of the NMR watershed extends from the Upper New Meadows on the Bath border to open water at Foster's Point across from Harpswell. New Meadows Road runs parallel to the New Meadows River, crossing Route 1, and becoming Foster's Point Road after crossing the State Road intersection. Both Route 1 and the State Road cross the New Meadows River and connect West Bath to Brunswick. Land use along this corridor is primarily residential on small lots with very little commercial activity on the waterfront. Commercial activity is found on the west side of New Meadows Road.

Existing Zoning

Zoning along the NMW is predominantly Residential. An area between Route 1 and the State Road is designated Business and Commercial. The two zones are under the Shoreland Overlay Zone. This zone applies to all land areas within 250 feet of the normal high-water line and requires a 75 foot shore setback, with a minimum shore frontage of 150 feet. Structures cannot cover more than 20 percent of any lot.

Future Growth

Growth along the NMW is expected to be in the Business and Commercial zone. Two of the existing businesses are currently expanding their building footprints. The Planning Board is in the process of reviewing development in the Business and Commercial zone, and will likely develop design standards for this area.

Town of Harpswell

Current Land Use

Harpswell's portion of the New Meadows River watershed is primarily residential with several commercial fishing and boating areas, but also Cundy's Harbor, a Town Harbor, centered on the commercial fishing industry in Harpswell. Some wetlands, clam flats, fields and wooded areas are also present, along with some unique geological features. Recent subdivisions have been relatively small, typically less than 10 lots.

Existing Zoning

The Harpswell portion of the NMR watershed includes three zoning districts, Shoreland Residential, Commercial Fishing, and Resource Protection. Lot sizes are consistently at 40,000 square feet, but setbacks and uses very from zone to zone. Subdivisions currently require a 80,000 square foot lot in the Shoreland Zone.

Future Growth

This area is expected to see continued growth, and expansions of structures located non-conforming lots. Increased seasonal conversions from cottages to houses along with an aging population.

City of Bath

Current *Land Use*

The land uses in that portion of the upper New Meadows watershed in the City of Bath are primarily low density, single family residential. The exceptions to this are a church and church school located on Whiskeag Road, a commercial rhododendron garden and greenhouse located on Ridge Road, and a horse pasture and stable also on Ridge Road.

Existing Zoning

Zoning in this part of Bath is Low Density Residential. The minimum lot size is 60,000 square feet. Along the New Meadows is an overlay zone called the Natural Resource Preservation Overlay District. This district requires that buildings be setback 150 feet from the water. A reduction of that 150-foot setback can be allowed provided the landowner demonstrates specific environmental and resource protection criteria are met. Buildings may never be closer than 75 feet from the water.

Future Growth

This part of Bath is not one that is likely to experience much development in the future.

Town of Phippsburg

Current Land Use and Shoreland Zoning

The Current Land Use and Shoreland Zoning for the area in Phippsburg bordering The New Meadows River has a minimum lot size of 40,000 sq. ft. with 150 ft. of frontage and a minimum set back of 125 ft. Also, all new septic systems will be set back 150 ft. from the high water line (50 feet over State minimum)

Future Growth

It is recognized that this part of Phippsburg along the New Meadows River could experience some development in the future. The Town of Phippsburg is currently re-writing its Comprehensive Plan; therefore future land use zoning will become dependant on the results of the plan.

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Figure 5. Composite land use map for the four New Meadows River shoreline towns

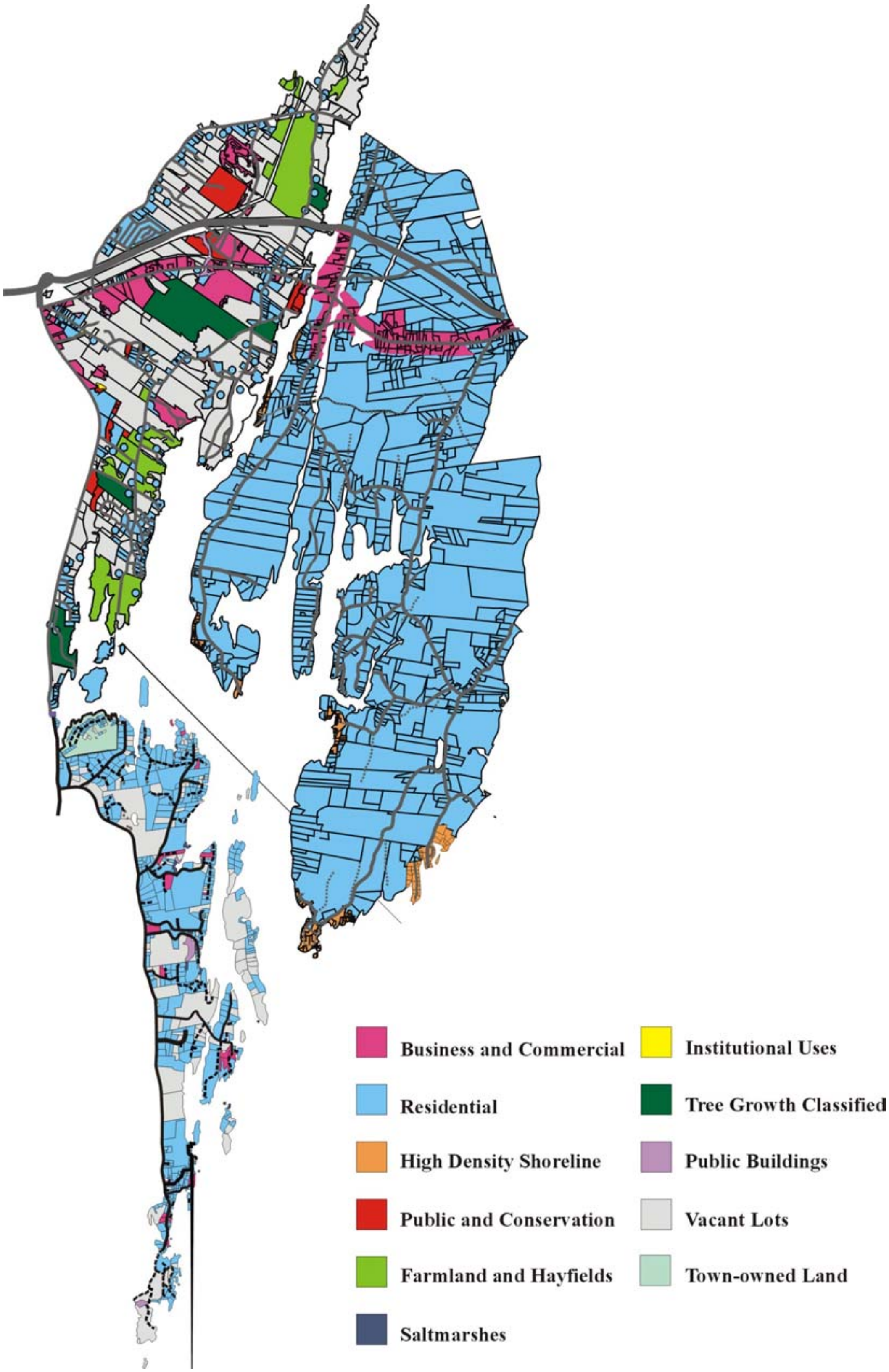


Figure 6. Land use map for the Town of Brunswick

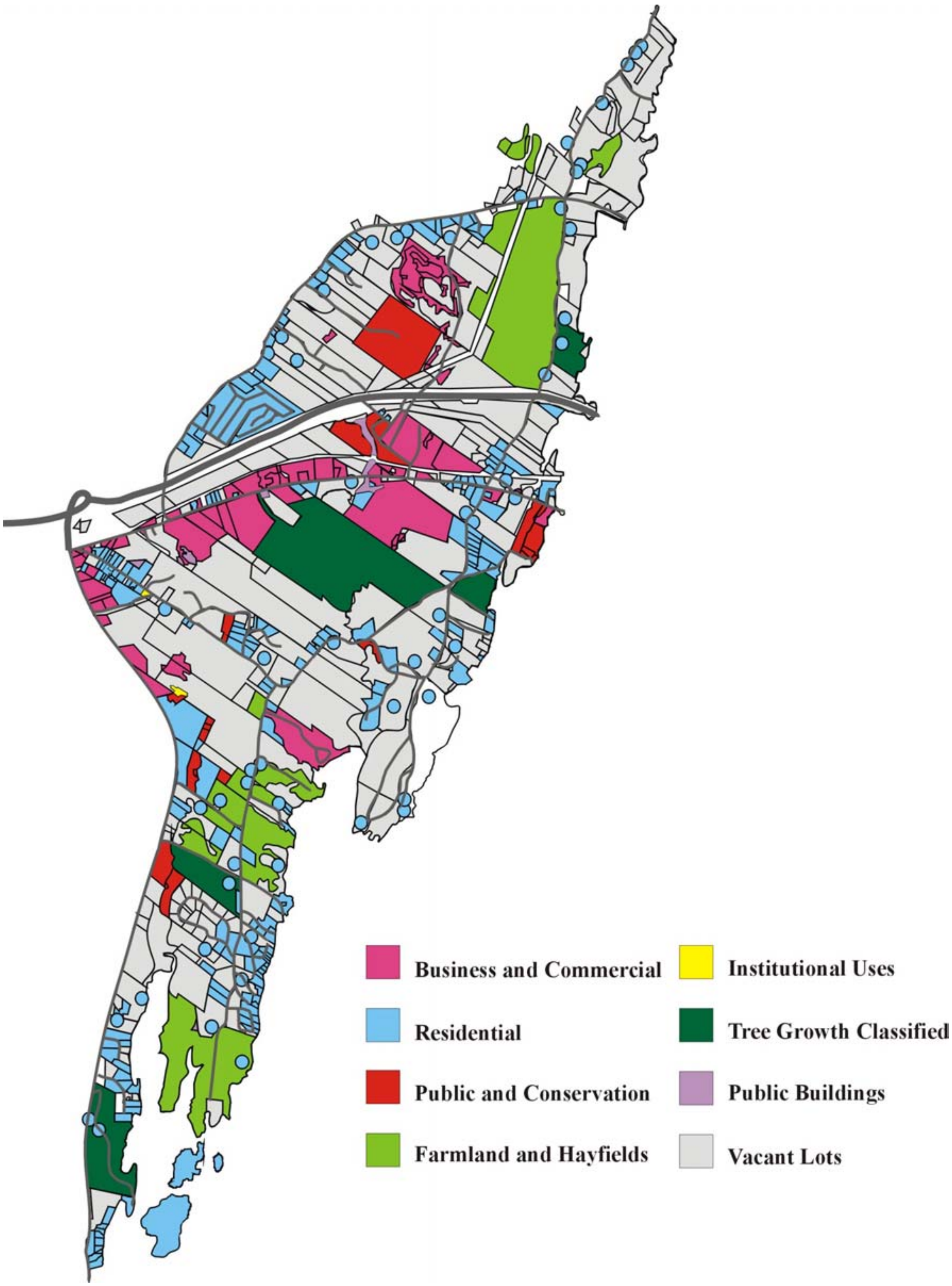


Figure 7. Land use map for the Town of West Bath

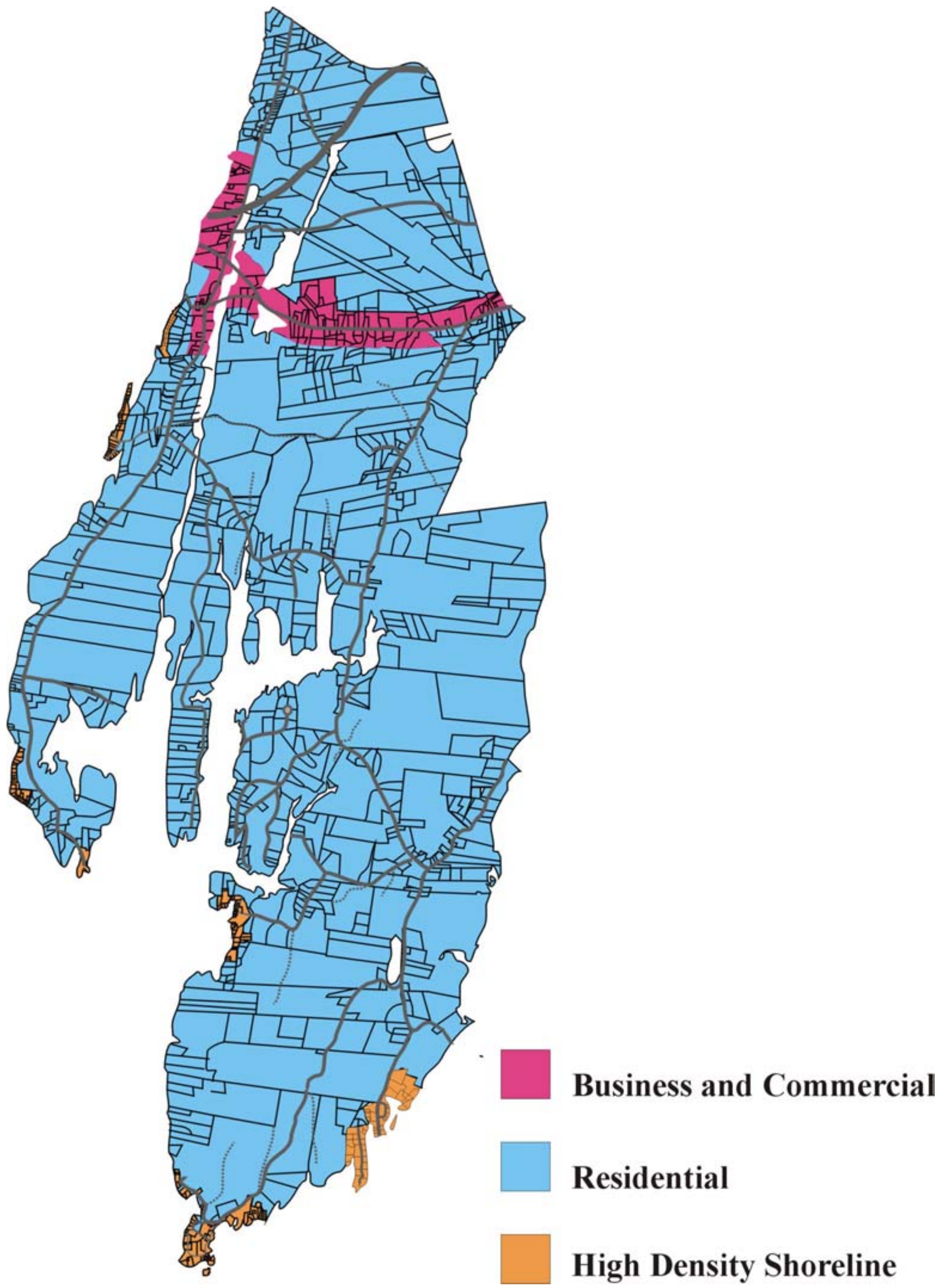


Figure 8. Land use map for the Town of Harpswell

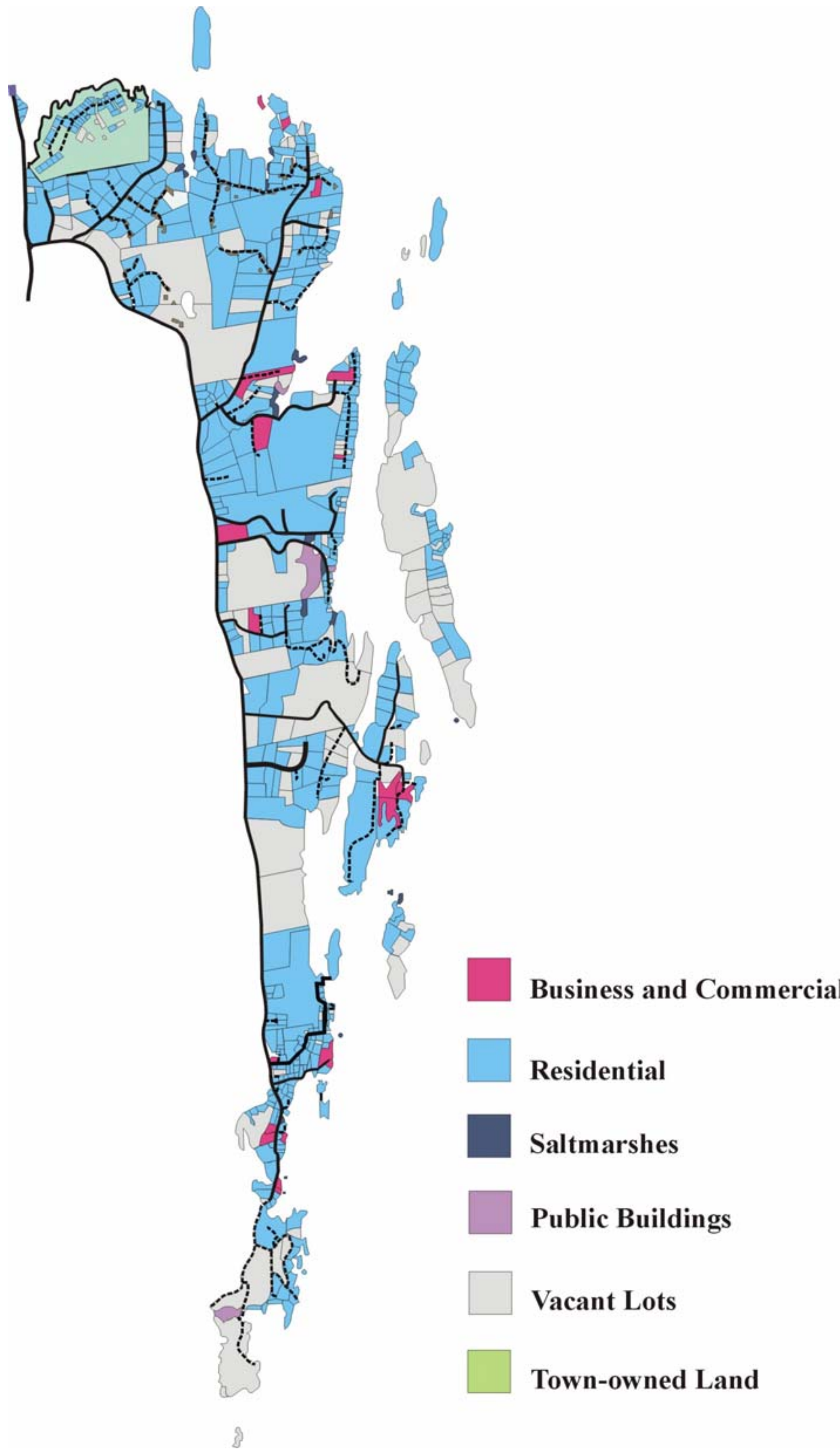


Figure 9.   Land use map for the Town of Phippsburg

To be Completed

Water Quality

Water quality is a general term that covers several categories, including physical and chemical characteristics, as well as pollutants and contaminants (toxic chemicals, petroleum derivatives), and biological agents, such as water-borne disease organisms. Each of these categories includes a set of parameters used to measure and describe the degree of quality of each. Limited data have been collected within the New Meadows River as part of numerous unrelated studies and efforts.

This section offers a brief introduction to the major parameters within each category for which data exist. Only the most recent data on conditions of the New Meadows River are discussed in detail.

Physical and Chemical Characteristics

Temperature is by far the most commonly measured parameter in coastal waters, often reported in nightly local weather reports, and therefore is the most familiar to the general public. The most obvious variations in seawater temperature occur over time, (*i.e.* seasonal), and spatial, (*i.e.* geographically, for example north to south).

The normal seasonal temperature range for open waters of Casco Bay is generally between about $20^{O}C$ in summer to $2\text{-}4^{O}C$ in winter; during any season temperatures can vary as much as $10^{O}C$ or more between open and sheltered waters, *i.e.* from the head of a bay compared to its mouth. These represent relatively wide variations on larger scales of both time and space. Variations also occur on small scales of both time and space, and often at greater frequency, that are much more subtle but equally important. For example, rather dramatic changes in water temperature can occur within relatively short periods of time at a single point on a mudflat during an incoming tide on a warm, sunny summer afternoon, when temperatures can reach $30^{O}\text{-}35^{O}C$; equally dramatic temperature fluctuations occur in coves on the outgoing tide on a frigid winter's night when temperatures can drop as low as $-2^{O}C$, the temperature at which seawater freezes. Furthermore, substantial changes in temperature occur with increasing depth with warmer water overlaying progressively colder, deeper water. However, since seawater reaches its maximum density at approximately $4^{O}C$ during winter the colder, less dense waters can be found overlaying the denser, slightly warmer water. The rate of change in temperature within a water column is affected by the amount of mixing that takes place within the water column; the total change and rate of change are smaller in strongly mixed waters than in calm, less mixed waters. Occasionally, sudden and dramatic temperature changes are seen at a specific depth indicating the presence of two distinct water masses. The point where this sudden change occurs represents the boundary between the water masses and is referred to as a thermocline.

Salinity, or the amount of salt in seawater, is probably the next most commonly measured parameter. Salinity is extremely important because of the major role it plays in determining the flora and fauna that exist in an area, since most organisms have a narrower range of salinity than temperature within which they can exist. Consequently, measurement of salinity helps in understanding and identifying the type of water body. Salinity is normally reported as parts per thousand (‰) instead of percent (%), or parts per hundred. Normal open ocean seawater usually ranges between 32-33‰, (around 3%).

Similar to temperature, significant variations in salinity occur over both time and space. In open waters removed from freshwater sources, these variations are usually small. In contrast, areas under the influence of substantial freshwater input will experience dramatic changes in salinity. Some of these changes are highly predictable, such as annual lowering of salinity in early spring resulting from flow from melting snow. In other cases dramatic change is unpredictable, with respect to the time, degree, and area as a result of episodic rain events of varying intensities. A change of salinity over distance, or depth in the case of a vertical profile within a water column, is referred to as a salinity *gradient*. Change over distance results in a horizontal gradient from very low near the freshwater source to high at some distance from the source; change with increasing depth results in a vertical gradient with lower salinity less dense water overlying denser, higher salinity water. Again, similar to temperature, sudden and dramatic salinity changes are occasionally seen at a specific depth indicating the presence of two distinct water masses; the point where this sudden change occurs represents the boundary between the water masses and is referred to as a halocline.

The third important parameter is *dissolved oxygen*, often abbreviated as D.O. Dissolved oxygen is essential to all organisms with the exception of certain bacteria; even plants, which produce oxygen in light, also require oxygen during their respiration phase in darkness.

The amount of D.O. in water, or D.O. concentration, depends on temperature and salinity. The natural capacity of water to hold oxygen decreases as temperature and/or salinity increases. The theoretical amount of oxygen water can hold at a specific temperature and salinity is calculable. When the amount of oxygen present in water is equal to the theoretical value, the water is considered to be 100% saturated. Waters that are well mixed and of high quality normally have D.O. saturation levels at or near 100%. Values greater than 100% are possible and are often seen following storms when wind and crashing waves introduce more oxygen than would normally be found under static conditions; the presence of a greater than normal amount of D.O. is termed super-saturation.

D.O. concentration is measured and reported in either milligrams per liter (mg/L) or milliliters per liter (ml/L). Values above 7 mg/L are considered good, and between 7 mg/L and 5 mg/L are considered acceptable. Values below 5 mg/L are considered low, and below 3 mg/L are considered critical. According to the available data, D.O. concentration in the New Meadows River generally ranges between 7-11 mg/L. However, knowing only the actual amount of oxygen present is of limited value since it gives no indication of how much oxygen is available relative to the total amount the water can hold at the temperature and salinity at which the measurement was taken. Consequently, the temperature and salinity values of the water are usually provided along with the actual oxygen measurements. But more often than not, D.O. is reported as percent saturation, that is, the actual amount of dissolved oxygen is expressed as a percentage of the theoretical amount the water could hold at 100% saturation, taking temperature and salinity of the source water into consideration. For example, seawater at $18.5^{O}C$ and a salinity of 26.5‰ can hold exactly 8.00 mg/L of oxygen. If the actual amount of oxygen measured from a sample of seawater having this same temperature and salinity were found to be 7.2 mg/L, the water would be reported as being 90% saturated.

With the exception of photosynthesis and non-oxygen dependent metabolic processes of certain bacteria, biological activity consumes oxygen. Since oxygen is continually being used by sea life, D.O. levels below 100% saturation are often found, particularly in shallow areas and near the bottom in deeper water. Occasionally D.O. can drop substantially below 100% in areas of high animal abundance, such as amid schooling fish. Saturations substantially below 100% are also often associated with the decomposition of accumulated organic material of either natural or man-made origin. These unusual occasions aside, D.O. saturation normally remains above 90%.

The State of Maine has established specific minimum threshold limits on dissolved oxygen saturation. The threshold limit for Class B marine waters, under which all areas of the New Meadows River fall, is 85% saturation (reference).

Nutrients and Eutrophication

In addition to requiring light and a certain temperature range, marine plants, whether microscopic algae or large kelp, also rely on a constant supply of nutrients to grow. As in most plants, nitrogen and phosphorus are the major nutrients required for growth, although trace amounts of certain other elements are essential; silicate, for example, are specifically required by certain types of algae. In the same way that growth can either be enhanced or constrained, depending on the availability of light, so too with the availability of essential nutrients. Provided suitable conditions of temperature and light, rate of growth will depend on the availability of nutrients. If the supply of even a single essential nutrient is interrupted, the rate of growth will decline.

Control of growth by limiting factors: light and essential nutrients

When a specific required element, be it light or a nutrient, is inadequate or lacking while other requirements are available in adequate amounts, the former is referred to as a limiting factor. Nitrogen is considered the principal nutrient limiting plant growth in the marine environment, since other nutrients are generally available in adequate amounts. The proportions, or ratios, of certain nutrients also are important and can affect the composition of the plant community. However, that discussion is well beyond the scope of this report.

Marine plant growth in the northern temperate region normally follows a predictable cycle through the course of the year. Growth during the winter slows, or may cease, due to low temperature, reduced light and reduced surface runoff that serve as a vehicle for the introduction of nutrients.

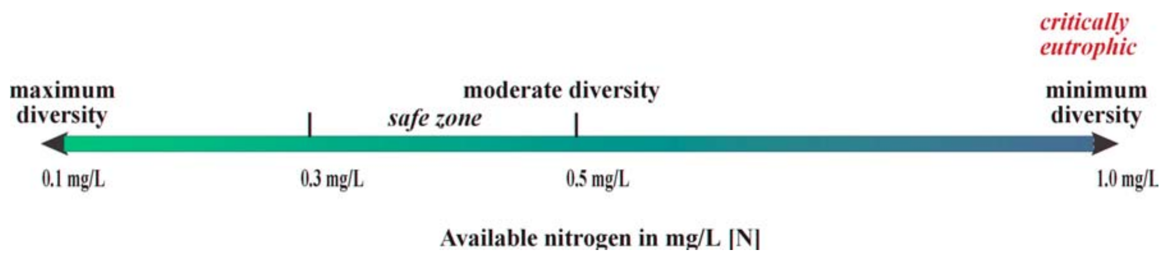
As the weather begins to warm in late-winter and early-spring, melt-water runoff introduces nutrients. At the same time, light increases in intensity and duration and water temperature begins to rise. Along the near-shore area where runoff has the greatest effect, this often results in a March-April bloom, often referred to as the spring bloom. This bloom serves as food for shellfish as they once again begin their annual growth cycle. As the seasons progress through spring and summer, conditions begin to favor the growth of higher plants, those being the seaweeds, kelps, and sea grasses. The nutrients to support this growth are provided in part by runoff from rain events. Occasionally these nutrient pulses also result in periodic summer algal, or phytoplankton, blooms. As fall approaches, the light and temperature conditions begin once again to favor the phytoplankton, resulting in another major bloom, often referred to as the fall bloom. As colder weather sets in during late fall and early winter, the cycle is completed.

Summer fluctuations in temperature and light are relatively small and changes occur slowly. Periodic algal blooms are therefore generally controlled by the availability of nutrients. Growth is maintained through a supply of nutrients within a normal range of both *amount* and *rate* of delivery. However, if either the amount or the rate of delivery of nutrients exceeds the normal range (often referred to as nutrient loading), and other conditions remain favorable, algae can begin to grow excessively. The growth of algae, in and of itself, is not necessarily problematic, but if conditions suddenly change, such as a rise in temperature or interruption of nutrient supply, the result can be a rapid decline or death of the algae, sometimes referred to as a crash. The decomposition that follows such a crash can cause a rapid depletion of the oxygen in the water that, in turn, can result in the death of the fauna in the affected area, further fueling the decomposition-oxygen depletion process. The process that leads to this cycle of nutrient-induced algal bloom followed by a crash and subsequent oxygen depletion is termed *eutrophication,* an ecological term for the end-stage in the natural progression and evolution of freshwater bodies. Eutrophication of marine waters is unusual due to their size and rates of exchange, however, eutrophic conditions can occasionally be found in sheltered waters with low rates of exchange.

Acceptable Nitrogen Level

The estimated level of available nitrogen to support maximum diversity in estuarine waters is 0.1 mg/L. The critical level, that is, the level at which eutrophication can be expected, is estimated at 1.0 mgN/L. The estimated range in which moderate diversity can be supported is 0.3-0.5 mgN/L (Jaworski, N.A., O. Villa, Jr. 1981). Levels above 0.3-0.5 mgN/L indicate progressively advanced stages of eutrophication, illustrated graphically in Figure 10.

Figure 10. Relative eutrophication scale based on available nitrogen concentration



During the winter, in coastal waters that are not nutrient enriched, average dissolved inorganic nitrogen levels are in the 0.18 to 0.24 mg/l range. In the summer, as phytoplankton use up most of the available nitrogen, this range may decrease to 0.01 to 0.04 mg/l or less. Phosphate concentrations will generally follow a 10-1 ratio with nitrogen, with a range of 0.01 to 0.03 mg/l in the winter and just a left-over trace amounts in the summer (0-0.01 mg/l). For Silicate, a range of 0.14 to 0.28 mg/l may be found in the winter, and the natural drawdown will leave almost nothing in the summer. However, a large rain event may raise the level to 0.56 to 0.70 mg/l. (Ted Loder, pers. comm.).

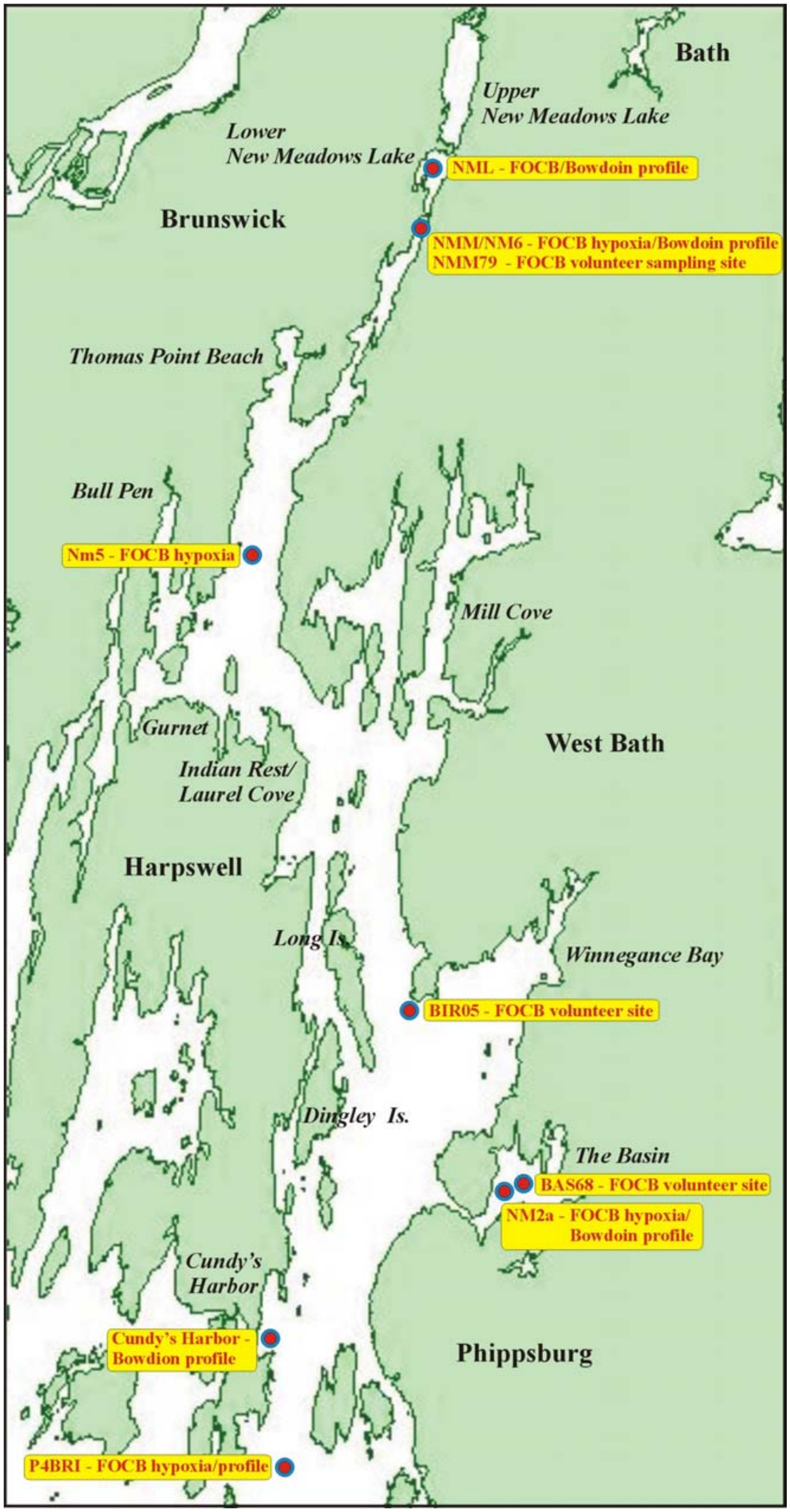
Existing data for the New Meadows River

The New Meadows Lakes, at the upper extreme of the New Meadows River, have been the focus of several studies, the earliest of which were associated with the construction of Route 1 in the mid 1960s. The Friends of Casco Bay (FOCB) have been monitoring the New Meadows lakes and several stations along the lower river since 1993. The Maine Department of Marine Resources also monitors numerous stations along the river for fecal coliform contamination as part of the National Shellfish Sanitation Program (discussed below). However, until recently, relatively little work had been done to develop comprehensive water quality data for the New Meadows River. Fortunately, just within the past two years the Friends of Casco Bay and Bowdoin College have both developed programs to study the physical and chemical characteristics of the river, including the lakes section. Because of the differences in methods and circumstances under which these various data were collected, the data sets are treated separately.

Friends of Casco Bay (FOCB) Data

Much of FOCB's data on the New Meadows River has been developed through its volunteer citizen monitoring program. Additional data have been collected through the more intensive and routine water column profiling program carried out by the FOCB staff as well as through collaborative efforts with others, including the University of Maine School of Marine Sciences, the Gulf of Maine Ocean Observing System, and Bowdoin College. FOCB has previously reported the results of these efforts and a detailed review of these data is not included here. A brief review of the most recent data from 2001 can serve to describe current conditions along the NMR and provides a point of departure in time to which future data can be compared. A full tabulation of data is included here as Appendix I. It should be noted that this tabulation represents a composite of 2001 data collected through a number of FOCB programs and studies which explains the apparent gaps in certain data sets. The locations of FOCB's sampling stations for its various programs and studies are shown in Figure 11 on the following page.

Figure 11. Friends of Casco Bay (FOCB) sampling station locations



Temperature and salinity of the New Meadows River

The temperature and salinity data clearly indicate that the New Meadows River is functionally not a river, at all, but rather a marine system. Therefore, the inclusion of "River" in the name New Meadows River refers to its geographic appearance rather than its physical and biological character and function. Given its physical and biological features, the system would more accurately be categorized as an embayment, or appendix of Casco Bay, but to avoid confusion, the New Meadows River will continue to be referred to as the river throughout this report.

The profile data show that, generally speaking, temperature and salinity changes are small through the water column from surface to bottom at all stations up and down the river, indicating that the water column is well mixed throughout most of the river's length from the mouth in the vicinity of Bear Island all the way up to the head at the New Meadows Marina. Even within the partially confined New Meadows Lakes, temperature and salinity, particularly the latter, change relatively little from surface to bottom, initially indicating well mixed conditions. Other data discussed later in this section show clear stratification and isolation of bottom water at specific locations within the Lakes). Certain data, however, appear to indicate external influences that may play an important role in how the river functions.

Although the data show that the river as a whole is well mixed vertically, on certain dates, data from the station at the mouth of the river at Bear Island (P4BRI) show distinctly lower surface salinity compared to the bottom. The FOCB profile taken on April 17 and May 10, 2001 show a surface to bottom salinity change of 27.1-31.5‰, and 27.7-31.0‰, respectively. These differences of 3-4‰ would not be particularly remarkable were it not for the fact that this station is a considerable distance away from freshwater sources along the river itself. If the lower surface salinity readings had been confined to the April profile, it might be argued that the lower surface salinity simply reflects the effect of the spring snow melt. However, given the depth of the water column off Bear Island, the volume of water exchanged at any stage of the tide in the vicinity of the station, and the station's close proximity to the open waters of Casco Bay, the volume of freshwater necessary to substantially depress salinity would be tremendous, perhaps more than can be accounted for from simple snow-melt and runoff. But the repetition of the results in May, well after snow-melt influences should have subsided, suggests that some other source of freshwater may be involved. Unfortunately, no temperature and salinity data were recorded at stations further up the New Meadows on these dates; thus there is no way of comparing the results from Bear Island to other locations along the river. Similarly, no weather conditions for these dates, or the days immediately preceding sampling, are included, so it is not immediately possible to determine the extent to which precipitation might have affected these results.

Clearly, the available data are insufficient to allow conclusions to be drawn, but they point to the possibility of external influences. Despite the insufficiency of data, these anomalies have led to preliminary speculation that a southerly flow from the Kennebec River rounding Small Point may play a role, perhaps a very important role, in how the New Meadows River functions as a system, particularly with respect to surface water circulation. The way in which surface water circulates will, in turn, affect the rates of exchange and flushing and therefore the New Meadows River's capacity to respond to any changes that occur along its course. Consequently, it is vitally important, first, to determine if the observed anomalies reflect episodic events or continual, consistent influences and, second, if the latter proves to be the case, to determine the magnitude of the influences and the possible effects these might have on the system as a whole.

Dissolved oxygen in the New Meadows River

The dissolved oxygen data show that, with only a few exceptions, D.O. saturation remains high throughout the water column at all times of year, including the high biological activity period of late summer and early spring, and surface waters are routinely super-saturated. Excluding the upper reaches of the New Meadows and the Lakes, saturation values below the 85% threshold are infrequent, and when found, generally occur at or near the bottom. Even when saturations in the lower river area drop below the 85% threshold, actual dissolved oxygen remains at or above 7.5 mg/L, indicating that dissolved oxygen levels over most of the river are generally good..

In sharp contrast to the lower New Meadows, at the upper, shallow reaches of the river and within the Lakes D.O. saturations frequently drop below the 85% saturation threshold, sometimes substantially. Just below the Old Bath Road causeway, in the vicinity of the new Meadows Marina (Station NMM), non-compliant D.O. saturation levels are often only slightly below 85% and usually above 80%. At the sampling location within the Lakes (Station NML) however, saturations frequently drop well below 85% and often reach 0%, or anoxic conditions, near the bottom.

The development of a stratified, anoxic layer within what is locally referred to as the “deep hole” in the Lower Lake has been known for some time. Indeed, this deep hole has been the focus of a FOCB study since July, 1998. The study has generated water column profile data that clearly identifies not only the existence of this layer, but also the period over which it persists during the year. The tabulated monthly data for this location is included here as Appendix II. These data are summarized below in Table 5, based on depth and date of sampling.

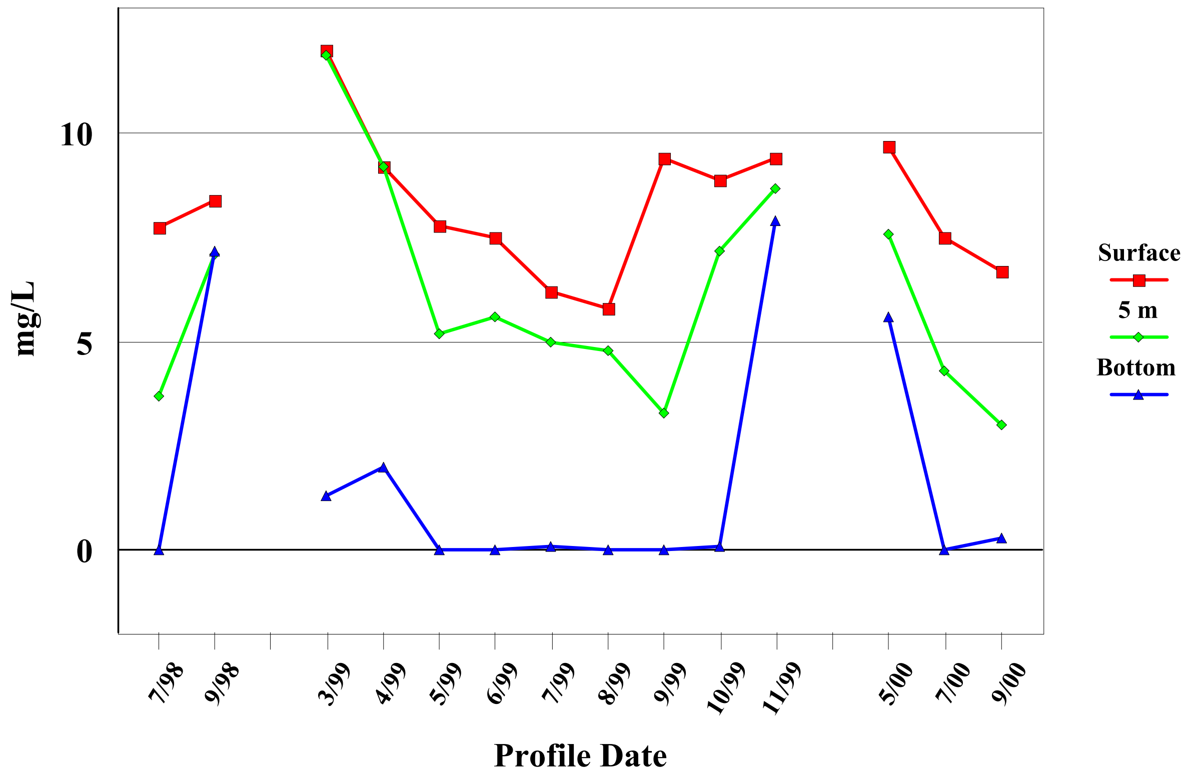
Table 5.
Dissolved oxygen concentration and percent saturation at various depths within the deep hole in the Lower Lake

	Surface		5 m		8 m	
Date	**mg/l**	**% sat**	**mg/l**	**% sat**	**mg/l**	**% sat**
7/98	7.8	100.5	3.7	45.8	0.0	0.0
9/98	8.4	109.1	7.1	91.1	7.2	91.8
3/99	12.0	104.9	11.9	107.2	1.3	11.7
4/99	9.2	100.7	9.2	100.1	2.0	19.2
5/99	7.8	94.5	5.2	64.1	0.0	0.0
6/99	7.5	106.9	5.6	77.9	0.0	0.0
7/99	6.2	86.9	5.0	69.8	0.1	1.1
8/99	5.8	80.5	4.8	65.3	0.0	0.0
9/99	9.4	131.6	3.3	45.7	0.0	0.0
10/99	8.9	99.0	7.2	81.2	0.1	1.2
11/99	9.4	92.7	8.7	89.0	7.9	80.2
5/00	9.7	113.7	7.6	84.5	5.6	53.2
7/00	7.5	101.9	4.3	57.1	0.0	0.0
9/00	6.7	86.7	3.0	39.1	0.3	4.0

As these data show, D.O. concentration at the surface is normally high, often exceeding 100% saturation. However, beginning as early as May and continuing through September, D.O. concentrations drop significantly at 5 meters below the surface. At 8 meters, at or near the bottom, extremely hypoxic (low oxygen) conditions are seen as early as March, and anoxic (absence of oxygen) conditions are established by May and continue through October. Although a set of continuous data for most of the year exists only for 1999, the partial data for 1998 and 2000 indicate that the development of this anoxic layer is an annual phenomenon.

These data are shown graphically in Figure 12, below, to better illustrate the times of year at which the anoxic layer becomes established and when destabilization of the stratified layer occurs.

Figure 12.
Dissolved oxygen concentration at various depths within the deep hole in the Lower New Meadows Lake over time



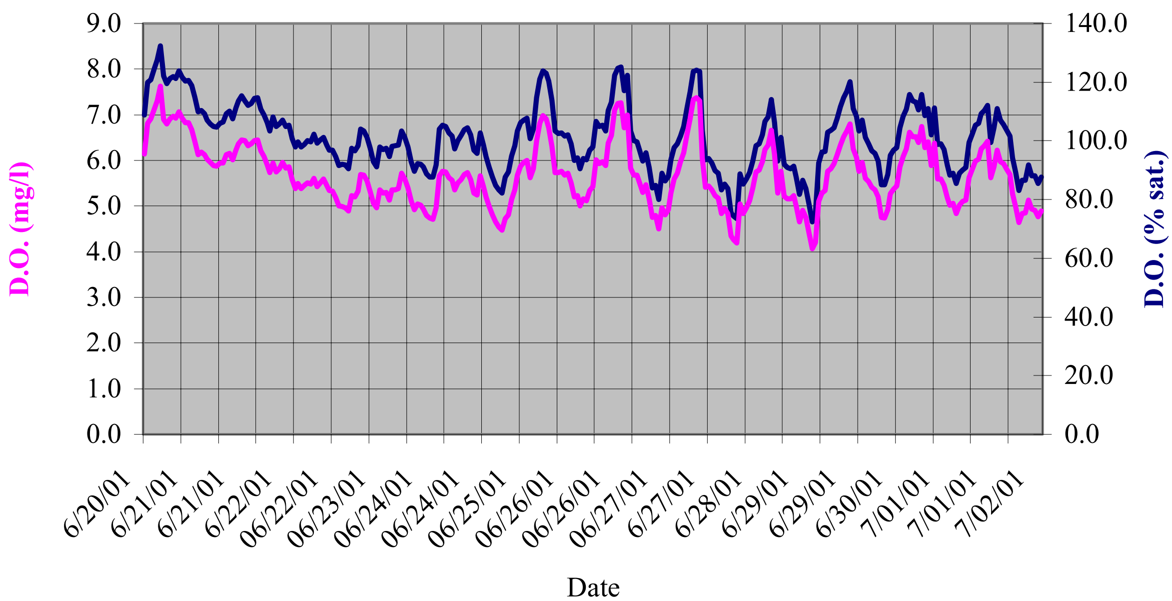
Given the complexity of factors that might contribute to the development of this anoxic layer, combined with the fact that only one full year's data is currently available, it is difficult to determine exactly why this phenomenon occurs. However, the deep hole is a unique feature in an otherwise uniformly shallow basin and vertical circulation within the deep hole is undoubtedly very limited. Furthermore, as the deepest point in the Lakes, the amount of organic material deposited in the deep hole is very likely greater than anywhere else within the Lakes. This combination of a hydrodynamic isolated layer and organic material deposition provides ideal conditions for anaerobic decomposition and may help explain the unusual results obtained from nutrient sampling in the same area.

In a different, but related FOCB study, temperature, salinity, dissolved oxygen, pH, and chlorophyll data were collected simultaneously on an hourly basis over a 24-hour period at a single location on three separate occasions between August and September, 2001 using an unattended sensor (refer to Appendix III). These data serve to illustrate the diurnal, or daily, fluctuations of certain parameters, as well as the relationship between them. For example, Figure 13 on the following page, shows the fluctuation of dissolved oxygen and chlorophyll for August 24, 2001, and clearly illustrates the relationship between them. Both peak in the afternoon when light intensity and photosynthesis reach their maximum. D.O. declines in the afternoon as photosynthesis slows in response to the setting sun. Both reach their respective minimum early in the morning toward the end of the phytoplankton's respiratory phase, only to start up again with the rising sun.

Figure 13.
Diurnal relationship between dissolved oxygen concentration and chlorophyll at station NM6

A similar study was conducted at the head of the New Meadows in the vicinity of the New Meadows Marina. This study focused on diurnal dissolved oxygen fluctuations over a 12-day period between June 20 and July 2, 2001(see Appendix IV). Figure 14 illustrates the rhythmic pattern of the diurnal fluctuations over the course of several days. However, although diurnally rhythmic, the range and amplitude of these fluctuations vary from day-to-day as a function of changes in tidal exchange, intensity and duration of light, wind, and other factors.

Figure 14.
Diurnal fluctuations in D.O concentration and saturation at station NMM over a 12-day period



The absence of additional data for other parameters makes interpretation of the D.O. data difficult. For example, the large amplitude, or spring, tides that were experienced in the area between June 23 and June 28 could explain the greater fluctuations observed during this period. Development of an algal bloom during this interval is an equally plausible explanation since this, too, could account for the elevated D.O concentrations during the day, as well as the depressed D.O. early in the morning just before sunrise.

It is worth noting that D.O. saturation consistently fell below the 85% threshold early in the morning throughout most of the period between June 25 and July 2. D.O. concentration was correspondingly low, consistently falling below 5 mg/L, occasionally approaching 4 mg/L, indicating the susceptibility of this area to low oxygen events.

Nutrients in the New Meadows River

Despite the fact that sampling for nutrients began only in late winter 2001, the data generated over this brief period already provide important information to our understanding of how the New Meadows River and the Lakes work.

Similar to the other data already reviewed, the nutrient data for the lower river stations indicate excellent, indeed almost pristine, water quality throughout the water column over most of the river's length. According to the currently available data, from Bear Island (Station P4BRI) at the mouth of the river all way up to the 'Middle Ground' (Station NM5), nitrogen concentrations are normally within the range of 0.01 and 0.03 mg/L and never reach 0.1 mg/L.

In the upper reaches of the river north of the Middle Ground, in the vicinity of the New Meadows Marina (Station NMM), nitrogen levels are substantially higher than those found south of the Middle Ground, and range from a low of 0.01 mg/L in early spring to a high of almost 0.6 mg/L in early fall. With the exception of the sample taken on June 11, 2001, all of the other samples show that most of the available nitrogen is in the form of ammonia, NH_4. This suggests a nearby biological source since ammonia is normally rapidly taken up by algae or converted to the inorganic nitrate, NO_3, and nitrite, NO_2, forms by bacteria. The biological source of the ammonia could be human, but excretion by fauna living on and in the bottom sediments is more likely.

The deep hole sampling location in the Lower Lake has been sampled on three occasions in 2001, September 18 and 25, and October 2. On each date, the nitrogen concentrations within the deep hole are significantly higher than those found elsewhere along the New Meadows, at times by more than an order of magnitude. It is interesting to note that, even though most of the available nitrogen is in the form of ammonia, the highest concentrations are found at or near the bottom.. D.O. data collected by Bowdoin College at the time the nutrient samples were taken show nearly anoxic conditions within the deep hole (see Appendix V).

The identification of anoxic conditions at the bottom of the deep hole suggests that the unusually elevated nitrogen concentrations observed at this station are likely the result of anaerobic microbial decomposition of deposited organic material. The extremely high concentrations recorded on September 18, 2001 are particularly interesting because this is the only occasion on which nitrate and nitrite, rather than ammonia, account for the majority of total available nitrogen. Furthermore, the nutrient sample was taken a meter off the bottom, at 7.5 meters, where salinity was slightly higher than directly on the bottom at 8.5 meters. But perhaps of greater importance is the fact that the water temperature at 7.5 meters was 6.5^{O}C higher than at the bottom, just a meter below.

At this point the data are insufficient to allow definite conclusions to be drawn. Nevertheless, it is clear that the deep hole may play an important role in the nutrient flux within the Lower Lake. Based on the results from the New Meadows Marina, its influence may extend into the broader upper river area. It is important, therefore, to determine the role the deep hole plays as an internal source of nitrogen, since the magnitude of its role could affect how this body of water is eventually managed. Additional work should be done to evaluate the magnitude and importance of this nutrient source for it may explain, at least in part, the algal blooms that occur in the Lakes and the susceptibility of the Lakes and upper reaches to fish kills and other low oxygen events.

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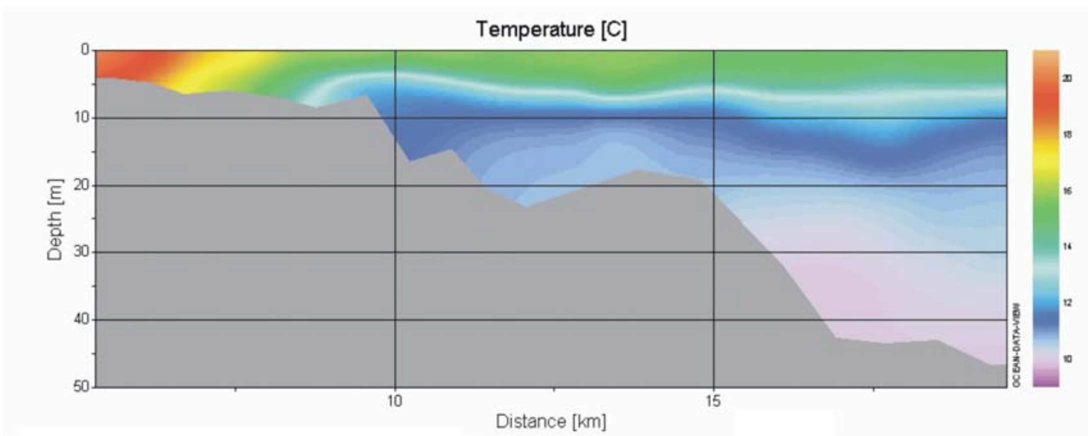
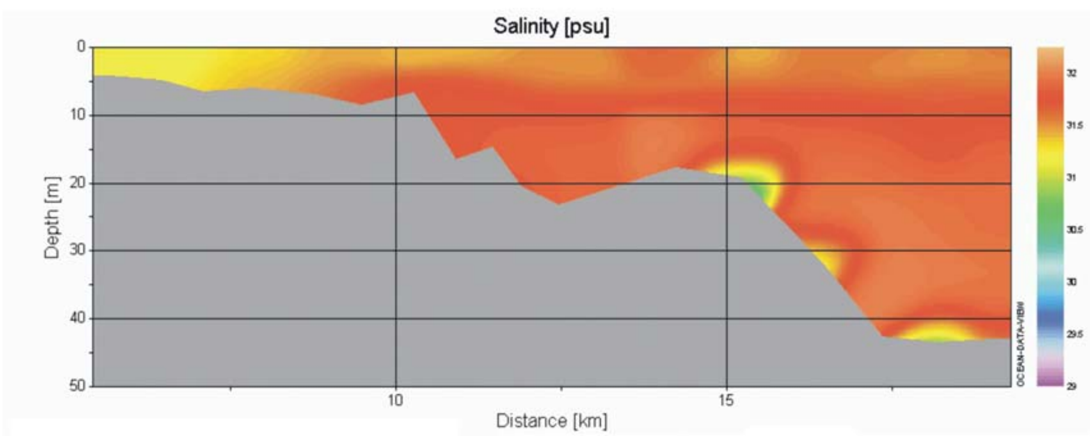
Bowdoin data

Bowdoin College conducted two cruises down the New Meadows River during the Fall of 2001 to profile physical and chemical parameters of the water column of the river from the New Meadows River Marina at the north to just south of Bear Island at the mouth of the river. Seawater temperature (^oC) and salinity were both recorded at 19 stations on September 6, 2001. The results of the profiling are shown graphically below in Figure 15 as composite, interpolated measurements taken at the 19 stations, with the northernmost station at New Meadows Marina shown at left to southernmost at Bear Island at right.

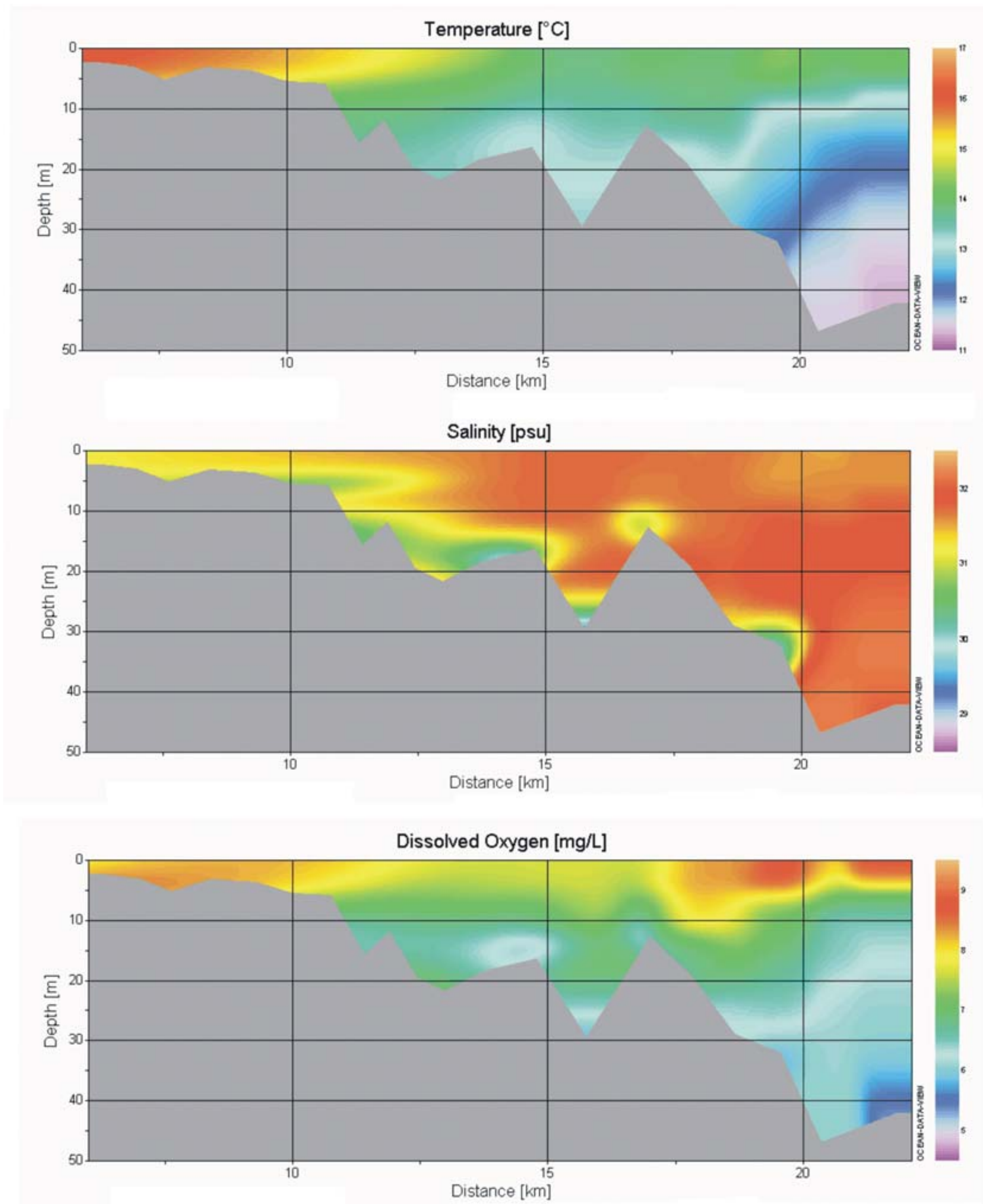
Figure 15. New Meadows River temperature and salinity profiles, September 6, 2001





A similar profiling effort was carried out on October 4, 2001 at 22 stations along the River. Nineteen of these stations were located as close as possible to the 19 stations sampled in September using Geographic Positioning Systems (GPS). This cruise included determination of dissolved oxygen in additional to seawater temperature and salinity. The results of the October profiling are shown graphically in Figure 16 on the following page. As in Figure 15, the data are presented as composite, interpolated measurements taken at the 22 stations with the northernmost station at New Meadows Marina shown at left to southernmost at Bear Island at right.

Figure 16. New Meadows River temperature, salinity and dissolved oxygen profiles, October 4, 2001



These data, particularly the salinity profiles, show that the river is a truly a marine system throughout its length from its upper reaches to its mouth at Bear Island. The location of several of the sampling stations used in these Bowdoin College water column profile studies were similar to those used in the FOCB sampling programs. A comparison between the two data sets for the similarly located stations within the same periods in September and October shows remarkable consistency for both temperature and salinity results between the two efforts. Similar to the FOCB data, the Bowdoin College data again show that, generally, there is relatively little vertical change in either temperature or salinity at any particular station along the River, indicating little if any stratification at this time of year. In September, the vertical differences in temperature and salinity at the upper, shallow reaches were negligible and in the order of only 1-2^{O}C and 0-0.5l, respectively. A greatest vertical differences were found at the mouth where temperature and salinity varied by 4-5^{O}C and 0.5-1l, respectively. The October data show the expected drop in temperature, but still indicate relatively small vertical differences in temperature and salinity, particularly in the upper reaches. As in September, the greatest vertical differences were found at the mouth where temperature varied by only 2-3^{O} C and salinity by 0.5-1l, respectively.

The large number of stations included in the Bowdoin College study allows for interpolation of data along the length of the river and the depiction of horizontal as well as vertical differences as shown in Figures 15 and 16. The September data show a temperature difference in the order of 4-5^{O}C and salinity differences in the order of 1.5-2l in the upper 5-10 meters of the water column over a 6-7 kilometer distance between the upper lower reaches of the river and the Sisters Islands. Beyond this point, to the mouth at Bear Island, temperature and salinity are longitudinally stable, showing remarkably little difference over more than 10 kilometers, suggesting a strong influence by the open waters of Eastern Casco Bay on the lower two thirds of the river. The October data show a similar trend to that observed in September. Longitudinal stratification is still obvious, but the degree of discreteness of layering is less than previously seen in September, suggesting that the longitudinal stratification is beginning to destabilize. Strong summer and fall stratification followed by increased mixing of the water column in the late-fall and winter as a result of cooling temperatures and fall winds is characteristic of most coastal waters in Maine.

All of these data are proving useful in extending our understanding of the New Meadows, but the most intriguing feature revealed by these two-dimensional depictions of vertical data over horizontal distance are the salinity depression anomalies found close to the bottom at several stations during both sampling periods, but particularly in October. These salinity anomalies were initially thought to be artifacts cause by the impact of the sensor on the bottom. However, close examination of the data showed that the decrease in salinity began some distance off the bottom, indicating that the salinity depression is very likely real and not merely a sampling artifact. For example, in October at station 18 near Bear Island the salinity at 29 meters was close to 32l, but at 32 meters the salinity dropped just below 25l, a drop of 7l over only 3 meters. If real, a salinity drop of this magnitude in close proximity to the bottom could only be caused by the introduction of a very substantial amount of freshwater. The fact that salinity depression anomalies were seen at a number of stations in two separate months suggests that this is not a unique phenomenon but rather a persistent feature. If this proves to be true, in order to cause a 7l depression in salinity, the volume of freshwater entering through the bottom would have to be tremendous and could profoundly affect both the manner and rate of flushing of the River. In view of the potential importance of these findings, additional work should be done to further our understanding of these anomalies and their implications to water quality management along the River.

Toxic metals and chemicals

The Casco Bay Plan, produced and approved by a stakeholder partnership and approved by EPA and the Governor of Maine in the fall of 1996, identified reduction of toxic contamination as one of five technical goals for the Casco Bay Estuary Project (CBEP). The CBEP has developed a monitoring program to track the implementation of the actions recommended in the Plan, including the need for toxic contaminant testing.

Responding to this need, the Casco Bay Estuary Project initiated three testing programs, one focused on lobsters, one on mussels, and a third on sediments. Sampling stations for each program have been located throughout Casco Bay, including the New Meadows River. Samples and test organisms are collected by CBEP for subsequent analysis by the University of Maine. Certain test beyond the University of Maine's capacity are performed by out-of-state laboratories.

In the New Meadows River, sampling of lobsters was conducted in 1997 on lobsters taken from a station located just south of Merritt Island, West Bath; sampling of mussels was conducted in 1998 on shellfish taken from a station located in The Basin, Phippsburg. Testing involved screening for a suite of chemicals falling into five categories: toxic metals, pesticides, dioxin, polycyclic aromatic hydrocarbons (PAHs, petroleum derivatives), and polychlorinated biphenyls (PCBs). The results of the lobster and mussel testing, as well as the human health risk assessment based on the mussel sampling results, are included here as Appendix V. Additional sampling of mussels was carried out in 2001 in the vicinity of Coombs Island in the upper New Meadows River; results of this sampling are not yet available.

Mussel test results

The New Meadows River test results revealed that toxic metal levels are below action level, that is, below the minimum level representing a health risk to consumers. The levels of the pesticide Dieldrin were initially found to be sufficiently elevated to possibly warrant a public health advisory; subsequent tests, however, showed the initial findings to be erroneous.

Seven additional compounds were evaluated for carcinogenic effects. Dioxin levels were found to be close to the reproductive and developmental toxicity action level and exceeded the cancer action level. It should be noted that the cancer risk is very small since the action level assumes habitual consumption of mussels taken from a specific location over a long period of time. Detailed examination of the dioxin results for the New Meadows River, and certain other areas of Casco Bay, suggests a source other than pulp and paper mills, possibly municipal waste incinerators.

With respect to PAHs, four compounds were evaluated for potential non-carcinogenic effects; none approached levels of concern. Seven additional compounds were evaluated for potential non-carcinogenic effects. Levels of certain of these compounds were elevated but never exceeded more than twice the action level, that is, a cancer risk of 2 in 100,000 for the habitual, frequent consumer of mussels from this area.

Total PCB levels in the New Meadows River mussels were slightly elevated above the action level. Again, the increased cancer risk is relatively small, ranging in the order of 1 to 3 per 100,000 for the habitual, frequent consumer of mussels.

Lobster test results

No formal health risk assessment is available for the lobster testing results. In lobster meat, however, levels of all compounds tested for were generally found to be substantially lower than those found in mussels. In contrast, levels found in the digestive gland, commonly referred to as the tomalley, which tends to concentrate such compounds, were generally found to be substantially elevated. Similar results from elsewhere in Maine have caused the Maine Bureau of Health to issue a health advisory urging consumers to avoid consumption of the tomalley.

Sediment test results

The Casco Bay Estuary Project sampled sediments at 65 stations in Casco Bay in 1991, five of which were located in the New Meadows River. The sediments were analyzed for PAHs, PCBs, pesticides, and metals. Table 6 provides a tabulated summary of the relative potential for biological effects for each pollutant or contaminant (refer to Appendix VI for complete analysis results).

Table 6.
Relative potential for biological effects for certain pollutants or contaminants in sediments from the upper one-third for Casco Bay

Pollutant/Contaminant	Number of stations in the upper one-third for Casco Bay	Number of stations containing sediments that could cause possible biological effects	Number of stations containing sediments that could cause probable biological effects
PAHs	4	3	0
PCBs	3	0	0
Chlordane (pesticide)	2	2	0
DDT (pesticide)	3	2	0
Silver	0	0	0
Cadmium	2	0	0
Mercury	0	2	0
Lead	0	0	0
Zinc	0	0	0

In 2000, sediments in New Meadows Lakes were sampled and tested for PAHs at four locations, two in the Upper Lake and two in the Lower Lake. Sediments from the station in the lower part of the Lower Lake contained almost twice as much, or more, PAH than the other three stations. However, the PAH levels in the Lakes sediments were lower than the levels found in sediments from four of the five New Meadows River locations sampled in 1991. None of the levels of total PAHs was high enough to be in the range of possible biological effects.

In 1994, tributyl-tin (TBT) (commonly used in boat anti-fouling paint before it became regulated), dioxins/furans and coplanar PCBs were measured in the sediments at selected stations in Casco Bay. These contaminants were found in all areas of the Bay, although generally in low concentrations. Usually the concentrations correlated to known former sources. One exception is in the New Meadows River where concentrations were found to be higher than expected since no point source(s) are known to exist in the area. Potential sources include localized combustion sources (possibly the former incinerator in Harpswell) and/or transport into the New Meadows River from the Kennebec and Androscoggin Rivers.

Biological

Bacterial contamination and the National Shellfish Sanitation Program (NSSP)

The potential risks to public health resulting from bacterial contamination of shellfish by water-borne disease agents is perhaps the most widely recognized, and consequently monitored, form of water pollution. In the United States shellfish sanitation concerns are addressed under the National Shellfish Sanitation Program (NSSP), a cooperative Federal/State government-Industry program designed to ensure public health safety for the consumption of shellfish in the United States based on a set of mutually agreed upon guidelines. The Interstate Shellfish Sanitation Conference (ISSC) is the organization responsible for establishing and periodically updating the NSSP guidelines outlined in the NSSP Model Ordinance. The current version, the 1999 Revision, is available at www.issc.org . The ISSC consists of representatives of the U.S. Food and Drug Administration (FDA), the National Marine Fisheries Service (NMFS), the U.S. Environmental Protection Agency (EPA), agencies of States that either produce or receive shellfish, and representatives of the shellfish industry. The Maine Department of Marine Resources (DMR) and selected individuals from the Maine shellfish industry represent Maine at the ISSC. Each participating State is required to establish an Authority within the state that is responsible for administering the NSSP and enforcing its associated code within the State; the DMR serves as the Authority in Maine.

According to the NSSP guidelines, the Authority is required to develop a Sanitary Survey for each growing area that consists of five components: 1) a shoreline survey, 2) bacteriological water sample analyses, 3) evaluation of hydrodynamic, meteorological and geographic effects on the area, 4) an integrated analysis of items 1-3, and 5) classification of the area and evaluation of the appropriateness of the designated classification. A sanitary survey of each growing area must be performed every twelve years. Each component must be routinely updated, as needed, and the entire Sanitary Survey has to be fully reviewed annually and reevaluated every three years.

The general public is more familiar with activities associated with water sampling and is therefore under the impression that the bacteriological analysis of water is the most important component in classifying an area. In actuality, the shoreline survey is far more important and the bacteriological sampling results are simply used to validate the shoreline survey determinations and resulting classification.

The shoreline survey is used to: 1) identify and evaluate all actual and potential pollution sources, 2) determine the distance of each source from the shellfish growing area and its actual or potential impact, 3) assess the effectiveness of all sewage or other waste treatment systems around the area, 4) identify the existence and impact of any poisonous or deleterious substances affecting the shellfish growing area, and 5) determine the existence and extent of impact of wildlife, including resident and migratory birds, and domestic animals on the water quality of the shellfish growing area.

Sampling stations for water quality assessment are established within each growing area based on the observations made and the information collected as part of the shoreline survey. Proper siting of the sampling stations is very important since the results of the analyses are used to determine if a pollution source is affecting water quality, to what extent, both in terms of area and time, and under what conditions. Water samples are periodically collected at these stations, at a frequency prescribed in the NSSP Model Ordinance guidelines, and analyzed for the presence and number of fecal coliform bacteria, an indicator of fecal contamination. Fecal coliform bacteria themselves do not necessarily represent a direct risk of disease since these bacteria are part of the normal digestive system bacterial flora and are usually non-pathogenic. However, their presence in the environment is an indication of raw, untreated fecal contamination and, therefore, indicate a potential risk to human health from diseases caused by associated pathogenic bacteria or viruses. The degree of risk is proportional to the amount of fecal coliform bacteria present and threshold, or standard, values have been established to classify shellfish growing areas.

Shellfish growing area classification

Shellfish growing areas are classified under one of five possible categories based on the results of the shoreline survey and bacteriological sampling:

1. Approved;
2. Conditionally Approved;
3. Restricted;
4. Conditionally Restricted; or
5. Prohibited

Approved classification is defined as an area that is "not subject to contamination from human or animal fecal matter at levels that, in the judgment of the Authority, present an actual or potential public health hazard" and where bacteriological analyses results meet the bacteriological standards of the category. *Approved* growing areas are "safe for the direct marketing of shellfish'.

A *Conditionally Approved* area is one which normally meets the standards for an *Approved* area, but under certain conditions, such as after a certain amount of precipitation, fails to meet those standards. When these conditions exist, the area is closed to harvesting until the bacteriological water sample analyses indicate that the area once again meets the *Approved* area standards; once these are met, the area is reopened to harvesting.

Restricted classification applies to areas where a limited degree of pollution is found and "levels of fecal pollution, human pathogens, or poisonous or deleterious substances are at such levels that shellstock can be made safe for human consumption by either relaying or depuration."

Relaying is defined as "...to transfer shellstock from a growing area classified as restricted or conditionally restricted to a growing area classified as approved or conditionally approved for the purpose of reducing pathogens... by using the ambient environment as the treatment process." *Depuration* is defined as "... the process of reducing the pathogenic organisms that may be present in shellstock by using a controlled aquatic environment as the treatment process." Harvesting of shellfish from these areas is allowed, but only under special permission and strict supervision by the Authority.

Similar to a *Conditionally Approved* area, a *Conditionally Restricted* area is one which normally meets the standards for a *Restricted* area, but under certain conditions fails to meet those standards and the area is closed to harvesting. Once conditions return to normal, the area is reopened to limited harvesting.

No harvesting of shellfish is allowed in areas classified as *Prohibited*. Areas under this classification are those where a Sanitary Survey has been completed and has found the area to be "...adjacent to a sewage treatment outfall or other point source outfall with public health significance, pollution sources may unpredictably contaminate the growing area, the area is contaminated with fecal waste so that the shellfish may be vectors for disease organisms, the concentration of biotoxin is sufficient to cause a public health risk..., or the area is contaminated with poisonous or deleterious substances causing the shellfish to be adulterated." Although rare, areas where a sanitary survey has not been completed are also classified as Prohibited

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A considerable area of the New Meadows River, principally along the West Bath and Phippsburg shorelines, remains closed to shellfish harvesting for a variety of reasons including:

- a lack of sufficient information on which to base classification
- the presence of a licensed overboard waste treatment system discharge
- boat anchorages meeting the definition of a marina, and
- unidentified non-point source pollution.

At the time the last shoreline survey was conducted, 28 licensed overboard discharges systems existed along the river, along with 13 identified fecal pollution threats and 21 non-point source pollution sources, resulting in the complete prohibition of shellfish harvesting in portions of 13 shellfish growing areas and conditional approval of two others along the river. Table 7 lists the current classifications of these areas, the reasons for closure or conditional approval, and the specific location and boundaries of each closure. Maps showing the closed areas and the most recent water quality results for their respective sampling stations can be found in Appendix VII.

Table 7.
Portions of NMR shellfish growing areas classified other than Approved

DMR Area ID	Area Location	Classification	Cause for closure
C 18 A	Indian Rest at Gurnet Straits	Prohibited	licensed overboard discharge (replaced); failed septic, reportedly repaired; requires DMR follow-up.
C 18 B (A)	Upper New Meadows Lake (upper reach)	Prohibited	unidentified non-point source pollution
C 18 B	Upper New Meadows Lake	Conditionally approved	conditionally approved based on one (1) inch of rain in 24 hours
C 18 B	Lower New Meadows Lake and Upper New	Conditionally approved	conditionally approved based on marina occupation - closed May 1 through November 15
C 18 B (B)	Kings Point area	Prohibited	licensed overboard discharges and broken holding tank on the shore
C 18 B (C)	Bombazine Island	Prohibited	licensed overboard discharges
C 18 B (D)	Fosters Point	Prohibited	licensed overboard discharges
C 18 B (E)	Treasure Island	Prohibited	gray water discharge to shore
C 18 E (1)	Cundys Harbor	Prohibited	licensed overboard discharges; boat activity; reported unlicensed gray water discharge(s) on Sheep Island
C 18 E (2)	Dingley Island	Prohibited	licensed overboard discharge
C 18 R (1)	Oak Ledge area	Prohibited	small prohibited area due to licensed overboard discharge
C 18 R (2)	Long Island, East side	Prohibited	unlicensed discharges
C 19	Sebasco Harbor	Prohibited	poor water quality; no shoreline survey
C 19 (A)	Winnegance Bay	Prohibited	outhouses near shore, unlicensed discharges, failing septic systems; most problems have been corrected, but not all; area needs DMR follow-up
C 19 (C)	Sabino	Prohibited	licensed overboard discharges; no shoreline survey

Water sampling results

The DMR has established 75 stations within shellfish growing areas along the New Meadows, approximately thirty of which are located within the Closed/Prohibited areas of the river, as shown below in Figure 17.

Figure 17.
Department of Marine Resources National Shellfish Sanitation Program water quality sampling stations on the New Meadows River

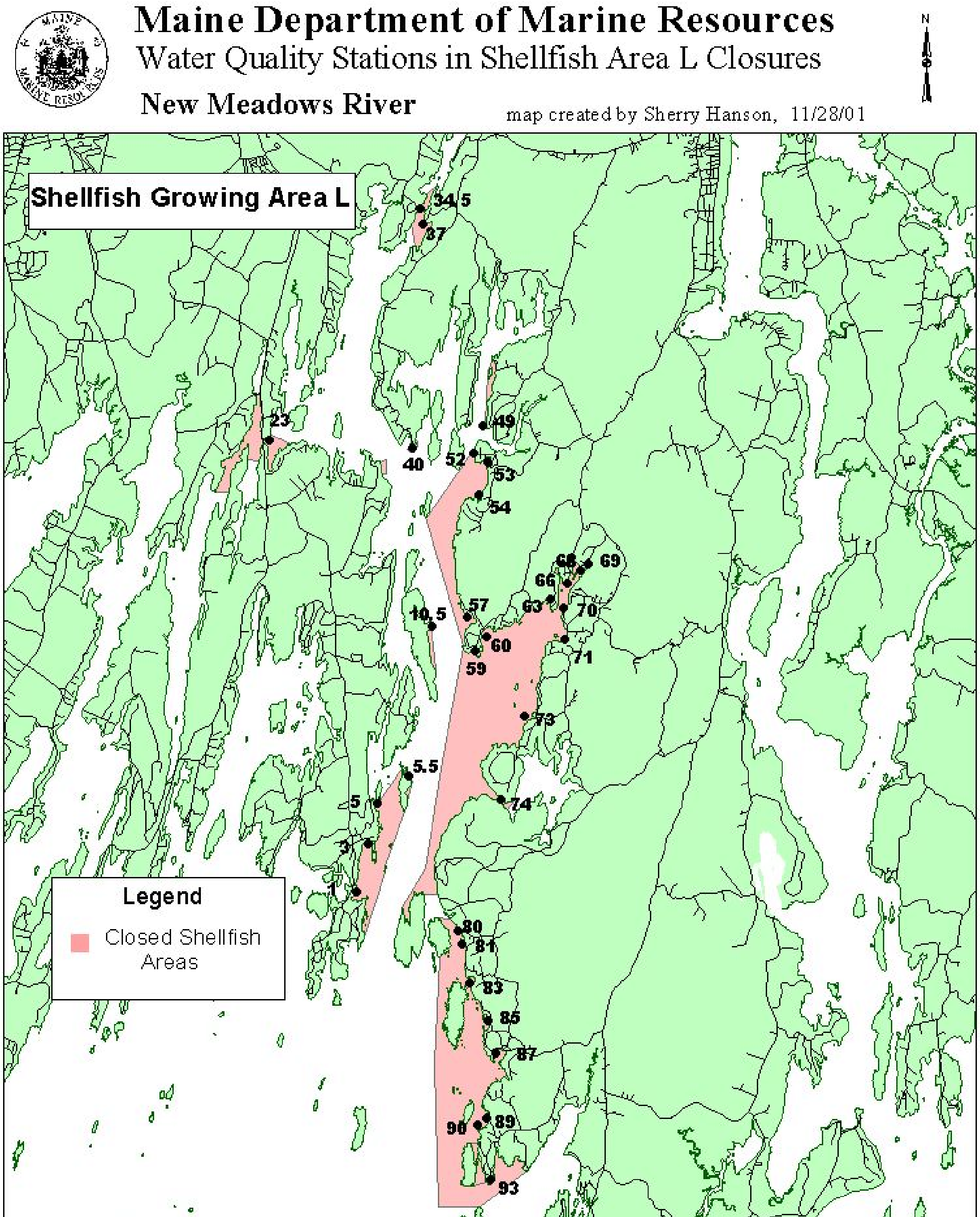


Table 8 summarizes the key fecal coliform values for the water quality stations in these closed areas. According to the NSSP Model Ordinance, in order for an area affected by non-point source pollution to be classified Approved using the three-tube decimal dilution bacteriological analysis method (refer to NSSP Model Ordinance), the geometric mean (GM) Most Probable Number (MPN) of fecal coliform bacteria cannot exceed 14 per 100 ml of water and the estimated 90th percentile cannot exceed 49 MPN per 100 ml.

Table 8.
Bacteriological analysis results for water samples taken at DMR sampling stations within closed areas of the New Meadows River classified *Prohibited*

Sta. No.	Location	Class	No. samples	GM	%>49	P90
1.0		P	30	6.7	10.0	34.4
3.0		P	30	7.2	10.0	41.4
5.0		P	30	7.1	10.0	43.8
5.5		P	30	8.2	16.7	**71.7**
10.5		P	30	6.2	4.2	35.8
23.0		P	30	4.0	6.3	15.8
34.5	Howard's Point, WB	P	30	4.1	0.0	9.1
37.0	Howard's Point, WB	P	30	5.1	3.3	19.4
40.0		P	30	3.5	0.0	7.6
49.0		P	30	3.5	3.3	7.6
52.0	Sabino, WB	P	12	4.3	0.0	14.0
53.0	Sabino, WB	P	30	4	3.3	10.7
54.0	Sabino, WB	P	30	4.7	6.7	22.6
57.0	Birch Pt., WB	P	30	3.7	0.0	8.5
59.0	Birch Pt., WB	P	30	4.7	3.3	15.8
60.0	Brigham's Cove, WB	P	30	3.1	0.0	4.1
63.0	Brigham's Cove, WB	P	30	4.8	3.3	15.8
66.0	Brigham's Cove, PH	P	30	5.1	6.7	19.2
68.0	Brigham's Cove, PH	P	30	4.6	3.3	14.7
69.0	Brigham's Cove, PH	P	30	6.7	3.3	30.4
70.0	Brigham's Cove, PH	P	30	6.5	6.7	39.9
71.0	Meadowbrook Cove, PH	P	30	7.3	10.0	39.3
73.0	Wynburg, PH	P	30	8.5	10.0	**69.9**
74.0	The Basin, PH	P	30	3.2	0.0	5.0
80.0	Sebasco, PH	P	30	5.6	3.3	22.5
81.0	Sebasco, PH	P	30	11.4	**20.0**	**137.2**
83.0	Sebasco Estates, PH	P	30	7.5	10.0	**49.6**
85.0		P	30	7.5	10.0	36.1
87.0		P	30	4.5	3.3	15.0
89.0		P	30	6.2	3.3	25.7
90.0		P	30	8.3	16.7	**76.3**
93.0		P	30	6.4	10.0	29.1

As the table clearly shows, with exception of station 81.0, the geometric mean (GM) criterion value of 14 MPN is not exceeded or even approached at any of the stations. The 90th percentile exceeds the criterion value of 49 MPN at only four of the thirty stations; water quality work recently completed by MER Assessment Corporation at several of these stations yielded similar results. Therefore, water quality within the closed areas appears to be good and the closures are therefore based primarily on the existence of potential, rather than actual, pollution sources. Removal or isolation of these sources may allow reclassification of these areas.

Remediation Efforts

NMRWP projects

Upper New Meadows River watershed and shoreline survey

A watershed survey to identify existing and potential non-point pollution sources was conducted in 2000. The survey covered the areas from Woodward Point, Brunswick to Foster Point, West Bath, including the Lakes area. The survey resulted in the identification of twenty-six actual or potential contamination sources, principally from erosion and/or sedimentation. These were found predominantly on state and town owned roads, as well as private roads. The NMRWP is now working with the Maine Department of Transportation and the individual municipalities to correct some of these problems by as early as spring 2002.

The shoreline surveys were conducted by volunteers trained and overseen by staff of the Maine DMR and covered the area from Kings Point to Sabino along the West Bath shoreline, including Williams Island. This effort, along with additional work by DMR staff, resulted in the identification of fifteen actual or potential non-point pollution sources, including several outhouses and at least one failed septic system. Work is ongoing within the municipalities to ensure correction of these problems.

Work with small communities

Some of the smaller municipalities along the New Meadows River have encountered difficulties in understanding and meeting state and federal requirements to remedy pollution problems. The NMRWP has sought and obtained funding through the Maine State Planning Office to furnish assistance to these towns, specifically on the issue of closed shellfish growing areas. This project was initiated in the spring of 2001 and is ongoing.

Dingley Island causeway replacement

The Dingley Island causeway is a 200' barrier that separates the north and south sections of the waterway and clam flats between Dingley Island and the Harpswell mainland. Sediments have been accumulating on either side of the causeway since its construction in 1946. Replacing the causeway with a small bridge would reestablish water flow between the two sides of the clam flat, thereby restoring a portion of the original habitat and protecting the future of one of Harpswell's richest clam flats.

Funding has been received to carry out feasibility and engineering studies for the bridge project. Additional funds have been requested for the construction of a bridge to replace a section of the causeway in 2003, the labor for which could be provided by the U.S. Navy through its Innovative Readiness Training (IRT) program.

The Dingley Island project has generated interest in the possibility of removing or expanding the culvert on the Berry's Mill causeway in West Bath. Flow to the mudflat area above the culvert has been restricted for many years. Clams do exist on these flats, but it is believed that increasing flow to these flats could significantly improve the resource. Funding for a further investigation into possible options of flow improvement has been requested.

Pump-out facility

One area of concern revealed by our work with small communities is the possible impact of discharges from recreational vessels at anchor for extended periods, potentially contaminating adjacent shellfish harvesting areas, leading to their closure. The nearest pump-out facility is located at the very head of the New Meadows River and access to this facility by larger vessels is difficult. The NMRWP is exploring various options for assisting towns with the installation of pump-out facilities along the River. A pump-out facility is already being planned for the Sebasco area and could be completed as early as 2002.

Town efforts

All four of the shoreline municipalities have been actively involved in water quality sampling to assist the DMR in ensuring compliance of open shellfish harvesting areas with NSSP requirements. In order to reopen closed shellfish harvesting areas, several towns have established programs to remove overboard discharges and replace failed septic systems.

The Town of Brunswick has successfully removed all overboard discharges within its jurisdiction. Harpswell has succeeded in opening numerous areas to harvesting areas, at least to conditional or seasonal harvesting.

Casco Bay Estuary Project

The Casco Bay Estuary Project launched its Sustainable Shellfisheries Program in 1998 and hired Normandeau Associates, Inc. of Yarmouth, and MER Assessment Corporation to assist with program implementation.

The program consists of three phases:

- Phase I - prioritization of closed shellfish growing areas according to size of shellfish growing area affected, abundance of shellfish resource, degree of contamination, type of contamination source, level of technical difficulty of problem correction, and cost;
- Phase II - removal of overboard discharges and identification of non-point sources of contamination in accordance with the Phase I area prioritization; and
- Phase III - development of a shellfish resource management plan to insure long-term sustainable harvests.

Phase I was completed in 1999 with the preparation of a prioritized list for remediation based on a review of all existing data for the listed criteria. A total of 33 overboard discharge systems were identified along the New Meadows River and adjacent Buttermilk Cove in Brunswick; two of these systems were subsequently combined. Additionally, five areas either potentially or actually affected by non-point sources of contamination were identified.

Phase II was started in 1999, and as of the end of 2001, 23 overboard discharge systems had been replaced by in-ground waste treatment systems. Bacteriological sampling for non-point sources of contamination has revealed only one problematic area at the head of Buttermilk Cove; sampling all other areas indicate acceptable water quality.

Phase III began in Fall 2001 and is scheduled to be completed by December 2002. This phase will focus on shellfish management measures currently used by the towns. Measures used elsewhere will also be evaluated for their applicability in this section of Casco Bay.

Marine uses

Commercial Fishing

The marine resources of the New Meadows River and the fisheries they support have played an important part in the regional economy since Thomas Purchase, Brunswick's first recorded resident, began trading his catches of sturgeon and salmon with Europe back in the mid-1600s. And despite the diverse economy that exists today, the fisheries continue to be an important part of the local economy, especially in the small communities of Harpswell and Phippsburg.

Although the stocks of sturgeon and salmon exploited by Purchase have all but disappeared, today's commercial fisheries are, for the most part, centered on marine species. According to the landings data collected by the Maine Department of Marine Resources (DMR), lobstering is the most important of the inshore fisheries coast-wide, and this undoubtedly applies to the NMR as well. Other important inshore fisheries include soft-shell clams, European oysters, scallops, mussels, quahogs, crabs, sea urchins, and kelp; emerging fisheries include sea cucumbers, whelks, periwinkles, and, more recently, green crabs. Smelts and menhaden, also known as pogies, are also fished within the area when schools move inshore; however, neither species has been seen in any quantity within the past five years. Shrimp and offshore ground fish stocks, including haddock, cod, flounder, etc., are fished by a small offshore fleet based in Cundy's Harbor and Sebasco, but clearly these are well beyond the influence of the NMR.

Unfortunately, quantifying the magnitude and importance of the inshore fisheries to the New Meadows River area economy has proven nearly impossible. The DMR maintains complete records of all fishing licenses, including addresses, and it is therefore possible to count the number of licenses held for individual fisheries within any given town. In the case of Harpswell, for example, 65 lobster fishing licenses were issued to residents of the town in 2001. However, segregating out only those licensees who fish either in part or exclusively along the New Meadows River is nearly impossible. Few fishermen fish exclusively within the New Meadows River area, thus most catches represent resources from multiple areas. Consequently, it is impossible to determine a NMR-specific level of effort. Similarly, landings are reported by dealers, not individual fishermen, thus lobsters, for example, caught by a NMR fisherman who sells to a Portland dealer are reported as Portland landings, not NMR landings. This same dilemma applies to all of the other fisheries, with the exception of soft-shell clams.

Soft-shell clams

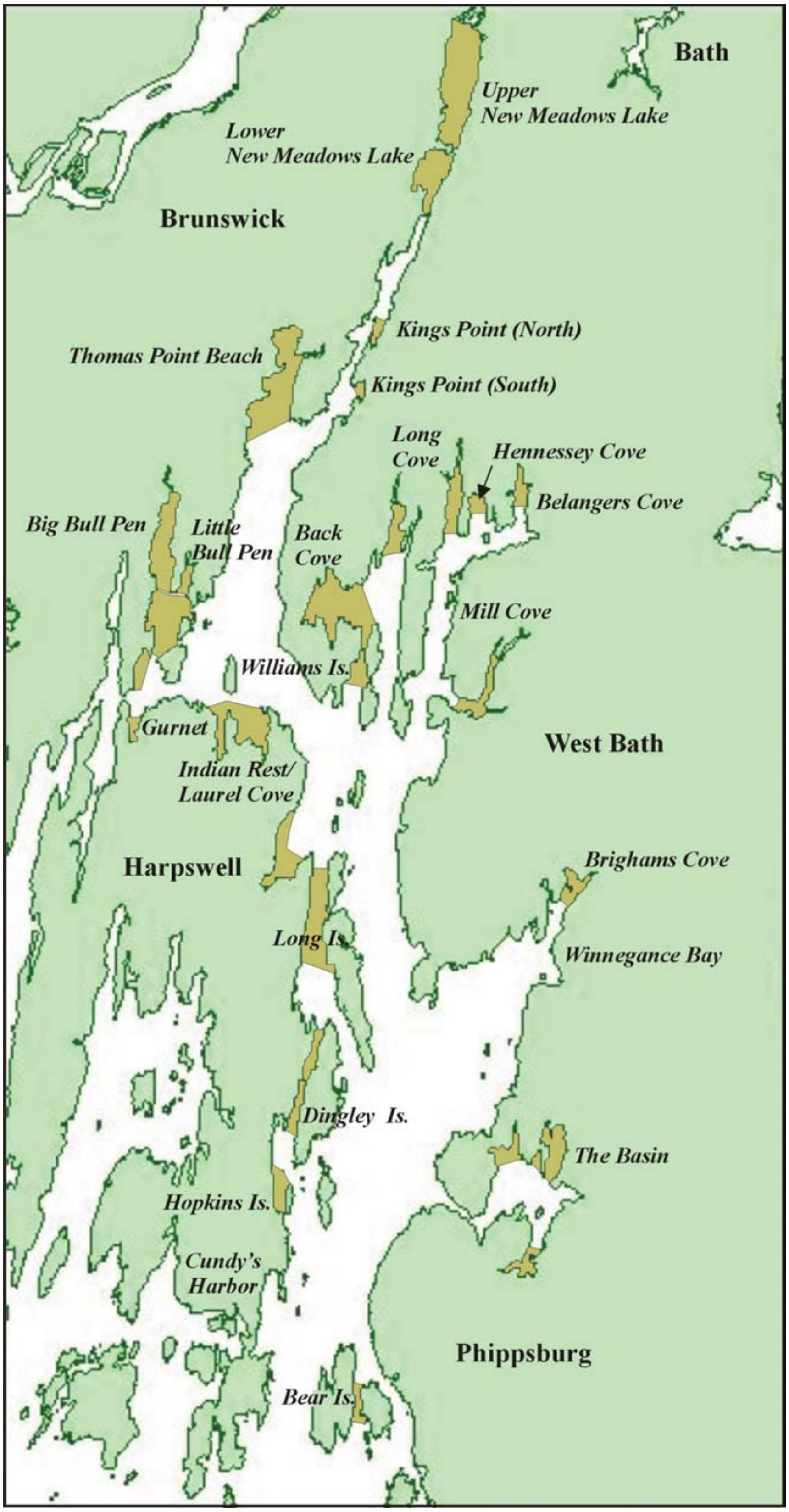
The soft-shell clam and alewife fisheries are the only inshore fisheries over which municipalities have been granted jurisdiction and management responsibility. The right to manage soft-shell clams was granted in 1963. Fishery management within each municipality is administered according to individually developed town shellfish ordinances, all of which are based on the Model Shellfish Ordinance developed by the Maine DMR. Each town has a Shellfish or Marine Resources Committee which is responsible for administering the ordinance and overseeing all activities associated with the management of the fishery, including licensing, municipal law enforcement, resource conservation efforts, etc., and periodically updating the ordinance.

All municipalities that have enacted local shellfish ordinances are required to provide the Maine DMR with annual reports on the status of their respective soft-shell clam resources and management programs. Table 9, on the following page, summarizes the data reported by the four towns for the year 2000, the most recent information currently available. The primary shellfish growing areas along the NMR over which municipal jurisdiction is applied are shown in Figure 18 on the next following page.

Table. 9 Annual Municipal Shellfish Program Review for 2000

	Harpswell	Brunswick	West Bath	Phippsburg
No. commercial licenses	**85**	**74**	**21**	**40**
No. recreational licenses	**480**	**162**	**87**	**323**
No. harvested bushels	**20,300**	**21,268**	**2,724**	**3,603**
Warden Services	4,160	1,100	586	752
No. clammers checked	248	4,320	487	555
No. warnings issued	30	75	3	11
No. summons "	36	20	2	6
No. court appearances	24	0	3	3
No. convictions	unknown	20	0	6
Improve enforcement by	hours,	hrs, wardens	hours	warden/selectmen
	more wardens	training		communication
Amount of budget	**$116,242**	**$105,520**	**$12,357**	**$13,245**
Management Activities				
predator protection			x	
reseeding	x	x	x	x
flat surveys	x	x	x	x
harvester surveys				x
enhancement		x	x	x
conservation	x	x	x	x
Management Controls				
limit no. of comm. Licenses	x	x	x	x
limit no. of recreational			x	x
restrict times	x	x	x	x
restrict areas	x	x	x	x
limit amount comm				
limit amount recreation				x
Required conservation hours	12	0	12	12
Proposed Management Activities				
predator control			x	x
reseeding	x	x	x	x
flat surveys	x	x	x	x
enhancement		x	x	x
conservation	x	x	x	x
Implementation by:				
harvester conservation	x			x
harvester volunteer	x	x	x	
harvester paid				
municipal employee		x		x
paid consultant	x			
Spinney Creek				
shellfish committee				
# Licenses determined by:				
calc. using survey data	x	x	x	x
survey data				
harvester input				
need/demand				
Program Performance	**84**	**84**	**74**	**74**

Figure 18. New Meadows River major shellfish harvesting areas



All of the towns along the NMR limit the number of municipal commercial shellfish harvesting licenses they issue. Each town therefore conducts shellfish stock assessment surveys in all or a portion of its shellfish growing areas each year to ensure that stocks are not being excessively depleted and to support any increases or decreases in the number of licenses issued. As a result, unlike other fisheries, NMR-specific data are available for soft-shell clams that allow some estimation of the magnitude of the resource and the economic value it represents. Table 10, below, summarizes the most recent available data for the NMR shellfish growing areas; unfortunately, these data are incomplete and consequently do not represent the complete magnitude or total value of the resource.

Table 10. New Meadows River Shellfish Flat Productivity

Harpswell	**Acres**	**Bu/ac**	**Total Bu.**	**Harv. Bu./ac**	**Harv. Bu.**
Laurel Cove	11.6	78.6	853	62	691
Indian Point	26.0	109.8	2,855	68	1,767
Wallace Shore	1.0	257.0	257	236	236
Dingley Is. N	13.5	183.4	1,556	152	1,001
Dingley Is. S	7.3	220.2	907	194	618
Gurnet landing	**(Town survey data not available)**				
Big Indian	"				
Bombazine Is.	"				
Ledgeview	"				
Long Is. (west side)	"				
Hopkins Is.	"				
Total	**59.4**		**6,429**		**4,314**
Brunswick					
Big Bull Pen	24.0	----	----	109	2,623
Little Bull Pen	5.0	----	----	121	606
New Meadows	32.7	----	----	62	2,014
Thomas Point Beach	21.7	----	----	114	2,466
Upper Coombs	22.2	----	----	90	1,988
Total	**105.6**				**9,697**
West Bath	**(Town survey data not available)**				
Total	**0.0**	**0.0**	**0**	**0**	**2,724**
Phippsburg	**(Town survey data not available)**				
Total	**0.0**	**0.0**	**0**	**0**	**0**
NMR Total	**165.0**	**0.0**	**6,429**	**0**	**16,735**

State-wide production comparison

A recent change in Maine's laws requires that all commercially harvested shellfish be identified by tag as to the Town in which they were harvested so individual town production can therefore be determined. However, the reported landings for each town include shellfish harvested from all areas of the towns, not specific flats or areas, thus it is not possible to determine NMR-specific landings from these data alone. Nevertheless, to put the magnitude and value of the regionally-produced resource into proper perspective, Table 11, below, compares the individual and combined landings for all shellfish growing areas of the four NMR area towns to Maine's total landings.

Table 11a. Maine Soft-shell clam landings (reported as *pounds* of shellstock)

	1997	1998	1999	2000	4 yr. Avg.	% of Maine total
						(4 yr. avg.)
Maine total	**7,375,089**	**10,313,091**	**11,684,442**	**11,193,259**	**10,141,470**	
Brunswick	411,466	386,751	400,553	519,713	429,621	4.2%
Harpswell	702,731	876,880	756,547	847,419	795,894	7.8%
West bath	120,645	93,980	76,731	99,693	97,762	1.0%
Phippsburg	179,186	198,233	248,072	250,001	218,873	2.2%
	1,414,028	**1,555,844**	**1,481,903**	**1,716,826**	**1,542,150**	**15.2%**
% of Maine total	**19.2%**	**15.1%**	**12.7%**	**15.3%**	**15.2%**	

Table 11b. Maine Soft-shell clam landings (reported as *bushels* @ 50 lbs./bu)

	1997	1998	1999	2000	4 yr. Avg.	% of Maine total
						(4 yr. avg.)
Maine total	**147,502**	**206,262**	**233,689**	**223,865**	**202,829**	
Brunswick	8,229	7,735	8,011	10,394	8,592	4.2%
Harpswell	14,055	17,538	15,131	16,948	15,918	7.8%
West bath	2,413	1,880	1,535	1,994	1,955	1.0%
Phippsburg	3,584	3,965	4,961	5,000	4,377	2.2%
	28,281	**31,117**	**29,638**	**34,337**	**30,843**	**15.2%**
% of Maine total	**19.2%**	**15.1%**	**12.7%**	**15.3%**	**15.2%**	

Considering the relatively small amount of shellfish growing area represented by these towns compared to the total area along Maine's coast, 15.2% of total production is remarkably high and indicates the exceptional productivity of the flats in these eastern Casco Bay towns. Even if the incomplete NMR production of 16,735 bushels is used, this still represents 7.5% of Maine's total production.

With respect to economic value, the ex-vessel bushel price, or price paid to the harvester directly, varies seasonally depending on demand and out-of-state supplies, among other factors. During the peak summer demand the price paid per bushel can exceed \$120, but during the winter when demand falls off the price may drop to \$50 or less. Because the price is higher and weather conditions are considerably more favorable in summer, the majority of clams are harvested during the summer and hence at the higher price.

Assuming an average annual price of $70-$80 per bushel, Table 12, shows the ex-vessel value of the NMR area production, based on the 16,735 estimated bushels harvested in 2001.

Table 12. Economic Value of estimated NMR area production for 2001

	Ex-vessel	Local Economic Activity Multiplier			
Price/bu.		**2.0**	**2.5**	**3.0**	**3.5**
$30	$502,037	$1,004,074	$1,255,092	$1,506,110	$1,757,129
$40	669,382	1,338,765	1,673,456	2,008,147	2,342,838
$50	836,728	1,673,456	2,091,820	2,510,184	2,928,548
$55	920,401	1,840,801	2,301,002	2,761,202	3,221,402
$60	1,004,074	2,008,147	2,510,184	3,012,221	3,514,257
$70	**1,171,419**	2,342,838	**2,928,548**	**3,514,257**	4,099,967
$80	***1,338,765***	2,677,529	***3,346,912***	***4,016,294***	4,685,676
$90	1,506,110	3,012,221	3,765,276	4,518,331	5,271,386
$100	1,673,456	3,346,912	4,183,640	5,020,368	5,857,095
$110	1,840,801	3,681,603	4,602,004	5,522,404	6,442,805

The economic benefit derived from a bushel of clams does not end with the harvester since additional economic benefits accrue from post-harvest handling and processing. A Casco Bay Estuary Project study in 1993-94 showed that the benefit accrued from post-harvest activities, such as shucking, transportation, and retail and restaurant sales, can result in a total local economic benefit 3.0-3.1 times greater than the ex-vessel value (Heinig, et al., 1994). Again, as Table 12 shows, the estimated $1.34 million ex-vessel value may therefore actually result in a total economic benefit to the area in the order of $3.3 to $4.0 million dollars.

Aquaculture

The sheltered conditions of the upper New Meadows River, particularly the lakes, combined with the high productivity of the area since the early 1970s when an experimental oyster farm was established in the Lower Lake. According the Maine DMR Aquaculture Lease Inventory, June 2001, there are six leaseholds in the area, including two long-term commercial or municipal sites and four short-term experimental sites. Table 13 provides some details on these current leaseholds.

Table 13. Aquaculture leaseholds within the New Meadows River

Lease holder	Site I.D.	Location	Acreage	Species
Andrew Johnson	JOHN NM2	Upper New Meadows Lake	16	oysters, quahogs
Towns of Brunswick/West Bath	TBTW NM7	Upper New Meadows Lake	16	oysters, quahogs
Dodge Cove Marine Farms, Inc.	DCMF NM3	Lower New Meadows Lake	0.365	oysters, quahogs, clams
Dodge Cove Marine Farms, Inc.	DCMF NM4	Lower New Meadows Lake	1.6	oysters, quahogs, clams
David Hennessey	DHEN WB	Brown Cove	2	oysters, quahogs, clams, scallops
Jim Hennessey	JHEN LC	Long Cove	2	oysters, quahogs, clams

More recently, SUG, Inc. (Shrimp Under Glass), has constructed a greenhouse off the Hill Road in West Bath that houses a series of shore-based, recirculating culture tanks to grow the freshwater shrimp, *Litopaneaus vannamei*. Production is expected to begin in early 2002.

Boating and recreational fishing

Recreational boating, both sail and motor, and recreational fishing have long been important activities along the New Meadows River. The New Meadows Marina, at the head of the river, offers dock space and boating services, including waste holding tank pump-out facilities. Although expansion of dock space is limited, sales consistently increased over the past several years, particularly within the last two, indicating continually increasing usage of the area for recreational boating. Nevertheless, the New Meadows River does not current suffer from vessel congestion.

Several other sheltered mooring areas exist along the river, most notably the upper reaches of the New Meadows River, the area between Bombazine Island and the Gurnet Bridge, Mill Cove in West Bath, Winnegance Bay, Cundy's Harbor, and The Basin in Phippsburg. The latter, due to its exceptionally sheltered location, is used extensively by sailing vessels. The fact that some vessels often stay for extended periods has prompted concern over possible impacts to water quality in the area as a result of overboard waste discharge. This concern has led to the previously mentioned investigation of new pump-out facility locations in the lower section.

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Conclusions and Recommendations

All of the available data indicate that the New Meadows River, on the whole, remains clean and healthy, particularly the lower River from the Sisters Islands south. Problem areas have been identified, but these appear to be localized within the Lakes and the upper reaches of the River, at least for now.

Preparation of this report has revealed the tremendous scope and volume of information required to develop a document of this type, as well as the complex process associated with such an ambitious data compilation and analysis project. This experience offers insight into the difficulties that may be faced as a watershed management plan is developed and implemented.

Analysis of the data compiled for this report has revealed a series of fundamental questions that need to be addressed. These questions will likely take some time to answer. On the other hand, there are problems that should be corrected as soon as possible, if not immediately; correction of some will likely be contingent on prior correction of others. Clearly, to achieve and accomplish the multiple goals and associated tasks that will undoubtedly ensue from this report, it is essential that a carefully thought out Strategic Plan be completed and implemented to ensure proper sequencing and coordination of all of the activities that will follow.

Recommendation 1 Complete and implement the NMRWP Strategic Plan

- prepare a clear and comprehensive plan of approach;
- prioritize steps to address both the fundamental questions and existing problems revealed in the preparation of this report;
- establish realistic time horizons;
- assign preliminary cost estimates to tasks

* * * * * * *

Collection of information for this report has revealed large variations in the amount, form, and method of access to information on certain subjects in certain municipalities. These variations seriously complicated and confounded the information compilation and analysis process, requiring much more time than anticipated. Since future NMRWP efforts will undoubtedly rely on continued collection and reporting of certain municipal information, specific information requirements must be identified and a standard format for collection and reporting needs to be developed.

Recommendation 2 Form a Subcommittee of the NMRWP to guide and oversee municipal data collection and reporting, specifically:

- determine the types of municipal information to be collected;
- develop means to facilitate and standardize the collection and compilation of the information;
- identify proper repository for all collected data and information;
- identify sources of funding such efforts where necessary.

* * * * * * *

The most serious problems in the New Meadows River are the anoxic layer and the exceptionally high levels of available nitrogen found in the deep hole in the Lower Lake. The anoxic conditions that exist within the deep hole for much of the year do not appear to be directly affecting the surrounding waters. However, the microbial activity within the anoxic zone appears to be releasing large quantities of nitrogen that may be indirectly affecting not only the Lakes, but also a portion of the upper River.

The possible role of the deep hole as a significant source of nitrogen driving the excessive growth of algae observed annually in the Lakes needs to be determined. Until the recent discovery of this internal source of nutrients, it has been assumed that the primary sources of nutrient input to the Lakes is fertilizers carried by freshwater discharges from the surrounding area streams, and leachate from septic systems. While these sources undoubtedly contribute some nutrients, their magnitude relative to the contribution from the deep hole may be substantially less than previously believed.

The susceptibility of the Lakes and adjacent upper River area to low dissolved oxygen events has long been recognized and has now been documented at specific locations within the Lakes and uppermost reaches of the River. Considerable discussion has focused on measures that might be taken to avoid or reduce low-oxygen events, particularly fish kills. As previously stated, the data collected to-date indicate that dissolved oxygen levels south of the Middle Ground are normally high. Because of the distance between the uppermost sampling station and the Middle Ground, however, it is unclear how far the susceptible area extends. If properly targeted plans are to be developed, it will be necessary to better understand the geographic extent of the susceptible area.

The identification of a possible influence by Kennebec River flow on the lower reaches of the New Meadows River may prove significant with respect to the rates of exchange and flushing of the river. Clearly, additional information will be necessary before an effective watershed management plan can be developed for the area to address these and other potential problems.

Recommendation 3 Promote and coordinate studies to improve our understanding of the New Meadows River system, specifically:

< **Determine the significance of Lower Lake deep hole nutrient contribution**

- the study initiated by FOCB should be expanded to increase the frequency of sampling and number of stations sampled;
- the Science Subcommittee of the NMRWP should develop an appropriate experimental design for an expanded effort in cooperation with FOCB, the University of Maine, Bowdoin College, and others;
- data collection methodology and reporting should be standardized as much as practicable.

< **Determine the extent of low-oxygen susceptibility in the upper reaches of the New Meadows River**

- the Science Subcommittee of the NMRWP should work to coordinate, expand and further formalize the current FOCB-Bowdoin College and other data collection partnerships;
- data collection methodology and reporting should be standardized as much as practicable.

< **Determine the extent to which Kennebec River and possible subsurface groundwater flows affect exchange and circulation within the New Meadows River**

- the Science Subcommittee of the NMRWP should work to coordinate, expand and further formalize the current FOCB-Bowdoin College and other data collection partnerships;
- data collection methodology and reporting should be standardized as much as practicable.

* * * * * * *

The existence of the NMRWP and the activities it sponsors are premised on the overall value of the New Meadows River. Furthermore, this value is used, either explicitly or implicitly, as justification for the efforts and monetary expenditures of the organization. Consequently, it is vitally important to be able to accurately quantify this value to the extent possible.

Some of the individual component values are difficult or impossible to quantify, such as highly subjective intrinsic aesthetic values. Others, such as marine resources, are comparatively more easily quantified. Although data do exist for certain component values, the data are generally either incomplete or insufficient, as illustrated in this report by the shellfish resource data. The NMRWP should, therefore, facilitate and standardize the collection and compilation on the component values of the New Meadows River. Given the difficulties inherent to determining certain values, the NMRWP may wish to begin with a process focused on shellfish resources where considerable data, albeit of varying quality, already exist.

Recommendation 4 Promote and coordinate the collection of information on the marine resources of the New Meadows River

- assist towns, to the extent practicable, in carrying out resource surveys of all shellfish growing areas and/or other important marine habitats within their jurisdiction;
- develop means to facilitate and standardize the collection and compilation of marine resources survey information;
- work with DMR to determine possible ways of quantifying the magnitude and economic value of the commercially harvested resources of the New Meadows River beyond municipal jurisdiction.

* * * * * * *

The health of soft-shell clam stocks and the accessibility to harvest them are often perceived as indicators of the quality of the surrounding waters. Most closures are due to actual and/or potential contamination sources, *e.g.* overboard discharges, failed septic systems, or poor water quality. In certain cases, closures are due simply to insufficient or incomplete information rather than actual contamination. In such cases, correction of the problem is a matter of procedure rather than mechanical removal of a contamination source.

Recommendation 5 Coordinate and facilitate reclassification of closed shellfish areas

- seek and coordinate opportunities to assist towns in the correction or removal of identified contamination sources;
- continue efforts to assist towns in compiling and reporting information required by DMR to allow reclassification of shellfish growing areas currently closed to harvesting;
- provide coordination between the Maine DMR and the municipalities to ensure completion of tasks required for reclassification of shellfish growing areas currently closed to harvesting;
- facilitate post-reclassification follow-up and coordination between municipalities and the DMR to insure shellfish areas newly opened to harvesting are accessible to harvesters.

* * * * * * *

The available dissolved oxygen and temperature data indicate that circulation within the New Meadows River is highly variable, the rate of exchange of the upper river being slower than the lower sections. Development of an effective watershed management plan will need to take this variability into account. The Casco Bay Estuary Project has already developed a bay-wide circulation study for Casco Bay. However, due to the large area covered by the study, the level of resolution will likely not allow determination of circulation at a local level within the New Meadows River. Prediction of rates of exchange, retention times, and the dispersion and fate of contaminants will require a more detailed understanding of local circulation and, eventually, the development of a predictive circulation model. Development of such a model would be a significant undertaking that would require extensive planning. It is therefore recommended that the NMRWP begin by investigating options for development of a detailed New Meadows River model.

Recommendation 6 Investigate options to develop a functional circulation model for the New Meadows River

- establish the level of predictive resolution desired;
- determine the types and amount of data required for model development;
- identify circulation modelers capable of developing a model at the level of predictive resolution desired;
- determine modeler availability and cost.

* * * * * * *

Directly or indirectly, runoff from the lands that comprise the watershed of the New Meadows River finds its way into the river, carrying with it rainwater or snow melt that has traversed the lawns, gardens, streets, rooftops, parking lots and other surfaces, picking up along the was a variety of nutrients and contaminants introduced into the water from lawn, garden and farm fertilizers, malfunctioning septic systems, and fuel spills, to mention a few of the more obvious sources (and/or potential sources) of point and non-point pollution of the river.

It is obvious that these sources of pollution many originate with the everyday practices of residents and businesses. It is therefore also obvious that successful management of the River requires the cooperation of all who live or work or vacation in the watershed. This cooperation requires that those in the watershed refrain from practices that compromise the quality of the River's waters and tidal flats. We believe that, to enlist the strong support of all of those in the watershed, they must be provided with information about behaviors that threaten the health of the river and its ecosystem, and environmentally benign alternatives. To this end, we recommend that the SC, with the continued support of the watershed municipalities, consider the following steps.

Recommendation 7 Expand the internal and external educational outreach opportunities of the NMRWP

- Add this State of the New Meadows River report, in its entirety, to the NMRWP web site;
- Develop a version of the report for inclusion as an insert in local newspapers;
- Secure support for a webmaster
- Develop briefing sessions for the governments, residents, and businesses that are stakeholders in the watershed;
- Resume efforts to create a table-top relief map of the watershed for use in outreach education;
- Explore opportunities for enlisting the assistance of the AmeriCorps Teach Maine program, the Maine Conservation Corps and the National Civilian Community Corps;
- Offer to the public a Community Day at which the focus will be on this report and its ramifications; and
- Develop presentations about the report for use in the schools.

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