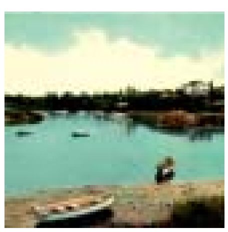
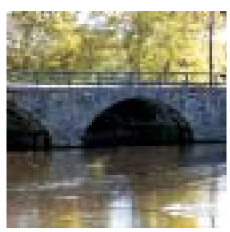
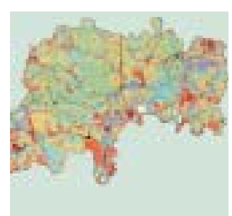
IPSWICH RIVER
Watershed Action Plan







Horsley & Witten, Inc.
Sandwich, Massachusetts

October 2003

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs
251 Causeway Street, Suite 900
Boston, MA 02114-2119

Mitt Romney
GOVERNOR

Kerry Healey
LIEUTENANT GOVERNOR

Ellen Roy Herzfelder
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1181
http://www.mass.gov/envir

October 29, 2003

Dear Friends of the Ipswich River Watershed:

It is with great pleasure that I present the 5-Year Watershed Action Plan for the Ipswich River Watershed. Over the next five years the plan will be used to guide local and state environmental efforts within the Ipswich River Watershed, as well as implement the goals of the Executive Office of Environmental Affairs. Our goals include the improvement of water quality; restoring natural flows to rivers; protecting and restoring biodiversity and habitats; improving public access and balanced resource use; improving local capacity; and promoting a shared responsibility for watershed protection and management.

The Ipswich River Watershed Action Plan was developed with input from a broad range of interests. This unique approach helps us focus on the problems and challenges that are identified with the stakeholders and community partners in each watershed, rather than being decided solely at the state level.

The Ipswich River has faced extremely low flow periods and other environmental impacts. The action strategies in the plan as they relate to these issues address:

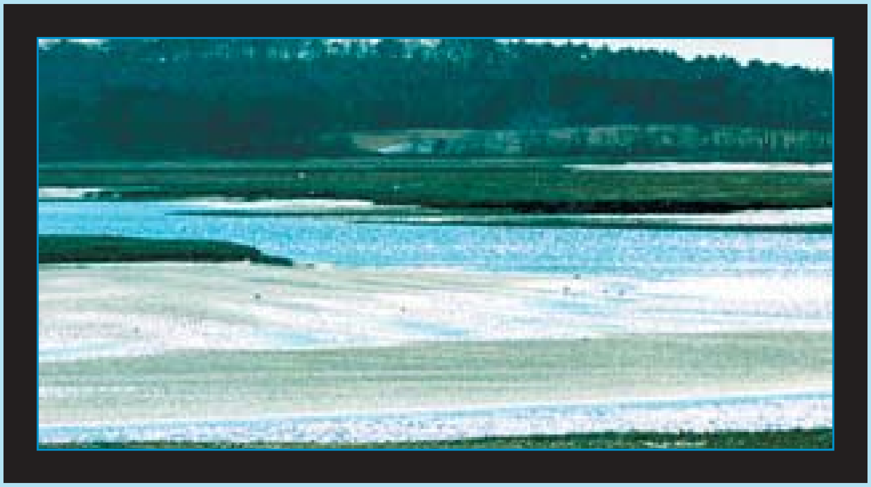
- Water Conservation
- Stormwater Management
- Alternate Sources of Water Supply
- Wastewater Alternatives
- Land Planning

I commend everyone that was involved in this endeavor. Thank you for your dedication, perseverance, and commitment. If you are not currently a participant, I strongly encourage you to become active in the Ipswich River Watershed restoration and protection efforts.

Regards,

Ellen Roy Herzfelder

Ellen Roy Herzfelder



This Watershed Action Plan is a critical component of the efforts now occurring to understand the problems in the watershed. The Plan includes a variety of best management measures to help restore the Ipswich River and to improve conditions in the watershed. The Plan is the result of four years of collaboration between a broad representation of interests in the Ipswich River Watershed. It has formed the basis for the creation of the Ipswich River Watershed Management Council and it lays the framework for future activities for the Council.

This plan is a working document. It should be viewed as a tool for municipalities, water supply boards, watershed advocates and state government to help achieve the goal of excellent water quality and sufficient water quantity for drinking water, fisheries, recreation and other uses.

This project was funded through a grant made available from the Executive Office of Environmental Affairs, the former Massachusetts Watershed Initiative.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

EXECUTIVE SUMMARY

The Ipswich River is an important economic and ecological asset to northeastern Massachusetts. This small coastal plain river, which flows about 45 meandering miles from source to sea, provides drinking water to over 330,000 residents and thousands of businesses in fifteen northeastern Massachusetts communities. Since pre-colonial times, the Ipswich River supported productive and diverse fisheries, including anadromous species such as smelt, alewives, shad and salmon, and flow-dependent resident freshwater species such as brook trout and fallfish. These bountiful fisheries, along with the extensive shellfish beds of the Ipswich River estuary, were a mainstay of the regional economy for centuries. During the early industrial era, the river provided "free" power to shipbuilders, tanneries, paper and textile mills. Today, the river is also an important recreational resource and a key part of the region's burgeoning eco-tourism industry. The estuary is part of the Great Marsh ecosystem, and the river hosts important regional bio-reserves including the Ipswich River Wildlife Sanctuary and many privately- and publicly-owned forests, parks and reservations.

The Ipswich River Watershed experienced less development and industrialization than nearby watersheds to the north and south, and thus was spared some of the pollution problems which afflicted rivers such as the Merrimack, Nashua and Charles. Since the Ipswich River was less polluted than others in the area, it became an important source of drinking water, not only for communities within the watershed but even more so for neighboring communities along the southern boundary and outside of the watershed. Today, much of the river's water is pumped for municipal water supply and is being consumed at a rate which has left the river significantly impaired. Approximately 80% is exported from the watershed, resulting in a significant net loss of water to the river system.

The impacts are evident in extremely low flows and periods of no flow that occur chronically during the summer months, and occasionally at other times of year when droughts coincide with seasonal water diversions to fill reservoirs. Fish kills and modifications to the species composition within the river ecosystem have been documented. Other adverse impacts, including extremely low dissolved oxygen in the upper watershed during the summer period, further degrade the river's ecology. Other issues of concern include frequent hazardous waste contamination, which has affected a number of water supply sources, as well as general pollutant loading from several non-point sources. Concerns have been raised about the loss of function of some vegetated wetland areas due to desiccation and other factors.

The first step to resolving the situation is to clearly understand the problem and its causes. To this end, the Ipswich River Watershed Association (IRWA) formed the Ipswich River Task Force in 1996 to investigate the causes, environmental impacts and potential solutions to the low-flow problems. This Task Force has since developed into the Ipswich River Watershed Management Council, an inclusive "stakeholder" group which has met regularly to pursue studies of the Ipswich River and to evaluate and prioritize solutions.

The IRWA, in concert with the Task Force/ Council and the Executive Office of Environmental Affairs (EOEA) former Watershed Team, spearheaded a number of key studies of the Ipswich River

Watershed, conducted by the United States Geological Survey and partnering agencies. These studies include a comprehensive hydrological model of the watershed; a study of the relationship of aquatic habitat and streamflow; an evaluation of potential management alternatives; and modeling of the "firm yield"[1] of communities that divert surface water from the Ipswich River for reservoir storage. In addition, the Ipswich River Fisheries Restoration Task Group, comprised of fisheries experts from federal and state agencies and non-governmental organizations, developed objectives and recommendations for fisheries restoration. The studies and reports are summarized in Chapter 5.

Building upon these studies and scientific findings, IRWA obtained funding from the former Massachusetts Watershed Initiative's "Communities Connected by Water" program to develop an Ipswich River Watershed Action Plan. The Plan, developed by Horsley & Witten Inc., is the result of the synthesis of scientific findings, and incorporated the input from many Council meetings, individual meetings with stakeholders to identify preferred courses of action, and several workshops and conferences to further prioritize restoration actions.

Following is a brief summary of key findings of the USGS studies:

- Baseflow, the river's flow between precipitation events which is provided by groundwater inflow to the river, is significantly diminished by municipal water withdrawals and the effects of watershed imperviousness.
  - Groundwater withdrawals by municipal wells are a major factor in reducing flow volume by more than an order of magnitude in the upper watershed, and by significant amounts basin-wide, during the critical summer/early fall periods.
  - A reduction in groundwater storage in the upper watershed occurs due to the presence of impervious surfaces, such as paved areas and buildings, which prevent the replenishment of groundwater aquifers.
- The Ipswich River's fish community has been seriously damaged by the chronic and extreme nature of low-flow/no-flow events, resulting in the loss of flow-dependent fish species, such as fallfish and brook trout.
  - Critical habitats, including riffles and streambank areas, are the first areas of the river lost when flows diminish; when riffles dry up, the river becomes segmented into a series of isolated pools instead of flowing water.
  - A flow regime that approximates the natural hydrograph seasonally, with minimum flows in the range of 0.42-0.49 cfsm[2], would result in sufficient flows to prevent loss of riffles and streambank habitats, and would provide adequate habitat for the protection of fisheries.
- There are a number of management alternatives that would result in improved flows, including:
  - Improved water conservation, achieving reductions in water withdrawals from 20-50%.
  - Stopping the use of wells in Reading and Wilmington seasonally (May-October) or when flows fall below 0.50 cfsm.
  - Reduction in the amount of water transferred out-of-basin via sewers.

[1] "Firm yield" is the estimated maximum release or withdrawal rate which can be maintained continuously during a repetition of the hydrologic period-of-record.
[2] Cubic feet per second per square mile

- A combination of options, such as seasonal reductions in the use of streamside wells and reduction in wastewater imports, which would result in flows at or exceeding simulated "natural" baseline flows.
- Increased water pumping and/or increased export of water would result in worsening of the low-flow problems.
- The "firm yield" of the reservoir systems supplied by surface water diversions from the Ipswich River would be substantially lower than the amounts currently withdrawn, if fisheries-protective thresholds governed withdrawals.

The focus of this Watershed Action Plan is to "balance the water budget" to help repair the current imbalance and to prevent future worsened conditions. The optimistic outlook is that there are solutions because hydrologic systems are repairable. Simply put, more water needs to be returned to the system, and less water needs to be exported or consumed, to balance the hydrologic budget.

This report presents an action plan to balance the hydrologic budget. It includes ideas from a broad group of "stakeholders" who have worked together over the past several years. The implementation of the plan will require broad support from diverse groups and individuals including water suppliers, land use planners, conservationists, elected officials, developers, businesses and industries, and the general public. It includes six recommended elements: improved water conservation; alternative water supplies; reduced export of wastewater; enhanced stormwater infiltration; increased water storage; and better land use policies and practices. The estimated hydrologic budget benefits of these proposed strategies are summarized in the following table.

Benefits of Proposed Action Strategies

	Headwaters (Mgd)	Upper Watershed (Mgd)	Entire Watershed (Mgd)
OVERALL WATER USE REDUCTION GOALS:	5	9	14.4
Water Conservation Objectives	0.75	0.99	5.4
Stormwater Management	0.32	0.81	2.15
Alternative Water Sources	6.4	6.4	6.4
Wastewater Management	2.0	2.0	4.7
TOTAL ESTIMATED BENEFITS	9.5	10.2	18.7

Improve Water Conservation: The Watershed Action Plan proposes reductions in water demand of 15% basin-wide, with higher reductions during the critical summer period. These reductions are achievable, based on widespread experience in Massachusetts and elsewhere, and a regional Water Conservation Plan has been developed by IRWA. Implementation of these water conservation measures is critical to success. However, the solution to the problem is not so seemingly simple as asking the water suppliers to pump less water. Water suppliers are fulfilling a critical public purpose, providing drinking and irrigation water to residents and businesses.

They have already made significant efforts in developing and implementing water conservation programs. While continuation and expansion of these programs is clearly part of the overall solution, water conservation alone will not solve the low-flow problem.

The use of valuable drinking water for lawn watering is particularly damaging, because lawn watering increases during hot, dry weather – the period of highest stress to the river's ecosystem. An estimated 15-20 million gallons per day are utilized for lawn watering within the Ipswich basin, an amount roughly equal to the estimated deficit determined by the hydrologic modeling by the United States Geological Survey (USGS). Improved water conservation programs could significantly reduce this consumption by encouraging alternative landscaping or utilizing alternative irrigation supplies, such as the capture of roof runoff collected in rain barrels or cisterns.

Alternative Water Supplies: Reduction in the use of streamside wells is a top priority action under this Action Plan. The use of wells in Reading and Wilmington, and potentially in Danvers and other communities, must be curtailed during low-flow periods or flow and no-flow deficits will continue. There is a need for alternative sources to meet water demand during low-flow periods. Out-of-basin sources such as the MWRA Water Supply System are being investigated by Reading and Wilmington for use on a seasonal basis. This Plan supports such initiatives, and encourages all the basin communities to investigate out-of-basin sources for emergency or seasonal use.

Reduction in Wastewater Exports: The majority of drinking water used for human consumption (including bathing and cooking) results in wastewater which, if properly treated, can be returned to the basin to recharge groundwater and thus help restore baseflow. Today, most of this water is exported via sewers, resulting in a large water deficit. While the public health concerns regarding water quality are important, technology to effectively treat and reuse or recharge treated wastewater has advanced greatly over the past decades, and is in wide use throughout the country and the globe. Industrial process water also provides significant opportunity for water treatment, which can result in additional water conservation through reuse programs, or improved recharge of groundwater aquifers. In addition, a significant portion – ½ or more – of the water exported via sewers is stormwater or clean groundwater, which enters the sewers by way of cracks and leaky joints. One of the principal recommendations is to reduce the amount of water exported via sewers, and improve wastewater management to address water quality ***and*** water quantity concerns. The proper treatment and retention of this water, minus the waste, is a key element of restoration of the region's hydrology.

Enhanced Stormwater Infiltration: Improved management of stormwater, which is generated by precipitation running off the ground, slopes and impervious surfaces, has potential to help balance the budget. Instead of routing the water to the nearest wetland or tributary, stormwater can be infiltrated into the ground, to restore and even enhance the natural groundwater recharge rates. Capture and storage of runoff from roofs can provide a small-scale alternative source of irrigation water for residents and businesses. Improved infiltration of stormwater into the ground is essential to improving groundwater storage and balancing the water budget. Municipalities must invest in improved stormwater management to meet regulatory requirements, and improvement of groundwater recharge should be a primary focus of such actions in the Ipswich River Watershed.

Increased Water Storage: Storage of water is also key. There is broad agreement that improving groundwater storage is essential. Small-scale storage opportunities, such as capture of roof runoff in rain barrels and cisterns for irrigation use, can provide a legitimate alternative to municipal pumping if broadly implemented. The Charles River Watershed Association's SmartStorm system has the potential to address the water deficit in an environmentally benign manner, without a large public investment. Large-scale storage reservoir opportunities are very limited in the watershed. Some may hold promise to address the water deficit, though the capacity of the river to support additional water withdrawals, particularly during droughts, is doubtful. Environmental impacts and potential costs and benefits of such proposals should be considered on a case-by-case basis.

Improved Land Use Policies and Practices: Future growth within the watershed must also be managed. Buildout studies conducted by the Metropolitan Planning Council and others suggest that the existing population of 330,000 may grow to 377,100, potentially resulting in an increased water demand of another 6.1 million gallons per day. Growth controls, land acquisition and "smart growth"[3] measures must all be employed to minimize the impacts of future residents in this watershed. Of particular interest are innovative solutions such as water banks, which require new development to identify and implement water savings to offset the increased usage which the development would cause. Concerns are widely shared about the unpredictable impacts of Chapter 40B "affordable housing" projects, which may result in water demand and increased imperviousness, beyond projections based on current zoning.

Summary: The Ipswich River is one of the most important natural resources in northeastern Massachusetts, but has been greatly damaged by water withdrawals and other factors. The restoration of the Ipswich River is possible by a combined menu of action strategies, to be implemented over the next decade. Such measures can achieve flows at, or even exceeding, natural baseline conditions, while meeting the water needs of the region. In restored condition, the Ipswich River will provide both economic and ecological benefits for current and future generations.

Ultimately, the successful implementation of the Watershed Action Plan will require both a restoration program to repair past mistakes and a preservation effort, including land use controls, to minimize the impacts associated with the continued future growth in the basin. It will require leadership, commitment, money, and time. The success will be the result of many, perhaps uncountable incremental actions by planning boards, homeowners, business owners, and elected officials.

[3] "Smart growth" is the term used by professional planners to define development while preserving open space and critical environmental areas.

http://www.bwlord.com/Ipswich/ipswich.htm

1. 0 BACKGROUND

"Riverine systems are intimately coupled with and created by the characteristics of their catchment basin, or watershed."
(Pacific Rivers Council)

1.1 Introduction

Historically, natural resource protection has taken place in response to crisis or specific interests. Limited financial and human resources, along with political constraints, have often precluded a more holistic vision of environmental protection. However, time has proven the "piecemeal" approach to be ineffective at solving our most crucial environmental problems, and a more integrated approach to environmental management is becoming embraced as the only truly meaningful approach.

In Massachusetts, neighboring towns often draw from a shared water supply without a shared vision of, or responsibility for, its protection and management. Thus a river can be healthy and flowing in one town, but polluted and/or dry in another, leaving the municipalities most affected to bear the impact of unwise choices made by other communities. Management of the parts does not ensure the health of the whole.

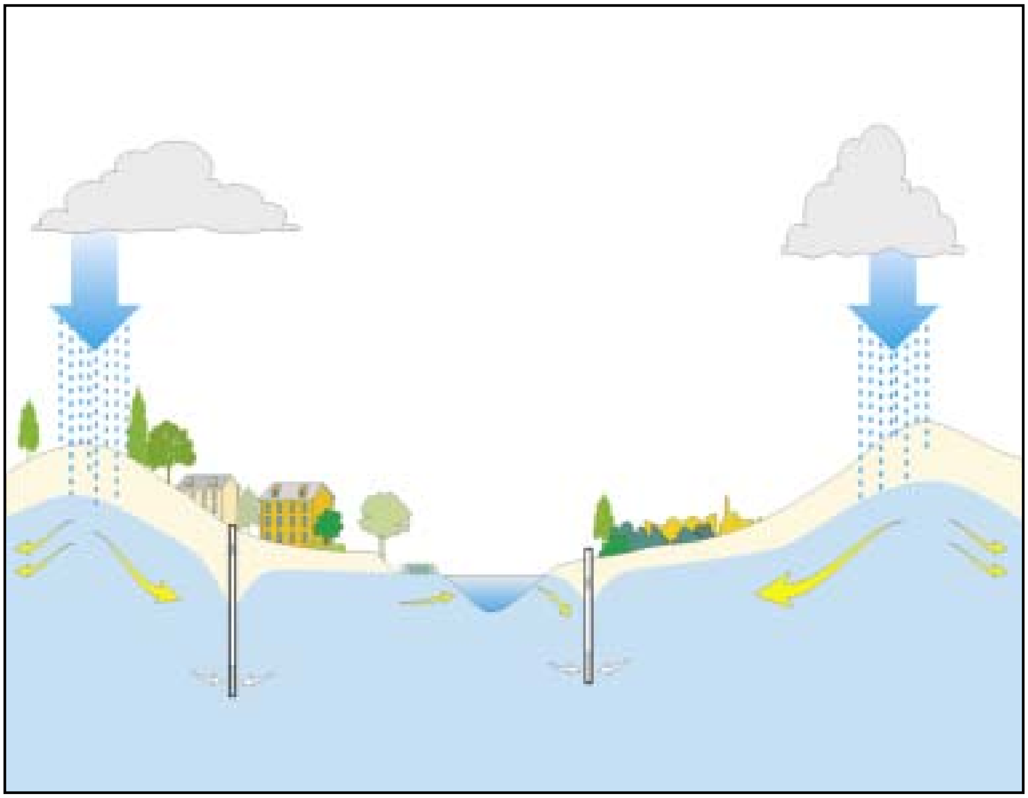
The Ipswich River is a case in point. Human land uses and water withdrawals in the watershed have altered the river to the point that it runs dry on a regular basis. As the most visible link in a progression of related events, this has forced a renewed look at how water resources are managed within the region. It has become evident now that in order to protect the river, it is essential to look at the entire system of which it is a part, namely its watershed.

1.2 The Watershed Approach

A watershed is the land area from which water drains into a surface water body, in this case the Ipswich River. In Massachusetts, many rivers, including the Ipswich, are fed year-round (perennially) by groundwater, which serves as a natural underground reservoir, or aquifer, continuously replenishing the river and providing "baseflow". Although precipitation and groundwater in Massachusetts are relatively abundant, some human land uses and water consumption patterns threaten the quantity and quality of water resources. The increased development of buildings, roads, and other impervious surfaces brings associated increases in water use and surface water runoff. In urbanized watersheds water draining from the land surface exits from the watershed more rapidly, diminishing the amount of water recharging or renewing groundwater aquifers, in turn diminishing the amount of water to feed the streams and rivers that rely on this groundwater for baseflow. The reduction of groundwater storage may also impact the amount of water available for water supply.

Compounding this situation, wells, surface water intakes and reservoirs providing water for human consumption withdraw groundwater and surface water which would otherwise replenish the river. Indeed, some wells may even pull water from the river itself (induced infiltration). The impacts to the river are exacerbated during droughts or dry summers because water demand increases coincide with the time the natural system has the least water to "spare."

Water may also be lost from the watershed through centralized sewering if the wastewater is diverted to another watershed, again diminishing water to the aquifer and further depleting groundwater levels. Sewers not only remove wastewater from the watershed, but may also remove clean groundwater through leaky pipes; this is called "infiltration." Stormwater can also enter sewer pipes in older systems where the drainage and sewer systems are combined; this is called "inflow." In many cases, the amount of "infiltration and inflow" equals or exceeds the wastewater flow, leading to a significant amount of "clean" water being removed from the watershed and unnecessarily treated.

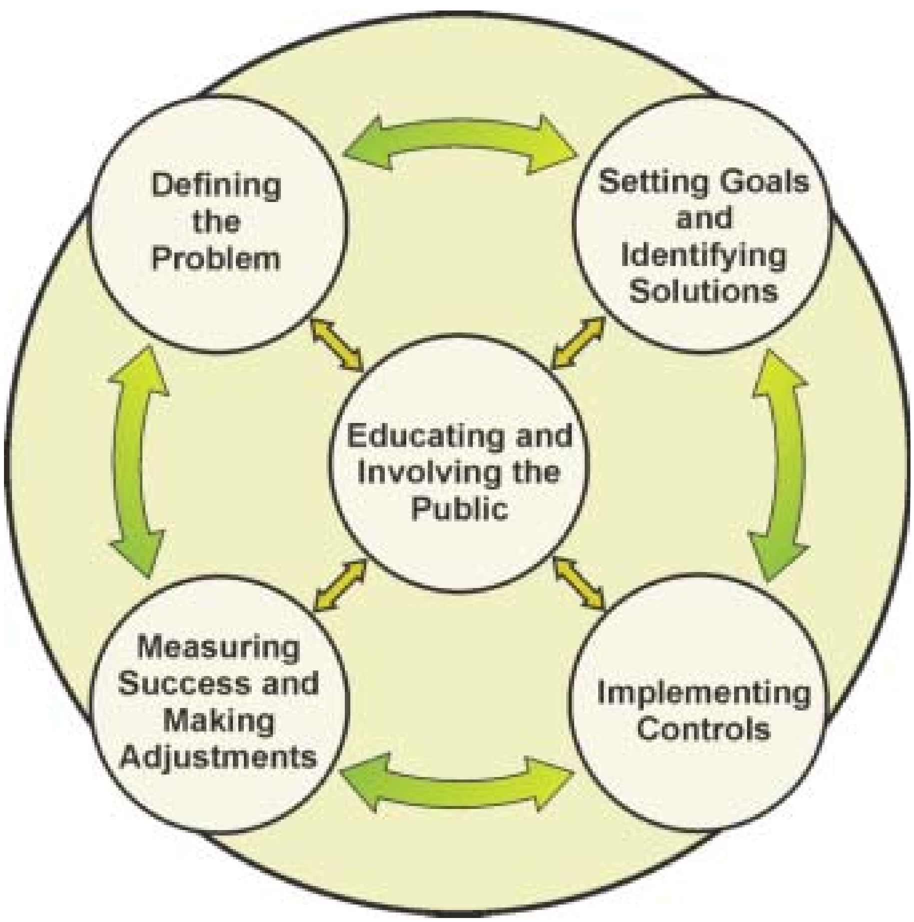


Watershed Hydrology

The net result of these human alterations to the hydrologic budget is the removal of more water from the watershed than is returned, leaving the river system dramatically altered and unable to sustain its other essential functions and values. This is the central problem in the Ipswich River watershed.

Because watersheds cross political boundaries, a new approach based on the watershed boundaries is being developed across the nation to address water issues. The watershed approach is a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within hydrologically-defined geographic areas, taking into consideration both ground and surface water flow (EPA, 1996). Because watersheds do not conform to the political boundaries established to manage towns and cities, there is a need for a strongly coordinated effort in managing watershed-wide issues. The watershed approach is based on the following guiding principles:

- Partnerships – Between the stakeholders affected by management decisions to ensure that environmental objectives are well integrated with those for economic stability and other social and cultural goals.
- Geographic Focus – Activities are directed within specific watersheds.
- Sound Management Techniques based on Strong Science and Data – These include assessment and characterization of natural resources, environmental objectives based on the needs of the aquatic system and of people in the community, prioritization of problems, development of management options and actions plans, and implementation and evaluation of effectiveness (EPA, 1996).



Elements of a Successful Watershed Program. Source: US EPA, 1994

A watershed action plan provides a framework for dealing with issues in the watershed; it is meant to provide a starting point by which stakeholders can evaluate, debate, choose management alternatives and come to terms with potential watershed policies. The plan is not stagnant and should be revised and updated in a timely manner. This dynamic framework allows for flexibility and creativity in solving complex problems.

The ecological and socioeconomic values of the Ipswich River watershed are vital aspects of a healthy watershed system. Yet current land uses, unless wisely managed, will continue to threaten watershed health. This Action Plan is aimed at identifying and correcting water resource problems within the Ipswich River watershed. It uses an integrated watershed approach, which includes broad stakeholder involvement, clear goal setting, strong science, effective management solutions, successful implementation, and consistent monitoring. The end product is intended to be a healthy watershed, in which natural processes and human land uses are sustainably intertwined.

1.3 Outreach and Public Participation

A key component of any watershed action plan is public outreach and participation. Because a watershed crosses political boundaries and includes many different users, all stakeholders should be included in the development of a watershed action plan and its implementation. Advocates for public involvement in environmental planning often herald the use of consensus-building among diverse interests to improve decision-making (Landre and Knuth, 1992). Methods for developing stakeholder involvement in the process of action plan development include forming a well-balanced group that represents all of the interested parties in the watershed, holding open meetings, encouraging diverse stakeholders to participate, and ensuring that everyone's concerns are heard and addressed. Although this can be a cumbersome process, the decisions and goals that result will be stronger and more widely understood.

The process by which this Action Plan has been developed has included multiple opportunities for public and stakeholder input. The project is an outgrowth of the work of the Ipswich River Task Force, an inclusive stakeholder group that has been working collaboratively since 1996 to identify the causes and effects of the Ipswich River's low-flow/no-flow events.

The Ipswich River Watershed Association and Steering Committee for the Communities Connected By Water (CCBW) project hosted an all-day workshop entitled "RiverVision 2000", on June 7, 2000. The workshop was held at the North Shore Community College in Danvers. The purpose of the workshop was to provide public outreach concerning causes of low-flow and no-flow in the Ipswich River, and to facilitate public involvement in forming a Watershed Management Council ("the Council") and a Watershed Action Plan. Approximately 50 stakeholders attended the workshop. The Ipswich River Task Force, since formalized as the Council, has provided continuous input as to the goals and objectives of the actiont plan, the development of the plan, its recommendations, and the structure, purpose and role of the Council into implementing the action plan. Recognizing the need to develop and implement action strategies, a workshop was held in December, 2001, at the Danvers

Town Hall. Approximately 40 members of the Ipswich River Watershed Management Council participated in the workshop. Comments have been solicited regularly throughout this process, and have been integrated into the Action Plan and into the formation of the council to the best extent possible.

Future implementation of the Action Plan will require a large degree of public participation, stakeholder involvement, and education, as well as funding. This action plan will require a concerted effort by all stakeholders to truly make a difference in the Ipswich River Basin.

1.4 Project Background

The Ipswich River Task Force was formed in 1996 in response to recurring no-flow/low-flow events, including a severe episode in 1995, which resulted in the upper half of the Ipswich River going dry, with large fish kills and other environmental damage. This environmental event sparked interest in the community to investigate the causes of the river drying up, protect river flows and develop a regional approach to managing this resource.

From the outset, the Ipswich River Task Force has been composed of a diverse group of key stakeholders including representatives from municipalities within the watershed, water suppliers, state and federal agencies, environmental organizations, and limited business representation.

In addition, through the former Massachusetts Watershed Initiative, an Executive Office of Environmental Affairs watershed team was established to assist the state in managing natural resources within the watershed. This team began to integrate permitting tasks throughout the watershed, and bring together experts from various agencies to work on management issues.

In 1997, after recurring instances of no-flow, the national environmental group American Rivers designated the Ipswich River as one of the 20 most threatened rivers in the country. The group named water withdrawals, development, and pollution as the central factors responsible for the river's degradation. In addition, the river is listed under Section 303(d) of the Federal Clean Water Act (FCWA) for failing to comply with Massachusetts Water Quality Standards. Reasons listed for impairment according to the Massachusetts Department of Environmental Protection's "1998 Final Massachusetts Section 303(d) List of Waters" are flow alteration, high nutrient concentrations, and the presence of pathogens including fecal coliform. In addition, low dissolved oxygen is listed as the cause of impairment in several tributaries to the Ipswich River, while confirmation is needed as to the extent of low dissolved oxygen in segments of the main river. As required under the Federal Clean Water Act, the United States Environmental Protection Agency (USEPA) instructed the Commonwealth of Massachusetts to prepare an action plan for the river to address these problems.

In the same year, the Task Force requested assistance from the U.S. Geological Survey (USGS) in the development of a watershed model to serve as a basis for water resource management decisions (Zarriello and Ries, 2000). This model was completed in 2000, and results are described in more detail in later chapters of this plan.

The Ipswich River basin's water management program has been identified by the state as a model for other basins in the Commonwealth in recognition of efforts previously undertaken by the Task Force. In September 1998, the State's Executive Office of Environmental Affairs awarded a Planning for Growth/Communities Connected by Water grant to the Upper Ipswich basin communities of Wilmington, Burlington, North Reading and Reading, and to the Ipswich River Watershed Association, to assist in the development of a region-wide and consistent local action plans. Today, the central concern within the watershed regards the effect that continued development is having upon watershed resources including the river, wildlife and natural communities, and drinking water resources.

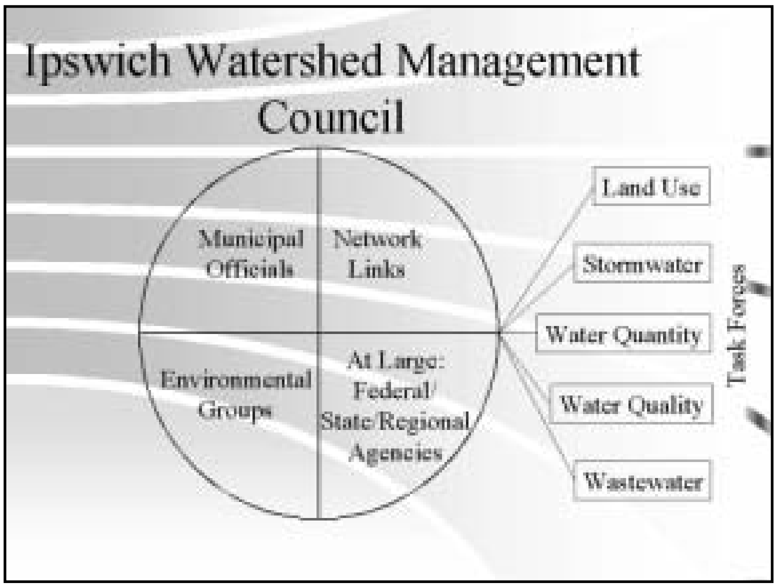
1.5 Goals and Objectives

http://www.ipswichriver.org/rivertour.html

As part of the action plan development, the Ipswich River Task Force Steering Committee reevaluated their goals and objectives and agreed to reform and rename the Task Force, to encompass broader stakeholder involvement and to address larger watershed issues, such as water quality and sustainable growth. The results of these deliberations are the following goals:

- Excellent water quality and sufficient water quantity for drinking water, fisheries, recreation and other uses;
- Restoration and protection of the biological integrity of the Ipswich River watershed, including environmental conditions necessary to support the Ipswich River's natural biological community; and
- A cooperative process among stakeholders.

In order to achieve this goal the Ipswich River Task Force and CCBW steering Committee felt it necessary to expand the representation of the Ipswich Task Force, and to formalize the organization into a long-term or permanent forum for addressing, resolving and recommending solutions for dealing with the issues that face the watershed. This newly formed group is named the Ipswich River Watershed Management Council. The group will consist of representatives from municipalities, environmental groups, other organizations working within the watershed and federal/state/regional planning agencies. Several subcommittees have been suggested to identify and research possible solutions to existing issues in the watershed; they include a coordinating committee, water supply and wastewater, water conservation, river ecology, outreach and land use subcommittees.



To achieve the goals of the action plan, the Ipswich River Watershed Management Council will:

- Advise local, state, and federal government agencies regarding watershed protection issues;
- Help to develop and implement sound management practices to achieve goals;
- Educate decision-makers and the public about watershed protection issues;
- Initiate research and assessment studies where necessary to address management questions; and
- Provide a regional forum for and expectation of joint problem-solving regarding management of the Ipswich River watershed.

2.0 THE IPSWICH RIVER WATERSHED

2.1 Watershed Values

http://coast.mit.edu/draw-ortho.cgi

Healthy watersheds, or river basins, have numerous functions that are essential to the health of the ecosystem including humans. Perhaps most obvious is the water supply uses provided by river systems -- this water is essential to all life, and to economic sustainability. But water supply is only one function of a watershed. Riparian corridors, consisting of rivers and streams, their beds, banks and floodplains and their associated plant and animal inhabitants, are one of the most productive ecosystems in the world. Rivers are a major factor in forming the landscape around us, and their flows help maintain floodplain communities, transport sediments and nutrients, and shape the river channel and valley. The natural watershed system, including vegetated wetlands and uplands, provides essential wildlife habitat. Wetlands cleanse surface water runoff, absorb and temper flood waters, stabilize stream banks, and watershed lands recharge groundwater. As a result, groundwater and surface water pollution is minimized, storm damage controlled, fisheries and wildlife habitat protected, and water supplies cleansed and replenished.

Along with their numerous ecological values, river basins provide many other social and economic benefits. Rivers provide habitat for numerous commercially valuable species, particularly fish and shellfish. Game fish, upland game and waterfowl are the basis of recreational and commercial fishing and hunting industries, worth billions of dollars nationwide annually. The Ipswich River system, including its anadromous fishery, contributes to the health and productivity of the larger Great Marsh and Gulf of Maine ecosystems.

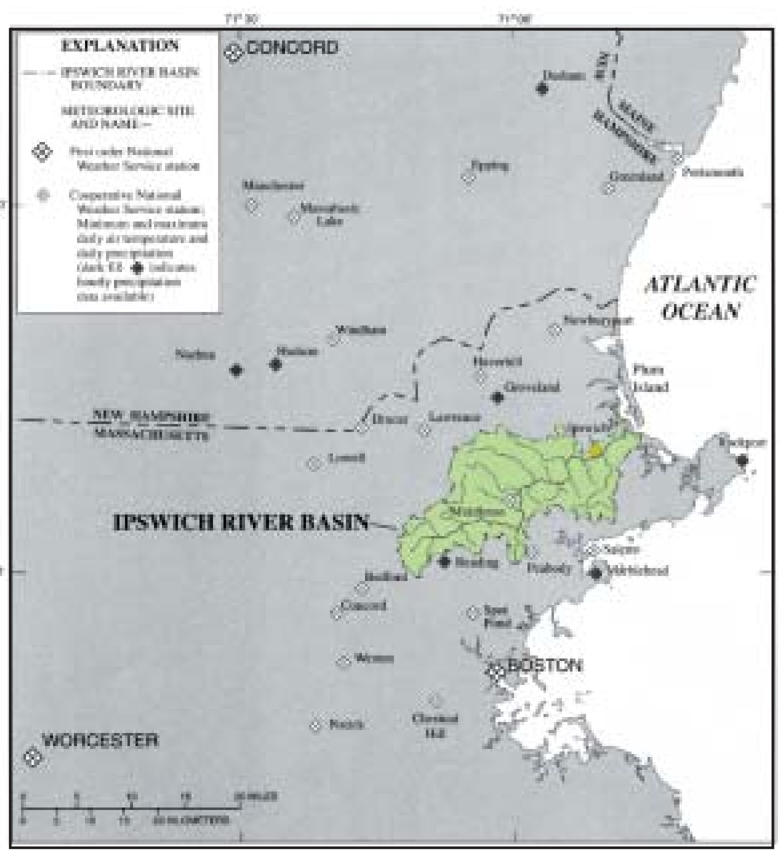
Recreational uses, such as canoeing and kayaking, hiking and biking, fishing and shellfishing, birding and wildlife observation are also important to the regional economy and quality of life. Lands within watersheds offer valuable real estate, attractive for residential and commercial development. In many towns within the watershed, the value of tourism is paramount, and scenic beauty in the Ipswich basin is some of the finest in New England. Other important functions of rivers include the assimilation of pollution from human (and natural) activities throughout the watershed. Each of these qualities have both social and economic value.

A river basin's natural functions are vital to humans, but are often compromised by the impacts of human development, which rarely finds a perfect balance between resource protection and use. Subsequently, many of the human values associated with development, including financial wealth, social interaction, recreation, and aesthetic appeal, may run contrary to ecological health. This Watershed Action Plan will seek solutions which balance and benefit sustainable economic activity and environmental protection. The focus of the Plan is restoring streamflows while protecting water quality; less attention is paid to issues which, while important, do not play a major role in “balancing the water budget.”

2.2 Characteristics of the Ipswich River Watershed

The Ipswich River watershed encompasses a 155 square-mile area, north of Boston, Massachusetts in Essex and Middlesex counties (Figure 1). The Ipswich River extends approximately 45 miles from its westernmost headwaters in the towns of Burlington and Wilmington, northeasterly to its mouth at Essex Bay and Plum Island Sound. The Ipswich River watershed includes all or portions of 22 towns (Figure 2). Of these, only three, Middleton, North Reading, and Topsfield, are entirely within the basin. Boxford, Hamilton, Ipswich, Lynnfield, North Andover, Wenham, and Wilmington are mostly in the basin. About half or less than half of Andover, Beverly, Burlington, Danvers, Peabody, and Reading are within the basin and less than 1 square mile of Billerica, Essex, Georgetown, Tewksbury, Woburn and Rowley are in the basin.

Figure 1. Ipswich River Basin



USGS

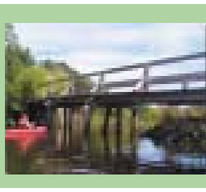
The basin can be divided into three subsections: the upper, middle and lower watersheds. The upper watershed drains 44.5 square miles to South Middleton and has a mean annual streamflow of 41 million gallons per day (Mgd) (Zarriello and Ries, 2000 p.7). The middle watershed drains 125 square miles, with a mean annual streamflow of 122 Mgd (Zarriello and Ries, 2000). The lower watershed, below the Willowdale Dam, includes another 30 square miles of drainage area to the Ipswich Dam and its flow is not measured by a streamflow gage. Below the Ipswich Dam the river becomes tidally-influenced.

Approximately 20 tributaries feed into the Ipswich River. In the upper watershed, the larger tributaries include Maple Meadow Brook, Lubbers Brook and Martins Brook. In the middle watershed, tributaries include Norris, Emerson, Boston, Fish and Howlett Brooks. In the lower watershed, the Miles River is the largest tributary. A number of tributaries, as well as the Ipswich River itself, have dams that were built to store water, power mills and/or for recreation. Three dams continue to impound sections of the river, one in Middleton and two in Ipswich. Smaller dams and remnants can be found in the mainstem and tributaries.

Figure 2. Ipswich River Watershed

USGS

The Ipswich River and its watershed is relatively flat and the river is a relatively slow moving and meandering system. The river winds through wetlands and a landscape dotted with glacial drumlins and small hills (Bickford and Dymon, 1990, p.66). Geologically, the watershed is



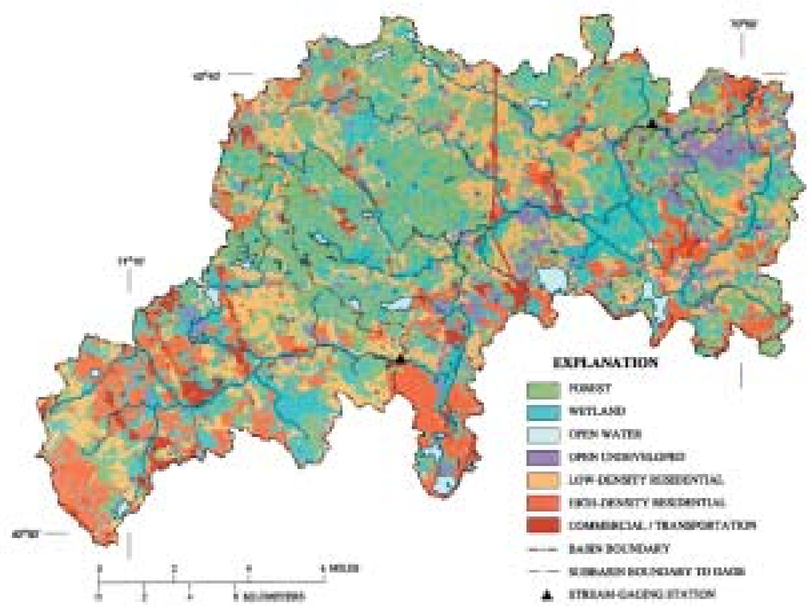
Baseflow is the part of a river's flow from groundwater seepage.

Permeability refers to the capacity of rock or soil to transmit water.

covered almost equally by glacial till and stratified sand and gravel deposits from the last glacier. Till deposits are generally thin and bedrock is at or near the surface is some areas while lower lying areas are generally underlain by stratified drift whose permeability generally is greater than till. Stratified sand and gravel drift composes the major groundwater storage in the watershed and maintains water to the river's baseflow as well as serving public and private drinking water wells. Stratified drift deposits and continuous aquifers are a dominant feature in the upper watershed, especially in the communities of Wilmington, Reading and North Reading, while glacial till dominates the geology of a larger percentage of the middle and lower watersheds. Generally, the upper watershed provides more readily available groundwater for public consumption.

As of 1991, approximately 39% of the Ipswich River watershed consists of forest and open space, wetlands cover about 21% (6% non-forested and 15 % forested), commercial areas comprised about 5% and residential areas 33% of the basin (Zarriello and Ries, 2000; p.7) (Figure 3). The largest of the wetlands is Wenham Swamp, which occupies an area of about 3 square miles along the Ipswich River near the border of Hamilton and Wenham. Pontius (2000) reports that the distribution of major land cover types in the watershed in 1991 was 44% forest, 31% residential and commercial, 17% wetlands and 8% agriculture and open. The slight disparity between these two studies is the result of the different land use categories used in the analysis. In general, the two studies paint a similar picture, but a consistent and thorough examination of current land use in the watershed would clarify these disparities.

Figure 3. Land Use in the Ipswich River Watershed



USGS

2.3 Watershed Hydrology

In the Ipswich River watershed, the natural annual hydrologic cycle follows a general pattern:

- Precipitation is typically evenly spread throughout the year.
- In late fall, when evapotranspiration by plants greatly decreases, groundwater recharge and streamflow begin to increase.
- During winter and early spring, flows are typically high, often resulting in some level of flooding and occasionally affecting structures built within the floodplain.
- When the growing season resumes in spring, groundwater levels and flows begin to decline.
- Flows diminish during summer, and are at their lowest in late summer and early fall.

However, changes from the typical hydrologic pattern occur frequently and can have significant impacts, especially when combined with the high level of human water withdrawals which occur in the Ipswich river basin. For example, drier than normal conditions for weeks or even months in summer occur fairly often, and are typically coupled with higher rates of groundwater withdrawal to meet the increased demand for outdoor watering brought on by the drier weather. Even short-term dry periods may result in extreme low-flow/ no-flow episodes. Prolonged droughts have very severe impacts in this basin. Dry winters occur rarely, but when they do, the low-flow conditions may be exacerbated by water withdrawals during those periods. The hydrology of the Ipswich River watershed, and the effects of human alterations of the water cycle, are addressed in greater detail in Chapter 4.

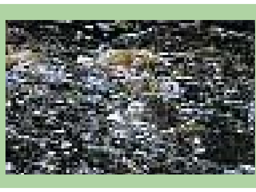
Evapotranspiration is the combined loss of water through plant uptake and evaporation to the atmosphere.

Recharge is the water that returns to aquifers through the infiltration of precipitation and other sources of water.

2.4 Biota and Habitat

2.4.1 Aquatic Habitat

Stream habitat along most of the Ipswich River is characterized by sandy streambeds, slow water velocities, and smooth, unbroken water surfaces (Zarriello and Ries, 2000). Because of human alteration and landscape setting there are few riffles and most of those that remain are not natural and typically occur downstream of dams or other manmade structures. The Ipswich River is classified as a warm stream due to its low flow, which renders the stream susceptible to seasonal and daily temperature variations. Currently, the Ipswich River is not considered ideal habitat for brook trout, which prefer cooler, more turbulent water such as that found in riffles, and gravelly stream beds. In the entire river, there are twelve riffle areas, the largest being near Mill Road in Ipswich. Only two of these riffles appear natural, the rest having been created by artificial and historic constrictions such as dams, mills and bridges.



Riffles are shallow rapids where water flows swiftly over gravel streambeds, providing valuable instream habitat for fish.

2.4.2 Fish and Shellfish

The native fishery that evolved in the Ipswich River watershed included a diverse assemblage of freshwater and anadromous fish. The resident fishery once included healthy populations of brook trout, banded sunfish, fallfish and bridle shiner. The anadromous/catadromous fishery was reported to be extremely abundant and productive, and included smelt, alewife and blueback herring, American eel, American shad, and sea run trout. Early reports indicate the presence of salmon and sturgeon in the coastal area during colonial times.

Over time, the assemblage of fish species that live in the Ipswich has changed from species that rely on flow for either some or all of their life cycle to a community dominated by generalists that are found in both lake and river environments. The reason for this shift is the river's loss of flow, including segmentation into a series of isolated stagnant pools during low-flow periods. These conditions have resulted in a loss of biodiversity and reduction in the ability of the system to react to other environmental changes. What was once a complex ecosystem has been diminished to a few dominant generalist species. The increasingly common periods when the river is pumped dry result in frequent kills of all fish (and most other aquatic organisms); this prevents fish from living long enough to reach maturity and reproduce, reducing the viability of the fish population.

Anadromous fish are those that migrate upstream to the river from the ocean to spawn.

Catadromous fish migrate downstream to the ocean from the river to spawn.

Freshwater shellfish are an important part of the aquatic fauna, and include numerous species of clams and mussels, including state-listed rare species. In addition to the instream habitat provided within the Ipswich river, the estuary and coastal region have historically been extremely productive shellfish areas, producing clam, quahog and mussel harvests of high commercial value. The shellfish beds in the estuary have recently been conditionally reopened for commercial harvest after decades of closures due to bacterial contamination.

2.4.3 Vegetation

The Ipswich River watershed is dominated by pine/mixed hardwood forests that provide habitat for many terrestrial and avian species, with extensive wetland communities of great ecological importance. Native tree species dominant in particular areas include white (and some red) pine; maples (sugar, silver, red); red and white oak; American beech, and white and green ash. Wetland communities include swamps, bogs, marshes and wet meadows. The watershed wetlands communities are dominated by many acres of red maple swamp; a silver maple floodplain forest in Middleton and Topsfield; Atlantic white cedar wetlands; bogs; and tussock sedge meadows. Many wetlands plants exist here and may dominate locally.

The Ipswich River flows into an estuary and is part of the Great Marsh, an expansive acreage of salt marsh dominated by marsh grasses. This huge marsh is ecologically critical land - as an important part of the Atlantic Flyway, the network of lands essential for migratory birds, many of which are globally threatened. The health of the river system and Great Marsh are also important to the integrity and productivity of the vast Gulf of Maine, an ecosystem of global importance.

The extensive wetlands of the Ipswich River watershed provide outstanding wildlife habitat and perform many important functions of value to humans. Of particular importance is the ability of wetlands to remove pollutants including nitrates from water. This water purification capacity may be compromised by frequent desiccation of wetlands during low-flow/ no-flow periods.

2.5 Recreational Use

The Ipswich River has been a major recreational resource in eastern Massachusetts for many years. Canoeing and boating, swimming, camping, fishing, shellfishing, hunting, hiking, birding, and other activities have attracted recreational visitors from within the watershed communities, and nearby urban areas as well. There is a network of state forests and parks, wonderfully supplemented by privately held conservation land, which forms an outstanding regional resource with the potential of becoming a regional bioreserve.

http://www.ipswichriver.org/rivertour.html

The Ipswich River has long been considered one of the premier trout streams in Southern New England. However, due to chronic low-flow conditions, the trout fishery currently consists of fish stocked by Massachusetts Department of Fish and Game (formerly DFWELE). Freshwater fishing for bass and other species is a common pastime. Fishing in the estuary and coastal waters is a major recreational use, including fishing for striped bass, blue fish, shad and other species. Recreational clamming will likely resume its popularity now that portions of the Ipswich River estuary have been reopened for harvest.

In recent years, kayaking, biking, cross-country skiing and other "passive" recreational activities have become very popular, and the Ipswich River watershed has become an important destination for these pursuits. Sea kayaking is increasingly popular in the estuary and coastal section. A number of fish and game clubs have active memberships in this region.

3.0 IMPAIRMENT OF THE IPSWICH RIVER WATERSHED

3.1 Overview

http://www.bwlord.com/Ipswich/ipswich.htm(Bruce Lord)

In 1997, the Ipswich River was named one of the twenty most threatened rivers in North America by American Rivers, a national rivers protection organization, due to the severity of its low flow problems, pollution threats and loss of critical habitats. The Ipswich River is also listed as "impaired" under the Clean Water Act, due to flow alteration, low dissolved oxygen, areas of nutrient enrichment and other pollution. Hazardous waste has threatened public water supplies in a number of watershed communities.

The Ipswich River Basin is a stressed basin under the hydrological criteria adopted by the Water Resources Commission in its 2001 Stressed Basins in Massachusetts report. A stressed basin is defined therein as one in which "the quantity of streamflow has been significantly reduced, or the quality of the streamflow is degraded, or the key habitat factors are impaired." The Ipswich River Basin meets all three of these criteria and is classified as "highly stressed," by the Water Resources Commission.

Development that has occurred without regard for protection of water resources is the principal cause of these problems. In the Ipswich River watershed, development patterns and activities have ignored the adage, "protect the headwaters." Facilitated by the construction of Routes 128 and 93, the headwaters communities of Burlington, Wilmington, Reading and North Reading have been transformed from semi-rural farm communities to densely developed areas. West Peabody, Danvers and North Beverly are also densely developed, with limited protection of water resources. The trend toward urbanization is spreading to other communities, where "sprawl" is changing woodlands, fields and former farms to subdivisions and shopping centers.

Protection of water resources has taken a back seat in a number of communities. Zoning has historically allowed development that threatens public water supplies and the environment of neighboring and downstream communities. Hazardous waste contamination has affected a number of municipal wells, and runoff from roadways and parking areas, construction sites, landfills, lawns and other areas threatens to further degrade water quality. The importance of improving source protection is a common ground issue for both communities, water suppliers and environmentalists.

Conversion of land from rural to suburban and urban as well as other human activities results in direct and indirect loss of wildlife habitat. Loss of biodiversity is occurring in the Ipswich River watershed, including significant losses of river-dependent species of fish, effects on food chain organisms, as well as impacts on terrestrial and avian species.

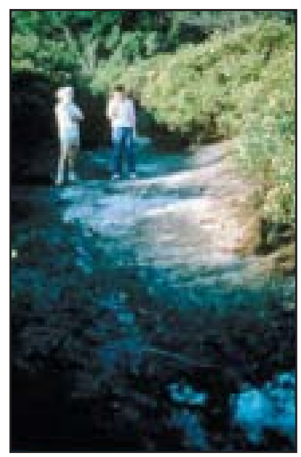
Development has also paved over significant recharge areas in the upper watershed and other communities, resulting in loss of recharge of groundwater, which affects baseflow supplying the

Ipswich River, as well as aquifers relied upon for public water supply. Increased residential, commercial and industrial demand for water accompanies development. Of particular concern are those communities that rely on groundwater wells, and that lack surface water storage capacity, so they must pump the most water during dry summers – when the natural system is most stressed and unable to afford such water losses. Conversion of forested land to lawns, and the practice of watering to keep those lawns green, even during droughts, is a significant factor exacerbating the Ipswich River's low-flow problems.

Development often results in expansion of sanitary sewer systems (though this need not be the case). Currently all the wastewater treatment plants serving the Ipswich River Watershed communities are located outside the watershed, and collect wastewater and transport it out of the watershed – causing more water losses. (The exception is the Town of Ipswich wastewater treatment plant, which discharges treated wastewater to the sensitive estuary. The Ipswich sewer collection system has for years experienced problems resulting in repeated discharges of raw sewage into the Ipswich River at the Ipswich town landing. This problem continues to result in serious pollution incidents.)

Sewers are prone to leaks, allowing groundwater and stormwater to infiltrate into the pipes. The result is that the sewers serve to dewater those areas of the watershed. Sewers are also a major "enabler of growth," meaning that where sewers are installed, increasingly intensive development, with accompanying water supply demands, is facilitated. These impacts will be considered in more detail below.

3.2 Low-Flow Problem



The Ipswich River experiences severe and chronic low-flow problems in summer and fall, and occasional low-flow problems in other seasons. During dry summer periods in 1995, 1997, 1999 and 2002, for example, the upper third to half of the Ipswich River dried up, resulting in fish kills, causing other ecological damage, and loss of instream recreational use. Low-flows also affect the lower half of the river, though sections of dry river bed are unusual. The extremity of low-flow events has increased in recent years, with new record lows having been set repeatedly during the late 1990's and again in 2002. Whereas the lowest flow ever recorded remained 0.10 cfs (at South Middleton) from 1957-1997, that low-flow record was broken repeatedly in 1997, 1999 and 2002, with flows as low as 0.01 cfs provisionally reported on several dates in 2002. Flows of less than 1 cfs have been recorded at the Ipswich gage in 2002 – despite its 125 square mile contributing drainage area. What is particularly remarkable is that these extreme low-flows have occurred during a period of "drought advisory," not even an acknowledged drought.

On average, no-flow events occur over 10% of the time (more than 36.5 days a year) in the Reading area. Summer flows in the upper river are significantly impacted and are evident in observations of flow upstream of a series of pumping wells along the river, no flow adjacent to the well, and reverse flow downstream of the well (as water is pulled upstream by the well pumpage). Low-flow advisories have been triggered every year since a public advisory system was implemented in 1997, requiring publication of public notices requesting water conservation during certain low-flow periods. In drought years, low-flow events can extend for six months.

The United States Geological Survey (USGS) developed a hydrological model of the Ipswich River watershed to examine the low-flow issue (Zarriello and Ries, 2000). The study found:

- Groundwater withdrawals are a major factor causing the extreme low-flow events of summer/fall.
- In the upper watershed, flows would be nearly 10 times higher without groundwater withdrawals, and with natural land cover.
- Surface water diversions, which occur only from December through May, are not a significant cause of the low-flows experienced in summer/fall.
- No-flow episodes in the Reading area would be reduced from >10% frequency to 1% frequency, if 1.7 mgd of treated water were discharged back into the ground in the upper watershed, instead of being sewered out of the basin.

Low-flows of later fall/winter/spring are much more infrequent; however, a drought during the late fall, winter and spring of 2001-2002 left the river at extremely low levels and caused concern about the adequacy of public water supplies for reservoir-dependent communities. These low flow periods warrant some consideration, as they may affect anadromous fish migration, fish spawning, floodplain ecology and other important functions of the Ipswich River's high flows. Management approaches that can allow communities to meet water demand, while causing less environmental harm, should be investigated. The model created by the USGS can be used to help evaluate and develop management options; a report from USGS evaluating the safe yield of several of the reservoir systems should help shed additional light on this subject. Further causes of low-flow/no-flow are discussed in Chapter 4, which deals with the water budget of the Ipswich River watershed.

3.3 Low Dissolved Oxygen

In an aquatic ecosystem, dissolved oxygen (DO) is one of the most critical water quality elements supporting aquatic life. While rivers vary in their natural levels of dissolved oxygen, unnaturally low levels of dissolved oxygen are intolerable to a healthy riverine ecosystem. The Ipswich River experiences extremely low dissolved oxygen, particularly in the upper watershed, during the summer months. Measured readings of DO below 1 mg/l, and even zero, have been documented. This is lower than the designated Massachusetts Surface Water Quality Standard (314 CMR4.05(b)) of 5 mg/l set for the Ipswich River. Creatures such as brook trout, stoneflies and mayflies, and indeed even more tolerant species cannot survive such low DO levels.

Low DO can also impact water and sediment chemistry by releasing nutrients bound to sediments. At low DO levels phosphorus, which under higher DO conditions is bound to sediments, will release into the surrounding water column. This enhances plant growth, which in turn will decompose and in the process further deplete DO in the water column.

While monitoring of dissolved oxygen levels within the river and its tributaries has been ongoing for sometime, no study of the causes of low dissolved oxygen in the Ipswich River has been conducted. However, a number of factors are known to affect oxygen levels, and are likely to play a role in the low dissolved oxygen trends seen in the Ipswich River watershed. Those factors include:

- decreased water volumes,
- higher water temperatures,
- anaerobic conditions in wetlands,
- low energy flows (impoundments or isolated pools),
- natural low gradient relief of the river channel,
- reduced baseflow (cool water source),
- segmentation of the river into ponded conditions due to dams and low-flows,
- nutrient pollution from septic systems and sewage resulting in biochemical oxygen demand, and
- loss of shading vegetation along streambanks.

The Ipswich River watershed Association, in collaboration with several research organizations, is planning to conduct further investigation of low dissolved oxygen in the Ipswich River.

3.4 Loss of Habitat


http://www.ipswichriverpark.org/images/photo_page/enlargements/ducks.jpg

Destruction, alteration, and encroachment upon wetlands and river areas have major impacts on critical wildlife habitats. Conversion of fields and forests to developed areas result in direct loss of wildlife habitat, as well as fragmentation of habitats, rendering them unable to support intact wildlife communities. In addition to direct losses from construction and conversion of these lands, indirect effects include encroachment of invasive species, introduction of predators (e.g. housecats, dogs, etc), deterioration of water quality and other impacts.

The effects of low-flows on aquatic habitat have been poorly understood in the past, though recent research has established important relationships between flows and habitat values. The recently published Assessment of Habitat, Fish Communities, and Streamflow Requirements for Habitat Protection, Ipswich River, Massachusetts, 1998-99 ("Aquatic Habitat Study") by USGS focused on characterizing the river's habitats, and identifying effects of low-flow events on those habitats (Armstrong, Parker and Richards, 2001). Some considerations regarding the relationship of low-flows and habitat include the following:

- Riffles: Riffles are shallow, gravel covered sections of the riverbed, with increased gradient, where water flows swiftly. Riffles are critical habitats, supporting macroinvertebrates essential to a healthy aquatic food chain, fish and other wildlife, and serving as oxygenation zones. They are important spawning areas. Riffles also act as hydraulic controls, behind which water levels are typically higher. As water levels decline, the riffle areas of the river are typically the first areas to dry out, which results in the segmentation of the river into a series of ponds, rather than a flowing water body. Ponded conditions do not support the same species as flowing water, and are also subject to stagnation, higher temperatures and decreased oxygen. When the riffles dry up, their critical ecological functions are diminished or lost. In the Ipswich River watershed, dams also play a role in the loss of riffle habitat, as several riffles on the river are partially filled and inundated by dams and their impoundments.
- Channel margins: The channel margins/ streambank areas provide very important habitat by providing physical structure, hiding places, shade, nutrients and food sources to a variety of fish and other creatures. Some species spend their entire life cycle in the channel margin areas, whereas others depend upon these areas for cover and other needs during juvenile stages. When the river dries up, the water recedes from the channel margins, eliminating this critical habitat. This means that species that cannot survive without this habitat will not be able to survive in healthy numbers in the Ipswich River watershed.
- Seasonal variability of flow: The natural annual flow regime of the Ipswich River shows high flows in late winter and into the spring, diminishing flows in late spring and throughout the summer, and recovery of flows in late fall and winter. The natural variation in flows supports ecological values. High flows, for example, trigger spawning migrations of anadromous fish, scour stream channels, provide spawning habitat and support floodplain ecosystem functions. Approximating the natural flow as closely as possible will help ensure that these natural functions can be supported. Note that the extreme low-flows that occur regularly on the Ipswich River are not naturally-occurring, but are the result of water withdrawals and other human activities.
- Water temperature and oxygenation: As water volumes decrease in the river, the water that remains is subject to more rapid temperature changes. In summer, diminished flows and volumes result in more rapid increases and higher water temperatures. Some aquatic creatures, such as brook trout, are highly sensitive to water temperature and cannot survive warm conditions. Spawning periods are also affected by temperature changes. Warm water cannot absorb oxygen as effectively as cold water, so higher temperatures are associated with lower dissolved oxygen. Low-flows in winter may have adverse consequences as well, resulting in more rapid freezing and freezing down to the river bottom, resulting in losses of fish and other creatures that cannot survive those conditions.

3.5 Loss of Biodiversity

The Ipswich River watershed has experienced a loss of biodiversity of serious proportions. Of particular note is the transformation of its fish community from that of a river system to a fish community more representative of warm ponds. The USGS/DFW evaluated the river's aquatic habitat, and conducted fish sampling in the mainstem and some tributaries of the Ipswich River. The key findings of this and other research include:

- River-dependent species are being eliminated from the Ipswich River system, and currently comprise less than 9% of the species found in the watershed.
- The river system is dominated by macrohabitat generalist fish species, which can tolerate the regular transformation of the river into ponded habitat due to low-flow episodes (as well as the effects of dams).
- Year-classes of fish are missing, possibly due to the frequency of low-flow/no-flow episodes and resulting fish kills.
- The river's once-productive anadromous fisheries have been extirpated by dams and low-flow conditions; while restoration efforts for blueback herring have been underway for several years, the success of this effort is not yet demonstrated.
- Dams on tributaries block fish movement into the tributaries, some of which could provide refuge habitat during low-flow periods.

"There are three general kinds of biodiversity: habitat diversity, genetic diversity, and species diversity. The survival of each is linked to the health of the other two, and together they comprise the wealth of ecosystems" (John Harte, 1996)

A target fish community has been identified by a working group including fisheries experts from the U.S. EPA, USGS, U.S. Fish and Wildlife Service, the Massachusetts Department of Fish and Game (formerly DFWELE - DFW, Division of Marine Fisheries and Riverways), Department of Environmental Protection and former Watershed Initiative, as well as several nongovernmental organizations. Section 5.2 offers more detail on recent studies of existing and target fish communities for the Ipswich River.

Impacts on other biota are also occurring. The macroinvertebrate community in the river system is affected by low-flows, exhibiting poor diversity in areas which are flow impacted. A diverse macroinvertebrate community is essential to the aquatic food chain, and because of their sensitivity to environmental changes they also serve as indicators of water quality.

Collectively, the various terrestrial and aquatic ecosystems within the watershed support diverse plant and animal communities. However these have been adversely impacted by development that has altered the natural communities in the area; and desiccation of the river and associated wetlands poses additional threats. Today, a number of organisms in the watershed are listed as threatened by the Massachusetts Natural Heritage and Endangered Species Program, including a number of amphibians and reptiles which depend on wetland habitats, as well as bridle shiner, American bittern, least bittern, pied-billed grebe, Northern harrier, golden-winged warbler, small bur-reed, glaucous sedge, long's bulrush, sweet bay magnolia, and variable sedge. Many of these are wetland species or species which depend upon wetlands and water for feeding and nesting habitat.

Macroinvertebrate species lack a backbone and are visible without magnification. They include insects, molluscs, crustaceans and worms.

3.5.1 Invasive Species

Another aspect of loss of biodiversity is the proliferation of invasive, non-native species. This problem is by no means unique to the Ipswich River watershed. These species often succeed in disturbed conditions, and are able to out-compete native species, and proliferate to the exclusion of a diverse community of plants or animals. Among flora of concern are Phragmites (giant reed); purple loosestrife, Norway maple, European buckthorn; Oriental bittersweet; Morrow's honeysuckle; multi-flora rose; crown vetch; Glyceria maxima; and many others. Long-term studies on invasive species have been and continue to be conducted within the Ipswich River watershed. To date, little work has been done to investigate correlations between invasive species colonization and low flow conditions. One area of concern that has been identified is the establishment of shrub-layer invasives such as European buckthorn in the silver maple floodplain forest, an extensive ecosystem of high value extending through much of the riparian corridor in Middleton and Topsfield. Further research is needed to evaluate this situation. In other areas, desiccation of the riverbed allows invasive plants to colonize the actual riverbed, in areas where heretofore only aquatic vegetation could have survived. This choking of the stream channel has been observed in a number of locations.

3.6 Pollution

As mentioned above, the Ipswich River experiences extremely low flows and dissolved oxygen, which impair the river's suitability for fisheries and other habitat. Portions of the river also experience impairment due to other types of pollution. The following issues to be addressed affect the suitability of the river for water supply as well as other important uses; the concentrations or mobility of these contaminants can be made worse by low-flow conditions:

- Hazardous waste: hazardous waste affects public water supplies and environmental quality in several areas of the watershed. Public wells have been contaminated in Wilmington, Reading, North Reading, Peabody, Danvers, Hamilton and Topsfield.
- Pathogens: Bacterial contamination has resulted in closures of shellfish beds and beaches in the Ipswich River watershed. The primary cause of contamination has been stormwater contamination and failures of the sewer collection system and wastewater treatment plant, not failing septic systems. Due to an outstanding effort led by the Ipswich Coastal Pollution Control Committee, many sources of bacterial contamination have been remediated in Ipswich, resulting in reopening of shellfish beds in the Ipswich River Estuary for the first time in decades. The reopening of shellfish beds has raised questions about future management of the clambeds for protections. Occasional beach closures have occurred in Wilmington at Silver Lake, in Middleton at Thunder Bridge, in Topsfield at Hood Pond and in Ipswich at Crane Beach. Stormwater is believed to be the source of contamination resulting in these closures, which typically occur after very heavy rains.
- Nutrients: The Marine Biological Laboratory at Woods Hole has been leading a multi-year investigation of nutrient dynamics in the Ipswich River watershed. The study has found that there is a significant input of nutrients from the land areas into the Ipswich River system, but that 90% of nitrate is removed from the water upstream of the estuary. This research indicates the importance of wetlands in removing pollution. Researchers have expressed

concern that low-flows may compromise wetlands' capacity to remove nitrates over time.

- Dissolved Oxygen: Water quality monitoring conducted by the Ipswich River volunteer monitoring program and by the Department of Environmental Protection's Division of Watershed Management has identified impairments to water quality stemming from low dissolved oxygen. This has been found throughout the watershed, in the main stem if the Ipswich River and in some tributaries.
- USGS is currently conducting a study of mercury contamination of water, sediments and fish tissue in New England Rivers. Preliminary findings indicate that the Ipswich River has high concentrations of methyl mercury, a highly toxic substance, in all three categories. Further research is taking place to investigate this situation.

3.7 Loss of Open Space and Land Use Changes

A recent study by Clark University examined land use change over time in the Ipswich River watershed, and indicated the largest change in land use from 1971-1991 was from forest to residential (Pontius, 2000). Another recent report, "Grow Smart North Shore," (Harvard University, 1999) describes the current pressures the North Shore region faces from residential, industrial and commercial development. Much of the area of the Ipswich River watershed lies within this North Shore Region. The report notes that, though the landscape and character are relatively well preserved, current low density land development patterns are threatening the region.

An example of this loss of open space can be seen in the City of Beverly; between 1970 and 1990, Beverly experienced a decrease in population by 0.4% while at the same time more than 750 additional acres were developed (Harvard University, 1999). The City of Beverly exemplifies a pattern of sprawl that is threatening other towns in the North Shore region due to their attractiveness and convenience to Boston. How does this relate to the health of a watershed? Sprawling land development wastes land and increases infrastructure, while also contributing to the loss of wildlife habitats, water pollution and excessive water consumption (Harvard University, 1999).

A particular concern is the trend toward very large homes with extensive lawn areas irrigated by in-ground sprinkler systems. This type of development is likely to exacerbate the summer water deficit in the Ipswich River watershed.

Impacts associated with "sprawl" land development include wetland losses, degraded water quality, increased water supply needs, increased infrastructure needs, loss of habitat, increased impervious surfaces, decreased aquifer/groundwater recharge, altered hydrology, traffic congestion, air pollution, and higher taxes.

3.8 Loss of Recreational Opportunities

The use of the Ipswich River watershed for recreation is greatly diminished by loss of flow. The severe low-flow problems of summer and early fall occur precisely at the height of the recreational-use season of the Ipswich River, and affect its suitability for canoeing, swimming,

Ipswich River Park Festivities http://www.ipswichriverpark.org/images/photo_page/enlargements/waiting.jpg

fishing and other instream recreation.

The upper half of the Ipswich River is often not usable for canoeing during the prime canoeing season of summer/early fall, and former canoe liveries/rental outlets which existed in the Upper Ipswich/ Middle Ipswich have ceased their operation. The lower half of the Ipswich River still supports a profitable canoe livery, though canoeing is impaired at times, as long sections of the riverbed become too shallow for canoe passage.

Native trout no longer survive in the Ipswich River, largely due to chronic low-flow conditions, combined with the related problems of warm temperatures and low dissolved oxygen. The sport fishery is supplied by the "put-and-take" program of the DFG, which stock trout each spring and fall. Other game fish, such as bass and pickerel that can tolerate warm, ponded conditions, attract many anglers. Recreational fishing also takes place in the tidally-influenced portion of the river, including fishing for striped bass, bluefish and shad, as well as shellfish harvesting.

While the river's water quality is usually in compliance with swimming standards, heavy rains sometimes result in beach closures due to high fecal coliform counts. This problem is considered a stormwater problem, as it is associated with wet weather conditions only.

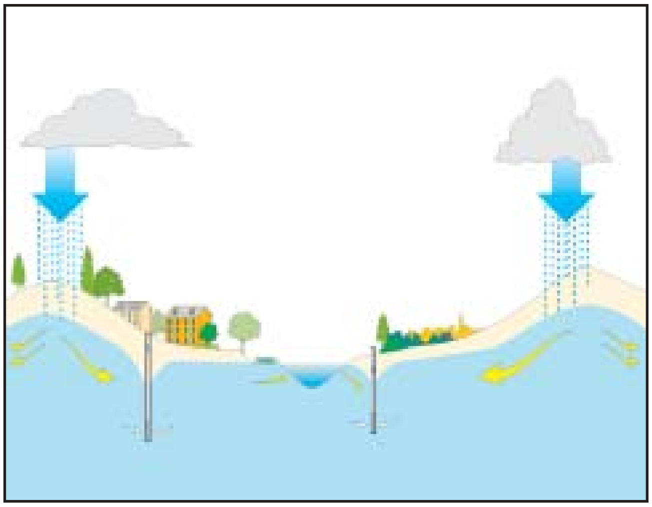
3.9 Loss of Other Uses

The Ipswich River's extreme low-flow and no-flow conditions make it unsuitable for one of the principal, if unheralded, uses of rivers: wastewater assimilation. While there are only two major permitted discharges of wastewater in the Ipswich River watershed, the no-flow episodes limit the assimilative capacity for even smaller wastewater and stormwater pollutant discharges to the river. At present, there is no proposal for surface water discharge of wastewater even in the chronically dewatered upper watershed, because of the watershed's importance for water supply and the lack of assimilative capacity. In addition, the antidegradation standards of the state's surface water quality standards provide added safeguards against pollution discharges. Tertiary treatment and/or groundwater disposal of effluent are the only options which are currently being considered in the Ipswich River watershed.

The broad quality of life associated with a healthy river is in jeopardy because of degraded conditions of the Ipswich River. Long-time residents of the upper Ipswich watershed express concern that stagnant conditions or no-flows of the river affect the desirability of riverfront properties, and may affect property values. Fish kills, which have occurred every two years recently, are not only a huge environmental loss, but create visual and odor problems.

4.0 THE WATER BUDGET

4.1 Components of a Water Budget


Watershed Hydrology

The water budget of a watershed is the sum of all water entering, cycling through and exiting the watershed after all natural processes and the effects of human activities are taken into account. Important features of the water budget include not only the amounts of water involved, but also the kinds of hydrological processes taking place, and their relative rates. Important natural hydrological processes that renew water resources include precipitation, recharge of groundwater from infiltration of surface runoff, and groundwater flow to support river baseflow. Natural processes that remove water from the watershed include evapotranspiration, groundwater discharge to the surface, and surfacewater runoff into streams and rivers that exit the watershed.

4.2 Factors That Can Affect The Water Budget

Human activities that alter the rates of water renewal and withdrawal can profoundly affect the water budget of a watershed. Examples of such human activities include withdrawal of groundwater and surface water for water supplies, reducing groundwater recharge by reducing infiltration of surface runoff, reducing baseflow by removing groundwater, increasing the rate at that runoff exits the watershed by channelizing runoff, and direct transfer of water outside of the watershed. The water budget of the Ipswich basin is discussed in terms of some of these important natural and human processes.

4.3 Water Withdrawals

Fourteen communities receive public water supply from sources within the Ipswich River watershed, including two not within the watershed (see Table 2 and Figure 4). Several communities have a significant number of private wells supplying residences and commercial enterprises. More than 330,000 people and thousands of businesses obtain all or some portion of their drinking water from the Ipswich River basin.

Current water withdrawal authorizations in 2001 under the Massachusetts Water Management Act total 32.81 Mgd (MADEP, 2001). The average amount withdrawn during 1999 was 30.28 Mgd. By 2020 the total water withdrawal authorizations under the Massachusetts Water Management Act will total 39.65 Mgd, an increase of 6.84 Mgd from today's permits. The amount of water pumped from smaller private sources is not known, and is not accounted for in the USGS model. In total, there are 96 registered or permitted public and commercial water withdrawals (Zarriello and Ries, 2000, p. 21).

The amount of water pumped in summer is often two times higher than the year-round average, and in some communities varies up to three times the year-round figure. Groundwater suppliers, which typically do not have much storage capacity, must pump the highest volumes of water in summer, when demand is highest. This high demand coincides with the period when the natural system's capacity to provide water is the lowest. The increased pumping during the natural low-flow season is a crux of the problem regarding water supply.

The communities of Beverly, Danvers, Lynn, Middleton, North Reading, Peabody and Salem use surface water for all or part of their municipal supplies. The towns of Hamilton, Lynnfield, Reading, Topsfield, Wenham and Wilmington use groundwater wells to supply 100% of their current supply. Ipswich obtains some of its water supply from groundwater wells in the Ipswich basin, but its principal supply is derived from surface water reservoirs in the Parker River Basin. Boxford does not have a municipal water system, but residents living in the Ipswich River watershed draw groundwater from the Ipswich Basin, as do residents in North Andover living in the basin, and those in other towns on private wells.

The Salem-Beverly Water Supply Board (SBWSB) has a reservoir system including Longham Reservoir, Wenham Lake and Putnamville Reservoir. Longham Reservoir and Wenham Lake, both in the Miles River subwatershed, are sources of water. Putnamville is a storage reservoir. Water is pumped to Putnamville Reservoir and Wenham Lake from the Ipswich River in Topsfield, and stored for year-round use. Pumping from the river occurs between December and May when flows at the Ipswich gage exceed 28 Mgd. The Cities of Beverly and Salem are 100% supplied from the Ipswich River watershed sources. A small section of the town of Wenham is also supplied by these sources.

The City of Peabody has a series of reservoirs in both the Ipswich and North Coastal watersheds, and several groundwater wells. The City of Peabody pumps water from the Ipswich River in Peabody between December and May (when flows at S. Middleton exceed 15 Mgd), and stores the water in reservoirs for year-round use. The reservoirs are located in the Norris Brook subwatershed. The groundwater wells have been inactive since the mid-1980's due to contamination. Reactivation of these wells will draw water from the groundwater in the Norris Brook subwatershed and will lower baseflow to Norris Brook and the Ipswich River. The City also purchases up to 1 Mgd from the Massachusetts Water Resources Authority (MWRA).

The City of Lynn diverts water from the Ipswich River near Wills Brook in North Reading, between December and May, when flows at the South Middleton gage exceed 10 Mgd. The water is stored in reservoirs located outside the Ipswich basin, for year-round use. The primary water source for the City of Lynn is the Saugus River.

The Town of Danvers supplies water to Danvers and part of Middleton, from water sources located in Middleton and North Reading. The main source is surface water, from Middleton Pond and the Emerson Brook Reservoir, with emergency supply from Swan Pond in North Reading. Danvers also has groundwater wells located adjacent to the Ipswich River, which it hopes to reactivate to supply water during the high-flow season, so that its reservoir capacity can be saved for the low-flow season.

The Town of North Reading operates groundwater wells in the Ipswich River watershed, and imports up to 1.5 Mgd of water supply during the summer from Andover (surface water, Merrimack Basin) to supplement its summer supply.

The Town of Ipswich's primary supply is from surface water reservoirs in the Parker River watershed. There are several groundwater wells located in the Ipswich River watershed, which are used seasonally (primarily in summer) to supplement supply.

The Town of Lynnfield receives part of its water supply from MWRA, and part from groundwater sources in the Ipswich River watershed. The Town of Lynnfield recently activated the first deep bedrock well for municipal supply in the Ipswich River watershed.

The Towns of Hamilton, Reading, Topsfield, Wilmington and Wenham are currently 100% supplied by groundwater wells in the Ipswich River watershed. Reading and Wilmington are investigating the possibility of purchasing water from the MWRA system.

The Town of Boxford has no municipal water supply system. Residences and other buildings located in the Ipswich River watershed draw water from private and small public on-site groundwater wells. North Andover's public supply is from the Merrimack River basin, though a few (less than 1%) of the residences in the Ipswich River watershed have private wells. Historically, those homes in North Andover that lie within the Ipswich River watershed have discharged their wastewater via on-site septic systems. Recent trends have been to extend sewers into these areas of North Andover and discharge water back to the Merrimack River basin. Other communities where private wells supply a significant number of homes include Topsfield, Middleton, Ipswich, Hamilton and Wenham.

The communities of Essex, Gloucester, Manchester, and Rockport (that are outside the basin) had legislated water rights to the Ipswich; however, changes in state water management legislation makes it unlikely those rights could ever be exercised.

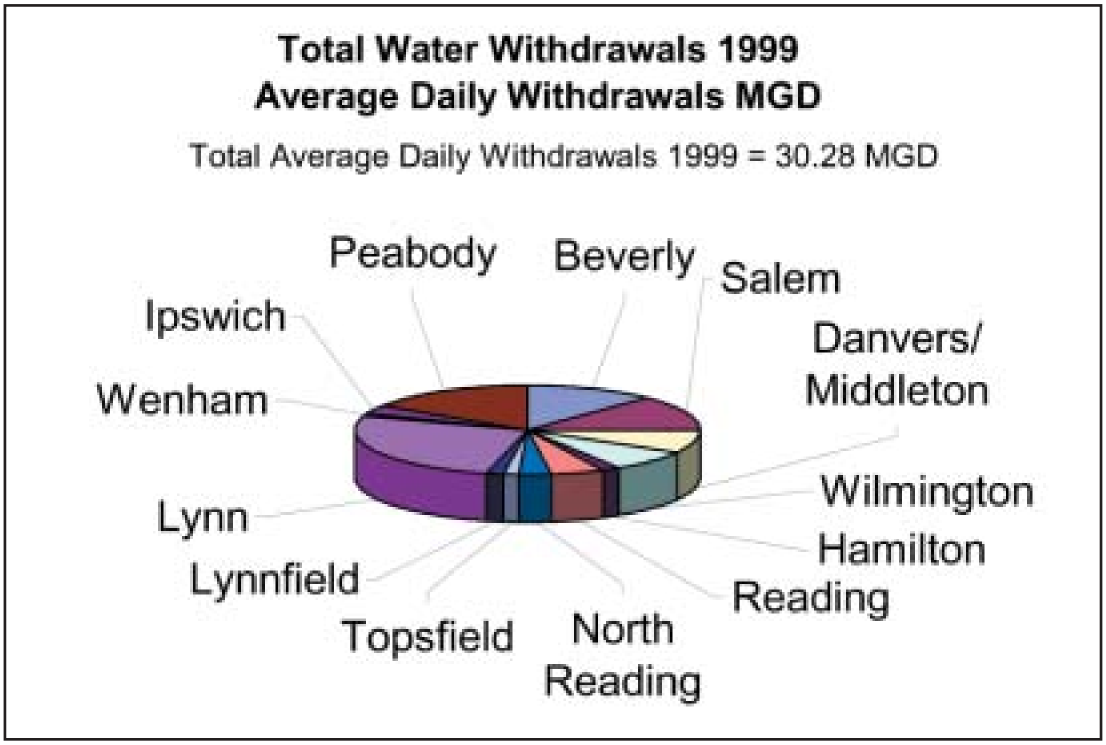
http://www.ipswichriver.org/

Table 1. Water Withdrawals and Interbasin Transfers in the Ipswich Watershed

Town	% Supply From Ipswich Basin	Surface or Groundwater Withdrawal	Average Daily Withdrawal 1989-1993 (Mgd) (USGS, 2000)	Average Daily Withdrawal 1999 (Mgd)	Wastewater System
Salem-Beverly Water Supply Board	100%	Surface water (Ipswich River & reservoirs)	10.13	10.02	Sewered discharge to Salem Sound
Danvers/Middleton	100% (3.2% from wells)	Surface water; supplemented by groundwater wells	3.42 (0.11 from wells)	3.39 (0.11 from wells)	Danvers sewered, discharges to Salem Sound. Middleton on-site septic systems
Wilmington	100%	Groundwater wells	2.53	3.07	Partially sewered to MWRA/Boston Harbor
Reading	100%	Groundwater wells	2.36	2.05	Sewered discharge to MRWA/Boston Harbor
Lynn	16%	Surface water diverted from Ipswich and Saugus Rivers	1.75 (average 1989 and 1993 data)	1.68 (total pumping was 10.17)	Lynn Sewer/ Wastewater System/ discharge to ocean
North Reading	100%	Groundwater wells; supplemented by surface water from Merrimack basin	0.86	1.19 includes water from Merrimack basin	One industrial area is sewered to MWRA/ Boston Harbor; the rest of town is on-site septic systems
Hamilton	100%	Groundwater wells	0.70	0.66	On-site septic systems
Lynnfield	100%	Groundwater wells; deep bedrock well	0.31 (not including 4 new wells built in 1997)	0.71	On-site septic systems
Topsfield	100%	Groundwater wells	0.49	0.53	On-site septic systems
Wenham	100%	Groundwater wells	0.32	0.39	On-site septic systems
Peabody	90%	2 wells and surface water diversion from Ipswich	3.7 (total pumping was 6.28; 0.07 from wells)	0.08 (total pumping was 5.31)	
Ipswich	17%	Surface water (Parker basin) plus groundwater wells (Ipswich & Parker)	0.21 (Ipswich wells)	0.21 (Ipswich wells)	Partial sewer discharge to Ipswich River estuary; remainder on-site septic systems
Sagamore Spring Golf Course in Lynnfield	100%	Groundwater and Surface water	0.006 from groundwater, 0.053 from surface water	N/A	On-site septic systems
Thompson Country Club in North Reading	100%	Deep bedrock well	0.023 (April-Nov)	N/A	On-site septic system
Boxford	N/A	Private and small public groundwater wells	N/A	N/A	On-site septic systems
Andover, Billerica, North Andover, Tewksbury	N/A	Outside basin sources (some private wells in North Andover are in Ipswich Basin)	N/A	N/A	Partial sewer; remainder on-site septic systems

N/A = No available data, impacts believed to be minimal

Figure 4. Total Water Withdrawals 1999



4.4 The Importance of Groundwater Recharge In Maintaining River Baseflow

4.4.1 Natural Groundwater Recharge

What keeps a river flowing when it is not raining? The answer is baseflow – water flowing into the river from the ground, which supplies the flow not provided by direct precipitation, snowmelt or runoff. River baseflow results from the total amount of precipitation in a river's drainage basin that infiltrates into the subsurface and recharges the groundwater, subsequently discharging into the river. Reduced baseflow in the Ipswich River has caused ecological damage including fish kills, habitat modifications, and increased pollution as the reduced amount of water in the river prevents proper assimilation of wastes.

The quantity and rate of groundwater recharge is affected by several factors, including precipitation, soil type, percent of pervious vs. impervious surface material, and the location and rates of water withdrawal and disposal. The most important factors which offset groundwater recharge and baseflow are groundwater withdrawals for municipal water supplies, interbasin transfers including water supplies and wastewater transfers out of the basin (sewers). The development of impervious surfaces and traditional stormwater management practices actually reduce the effective recharge rate and subsequently baseflow.

Groundwater recharge is enhanced by permeable soils, reduced slopes and natural vegetation. In the Ipswich River watershed, permeability of soils varies considerably, from the sand-gravel deposits that predominate in the upper watershed to the glacial till of the northern/central and lower watershed. Slopes in the upper watershed and along the river mainstem are generally slight, with a total elevation change from the headwaters to the sea of only 110 ft. However, sections of the watershed, including subwatersheds of key tributaries, do exhibit steeper gradients, associated with drumlins (glacially-formed hills). Sand-gravel deposits and low slopes result in greater groundwater recharge, and higher potential for baseflow. Glacial till and steeper slopes are associated with lower groundwater recharge and lower baseflow.

The relationship of natural vegetation and groundwater recharge is somewhat more complex. Natural vegetation intercepts rainfall, slowing its impact on the ground, which has an effect of increasing infiltration into the ground and diminishing runoff. The consistency and structure of humus and root structures of trees and shrubs also enhances infiltration. That water that remains in the root zone is subject to evapotranspiration, while water that penetrates deeply to the water table (recharges) becomes part of the groundwater storage.

Wetlands are complex natural systems in terms of surface-groundwater interaction. Wetlands act as huge sponges, absorbing water during rain and high flow events, and releasing it slowly back to surface water. Because groundwater is at or near the surface in wetlands, this water is within the root zone of wetland vegetation, which results in higher evapotranspiration rates in wetlands than in the drier portions of the landscape. In addition, the soils and subsurface structure of wetlands may enhance interchange with deeper groundwater, or may serve as impediments to exchange of water, depending on the soil structure and other conditions.

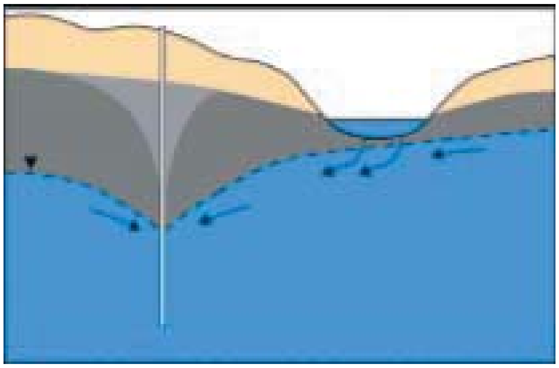
4.4.2 Impacts of Groundwater Withdrawals

Baseflow to the river is affected by pumping wells located within the watershed. Pumping a well intercepts groundwater that would otherwise flow into the river as baseflow, thus reducing the river's source of water to keep it flowing.

In addition, wells located near the river or its tributaries can cause induced infiltration. The effect of pumping a well is to lower the groundwater table at the well into a "cone of depression." This cone changes the slope of the groundwater table, creating a gradient from the nearby river toward the well, thus "inducing infiltration" from the river to the well. In the Ipswich River watershed, a number of municipal wells completely dewater the riverbed through these processes.

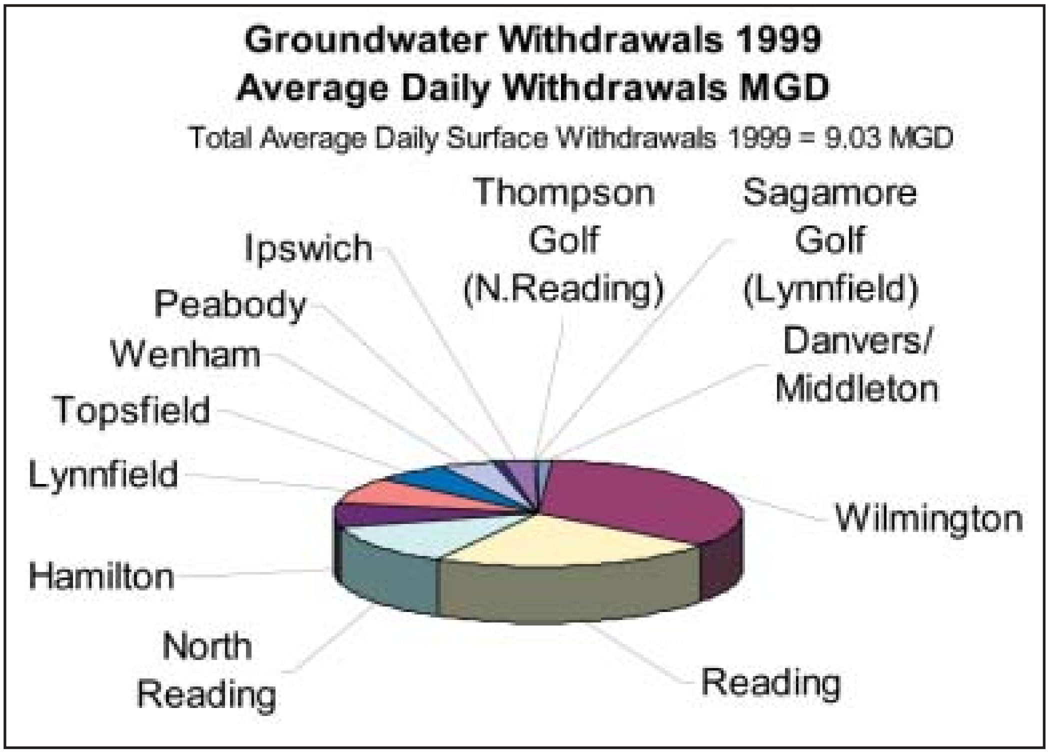
a) intercepting groundwater baseflow that would otherwise discharge into the river, supplying flow; the result is reduced surface flow;

b) inducing infiltration, thus causing surface water from the river or stream to flow from there through the ground and into the well; the results are reduced surface flow, dry riverbeds in the vicinity of the wellfield, and reverse flow



These effects of groundwater pumping are exacerbated because municipalities relying on this source must pump the most water in summer-early fall to meet high seasonal demand. This pumping occurs exactly when the natural system can least afford it. These suppliers typically have storage capacity sufficient to meet demand for only a few days at most. There are no large-scale storage sites available in the entire watershed, with the exception of the Topsfield reservoir site owned by the Salem-Beverly Water Supply Board. Figure 5 shows groundwater withdrawals by town in 1999.

Figure 5. Groundwater Withdrawals 1999



As part of the USGS study, scenarios were modeled evaluating how much streamflow reduction was caused by different factors. They found that at South Middleton, the effects on the 7Q10 low flow were as follows:

Actual flow with current land use and current water withdrawals:	0.35 Mgd
Simulated flow: current land use, no groundwater withdrawals:	2.65 Mgd
Simulation: undeveloped land use, no groundwater withdrawals:	3.75 Mgd

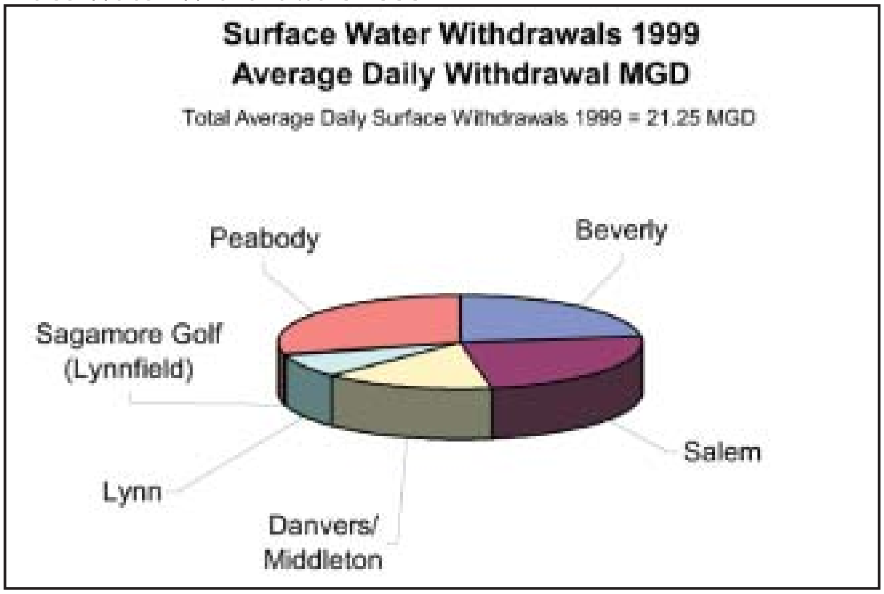
This simulation represents the 7Q10 flow at S. Middleton gage.
7Q10 refers to the statistical 10-year low flow over a 7 day period.

4.4.3 Effects of Surface Water Withdrawals

Diverting surface water from the Ipswich River from December to May, and storing the water in reservoirs for year-round use, is not a significant factor causing the extreme low-flows of summer to early fall in the Ipswich River system. These withdrawals represent the largest amount of water withdrawn from the Ipswich River system, but are actually more benign than the year-round (especially summer) withdrawals by municipal wells.

However, concern does exist about impacts of surface water diversions during the actual pumping period, December to May. During occasional years when flows are low in winter and/or spring, pumping can significantly alter the flow patterns. In some years, flows at the Ipswich flow measuring gage are lower than at the South Middleton gage – a phenomenon that sometimes occurs as a result of pumping that takes place between the two gages. Pumping from the river during that period is allowed to occur below flow thresholds important for the protection of fisheries and other interests. The combined pump capacity could result in removing more than two thirds of the river's flow at a given time. There is also concern that reduced flow in winter may result in more rapid freezing, affecting survivability for fish. In spring, reduced flows may affect the trigger flows needed for anadromous fish migration and other ecological functions of high flows.

Figure 6. Surface Water Withdrawals 1999



The thresholds in question are:

Water Supplier:	Current Diversion Threshold:	USFWS ABF Threshold: (November – February)
City of Lynn	10 Mgd @ S. Middleton gage	>28 Mgd @ S. Middleton min
City of Peabody	15 Mgd @ S. Middleton gage	>28 Mgd @ S. Middleton min.
SBWSB	28 Mgd @ Ipswich gage	>80 Mgd @ Ipswich min.

Water suppliers' concerns are that they will not be able to pump sufficient water during the pumping period, if the diversion threshold were to be raised to the fisheries standard. This project will consider alternatives that would enable the water suppliers to meet demand, while still preserving flows needed to support healthy aquatic ecosystem and other values. These alternatives include: reducing demand; increasing pump and storage capacity, and adaptive management approaches.

Other considerations regarding surface water diversions and reservoir storage include:

- Impacts of proposed reservoir construction on wetlands/ outstanding resources;

- Potential for the river to support additional diversions, especially during "dry" winters and springs, and

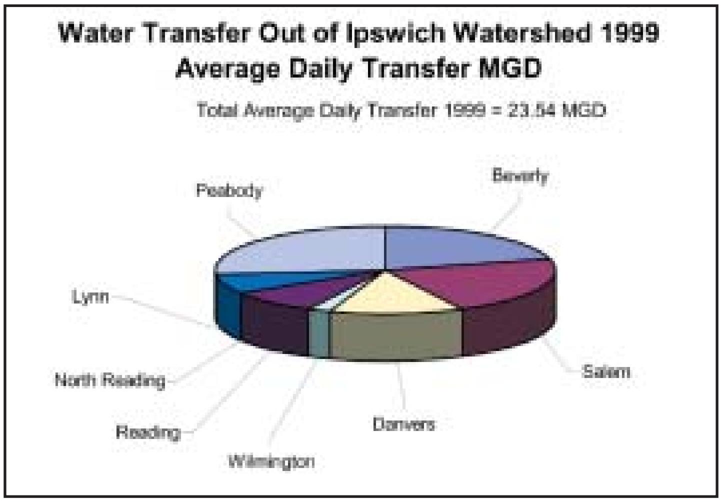
- Potential for water stored in reservoirs to be part of the streamflow solution, through either controlled releases or servicing as a regional resource to help other communities meet demand while reducing groundwater pumping.

4.4.4 Transfer of Water Outside of the Watershed

An interbasin transfer occurs when water (including wastewater) is transported from one watershed to another. The Massachusetts Interbasin Transfer Act (M.G.L. c.21, §8C) regulates some interbasin transfers. To be regulated under the Act, transfers of water must cross not only a watershed boundary, but also a town/city boundary. Transfers that predated the passage of the Act were "grandfathered," including most of the Ipswich River watershed transfers. Additional transfers of wastewater due to expansions of sewer systems have been ruled exempt from review by the Massachusetts Water Resources Commission.

The Ipswich River watershed is subject to a very high loss of water via interbasin transfers. These transfers include water that is pumped from the Ipswich River watershed sources, and then used for water supply elsewhere, as well as wastewater that is transported via sewers out of the watershed to treatment plants, and then discharged into Salem Sound, Boston Harbor or the Atlantic Ocean. The end result is that, of the water pumped from the Ipswich River watershed sources by municipalities, 80% is discharged outside the Ipswich River watershed, resulting in a net loss of 23.54 Mgd on average. In addition, sewers can remove groundwater and stormwater that leaks into them, resulting in additional unaccounted for water losses.

Figure 7. Water Transfer Out of Ipswich Watershed 1999



Transfer of water outside of the basin via sanitary sewers reduces artificial recharge and thereby reduces groundwater supplies. Older sewer systems, which receive stormwater flow in addition to wastewater, are particularly effective at transporting water outside of the basin and reducing groundwater recharge. Infiltration and inflow typically account for 55-65% of the total flow in a sanitary sewer, and sometimes more. Thus sewers are a major conveyor of water out of the Ipswich River watershed. The watershed loses not only the recharge of the water component of wastewater, but an equivalent or higher amount of clean groundwater, plus stormwater that could otherwise recharge groundwater and subsequently supply flow to the river.

All the sewers in the upper and middle Ipswich watersheds transfer this water completely out of the watershed. The upper Ipswich communities that are currently completely or partially sewered (Burlington, Wilmington, Reading, Andover, North Andover) transfer water to the MWRA Deer Island plant and Boston Harbor, or the Lawrence Sewer District and Merrimack River. The mid-basin communities (Peabody, Danvers, Beverly) transfer water to the South Essex Sewerage District and Salem Harbor. The Cities of Salem and Lynn are not located in the Ipswich River watershed, but receive water supply from the Ipswich, which is then sewered to treatment plants and discharged to Salem Sound/ Atlantic Ocean.

There are very few interbasin transfers of water into the Ipswich River watershed to compensate for these issues. Currently, the Town of North Reading imports water from Andover (Merrimack Basin) in the summer. The Towns of Reading and Wilmington are investigating purchases from the Massachusetts Water Resources Authority (MWRA), which would be subject to Interbasin Transfer Act review.

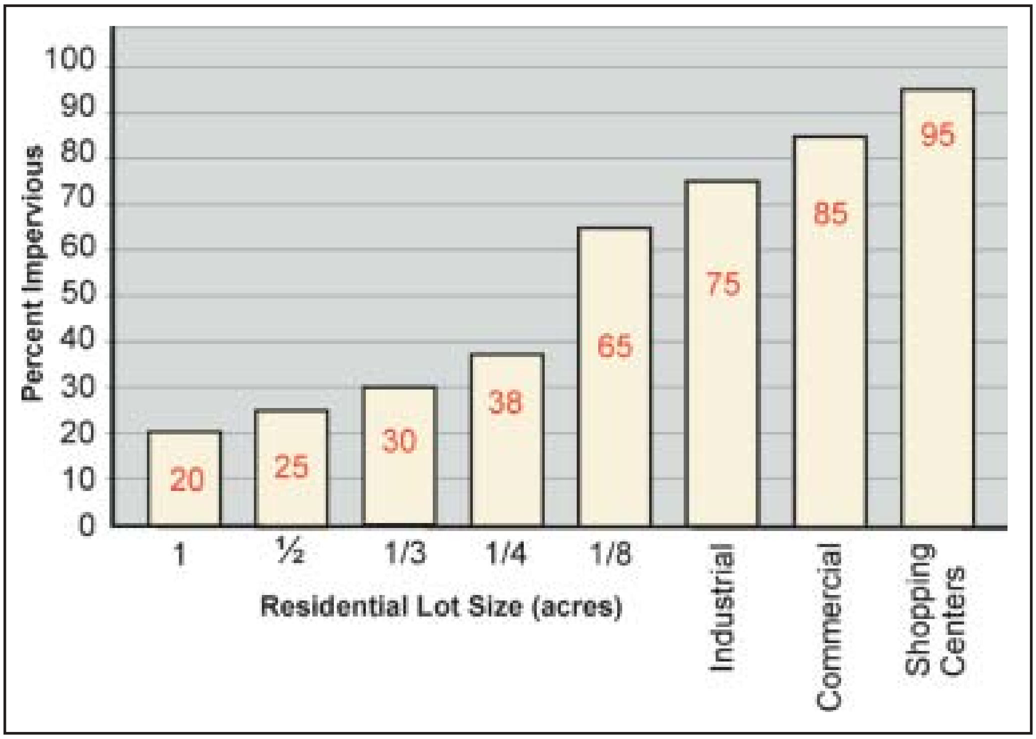
Use of suitably treated wastewater to recharge the aquifer could address this major shortcoming of conventional sewerage. Treated wastewater is commonly used to recharge the aquifers throughout the nation.

4.5 Effects of Impervious Areas

4.5.1 Reduced Recharge of Groundwater

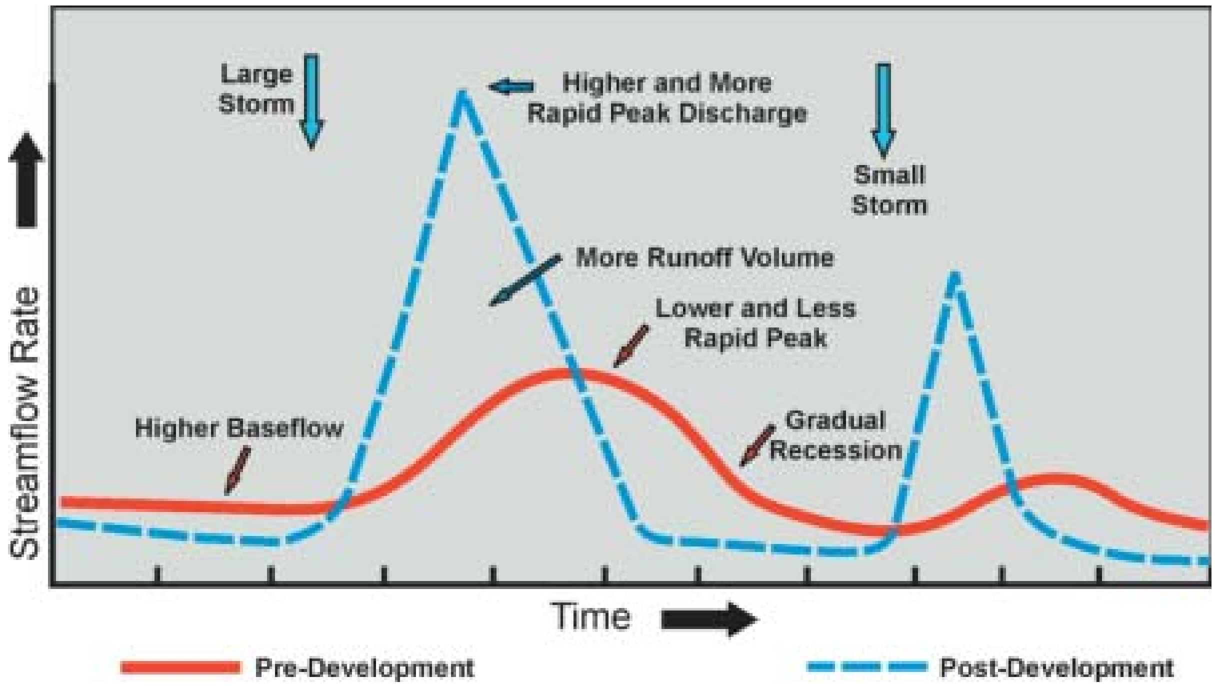
Changing land use can also reduce groundwater recharge, particularly when the area of impervious surface increases over time. The natural capacity of the soils for recharge are masked and sealed off by the placement of impervious surfaces of them. Constructing hard surfaces on the land – buildings and structures, roads, parking areas, even the compaction of soils in many lawn areas and construction sites – results in diminished infiltration of water into the soil and groundwater recharge.

Urbanization within the Ipswich River watershed has caused an increase in impervious land cover. Impervious cover is made up of all man-made hard or paved surfaces, including rooftops, roads, parking lots, driveways and sidewalks, which do not allow groundwater infiltration.



4.5.2 Increased Runoff Rates

Impervious surface area is an important factor in channelizing surface water flow. The sheet flow velocity of runoff from a paved surface is about 10 times faster than over a vegetated surface (Schueler, 2000, p. 7). The amount of impervious surface is considered the most critical factor when estimating the rainfall-runoff relationship in a watershed. Increased impervious land cover within the Ipswich River watershed has resulted in reduced water infiltration to groundwater, increased flooding, as well as potentially harmful effects upon water quantity and quality, biodiversity and wildlife habitat.



Studies have found that when 11-25% of a watershed area is converted to impervious surfaces, streams are considered "impacted." When watershed imperviousness exceeds 25%, streams are considered to be "degraded," and to suffer severe and unavoidable environmental damage. These correlations indicate that stream degradation can occur with 10-20% development of a watershed. Impacts can include reduction of water quality, stream channel erosion and instability, habitat loss and decreased biodiversity (Schueler, 2000, p. 7).

In the upper Ipswich watershed, approximately 12% of the area is impervious (Zariello and Ries, 2000). Existing stormwater management practices tend to channel urban stormwater runoff directly into the river and wetland, or into catch basins, which do not function to infiltrate the water. While this method returns water to the river quickly, resulting in higher flows during storm events, it robs groundwater of the replenishment it needs to support river baseflow plus water withdrawals for human use.

The USGS modeled several scenarios to estimate the amount of streamflow reduction that is attributable to imperviousness/ land use change. The results for the upper Ipswich watershed indicated a significant reduction (29%) in the loss of flow.

Flow simulation with natural land use and no water withdrawals:	3.75 Mgd
Flow simulation with current land use and no water withdrawals:	2.65 Mgd
Reduction attributable to land use change:	1.1 Mgd

The simulation for the lower watershed indicated a less significant role of imperviousness in causing streamflow reduction. In addition, surface water runoff carries pollutants directly into surface waters without the filtering action normally performed by soils. Thus, imperviousness alters not only flow in the river but decreases water quality by carrying untreated contaminants carried on particles into the river.

4.6 Dams

In total, there are over 30 dams on tributaries and the mainstem of the Ipswich. Some of these impoundments were built for surface water supply storage, power supply to former mills, and/or for recreation. Three dams continue to impound sections of the river; one in Middleton and two in Ipswich. A number of small dams still exist, in various state of function/ disrepair, on the tributaries.

Dams significantly alter the flow and ecology of a river or tributary in a number of ways. Dams store water upstream, and diminish flow downstream – sometimes totally, leaving the downstream reach dry. In storing water upstream, they also transform a flowing river into a pond – a different type of resource. The creation of standing open surface water increases losses to evaporation.

When this pond is formed, it floods an area that was previously valuable in a number of ways. First, dams almost always flood bordering vegetated wetlands. The deeper ponded habitat is a different habitat that provides different functions than the wetlands it supplants. Dams were typically sited on areas with significant grade – the very riffle habitat that is so scarce in the Ipswich River watershed. The flooded area upstream often covers a riffle, essential in aerating the river and providing habitat. In transforming this area into a pond, the riffle is lost, and the ponded water tends to be warmer and lower in oxygen.

Dams also trap sediments, nutrients and pollutants. Dams impede fish movement, including migration of anadromous fish into their spawning habitat, and movement of freshwater species in and out of tributaries when seeking food, spawning areas or refuge during drought.

Attitudes towards dam removal have changed greatly in recent years. Small dams that were used historically but are no longer functional are being removed at an increasing rate. This effort is gaining support by environmental regulators and citizens alike. Dam removal does require study to understand the alterations that will occur as the river reverts back to its natural state. Some of the issues that need to be understood in considering a dam removal project include:

- Sediment contamination upstream of the dam
- Wetland alterations (gains and losses, wetland types, invasive species, etc.)
- Fish habitat alterations
- Human values associated with the ponded water (water supply, recreation, aesthetics)
- Downstream flooding of developed areas

While there is no intent in this report to consider removal of any dams used to impound water for water supply, the following impacts nevertheless are associated with such dams:

- Reduced flow to tributary/ river downstream of the dam, which may affect flows during low-flow periods; some downstream reaches are totally de-watered for months as a result of impoundments for water supply
- Increased evaporation of impounded water

On the positive side, impounded water may be used not only as a source of water supply, but also as a means of increasing infiltration and distributing water to augment streamflow during dry periods. Such management requirements are typical in many hydrologically-stressed systems, such as those in the arid West. Reservoirs along major rivers such as the Colorado, Columbia, Snake and others, are periodically used as a source of water for controlled releases during low-flow or drought periods, in order to sustain riverine ecosystems (ref: Grand Canyon and Colorado River Management Plan, etc.)

4.7 Summary

The most significant cause of the extreme low-flow/no-flow problems of the Ipswich River is the reduction of baseflow due to groundwater withdrawals for water supplies (USGS, 2000). Such man-made withdrawals have reduced the average low-flow of the river to nearly one-tenth of its natural low-flow rate during summer, at the Middleton gaging station.

5.0 SUMMARY OF ANALYSIS

5.1 Summary of Ipswich River Flow Modeling by the USGS

5.1.1 Summary of the USGS Model (USGS, 2000)

In order to better understand the effects of water withdrawals on streamflow conditions in the Ipswich River, the USGS developed a precipitation–runoff model in 2000 (Zarriello, USGS, 2000). Various simulations were made using the model to determine the impact of different water and land use patterns on streamflow. The findings of the report help to paint a clearer picture about the intricate nature of the way water travels through the Ipswich River Basin, and how human activities within the basin affects the River's volume and flow.

The USGS's Ipswich River model can be summarized into three basic steps. Data was collected and compiled, a computer program, Hydrological Simulation Program-FORTRAN (HSPF), along with associated software, was used to create a computer model of the River Basin; and finally, the model was calibrated to ensure its accuracy. The data for the model were obtained from various sources and include information such as:

- Land use and soil types obtained from MassGIS which were used to segment the watershed into areas of similar response to water infiltration;
- Meteorological information (including precipitation, evapotranspiration, snow buildup and melt) gathered from 30 weather stations around the area to determine precipitation and tendency for evaporation;
- Water withdrawal information was obtained from local water suppliers along with information from the Massachusetts Department of Environmental Protection (DEP) for the period beginning January 1, 1989 through the most recently available information at the time of the analysis; and
- Observed daily flow data for the Ipswich River taken from the USGS gaging stations at South Middleton and Ipswich, which date back to the 1930's.

The Ipswich River Basin model was calibrated for the period of January 1, 1989 to December 31, 1993. It should be recognized that land development and its associated water demands since 1993 are not reflected in the analysis. The study period was chosen for calibration because accurate water withdrawals could be obtained or estimated for this period, and because 1991 land use data were used to define the geographical portion of the model. By comparing the modeled flow levels with the observed flow levels at the South Middleton and Ipswich gaging stations, it was possible to determine the model's accuracy.

The following hypothetical scenarios were identified by the Ipswich Task Force and simulated using the calibrated model:

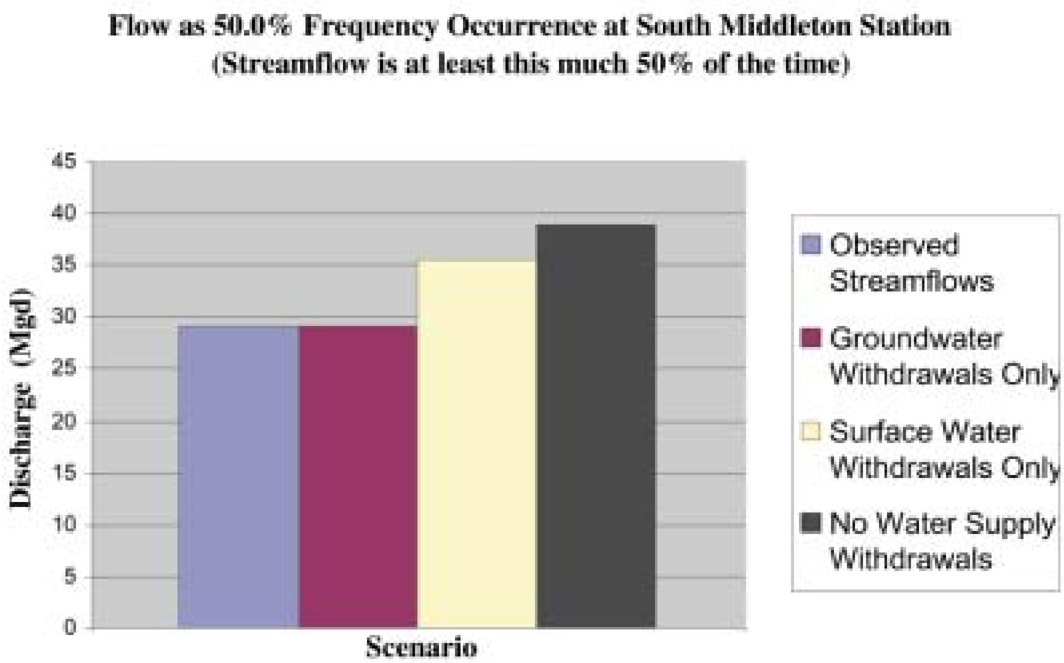
1) Stop all withdrawals during the 1989-1993 calibration period.
2) Allow only groundwater withdrawals for the 1989-1993 calibration period.
3) Allow only surface water withdrawals for the 1989-1993 calibration period.

4) Simulate long-term (1961-1995) streamflows with 1991 land use conditions as developed in the calibrated model, and stop all withdrawals.
5) Simulate long-term (1961-1995) streamflow conditions by reverting developed land to undeveloped land and stop all withdrawals
6) Simulate long-term (1961-1995) streamflows in response to average 1989-1993 water withdrawals.

Results of running the first three scenarios showed that when comparing no withdrawals to only surface water withdrawals, similar effects on low-flow occurrences occurred in the Ipswich River. Additionally, when the model was run with only groundwater withdrawals it was found to be very similar to the simulation of the 1989-1993 flow conditions (existing condition). These findings are illustrated at both the South Middleton Station and the Ipswich Station. A flow duration graph shows the percent of the time or frequency that a discharge in a stream will be exceeded. Less than 50% of the time, the first three scenarios and the existing condition simulation were similar at both gaging stations at high to medium flows (Figure 8.). However, during low-flow periods groundwater withdrawals have a large impact on the flow in the Ipswich River. Surface water withdrawals do not show a significant impact because they are not allowed to occur during low-flow conditions (see Figure 8).

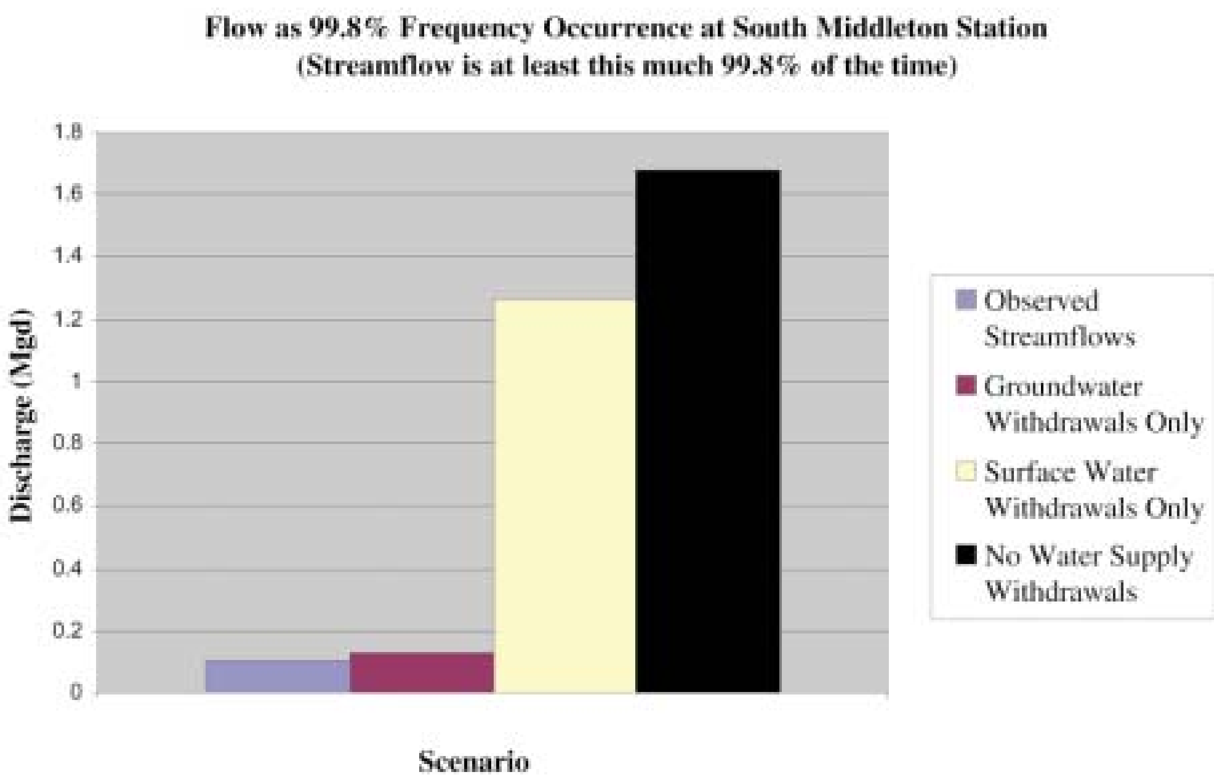
The following bar graphs illustrate the simulated discharge rates in cubic feet per second at different exceedance probabilities for the first three simulations and the baseline at the South Middleton station. Similar results were demonstrated in flow duration curves at the Ipswich Station, but due to the relative higher rate of groundwater water supply withdrawals compared to streamflow at the South Middleton Station, the impact at South Middleton Station is more dramatic.

Figure 8.



High flow rates, greater than 387.8 Mgd, at the South Middleton station occur occasionally (0.05% of the time); at this high flow there is no observable difference between the modeled scenarios. At lower flows, the difference in modeled scenarios is more dramatic. The differences between the scenarios becomes more apparent in the higher frequency flow occurrences. At a 99.8% flow exceedance probability, the impact of groundwater withdrawals becomes apparent during low flows. The surface water withdrawals do not significantly affect the low flows and have a minor effect on the 50% flows.

Figure 9.



The USGS also modeled the Ipswich River under long-term conditions (Scenarios 4-6 above) and as a result were able to create seven day/ten year low flow graphs (7Q10). The 7Q10 is a commonly used flow statistic, and that estimates the likely minimum low flow for seven consecutive days on average once every ten years. As in the flow duration graphs, they demonstrate that groundwater withdrawals have an especially large and diverse impact during low flow conditions.

Seven day/ten year low flows were modeled for the Ipswich River at the South Middleton and Ipswich Stations under scenarios with 1991 land use and no withdrawals, undeveloped land and no withdrawals, and with 1991 land use and 1989-1993 withdrawals. At South Middleton Station, the modeled results were:

- A 7Q10 of 2.65 Mgd for 1991 land use and no withdrawals (scenario 4);
- A 7Q10 of 3.81 Mgd for undeveloped land and no withdrawals (scenario 5);
- A 7Q10 of 0.35 Mgd for 1991 land use and 1989-1993 withdrawals, which represents less than 1% of the natural 7Q10 flow (scenario 6).

Similar 7Q10 flows were found at the Ipswich Station: 5.36 Mgd, 5.3 Mgd, and 1.74 Mgd, respectively. This data further reinforces the evidence that groundwater withdrawals have a large impact on low flows.

5.1.2 Summary of the Effects of Alternative Water Management Options on Streamflow in the Ipswich River (USGS, 2002)

Using the initial precipitation runoff model, the USGS modeled alternative management options being considered by the Ipswich River Watershed Management Council to restore flow to the Ipswich River. In an effort to provide a means to ensure effective management strategies, scenarios were modeled to examine the outcomes of reducing withdrawals, returning wastewater to the river basin, and combinations of both. The modeling focused on the upper reaches of the Ipswich River, where the low flow problems were most common due to the ratio between high withdrawal rates and naturally low streamflow. While natural flows can be expected to be relatively low (compared to the lower reaches of the river) existing conditions are significantly lower than natural conditions as a result of water withdrawals (including groundwater wells). In this area even relatively small rates of withdrawals will have significant impacts.

Management alternatives modeled within the spectrum of withdrawal rates included:

1) Ending “seasonal” (May 1st to October 31st) withdrawals.
2) Limiting withdrawals to periods of a minimum flow threshold (0.49 cfs/mi2 or 14.22 Mgd at the South Middleton gage station).
3) A 20% reduction in “seasonal” withdrawals.
4) A 50% reduction “seasonal” withdrawals.
5) A 20% increase in withdrawals.

Within the scope of wastewater management options:

1) Return 1.1 Mgd to the basin.
2) Return 1.5 Mgd to the basin.
3) Return 1.7 Mgd to the basin.
4) No septic effluent (reducing wastewater returned to the basin by sewering existing septic systems).

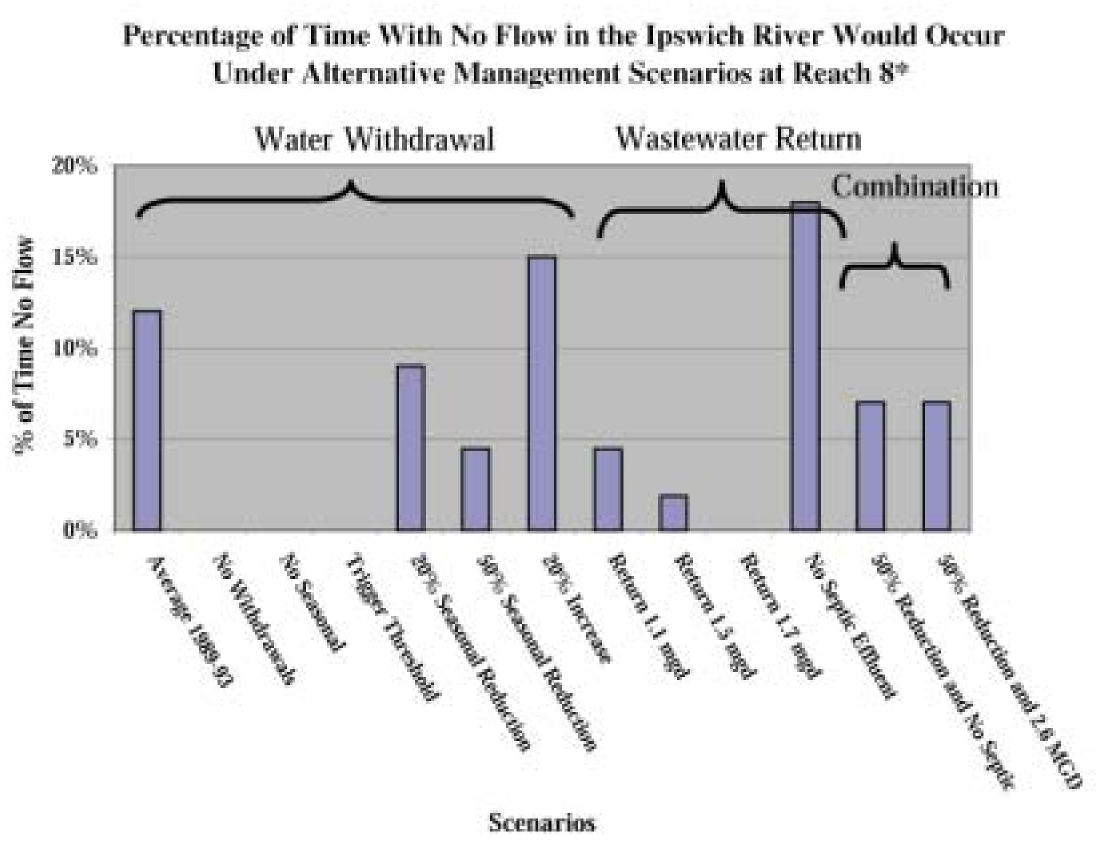
Lastly, combinations of management alternatives were considered:

1) 50% reduction of seasonal withdrawals and no septic effluent.
2) 50% reduction of seasonal withdrawals and 2.6 Mgd of treated wastewater returned to the basin.

The results of these scenarios were reported for the reaches of the river near the Reading pumping stations (referred to in the USGS model as reach 8) and the South Middleton gaging station (reach 19). The results were reported in flow duration curves, 7Q10 flows and annual hydrographs compared with the lowest flows ever recorded in the Ipswich which occurred in 1993.

For the stream reaches near the Reading pumping stations, the river still runs dry for a significant number of the management options (Figure 10).

Figure 10.



* Reach 8 begins at Mill Street at the Reading/North Reading boundary

However, the following scenarios maintain some flow in the river at all times:

1) A combination of reducing seasonal withdrawals by 50% (approximately 2.97 Mgd) and returning 2.6 million gallons of treated wastewater per day to the watershed. The model indicates that the flow would be greater than the flow in the no withdrawal scenario for reach 8 and close to no withdrawal flows in reach 19.
2) Stopping all “seasonal” (May 1 to October 31) withdrawals.
3) Limiting withdrawals in headwater reaches to periods when the streamflow in the Ipswich

is at or above the minimum aquatic habitat threshold of 0.5 cfs/mi2. The aquatic habitat threshold rate equates to a flow of 5.98 Mgd in reach 8 and 14.22 Mgd at the South Middleton station. This scenario is almost equivalent, in terms of beneficial impacts to the river, to stopping all withdrawals.

4) Infiltrating 1.7 Mgd wastewater return.
5) No withdrawals.

Based on the modeling, it is possible to define management actions to restore constant flow to the Ipswich River although the volumes of water that would need to be conserved, acquired elsewhere, or reused within basin are significant.

5.2 Aquatic Habitat Studies in the Ipswich River

The Ipswich River's native fisheries are seriously degraded as a result of flow alterations caused by water withdrawals and diversions, dams and changes in land use that increase imperviousness and deplete groundwater through sewer I/I. The users of developed land have a greater demand for water supply than undeveloped land. These flow alterations have resulted in a loss of habitat and an altered ecosystem dominated by species that are macrohabitat generalists—those which tolerate warm temperatures and ponded conditions—rather than the native flow dependent species. These "substitute" species are not the natural fish community that would exist in flowing conditions, and represent a stressed condition in the river.

In 1998 and 1999, the USGS and Massachusetts Division of Fisheries and Wildlife, in cooperation with the Massachusetts DEP and DEM, examined the existing fish species community and habitats, and the relationship of flow to aquatic habitat within the Ipswich River (Armstrong, USGS, 2001). The study focused upon reviewing methods for establishing minimum streamflows based on minimum habitat requirements (Armstrong, et al., 2001).

In 2000, the Ipswich River Fisheries Restoration Task Group was established to review the available information and compare fish and habitat data with reference rivers to develop a target fish community with the goal of reestablishing a more natural fish community. The Fisheries Restoration Task Group consisted of representatives from Ipswich Watershed Association, Essex County Greenbelt Association, Massachusetts Audubon Society, Massachusetts Department of Environmental Protection, Massachusetts Division of Marine Fisheries, Massachusetts Division of Fisheries and Wildlife, US Geological Survey, Environmental Protection Agency, the US Fish and Wildlife Service, Massachusetts Riverways Program (DFG), National Marine Fisheries Service, and former Massachusetts Watershed Initiative.

The following is a summary of the existing information, reports and conclusions regarding existing aquatic habitats and communities, potential habitat and minimum streamflow requirements needed to restore a more natural flow regime and sustain a healthy riverine aquatic ecosystem in the Ipswich River.

5.2.1 Aquatic Habitat Study

The purpose of the USGS aquatic habitat study was to describe the existing stream habitat and fish communities of the Ipswich River, determine relations between flow quantity and habitat, and determine adequate minimum streamflow requirements to maintain quality aquatic habitat in the Ipswich River (Armstrong, et al., 2001). The study describes macrohabitats that exist within the mainstem and tributaries of the Ipswich River, quantifies the quality of the habitats, and surveys existing fish communities. The study focused on evaluating several methods for establishing minimum low-flow aquatic habitat requirements at four critical low-flow riffle sites and at the two USGS gaging stations. The methods evaluated included the Tennant Method, (Tennant, 1976), the New England Aquatic Base-Flow (ABF) Method (USFWS, 1981), the Wetted Perimeter Method (Nelsen, 1984; Leathe and Nelson, 1986), the R2CROSS Method (Espegren, 1996; 1998), and the Range of Variability Approach (RVA) (Richter, 1996).

The study found that minimum streamflow values for the summer needed to preserve habitat sufficient to support a healthy fish population (using an average of the four methods at four critical riffle sites) ranged from 0.44 cubic feet per second per square mile (cfsm) to 0.65 cfsm. The overall average of all methods at all sites was 0.49 cfsm, which equates to 14.06 Mgd at the South Middleton Station and 39.5 Mgd at the Ipswich station. Three of the four riffle-study sites (Mill Street, Log Bridge Road, and Mill Road) have altered channels affecting results when using some of the methods to determine minimum streamflows. To accommodate for this, the R2CROSS method was applied at the single natural riffle site and the Wetted Perimeter method at the 3 altered sites. The resulting average minimum streamflow was 0.42 cfsm. The Range of Variability (RVA), an alternative to the single minimum streamflow threshold, identifies streamflows defined by the 25th and 75th percentile ranges for monthly mean streamflows. The RVA method evaluates the magnitude, timing, frequency, and duration of low streamflows. Using this approach, Armstrong (2001) reported that restoration could be achieved by maintenance of a minimum streamflow of approximately 0.42 cfsm for the summer period, together with higher streamflow requirements in other seasons.

5.2.2 Existing Habitat Conditions Survey

As part of the USGS study, a survey of the habitat and fish community at several sites was conducted in 1998 and 1999 and included sites at: Russell Street in Middleton, Mill Street in North Reading, Log Bridge Road in Middleton (a former dam), Route 1 in Topsfield where a natural riffle exists, Willowdale dam, and Mill Road in Ipswich. These sites represent natural or altered riffle habitat. The study focused on riffle habitat as it represents an important habitat and a potential ecological "bottleneck" if streamflow is depleted. This ecological bottleneck can occur if the riffle itself is dry or if stream reaches in between riffles are dry, thus creating isolated, segmented pools of water with no ecological connections between them.

The Ipswich aquatic habitat is characterized by low gradient glide pools with sandy streambeds, a partially closed forest canopy over the river, and shrub and grass wetlands adjacent to the river. Riffle and run habitats are uncommon, and most of the remaining ones are associated with artificial features such as areas of fill, bridges, and old mill dams. Many natural riffle and run habitats have been lost due to urbanization and its associated effects. Other representative aquatic habitats occur along the banks and in deeper water habitats such as beaver dams, manmade impoundments, downstream pools and canals. During low flow events, bank habitat is diminished as the water recedes from the banks, eliminating important refuge and foraging habitats for a number of species. During flooding events the overtopping of the banks and saturation of abutting floodplain creates and sustains adjacent wetland habitats. Habitat assessments in the headwaters of the Ipswich River in early summer of 1998 indicate that good habitat is present when sufficient water is available, though in 1999 these areas were dry. Thus good habitat does not appear to be a limiting factor in the Ipswich River if adequate streamflows are maintained (Armstrong, 2001).

A survey of fishes in 1998 and 1999 by the Massachusetts Department of Fisheries and Wildlife reveals a fish community dominated by typical pond or generalist species such as pickerel, American eel, and pumpkinseed. These species are macrohabitat generalists, those that take advantage of and thrive in both standing pools and running water. Macrohabitat generalists comprise ~91% of the existing fish community in the Ipswich river (Figure 11). Fluvial species consisting of creek chubsucker, fallfish, white sucker, sea lamprey ammocoetes and brown trout comprise 8.9% of the total community. Several fluvial species expected to be present such as common shiner, blacknose dace and longnose dace are entirely absent from the fish community. This represents an ecosystem "shift" from a natural population (which developed over several thousand years to a natural stream corridor) to a substitute population which has developed in response to an impacted environment over the past 100 years.

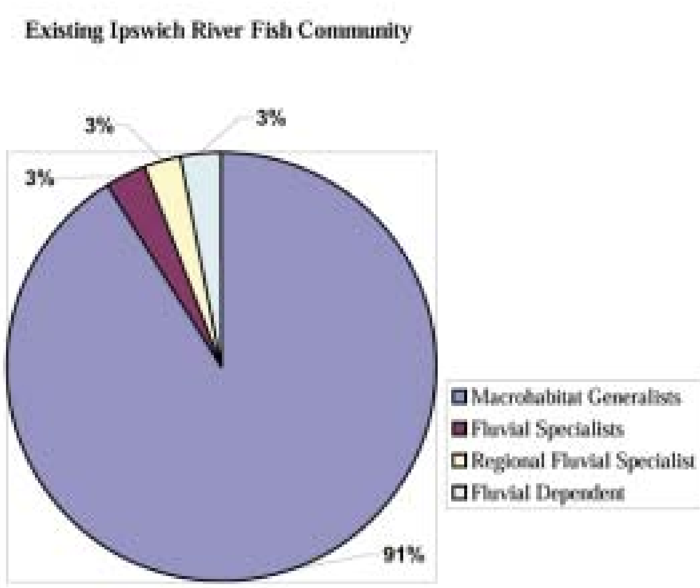


Figure 11. Existing Ipswich River Fish Community

5.2.3 Target Fish Community and Streamflow Recommendations

In developing recommendations for reestablishing a fluvial fish community for the Ipswich River, the Task Group reviewed historical data on the Ipswich, recent reports on aquatic habitat from the USGS and compared the Ipswich with similar coastal rivers which could be used as reference rivers. A survey of similar coastal streams was conducted from Cape Elizabeth, Maine to the southern coastal region of Massachusetts. The Lamprey River in New Hampshire was selected as a suitable reference river due its similar flow and size, geographic proximity, relatively unimpacted condition, and because it contained the expected native resident fish species. Adjustments to the target fish community were made based on the professional judgment of the task force members and fish species data from other streams such as the Quinebaug.

Figure 12 shows the resulting recommended target fish community for the Ipswich River. Fluvial or stream species comprise 66% of the total while generalists account for 29%. Diadromous fish (eels, herring, etc., those that migrate to and from the ocean and river environments) were also included as target fish, but no attempt was made to estimate their abundance due to the wide variations in population that occur naturally in these species.

The Task Group identified the following broad management objectives to restore the Ipswich River's aquatic habitat to a healthier condition:

- Maintain flow over the riffles;
- Maintain water to the channel margins; and
- Maintain seasonal variation in flow which mimics the natural hydrograph.

In order to meet the stated objectives the Task Group recommends that the following minimum streamflows:

- June-October 0.49 cfsm (Action Threshold)
- November- February 1.0 cfsm*
- March-May 2.5 cfsm*

*Provisional recommendations pending further study

The June-October recommendation is suggested as an action trigger flow based on the range of values reported in the USGS study and to provide a margin of safety that recognize flows will continue to diminish below the trigger flow due to a lag time response of groundwater to pumping and natural factors.

The recommendations for November through May are provisional and require further study. The reason for choosing these streamflows is to provide some protection to stream habitats at other times of the year and to mimic the seasonal hydrograph. Concerns over lowered streamflow in the winter include more rapid freezing and freezing of the river bottom having adverse impacts on aquatic habitat. In November there are concerns that juvenile anadromous fish become entrained (sucked) into surface water diversion intake pipes during their downstream migration. Lowered streamflows in the spring may affect the natural functions of high flows, which include river bottom scouring, maintenance of floodplain ecosystems, and triggers for upstream migrating fish. Most of the recommended flows for November through May are lower than the monthly median flows that currently exist in the river.

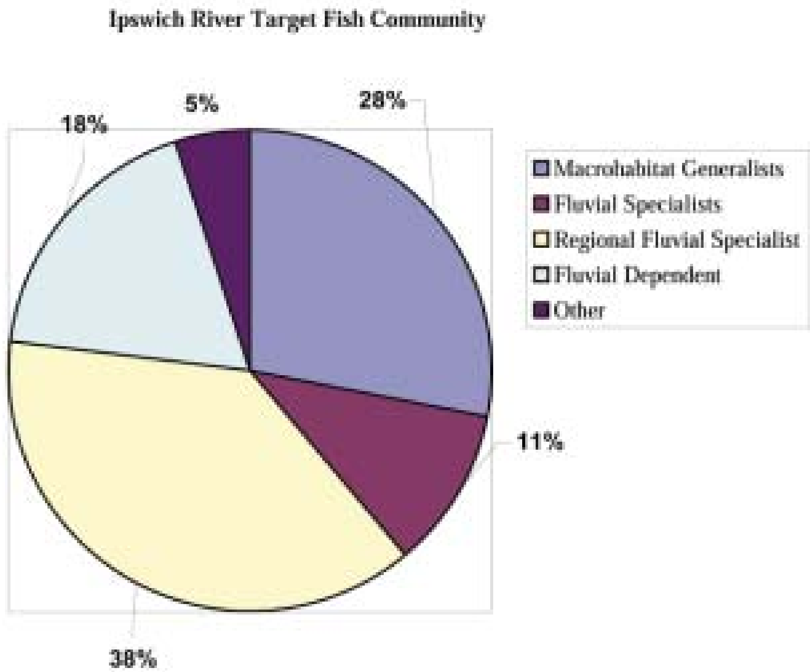


Figure 12. Ipswich River Target Fish Community

5.3 Future Community Growth

Since the Ipswich is already an impaired river, future growth in communities dependent on the Ipswich or within the watershed must be considered in developing an action plan. A responsible plan will remedy the problems of today as well as address the potential for future problems. Since water supply, impervious surfaces and sewer infiltration inflow area are particularly relevant concerns in regards to low-flows in the Ipswich, an awareness of future increases in population, and the accompanying industrial and commercial growth that will occur in the watershed, all of which are (without intervention) likely to lead to further increase in hydrologic alteration of the river system, requires consideration. The information provided here is based on two methods for predicting future population projections.

In 2000, the Metropolitan Area Planning Council (MAPC) undertook a project to predict future population and the subsequent water needs of towns within the Ipswich watershed. This was done by calculating the potential for future development under the respective community's regulations and zoning. These projections assume the current zoning within each community will remain the same and that development will progress to the maximum allowable limit; this is referred to as a buildout analysis.

Using GIS data and information obtained from the communities, the MAPC determined the additional commercial and industrial square footage, as well as the number of future housing lots that could be built. The analysis accounts for existing land use in the communities, paying attention to lands currently not developed or under-developed. The MAPC buildout analysis removes land considered not buildable because of regulatory constraints, such as the Massachusetts Wetlands law or local conservation bylaws, or because the land is protected by a conservation program. Further, land that is "partially constrained" because it is limited in development potential due to regulatory concerns was considered and verified with town officials. The developable land was then further reduced by 10-30%, depending on projected use, to allow for the creation of roads and infrastructure that will be needed to support any future development. It should be noted that changing policies (such as the current consideration to relax the minimum percolation requirements for septic systems) will further exacerbate those problems.

Once the amount of allowable commercial, industrial, and residential development was quantified, future water needs were determined by multiplying predicted future land use by a standard water use factor. In the case of land available for commercial/industrial use, the future square footage was multiplied by a factor of 75 gpd per 1,000 sq. ft. Future residential population growth was determined by multiplying the number of future developable lot by the average number of residents per household that currently exists within the community. The number of future additional residents is then used to determine future residential water demand by multiplying by a factor of 75 gpd per person (http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#regs). Table 2 shows a summary of the results of the MAPC Buildout Analysis.

The Massachusetts Department of Conservation and Recreation (DCR, formerly DEM), Water Resources Commission also conducts analyses on projected future water demands and provides this information to the Department of Environmental Protection, which uses this information in permit reviews and water withdrawal allocations. DCR's forecasts for 2005 and 2010, use two different methods. Either the forecasted population and additional commercial/industrial area is multiplied by the average water use over the last couple years; or in the case of towns where there is inaccurate water measurements or significant unaccounted for water, forecasted population is multiplied by a standard factor of 70 gallons per day per person and equated to a proportional amount of commercial/industrial use.

DCR uses population forecasting information provided by the Massachusetts Institute for Social and Economic Research (MISER), to predict the future populations of the communities to a specified date. MISER's population projections were created using data from the 1990 census, past MISER estimates, birth/death rates from Massachusetts Department of Public Health for 1986-1995, international immigration information provided by Immigration and Naturalization Services (INS) for 1991-1995, and three different estimates of domestic immigration data provided by the Internal Revenue Service and the U.S. Bureau of Census. DCR utilizes MISER's population forecasts to predict future water use and reported for the year 2005. DCR's results predict an additional need for 1.44 Mgd by 2005 under the mid-level scenarios for growth. Though 2010 population forecasts predict even further growth in numbers, water predictions were not given.

The MAPC study reveals that there will potentially be a need for over 6.1 Mgd additional supply if the communities in the Ipswich watershed achieve their maximum build-out based on today's zoning and regulations. That volume of water would pose a significant challenge to meet, and should be strongly factored into any action plan. The MAPC predicts that in the meantime (before buildout takes place), an additional 1.9 Mgd will be required by 2005.

Both the studies reveal the potential for additional stresses on the watershed if the water is to be provided from existing sources. While neither prediction is certain, it is reasonable to assume that communities within the Ipswich watershed will continue to grow and water demand may increase. The time frame in which this may occur is contingent upon many factors; therefore it would be prudent to use the worst-case scenario or the buildout analysis in any watershed management or planning initiative. Buildout will increase water supply demands, increase impervious surface, decrease recharge, and potentially increase infiltration inflow (I/I) problems.

Table 2. Summary of Buildout Analysis for Towns within the Ipswich Watershed						
Town	**Additional Buildable Commercial/ Industrial (sq.ft.)**	**Commercial / Industrial Water Use (GPD)**	**MAPC Buildout Future Residents**	**Residential Additional Water Use (GPD)**	**% of Town Receiving Water from Ipswich Watershed**	**% of Land Area of Town within Watershed**
Andover	17,709,399	1,328,205	10,053	753,975	0	17
Burlington	542,715	40,704	890	66,750	0	29
Danvers	7,098,089	532,357	3,967	297,500	100	28
North Reading*	766,254	57,469	2,492	186,891	100	100
Reading*	-	-	2,050	153,769	100	48
Ipswich	3,032,738	227,455	10,102	757,687	17	55
Peabody	5,373,491	403,012	6,705	502,891	1.2	27
Wilmington*	4,651,225	348,842	3,677	275,793	100	83
Salem	4,360,986	327,074	2,747	206,038	100	0
Hamilton	-	-	4,007	300,458	100	85
Wenham	266,446	19,983	2,707	203,010	100	92
Beverly	7,219,391	541,454	4,011	300,835	100	24
Topsfield	431,491	32,362	2,630	197,236	100	100
Lynnfield*	748,382	56,129	1,137	85,290	100	32
Middleton	7,042,395	528,180	4,746	355,984	100	100
Lynn*	8,048,209	603,616	10,133	759,948	16	0
Boxford	12,885	967	5,874	440,521	62	62
North Andover	8,365,795	627,435	6,831	512,338	0	59
Sub total	34,491,208	3,115,021	47,122	5,602,939		
Upper basin increase				**1,382,353**		
Total potential water use buildout		**2,972,942**		**3,136,887**		
Total of Commercial and Residential				**6,109,828**		
Based on Metropolitan Area Planning Commission Buildout Analyses						
Assumes:						
- Water use projections for commercial square footage is based on 75 gpd/1,000 sq ft of commercial space						
- Water use projections for residential assumes 75 gpd per capita consumption						
Denotes Towns that lie within the upper basin						
*Towns that receive water from the upper basin						

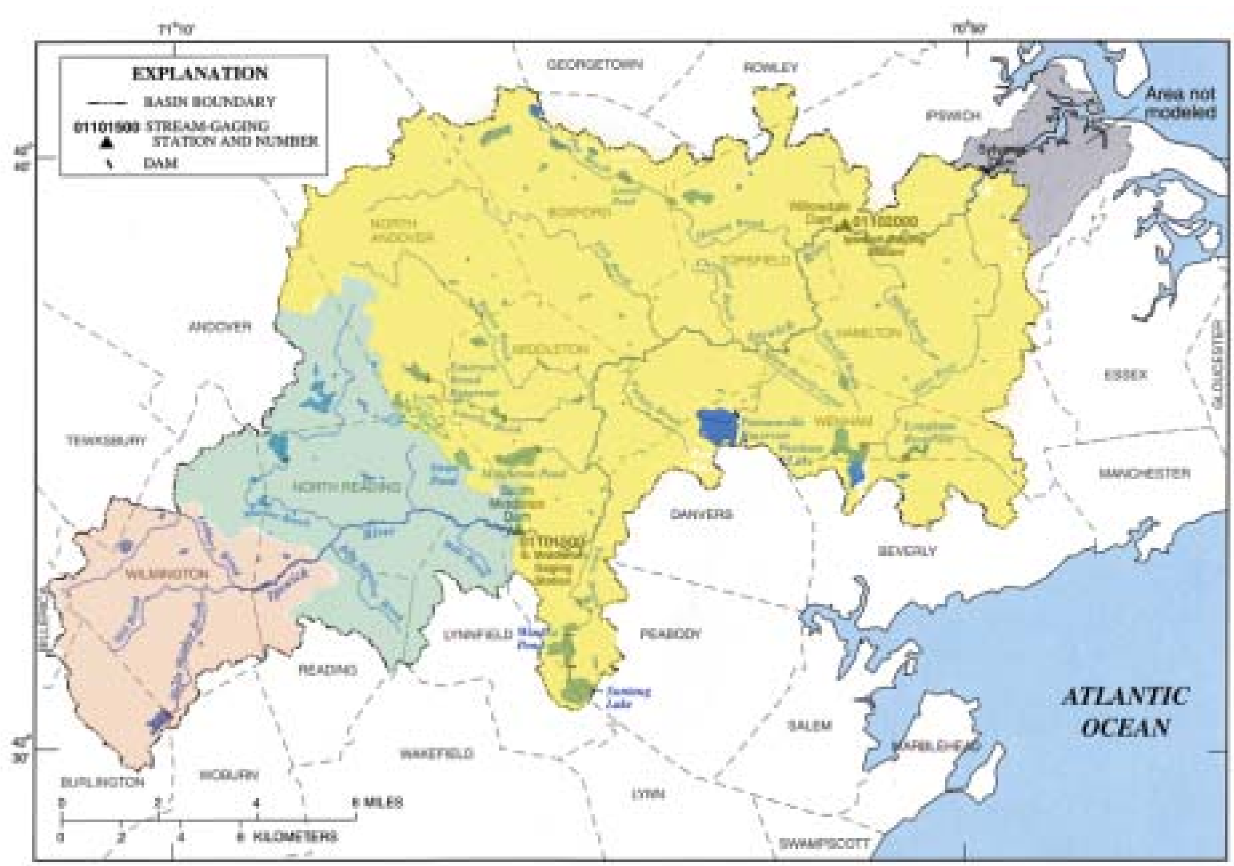
Table 3. Population Forecasts for Permitting Withdrawals

Town	1990 Census	2000 Census	1996-1998 Average water volume (MGD)	Actual Growth 1990-2000	Predicted Growth Buildout	MAPC Population Forecast 2005	MAPC Forecast 2005 Water Use	MISER Population Forecast 2005	MISER Forecast 2005 Water Use	MAPC Population Forecast 2010	MAPC Forecast 2010 Water Use	MISER Population Forcast 2010
Andover	29,151	31,247		7%	32%							
Burlington	23,302	22,876		-1.8%	4%							
Danvers	24,174	25,212	3.44	4.3%	16%	24,600	3.45	25,663	3.49	24,548	3.48	25,751
North Reading	12,002	13,837	1.14	15.3%	18%	13,400	1.15	12,941	1.11	13,686	1.18	12,874
Reading	22,539	23,708	2.43	5.2%	9%	23,799	2.64	24,186	2.68	23,798	2.06	24,030
Ipswich	11,873	12,987	1.31	9.4%	78%	12,533	1.26	11,947	1.21	12,594	1.27	11,898
Peabody	47,264	48,129	5.63	1.8%	14%	51,253	5.88	51,799	5.93	51,901	5.94	52,119
Wilmington	17,651	21,363	2.96	21.0%	17%	22,289	3.09	20,232	2.81	23,364	3.24	20,244
Salem	38,091	40,407	10.32	6.1%	7%	39,393	**11.12**	40,709	11.35	40,581	**10.94**	41,434
Hamilton	7,280	8,315	0.62	14.2%	48%	8,325	0.66	7,783	0.62	8,529	0.68	7,758
Wenham	4,212	4,440	0.39	5.4%	61%	5,053	0.39	5,047	0.39	5,385	0.41	5,538
Beverly	38,195	39,862	**	4.4%	10%	40,806	**	41,505	**	41,268	**	42,054
Topsfield	5,754	6,141	0.50	6.7%	43%	6,493	0.55	6,549	0.56	6,597	0.56	6,605
Lynnfield	11,049	11,542	0.63	4.5%	10%	12,044	0.61	12,512	0.66	12,150	0.64	12,530
Middleton	4,921	7,744	***	57%	61%	6,231	***	5,783	***	6,616	***	
Lynn	81,245	89,050	11.04	10%	11%	85,267	11.51	80,989	11.01	86,740		
	263,386	278,819	40.41		17%		42.31		41.82		30.40	
			Predictions for increase water use				**1.90**		**1.41**			

**Shared water supply with Salem ***Shared water supply with Danvers
Source: Massachusetts Department of Environmental Management Water Resources Commission

6.0 MANAGEMENT OPTIONS FOR IPSWICH RIVER BASIN

How much water is needed to restore a more natural flow regime in the Ipswich River such that aquatic life and other designated uses of the river would be fully supported? According to the hydrologic modeling conducted by the USGS, the management options needed to restore natural flow to the river to alleviate summer low flow conditions consistently would require 5-6 million gallons per day (Mgd) of water to be added to the headwaters reaches (above Mill Street at the Reading/ North Reading boundary). Applying the fisheries threshold guidance of 0.49 cfsm for the summer period (based on the USGS Aquatic Habitat Study and Fisheries Task Group Restoration Report), a total of about 9 Mgd would be required in the upper basin (above the South Middleton streamflow gage) and about 14-15 Mgd would be required in the entire basin to meet the articulated aquatic habitat threshold of 0.49 cfsm. These targets are cumulative; thus the 9 Mgd target for South Middleton includes the 5 Mgd target for the headwaters reach, and the entire basin target includes the upper basin figure.



Ipswich River Sub-Watersheds

Table 4. Summary of Streamflow Targets and Deficits by Watershed

	Reach 8 (Headwaters)	South Middleton (Upper Watershed)	Ipswich (Entire Watershed)
Healthy summer streamflows: Summer fisheries (0.49 cfs) converted to Mgd	8.82 cfs 5.69	21.56 cfs 13.9	61.25 cfs 39.5
Avg. summer monthly medians (Mgd) July-Sept	n/a	4.9	25.1
Estimated deficit (Mgd) July-Sept	5	9	14.4

In the headwaters, 5-6 Mgd is the approximate equivalent of shutting off the wells that provide Wilmington and Reading their current supply of water (but is less than current summertime usage by those towns of about 7 Mgd). It is, of course, impossible for these towns to go without water, so instead a plan that will accomplish the same result is needed for that subregion. It is likely that this plan will include the purchase of water from MWRA or other sources and may also require implementation of a variety of measures, with a cumulative result totaling 5-6 Mgd, rather than any single measure providing that volume of water.

Similarly for the remainder of the watershed, the communities involved need to identify measures which, taken together, result in a net gain of water sufficient to meet the flow deficit. It is interesting to note that the 14.4 Mgd deficit for the entire watershed is approximately equal to the estimated amount of water used for lawn watering (15-20 Mgd). While it may be unreasonable to expect homeowners to completely stop lawn watering, it does suggest that the Watershed Management Council should develop a policy on lawn irrigation and that public education programs directed at water conservation could have significant benefits. At the same time, it is important to consider the potential loss of water which may occur as a result of projected growth (buildout), and to avert or mitigate any such losses.

Numerous potential management strategies were identified in meetings held with various stakeholders during the fall of 2001. A summary of these strategies is included in Preliminary Management Options. Stakeholders who were interviewed included water suppliers, representatives from local, state, federal agencies, and environmental organizations that together have been working since 1996 to determine the cause and combat the low-flow incidents in the Ipswich River.

Recognizing the need to develop and implement management strategies, a workshop was held in November, 2001, at the Danvers Town Hall. Approximately 40 members of the Ipswich River Watershed Management Council participated in the workshop. Watershed Council members were divided into three groups and were asked to develop a priority list of management measures that, in their judgment, would effectively help to manage the low-flow issue. The workshop resulted in agreement on several management measures to consider in more detail. The management measures are:

- Improve water conservation
- Purchase water from out-of-basin sources
- Reduce exports of water via sewers
- Enhance stormwater infiltration
- Increase water storage
- Improve land use policies and practices

A combination of these measures is intended to provide enhanced baseflow in the Ipswich River. It is recognized that implementation may occur over a broad timeframe. Some measures could be implemented sooner at minimal costs. Others may require significant funding over longer periods of time.

6.1 Water Conservation

During the recent workshop on management alternatives and in several subsequent meetings, the Watershed Management Council identified water conservation as a high-priority approach with widespread support. The workshop noted the need to develop a regional water conservation plan.

Proposed Policy Statement:

> *"The Council will work together to develop a water conservation plan for the benefit of the watershed its communities and residents, with a goal of implementation by all that withdraw water from the watershed."*

IRWA is currently developing a regional water conservation plan and program, under contract with the former MWI and the Riverways Program (DFG). The plan, which will be flexible and will allow for local priority-setting, will provide guidelines to assist communities in reducing peak- and year-round demand. The plan could incorporate water use reduction goals based upon per capita residential use and water audits for commercial/industrial uses.

Modeling by the USGS indicates that water conservation has significant potential to assist in bringing the water budget into balance, but water conservation alone cannot cure the low flow problem. Reducing water demand and improving supply efficiency is probably the least expensive measure that could be instituted to help achieve the goal of returning flow to the Ipswich River. Effective water conservation should be a requirement of virtually any water supply alternative for the region. With fewer regulatory hurdles than other management options, this approach should be part of the overall strategy to improve flow in the Ipswich River. However, estimates of potential savings must take into account that some conservation measures have already been implemented, and that projected growth in communities using the watershed for water supply may result in additional water demand.

Reasonable goals for water conservation must be identified. Reductions of 20-30% have already been achieved by water systems in Massachusetts, including the MWRA system, and the Executive Office of Environmental Affairs has indicated that this level of water savings is achievable. A review of water conservation programs by the US EPA indicates that other communities throughout the nation, which have implemented water conservation plans, have reduced water consumption by 7-15% (US EPA, 2000). According to Amy Vickers, a noted water efficiency expert, reductions of 15-30% now reflect the industry standard (Vickers, personal communication, 2002).

Based on volumes of water pumped from the watershed in recent years, a 15% reduction in demand would result in a savings of about 750,000 gallons per day in the headwaters communities of Reading and Wilmington (combined), 1.0 Mgd in the upper watershed and 5.4 Mgd per day throughout the entire watershed. In communities that have not yet implemented effective water conservation measures, higher savings are achievable.

Several communities in the watershed have high non-account (unbilled) water. This non-account water includes leakage, un-metered water use (either through lack of meters or inaccurate meters), unbilled municipal water use, as well as water used for specific unbilled purposes, such as fire hydrant flushing, fire-fighting, and treatment plant operations. Non-account water presents an opportunity for several communities, notably those with the highest daily water use in the region, to save literally millions of gallons of water a day, reduce pumping costs, and recoup revenue for water that is currently distributed to customers but not accounted for and billed. This opportunity can translate into significant gains in the effort to close the water deficit for the middle and lower watersheds.

The numbers calculated above are based on consistent water consumption throughout the year. This, of course is not how water is actually consumed; in fact water consumption increases substantially in most communities during the summer time, when residents water their lawns and gardens and increase other water demands. These water withdrawals are particularly damaging, because they coincide with periods of naturally low-flows.

For many communities, future efforts in water conservation may prove most effective if they are focused on outdoor water use. A huge potential for water savings lies in the area of lawn irrigation. In the Ipswich River watershed, communities use 25%-160% more water in the peak month than the winter period, according to the annual statistical reports filed with the Department of Environmental Protection. Estimates for the Danvers/Middleton water system place the volume of lawn watering at around 1 Mgd (personal communication Fred Merriam, Danvers/Middleton Water Department). The estimated increase in water demand in the peak summer period is 15-20 Mgd basinwide, over and above the average year-round demand. Much of this increased demand is for lawn watering, and could be saved. Saving even half this much water in the summer months could make a very significant difference for the Ipswich River.

To achieve such savings, the watershed communities would need to enact policies to discourage lawn watering. The Massachusetts Water Resource Commission's "Guide to Lawn and Landscape Water Conservation" includes the following recommendations:

- Develop a drought management plan;
- Implement water use restrictions;

- Provide public outreach and education;
- Implement effective conservation rate structures;
- Promote alternatives to automatic irrigation systems;
- Promote alternative lawn and landscape designs and watering methods;
- Implement water use restriction by-laws;
- Implement in-ground irrigation system by-laws to eliminate unnecessary irrigation; and
- Enact bylaws that will reduce land clearing and lawn sizes.

Water conservation policies should be proactive, before there is a low-flow event, to prevent depleting water reserves, either in reservoirs or aquifers. Improved water conservation in the region will require the establishment of clear goals and objectives, funding, staffing, technical assistance, and accountability. While water conservation is not likely to cure the problem alone and will probably need to be accompanied by additional measures in order to help restore adequate streamflow at all times for the Ipswich River, it is an important and necessary part of the restoration of the river.

The water conservation plan for the Ipswich Basin currently being prepared will provide further details regarding appropriate implementation steps.

Recommendations:

- Develop and implement a comprehensive water conservation plan for the region;
- Implement effective water use restrictions throughout the region, applying to lawn irrigation and other non-essential uses, especially during low-flow periods;
- Secure funding and staffing to coordinate water conservation efforts, provide ongoing technical assistance, education and outreach programs, and develop pilot and demonstration projects;
- Work with state officials to secure funding assistance for communities to implement improved water conservation measures;
- Develop and implement appropriate controls on automatic irrigation systems;
- Evaluate rate structures and provide guidelines to assist communities in implementing conservation rates;
- Measure the success of the program regularly to ensure its effectiveness and that implementation is occurring throughout the communities relying on the Ipswich River for all or part of their water supply; and
- Provide recognition for positive accomplishments in water conservation.

- **Implementation Steps:**
  - Complete IRWA Conservation Plan
  - Adopt Conservation Plan through MOU process
  - Implement Massachusetts Water Resource Commission's "Guide to Lawn and Landscape Water Conservation"

- **Management Goals:**
  - 0.75 Mgd (headwaters) over 10 year period
  - 0.99 Mgd (upper watershed) over 10 year period
  - 5.4 Mgd (entire watershed) over 10 year period

6.2 Stormwater Management

Proposed Policy Statement:

> *"Stormwater management is an important component of the hydrologic budget for the Ipswich River. Urbanization of the watershed results in impervious surfaces which preclude the infiltration of precipitation, and ultimately recharge to groundwater. Groundwater provides the majority of baseflow in the Ipswich River during times of low flow.*
>
> *Therefore, reductions in infiltration/recharge have direct and significant effects on baseflow in the river. The proposed stormwater management goal is to maximize recharge of precipitation and stormwater runoff within the basin to preserve and enhance baseflow within the Ipswich River. This can best be accomplished through the following objectives/steps: 1) all new development within the watershed will minimize impervious surfaces and will provide for infiltration/recharge of at least 150% of the natural recharge rate, 2) all re-development within the watershed will provide for infiltration/recharge of at least 100% of the natural recharge rate and 3) towns within the watershed will design stormwater remediation projects to increase infiltration/recharge. The first two objectives can be accomplished either on-site or by off-site mitigation projects as long as the mitigation occurs in the Ipswich River watershed."*

There has been much concern recently over the relationship between stormwater and pollutant loading in receiving water bodies and the loss of infiltration of precipitation to groundwater, which is critical to maintaining streamflow in the dry times of the year.

Recent studies confirm that increases in land development result in degradation of the natural environment, greater impervious surfaces, less infiltration, greater surface runoff and higher pollutant loading to wetlands and rivers. If properly employed, stormwater management measures can improve water quality, increase groundwater recharge and storage in aquifers, store water on-site to use for irrigation purposes (in place of public water supply), and decrease peak flows and flooding.

The upper reaches of the river, the towns of Burlington, Reading, North Reading, and Wilmington, have become densely developed, resulting in more impervious surfaces. Land above the South Middleton gaging station contains 35% more residential development than the area below the station and 50% more commercial land use. Conversely, the upper basin has, on average, 22% less forests and open space (Zarriello & Riess, 2000). It is at these headwaters where the low-flow occasions are most severe, and what little retention and absorption ability that exists has been adversely limited due to increased development. It is essential to increase efforts to assure that stormwater is retained and absorbed to help restore baseflow to the river.

The Massachusetts Stormwater Policy and Standards require that new development maintain the amount of recharge pre- and post-development. This is accomplished through the design and installation of infiltration systems to collect and infiltrate stormwater from impervious surfaces. Unfortunately, the policy exempts single-family homes and small housing developments from most of the regulations and only regulates future development. It is also limited to those projects within the jurisdiction of the Massachusetts Wetlands Protection Act. The Policy and Standards also recommend that for “re-development” projects, infiltration/recharge should approximate that of the pre-existing natural environment.

Since the Ipswich River watershed already has a diminished baseflow, the infiltration standard needs to be upgraded to improve the existing conditions and should not exempt single family homes, as much of the potential development in the upper watershed is “infill” within already subdivided lots. All communities in the Ipswich River watershed should adopt local stormwater regulations to apply such standards for all development wherever it occurs in the community (not just wetland resource areas). This could be accomplished by integrating stormwater management standards into the Zoning Bylaws and Subdivision Rules and Regulations. Further, requirements for greater than 1:1 mitigation of stormwater impacts (to 1.5:1 or 150%), primarily relating to the infiltration standard, should be adopted for new development to begin to address the diminished baseflow. In addition, the redevelopment standard should be 1:1 (100%).

Table 5 provides a summary of the potential benefits of the 150% infiltration policy. This is based upon the buildout analysis conducted by MAPC (2000) for potential commercial building area within the watershed towns. Adjustments were made to account for the towns which are located partially within the watershed. Impervious areas were estimated at two times the building area to account for rooftops and parking lots. An average groundwater recharge rate of 12 inches per year was used as the pre-development stormwater policy standard. Finally, the supplemental recharge (or water supply benefit) was calculated at 50% of the natural (pre-development) recharge (150% - 100%).

Table 5. Potential Benefits of the 150% Stormwater Infiltration Policy

	Additional Commercial (Building) (acres)	Estimated Impervious Area (acres)	Natural Recharge at 12 inches/year (Mgd)	Supplemental Recharge from 150% Policy (Mgd)
Headwaters	72	144	0.13	0.06
Upper	180	360	0.32	0.16
Total	518	1,036	0.93	0.47

A policy that requires a net increase in recharge to offset prior development impacts could be accomplished either through on-site or off-site mitigation. This would allow new development to either design on-site facilities to accomplish this standard, or to retrofit and upgrade older developments (off-site) with better stormwater management, if they are unable to meet those standards on-site. Zoning bylaws, subdivision rules and regulations and wetlands bylaws could be amended to require an infiltration requirement of 150% of the (pre-development) natural recharge. The creation of impervious surfaces precludes natural recharge, but allows for efficient collection of runoff, which could be directed to engineered infiltration structures such as perforated pipes below parking lots, dry wells at roof corners or recharge/infiltration basins.

If, through the planning phase of a project, it is determined that a site does not have adequate capacity for additional infiltration of groundwater on-site, off-site mitigation could be required. Off-site mitigation could include repairs to existing stormwater management systems, construction of new infiltration systems, or removal of infiltration and inflow from an off-site sewer system. A review of the surficial geology suggests that there are many locations throughout the watershed that have high-permeability soils with a high capacity for infiltration available for off-site mitigation (see Figure 13). It should be noted that adequate depth to groundwater is also necessary to implement stormwater infiltration projects. Generally the depth to stormwater must be at least 4 feet from the land's surface.

Another option to implement these proposed stormwater infiltration requirements is the creation of a stormwater utility; this option would require special state legislation. Such a utility could raise funding through fees assessed on the basis of the amount of impervious surface proposed. The funding could then be used to implement mitigation projects throughout the watershed.

Another stormwater management option is the infiltration of residential roof runoff. There are approximately 40,000 existing homes in the watershed. Based upon the land use statistics reported in the USGS report, 6,850 are in the headwaters and 17,150 in the upper watershed. Assuming an average roof area of 1,000 square feet and an annual runoff rate (from roofs) of 40 inches/year yields a roof runoff volume of 2.7 Mgd for the entire watershed. If 25% of homeowners installed drywells to infiltrate roof runoff, this represents a potential increased ground water recharge volume of 0.68 Mgd. The corresponding values for the headwaters and upper watershed are 0.12 and 0.29 respectively.

A related issue is basement flooding. Due to poor soils and high water tables in many areas within the watershed many basements are flooded during the spring (high water table) months. The first implication of this is that those homeowners willing to install drywells for their roof drainage should be educated to install the drywells greater than 50 feet from basement walls so as not to exacerbate the basement flooding problem. It is also possible that if the drywells were properly sized they could accommodate some of the pumping of floodwater from basements. Currently, it is likely that much of the basement floodwaters are pumped into the storm drain system. This is actually an indirect form of groundwater withdrawal and impacts baseflow in the river, while exacerbating flooding. A public education program to re-direct this pumped flood water into dry wells and yield additional benefits would be advisable.

Recommendations:

- Increase infiltration of roof runoff throughout the watershed, aiming for implementation by 25% of homes and businesses within 10 years;
- Require at least 150% recharge for new development;

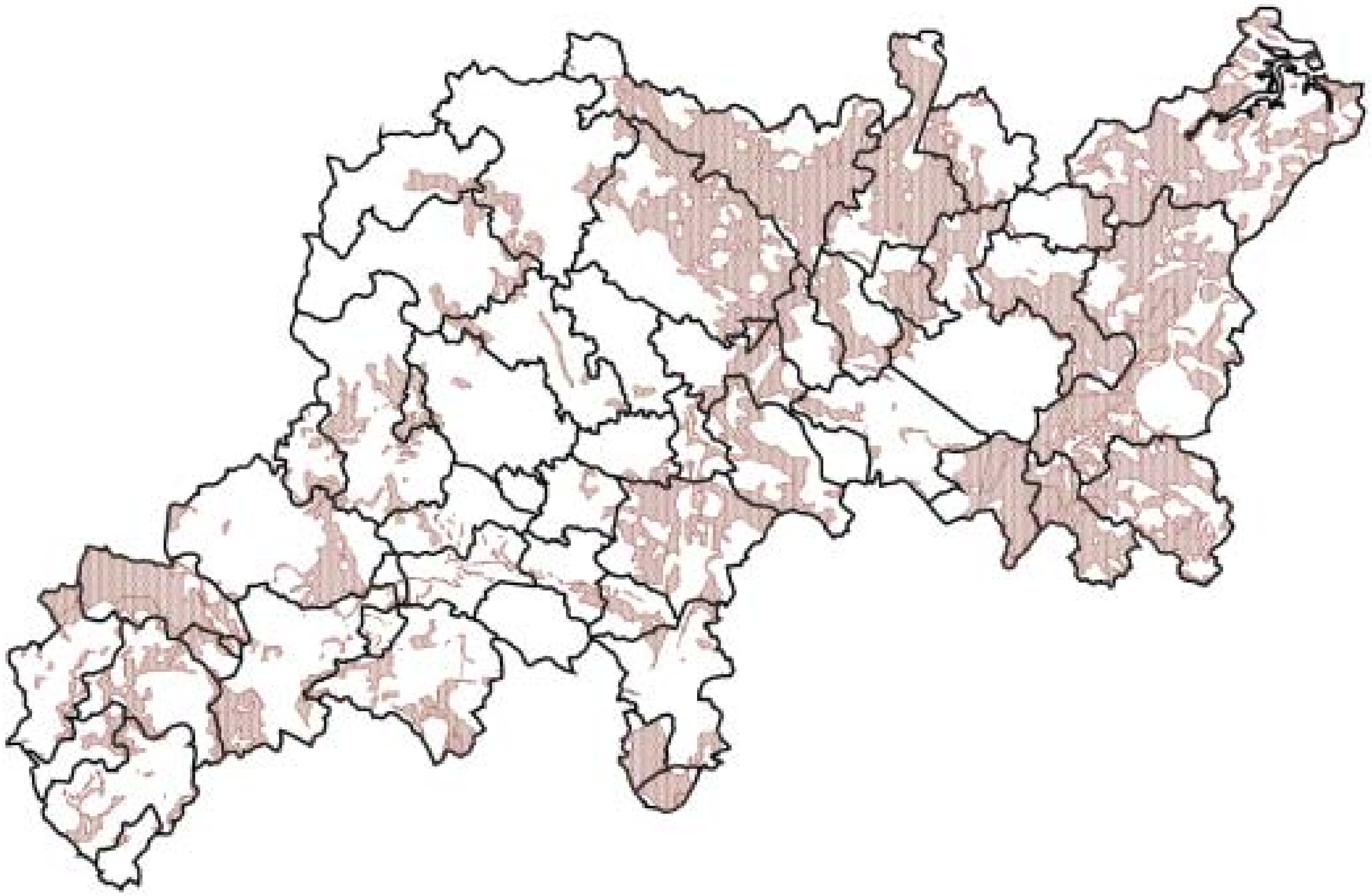


Figure 13

Ipswich River Basin
with Potential
Recharge Areas

Horsley & Witten, Inc.

- Improve municipal drainage to decrease runoff, increase infiltration and improve water quality;
- Require improved infiltration (100%) for redevelopment projects;
- Create local stormwater utilities (reference "How to Create a Local Stormwater Utility" by City of Chicopee/ Pioneer Valley Planning Commission);
- Integrate enhanced infiltration into Phase II Stormwater Management requirements;
- Pass local bylaws, ordinances, or regulations to extend jurisdiction of the Massachusetts Stormwater Policy and Standards to all development in the community;
- Eliminate the exemption of single-family lots from stormwater management requirements; and
- Provide public education to redirect pumped basement water into dry wells.

- **Management Goals:**

Table 6. Stormwater Management Goals

	Roof Infiltration (Mgd)	150% Infiltration New Commercial Development (Mgd)	Town Remediation Projects (Mgd)	Total (Mgd)
Headwaters	0.12	0.06	0.14	0.32
Upper	0.29	0.16	0.36	0.81
Total	0.68	0.47	1.0	2.15

6.3 Alternative Sources of Water Supply

Water withdrawals from the Ipswich River, especially "streamside" groundwater wells, are a major factor causing the low-flow problems of the river. Replacing these sources of water with less damaging supplies is essential to restore the river to health. The first priority is to reduce or eliminate the use of the most damaging wells during low-flow periods. USGS's recent modeling of alternatives shows that reducing the use of the Reading and Wilmington wells is a very important component of a restoration plan.

6.3.1 Importing Water From Out-of-Basin Sources

During the workshop held by the Watershed Management Council to prioritize alternatives, there was a consensus that sources of water from outside the Ipswich River watershed should be investigated. These include, but are not limited to new wells located in a watershed community outside the Ipswich River watershed; and connecting to other existing sources such as the Andover water supply system or the Massachusetts Water Resources Authority (MWRA) supply. The Watershed Management Council also agreed, by consensus, to the following position:

> *"The Ipswich River Watershed Management Council will support efforts to obtain out-of-basin sources of water, especially to reduce the dependence on streamside wells during dry periods and to alleviate low-flow problems as a first priority."*

The USGS model indicated that the most direct impact on the river from existing groundwater sources are the "streamside" wells in Wilmington and Reading. These wells are in close proximity to the river, such that they cause induced infiltration during pumping and have a direct effect on stream flow. To be consistent with the current non-withdrawal policy on surface water during the summer months, these streamside wells should be prioritized for possible replacement with alternative supplies, at least during the critical summer months.

Based on USGS findings, there is concern that newly reactivated wells in Danvers will deplete streamflow if pumped during low-flow periods. These wells, and wells in other communities, should be monitored to determine their impacts on surface waters, and alternative sources should be sought where adverse impacts occur.

Importing water from outside of the Ipswich River basin, from the MWRA or another source such as the Town of Andover (Merrimack basin), has the potential to supplement existing water supplies. Costs for a community to join the MWRA water supply system or to obtain water from Andover are substantial, and include the capital costs of connecting to the system and the annual assessments for the water. Further, there are legal hurdles concerning the transfer of water from one basin to another, which is regulated under the Massachusetts Interbasin Transfer Act. Peabody, Lynn and Lynnfield already draw some water from the MWRA, and North Reading purchases water from Andover to meet peak summer demand.

The problem of low-flow in the upper reaches is unlikely to be solved unless Reading and Wilmington augment their water supplies with water from an out-of-basin source. These two communities are currently evaluating the option of importing water from MWRA. This alternative supply could potentially provide drinking water for these communities during the low-flow period, thus reducing or eliminating the use of the streamside wells, which are known to cause low-flow problems. This approach would result in a reduction of at least 0.6 Mgd for Reading and 1-2 Mgd for Wilmington on an annual average; however, if the purchases occur in the May-October period only, they would replace 1.2-2.4 Mgd for Reading and 2-4 Mgd for Wilmington during the critical low-flow period (depending on whether the water imports are concentrated during 3 months, or whether they occur over 6 months). Conceivably, these communities could purchase even more water from MWRA to ensure that the streamside wells would not have to be pumped during low-flow periods, even during a serious drought.

Several concerns have been raised about the proposed import of water. The first is that this approach is "robbing Peter to pay Paul;" that is, that the underlying water budget imbalances are not addressed but simply displaced to another watershed. Indeed, the Ipswich River itself suffers from this scenario already, as most of the water withdrawn from the Ipswich River watershed is transported out-of-basin via water supply and/or wastewater systems.

An additional concern has been raised that importing water to these communities may serve as an enabler of growth, rather than (or in addition to) restoring flows to the Ipswich River. Another issue is that the investments of Reading and Wilmington in purchasing water from MWRA will be useless if downstream communities, such as Danvers (with the requisite DEP approval), increase groundwater withdrawals from existing or proposed wells. These scenarios need to be understood and addressed to ensure that the flow restoration objectives of potential water purchases are realized.

Communities with reservoirs are less vulnerable to the impacts of low-flow events in summer, but may experience problems during dry periods that coincide with their seasonal pumping period. It may be advisable for these communities to investigate the possibility of establishing emergency connections with out-of-basin sources of water, to protect their systems from potential water shortages during low-flow periods on the Ipswich River.

Other communities facing water supply deficits now or in the near future may also consider purchasing water from other sources, whether within or outside the Ipswich River watershed, especially to avert additional pumping of groundwater to meet peak demand.

Another potential out of basin source that could be developed is desalination. While presently an uncommon alternative in the northeast portion of the United States, recent advances in the technology have reduced the costs of desalination and made this option more feasible. Desalination could have the ability of supplementing existing water supply systems in the Ipswich Basin.

Water supply management measures may help alleviate the flow issues of the Ipswich River. An evaluation of the benefits and impacts of management measures in reducing impacts on the river may also be warranted.

Recommendations:

- Reading and Wilmington should purchase sufficient water from the MWRA and/or Andover to allow them to eliminate the use of streamside wells during low-flow periods;
- Other communities that rely on streamside wells should seek to purchase water from out-of-basin or less damaging in-basin sources;
- The Massachusetts Water Resources Commission should investigate the prices charged by out-of-basin providers of water, to determine whether charges are reasonable; economic incentives to assist in restoring the Ipswich River may be warranted;
- The Watershed Management Council should investigate the feasibility of desalination for Ipswich Basin communities;
- Monitoring of the impacts of other streamside wells should be done to quantify impacts and to trigger reductions in use of these sources during low periods; and
- Communities that rely entirely on Ipswich River watershed sources should investigate emergency connections with out-of-basin sources, to reduce vulnerability to low-flow episodes in the Ipswich River.

6.3.2 Increased Water Storage

Proposed Policy Statement:

> *"The Ipswich River Watershed Management Council recognizes that storage of water is key to restoring flow to the Ipswich River and to improving aquatic habitat. Storage is also a key factor in providing a reliable source of drinking water, especially during dry seasons and drought years. In order to achieve better management of the Ipswich River and public water supplies, the Council supports improving storage within the Ipswich River watershed in the following ways:*
>
> *1. Improving storage in the groundwater reservoir throughout the watershed by promoting infiltration of stormwater and roof runoff on a large-scale (new development and redevelopment projects) and a small-scale (individual residential properties). The existing Stormwater Management Policy address this issue within Chapter 131 Wetlands Protection Act. The Policy should be incorporated into subdivision regulations, site plan bylaws and special permits.*
> *2. Small-scale storage measures, such as cisterns and small basins, should be used to improve water storage on a site-by-site or subdivision basis, particularly to provide a source of irrigation water;*
> *3. Investigating in more detail the technical and regulatory feasibility of creating new or expanding existing surface water reservoirs within the Ipswich River watershed. Such projects should be viewed on a case-by-case basis, while evaluating the overall benefits and harm of each project. Reservoir creation and expansion shall be considered only where it has been scientifically determined that the source water can hydrologically support the additional withdrawal without approaching winter/spring fisheries thresholds as modeled during a drought of record.*
> *4. Encouraging and supporting wetland restoration projects, especially those that create additional surface storage by removing fill in historical wetlands and floodplains."*

Dating to the early 1970s and beforehand, studies have explored the feasibility of diverting water from the Ipswich River and storing it in reservoirs. These studies relied on the concept that water taken from the river during peak flow periods could be harvested and stored for use in drier times, without impacting the river. The proposed reservoirs in the previous studies were never brought to completion as they were originally envisioned, due to a number of political, economic and environmental concerns. Available storage capacity does not currently exist in the upper watershed to enable water harvesting in the volume necessary to meet water supply demands, or restore flow in the Ipswich River. In addition, the existing reservoirs do not have the available capacity to meet the demands of all the communities throughout the watershed. Whether other sites in the mid-basin may be considered viable options from a regulatory, political and economic standpoint is currently unknown. However, there may still be an important role for increased water storage capacity to solve the Ipswich River's flow problems.

The recent USGS modeling indicates that seasonal (winter-spring) surface water withdrawals from the river do not significantly impact extreme low-flows of summer and fall. Surface water diversions that occur during high flow periods, when the relative amount withdrawn is small compared to the total flow volume, appear to be relatively benign, based on current knowledge. However, questions remain about the impacts of these diversions during "dry winters" and "dry springs." Unfortunately, these are the same conditions whereby water suppliers are in the greatest need of water to replenish reservoirs. Further consideration of flows needed to support ecosystem functions and all designated uses of the river throughout the year is warranted to determine if the river has sufficient capacity to support such withdrawals, and what restrictions on such withdrawals would be needed.

While acknowledging that many questions would need to be answered prior to making a recommendation to construct additional reservoir storage, harvesting some high flow volume for later use during low-flow periods is an alternative which warrants further investigation. Proposals to do so should explicitly describe how these proposals would improve flow in the Ipswich River.

To pursue the option of constructing new or expanded reservoirs, there would be significant regulatory hurdles to overcome. Earlier studies of potential reservoir sites identified several sites, which have extensive wetland acreage, which would be transformed to deep water habitat. Deep water habitat commonly provides lesser environmental values than vegetated wetlands with shallow standing water or saturated soils. These wetlands are protected under the Massachusetts Wetlands Protection Act and Federal Clean Water Act, and conversion to reservoirs would necessitate a showing that this approach is the least environmentally-damaging option. In addition, this alternative would require that water conservation efforts have been fully implemented, and that other alternative sources of water are not feasible.

Additional concerns have been raised by fisheries specialists about proposals to create new or larger impoundments on streams. These impoundments transform flowing habitat to ponded habitat, contrary to the ecological need in this watershed. Also, dams to create the impoundments block fish movement, preventing both migratory and resident species from accessing essential habitats during certain periods. Construction of dams and impoundments may "drown" essential and scarce riffle habitats and may contribute to diminished dissolved oxygen. These concerns would have to be addressed in any proposals to create or expand on-stream reservoirs.

In addition to the regulatory questions, other issues would need to be addressed to determine if reservoir construction or expansion were feasible. These issues would include economic analysis and consideration of factors such as community decision-making, which doomed at least two reservoir proposals in the watershed several decades ago. Of the large-scale reservoir sites identified in prior studies, the following remain:

1) Topsfield site owned by Salem-Beverly Water Supply Board;
2) Town of Danvers Emerson Brook Reservoir, located in Middleton (possible expansion of existing reservoir); and
3) Lynnfield Center Water District reservoir site south of Ipswich River.

Potential sites which were rejected in the past due to inadequate capacity for drinking water supply may still hold potential for smaller scale storage for flow augmentation or for groundwater recharge.

Other storage options may hold potential to help solve the water deficit in the Ipswich River watershed. Use of sand and gravel aquifer sites may meet a portion of the need to supply water or augment flow. Use of on-site storage, such as cisterns and rain barrels, may provide a reasonable alternative to the use of drinking water for lawn irrigation. Small storage tanks at the subdivision scale might also be used to provide non-potable, outdoor water supply. Man-made storage tanks may be warranted to provide additional reserve capacity. All of these require further evaluation.

In sum, storage of water is essential to restoring flow to the Ipswich River and to improving aquatic habitat. Storage is also a key factor in providing a reliable source of drinking water, especially during dry seasons and drought years. In order to achieve better management of the Ipswich River and public water supplies, the Council supports improving storage within the Ipswich River watershed in the following ways:

1. Increasing storage in the groundwater reservoir throughout the watershed;
2. Increasing use of small-scale storage measures, such as cisterns and small basins, to provide irrigation water or other non-drinking water supply for residential, business and municipal properties; and
3. Investigating in more detail the technical and regulatory feasibility of creating new or expanding existing surface water reservoirs within the Ipswich River watershed. Such projects should clearly describe how they would improve flow in the Ipswich River, and include modeling to establish the capacity of the Ipswich River to provide more water than is currently committed, especially during the planning drought periods, while applying thresholds that protect fisheries and other ecological values. Proposals should be considered on a case-by-case basis, while evaluating the benefits and harm of each project.

Recommendations:

- Increase storage of water in aquifers by implementing measures to increase groundwater recharge;
- Increase the use of small-scale storage of stormwater to provide irrigation water and other non-drinking water uses;
- Improve guidance regarding infiltration and storage in subdivision rules and regulations or other local laws and regulations;
- Provide subsidies or economic incentives for residences and businesses to install cisterns or other small-scale water storage features; and
- Evaluate reservoir proposals on a case-by-case basis, focusing on their impact on restoring streamflows in the Ipswich River.

6.3.3 Other Water Sources

Several communities are investigating the possibility of locating new water sources within or outside the Ipswich River watershed. Capture of stormwater for use in irrigation, as well as other water reuse options, are dealt with in other sections of this chapter.

The establishment of new water sources in the watershed is not a recommendation of this report, unless such sources are not damaging in themselves and replace existing, damaging sources. The viability of bedrock wells, and their impact on streamflows, is a matter that warrants particular attention. Recent research by USGS indicates that, where there is a connection between the deep bedrock aquifer and the overburden aquifer, deep bedrock wells may function no differently than groundwater wells in terms of the timing and magnitude of their impacts on surface waters. Such proposals would need careful investigation, including extended pump tests, as well as stringent monitoring to evaluate localized and cumulative impacts.

- **Implementation Step:**
  - Replace stream-side wells (seasonally) with MWRA and/or Andover water

- **Management Goal:**
  - 3.2 – 6.4 Mgd (headwaters, upper watershed and entire watershed)

6.4 Wastewater Alternatives/Reduction in Wastewater Exports

Proposed Policy Statement:

> *"The USGS modeling of management scenarios found that recharging aquifers with treated wastewater would result in improvement in stream flows in the Upper Ipswich watershed. This approach can provide a reliable source of water for groundwater recharge, regardless of the weather. The need to ensure water quality is paramount, especially in light of the use of the watershed as a drinking water source. Further action to address wastewater management in the Ipswich River watershed should seek to retain water in the basin to the maximum extent possible, while ensuring water quality and protecting public health and environmental quality.*
>
> *Where sewers exist, improved control of infiltration and inflow should occur and be maintained, to eliminate the additional loss of groundwater and stormwater via sanitary sewers."*

The appropriate application of wastewater technologies provides adequate treatment to permit in-basin discharge of wastewater; wastewater treatment technologies can effectively address the issue of keeping water local while protecting water quality within the watershed. These technologies improve the quality of wastewater, particularly from old on-site disposal systems, such as cesspools, and from old or failing Title 5 systems. However, because of stranded costs for wastewater investments already made, communities utilizing centralized sewer systems outside the basin often do not have a financial incentive to invest in technologies to retain wastewater in the Ipswich River watershed.

Industrial wastewater treatment: Industrial wastewater treatment employs a range of technologies to treat and/or reuse water for industrial applications. These technologies can produce water ranging from slightly polluted water suitable for reuse for some applications, to "ultrapure" quality needed for some industrial processes. The benefits of industrial wastewater treatment include reduced water consumption, reduced exports of water from the watershed, removal of production constraints where water availability is a limiting factor, as well as financial savings to the businesses that employ these systems. Increasing the use of appropriate wastewater treatment technologies provides an alternative which is economically beneficial to many businesses, and which can reduce the overall export of water from the Ipswich River watershed without imposing a financial burden on municipalities. Providing technical assistance to businesses to adequately treat wastewater and reuse it or discharge it within the watershed should be a priority action to help balance the water budget in the Ipswich River watershed.

Sanitary wastewater treatment: Treating sanitary wastewater in the Ipswich River watershed, and discharging it via ground disposal, has significant potential to help restore groundwater recharge, which supplies baseflow to the Ipswich River. A range of treatment options, including conventional septic systems, alternative on-site systems, and small- to large-scale off-site options, exists to remove pollutants from sanitary wastewater.

However, because of the importance of the Ipswich River watershed as a public water supply, and the need to protect the aquatic ecosystem, the use of in-basin treatment and discharge must address several critical water quality concerns, as well as water quantity priorities, including the following:

- Removal of pathogens, especially viruses;
- Removal of endocrine-disrupting chemicals and other artificial hormones;
- Reduction in nutrients; and
- Retaining water in the watershed.

Most of the water supply obtained from the Ipswich River watershed is derived from local groundwater or surface water withdrawals, and little is currently brought in from outside of the watershed. Several of the larger communities discharge wastewater to the ocean by way of sewers managed by a local authority such as the South Essex Sewerage District, Lynn Water and Sewer District or the MWRA. It has been estimated that only 10-20% of the water removed from the Ipswich River watershed for water supply use is returned to the watershed (Report of the Planning for Growth in the Upper Ipswich River Watershed Project, p. 16).

Aquifer recharge with treated wastewater is a means of producing high quality water, which can enhance baseflow in the river. It is possible to recycle water to the aquifer by injecting treated wastewater and allowing it to infiltrate into the ground. The process of infiltration further eliminates biological and mineral contaminants in the water as it travels through the unsaturated soil. Further, significant reduction in viruses, nitrogen, phosphorus, and heavy metals can be achieved through treatment processes, ultraviolet radiation, and filtration through soil. When wastewater recharge is coupled with a proper pre-treatment system, it can be used to offset the loss of streamflow. The City of Sierra Vista, Arizona has undertaken a $7.5 million wastewater system that is designed to restore flow in the San Pedro River, which similar to the Ipswich has seen habitat destroyed as a result of low-flow occurrences. Recycled water, under proper treatment, has been used successfully to help restore groundwater levels and consequently drinking water supplies.

With respect to maintaining flow in the river, it would be preferable to have as much water as possible, including recycled wastewater, recharged back into the ground and consequently supplying the river with needed flow. One of the benefits of using treated wastewater to recharge groundwater is that it provides a reliable, daily source of water, independent of the weather. In the headwaters, the current volume of water sewered from Reading and Wilmington is ~5 Mgd – sufficient to meet the flow restoration target volume. If 40% of this water were retained in the upper watershed this would represent a water savings of 2.0 Mgd. Throughout the entire watershed 23.5 Mgd of wastewater is exported from the watershed (see Figure 7). If 20% of this wastewater were retained this represents 4.7 Mgd. Such a goal could be achieved by a combination of: 1) reduction in I/I; 2) industrial water conservation, treatment and reuse; and 3) development of package treatment plants or other in-basin treatment facilities to provide tertiary treatment and then discharge the clean effluent to the ground.

There are many concerns with releasing used water into an environment, and especially in the case of the Ipswich River, it is important to address a possible perception that polluted water would be flowing into people's drinking water supply. The vast majority of municipal public water supply wells draw from aquifers (Zone II areas) and watersheds (Zone III areas) that include numerous sewage disposal systems (both Title 5 systems and sewage treatment plants). These sources of pollution exist currently, and all wastewater management measures should be based on the premise that pollution sources affecting water supplies will be reduced. Concerning chemicals that act as artificial hormones in the environment, a program to reduce the use of such chemicals should be developed, addressing not only the chemicals found in wastewater but also larger sources, such as lawn care/ golf course chemicals.

Many communities in the United States and abroad have turned to wastewater management as a necessary system in replenishing depleted groundwater supplies. There are extensive programs in the western parts of the U.S., and California alone has over 200 water agencies already using or working on recycled water systems. Orange County residents have been drinking groundwater enhanced by reverse osmosis (RO) purified water for more than two decades. A water district in Los Angeles County began groundwater augmentation under the same method; the project has been a success and plans are in place to double its size. Other water suppliers in the county are now pursuing similar water treatment facilities. Astronauts put the same RO purification and reuse processes to work on the space shuttle, and from a public sentiment concern, groundwater augmented with recycled water looks, smell, and tastes as it normally would. (Reference Dublin San Ramon Services District, www.dsrsd.com/grrecycling.htm).

It is important to understand the constant need for monitoring and the potential large costs of a wastewater treatment and recharge program. It is also important to site the project so that the recharged water would have enough travel time prior to reaching a wellhead to ensure that the requisite filtration is achieved. If using recycled water for streamflow support only (via groundwater), it will be important to consider that the river provides drinking water to other communities further downstream and measures must be implemented to assure that the water will be as clean as the ambient water, or more so. Treatment technologies that produce effluent cleaner than the water in the river should be employed.

One challenge in advocating the infiltration of treated recycled wastewater is finding suitable sites where there is adequate percolation. Typically, sandy-permeable soils are preferable. In some cases, they are the same sites which qualify as good water supply development sites. One option to consider may be to utilize some of the existing water supply sites near the river (where induced infiltration occurs) if alternate locations can be found for new wellfields. This would enhance baseflow at locations downgradient from drinking water wells; and wellfields located further from the river would minimize the induced infiltration and short-term reductions in baseflow in the river. The use of "wicking wells," which has occurred in communities such as Fairhaven, may offer some promise for discharge of treated wastewater effluent to groundwater even where land suitable for infiltration is scarce.

The towns of Reading and Wilmington are already assessed approximately $2.7 million and $1.5 million annually for MWRA sewer access, respectively. Ironically, if the towns were able to treat and recharge their wastewater, they would save that $4.2 million and avoid the potential capital costs and the $2.9 million that will be assessed annually for water purchases from the MWRA. A full analysis of the alternatives and their economic implications should include consideration of this possibility.

Recommendations:

- Protection of water quality and public health are extremely important considerations and must be fully addressed in all wastewater planning efforts;
- A pollution-loading model should be developed to evaluate the effect of wastewater management options on water quality, to ensure that the safety of drinking water is not compromised;
- Source use reduction should be employed to reduce the use of endocrine-disruptors and other harmful chemicals;
- The amount of water exported from the Ipswich River watershed via sewers should be reduced by 20-40% over the next decade, by a combination of methods:
  - Effective infiltration/ inflow control, to ensure that I/I is <25% of total volume sewered;
  - Implementation of water conservation and wastewater treatment technologies to reduce wastewater export volume;
  - Providing assistance to businesses to implement innovative technologies to reduce water demand and treat and recycle/ reuse wastewater; and
  - Construction of appropriate wastewater treatment facilities (small- to large- scale) to provide adequate in-basin treatment of wastewater and groundwater discharge of treated effluent, or water reuse where appropriate.
- Economic incentives should be developed/ provided to encourage communities to work together to build and utilize wastewater treatment facilities, where large-scale treatment works are indicated; and

- In the next decade, the MWRA should construct or subsidize a satellite wastewater plant to serve the communities of Reading and Wilmington.

- **Management Goals** (through I/I reduction and/or treatment and discharge; not including water conservation progress):
  - 2.0 Mgd over 10 years (Headwaters)
  - 4.7 Mgd (basin-wide)

6.5 Summary of Benefits from Proposed Management Strategy

The benefits of the proposed management strategies are summarized in Table 7. The implementation of the preceding management strategies has the potential of enhancing in-stream baseflow in the three sub-watersheds to meet the articulated goals. This will require implementation of many steps as outlined above and is likely to take several years to accomplish. Although this is only a preliminary analysis of the incremental water savings of each management strategy, it does demonstrate that it is possible to achieve the articulated goal of restoring minimum baseflow in the Ipswich River. Future discussions of the Watershed Management Council and others may suggest that some of the individual water savings objectives need to be modified. The total overall goal must be maintained.

Table 7. Benefits of Proposed Management Strategies

	Headwaters (Mgd)	Upper Watershed (Mgd)	Entire Watershed (Mgd)
OVERALL WATER USE REDUCTION GOALS:	5	9	14.4
Water Conservation Objectives	0.75	0.99	5.4
Stormwater Management	0.32	0.81	2.15
Alternative Water Sources	6.4	6.4	6.4
Wastewater Management	2.0	2.0	4.7
TOTAL ESTIMATED BENEFITS	9.5	10.2	18.7

6.6 Land Planning

Recent work to project future growth of communities, including build-out analyses, water demand projections and other estimates, presents a sobering view of the future of this region. The implications of existing development are seriously damaging the Ipswich River ecosystem; future growth has the potential to make the situation even worse. The MAPC build-out study revealed that there will potentially be a need for over 6.1 Mgd (3.0 Mgd commercial/industrial and 3.1 Mgd residential) more water supply demand generated if the communities in the Ipswich watershed achieve their maximum build-out based on today's zoning and regulations. Based upon utilizing the MAPC Buildout Analysis the upper watershed communities increased demand is estimated at 1.38 Mgd and 0.55 Mgd for the headwaters. That volume of water would pose a significant challenge to meet, and should be strongly factored into any action plan. Further, the MAPC predicts that an additional 1.9 Mgd will be required by 2005. Table 8 displays the impacts of the potential water demands associated with buildout as compared to the management benefits recommended. This analysis suggests that the buildout demands will exceed the articulated goals by 2.0 Mgd throughout the entire watershed. This assumes that all of the preceding management strategies are implemented. Therefore, additional land use strategies must be employed to reduce future potential (buildout) demands by at least 2.0 Mgd.

Table 8. Impacts of Potential Water Demands

	Headwaters (Mgd)	Upper Watershed (Mgd)	Entire Watershed (Mgd)
Total Estimated Benefits	9.5	10.2	18.7
Additional Buildout Demands	-0.55	-1.4	-5.4
Net Estimated Benefits	8.9	8.8	13.3
Overall Water Use Reduction Goals	5	9	14.4

The need for careful planning and management of future development is paramount. At the current state of land use, the river is already severely impacted, both directly and indirectly. Further growth is likely to result in more water withdrawals, diminished groundwater recharge, additional water losses through sewering, and consequently more severe low flows than occur now – a completely unacceptable scenario. The adoption of land use controls and stormwater management measures to enhance water quality and quantity, and implementation of wastewater management measures to keep water local, is critical to the future health of the Ipswich River. Unless effective measures can be implemented to restore the natural hydrology of the watershed and address the causes of low-flows, it is unrealistic to expect that future development can coexist with a healthy Ipswich River. Communities need to work cooperatively to achieve water resource protection and address the impacts of growth on the Ipswich River. Further technical assistance, including local analyses of the "water budget," and the implications of "build-out" on water resources, would help identify potential conflicts and pitfalls and measures needed to achieve better protection.

At the watershed scale, there is a need to identify lands of regional importance, and a mechanism to protect key land and/or its most valuable characteristics. Some ponds and lakes, streams, river segments and adjoining lands may need protection beyond that offered under existing laws. Areas suitable for high rates of infiltration and groundwater recharge may be a high priority for protection. Critical habitats, aquatic and terrestrial, should be identified and prioritized for protection as well.

Recommendations:

- Communities should employ a toolbox of measures to manage and control growth, including:
  - Moratoria on Development: This provides an opportunity for towns to study management options to reduce the impacts of the projected buildout. Towns may adopt moratoria for a period of up to two years while they conduct studies and develop remedies to documented problems.
  - Zoning (Performance Hydrology): Special Permits issued under zoning could be required to meet water supply demand/conservation goals. Under this provision applicants would need to provide innovative site designs to reduce water consumption and to promote water reuse
  - Subdivision Rules & Regulations to minimize impervious surfaces and improve infiltration of road drainage. This is best accomplished by integrating the existing Massachusetts Stormwater Policy and Standards into the Subdivision Rules and Regulations for town-wide application.
- Land Acquisition of Open Space: Purchase developable property to reduce future potential water demands.
- Regional Watershed Commission: To coordinate the efforts of the watershed communities to implement the land use and water management plans.

- **Management Goals:**
  - Reduce future potential growth in water supply demand for the entire watershed by 2.0 Mgd

Clearly, a comprehensive watershed management strategy is needed which transcends water supply options and embraces land acquisition programs which will decrease future water supply demands in a natural system which is already over-taxed and at the same time provide enhanced recharge, water quality protection and other open space benefits. There are many actions which can be (and arguably should be) taken to re-direct land use management in the Ipswich basin. The responsibilities to achieve this go far beyond the water supply (utilities) and include land use planers, "green" developers, health agents, land trusts, and the general public.

7.0 REFERENCES

Armstrong, D.S., T.A. Richards and G.W. Parker. 2001. Assessment of habitat, fish communities, and streamflow requirements for habitat protection, Ipswich River, Massachusetts, 1998-99. U.S. Geological Survey Water-Resources Investigations Report 01-4161.

Bickford, Walter E., and Dymon, Ute Janik, eds., 1990. An Atlas of Massachusetts River Systems – Environmental Designs for the Future, Massachusetts Department of Fisheries, Wildlife & Environmental Law Enforcement, Amherst, MA.

Bratton, L. 1991. Public water-supply in Massachusetts, 1986. U.S. Geological Survey Open-File Report 91-86.

Camp, Dresser & McKee Consulting Engineers. 1971. Alternative regional water supply systems for the Boston Metropolitan Area, Boston, MA, 105 pp.

Dalton, J.D. 1977. Wipswich and Parker Rivers 1976 Water Quality Analysis and Water Quality Management Plan. Water Quality and Research Section, Massachusetts Division of Water Pollution Control.

Delaney, D.F. and Gay, F.B. 1980. Hydrology and water resources of the coastal drainage basins of northeastern Massachusetts, from Castle Neck River, Ipswich, to Mystic River, Boston. U.S. Geological Survey, Hydrogeologic Investigations Atlas, HA-589.

Department of Environmental Protection. Water users address list.

Earth Tech. 2000. In-town solution requires extensive testing and analysis, Holliston, Massachusetts, Boston, MA, 22 pp.

Espegren, G.D. 1996. Development of instream flow recommendations in Colorado using R2Cross: Denver, Colorado, Water Conservation Board, 34 p.

Espegren, G.D. 1998. Evaluation of the standards and methods used for quantifying instream flows in Colorado: Denver, Colorado, Water Conservation Board, 18 p.

Gay, F.B. and Delaney, D.F. 1980. Hydrology and water resources of the Shawsheen River Basin, Massachusetts. U.S. Geological Survey, Hydrogeologic Investigations Atlas, HA-614.

Graduate School of Design Harvard University. February 1998. Mass Bay Commons, Cambridge, MA, 47 pp.

Harvard University Graduate School of Design. 1999. Grow Smart North Shore, Cambridge, MA, 77 pp.

Interdisciplinary Environmental Planning. 1979. Martins Pond euthrophication study (phase II) and reclamation program, Wayland, MA, 30pp.

Ipswich River Basin Task Force. 1996. Goal statement and tasks, Ipswich, MA, 1 pp.

Ipswich River Basin Task Force. 1998. Master planning committee draft management principles, Ipswich, MA, 10pp.

Ipswich River Watershed Association. Living within our limits: balancing the water budget in the Ipswich River Watershed, Ipswich, MA, 24pp.

Ipswich River Watershed Association. 1997. Fecal coliform data report-how animal wastes pollute water, and what you can do about it: an integrated monitoring and education project, Topsfield, MA, 15 pp.

Ipswich River Watershed Association. 1997. Riverwatch volunteer monitoring program, Ipswich, MA, 32pp.

Ipswich River Watershed Association. 1997. The Voice of the River, Fall, 8 pp.

Ipswich River Watershed Association. 1997. 1998 Low Flow/No Flow Study. 14 pp.

Ipswich River Watershed Association. 1998. The River Watcher, 2(1-12).

Ipswich River Watershed Association. 1999. River Watch volunteer monitoring program, 1998 appendices, Topsfield, MA, 106 pp.

Kaynor, E.R. 1972. Historical, political, and social factors affecting public policy on river diversion: out-of basin diversion of Connecticut River flood waters to Boston Metropolitan Area, Water Resources Research Center University of Massachusetts at Amherst, Publication No. 25.

Landre, B.K. and Knuth, B.A. 1992. Success of Citizen Advisory Committees in Consensus-Based Water Resources Planning in the Great Lakes Basin. Society and Natural Resources, Volume 6, pp. 229-257

Leathe, S.A. and F.A. Nelson. 1986. A literature evaluation of Montana's wetted perimeter inflection point method fro deriving instream flow recommendations: Helena, Montana, Department of Fish, Wildlife, and Parks, 70 p.

Massachusetts Department of Environmental Management, Division of Water Resources. 1989. Water: what price do we pay?, Boston, MA, 50pp.

Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control. 1984. Baseline water quality studies of selected lakes and ponds in the Parker and Ipswich River Basins, Westborough, MA, 79pp.

Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control. 1985. Ipswich River Basin 1982-1985 water quality survey data and wastewater discharge survey data, Westborough, MA, 66pp.

Massachusetts Water Resources Authority. 1990. MWRA long range water supply program, Boston, MA, 126 pp.

Massachusetts Water Resources Commission, Water Quality Section, Division of Water Pollution Control. 1973. Ipswich River study part A: data record on water quality, Westborough, MA, 54pp.

Massachusetts Water Resources Commission. 1978. Ipswich River Basin water allocation study summary, Westborough, MA, 7pp.

Metropolitan Area Planning Council Water Quality Project. 1978. Results of the review process of the Ipswich River Basin preliminary report, Boston, MA, 28 pp.

Metropolitan Area Planning Council's Public Participation Task Force. 1976. Public participation program, Boston, MA, 51 pp.

Massachusetts Office of Water Resources, Department of Environmental Management. 2000. Stressed Basins in Massachusetts.

Nelson, F.A. 1984. Guidelines for using the wetted perimeter (WETP) computer program of the Montana Department of Fish, Wildlife, and Parks: Bozeman, Montana, Montana Department of Fish, Wildlife, and Parks, variously paged.

Pontius, R.G. Jr., Claessen, L., Hopkinson, C. Jr., Marzouk, A., Rastetter, E.B., Schneider, L.C., Vallino, J. 2000. Scenarios of land-use change and nitrogen release in the Ipswich watershed, Massachusetts, USA. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs. Banff, Alberta, Canada, September 2-8, 2000.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems: Conservation Biology, v. 10, p. 1163-1174.

Sammel, E.A., Baker, J.A., and Brackley, R.A. 1960. Water resources of the Ipswich River Basin, Massachusetts, United States Government Printing Office, Washington D.C., 83pp.

Sammel, E.A., Brackley, R.A., and Palmquist, W.N., Jr. 1964. Synopsis of water resources of the Ipswich River Basin, Massachusetts. U.S. Geological Survey, Hydrologic Investigations Atlas HA-196.

Schueler, T.R. and H.K. Holland. 2000. The Practice of Watershed Protection: Article 1. The importance of imperviousness. The Center for Watershed Protection, Ellicott City, MD.

Socolow, R.S. 1994. Water-quality data for selected wetland streams in central and eastern Massachusetts. U.S. Geological Survey Open-File Report 93-482.

Tennant, D.L. 1976. Instream flow regimens for fish, wildlife, recreation, and related environmental resources, in Instream Flow Needs, v. II: Boise, Idaho, Proceedings of the symposium and specialty conference on instream flow needs, May 3-6, American Fisheries Society, p. 359-373.

Toohill Environmental Associates. 1996. The Sister Pond project: a lake management plan, Littleton, MA, 38 pp.

U.S. Department of the Army, New England Division, Corps of Engineers. 1971. Flood plain information: Ipswich River, North Reading & Wilmington, Massachusetts, Waltham, MA, 58 pp.

U.S. Environmental Protection Agency. 1999. Smart growth strategies for New England, conference summary and outcomes, Boston, MA, 16 pp.

U.S. Environmental Protection Agency. 1994. EPA's Polluted brochure EPA-841-F-94-005.

U.S. Environmental Protection Agency. 1996. Watershed Approach Framework. EPA 840-S-96-001. Office of Water.

U.S. Fish and Wildlife Service. 1981. Interim regional policy for New England stream flow recommendations: Newton Corner, Massachusetts, U.S. Fish and Wildlife Service, 3 p.

Wandle, S.W., Jr. and Fontaine, R.A. 1984. Gazetteer of hydrologic characteristics of streams in Massachusetts, Merrimack River Basin. U.S. Geological Survey Water Resources Investigations Report 84-4284.

Whitnam & Howard, Inc. 1975. Draft report on implementation study of 30-B regional water supply system, Boston, MA, 68 pp.

Wilmington, Town of. 1996. Annual Report, Wilmington, MA, 163 pp.

Wilmington, Town of. 1997. Annual Report, Wilmington, MA, 196 pp.

Wilmington, Town of. 1998. Annual Report, Wilmington, MA, 183 pp.

Woods Hole Oceanographic Institution Marine Policy Center. 2000. Resource economics model: Ipswich River watershed, Woods Hole, MA, 43pp.

Zarriello, P.J. and Ries, K.G., III. 2000. A precipitation-runoff model for analysis of the effects of water withdrawals on streamflow, Ipswich River Basin, Massachusetts. U.S Geological Survey Water Resources Investigations Report 00-4029.

Zarriello, P.J. 2002. Effects of water-management alternatives on streamflow in the Ipswich River Basin, Massachusetts. U.S. Geological Survey Open-File Report 01-483.

Dublin San Ramon Services District. www.dsrsd.com/grrecycling.htm

www..state.ma.us/dep/brp/wwm/t5pubs.htm

APPENDIX A

Appendix A. Ipswich River Watershed Action Plan

Preliminary Action Strategies

I. Water Resource Management

A. Water Supply

1. Water supply protection with BMPs in water supply zones, setbacks, bylaws, statewide implementation
2. Storage is the key, especially in the headwaters
3. Reservoirs
    a. Augment summer flows with water from new (Topsfield, Lynnfield, Emerson Brook, sand and gravel sites, other) and existing reservoirs
    b. Expand design of proposed Topsfield reservoir by digging it deeper to allow greater storage, fill by skimming floodwaters
    c. Any new drinking reservoir needs to be tied to planning for growth in headwater communities - need to manage future growth
    d. Increase Emerson Brook from 200 acres to 300 acres
    e. Do not need more than 2 years of storage for current water supply demand
4. Wells
    a. Site new deeper wells further from the river and curtail use of shallow streamside wells on and near the river when flow is low - alternate use of well for optimal effect
    b. Reduce use of wells in Wilmington, Reading and North Reading
        i. 600,000 gpd to 1.2 mgpd (on annual average used during the low flow period) is a target for the import of water to Reading to reduce use of wells (Note, 600,000 gpd = 219 million gallons per year)
    c. Do not use wells during low flow period, shut off wells in headwaters from May to October
    d. Investigate expanding pumping window for surface withdrawal into November and at the same time raise diversion threshold
    e. Goal to add enough new storage and necessary connections to allow streamside wells to pump minimum needed for maintenance
    f. Get the state to help site bedrock wells and eliminate the need for streamside wells
5. Other sources of water
    a. MWRA water supply to supplement summer demand
    b. Supplement with Concord River via Middlesex Canal
    c. Supplement with Merrimack River water
    d. Use Spot Pond for supplemental summer water, if available
6. Conservation Efforts
7. Keep dams and add more dams to raise level of the aquifer
8. Acquire flood prone land as well as all developable land
9. Long-term plan is needed (up to 20 years) to evaluate individual water supply operations such as type and size of pumps at diversion sites (Lynn, Peabody, Salem-Beverly)
10. Summer time differential rates - charge higher for lawn watering, and other types of summer demands
11. Work together to implement voluntary controls rather than strict regulatory controls, i.e., give voluntary controls a chance to work first, be prepared to implement and abide by strict regulatory controls if they do not
12. Help communities and water districts with replacing old water meters
13. Review WMA permits every 5 years
14. Reduce or retire water rights based upon the amount of water obtained from outside the watershed
15. Intercommunity cooperation of water sharing, need infrastructure to move raw water between communities

B. Stormwater Management

1. Groundwater recharge
    a. Return stormwater to infiltration basins and detention basins through oil separators or other more effective BMPs for aquifer recharge
    b. Require better than natural recharge for new projects and retrofits
    c. Implement through town bylaws and state building code
    d. Statewide water supply regulations should incorporate stormwater infiltration
    e. Provide recharge at locations that need recharge, not all areas can receive additional infiltration (high groundwater areas)
    f. Infiltration from large impervious sites may be effective
2. Sand and gravel sites a possibility for flow augmentation reservoir
3. More swales and infiltration, less culverts and discharge to river
4. Manage stormwater better to keep it in basin
5. Reduce infiltration and inflow into sewers and utilize bio-swales in stormwater management plans

C. Dams

1. Add low level dams with riffle spillways and/or raise dams one or two fee to provide additional storage for headwater aquifer
2. Remove dams to improve biodiversity
3. Provide low level release at South Middleton dam during low flow

D. Land Use

1. Open space protection is needed to protect water quality and quantity, and to reduce future water supply demand
2. Watershed based land protection through a pooled effort of resources
3. Inventory and prioritize open space parcels
4. Create a land trust for water supply open space lands
5. Develop water supply protection plans
6. Building moratorium for water-poor towns or water supply hookup moratorium (Brockton had this)
7. Update local bylaws and regulations for stormwater management
8. Limit or restrict in-ground water sprinklers

E. Legislative Actions

1. Change Water Management Act, cannot withdraw more than DEP determined safe yield based upon hydrologic stressed basin policy providing different rules
2. Explore regulatory and legislative incentives

F. Wastewater

1. Treatment and groundwater disposal
    a. Infiltration of treated wastewater, especially in headwaters (Wilmington, North Reading, Reading)
    b. Encourage package plants at industrial sites, with discharge to groundwater
    c. MWRA should build satellite groundwater discharge plant to help headwaters
    d. Lubbers Brook/Aldrich Road as wetland restoration and wastewater treatment
    e. Package plants at new housing developments
    f. Explore new technologies and alternative designs of wastewater treatment for groundwater disposal
    g. Long-term plan of having many small wastewater treatment facilities instead of one large facility
    h. JT Berry site as a regional wastewater treatment disposal site
    i. Camp Curtis Guild as possible wastewater treatment plant site

2. Develop plan to treat wastewater locally
   a. Encourage businesses to treat wastewater locally
   b. Return wastewater from MWRA to Wilmington to augment low flows and/or recharge aquifer during the summer
3. Surface water discharge to Ipswich River
   a. Proceed cautiously with surface water disposal of wastewater
   b. Do not discharge to any surface waters
4. Convert Butters Rows water treatment plant to wastewater treatment plar in light of contamination issues at aquifer, replace with MWRA water
5. Desalination plant for water supply needs, Salem Harbor

G. Water Conservation

1. Water supply benefits
   a. Reduce use of wells through water conservation and adaptive management of wells (bedrock wells and stream-side wells)
   b. Continue with reducing water leaks, unaccounted for water
   c. Help communities purchase and install new water meters
2. Implement regional water use plan
   a. Need watershed-wide approach to water conservation
   b. Need staff to manage the water conservation effort
   c. Watershed goal of water use reduction of 10-15% and a summer use reduction of 50%
   d. Develop a watershed-wide consistent water use restriction plan
3. Ban in-ground lawn sprinklers or, at the very least, ban hooking them up public water supplies
4. Need to do a better job of recycling water
5. Seek technical support from MWRA for water conservation and I/I removal
6. If certain river flows are reached then water use restrictions need to be implemented, voluntary in some cases, mandatory in other cases
7. Collect and use rainwater, subsidize rain barrels, cisterns

H. General Recommendations

1. Meet with local planners and organizations to discuss implementation of recommendations
2. Need of suite of management tools to improve flow conditions
3. To optimize biodiversity one would need to remove dams or provide fish passage
4. Provide low level release at Middleton dam to augment flow in low flow period
5. Use the target fish list as a guide to measure success of the restoration of the river's biological integrity
6. State should help with siting a new reservoir(s) in exchange for towns implementing planning for growth and coordinated zoning bylaws
7. Need full range of options on the table to evaluate options
8. Put the same amount of water into the watershed as is taken out; allow MWRA wastewater hook-ups and offset by MWRA water supply
9. Local authorities need to be brought up to speed to develop watershed protection plans, open space protection
10. Request grant from MWRA to evaluate and build state of the art treatme plant at headwaters of Lubber Brook
11. Expand bottle bill to help subsidize water conservation and improve efficiency of municipal water supply systems

I. Questions that frame the problem and solutions to problem

1. How do we provide adequate drinking water supply?
2. How do we deal with adequate wastewater treatment in upper watershed, especially for industrial sources, so it does not affect water quality or affect downstream water supplies?
3. Reservoirs
   a. Need to use the USGS model to investigate new and expanded reservoirs; can the river support another reservoir?
   b. Need to investigate how much storage needs to be added?
   c. Can we reevaluate reservoirs, their upside and downside in terms of environmental impacts?
   d. Evaluate sand and gravel sites in terms of its capacity, ability to provide flood protection, ability to recharge aquifer and how to fill?
4. Thresholds
   a. What needs to be the flow trigger(s) to implement various levels of voluntary, mandatory water use restrictions?
   b. What triggers a dry year designation?
5. Need to investigate the affect of dams on flow, aquifer and fish.
6. How does summer water use affect the river flow, use USGS model to determine?
7. How effective is a reduction of water use by 10-15% in helping river flow
8. Look into Burlington supplying water to Wilmington from Mill Pond reservoir.