The Economic, Social, and Environmental Impacts of Water Use in Rhode Island

Impact Analysis Subcommittee Report
to the RI Water Resources Board's *Water Allocation Program Advisory Committee*

October 2003

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The subcommittee met from October 2002 through October 2003.

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For more information about the Water Allocation Program:
http://www.wrb.state.ri.us/programs/wa/index.html

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Executive Summary

The Impact Analysis Subcommittee investigated the system of interactions between water supply, land use and development, the natural environment, and the well-being of Rhode Islanders. We find that while many of the pieces of a solid long-term water management system are in place, there are two critical gaps that leave the door open to increasing levels of water scarcity and economic and environmental damage.

Concern #1 Land Use
The quantity and location of water demand depend more on municipal land use planning than on any other factor. Absent land use regulations that make sense in the context of available water resources, no amount of conservation effort or supply system expansion can assure long-term water availability. Besides new residents and businesses using more water, some types of land development decrease the water available for both human use and for the environment. Municipalities have insufficient information and analysis tools to efficiently protect the state's long-term water resource interests. Simultaneously, many communities are struggling with fiscal stress resulting from rapid land use change. They are making choices that impact future water supply and demand without a focus on water. Water issues are bigger than municipal boundaries and will be best addressed by cooperative planning across multiple levels of government. The immediate next step is for the state to partner with municipalities to create a build-out analysis that can be analyzed at the watershed, municipal, water supply area, and statewide level. The state should work with municipalities to evaluate the fiscal and water resource impacts of alternative zoning and regulatory scenarios. The tool and technical assistance will provide value to both state and local officials in managing a host of growth issues.

There is not a one-to-one relationship between the quantity of water available and the population and job base that can be sustained. Communities can consider tradeoffs between differing land development and conservation practices and total population at build-out. Communities may also tolerate more or fewer water scarcity events. Having the knowledge to make deliberate decision on these tradeoffs will serve the public interest far better than flying blind.

Concern #2 Environmental Protection
Water flow in streams and wetlands is not protected from excessive withdrawals for human use. The hot, dry spells in which human water demand increases are also critical periods for ecosystems. Protecting productive ecosystems requires the establishment of stream flow standards for all streams, but higher standards for priority habitats. The standards need to be linked to triggers for specific actions to cut water withdrawals in the relevant region.

In the long term, implementation of recommendations in this report will help control municipal costs, state costs, and the costs of water supply. However, in the short-term, build out analysis and environmental protection will require some additional resources, staff time from a variety of agencies, and leadership.

The Economic, Social, and Environmental Impacts of Water Use in Rhode Island

Introduction

The mission of the Impact Analysis Subcommittee is to evaluate the social, economic, and environmental issues springing from water supply and use in Rhode Island and to create a framework for assessment of public policy decisions. The subcommittee articulates several findings about the system of interactions between water supply, land development, the environment, and the well-being of Rhode Islanders. We conclude with the questions we feel are most important to answer in order for policymakers to manage water resources for optimum impact. Consistent with the Water Allocation Program goals, we focus extra attention on the Blackstone and Pawcatuck regions. A complete annotation of priority aquatic habitats in these regions as well as broader discussions of economic impacts, environmental impacts, and development practices are found in the appendices.

Rhode Island's 96,000 acre land development binge between 1961-1995 reduced water supply by 10-23 billion gallons--enough to serve 250,000-600,000 residents

Why Do We Care?

How we manage water resources will influence the wellbeing of Rhode Island communities and their residents far into the future. Around the country is not uncommon to find economic impact studies concluding that supplying more water for human use will fuel economic growth. Unlike many other regions of the U.S[1]., Rhode Island is pursuing wellbeing maximization instead of growth maximization as its economic policy objective. The Governor, the Economic Policy Council,[2] and many if not all communities in Rhode Island set economic goals in terms of increasing prosperity, job quality, average incomes, and quality of life, versus increasing total jobs or total population. These aims suggest three guiding objectives for water policy:

> **Enhance Reliability.** Minimize the frequency and severity of periods when water availability is insufficient for established human and ecological uses. These scarcity events can cause economic hardship, social stress, unemployment, and environmental damage. Involuntary business closures, well failures and periodically inadequate streamflow to support aquatic life have become more frequent in Rhode Island. While precipitation and temperature are external variables, state and local policy can influence both short-term supply and demand conditions during droughts through watershed health, water supply system infrastructure, and demand management decisions. The ability to make demand equal the available supply at the least social cost is the key to reliability.

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[1] See discussion of Water for Texas on page i.
[2] See RI Economic Policy Council Vision and Goals. www.ripolicy.org

Rhode Island's ecosystems produce services worth a couple billion dollars a year.

Enhance ecosystem services and the health of the environment. Wetlands, streams, rivers, and ground water flow provide services with direct value to Rhode Islanders. Avoid alterations in hydrology that increase storm water runoff, flooding, or degrade habitat. A healthy environment with accessible recreation opportunities is an increasingly important factor in businesses' ability to attract highly-educated people.

Enhance economic diversity. A more diverse economy is more stable. Therefore we seek to avoid a complete shift toward only the highest value uses for water. For example, many Rhode Island communities have articulated preserving open space, including working agricultural lands as an important community goal. Others talk about preserving rural character. Agriculture can be a large consumptive user of water, relative to output, yet supporting agriculture is important to Rhode Islanders.

Findings

- Water is used to produce valuable ecosystem services such as waste treatment, water control and habitat. Replacing these services with technology would cost untold billions of dollars a year as New York City found out when development in their source watershed degraded water quality.[3]
- Land development can reduce the available water supply through impervious surface expansion. We estimate that the development of 96,000 acres in Rhode Island between 1961 and 1995 reduced the available water supply by somewhere between 10 and 23 billion gallons a year – enough to serve 250,000-600,000 residents.[4]
- Water is inexpensive in Rhode Island compared to the U.S.
- Even in a no job growth scenario, RI needs to accommodate new employers – even large employers—because the economy is dynamic. RI needs the flexibility to meet the water needs of important businesses and institutions to remain prosperous.
- A trend toward more frequent and severe water scarcity will increase costs, decrease quality of life, and decrease the flexibility Rhode Island has to pursue strategic, economic development opportunities in the future.
- Environmental assets and quality of place are important economic competitiveness factors influencing the region's ability to attract and retain mobile talent.[5] Rhode Island's business competitiveness strategy is based, by necessity, on quality not cost.
- Rhode Island is the second most densely developed of the 50 states. Much of the land area is urbanized or suburbanized with significant alteration to hydrology and ecology. Remaining unfragmented forests and healthy aquatic habitat are, therefore, more scarce and precious to the well-being of Rhode Island than when

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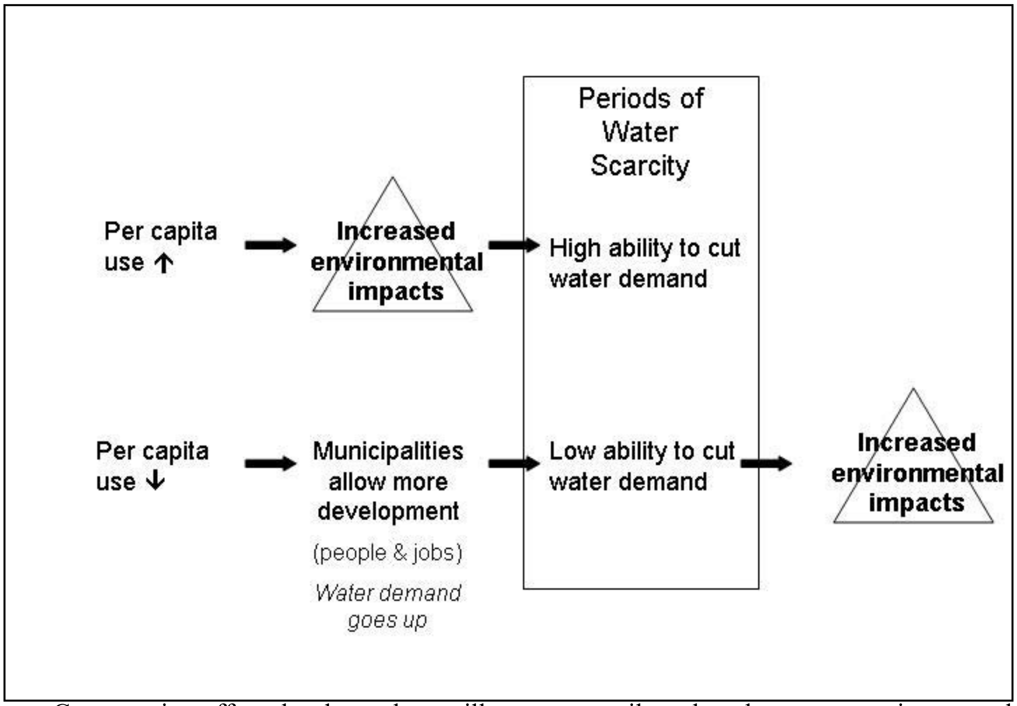
[3] See p. xiii.
[4] *American Rivers 2002 & Grow Smart RI 1999*
[5] See Appendix A for an in-depth discussion of water and economic well-being.

such environmental resources were abundant. Setting minimum standards for stream flow is a crucial first step to protecting environmental resources during drought.

The Conundrum



Conservation efforts by themselves will not necessarily reduce long-term environmental impacts. Ironically without getting a handle on development, conservation efforts could actually make it harder for water suppliers to cut water use during the inevitable periods of low precipitation. Implementing land development best practices will require a tremendous about of will and leadership, but it is the only policy option to protect the environment from excessive water withdrawal.

- Water scarcity is a real concern and the existing development trend – with declining use of urbanized land and the conversion of rural communities to medium density communities – exacerbates the problem. These trends shift water demand growth away from established large supply systems to smaller suppliers and self supply areas creating the need for new investments in supply infrastructure to serve the same population. Rural density areas meeting water needs with private wells and septic systems have minimal impact on hydrology. As development density grows, the hydrology is much more significantly altered by sewer systems moving water out of basin and increasing impervious surfaces. More intensive use of already urbanized areas has much less impact on watershed function than the same new development on greenfield sites. In short, water-smart growth looks a lot like the fiscally-smart growth policies promoted by Grow Smart Rhode Island or the Governor's Growth Planning Council. Water restrictions, business closures, well failures, and low stream flow levels have occurred in years without exceptionally low precipitation. Water scarcity will become more frequent and severe as land development diminishes water supply and increases demand in many communities. These are costs new residential development occasionally imposes on existing community residents.

- The capacity to cut water use during periods of scarcity and the long-term control of land development are the two policy levers that will most influence the degree to which droughts will result in water shortage. Optimizing water use is also critical, but if we can't control development, cutting per capita water use will only enable faster population growth. (See the Conundrum diagram previous page).
- Design and technology offer the potential to do more with less water and use water multiple times – effectively expanding the water supply.
- Short and long-term water management require different approaches. The Water Resources Board and the state's water suppliers are organized to address short-term issues, such as drought events. Long-term water resource planning requires a different set of priorities and is heavily dependent on municipal land use decisions. For example, meeting household water needs is a very high priority during drought events, but expanding domestic water use is a very low, long-term priority compared to environmental protection and sustaining a diverse economic base.
- Municipalities have the authority for land use planning and regulation, but they do not have the information or analysis tools to optimally manage the water resource dimension.[6]

It is within the power of the State of Rhode Island to avoid a future of increasing water use conflicts and more difficult water allocation decisions and, instead, create a future where:

- The health of our most productive ecosystems is not compromised
- The quality of our natural and built environment remains an important positive factor for economic competitiveness.
- Water availability is not a barrier to business development
- Diverse economic activities, including agriculture, remain profitable
- Affordable housing needs are met while protecting healthy, functioning watersheds
- Involuntary drought water use restrictions, particularly business closures, are minimized

Critical Concerns

The Impact Analysis Subcommittee finds that while many of the pieces of a solid, long-term, water management system are in place, there are two critical gaps that leave the door open to increasing levels of water scarcity and economic and environmental damage: the status quo in land development and environmental protection. Improving management in either area relies on an understanding of water availability. To that end, the cooperative basin studies underway by the Water

[6] See Appendix A.

Resource Board and USGS are important. They will model the hydrology of local watersheds and answer the question of how much water is available.

Concern #1 Land Use
Update land development ordinances to help assure long-term water availability.

Where new water users locate and how large total water demand grows depends more on municipal land use planning than on any other factor. Similarly the protection of watershed function also is most influenced by municipal development regulations. Absent land use regulations that make sense in the context of available water resources, no amount of conservation effort or supply system expansion can assure long-term water availability.

Where new water users locate and how large total water demand grows depends more on municipal land use planning than on any other factor.

Today many communities have land use regulations that, at build out, may exceed available water supply or allow severe impairment of watershed function with allowed impervious surfaces[7]. One tactic used to cope with this situation is to place the burden of proof on new development applicants to prove water availability. This "prove it" method is not easy or necessarily fair to developers and land owners and does not assure that the sum of small decisions will not compromise water availability for others in the local area. Streamlining permitting processes is an economic development priority, and it will be a challenge to fit water approvals within the timeline of other development approvals.

We recommend that the state take a leadership role in developing and implementing a comprehensive build-out analysis that examines water use at the municipal, watershed, and statewide level. The project will require financial support at the state-level with municipalities and regional planning organizations as partners. Water resources represent only a small portion of the planning responsibilities of municipalities and most water use impacts extend beyond municipal boundaries. The Comprehensive Planning statutes and State Guide Plan already require municipalities to consider water resource issues, but the complexity of water and growth issues exceed the planning resources of many communities.

This build-out analysis project has benefits beyond water resource management and is also needed for municipalities to better understand the fiscal consequences of their land use ordinances. The build-out analysis should incorporate analyzing the fiscal and water resource implications of a number of alternative zoning and regulatory scenarios under consideration by municipalities. To get full value from this work, communities will need technical assistance to understand implications of basin studies and build-out analysis and incorporate the findings into updated municipal ordinances.

Moreover, most land use ordinances focus on planning at the scale of the whole town, while the decisions that really matter are made at the design scale of individual sites. The state should also play a role in developing model land development and landscaping codes that can improve water resource protection. California developed an effective process for updating local codes throughout the state with minimum

[7] the impacts of development practices on water supply / demand issues are covered in detail in Appendix D.

burden on local government described on p. xlvi. The state developed and enacted a landscaping ordinance giving communities a timeframe to either adopt an alternative ordinance or pass a finding that no ordinance was necessary. The ordinance went into effect automatically in communities that took no action.

There is not a one-to-one relationship between the quantity of water available with the total population and job base that can be sustained. Communities can consider tradeoffs between differing land development and conservation practices and total population at build-out. Communities may also choose to tolerate more, or fewer, water scarcity events and the accompanying water restrictions.

Concern #2 Environmental Protection
Establish stream flow standards, priorities, and protocols to protect the environment.

Water flow in streams and wetlands is not protected from excessive withdrawals for human use[8]. The hot, dry conditions in which human water demand increases are also critical periods for ecosystems. Protecting productive ecosystems requires the establishment of minimum stream flow standards for all streams, but higher standards for priority habitats. The aquatic base flow standards, for example, are designed to avoid killing aquatic animals and do not represent optimum flow for maintaining the health of our top priority habitats. The state must establish a process that prioritizes natural resources including habitats, wetlands, and waterways. While we discuss the value of ecosystem services in Appendix B, environmental priorities are not easily reduced to an economic question. Priorities must come from a participatory planning process that combines ecological knowledge and community values.

The standards need to be linked to specific protocols for action that will avoid damaging levels of water withdrawals from priority habitats. Environmentally important aquatic habitats[9] exist in areas served by private wells and public suppliers; therefore public authority to manage water demand must extend to all users. While self suppliers usually operate in a closed system (water withdrawn is returned into the same watershed via septic systems), their rapidly growing water use has the potential to impact public supplies and water levels in priority habitats.

USGS has been monitoring stream flows in Rhode Island for the greater portion of the twentieth century (some data go as far back as 1930). As the Stream Flow subcommittee will address in their report, consistent monitoring needs to be in place to determine an appropriate stream flow standard. We strongly recommend continued funding for stream flow monitoring because it is essential for implementing one of our key recommendations—enforceable protection of priority habitats from damaging water withdrawals.

Demand Management
We caution against focusing on demand management to the exclusion of tackling the two areas of critical concern: land development regulation and enforceable environmental protection standards. However, demand management spans a variety of tools will help Rhode Island meet its development and environmental goals. There

[8]See Appendix B for a discussion of water and environmental impacts.
[9]See Appendix C.

are technologies and development practices that can significantly reduce future water demand. The appendices of this report include the results of our research on market and non-market approaches to demand management.

Where will the resources come from?

In the long term, implementation of these recommendations will help control municipal costs, state costs, and the costs of water supply. However, in the short-term, land use and environmental protection concerns will require some additional resources beyond money currently appropriated. Cost items include ongoing funds to support additional stream flow monitoring as well as funds for specific planning activities. Waiting for municipalities to fund these activities on their own will not serve the larger state interest.

From an economic efficiency standpoint, any additional revenues needed for water resource management should be raised through the pricing structure for water. However, it may not be necessary to impose additional costs on consumers if the Water Resource Board were allowed to spend more of the money collected from water consumers. More than half of the $5.9 million surcharge collected under the Public Drinking Water Protection statute last year was diverted to state general revenue and not used for water supply protection.

Appendix A

<u>Water and Economic Well-being</u>

In this appendix, we discuss economic concepts like efficiency and distribution as well as policy questions like economic and social priorities.

Understanding Economic Impacts

In preparing this report we reviewed other water policy economic impact studies for inspiration and concluded that undertaking an economic impact modeling project would not answer important questions for policy makers in Rhode Island. To illustrate, the Texas Water Development Program developed an economic impact model that estimated to total economic losses related to water shortages statewide and by 16 geographic regions. Estimates of costs are broken down by a half-dozen different sectors.

Construction of Texas Model:

benefit of unit of water consumption	x	water use	=	economic impact

The purpose was to generate summary economic loss figures to inform decisions-makers about the magnitude of water scarcity's economic impact – and probably to make supply expansion look like a bargain. The model translates economic growth projections into water use projections showing the magnitude of use conflicts 10, 30, and 50 years out.

The economic model generated good headlines: "If the State (of Texas) does not ensure that there is enough water to meet projected needs, models project that there will be 7.4 million fewer jobs, 13.8 million fewer people, and 38 percent less income Statewide in 2050."

Despite the model's success in assigning an economic value to water scarcity, it did not answer the question of whether Texans would be worse off economically. It said there would be fewer people and fewer jobs, but no claims are made about per capita income. The model was a consumption model not taking into account the supply impacts of land use change. How would 13.8 million additional people impact the environment or the health of watersheds? One of the simplifying assumptions is that conservation is ignored. The average water use per $1,000 income is constant within industries and over time.

Rhode Island's water policy will have an economic impact, but to understand the impact, it is necessary to first articulate economic goals for the state. What are the tradeoffs in terms of reaching those goals of the status quo verses other approaches to water supply and demand management?

Rhode Island is in a water rich region. Consumptive water use is less than 1 percent of renewable supply in New England (USGS 1984). Our current population and job base can be served by our renewable water supplies. Some communities are experiencing rapid growth and many others will allow significant new growth before they reach buildout raising the twin threats of increased water demand and degradation of watershed function. We could, through poor planning and decision making, increase the frequency of water scarcity in Rhode Island, making us poorer in the process. Recent droughts caused losses in economic welfare such as shutdowns at Ocean State Power, private wells going dry, and limitations on water use imposed on customers. Long-term trends include increasing demand for water in some local areas and increasing impermeable surfaces, thus reducing clean, fresh water supply for both humans and the environment.

These trends raise the possibility of reduced flexibility to meet economic development objectives within the next 20-50 years. Environmental priorities are even more vulnerable. While the environment is protected under federal and state laws, it is not truly protected when water is in short supply. We have a system that makes the environment the lowest priority user – allocated the remainder after public and private wells and surface water diversions.

We find that regions with water scarcity have been able to grow and prosper even with strict conservation measures in place and high cost water. Denver is one city that has experienced significant growth over the past decade, 19% in population and 17% in real median income (U.S. Census), in the face of extensive water conservation efforts and a detailed water-pricing scheme. The City's Water Board enforces a series of restrictive spring/summer water use rules, promotes public education on conservation, and has a robust system of incentives for residential and business customers. (http://www.water.denver.co.gov/conservation/conservframe.html).

Communities React to Water Scarcity

Each year, many Rhode Island communities face tough decisions about water use. Reacting to drought conditions in the summer of 2002, 13 municipalities imposed mandatory water restrictions, 6 implemented voluntary restrictions, and the State placed a ban on all non-essential water use in Washington County, Newport County, Bristol County, and other individual towns. As of June 2003, 7 water districts had already implemented some form of water restriction for the upcoming summer.

According to Anthony Sylvia, Newport's Deputy Director of Utilities, "supplies (were) so low it (was) really a matter of watering your lawn or not having enough water for drinking or bathing" (Providence Journal, 9/23/02). In Newport, ban violators faced a three-strike penalty system – a written warning, a $100 fine, and water shut-off coupled with an $80 restoration fee.

In 2002, precipitation was 5 to 11 inches below normal and many of the state's reservoirs remained below capacity. That past June, the City of Woonsocket imposed a citywide water ban after finding its main reservoir was two feet below normal water levels.

In addition to water bans, many communities throughout the region are considering the connection between residential growth and increasing water scarcity. Officials from Swansea, Massachusetts face this predicament on a regular basis. While town officials are exploring many innovative options to increase the water supply, such as transforming brackish water into drinking water using Navy technology, officials realize that finding ways to slow growth are necessary. Many towns across Rhode Island have implemented growth management plans that seek to pace development in a more reasonable manner, though most do not specifically address the issue of water scarcity.

In addition to changing regulations, many communities are looking toward best management practices as a way to ease water related problems. In Waterford, Connecticut, EPA is studying the water quantity and quality benefits derived from a model "green" neighborhood, as it compares to a traditional subdivision. Though the *Jordan Cove Urban Watershed Project* is primarily concerned with pollution from storm water run-off, the project's results may yield important conclusions with respect to water re-use and groundwater recharge.

Denver's water pricing encourages conservation, with both a fixed service and block consumption rate. Additionally, the supplier applies a surcharge in the spring/summer months to encourage users to conserve in peak demand months. Surcharge rates range from $0 to $11.85 per 1,000 gallons for residential users. All other surcharges range from $0 to $6.47 per 1,000 gallons. Proceeds from the surcharge fund drought and forest fire mitigation. The Denver Water Board also charges a System Development Charge. This one-time tap fee finances a portion of water system, and can also be used for drought and forest fire mitigation. The experience of Denver and other growing cities suggests that Rhode Island, with its relative water abundance, has considerable freedom to implement wise water conservation measures without fear of constraining income growth.

Denver Water Rates (consumption rate only)		
Customer	**Gallons/Mo.**	**Rate/1,000 Gallons**
Residential		
First	11,000	$1.58
Next	19,000	$1.90
All Over	30,000	$2.37
Multi-Family		
First	15,000	$1.39
All Over	15,000	$1.67
All Others		
Winter	--	$1.36
Summer	--	$1.63
Source: Denver Water Board, 2003 Water Rates http://www.water.denver.co.gov/rateinfo/rateinfoframe.html		

There are several unique features to consider in understanding the economics of water:

- Water is necessary for life therefore access to sufficient quantities of low cost water is a basic social justice issue.
- Water supply and use are not regulated effectively by a market. Pricing is not used in Rhode Island or most places to balance supply and demand.[10]
- Water needs are largely determined by long-term investments and social conventions.
- Water can be used more than once.
- Total available water supply in some watersheds is being reduced by land development decisions that are primarily the jurisdiction of municipal government.
- Water supply fluctuates with precipitation and temperature. In the last 50 years, RI's annual rain fall has varied from as little as 28 inches to as much as 64 inches.
- Expanding water supply capacity is a long-term investment. Year to year storage capacity is costly to augment.
- Drought is an unusual economic phenomenon in that it affects both supply and demand. Demand increases when supply is lowest.

Priority Economic Assets

Water resource planning needs to be integrated with land use planning—where facilities can be built and how. It also makes sense to press firms to adopt best water conservation

[10] To illustrate: watering bans, a non-market mechanism, are common in summer months. Using price to balance supply and demand would mean significantly changing prices to reflect short-term supply conditions – doubling the price to achieve a 20-40% decline in usage. It would also mean restructuring water rates to eliminate and fixed charges, converting entirely to charges based on water use.

and reuse practices within their industry. However, it does not make sense to restrict our industry targets for economic development to those that are low water users because water does not yet rank among the major constraints to economic growth. Rhode Island's economic growth goals call for a balanced economy and significant water users like hospitality and biomanufacturing are important to that balance for other strategic reasons.

The economy is dynamic and even in a no population growth scenario, new business will be created with new facility requirements. Rhode Island's economic health depends on the flexibility to accommodate the needs of growing businesses and adaptively reuse obsolete facilities. Our economic vitality also depends on preserving the quality of place assets that attract an educated and talented workforce. Preserving and enhancing both our unique built environment and natural environment figure prominently in this vision of quality of place. Distinct from the value natural ecosystems have as habitat and natural resources, they have additional value as aesthetic and recreational resources.

Below is a summary of economic development priorities articulated by the RI Economic Policy Council[11] that have relevance for land use and water resource planning:

- Focus on increasing prosperity. Population growth is not a goal.
- Increase investment in Providence and other urban centers. Build on Providence's assets as a hub of creativity.
- Grow high wage jobs, hold onto middle wage jobs. One of our greatest wage growth opportunities, biomanufacturing, is a large water user. Holding onto our manufacturing base is also important.
- Invest in the research infrastructure at the University of Rhode Island to improve our economic competitiveness.
- Enhance quality of place by making development respond to community character. Nurture vibrant, walkable communities at the village and town scale as well as urban centers. Many of our villages and towns have small lots and no sewers and are good candidates for new wastewater technologies.
- Preserve rural landscapes including agricultural and working landscapes. Agriculture is water dependent and threatened by growing development and competing water demands.
- Promote sustainable use of Narragansett Bay so that new development, on net, improves the health of the Bay ecosystem. The Bay depends on fresh water flow from ground and surface water and is threatened by over pumping and sewage discharge.
- Preserve the Borderlands as an unfragmented forest system in perpetuity. Forest health depends on adequate ground and surface water flow.

It is imperative that we not allow ourselves to get into a position where we cannot site another new biomanufacturing facility or cannot permit URI to build new facilities on campus because we have not managed non-strategic development well. The URI is of particular concern because it an institution critical to our economic future located in a

[11] The RI Economic Policy Council was created by executive Order to advise the Governor on economic policy. The Council is comprised of leaders from business. labor, higher education, and government.

groundwater dependent area with ecologically important streams and wetlands. Water availability is very local so making sure we plan adequately for growth at URI means close examination of the connection between water and land use planning.

Water Consumption and Economic Efficiency

Options for allocating scarce commodities such as water include interruption, rationing, queuing, and pricing. Interruption is a complete disruption in supply for a period of time. Examples include rolling electricity blackouts or residential outdoor watering bans. During a residential watering ban, the consumer may purchase unlimited amounts of water at the prevailing price, but is not allowed any water for specific uses during specified times. Rationing limits the quantity that may be purchased and imposes a penalty such as a fine or service cut-off for consumption that violates the ration system. Queuing imposes waiting costs on the consumer as was done during the U.S. gasoline crisis in the 1970s under price controls. Pricing is a flexible tool for influencing consumer demand and is used for most commodities including utilities such as electricity and telecommunications. Pricing is most effective when consumers are well informed about conservation alternatives.

Woo and Lo (1993) find that pricing is more efficient than interruption in resolving a water supply shortage to achieve the same reduction in consumption. In their modeling using empirical non-residential water market data, they found the welfare loss due to pricing to be only half the loss due to interruption. They note, “there is general consensus supporting the use of prices to efficiently allocate scarce water resources. However, pricing continues to play little role in water shortage management. ... Growing demand for water is met by new supplies and conservation programs (e.g., public education, improved irrigation practices, leak detection and low flow shower heads). If a severe shortage develops, a water utility resorts to such non-market programs as quantity rationing or service interruption to reduce water consumption.” (Woo and Lo 1993: 341).

Non-market conservation and drought management methods impose costs. “Consumers lose the ability to choose for themselves how best to use water, given its price. Instead, the utility in effect draws up its own ranking of uses and limits or proscribes those near the bottom. Second, consumers who have already gone to some expense and care to conserve water complain of unfairness in being asked to cut back further along with their less conservation-minded neighbors,” (Moncur 1987: 393). The downside for the water supplier is a loss in revenue and the addition of policing responsibilities.

Technical barriers to using pricing are mostly a thing of the past. A big reason for avoiding market-based conservation programs has been eliminated with the wide adoption of metering and computerized billing systems, without which all but the simplest pricing systems were impractical. Today, resource economists are arguing for pricing water at the long-run marginal cost of supply whenever it exceeds average cost. “Basic economic principles suggest that the solution (to water shortages) lies in increasing the price of water to the level of its marginal cost. Marginal cost covers not only operating and capital inputs, but also the scarcity value of the water source, which, during a drought, carries a temporary premium,” (Moncur 1987: 393).

What about water users on private wells? Water use from private wells cannot be easily influenced by pricing, but policy makers have other options. Private wells paired with septic systems have minimal impacts on water quantity. For these consumers the vast majority of consumptive use is outdoors, which could be limited through non-market mechanisms like watering bans when necessary. This would be warranted if stream flow or wetland water tables dropped below a trigger threshold. For consumers with private wells and sewer connections, conservation water use pricing could be combined with sewer charges.

Pricing is an alternative to non-market conservation measures like watering bans, but not a substitute for education. Information and technical assistance improve consumer's ability to respond to price.

Do consumers respond to water prices by changing consumption behavior?

A variety of studies show that both residential and commercial consumers respond to prices. The American Water Works Association 1998 report on this subject[12] states that "water price has a significant and negative impact on water use." What that impact would be for Rhode Island cannot be predicted with accuracy from existing research however. The most recent study of the price elasticity of water that including the northeastern United States is based on 1963-65 data. Howe and Linaweaver found that indoor domestic demands are relatively unresponsive to price changes, outdoor water demand is more responsive to price, but much more so in the East than in the West. Overall urban price elasticity of summer demand was found to be between –0.3 and –0.4. (1967: 13). This means doubling the price would cut outdoor water consumption by 30-40%. The long-run price elasticity estimates exceed the short-run figures. Since the 1960s there has been an increased availability of water conserving appliances for the home, but elasticity estimates remain in that ballpark. The 1998 American Water Works Association study which improves on the methods of early studies found a -0.2 price elasticity during the peak season and -0.1 on an annual basis for their study cities in the arid and semi-arid Southwest. They also found that responsiveness to price and non-price conservation measures differs measurably from city to city within their study area.

In short, the only way Rhode Island can determine how effective price can be in controlling water demand is by implementing a conservation pricing program and evaluating the results. We can be confident that suppliers won't lose revenue and that the price elasticity will likely fall between -0.2 and -0.4. Virtually all studies of consumer response to price indicate that water demand is price inelastic – meaning suppliers increase revenue by increasing prices. There are several applicable lessons to be learned from other studies:

1. If you want to be able to draw conclusions about consumer response to prices it is important to structure all costs based on units of water consumed – eliminating all fixed customer charges or service fees.

[12] American Water Works Association Research Foundation. 1998. p.xxii.

2. Persistence is beneficial. Too short an experiment cannot tell you how consumers will respond over a longer time horizon. Good studies look at behavior over years not months.
3. Keep track of all price and non-price conservation programs implemented during they study period so that they can be included as variables in the model. If this is not done, evaluators will be highly uncertain about the impact of pricing.

The AWWA study suggests demand management is not for the timid; Non-price programs require multiple programs sustained over time and conservation pricing requires large price increases to achieve modest declines in usage.

Land Use and Economic Efficiency

There is no market system in place to send price signals to developers or homebuyers about water use decisions. In fact, consumers generally don't even know if they are buying a house lot that contributes to storm water problems or even how water efficient the appliances are. Developers and buyers are not rewarded with cost savings for socially efficient choices.

Morris (1990) argues that water should be priced at the long-run marginal cost for developing new water supplies and that one time costs like hook up costs and customer costs should be pro-rated and billed as part of the per unit water rate. Much of the literature on conservation water pricing is about the budget of the water supplier and conservation (increasing block) pricing is justified when a reduction in water use can postpone or avoid a major new capital expenditure. In Rhode Island, we also find that developing new supplies has environmental costs. Even when studies conclude that no environmental damage can be documented from a proposed withdrawal, there is some marginal cost to environmental health in terms of ground and surface water flow volumes. Because of the complexity of ecosystems and their chaotic variability, low level impacts cannot be demonstrated through short term observation. Yet many small projects with "no significant impact" add up to changes in local hydrology.

Many regions of the country have impact fees for development tied to water demand. Especially in the West where urban water supplies come from remote locations, there is not an equal concern with the impact of development on watershed function and the water supply. In Rhode Island, we live within the watersheds that supply our water. The way we develop our land contributes to the water supply equation as well as the demand equation.

Rhode Island, with its relatively slow population and job growth, nonetheless, has been decentralizing at a rapid pace adding new, larger houses, roads, and parking areas outside our urban areas – increasing impermeable surfaces. "As the impervious surfaces that characterize sprawling development – roads, parking lots, driveways, and roofs – replace meadows and forests, rain no longer can seep into the ground to replenish our aquifers. Instead, it is swept away by gutters and sewer systems," (American Rivers et. al. 2002). The American Rivers study estimates groundwater infiltration "losses" from land development between 1982 and 1997 to be between 43.9 billion and 102.5 billion gallons annually for the Boston metropolitan area – enough to supply the average daily household needs of 1.2 million to 2.8 million people. Grow Smart RI (1999) calculated that 96,000 acres of land were developed in RI between 1961 and 1995. Applying Boston metro factors from the American Rivers study yields an estimated water loss between 10 and 23 billion gallons of water or enough to supply between 250,000 and 600,000 RI residents. This water is not available for use by ecological systems or humans and it increases peak flow in sewer systems and streams aggravating the impacts of floods. "Precipitation runs off of impervious surfaces much more rapidly and in much greater volume than under natural conditions. The result is a decrease in groundwater flows into streams, less recharge into aquifers, and increase in the magnitude and frequency of severe floods, and high stream velocities that cause severe erosion and mobilize large quantities of sediment, damaging water quality, aquatic habitat, and infrastructure, such as roads, bridges, and water and sewer lines," (American Rivers et. al 2002: 5).

Nelson and Moody (2003) find that impact fees do not constrain economic development. When fees are tied directly to costs they improve economic efficiency and predictability. They improve the development process by making sure that the community can provide the quality of infrastructure desired to support development. "Impact fees, like user fees, offer a more efficient way to pay for infrastructure than general taxes, and ensure benefits to those who pay them. Academic literature suggests that the aggregate benefits of impact fees improve efficiency in the provision of infrastructure. While impact fees often do not reflect the full price of infrastructure improvements, fees do make the economic linkage between those paying for and those receiving benefits more direct, and so promote economic efficiency. The obvious direct economic benefits include the actual infrastructure investment, such as new roads, new schools, and new water and sewer extensions. Indirect benefits include improved predictability in the marketplace, knowing when and where infrastructure investment will occur, and that all developers are treated equitably." Impact fees are used in Rhode Island for schools and could potentially be used for water-related infrastructure impacts.

Distributional Issues

The many options available in water price design result in different distributional consequences. The two biggest social policy concerns are income effects on water usage and the distribution of the costs for new growth. The first is typically handled through an increasing block rate structure, the latter through an impact fee charged for new connections to the water system.

Income effects

Making sure adequate water is available at a reasonable cost is a basic social justice issue. Most utilities, including telephone and electricity, have some provisions to protect low-income customers whether they be special subscription rates or limitations on cut-offs of service for non-payment. For the same reason, we recommend keeping residential water prices for the first 50 or so[13] gallons per person per day at current low prices through block pricing. Above that, prices could be set at as needed to achieve necessary water reductions during periods of shortage or at the long-run marginal cost during the rest of the year. The

[13] There is a rates subcommittee addressing conservation pricing.

logistical barrier to implementing such a system is that water utilities do not currently have information on the number of people per account.

Because water does not represent a large fraction of the typical household budget, we would expect the income effect to be modest, but this is not supported by empirical studies. Howe and Linaweaver (1967:28) found that income elasticities for domestic outdoor water use to be about 1.5 in metered eastern areas of the United States. This means people with more income use more water than lower income people. Some people would make the social argument that wealthier people don't have a right to water their large lawn during periods of drought and ecological stress. From a long-term efficiency stand point, welfare can be maximized by charging large volume residential customers for water at a rate sufficiently high to pay for the installation of water conserving technologies for other customers that will save equal or greater volumes of water during peak periods.

Setting block pricing for commercial and industrial customers is not indicated by the same logic of need. Industrial and commercial uses of water have higher economic values than residential users at current levels of consumption and their demand is less price elastic (Jenkins et al. 2003: 59). Thus, marginal cost pricing will induce efficient levels of investment in water saving technologies.

Distributing the costs of new growth

Increasingly, other areas of the country are trying to make sure the high marginal costs of supplying water to new customers are not subsidized by shifting those costs to pre-existing customers. The characteristics of these new customers are different than old customers: they have larger structures, larger lots, are more likely to have sprinkler systems, and are located farther from installed infrastructure. They also tend to be wealthier. A Seattle study cited in American Rivers *et. al.* (2002: 5) found that suburban "estate" properties consumed as much as 16 times more water than homes on a more traditional urban grid, with small lots. Nor are these concerns new. As early as the 1960s, studies mention the use of water impact fees calculated based on lot frontage of total lot size justified by these larger properties impact on water demand (Howe and Linaweaver 1967).

Similarly, pricing in the form of impact fees tied to watershed impacts can be more socially efficient than fixed development regulations. Developers could be able to avoid such fees to some degree by following best practices in terms of water systems, appliances, landscaping, storm water management, and permeable surfaces.

Pricing Policy Can Provide the Resources to Avoid Scarcity

New revenues from marginal cost pricing, conservation pricing, and impact fees are an appropriate revenue source for investments that will reduce the probability of future shortages and rate hikes. Examples could include development of new water supplies, land purchases, development rights purchases, incentives and technical assistance to customers to install water-conserving technologies. For example, additional revenues could be used for grants to install better irrigation systems on farms or golf courses, essentially creating a system whereby consumers willing to pay a marginal price for water pay others to use less.

Current pricing is designed to cover only the direct costs of the water supplier including some funds for supply protection and demand side management programs.[14]

Long-Term Predictability

Under pricing water may result in business and environmental losses far in excess of the savings from low cost water. It is natural for planners and political leaders to want to be conservative and only impose conservation measures during periods when drought makes them necessary. That non-interventionist approach can result in high private costs when people incorrectly evaluate risk.

Conservation over the long-term is less disruptive and costly than over the short-term. Many of the decisions that make the biggest impact on firm and household water consumption are capital investments. Facility and location decisions made now will impact the water needs of those developments over planning horizons of 20 years or more.

The U.S. Army Corps of Engineers (1994: iv) finds that drought impact studies understate people's aversion to droughts: "The level of conflict and anxiety droughts stimulate is still apt to be far greater than the magnitude of impacts would suggest."

Water management policy needs to look 50 years out and be reflected in land use policy so that firms and households can make investment decisions with better knowledge of long-term water availability. Even conservation pricing policies should be phased in over a relatively long period of time so that consumers have an opportunity to adapt.

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[14] The Watershed Land Acquisition Program, enacted by the Rhode Island State Legislature in 1989 as part of the Water Quality Protection Plan, generates approximately $2.2 million annually for Providence Water for the purpose of acquiring land and protecting the state's raw water supply. Since 1990, the Providence Water Supply Board has purchased 1,440 acres of critical watershed land (Providence Water website). This program is open to many major suppliers.

Appendix B

Water and Environmental Impacts

Appendix B will examine two important concepts; the hydrologic cycle, and the economic value of ecosystem services. An outline of the range of environmental impacts of water withdrawal for human use as well as an examination of the water-related environmental impacts of current land development trends will follow. Finally, general principles regarding the protection of Rhode Island's sensitive stream and wetland habitats will accompany the acknowledgement of discrete areas of the Blackstone and Pawcatuck watersheds in need of priority consideration.

The Hydrologic Cycle

The hydrologic cycle is the continuous transfer of water from one of four storage site to another. These four storage sites are: in the oceans of the world, in the atmosphere as clouds and water vapor, on the land surface in lakes, ponds, streams, and rivers, and underground as groundwater. The six solar-driven processes that carry out this transfer of water from storage site to storage site are:

- Evaporation – the transfer of water from oceans, surface waters and soils to the atmosphere.
- Transpiration – the transfer of water to the atmosphere as a part of the plant respiration process. Note: Transpiration from plants and the portion of evaporation coming from soils and surface waters is known collectively as evapotranspiration.
- Precipitation – rainwater.
- Infiltration – water soaks into the ground, replenishing soil moisture and deeper groundwater supplies. Water which does not infiltrate is known as surface runoff.
- Runoff - water flowing from the land surface back to the oceans.
- Baseflow – the movement of groundwater to surface flow through seepage into lakes, wetlands, and stream channels.

Water supplies for human use interrupt the hydrologic cycle in three ways. First, water is pumped directly from rivers and streams. Ocean State Power in Burrillville, R.I. is a good example. The plant has a permit from RIDEM to pump a maximum of 4.4 million gallons per day from the Blackstone River for cooling purposes. Second, rainwater surface runoff is accumulated through a catchment system of rivers and streams and stored in reservoirs. This catchment system, or drainage basin, is defined as an area of land that drains to a common outlet. The strategic placement of a dam at this common outlet can impound water from a large drainage basin, helping to mitigate the geographic variability of rainwater supplies. Here in Rhode Island, the Scituate Reservoir system drains approximately 60,000 acres, or 9% of the state's land area, and has a storage capacity of 41.3 billion gallons, supplying drinking water to nearly 60% of the state's population (Providence Water website). Finally, water can be pumped from underground aquifers. Much of the water supply of rapidly-growing southern and western Rhode Island comes from underground sources.

As a consequence of human use, water returns to the hydrologic cycle in three ways. First, water is returned directly to the atmosphere through evaporation as a result of landscape maintenance, a significant portion (approximately 10%) of residential water demand. Water used in lawn watering is nearly 100% lost to the atmosphere (Cox 2003: 4). Second, water passing through the sewage treatment process along with un-captured storm water runoff is discharged to the oceans directly or via stream and river flow. Third, water is returned to groundwater through individual septic sewer disposal systems (ISDS). This last process, unlike the first two, generally does not result in the problematic situation of out-of-basin transfer, and is an important source of groundwater recharge.

A critical aspect of the interruption of the hydrologic cycle for human use is the pumping of and the discharge to groundwater aquifers. Pumping and discharge lead to two major concerns; overdrafting or water mining, which is the withdrawal of groundwater at unsustainable rates, and contamination of groundwater by surface pollution sources. Aquifers are recharged by infiltration from the surface at rates that vary according to the water transmissibility of their geologic makeup. Movement of water through ground water aquifers can take decades or even centuries in some cases. Two things happen as a consequence of these extremely long recharge rates. If a groundwater well is pumped dry, it is lost as a water supply source in the short term. Also, if a groundwater aquifer is contaminated, the remediation is costly, detection is often too late, and even if the pollution source is removed, purification will take decades or longer. Rhode Island's aquifers are unconfined and unconsolidated sediment layers. The consequence is that groundwater pumping can impact stream flow relatively rapidly.

Ecosystem Services

The environmental impacts of water withdrawal for human use cannot be understood without efforts to calculate the value of goods and services healthy watershed ecosystems provide. Historically, these values have not been properly accounted for and, as a result, have been excluded from decision-making processes regarding water supply management. Methodology for calculating economic values for ecosystem services continues to be vigorously debated; with researchers stressing their efforts are only starting points. Costanza, et.al, (1997) identify eight, water-related ecosystem services for which economic values can be calculated:

- Disturbance regulation – flood control, storm protection, drought recovery and other ecosystem responses to disturbance
- Water regulation – provision of water for transportation, and other industrial or agricultural uses
- Water supply – provisioning of water by watersheds, reservoirs, and other aquifers
- Erosion control & sediment retention – prevention of loss of soil by wind or runoff; storage of sediments in lakebeds or wetlands
- Waste treatment – pollution control and water purification.
- Refugia – nurseries, habitats for migratory species, and over-wintering grounds for local species
- Recreation – eco-tourism and other outdoor recreation opportunities
- Cultural – aesthetic, artistic, educational, and scientific values

Estimates of Narragansett Bay Ecosystem Values[1]

(Pacheco and Tyrrell 2003)

Ecosystem Service	Global values by ecosystem service ($/acre)[2]							
	Estuaries	Shelf	Forest	Grass/Range	Wetlands	Lakes/Rivers	Cropland	Urban
Gas Regulation				2.8	53.8			
Climate Regulation			57.1	0.0				
Disturbance Regulation	229.5		0.8		1836.9			
Water Regulation			0.8	1.2	6.1	2203.6		
Water Supply			1.2		1537.8	856.7		
Erosion Control			38.9	11.7				
Soil Formation			4.0	0.4				
Nutrient Cycling	8539.1	579.1	146.1					
Waste Treatment			35.2	35.2	1690.4	269.1		
Pollination				10.1			5.7	
Biological Control	31.6	15.8	0.8	9.3			9.7	
Habitat/Refugia	56.9				123.0			
Food Production	210.8	27.5	17.4	27.1	103.6	16.6	21.9	
Raw Materials	10.1	0.8	55.8		42.9			
Genetic Resources			6.5	0.0				
Recreation	154.2		26.7	0.8	232.3	93.1		
Cultural	11.7	28.3	0.8		356.5			
Area (acres)[3]	100,208	500,000	318,995	5,636	102,249	18,756	50,112	191,572
Total Value ($1000/year)	**926,312.7**	**325,750.0**	**125,077.9**	**555.7**	**611,786.4**	**64,503.8**	**1,869.2**	**0.0**
						TOTAL ($1000/year):	**2,100,000**	

Note: Blank cells = not available; Shaded cells = service does not occur or is negligible

[1] Estimates refer only to the Rhode Island portion of Narragansett Bay, not the entire watershed

[2] Calculated from the $/hectare estimates of Constanza et al. (1997) based on conversion factor of 2.471 acres/hectare. All values are in 1994 U.S. dollars.

[3] Source: Tyrrell and Harrison (2000)

Andrada Pacheco and Tim Tyrrell applied Costanza's figures to Rhode Island's ecosystems to come up with a ballpark estimate of the value of ecosystem services in Rhode Island of 2.1$ billion per year or 6% of gross state product (see table above). This figure is larger than a number of individual industries like health services at $2.6 billion or banking at $4 billion. Are these figures real? Tyrrell cautions that these figures are derived from a mix of methodologies including revenue generation and replacement cost. The figures illustrate a number of interesting things, like the range of services provided by wetlands and the high economic value assigned to those services. While precisely valuing ecosystem services is problematic, they have real economic value.

The New York City drinking water system provides a fine example in which naturally-occurring public utilities and the services they provide have value in terms of what it would cost to replicate their services using technological methods.

The nearly 2,000 square mile Catskill/Delaware watershed in upstate New York is the largest unfiltered water supply in the U.S., providing nearly 1.4 billion gallons of fresh drinking water per day to New York City. The superb filtering and storage capacity of this high-quality watershed has historically provided massive quantities of some of the best drinking water in the world. However, beginning in the early 1970s, water quality began to fall as a result of poor land development practices in the watershed. Residential development, water-quality damaging agricultural practices, and heavy forest clearing combined to limit healthy ecosystem function.

Water quality deteriorated to the point where, in 1986 with the passage of the Safe Drinking Water Act, New York City was forced to consider building a filtration plant to restore water quality to safe standards. Construction costs to build a plant that would reproduce the function of the formerly healthy watershed were estimated at $6-8 billion. Annual operation costs of $300 million and eventual replacement costs moved the price tag to nearly $9 billion (Heal 2000: 49-50). Facing these enormous costs, New York City adopted, and received EPA waivers for, an alternate strategy, that of rehabilitating the watershed and restoring its ecosystem functions. Through an aggressive campaign of land acquisition, purchase of conservation easements, and the promotion of best management practices for farming and forestry, New York City is restoring watershed function for a fraction of the cost of the technological solution to their water quality problems.

Environmental Impacts of Water Withdrawal

Significant environmental impacts of water withdrawal result from two important processes: the reduction of stream flow from direct pumping, and the interruption of baseflow (the seepage of groundwater into wetlands, lakes, and streams). The consequences of these two processes are threefold. First, healthy ecosystem function is impacted. Second, critical aquatic habitat is lost and, third, instream flow for downstream uses is reduced.

A decline in moisture content significantly reduces a watershed's ability to function as a healthy ecosystem. When moisture is removed, several results may occur:

- Average physical area of wetlands decreases.
- Flood control functions decline because water-retention ability is degraded.
- Erosion control functions decline as dried-out soils fall prey to wind and runoff forces.
- A general concentration of salinity, oxygen-starving nutrients, toxic chemicals and water-borne micro-organisms, results in the loss of equilibrium in the system.

Most importantly however is the loss of a watershed ecosystem's water purification capabilities. As an example, it is estimated a healthy wetlands may remove as much as 90% of nitrogen in the system by the time water reaches the coast (Cox: 2003). The dewatering of these wetlands as a result of groundwater pumping can significantly increase nitrogen levels downstream. Declining moisture content also affects infiltration rates which in turn threatens groundwater quality from non-point pollution sources. This overall filtering capability, both in purifying surface waters and protecting groundwater quality, is a healthy watershed's most important function, and is significantly degraded by water withdrawal.

Loss of aquatic habitat, primarily from declining or intermittent stream flow is another important environmental impact of water withdrawal. Minimum flow rates are an absolute requirement of stream habitats. Intermittent or low stream flow results in:

- Loss of riffles and rapid flow sections necessary for water oxygenation and species reproduction.
- Loss of channel margins which provide shade and cover.
- Increased water temperature.
- Segmentation resulting in changes from stream to pond habitat.
- Increased light transmission resulting in the altering of stream-bed micro-habitat.
- Changes in sedimentation characteristics providing fish spawning habitat.
- Encroachment of invasive species of flora in the streambed.
- Wintertime freezing down to the bottom of the streambed.

These impacts are not exclusive to stream habitats. Similar fragmentation of habitats, disruption of reproductive cycles, altering of species populations, and the encroachment of invasives can be found in the dewatering of wetlands as well.

Loss of instream flow for downstream use is the third important environmental impact of water withdrawal. The Ipswich River in Massachusetts serves as a fine example. Its upper reaches have been pumped dry four of the last eight years as a result of demand exceeding supply (Glennon 2003:13).

The key to understanding what happened with the Ipswich River is to acknowledge that the river is not drying up from direct pumping. A significant source of stream flow is seepage from shallow groundwater. This baseflow is interrupted by groundwater pumping. Groundwater that would have recharged the stream is diverted by wells and can, at times, actually flow from streams (or even uphill) to get to groundwater wells.

The affluent communities in the upper reaches of the Ipswich River watershed are entirely dependent on groundwater sources. Furthermore, Ipswich water is exported at very high rates. Fully 80% of the water pumped from the Ipswich River watershed is discharged outside of the watershed (Cox 2003: 5). To further compound the problem, extensive sewer systems and abundant impervious surface limit groundwater recharge within the watershed. The combination of heavy groundwater pumping to satisfy demand and limited groundwater recharge rates has resulted, not unexpectedly, in a bone-dry riverbed.

This severely reduced or non-existent stream flow has several effects downstream:

- Limits recreational opportunities.
- Diminishes aesthetic and scenic values.
- Reduces property values – the ultimate irony for the waterfront homeowner/water user.
- Destroys habitat as noted above – another aesthetic value.
- Reduces water quantity to assimilate downstream effluent discharges and storm water runoff, thereby decreasing water quality.

Water-related Environmental Impacts of Development

There are several environmental impacts related to increased water demands as a result of current development practices. First, as discussed in the previous section, increased demand calls for additional pumping from surface and groundwater sources. As noted with the Ipswich River, reduced stream flow caused by pumping brings a host of environmental problems. Second, pressure to create additional reservoir storage increases. The environmental impacts of dam construction are considerable. Third, increased demand necessitates increases in out-of-basin transfers, interrupting the local hydrologic cycle. Fourth, increased development leads to increases in impervious surfaces, a critical factor for both runoff and infiltration. Lastly, reduced surface flow and excessive groundwater pumping can lead to saltwater intrusion of coastal water resources. Finer points of these impacts deserve consideration.

Dam construction and the resulting impounded water have several important environmental impacts:

- The replacement of a flowing-water ecosystem with a still-water system. The accompanying inundation of streams and wetlands reduces ecosystem functions.
- Dams create an obstacle to upstream fish migration.
- Thermal and oxygen levels of downstream releases are variable, causing changes in downstream ecosystem functions.

- The disruption of natural sediment transport systems causing siltation above the dam and changes in stream channel habitat below the dam.

Out-of-basin transfer, which creates a net loss of water from the supplying basin, happens in three ways. First, water suppliers pump water from one watershed to consumers in another. Newport Water District (NWP) offers an example of this occurrence in Rhode Island. NWP pipes water from reservoirs in Tiverton and Little Compton across the Sakonnet River Bridge to supply its reservoirs and customers on Aquidneck Island. Second, sewage treatment systems discharge treated water out-of-basin. In Rhode Island's case, this is often into Narragansett Bay. Water that enters sewage treatment systems is effectively lost to the supplying basin, in contrast to water returned to groundwater within the basin through individual septic systems. Amgen's new bio-tech plant in Coventry is expected to pump as much as one million gallons per day into sewage systems, losing it to groundwater recharge. Lastly, un-captured storm water runoff flows out of basin (into the bay) rather than being made available for infiltration and recharge of in-basin groundwater.

This last point speaks directly to the double-edged sword of the increase of impervious surface that accompanies development. Impervious surface creates two serious environmental impacts. One, runoff from roads, parking lots, and buildings is captured by storm sewer systems, decreasing groundwater infiltration which ultimately decreases available drinking water supplies. It is estimated the city of Boston loses up to 100 billion gallons of water per year to runoffs. Two, this same runoff carries significant amounts of non-point source pollution which degrades receiving waters and taxes what watershed filtering that does take place. In addition, because the water-retentive capabilities of watersheds are not being utilized, impervious cover runoff greatly increases the frequency and intensity of downstream flooding.

A final environmental impact of increased water demand is the increased threat of saltwater intrusion into coastal community water supplies and ecosystems. Decreasing freshwater stream flow through increased water supply pumping upsets the delicate freshwater/saltwater balance in coastal estuarine habitats. Additionally, because of the decreased pressure of freshwater flows, saltwater becomes free to move inland and upstream into previously exclusive freshwater ecosystems. A potentially more serious problem from a freshwater supply point of view is excessive pumping of groundwater creates a reduction of underground hydraulic pressure allowing nearby saltwater to move into and contaminate the aquifer, effectively eliminating any wells pumping from that aquifer as water supply sources. This could become a serious problem in Washington County where suburban growth is on the increase and water supplies are almost exclusively dependent on groundwater sources.

Appendix C

Blackstone & Pawcatuck Watersheds – Priority Aquatic Habitats

Establishing priorities among ecological resources is one of the most fundamental planning tasks to guide water resource management. Along with stream flow standards and wetland standards, establishing priorities allows land use planners to protect the most valuable resources. The priorities outlined below from this subcommittee represent a starting point. It is important to establish an ongoing process with legal standing for setting and reviewing priorities. Environmental priorities need to influence water supply plans. The Wood and the Queen are targets for water supply development because of the quality and quantity of water – precisely the characteristics that sustain healthy aquatic ecosystems.

Our subcommittee focused on streams and associated wetlands, not vernal pools or other wetlands, some of which may also be impacted by water withdrawals or alteration of flow regimes. The subcommittee included representatives from: RI DEM Fish & Wildlife, RI DEM Natural Heritage Program, RI Natural History Survey, Wood Pawcatuck Watershed Association and The Nature Conservancy.

Priority Aquatic Habitats of the Blackstone River Watershed:

Even in the Blackstone River, a long-term urbanized and industrial river system, there are still ecologically important areas. There is a species of dragonfly only found in Rhode Island on the Blackstone even though the Blackstone is not exceptional in water quality. In the Blackstone, headwater streams are very important refugia for fish especially in hot summer months.

- Headwater streams – all headwater streams indicated as supporting brook trout. Important as refugia when downstream warms up in the summer months. Forested landscape is critical as habitat for odonates and for maintaining water temperature and quality of streams.

- Abbott Run Brook – forested stream, supports freshwater mussels, odonates. An example of good quality stream that lacks brook trout.

- Long Brook – RI's only location for the state-listed American Brook lamprey.

- Nipmuc River – supports wood turtle and has good quality riparian habitat.

- Clear River – supports good populations of river odonates including species rare in RI, wood turtle, brook trout.

- Lower Portions of Branch River & main stem of Blackstone River below its confluence with the Branch River – breeding habitat for river odonate species associated with larger rivers. Timing of dam releases is critical.

Priority Aquatic Habitats of the Pawcatuck River Watershed:

The strong consensus of the subcommittee was that the aquatic habitat of the Pawcatuck watershed should be a priority for protection and that measures be taken to prevent loss of biological diversity and quality of the systems here. This watershed has the highest concentration of globally ranked priority species of any watershed in the state and an overwhelming proportion of the state-rare species. In particular, the systems of the upper Wood River and Queens River and several large wetland systems were identified as exceptional for their condition and aquatic diversity. In addition to its statewide importance, a study by The Nature Conservancy (2002) further supports the importance of the Wood-Pawcatuck watershed, identifying it as among the most ecologically intact watersheds from Connecticut to southern Maine based on analysis of forest cover, development, road density, dams and point source pollution.

Within the Pawcatuck watershed, river-based systems of greatest ecological significance are:

- Wood River headwaters south to Wyoming Pond – highest rating. Should be lowest priority for water withdrawal in the state. High diversity of aquatic species, exemplary riparian and aquatic habitat, in good quality forest context. Forested landscape critical.

- Queens River (and Uspequaug River) headwaters to confluence with Pawcatuck (north of Kenyon village) – diverse riparian and aquatic communities, brook trout, large populations of river odonates and other invertebrates. Largely forested; forest landscape is critical.

- Meadowbrook – Brook trout are present but portions of the brook may dry up under extreme conditions.

- Large Wetlands Areas – Phantom Bog, Great Swamp. Exceptional quality wetland communities; including bogs, fens and old growth red maple swamp.

- Blackwater streams – Poquaint Brook, Charles River and Lower Chipuxet River – slow-moving tannin-stained streams that run through wetlands. They support three state-rare odonate (dragonfly/damselfly) species. One is the Blackwater Bluet, a damselfly that occurs only in this habitat, and not known anywhere else in New England.

- Lower Pawcatucket – main stem from Bradford to mouth. Good wildlife habitat, diadromous fish, river odonates, water flow important to ecological integrity of Little Narragansett Bay.

- Other sites identified as important but not as high ranked as above. Recognized need to identify and prioritize other wetland systems that may be impacted by water use and practices.

Summary of findings

As a result of examination of aquatic habitats in the Blackstone & Pawcatuck watersheds, some general principals applicable to all RI watersheds are:

- Species richness derives in part from intact ecosystems and natural processes: the combination of coldwater or warmwater streams, associated wetlands, and adjacent forests. Forest cover affects stream temperature and detritus is an important source of nutrients. Other natural processes include fluctuations in stream flow, scouring of shores, movement of organisms through the system, etc.

- Forest cover between streams is important as it allows movement of species between tributaries, provides habitat, and affects groundwater infiltration.

- Groundwater withdrawal can affect streams both by decreasing water flow and increasing water temperature.

- Species such as Brook trout, odonates, freshwater mussels, northern stream turtle, and the wood turtle are valuable indicators of healthy, high-priority aquatic habitat.

- The brook trout is especially valuable as an indicator of healthy cold water streams. A draft map of Brook trout sampling locations and results was supplied by RI DEM Fish & Wildlife as a working map (2003 draft).

- Headwater streams are very important. Because of the relatively small size of their watersheds, headwaters are especially vulnerable.

- Ecologically important habitats exist even in some long-term urbanized and industrial rivers such as the Blackstone.

- Cold water streams are not the only valuable streams. Warm water streams have been identified because of other suites of rare and endangered species.

Appendix D

Development Practices and Water Supply & Demand

This appendix is presented as an outline bringing together the considerable information the subcommittee learned on development practices and their relation to water supply and demand.

Section I: Lawn and landscaping Choices

A. Volume of water.

Total Water Consumption in Rhode Island by Selected Sectors [1]:

- Total Water Use in Rhode Island - 137 MGD (Million Gallons per Day)
  - Domestic 46% or 64.3 MGD
  - Outdoor Use 32%* of Domestic Use or 20.58 MGD
    - Lawn Watering Use:
      - 32% [6] [7] of Outdoor Use
      - 6.59 MGD
      - 10% of Domestic Use
  - Commercial 16%
  - Industrial 10%

Land development is the biggest driver of changes in water demand. How much development, what kind of development, and where development takes place, all matter in the demand equation. Rhode Island is experiencing rapid growth outside the service delivery areas of our largest public water suppliers. Land use decisions within the distribution area of a public water supply system determine water quantity demanded. A growing number of Rhode Island water users are self-suppliers on private wells.

Differences in water consumption across the country:

- In Rhode Island residential water use is a big issue. Forty-six percent of water use in Rhode Island is residential compared to 17% nationally. Rhode Island has a relative absence of large-scale agriculture and heavy industry. Per capita residential water use in Rhode Island is not out of line nationally. We could not find a decisive accounting of national average water use, but the USGS reports that each person uses about 80-100 gallons of water per day (USGS 2003). National studies of individual water supply districts show a range from 46 to 450 gallons per person per day. Rhode Island communities have average daily per capita water use in the 50-160 gallon range. Some individual communities like Jamestown and Narragansett, have remarkably low per capita water use on a national scale, while none of our communities are among the top water users.

- The amount of outdoor water use is less in wet climates such as the Pacific Northwest, and higher in dry climates like Southern California. However even in wet climates, the lawn area is often the single highest user of water in the house. [5]

- Per capita use of public water is about 50 percent higher in the west than the east mostly due to the amount of landscape irrigation in the west. However, per capita use can also very greatly within a singe state. For example in 1985, the demand for municipal water in Ancho, New Mexico totaled 54 gallons per capita per day while in Tyrone, New Mexico, municipal demand topped off at 423 gal per day. Rural areas typically consume less water for domestic purposes than larger towns. [4]

Capacity Constraints

For those watersheds that contain drinking water supplies, capacity is reached when the calculated safe yield of a water supply is met or exceeded. Some water districts in Rhode Island project that in 20 years maximum daily demand will exceed safe yield, but most have capacity in place to meet demand well into the future.

Capacity constraints are not absolute because investments can be made to increase supply and decrease demand. Without detailed hydrologic studies, we do not know what the maximum potential is for developing additional sources of public water supply without unacceptable environmental impacts.

Management options that can impact long-term supply and demand conditions:

<u>Creation of new supplies</u> – should we be building more reservoirs, and/or exploring for large groundwater aquifers?

<u>Expansion of existing supplies</u> – should we be expanding existing supplies, reservoirs, and/or drawing more from large groundwater aquifers?

<u>Conservation</u> -

- education about why and how to conserve water
- voluntary restrictions
- mandatory restrictions
- pricing

Regulation – within the planning and zoning process in each community:

- Adjust zoning to be consistent with estimated water supply at the watershed level.
- Enable boards to deny applications based on water supply & demand issues.

B. Demand during growing season corresponds to critical period in natural environment.

- Both water supply and demand fluctuate, seasonally driven by weather (primarily temperature and rainfall). In times of decreased supply (i.e. summer months, prolonged drought) water suppliers "walk a fine line" between wanting demand to remain high to maximize revenues, yet not too high so that the source of water is depleted. There isn't much control over supply, especially in the short term. Storage capacities are limited, and supply is weather dependent (very unpredictable).

- Water demand usually increases in the summer. As people are filling their swimming pools, spending more time on their lawns and cars, they consume additional water. The priority use of water in the state of Rhode Island is drinking. Restrictions on outdoor water use are sometimes ill-received because some people believe that they have a right to water -- no matter what the use. Only three Rhode Island Water Suppliers enforce mandatory seasonal restrictions on water use. These three are all supplied by groundwater and without these restrictions, would most likely face severe shortages every year. (31)

- The average RI increase in summer water use is 63% statewide. (31)

    - Johnston's production increases by 156% in the summer time. Johnston is located in the northern part of the state and relies on the Scituate Reservoir for its supply. Johnston is mostly a suburban community. The significant increase in water use in the district is curious simply because there is not a large agricultural community in Johnston, there are only three major users who are either residential or commercial, and there is virtually no influx of summertime tourists. Therefore, the increase in water use seems to be solely attributable to outdoor lawn watering, car washing, swimming pool filling and other outdoor water uses that occur in the summer. These are all activities that mandatory, or even voluntary, water restrictions could impact significantly. (31)

- Major Summer Water Uses:

    - Watering the lawn and garden.

Lawns require 1” of water a week to remain actively growing. For 1,000 square feet of lawn this means over 600 gallons of water per week, or more than 90,000 gallons during the growing season. [7]

- Golf courses and car washes are major commercial water uses during summer months.

- How to calculate the water requirements of your lawn:
  Irrigated area (SF) x evapotranspiration rate = water requirement in gallons.
  This calculation will give you a rough estimate of the amount of water your landscape needs over the course of the entire irrigation season. [5]

- Washing the car.

- Other outdoor cleaning-- the patio or deck. [7]

- Pool filling.

- Community restrictions:
  Many public water supplies have restrictions on water use. Private well owners should use public water supply restrictions as guidelines for conservation practices. [7]

C. Alternative landscaping choices & benefits.

1) Alternative Landscape Design at the individual lot level: Xeriscaping & Sustainable Landscaping.

- “Xeriscaping,” or drought tolerant landscaping.
  - Defined as “Water Conservation Through Creative Landscaping.
  - Word derived from Greek meaning dry.
  - Began in Colorado in 1981 from concerns with local water shortages.
    Mission was to create an educational demonstration garden to show the beauty possible through proper selection and use of plants that require minimal irrigation and develop an ongoing public involvement and education program. [17]

  - Now a registered trademark of the National Xeriscape Council.
  - A holistic, ecologically sensitive approach to gardening.
  - A way to work with nature rather than against it.
  - Benefits arise from utilizing plants to increase or decrease the impact of sun, wind, and water, or its lack, upon the local environment.
  - Philosophy is most clearly seen in organic gardening. [19]

- Seven principles of sound Xeriscape design:

  1. Plan your landscape to minimize expense and maintenance.
  2. Use drought-tolerant plants, and use sun exposure as a guide to placement.
  3. Irrigate efficiently: group plantings according to similar water needs, use low-volume irrigation devices. Water early in the day.
  4. Use turf only where it is needed for functional purposes. Consider turf alternatives such as mulches and drought-tolerant ground covers.
  5. Use mulches for water retention, long-term slow fertilization and to limit weed growth.
  6. Improve the soil to allow, where appropriate, better absorption of water.
  7. Maintain your landscape properly to save maintenance costs. (18)

- Sustainable Landscaping.

  - From a global perspective.
    "The water crisis in the world is due essentially to the unsustainable use and management of water resources and to the destruction of ecosystems such as forests, wetlands, and soil that capture, filter, store and release water," said Phillippe Roch, director of the Swiss Agency for the Environment, Forest and Landscape. "If we fail to protect forests and wetlands, if we do not manage soils with precaution, water will disappear. We can build all the water pipes and treatment plants we want; there will be nothing to drain or clean." (2)

  - In Rhode Island.

    - A joint resolution created a special legislative commission to study the concept of sustainability as it could be encouraged by state government. Reference S.2854 (2000) www.rilin.state.ri.us/PublicLaws/law00/res00/res00249. (11)

    - The Environment Council of RI included in their Legislative Agenda adopted January 8, 2003:
      - Government Structure - to promote sustainable development including economic development incentives for ecologically sound, sustainable activities as well as education and coordination across all relevant agencies.

    - Land - encourage environmentally sensitive, sustainable development; discourage suburban sprawl. [3]

- From RI Home*A*Syst, Sustainable Landscaping Practices for New England [12]

  - Sustainable is the power to continue to endure.
  - In the landscape, sustainable means those practices that do not hinder the functions of natural ecosystems.
  - Sustainable plants are a key part of the formula for sustainable landscape practices.
  - Sustainable plants flourish in the landscape with a minimal amount of water, fertilizer, pesticides, and maintenance.
  - They do not require supplemental water after establishment.
  - The sustainable practices we recommend in the home landscape are as follows:

    - Plant native plants from the Sustainable Trees and Shrubs for Southern New England. This publication is available at the URI Cooperative Extension Education Center at http://www.uri.edu/research/sustland/spl1.html.

    - Remove exotic invasive plants. Exotic invasive plants are non-native, alien, or introduced species out of their native range that successfully colonize native ecosystems, causing native species to go locally extinct. Refer to Invasion of the Land (and sometimes water) Snatchers! Exotic Invasive Plants in Rhode Island, by Lisa L. Gould, available at URI Cooperative Extension Education Center. http://www.uri.edu/ce/index1.html.

    - Plant the right plant at the right place. Plant sun lovers in the sun and shade lovers in the shade and so on. In the northeast, evergreen vegetation should be planted on the northwest side of the house as a wind barrier from prevailing northwest winds. Plant deciduous trees on the north, east and southeast sides to provide shade in the summer and allow for sun in the winter.

    - There are also aggressive native plants in our landscapes and although they can be a nuisance, they play an important role in the functions of our native ecosystems because they provide food and habitat for wildlife. However you may need to control these plants around the home. For example, Poison Ivy is an important food source for wildlife.

    - Paving material.

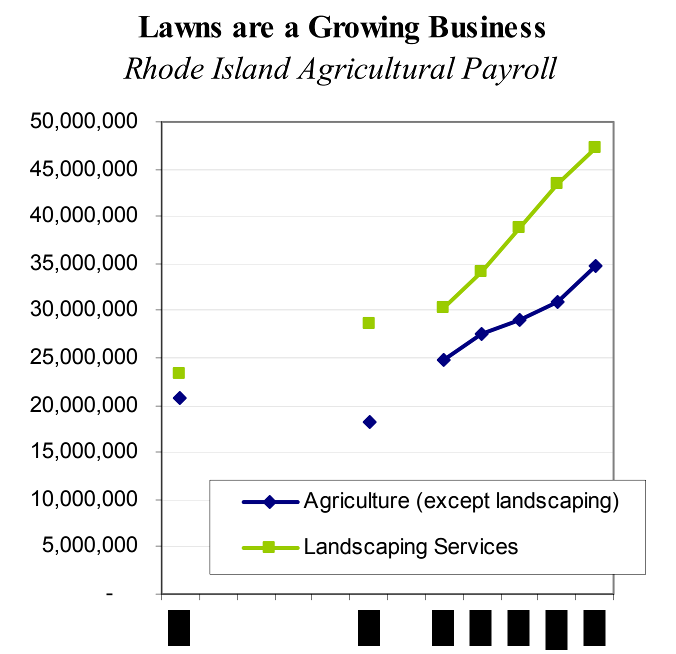
- Important component to maintaining sustainable landscape practices.
- Impermeable surfaces increase storm water runoff, which creates erosion and can carry pollutants off your property to nearby waterways.
- Permeable paving materials enhance groundwater recharge.
- Permeable paving materials in many cases are more visually appealing, generate less heat during the summer, and decrease storm water runoff. However, in the northeast, permeable surfaces are more labor intensive due to heavy periods of rain or during snow removal and occasionally have to be raked back in place.
- Options for permeable paving materials include:
  - crushed shells
  - crushed stone
  - gravel
  - turf blocks
  - stone dust
- The following materials can be set in stone dust or turf to create a solid permeable surface:
  - blue stone
  - cobblestone
  - fieldstone
  - granite

- In the event that impermeable surfaces must be used in the home landscape, consider using stamped concrete or stamp it yourself with a pattern that is pressed into the surface. This can help direct storm water to planted areas and slow the velocity of runoff.

- Integrated Pest Management (IPM):

  - Landscape conservation is a major benefit resulting from the practice of Integrated Pest Management.
  - IPM strategies reduce the need for pesticides in the landscape and promote the growth, sales and consumer demand for pest-resistant plant materials.
  - Training, programs, and workshops offered through URI Cooperative Extension, GreenShare Program.
  - In partnership between URI, nursery growers, and garden centers to work together to evaluate and promote trees, shrubs, vines, etc, that flourish without the need for intensive management.

- Other energy saving tips:



Landscaping and lawn services have eclipsed other agriculture businesses in Rhode Island in terms of employment and payroll. Source: RI Labor Market Information. ES202 data.

  - Plant vegetables and fruits, just as attractive and to make your garden more productive and useful. And they have little need for water once roots are established. [18]
  - To avoid stress to grass and to save water, set the blades on your mower so that no more than one-third of the leaf blade is cut. [18]
  - If soil is improved too much, plants become dependent on extra care. [18]
  - Watering lawns too frequently reduces their drought-resistance. Wait until early signs of wilting are evident before watering. [18]
  - Leaving clippings on the lawn is beneficial if frequently mowed. Clippings provide nutrients and moisture. [29]
  - To reduce spent time in maintenance, arrange plants in beds rather than as isolated specimens. [18]
  - Abide by town's water bans. [6]
  - Sample list of drought-tolerant trees and shrubs in New England can be found at: http://www.uri.edu/ce/factsheets/sheets/droughttolerant.html. [28]

- Turf Grass. [24] [22]
  - Variables influencing the amount of water used by turf grasses include:
    - amount of solar radiation
    - humidity
    - grass species
    - rate of growth

- Rooting depth and soil texture also affect the water requirements of turfgrass. Grasses which are more deeply rooted can extract water from a greater volume of soil and may be more drought tolerant than shallow-rooted species.
- Finer textured soils hold more water than coarse soils and require less frequent irrigation. Because so many factors interact to determine turfgrass water use, it is difficult to give a general estimate of how often to water a lawn.
- The best technique for determining when to irrigate is to observe both soil and plant conditions in the lawn and then water when the turf needs water, rather than based on the calendar.
- To conserve water and avoid detrimental effects of over watering, water lawns just prior to the development of wilting and drought stress. Wilting occurs because the plant's internal water content drops so low that the plant cannot remain turgid (stiff), and plant cells begin to shrivel. Turf grasses undergo a series of visible changes when they begin to wilt. Development of bluish-green coloration and the rolling or folding of leaf blades are two noticeable changes. If footprints remain visible on the lawn for several minutes after walking on it, wilting is occurring. Although these initial symptoms of wilting will not usually presage permanent injury to the lawn, the lawn should be watered soon to avoid drought stress and possible turfgrass death.

- The following turfgrass types are listed in order of their tolerance to drought:

    - fine-leaved fescues
    - tall fescue
    - Kentucky Bluegrass
    - Perennial ryegrass,
    - Bentgrasses

- Reducing water demands on plants:
    - All of the water added to the garden may not be available to plants particularly if the soil is heavy clay (although this is rare in Rhode Island).
    - Adding humus to soil can increase the amount of water. Humus also adds air spaces to tight clays, allowing moisture to drain to lower levels as a reserve instead of puddling and running off the top of soil.

- The moisture-capacity of sandy soils is also improved by adding organic water. Sandy soil drains so quickly that roots are unable to reach water only a few days after a rain. Humus in sandy soil gives the water something to cling to until it is needed by the plants.
- Mulching can significantly decrease the amount of water that must be added to the soil.
- Shading and the use of windbreaks are other moisture-conserving techniques. Plants that wilt in very sunny areas can benefit from partial shade during the afternoon in the summer.
- Young plants need particular protection. Air movement across a plant carries away the moisture on the leaf surfaces, causing the plant to need more water. [23]
- Proper irrigation can:
    - Aid in seed emergence.
    - Reduce soil crusting.
    - Improve germination and plant stand.
    - Reduce wilting of transplants.
    - Increase fruit size of tomatoes, cucumbers, and melons.
    - Prevent premature ripening of peas, beans, and sweet corn.
    - Maintain uniform growth.
    - Improve the quality and yield of most crops. [23]

- There are many educational resources about sustainable landscaping available in Rhode Island including,
- URI Cooperative Extension http://www.uri.edu/ce/index1.html

- Home*A*Syst, and GreenShare programs, etc. also, new website: http://www.healthylandscapes.org/.
- Master Gardener Hotline 800.448.1011.

2) Alternative Landscaping Design at the Larger Level - Community/Town/State/Watershed:
Principles of Smart Growth/Growth Centers, Comprehensive Community Plans, and Conservation Subdivision Design.

- Impervious landscaping

- Many urban water managers assume that land that hasn't been paved must be providing some benefit to the watershed. While it is true that pervious areas are generally green. Green areas are not always environmentally benign. In fact, many pervious areas in the landscape are as intensively managed or cultivated as cropland, as far as the input of water, fertilizer or pesticides are concerned. (30)

    - Private turf (lawns).

        - Home lawns comprise about 70% of the total turf area in the country
        - Others estimate that lawns occupy a total of 25 to 30 million acres across the country. Lawns are categorized as either high-input or low-input lawns:

            - High-input lawns are regularly fertilized, irrigated and receive applications of herbicides or insecticides. Homeowners apply chemicals to roughly two thirds of high input lawns while the remaining third is treated by lawns care companies.

            - Low input lawns are regularly mowed but seldom receive any chemicals. The percentage of high and low- input lawns are about equal in urban areas.

    - Public turf.

        - About 30% of the remaining turf is in urban areas.
        - Located within parks, golf courses, schools, churches, cemeteries, median strips, utility corridors and office parks.
        - The greatest share contained within parks, golf courses and school grounds.
        - Management of public turf runs the gamut from regular mowing to very intensive turf grass management (ex. golf course).

    - Commercial turf.

        - Intensely landscaped commercial areas comprise as much as 32% of the urban landscape.
        - Although commercial areas are highly impervious, many localities require that 5-10% of the site be intensively landscaped to provide visual relief, shade and create a more attractive environment.

- Much of this landscaping is comprised of small fragments that are graded to run onto adjacent impervious areas.

- Community benefits of Low-Input Lawn: [29]

  In addition to reducing nutrient and pesticide runoff, low-input lawns provide other economic benefits to the community.

  - Reduced summer water demand.

    In California, it was estimated that 30% to 50% of all residential water use went into landscaping. Many western municipalities now offer rate rebates to homeowners who implement water efficient landscaping, i.e. Xeriscaping.

    Changing watering techniques and replacing water-demanding plants with water-efficient and locally adapted ones can reduce water by 20% to 43%.

    Full conversion to Xeriscaping, i.e. growing turf solely with available rainfall supply, can easily cut water use by 50% to 60%.

    One of the first principles of Xeriscaping is to reduce turf coverage on the lawn. As a general rule, grass consumes eight units of water, trees consume five units of water, and shrubs and ground covers consume four units of water. A one acre lawn consumes up to a half million gallons of water a summer in some regions of the country. A well-shaded lawn however uses up much less surface water on a hot sunny day than an unshaded lawn.

  - Preservation of landfill capacity:

    Yard wastes (clippings, fallen leaves, trimmings, and uprooted weeds) can make up to 20% to 25% of household garbage. A one-acre lawn generates almost six tons of grass clippings a year. It is estimated that yard waste fill up from 10% to 50% of the nation's landfills.

  - Reduced cost for management of public lands.

    Integrated pest management (a pest control approach that minimizes pesticide use) is an excellent investment on public lands. It was reported that IPM reduced community pest management costs by 22%.

- Planning Initiatives in Rhode Island.

  - Rhode Island is in the forefront on planning initiatives.

    "Since passage of one of the country's best state planning laws, the Comprehensive Planning and Land Use Regulation Act in 1988, Rhode Island has continued to strengthen and expand its collection of planning statutes and practices in order to better address the full spectrum of growth management and related issues facing communities in the Ocean State." (11)

    The RI General Assembly directed the Department of Administration to assign necessary staff to perform functions required by the Comprehensive Plan and Land Use Regulations Act to help address sprawl, urban revitalization, and inter-municipal coordination. (11)

    Legislators approved the Development Impact Fee Act to help local government ensure that adequate public facilities are available to serve new growth. Also see imbedded reference to H7308 (2000). (11)

    Rhode Island voters also approved two bond issues in November 2000 to help combat sprawl. Gov. Almond's 10-year Open Space 2000 campaign called for $34 million to protect the state's natural heritage. The DEM was to use $10.8 million to purchase land or development rights, in Dec. 2001, the governor used $6.5 million of the bond issue to provide matching grants to local communities to protect more than 100 acres of land. (11)

  - Smart Growth. (11)

    - In Rhode Island, the Growth Planning Council, created in 2000 by executive order from Gov. Almond is comprised of representative from the public, private and nonprofit sectors.
    - Charged with examining economic, environmental and social impacts of development in the state; inventorying existing state programs, policies and expenditures and evaluating their effect on sustainable development; and recommending

legislative and regulatory changes, including the 1988 Comprehensive Planning and Land-Use Regulation Act.

- In their first annual report, www.State.ri.us/dem/pubs/growth1.pdf released in August 2001, the 30-member council recommended an increased focus on government investment in urban communities; the use of incentives to channel growth to areas that can accommodate sustainable development; and increased support for local planning process.
- Additionally, the council proposes the creation of a planning institute-- a permanent, nonprofit corporation to improve planning capacity in areas where it needs improvement or where planning resources are lacking.

- In the 2002 Annual Report [8] Intro by Jan Reitsma: "This year the Council also examined infrastructure barriers that limit our ability to promote compact growth. It is clear that water supply infrastructure is the prime constraint to compact growth. To being to address this crucial issue, we analyzed the obstacles facing the development of new small water systems to support compact growth. We also looked at how the existence of water supply infrastructure can lead to unsustainable growth. Recommendations for addressing these issues were drafted. Drinking water supply is an issue that begs more attention from the state as our population continues to grow in rural and suburban areas that may not be prepared, or able, to provide safe supply."

    - "Growth Centers – a new vision for land development." "Poorly planned development can destroy the very core of what we care about in the places where we live or work, unless we plan for growth in the right places. This is why the Council (Governor's Growth Planning Council) proposes that the State invest in Growth Centers, places where development can be accommodated with the necessary infrastructure without depleting a community's resources. The proposal is not to obstruct development outside of Growth Centers, but to give priority to public investments within these areas. By planning ahead, communities can reduce their costs for building and maintaining the infrastructure needed to support residential, commercial, and industrial growth. At the same time, by directing future growth to specific areas the character of the community can be preserved, including historic areas and open space.” [8]

- Criteria for Growth Centers: [8]
    - Strengthen and encourage growth in existing centers
    - Scale new infrastructure to support compact growth
    - Include mixed land uses
    - Create a range of housing opportunities and choices
    - Protect and enhance critical environmental resources
    - Provide a variety of transportation choices
    - Promote community design that contributes to a sense of place
    - Encourage growth in appropriately scaled centers.

- In their 2002 report [8] , the Growth Council states there intentions to work with the new Governor on issues including regionalism and drinking water supply:

    - Regionalism: “Municipalities share natural and built attributes, and share concerns such as infrastructure needs, economic health and housing demand. We will strive to address these cross- boundary issues in a cooperative, not competitive, fashion. We will support efforts like the creation of a West Side Master Plan for Aquidneck Island which brings three island communities together to plan for regional employment, transportation, mixed-use development, and open space protection.”

    - “Drinking water supply – in the midst of current drought, the importance of water supply to future growth is apparent. Rapid development in our non-urban communities has put a strain on existing water supplies, and the siting of new sources has a highly significant impact on the location of new development. The council will think critically on how best to integrate drinking water supply policy with policies for land use planning.”

- Grow Smart Rhode Island [9]:

    “Grow Smart Rhode Island was formed to ensure "that Rhode Island develops in a way that will promote economic vitality while protecting the environment and preserving community character," said James H. Dodge, chairman, president and chief executive officer of Providence Energy Corp. This project's goals are to minimize unplanned, low density, single use development in rural parts of Rhode Island and stop the declining vitality of the urban centers. The group includes members of the business, environmental, academic and nonprofit communities. It will study the economic, environmental and social impacts of development trends in the state, set up statewide planning meetings, and advocate for policy changes. 3/1/1998",

- South County Design Manual. (14)

  Design Manual proposes different creative approaches to design, growth management and regulations (including Model Land Use Ordinances, Transfer of Development Rights,) using detailed analysis of districts within the town that determines which areas should be protected and which areas are more suitable for development.

  Every town has a Comprehensive Plan which is suppose to provide for a coordinated approach to development and balance demand for services with supply. This in turn is meant to be implemented through the zoning map and ordinances. So why are these tools not working better? The problem is that comprehensive plans and regulations focus primarily on *planning* at the scale of the *whole* town while the decisions that really matter are made in *design* at the scale of *individual* sites.

  It has been argued that there is no longer such a thing as "rural", that almost all areas serve the large urban centers. By this argument all of Washington County is a suburb of Providence, or exists as a summer home for people from metro regions. And to some extent this analysis explains why, despite relatively low development densities, the rural character of the region is disappearing. As Washington County towns become bedroom communities for urban centers, as they become more dependent on industries that do not use local resources – other than the human work force – the principles that used to provide order to the landscape disappear.

Many towns say in their Comprehensive Plans that they want to protect “rural character”. But it is rarely defined. One way to preserve rural character is to identify and support functional relationships that bind towns and villages to their surrounding landscapes. The most basic of these functional relationships is the link between the town center and its surroundings for water supply, stormwater management, and sewage disposal. We have learned to hide these functions, like the plumbing in our houses, behind closed doors…rather than watching the water disappear down a catch basin, residents could observe the flow of water from driveways and roads as it travels from their street into their neighborhood park system. Allow residents to understand that the meadow at the entrance of their town also contains the recharge fields for the treated wastewater that originates from their homes, and that this water cycles back into the aquifers that provide their sole source of drinking water.

- Residential development – cluster zoning – open space:

Cities and towns manage development through zoning and subdivision regulations that in an attempt to make the process fair and equitable to all landowners, limit densities and design approaches to an extremely narrow list of alternatives. This has resulted in most of Washington County being zoned for 1 or 2 acre house lots on 26 or 30-foot wide roads, with predictable results, one subdivision looks much like any other, with no relationship to the surrounding landscape

Common solutions to this problem, such as cluster development are often of limited use in protecting open space and rural character because they rearrange open space and buildings on individual parcels with out recognition of the larger landscape. Even when preserved open space provides some public benefit, the design of roads and buildings tend to follow suburban models. On the ground, these projects are often little more than cramped versions of standard subdivisions: it’s no wonder that many people don’t support cluster zoning…Driven by market forces that reward standardization, residential, commercial and industrial development has been simplified to a few simple models. For all forms of development, builders are often required by local land use ordinances to modify a site to fit a proven plan rather than to custom-design a plan to fit the vagaries of different sites. Those who would do so are often stymied by local regulations that encourage the tried and true solution, even it if doesn’t quite fit the site.

The Manual proposes eight planning and design scenarios that make the ideas of “neotraditional town planning, “new urbanism,” “sustainable design” “smart growth,” etc. tangible by showing how they could be applied to solve local problems with architectural and site planning approaches that are based on local traditions. The manual selects eight sites in Washington County and shows how they would most likely be developed in today’s market, following current zoning and other regulations. A more creative development alternative for each site was drawn to demonstrate how the same or greater amount of development could be accommodated in each site while preserving important resources.

The Manual advocates an approach to greenspace planning in which priority conservation areas and connected corridors of open space form the backbone of future land use. Development is accommodated in new or revitalized town and village centers with an emphasis on mixed use development and pedestrian friendly streets. Community centered neighborhood planning is fundamental to more livable communities, and in rural districts, creative approaches to design can allow continued growth while protecting and reinforcing the natural and cultural heritage of our rural landscapes.

- The Conservation Design Concept – from Growing Greener, Randall Arendt. [25]

Each time a property is developed into a residential subdivision, an opportunity exists for adding land to a community-wide network of open space. Although such opportunities are seldom taken in many municipalities, this situation could be reversed by making several small but significant changes to three basic local land-use documents – the comprehensive plan, the zoning ordinance and the subdivision and land development ordinance. Conservation Design rearranges the development on each parcel as it is being planned so that half or more of the buildable land is set aside as open space. Without controversial "down zoning," the same number of homes can be built in a less land-consumptive manner, allowing the balance of the property to be permanently protected and added to an interconnected network of community green spaces. "This density-neutral approach provides a fair and equitable way to balance conservation and development objectives."

Conservation design offers a more effective and less costly approach to stormwater management compared with conventional development due to its lesser disturbance of the parcel as a whole, leaving a greater percentage of woodlands and meadows in their natural state, and it ability to provide more filtering of runoff and replenishing underlying groundwater supplies.

Good conservation design aims for surface drainage, wherever possible, rather than piped systems because the former allows runoff to percolate into the soil.

Aquifer replenishment is essential for maintaining stream flow during the dry summer months, which is in turn necessary for the health of aquatic habitats.

Manicured lawns function almost as "green asphalt", causing most of the water that falls on them to runoff. In contrast, natural forest soils with similar overall slopes can store up to 50 times more precipitation than graded turf.

Conservation subdivisions also offer greater opportunities to implement environmentally sensitive wastewater treatment and disposal systems known as "land treatment," "spray irrigation," and "wastewater reclamation and reuse." These terms describe variations of a well-documented technology that is superior to conventional mechanical systems in many ways because they produce only very small amounts of sludge by-products and because they help to replenish local aquifers, rather than diverting the treated water into rivers, lakes, or oceans where it flows into different

> systems, often carrying heavy nutrient loads that degrade the receiving waters and aquatic habitats downstream.
>
> With spray irrigation, wastewater is heavily aerated in deep lagoons where it receives a "secondary" level of treatment, similar to that provided by conventional sewage plants. It is then applied to land surface at rates consistent with the soil's natural absorption capacity. Nutrients in the treated wastewater are taken up by the vegetation, which may range from woodlands and meadows to farm fields and golf courses. This approach has a long and successful track record in Chester County, PA where more than 50 systems have been in operation for upward of 20 years.

A Rhode Island example of water re-use is the Jamestown Golf Course. The Town of Jamestown received a $94,700 DEM Aqua Fund grant to build a pump station and pond to connect to an underground irrigation system that waters the fairways and greens on a regular basis. The system uses wastewater from the island's sewer treatment plant that irrigates the lawn. Applying effluent to turf adds a polishing stage to the wastewater treatment process, as the grass takes out nutrients, returning water to the environment that is cleaner than treatment plant effluent. This is the first instance of land application of effluent in the state. (26)

D. Community/neighborhood social pressures

- History & Public Conceptions of the American Lawn - Anecdotes.
  - Large, formal lawns and gardens - control over nature (16)
    - Followed by informal English garden style - a revolt against order, discipline and moderation.
    - The English cottage style is widely emulated in the U.S.
    - An informal style meant to evoke a mood of lighthearted gaiety.
    - While cottage gardens are popular, lawns are the dominant element in American landscaping:

      Lawns had both Elitist and Democratic Elements.

      - Only aristocrats could maintain lawn grass, so lawns were rare.
      - Then in 1830, Edwin Budding invented the lawn mower.
      - Suburban homeowners could then elevate their social status by having a lawn of their own.

      - In 1870, landscape architect Frank J. Scott's influential moralistic manifesto, "The Art of Beautifying Suburban Home Grounds of Small Extent", a smooth, closely shaven surface of green is by far the most essential element of beauty" in a front yard, Scott wrote. (19)

Open, monotonous lawns linked the homes of community together into appearance of collectivism.

- Lawns really took root in the 1950s as postwar prosperity coalesced with the rise of suburbia. [19]

- Today, Americans are still obsessed with lawns because of our desire to impose our will on nature. They allow us to transition freely between outdoors and inside.

- Our attachment to lawns is so enduring that some claim it's hard-wired into our genetic code. According to this theory, Homo sapiens are more comfortable amid grassy plains where there are no places for predators to lurk. [19]

- Lawns are the poor man's answer to a formal garden with neat lines or boxwood hedge.

  - The whole point behind a lawn, aesthetically speaking, is its uniformity. It should be uniform not only in height, but also in composition (no "weeds") and in color. The more precision the better."

  - Formal landscape designs are a more cautious choice from a property value standpoint. You might like the look of a back-to-nature yard, but depending on your design selection, a potential buyer might see it as "run-down", driving down the property value.

  - Opponents of natural landscaping: "…shoddily maintained lawn is considered not only an eyesore but also a sign of civic irresponsibility that reflects poorly on the entire neighborhood. The appropriate punishment for this crime? Public opprobrium. And if these social pariahs can't be shamed into cleaning up their act, they can be prosecuted under anti-weed ordinances that have been promulgated in hundreds of cities." [19]

  - "…anti-lawn activists are actually hoping for a water shortage because skyrocketing water prices and water rationing may do what all their proselytizing failed to accomplish – drive a stake through the heart of the lawn." [19]

  - "It's just habit…its nothing more than what we're accustomed to. I honestly think we're going to replace the turfgrass lawn with a new paradigm of beauty," Brad Henderson ….He may be onto something, but I'm not holding my breath. For most people, planting or not planting a lawn isn't about what's good for the environment. It's about fashion – what we think looks good…Look for lawns to shrink in the coming decades, but don't expect them to disappear. They may not make much sense, but then, neither does most fashion." [19]

- Public Conceptions of Water Supply.

    - "Of the earth's water, 97 percent is saltwater found in oceans and seas, and 3 percent is freshwater, of which only 1 percent is available, while 2 percent is currently frozen in glaciers and polar icecaps. More than half of humanity relies on water from mountains, often thousands of kilometers away from the source. All of the world's major rivers originate in the mountains". [2]

    - "Public opinion appears to be clear about the urgent need to project water resources. According to the results of a Gallup International survey, more than half of the world's populations believe that access to clean drinking water should be added to the list of basic human rights – even if additional taxes would be required to achieve universal access. Responses by the 36,000 people surveyed in 36 countries. …" [2]

    - "The World Economic Forum, in association with the United Nations Environmental Program (UNEP), has launched a water initiative to create public-private partnerships to improve the management of watersheds "from the summit to the sea." Members of the initiative include top business, NGOs, international organizations, and governments with the aim to improve the quality and quantity of water for both business and communities by sharing best practices and partnering in the maintenance and management of water and watersheds around the world…The World Economic Forum Water Initiative is intended to facilitate private sector participation in the maintenance of watersheds and put water management at the forefront of economic development. [2]

    - In February 2000, the RI Statewide Planning Program released its telephone survey of 452 Rhode Islanders on issues pertaining to growth. Chief among the state's residents concerns for the next five years were protecting drinking water, cleaning Narragansett Bay, keeping property taxes low, and improving quality of life.[11]

E. Incentives/Economic Benefits

- Water is relatively cheap for the consumer, when compared to other utilities or services. Pricing is constant throughout the year, regardless of supply or demand. Providence Water has a decreasing block pricing scale with large steps – a very large consumer is charged less per unit of water. A residential user would not approach the existing thresholds.

- Water conservation saves money – but the social savings exceed the savings to the consumer. If you receive your water from a public supply, the cost of treating, pumping and delivering water to your home increases, as does the cost of treating the wastewater that leaves your home. In most urban areas of the state, sewer bills are tied to the amount of water you use. [7]

- If you have a private well and septic system, water conservation will help reduce costly repairs. You can also prolong the life of your septic system by reducing the amount of wastewater that goes into it.

- You can cut your home's energy use by planting tees, shrubs, groundcovers and other landscaping. Computer models have found that as few as three well-placed trees around a home can save up to $250 each year in energy costs. A well-designed landscape can typically save enough energy that the investment is returned in eight years or less…The U.S. Department of Energy has noted that an 8 foot tall deciduous tree (one that sheds its leaves) costs about as much as an awning for one large window. But the tree will save hundreds of dollars in reduced cooling costs while still letting winter sun into the home to further save on heating and lighting costs." [15]

- Trees and landscaping add value to a home, giving it a higher worth and resale price. A study a few years ago found that the average added value for homes with trees was 5 percent to 10 percent, but some homes are worth 20 percent more because of the trees.

- There is also potential economic savings during the initial landscape construction by using less expensive plant species and smaller sizes, as well as increasing the space between plants. Well done residential designs can often be irrigated with inexpensive hose-end-equipment. In addition, the beauty of Xeriscape designs can result in increased real estate values. "Green" industries such as landscaping companies can benefit from diversification in landscaping by offering water efficient designs. [21]

- Xeriscaping promotes the use of native trees and plants which are oftentimes significantly less costly than exotic or non-native plants.

- Homeowners association covenants that require large lawn and landscape areas can be updated to require landscaping according to Xeriscaping and sustainable landscaping principles.

- In addition to reductions in water and energy costs, there are significant additional cost savings in deciding to landscape according to the principles of Xeriscaping and sustainable landscaping through the reduction or elimination of:

    - Lawn mowing/maintenance contractors.
    - Costs of fertilizer and pesticides.
    - Expense of purchasing lawn care equipment including mowers.
    - Expense of maintaining lawn care equipment including fuel
    - Expense of irrigation installation and maintenance

    - Also, there are significant time savings in maintaining lawns and landscaping.

- In some areas in the country, free water-use audits are offered by municipalities and water companies to educate customers on how to conserve water by making simple property changes, such as planting drought-resistant plants. (33) Some municipalities offer rebates:

    The city of Santa Rosa, California has an Efficient Landscape Water Management Rebate Program for large landscapes. As an incentive for efficient landscape water management, customers can earn $500 for each acre-foot (325,851 gallons) of water savings below their "Efficient Irrigation Goal" each year. That is approximately $1.53 per 1,000 gallons saved. The program includes a site assessment and evaluation of irrigation system performance, an estimated water budget, an analysis of previous water use, and recommendations for improving water management practices. (32)

    Through a 2001 Executive Order, the Maryland Department of the Environmental launched a water conservation initiative targeted at facilities owned, leased, or managed by the state. The order requires state facilities to conduct water use audits and to take steps to reduce their water use in the buildings and on the landscape. A 10% reduction in total water use is required by 2010. (39)

- In Rhode Island, a study on water use audits (31) found the following practices:

    Regarding Major User Technical Assistance Programs (MUTAP) **(**A major user is defined as a user that consumes more than 3 million gallons of water per year)**:**

- Three water suppliers did not offer the MUTAP at the time of their water supply plan's preparation. Two of these water suppliers were to begin a MUTAP in 2002. One water supplier stated that it would not implement any type of MUTAP because it had been denied funding for such a program from the Public Utilities Commission. One water supplier failed to mention any type of MUTAP in its plan.
  - All 21 water suppliers audit sanitary equipment. None mention the existence of an auditing program for industrial/manufacturing processes. Two water suppliers offer MUTAPs as extensions of their Residential Retrofit Programs (RRP).
  - Of the 15 other water suppliers that offer a MUTAP, only one takes the initiative to schedule visits to the sites of its major users; the others conduct audits only upon request.
  - One water supplier has entered into a partnership to conduct water audits with the Narragansett Bay Commission. (The details of the audits or the partnership were not provided in the plans.)

- In their 2003 Legislative Agenda, the Environment Council of RI supports the promotion of residential and institutional scale water conservation efforts by providing financial incentives through the rate structure. [3]

- The RI Water Resources Board requires Water Supply System Management Plans from major water suppliers. One of the elements of the WSSMP is implementation of a residential retrofit program. Kits containing low-flow faucet aerators, low-flow shower, and other water-saving devices and information designed to reduce in-home water use are made available to residents often free of charge. The impacts of the retrofit program have not been studied. There is no follow up to determine whether customers install the kits and no record of water use before and after kits are distributed. [26]

- The study also states that Rhode Island's water rates are not high enough to encourage water conservation and recommend a rate structure to promote water conservation. When a user's water consumption exceeds a threshold, per- gallon rates will increase. The threshold should be set just below the average annual use to encourage conservation. Rates need to be set high enough that there is an appreciable increase in the water bill such that water-saving technologies become economical. [27]

- The average annual cost for water for a family of four served by United Water Rhode Island is approximately $325. [20]

- United Water Rhode Island promotes the use of Xeriscaping and offers to visit communities to present the concept of Xeriscaping. [20]

- A resource guide entitled Xeriscape Programs for Water Utilities, authored by Ken Ball, was published by the American Water Works Association in Denver, Colorado to assist water suppliers in developing Xeriscape programs. [17]

- There are programs that recognize and encourage the use of natural landscaping practices to attract wildlife through certification programs, including the National Wildlife Federation at: http://www.nwf.org/backyardwildlifehabitat/tipsandprojects.cfm

- Water Conservation Ordinances:

- The State of California passed the State Water Conservation in Landscaping Act (AB325) in 1993 requiring that the state Department of Water Resources develop a Model Landscape Ordinance to address the efficient use of water in landscaping.[34] Cities and counties could adopt the Model Ordinance, adopt their own ordinance, or issue findings that no ordinance was necessary. If no action was taken, the Model Ordinance automatically went into effect. As of 1993, 257 agencies adopted a different ordinance, 59 agencies issued findings that an ordinance was not necessary, and the rest either have the Model Ordinance or a similar ordinance in place.[35]

    - The Model Ordinance applies a water allocation budget to projects involving contractor-installed landscaping for areas greater than 2,500 square feet.

    - The California Landscape Contractors Association calls the Model Ordinance with its water budget approach the most effective and fairest method of conserving landscape water. [36] However suggestions for improvement include:

        - Rebates for retrofitting irrigation systems;
        - Water banking credit for delaying water use during critical periods;
        - Penalties for water abusers through the utilization of multi-tiered pricing schedules;
        - Emphasis on use of reclaimed water as alternative long-term source for landscape irrigation.

- In Rhode Island, the Environment Council adopted a resolution in November 2002 calling on all municipalities that draw water from the Scituate Reservoir to pass and enforce an ordinance to control the amount of water drawn from the Reservoir. It was further resolved that these ordinance should include regulations relating to the irrigation of lawns to limit lawn irrigation to even or odd dates (coinciding with billing addresses) and create penalties for users who do not irrigate efficiently. The low water use landscape technique known as Xeriscaping is encouraged for new developments. (37)

- Grants offered to teachers seeking to do creative classroom projects that increase students' awareness of the importance of water: The Water Education/Water Awareness Committee in Rancho Cucamonga, California offers grants up to $500 per project. (38)

Section II: Stormwater Management(39)

Several studies have tried to document and assess the impact of urbanization and development on rainfall runoff and attendant effects on stream flow and quality. The impact on water and habitat quality is well documented nationally. However, direct evidence of impacts on stream baseflows has been difficult to obtain and the results of studies that have been done are mixed.

Subwatersheds between 1 and 10 square miles, a common scale in many parts of the state, are more strongly influenced in changes in impervious cover than larger watersheds (Art. 18, Practices in Watershed Protection, 2000 - PWP). Where the percent Total Impervious Area (TIA) exceeds 20%, the percent of fine sediment in receiving stream bottoms has been found to be greater than 15%, a level considered serious because it interferes with incubation (Art 18 PWP). When the TIA exceeds 10-15%, 90% of sensitive organisms are lost from streams (Art. 28 PWP). Where TIA is greater than 25-30% most indicators of stream quality (aquatic diversity, water quality, habitat scores) are considered poor. The combination of reduced infiltration and increased runoff due to impervious surfaces produce impacts that include (Art. 28 PWP):

- decline in baseflow
- decline in habitat due to reduced wetted perimeter during low flow
- increase in sediments
- shallower flow, loss of riffles and changes in channel shape
- decline in quality, including lower dissolved oxygen (DO) and higher temperature
- decline in woody debris along stream banks (edges become eroded and in worst cases must be armored for protection)

Studies in Long Island and North Carolina attempted to establish a relationship between urbanization and reduced stream baseflow, but the results were mixed (Art. 10 PWP). In these studies, it was difficult to separate other causative factors from the results. In some cases, loss to streams might be explained by out-of basin transfer of groundwater supplies via sewering to ocean outfalls. Changes in cover type, precipitation patterns during the studies, and agriculture could also have affected the results. Nevertheless, it is likely that streams may experience more immediate effects from development, relating mostly to changes in runoff patterns and non-point pollution impacts, before impacts from declining baseflows become evident. Consequently, efforts to protect streams from such impacts may help protect streams from low baseflow impacts before they are realized.

Several alternatives exist to encourage maintenance of baseflows to protect water supplies. These include on-lot or case-by-case designs, as well as on a planning scale. Practices that may be implemented on a lot by lot basis include (Art 10 PWP):

- maintain forest cover where possible (i.e. limit clearing)
- retain topsoil and soil structure, particularly over soils with high infiltration capacity
- reduce impervious surface area
- infiltrate stormwater (e.g. infiltration systems, porous pavements, unlined detention basins
- reduce storm sewer inflow

On a planning scale, adoption of cluster designs, open space preservation, and similar techniques becoming known as "conservation design" (see discussion on landscaping choices) can help sustain infiltration rates after development.

Notwithstanding the benefits of stormwater infiltration as a means to offset infiltration losses due to impervious surface growth resulting from development, some reserve must be applied in certain circumstances where stormwater may pose risks of contamination to drinking water supply aquifers. Stormwater can contain significant concentrations of pathogens, heavy metals, pesticides, and nitrates. Risk factors are dependent on mobility, concentration, and solubility of the contaminant in water. Soils with little or low organic content horizons and/or sandy textured soils are considered more vulnerable. Infiltration is not recommended where: collection pipes may carry or intercept dry-weather sewage flows or excessive salts from parking lots, on properties with manufacturing or heavy industry, or at sites involved in construction (due to clogging susceptibility) Residential areas pose the least risk because of its low contamination potential (Art. 104 PWP).

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