Task 1B-3 White Paper – REVISED DRAFT 10-18-16

Potential Water Management Options

This paper outlines the broad strategies that may be used to address Connecticut's water supply needs. These strategies are comprised of different methods or "options" that can be implemented independently or in combination with other options. The options can be grouped into demand management and supply management alternatives, and **Table 1** below lists the options discussed in this paper:

Table 1: Water Management Options Addressed in this Paper

Demand Management Options	Supply Management Options
Water Conservation and Incentives	Use of Class B Water for Non-Potable Uses
Land Planning and Management	Municipal and Industrial Reuse
Changes in Development Patterns	Interbasin Transfers
Green Building and LEED	Conjunctive Surface/Groundwater Use
	Collector Wells and Riverbank Filtration
	Aquifer Storage and Recovery
	Water Banking
	New Storage
	Expansions / Reoperation of Existing Storage
	Flood Control and Water Supply Together
	Flood Skimming
	Stormwater Capture
	Desalination

1. Demand Management Alternatives

1.1. Water Conservation

Water savings from water conservation can act to reduce future water demands and therefore avoid or postpone the design and construction of new water supply and wastewater facilities. In addition, water conservation may serve several environmental and public health benefits such as:

- Leaving additional water in streams and rivers.
- Reduce wastewater flow and have a positive water quality impact.
- Reduce pressure for additional sources of supply.
- Reduce energy consumption.
- Increase supply during dry conditions.

In addition, enhanced water conservation can work in tandem with drought management plans to buffer against drought.

"Municipal and Industrial" (M&I) is a term that encompasses public water system water needs as well as industrial water needs (including industries that are served by public water systems, or that rely on their own sources of supply). M&I water conservation programs result in improved water use efficiency. M&I water savings occur through the modification of water-using fixtures (e.g., showers, landscapes, cooling towers) and behaviors (e.g., showering time, irrigation schedules, maintenance schedules). The effects of conservation on M&I water demand are the result of both passive and active water conservation efforts (see definitions below). These conservation efforts, though somewhat unpredictable in their rate of success since they require changes in consumer behavior, can be effective means of reducing water supply needs, with little direct cost to the community (although it is possible that indirect costs may occur, such as increasing rates to offset declining revenue).

Water conservation can be grouped into the following categories or levels (these are not national standards, but common categorizations):

- **Level 1 Water Conservation Savings:** This level is defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficient of water use. These conservation savings are sometimes termed "passive" savings because water utilities do not actively find and implement the programs that produce these savings, these savings occur as new construction and remodeled buildings become more water efficient over time. There are federal manufacturing standards for water-using fixtures and appliances, and some state have codes that provide even more efficient standards. In addition, landscaping ordinances contribute to these passive savings.

In contrast, water conservation savings resulting from utility-sponsored water conservation programs are referred to as "active" savings. Note that emergency conservation programs and short-term drought-response restrictions are not included among these long-term water conservation programs. Temporary drought restrictions include requests for voluntary demand reductions or mandatory water use restrictions during drought conditions. This type of demand modification usually involves drastic, temporary behavioral changes such as not watering the lawn or washing the car. Droughts can also result in permanent water conservation benefits, such as retrofitting indoor plumbing devices with more efficient water saving devices or reducing or eliminating high water use landscaping.

- **Level 2 (Basic) M&I Conservation**: This level of conservation consists of programs for metering and leak deduction, and can generally achieve about a 4 percent[1] water demand reduction in addition to the passive conservation reductions. Universal metering, as opposed to unmetered use, provides an awareness of use in addition to the transition from flat fees to volumetric charges. Leak detection and repair in the distribution system can reduce unnecessary water (and revenue) losses.

[1] This estimate is based on CDM Smith's experience with water conservation programs across the United States.

- **Level 3 (Moderate) M&I Conservation**: This level of conservation typically includes programs for metering and leak detection, as well as education, rebates for water-efficient toilets and washers, and a rate structure that promotes effective water use. This level of conservation can generally achieve about 5 percent water demand reduction in the short- to mid-term (10 years). The estimated percent reduction is inclusive of Level 2 savings.

- **Level 4 (Aggressive) M&I Conservation**: This level of conservation typically includes programs above and beyond moderate conservation, including steep pricing rate and surcharges, rebate for landscape changes, residential and commercial audits, turf replacement and restriction, rebates for irrigation sensors and controllers, sub-metering of master-meter properties and fixture retrofit upon sale of properties. This level of conservation can generally achieve about a 10 percent water demand reduction in the short- to mid-term (10 years). All efforts described in the previous levels are assumed to be in place, thus the percent reduction is inclusive of those savings.

- **Level 5 M&I Conservation:** Program savings are influenced by the level of participation and compliance with a given program. The prior levels of conservation effort (2 through 4) assume a reasonable level of program participation, Level 5 assumes total participation by all customers and is intended to represent a maximum level of effort in water use efficiency. Such a level of conservation is estimated to achieve about 15 percent water demand reduction in the short- to mid-term (10 years).

It is also important to note that the *realistic* level of future water demand varies by location given the currently implemented or budgeted water conservation programs. Local attitudes and the "conservation ethic" of the community can have a significant impact on the success of water conservation programs. It is also important to note that there is a downside to water conservation from the standpoint of revenue generation depending upon the design of the water rate structure. Leak detection can also contribute to water savings for public water systems.

Evaluating New Supply from M&I Water Conservation

The ability to develop new supplies from water conservation or to carry over conserved water for later use is dependent on the local utility because this will depend on the system storage, diversions, firm yield of water supplies, total water consumption, etc. The benefits of water conservation include:

- Implementation costs can be significantly lower than new water supply development or other alternatives.

- There are no permitting requirements to implement water conservation.

- Implementation is within the control of the local water provider and does not require approval of other entities (although rates that account for conservation must be approved by PURA or a local board).

- No new diversions are required.

- Existing water supplies can be stretched to supply the demands of new growth.

- Lesser environmental impacts than new water supply development.
- Can reduce water and wastewater treatment, distribution, collection, capital, and operations and maintenance costs.

Although the potential for capital cost avoidance is significant when conserved water becomes “new” water, the savings needs to be weighed against the continuing operations and maintenance costs that occur even as revenue decreases due to the customers’ conservation efforts. The timing of this issue may be a key consideration, since the decrease in revenue occurs prior to the re-purposing of conserved water as new water supply, and therefore well ahead of any opportunity to restore revenue from the distribution of the “new” supply.

Status of Water Conservation in Connecticut

Domestic and Potable Water Use

The State of Connecticut encourages or requires water conservation through several resources. The DPH maintains water conservation fact sheets for owners of private wells, as well as customers of water utilities. These conservation tips are often passed on to residents and business owners through local health departments, municipal departments, municipal commissions, and water utility bill stuffers.

All water utilities serving greater than 1,000 people maintain a Water Conservation Plan, as required by the Individual Water Supply Plan regulations. The Water Conservation Plan is designed to meet the long range conservation goals of the water utility. Water conservation plans focus on supply management and demand management programs. Supply management is focused on reducing the loss of water through metering, water accounting, leak detection, leak repair, etc. Supply management can also include promotion of the recycling of water, especially in large industrial settings. Demand management actions are designed to encourage the reduction of the peak and average daily demands caused by customer water use habits. This is accomplished through residential retrofits, raising public awareness of water consumption, strategic rate-setting, etc.

Water utilities that maintain water diversion permits (including those that file Water Conservation Plans and those that do not) are typically required by permit condition to conduct leak detection surveys every three to five years. The results of the leak detection surveys are required to be submitted to DEEP in the annual reports that are prepared pursuant to diversion permit conditions.

Since the advent of the Water Supply Plan regulations in the 1986 and the National Energy Policy Act of 1992– and coupled with the diversion permit conditions imposed on many water utilizes – major water utilities in Connecticut have made significant progress in reducing non-revenue water (calculated by comparing water produced with water consumed) while *also* observing a reduction in the per capita water demand (gallons per day per person) calculated from metered water consumption. Many water utilities are experiencing non-revenue figures well below the oft-cited industry standard (15%) while many customers are enjoying per-capita demands on the order of 30 gpd/person to 60 gpd/person[2]. These are figures that are well below the design standard of 75 gpd/person that is required for designing new water systems. A national study of single-family residential water use conducted in 1999 by the Water Research Foundation showed an average indoor residential water use of about 69 gallons per capita per day. A repeat of this study conducted in 2015 showed this number to have dropped to about 59 gallons per capita per day. This is about a 15 percent decrease over 15 years due primarily to improved water efficiency for toilets and clothes washers.

The challenge in the coming years will be to further conserve water using these top-down approaches. Water utilities are challenged to suggest new ideas or techniques in their Water Conservation Plans, and most consumers are accustomed to seeing the same water conservation bill stuffers year after year. New high-level approaches will be needed to encourage conservation, including incentives for the water utilities. At the same time, water utilities need methods for paying for operating expenses and infrastructure repairs and upgrades while experiencing a declining revenue stream. In particular, water utilities that are not permitted or otherwise able to include a water conservation surcharge (to compensate for revenue reductions due to conservation) will experience this challenge.

Other Water Users

The State of Connecticut has fewer tools available for encouraging water conservation among industrial, agricultural, and other non-potable water users. The chief mechanism is through the water diversion program. Permitted withdrawals (those that exceed 50,000 gpd, and which were not registered in 1983 pursuant to the Water Diversion Policy Act) are required to abide by a series of special conditions that result in metering, reporting, and water conservation. Many permits require the completion of water conservation plans and the annual reporting on progress made toward water conservation. For example:

- Prides Corner Farms (a large grower of container plants, trees, green roof materials, and other products) must annually report on water conservation practices for its four nurseries in Lebanon.
- Various sand and gravel producers must recycle wash water, and diversion permits will stipulate the volumes of recycled water and makeup water that can be withdrawn each day.

Aside from the water diversion program, there are not many top-down tools to encourage water conservation. The registered diversions are not required to implement water conservation techniques (except for the public water systems, which must conserve as described above). The Natural Resources Conservation Service (NRCS) typically works with the agricultural and nursery water users in Connecticut to identify a variety of soil and water conservation techniques, but these are often guidelines.

[2] Refer to the Water Utility Coordinating Committee (WUCC) process and reports for figures that have been compiled from Water Supply Plans.

Individual Water User Level Conservation

Domestic and Potable Water Use

Modern appliances, water fixtures, and practices have made water conservation an achievable task at the water user level. There are a number of ways that individuals can significantly reduce their water use.

Replacing old faucets, showerheads, and toilets can significantly reduce water consumption. A modern showerhead with a flow rate of 2.5 gpm can use half the water of an older unit. Often, due to better technology, the perceivable difference in water output is minimal, despite the drastically reduced flow rate. Modern appliances like dishwashers and washing machines are also able to do more with less water. Home practices such as stormwater capture for reuse-(i.e. rain barrels), drip irrigation, reducing at-home carwashes, and watering lawns outside the heat of the day can also conserve significant amounts of water.

At-home water conservation efforts can be inexpensive, and can pay for themselves in the water savings. For example, based on one local utilities billing rate, changing a 5 gpm shower head to a 2.5 gpm low flow showerhead would save $50 dollars per year in water usage per person, based on one 10-minute shower per day.

Other Water Users

Other users of water typically conserve water as a cost-saving measure. For example, agricultural and nursery water users can install drip irrigation systems to save water and therefore save money spent to purchase and/or pump water. Businesses and industries can save water by retrofitting cooling towers, restrooms, and irrigation systems.

Incentives for Water Conservation

Many states have rebate programs and incentives for the purchase of environmentally friendly household appliances and products. Currently, states like California offer rebates on the purchase of new toilets, clothes washers, rain barrels, pool covers-which reduce evaporation, and other water saving devices and appliances. Currently Connecticut does not have such a rebate program. Some utilities offer cost-sharing or incentives based on volumetric reductions in water use for commercial and industrial customers. Due to the state budget considerations, and relative abundance of water, it seems unlikely that the state would pursue these options immediately. However, if the financial investment was made, the benefits to the consumer and to water conservation efforts could be significant. Reviewing and updating the building code may also be an important consideration to ensure that the most efficient water saving devices are required.

On a broader level, there are incentives for conserving water in the agricultural industry available through the Natural Resources Conservation Service (NRCS). For example, in the Little River and Broad Brook watersheds[3], the National Water Quality Initiative program offers “technical and

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[3] Refer to www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/programs/financial/equip/?cid=nrcs142p2_011038

financial assistance to farmers and forest landowners interested in improving water quality and aquatic habitats in priority watersheds with impaired streams. Qualified producers may apply for financial assistance to install conservation practices in the designated watersheds to address documented phosphorus, bacteria, and sediment impairments which may be caused by soil erosion, exposed soil, and lack of riparian buffers and filter strips."

1.2. Land Planning and Management

Land use planning and management affect many resource management strategies for a State Water Plan. More efficient and effective land use can be linked to several resource management programs including watershed management, water use efficiency, groundwater quality, flood management, parks and recreation, climate change adaptive management, and agricultural lands stewardship. In addition, planning for more compact and sustainable communities, both urban and rural, can assist in reducing impact on water resources. Important considerations of water issues and land use planning include not only the effects of the physical environment, but also the economic and social impacts of land use planning and development.

Stronger collaboration between land use planners and water managers can promote more efficient and effective land-use patterns and integrated regional water management practices, which can produce safer and more resilient communities. Integrating land use and water management consists of planning for the housing and economic development needs of a growing population, while providing for the efficient use of water, water quality, energy, and other resources. The way in which Connecticut uses land — the type of land use, transportation, and level of use — has a direct relationship to water supply and quality, flood management, hazard mitigation, and other water issues. Likewise, the better integrated water resources are, the more efficient local communities can be at producing land use planning benefits and opportunities. For example, compact development patterns in existing urban areas can limit the amount of development in floodplains, leading to improved flood management and safety and more efficient infrastructure.

Land use planners consider water throughout the local land use planning process, and water is a critical element in adopting efficient land use planning policies. The availability of water supplies, water resource features such as streams, wetlands, and groundwater recharge areas, and policies and regulations about water quality, drainage, and flooding are all considered for a community's land use vision. Planners should also consider the benefits of integrating water related features for flood management, water supply and quality, recreation, and climate change adaptive management.

Land use planning and management share strategies and benefits with watershed planning and management, agricultural lands stewardship, water use efficiency, water quality management, and climate change planning, to name a few. The themes of flood risk and surface water management can meet sustainability issues in land use planning. These strategies benefit from participation by all levels of government relying on local knowledge and management capacity. In common with many other cross-cutting themes in local government, the quality of outcomes depends on joining services and various stakeholders effectively. These listed management strategies and others tie in with the following sustainability issues:

- Climate change adaptation includes preparing for flooding.
- Biodiversity — sustaining existing biodiversity and its potential enhancement — comes by

- Managing waterways
- Community engagement increases public awareness of the issue.
- Development and provision of green infrastructure increases sustainability.

1.3. Changes in Development Patterns in Connecticut

Managing development in harmony with existing and proposed public water infrastructure can provide numerous economic and environmental benefits. Development that is situated around and within water distribution systems reduces the need for additional pipelines and infrastructure. As opposed to extending pipelines out long distances to developments, local use saves energy required to pump water further, and reduces unaccounted for water due to leakage from long mains.

Developing so that one large water supply utility can serve a large group of customers can pay dividends not only economically, but can also increase service reliability and safety. Small systems cost more to maintain per unit water produced, due to the economics of scale and the reduced spatial component of critical infrastructure like towers and treatment stations. Large systems are much more likely to feature redundancy in supply sources, storage, and treatment; and also are required to submit water supply plans that can help build capacity. Their infrastructure is more likely to be staffed and accessible during emergency situations, and more likely to be prioritized when the need for repairs is present.

If focusing water service within the footprint of existing distribution systems can be prioritized, there may be more opportunities for developing and redeveloping land in such a way that per-capita water use can be minimized. For example, smaller lots with xeriscaping tend to use less water than larger lots with turf grass irrigation needs. Plus, newer housing units are fitted with the low-flow and low-flow fixtures that are available to contractors. Cluster development may accomplish some of the same goals, but not if such development is occurring far from distribution systems.

1.4. Green Building and LEED in Connecticut

LEED, or Leadership in Energy and Environmental Design, is a certification issued by the United States Green Building Council. This program uses a process by which points are awarded to buildings based on the implementation of various sustainability practices. Depending on the number of points earned, one of four LEED ratings are achieved: Certified, Silver, Gold, or Platinum.

LEED certifications can apply to building design and construction, interior design and construction, building operations and maintenance, and to larger scale neighborhood development. The LEED scorecard bases its rating on factors such as indoor and outdoor water use reduction, renewable energy usage, high efficiency fixtures and lighting, environmentally friendly cleaning and waste management practices, and numerous other factors.

Buildings built to LEED standards will tend to reduce consumption of natural resources, and use materials which are more environmentally friendly. Some buildings with LEED certification can even achieve a carbon neutral or carbon negative state, meaning that the net carbon footprint of the building is offset by renewable resource generation and energy efficient practices within or around the building.

Effective July 1, 2007, Connecticut passed Public Act 07-242, An Act Concerning Electricity and Energy Efficiency. PA 07-242 requires the state building inspector and the Codes and Standards Committee to amend the State Building Code to require buildings costing $5 million or more, or renovations costing $2 million or more, to meet the LEED silver standard or its equivalent. These requirements apply to both private and public sector projects, other than residential buildings with up to four units. These types of projects are required to exceed the current building code energy efficiency standards by at least 20%.

The State of Connecticut does not provide financial assistance for building owners or developers to meet or exceed LEED requirements. However, there are some incentives for building owners and developers. For example, the State exempts various energy efficiency goods, such as furnaces that meet federal Energy Star standards and insulation, from the sales tax. Municipalities are also required to exempt several types of renewable energy systems from the property tax. Connecticut also has a net metering law where buildings that use renewable resources systems to generate electricity sell the power back to the electric companies.

The Connecticut Green Building Council (CTGBC) is Connecticut's local chapter of the US Green Building Council (USGBC). Throughout the year, CTGBC holds a series of workshops on green building topics, networking opportunities, membership meetings, educational forums, seminars on green buildings and periodic Connecticut-based LEED training in connection with the US Green Building Council.

2. Supply Management Alternatives

2.1. Use of Class B Water for Non-Potable Sources

Connecticut uses only Class A or Class AA surface waters for drinking water. Section 22a-417 of the Connecticut General Statutes prohibits discharge of sewage to water supply impoundments. Therefore, Class B surface waters, which are designated in accordance with the Connecticut Water Quality Standards to ,in part, receive and assimilate treated wastewater are not utilized for public drinking water supply. This topic is discussed further in the 1B-4 paper, as the prohibition itself creates a set of challenges in the State, despite its numerous benefits.

According to various water supply plans, residential use water accounts for about 2/3 to 3/4 of the water consumed by customers of water utilities. The remaining water is used for commercial, industrial and public service uses. Some of the water used by industries is not intended for drinking, depending on the nature of the industrial customers. For example, many large water utilities provide water to power generation facilities on a daily basis or in reserve, and sometimes at levels of 0.3 mgd to 0.5 mgd. This is sometimes water that could be sourced from class B rivers. Major class B sources in the state, like the Connecticut River and Housatonic River, could potentially provide large quantities of non-potable water depending on the proximity to such sources; the adequacy, quality and availability of the supplies; and permitting considerations. Connecticut has many examples of golf courses, nurseries, and small agricultural facilities that utilize the adjacent public water system (typically Class A water) for supply (either backup, supplemental, or the primary supply).

However, using Class B waters for specific customers like power plants and golf courses is relatively easy compared to the more difficult scenario of using Class B waters for the non-potable needs of customers that otherwise have mostly potable needs. For example, a large commercial establishment may have mainly potable water needs for drinking and sanitation, but landscaping needs that could be served by Class B waters. Connecticut, like all States, has a strict public health code that has provisions in place to monitor for, and prevent, cross connections between potable and non-potable systems. Plus, the cost barriers are significant to installing separate potable and non-potable water systems on a parcel, neighborhood, or system scale. Consideration would need to be given to the impacts on ratepayers and users of systems where redundant piping would be required, and the incremental effects on growth and economic development.

There are situations where there has been linkage of non-potable sources to non-potable uses (e.g., some of the power generation facilities that have been proposed or constructed in the last 15 years), but more progress is desired by many people. The following two examples highlight situations where potable water will be used for non-potable uses that could have potentially been supplied by Class B waters:

- One of the State's most recent gas-fired power plants was developed in Middletown and uses water from collector wells that draw from the Class B Connecticut River. the Towantic Energy facility, which is under construction, in Oxford needs a backup source of water for cooling, and the only viable source appears to be the local public water system. Not only is water is needed for cooling, but additional water is needed for air emissions during oil-fired operations. Many people believe that non-potable waters should have been a priority consideration in siting the facility.

- A large nursery is expanding in Connecticut and has purchased a new site in a town with an extensive public water system. To avoid the expenses and permitting uncertainties associated with developing new ponds and/or groundwater supplies, the nursery plans to use the potable water system for irrigating product. Although not a concern for this example, other nurseries that grow food products may be constrained by requirements to utilize high quality waters for irrigation.

An additional point regarding power generation facilities is that some facilities have very specific water quality needs that may not be met with Class B waters. In some cases, this can be addressed by treatment processes employed by (and located at) the power generation facility. But in other cases, the generation facility may be better served by using potable water for cooling and other processes.

2.2. Municipal and Industrial Reuse

M&I reuse (sometimes referred to as "water reclamation") involves a second or consecutive uses of consumable water supplies that have first been used to meet municipal or industrial needs but not fully consumed. Consumable effluent is defined as effluent that a public water system can reuse. Nationwide, this can be both potable and non-potable, but in Connecticut the prohibition of Class B water for potable use would limit reuse water to non-potable uses.n-potable Reuse

Non-potable reuse involves the capture and use of reusable return flows for duel supply (flushing toilets), the irrigation of landscapes, or for industrial uses such as cooling or process water. Since return flows from landscape irrigation are hard to capture in one location, non-potable reuse to date has involved the reuse of consumable effluent discharged from wastewater treatment facilities. The effluent undergoes additional treatment to meet non-potable reuse standards. This treatment usually involves filtration and additional disinfection.

Potential benefits of non-potable reuse include:

- Improves M&I reliability.
- Maximizes successive uses of water.
- Maximizes beneficial use of water.
- May not require new diversion structures.
- Lesser environmental impacts than a new water supply project.
- Does not use higher quality drinking water for irrigation.
- Does not use high quality water for snowmaking.

Potential issues and concerns include:

- Can be very expensive.

- Must have consumable effluent (a source of effluent that isn't needed elsewhere) to reuse or identified return flows.
- Wastewater treatment plant needs to be near irrigation demands.
- Must have storage to regulate year round effluent flows and meet demands during irrigation season.
- Public acceptance of the reuse of effluent for landscape irrigation must be achieved.

2.2.1 Reclaimed Water for Non-Potable Uses in Connecticut

Two water reclamation facilities have been established in Connecticut. The Mashantucket Pequot Tribal Nation uses reclaimed water (treated sanitary wastewater) as the predominant supply for its Lake of Isles Gold Course irrigation. This supply is augmented by potable water, but as wastewater supplies have increased, potable water use has lessened.

The University of Connecticut opened its reclaimed water facility in 2013. Most of the output from the $25 million facility is used to provide heating and cooling water at the University's Co-Gen power facility. The facility has the ability to process up to 0.5 mgd on peak days, which is enough to supply the entire water needs of the plant. The facility can also be potentially used for gray water in new buildings and field irrigation.

Despite these two successes, there were significant barriers that Mashantucket Pequot Tribal Nation and UConn could traverse by virtue of their unique nature as water and wastewater utilities. For example, Mashantucket Pequot Tribal Nation is sovereign, although the Lake is Isles Golf Course is not. The tribal utility authority could access funding reserves to pay for the microfiltration facility, and had readily available land for the facility. The State of Connecticut had a keen interest in funding significant water conservation measures at UConn, and the State obviously had land available for the facility. Both Mashantucket Pequot Tribal Nation and UConn also had easy access to sanitary wastewater effluent.

Even with UConn's success in using reclaimed water for heating and cooling, some other intended uses (for example, landscaping needs) have not yet materialized due to logistical and permitting barriers.

When considering how the Mashantucket Pequot Tribal Nation and UConn proceeded with reclaimed water facilities, it is extremely difficult to find other easy examples in Connecticut. Following in the same model, attention could turn next to the largest of the State's universities (such as the Connecticut State University system) as well as the larger industrial and commercial facilities in the State that have sufficient control of their land (such as Pfizer, ESPN, etc.) and easy access to treated effluent.

It is very difficult to conceive of a mechanism that the average municipal water and sewer departments could fund construction of reclaimed water facilities, and even if they could, it would be challenging to identify customers for this water. Along with the significant operations costs, these are significant barriers to implementation of reclaimed water.

2.2.2 Household Graywater Use in Connecticut

A broad definition of gray water is wastewater drained through sinks, lavatories baths, showers and washing machines. Although it is wastewater, gray water is largely devoid of any human waste. Gray water can be used to flush toilets, water grass, and in many other non-potable applications.

Cost considerations in addition to the gray water collection system include the additional plumbing needed to allow appliances to operate using the separate greywater system, and a treatment system to remove pathogens from gray water before re-use. Although gray water does not contain human waste, water from dish, hand and clothes washing can contain sufficient pathogens as to be a biological concern. Gray water systems can use multistage systems utilizing media filtration and UV sterilization to render water fit for reuse.

If pursued extensively in Connecticut, gray water systems (just like capture and use of stormwater at the end of this paper) would not be a comprehensive solution for multiple properties or neighborhoods. It would likely be used case-by-case to reduce the use of potable water supply through individual service connections to individual properties. Cross-connection issues would be important to address to ensure that drinking water systems remain safe. Several examples of LEED-certified buildings that use graywater and/or stormwater can be identified. The potable water needs of these buildings are therefore limited to drinking, cooking, etc.

2.3 Coordination Regarding Interbasin Transfers

Interbasin transfers remain a contentious issue within the state of Connecticut. By definition, an interbasin transfer moves water from one subregional drainage basin to another. The subregional drainage basins "of record" are those delineated in the *Atlas of Public Water Supply Sources and Drainage Basins* (1982, CT DEEP). The reasons for performing such transfer are numerous, but fundamentally involve extending water from a place of surplus to a place needing supply.

Many of our longest interbasin transfers are quite old, and date back to the time that our industrial cities (Hartford, Waterbury, Bridgeport, New Britain) were siting and developing surface water supplies that were quite distant from the city centers. In recent years, interbasin transfers have typically involved movement of treated water through pipelines from systems that have excess water to systems that need additional water.

Both the DEEP and DPH allow interbasin transfers. Transfers of 50,000 gallons or more per day require diversion permits. In some cases, a higher level of environmental review has been required[4] due to the triggering of the Connecticut Environmental Policy Act due to State-funded or State-sponsored actions. The environmental, economic, and societal effects of interbasin transfers are varied but generally positive, or they would not be authorized or desired. Opponents argue that transfers alter ecological conditions by redistributing flows from one river basin to another. From an economic and societal standpoint, opponents argue over priority of water distribution in the event that a large scale water shortage afflicts the source basin, and/or the basins it supplies.

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[4] University of Connecticut Environmental Impact Evaluation for New Water Supply (2011-2013) and Town of Middlebury Environmental Impact Evaluation for water main extension and interconnection (2006-2007).

Although the opposition to interbasin transfer is well documented, proponents note major benefits to the practice. Some view the transfer as a way to encourage development and economic growth in an under producing basin by using surplus water from another. Others note that interbasin transfers help strengthen the water utilities' ability to provide water under adverse conditions, as multiple sources of supply increase redundancy and reliability of the system. Proponents further note the potential benefit of moving water from water rich areas to more environmentally stressed areas to reduce impacts from developing additional supplies in areas where there may be demands.

Ideally, the state may one day be able to plan or "pre-program" potential interbasin transfers in order to more effectively address water needs and imbalances. Connecticut's development patterns of suburbanization superimposed on traditional New England villages and old industrial cities means that water demand will not always be balanced with supply availability. Thus, while some sources may be stressed, others will be underutilized. Planning interbasin transfers before problems arise enables the state to balance the interests of various parties and acclimate to changing demands in a timely manner when the need finally arises. The WUCC process can also help in this regard.

2.4 Conjunctive Use of Surface Water and Groundwater

Conjunctive management or conjunctive use refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. Surface water and groundwater resources typically differ significantly in their availability, quality, management needs, and development and use costs. Managing both resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit.

Conjunctive management thus involves the efficient use of both resources through the planned and managed operation of an aquifer and a surface water storage system combined through a coordinated conveyance infrastructure. In its simplest form, conjunctive use involves using surface water when surface supplies are ample, such as during average to above average runoff conditions. When surface water supplies are in short supply, such as during below average runoff conditions, groundwater supplies would be used to a large degree to meet demands.

The necessity and benefit of conjunctive water management are apparent when surface water and groundwater are hydraulically connected. Well-planned conjunctive management that prevents groundwater depletion and helps maintain baseflow to streams and support for ecosystem services not only increases the reliability and the overall amount of water supply in a region, but also provides other benefits such as flood management, environmental water use, and water quality improvement. In Connecticut maintaining baseflow can be accomplished by preventing groundwater depletions along smaller streams. Except for very short reaches, almost all streams are gaining reaches.

Physical and legal limitations affect the reliability and sustainably of groundwater as a source of supply. Physical availability measures the amount of water an aquifer can produce, both in the short- and long-term, and primarily affects the sustainability of the resource. Legal availability relates to the amount of water that can be extracted from an aquifer under the water rights administration system that exists in a particular area, and can affect the reliability of the supply.

In the context of water supply, aquifers can be categorized as being renewable or non-renewable. Aquifers that are located in the floodplain adjacent to rivers typically are composed of stratified glacial deposits and have a hydrologic interaction with those rivers; they dynamically get water from or discharge water to the rivers throughout their reaches. Aquifers of this type are referred to as tributary or valley-fill aquifers. They usually are unconfined aquifers that are relatively shallow. Valley-fill aquifers are considered to be a renewable source of water since they are hydrologically linked to renewable supplies such as precipitation and infiltration of surface water.

The other category of aquifer, non-renewable, is one that is not replenished from renewable sources such as rivers or infiltration of rainfall. Non-renewable aquifers generally are located deep below the land surface, in consolidated bedrock deposits, and would be classified as confined aquifers. Although non-renewable aquifers are common in many parts of the country, Connecticut has few deep, extensive confined aquifers. The fractured bedrock aquifers are locally recharged, although at a slower rate than the valley-fill aquifers.

Conjunctive use of surface water and groundwater can maximize the benefits and reliability of both surface water and groundwater sources of supply.

2.4.1 Conjunctive Use of Groundwater and Surface Water in Connecticut

Conjunctive use relies on the combined strengths of nearby surface and groundwater sources (typically in the same drainage basin) in order to balance aberrations in capacities based on seasonal and other factors. Small and moderately-sized surface water systems, while able to be filled very rapidly under certain conditions, are also susceptible to high rates of evaporation and severe dry spells. This is not typically the case for the largest surface water reservoirs in Connecticut. Groundwater sources can be slower to recover than surface water, in some cases, however their output is generally steadier, with less variation over time, similar to the largest of the surface water reservoirs.

By reducing reliance on a single type of source, a utility's resilience to adverse conditions increases dramatically. For example, if an intense rain event occurred in a drought stricken area, producing high runoff, a surface water body or flood skimming operation may be able to take advantage of the high rates of runoff. Consequently, in a situation where high ET and low rainfall caused reservoir supplies to suffer, groundwater may be able to augment supply during that time.

Many water utilities in Connecticut already utilize groundwater supplies and surface water supplies. Examples include Manchester, Middletown, Wallingford, Meriden, Aquarion Water Company, RWA, and The Connecticut Water Company.

However, many water utilities in Connecticut formerly operated small reservoir systems but made them inactive due to the requirements for filtration under the SDWA, opting to develop wellfields. These systems now utilize wells for most (or all) of their daily supply, although the old reservoirs are still located nearby and have been relegated to other beneficial uses such as passive recreation. It may be useful to evaluate whether some of these systems could identify methods of restoring reservoirs to public water supply, thereby reducing the stress on their wellfields and the aquifers that are tapped. Returning pre-SDWA reservoirs to active use in part to reduce stress on wellfields would come with substantial costs for designing, building, and operating new filtration plants. There could also be significant and challenging environmental and social conflicts to address when reactivating these sources, such as those experienced by RWA when the Lake Whitney Reservoir was reactivated.

Likewise, systems that operate only reservoir systems may be situated in places that are underlain by productive aquifers. These systems may wish to explore the possibility of using groundwater if there is a need to reduce stress placed on surface water systems and the rivers that flow through them.

It should be noted that conjunctive use issues are not limited to public water systems. There are many water users in Connecticut that use both surface water and groundwater for flexibility and reliability, including many of the sand/gravel production and washing facilities, many golf courses, and several nurseries.

2.5 Collector Wells and Riverbank Filtration for Potable Uses in Connecticut

Riverbank filtration involves the process of installing pumping wells near a river channel, in order to induce a hydraulic gradient and filter water through the riverbank. Not only does the induced infiltration greatly increase the amount of water the well can pump, the induced infiltration also causes the water to flow through the substrate and banks where a variety of physical and chemical purification processes occur. Riverbank filtration uses large vertical wells which draw water some horizontal distance from the stream channel. Often, the influence of these wells draws from both “true” groundwater sources by intercepting groundwater that would have discharged to the river, as well as river water. The State has several examples of riverbank filtration, , although the aquifer thicknesses and pathways traversed (from riverbed to wells) are more substantial in Connecticut than they are in many other settings in the United States. Most high capacity wells in Connecticut are located near streams and benefit from the induced infiltration and riverbank filtration.

A related practice to bank filtration is achieved with collector wells, which are large, vertical caissons with horizontal arms that draw water from beneath a river. They are composed of a central shaft, which is installed some distance below the surface. Several appendages are projected out horizontally underneath the stream channel. Since collector wells are situated directly below the stream channel, they are more likely to draw from predominately surface-sourced water, as opposed to tapping into the aquifer. Several collector wells are operating in Connecticut. including the most recently-constructed (the River Road Collector Wells in Middletown, currently used by a gas-fired power plant). Other inactive or active collector wells are located in Naugatuck (Naugatuck River), Wallingford (Quinnipiac River), and Rocky Hill (Connecticut River).

Although wells located close to rivers are common in Connecticut, river water quality must be carefully controlled to minimize pollutant inflows, as bank filtration has a limited capacity to remove many contaminants, like herbicides, nutrients, some organic compounds, and emerging contaminants such as pharmaceuticals. As point and nonpoint discharge sources have been reduced in many areas of the United States in recent years, the water quality of rivers and streams has improved dramatically. This has led to the possibility that effective riverbank filtration can occur in this area. In class AA waters, collector wells would not be expected to be contaminated with pharmaceuticals and other pollutants associated with sewage effluent, except that which has emanated from nearby septic systems in the watershed. However, in class B sourced surface waters, these contaminants may become prevalent. The State has seen several incidents where wells pumping near streams have had adverse effect on streamflow levels during low flow periods. Thus, careful consideration must be given to the location and operating parameters of such wells.

Whether or not collector wells will be permissible for potable water in Connecticut remains to be seen. The State's process for evaluating groundwater under the influence (GWUDI) of surface water is quite rigorous, but many wells located near watercourses have passed the testing and been authorized for potable supply without filtration. However, the ability of a collector well to pass the GWUDI evaluation has not been tested. This will be important to determine in the near future, because it will help determine whether collector wells are potentially viable as drinking water sources. The State may need to look to other states that are using collector wells for potable supply, from near (New York) to far (the Midwest and beyond). If water from collector wells is not appropriate for drinking without treatment, the provisions of the SDWA would apply.

2.6 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) involves pumping surface water underground into the aquifer for future recovery. Where aquifers are large and have the capacity for additional storage, this process can be used to store excess surface water runoff that would be unpractical or impossible to store in a surface reservoir, treated effluent from wastewater treatment plants, or excess drinking water from a public water supply system. ASR can be achieved via surface spreading, infiltration pits and basins, or injection wells.

ASR has not been used in New England, according to the EPA, primarily because the aquifers are not areally extensive and because the depth to water is shallow. Even where ASR might be feasible, its use does have risks. Raw water injected into the aquifer may have pathogens, which could proliferate and require extensive treatment upon recovery. Additionally, chemical compounds in pre-treated effluent and drinking water can react with compounds in the aquifer, creating chlorinated compounds and other toxic byproducts. There are other issues with ASR, which can interfere with recovery, due to well clogs, and cause undesirable chemical characteristics of the water.

2.7 Water Banking in Connecticut

Interestingly, one of the State's first water banking operations was recently constructed, and it is the opposite of ASR. The City of New London will soon be storing (in its reservoir) water withdrawn from wells located in East Lyme, and then selling the water back to East Lyme when diversion permit conditions make it impossible to fully utilize the wells. Perhaps if ASR cannot be pursued in Connecticut, additional examples of water banking may be identified.

2.8 Development of Additional Storage

Storage projects capture water during high flow years and seasons to be used during low flow periods. These storage projects include the construction of new reservoirs, enlargement of existing reservoirs, or rehabilitation of existing reservoirs that have reduced storage volumes due to various structural problems (e.g., spillways unable to meet the current probable maximum flood criteria, etc.)

2.8.1 New Storage Projects

New storage projects include the construction of dam embankments to create on-channel or off-channel reservoirs. Off-channel reservoirs require the construction of diversion or pumping facilities from the river to stream to deliver the diverted water to storage. Storage options will vary greatly in their feasibility, while project considerations, such as firm yield, capital costs, and permitting are site specific.

The benefits of developing new storage projects include:

- Water sources will be diversified if the water to be stored is from a new source. This can reduce the risk of supply shortfalls as not all water sources may experience shortages at the same time.
- The reliability of the overall water supply system can be increased and the risks reduced. The development of additional new storage can help protect against potential water shortages due to structural failures such as storage restrictions of the temporary inability to use a supply due to water quality concerns.
- Overall system efficiencies are increased by minimizing system spills.
- There is the potential for hydropower generation.

The potential issues and conflicts in developing new storage projects include:

- There may be environmental impacts to the aquatic and terrestrial environment. These impacts are likely to be more significant than those resulting from enlarging existing storage facilities.
- Loss of recreation associated with free-flowing streams, such as fishing, rafting, and kayaking.
- Water quality impacts can be associated with impounded water.
- Cultural impacts associated with inundation of lands.
- Permitting and mitigation can be more expensive and lengthy than other water supply options and have an uncertain outcome.
- A significant amount of storage may be required to produce substantial yield.
- Dam safety is already a significant concern in the United States, and these projects would lead to more dams.

2.8.2 Expansion and Reoperation of Existing Storage Facilities

The expansion and reoperating of existing storage facilities can be a cost-effective means to develop additional storage. Options for increasing storage in existing facilities include raising dam embankments, dredging sediments, and deepening reservoirs and raising spillway levels.

The expansion and reoperation of existing storage facilities has several benefits including:

- There are likely to be less environmental and recreational issues than for new storage, since the reservoir already exists.
- Permitting and mitigation requirements may be less difficult than for construction of a new storage facility.
- Overall system efficiencies are increased by minimizing system spills.

- Corps of Engineers Flood Control facitilties can be expanded to be used for water supply as a secondary use

The potential issues and conflicts in expanding existing reservoirs include:

- Environmental and recreation impacts can also occur here depending on the size of facility.
- Expanding existing storage facilities does not diversify water sources and the risks of structural failures or water quality catastrophes are not reduced.
- Permitting and mitigation, though typically less difficult than that for new storage, can still be expensive and lengthy with an uncertain outcome.
- A significant amount of storage may be required to produce substantial yield.
- There are a limited number of reservoirs that can be enlarged. Many reservoirs are not cost-effective to enlarge or have small watersheds that do not allow for a proper refill.
- There is a limited volume of increased storage available through reservoir enlargements.
- The enlargement of existing reservoirs may not be cheaper than new storage. The original dam embankments and spillways, in many instances, were not designed or constructed to current engineering standards. Upgrading the existing facilities to be compatible with an enlargement may not be cost-effective, given the heightened concerns about dam safety in the nation.

2.9 Flood Control Reservoirs for Water Supply in Connecticut

Because Connecticut allows public water supply from Class A surface waters but not Class B or lower quality, the number of flood control impoundments available for potential use as a public water supply reservoir is limited. However, one noteworthy example is Mansfield Hollow Lake. This impoundment has a normal pool elevation that allows for significant areal extent and volume. In contrast, many other flood control reservoirs in Connecticut do not maintain significant volumes behind the dams. Thus, Mansfield Hollow Laker has often been cited as a reservoir that should be considered for public water supply in the Town of Mansfield, potentially providing relief to the UConn area. Because UConn and the Town of Mansfield have elected to pursue other options for water supply (increased conservation, reclaimed water for non-potable uses, careful use of the two wellfields that supply UConn, and a regional pipeline from Tolland), further discussions related to Mansfield Hollow Lake as a direct source have ceased.

However, the question of using Mansfield Hollow Lake as a mitigating factor for the downstream Willimantic Reservoir (operated by Windham Water Works) is still quite germane. At some point in time, Windham Water Works will need to renew its water diversion permit, and this will call into question to conditions of the Natchaug River. Although the current permit limit was found to cause only minimal impacts to fish habitats in the Natchaug River (based on an instream flow study), Windham Water Works may become an important hub for public water supply in the future if conditions in eastern Connecticut change. An increase in the diversion permit limit would likely necessitate a modification in the operation of the Mansfield Hollow Reservoir to retain and release water in a manner that benefits the ecological health of the Natchaug River.

There are few – if any other – examples of flood control impoundments upstream of water supply reservoirs. However, there are examples of flood control, recreational, and hydropower impoundments upstream of wellfields that lie along rivers. It is not too soon to begin thinking about these impoundments as potential mitigating factors for low instream flow conditions. If the impoundments could release water when the downstream public water supplies are needed most, instream flow conditions could be maintained or even improved.

One potential example where this arrangement could occur is along the West Branch Farmington River. The West Branch Reservoir is downstream of the flood control reservoir. The West Branch reservoir also maintains the flow in the Farmington River for fisheries, recreation, power and wastewater assimilation. There may be available water in the combined reservoirs for future supply.

It is important to note that if flood control reservoirs are used for public supply, supply would be secondary. In other words, if the operator needed to release water from the reservoir to create storage in anticipation of a major storm, this would happen without haste and the availability of supply could be affected if the impoundment did not refill quickly. This underscores the inherent conflict in reservoir management for the goals of flood control (water level to be kept low as possible for flood storage potential) vs. water supply (water level to be as high as possible as much of the time as possible for drought periods). This points back to the ideal situation at Mansfield Hollow Lake, where a normal pool elevation is maintained.

Aside from public water supplies, there are other potential uses of flood control impoundments in Connecticut. Non-potable uses such as power generation, golf courses, agriculture, nurseries, extraction (sand/gravel), and certain industries could utilize water from flood control impoundments while avoiding significant adverse environmental impacts that would occur due to equivalent withdrawals from free-flowing streams. The challenge would be the siting of these facilities near flood control impoundments, since the impoundments are often on State or federal land.

2.10 Flood Skimming and Storage in Connecticut

Flood skimming and storage refers to the diversion of water from a stream during high flow conditions to a separate surface water impoundment (i.e. not an impoundment located directly downstream). This can take advantage of the increased supply which would ordinarily flow downstream as runoff. Water can be pumped into large reservoirs which are not formed by impoundments of the source stream. Thus, a separate source of supply can be used to fill the reservoir, essentially using the reservoir as a storage tank.

While there was some discussion about using flood skimming back in the 1980s and 1990s, few examples can be found in the State.

Water utilities that own multiple reservoir systems with an interconnected transmission system may be able to apply the same concept as flood skimming by maximizing use of run-of-the-river reservoirs during typical high flow seasons (winter, spring), and reducing withdrawals from other reservoirs to promote refilling for serving high demands during summer months.

2.11 Stormwater Capture in Connecticut

Stormwater capture can be an effective method of collecting and then “producing” non-potable available water in a residential, commercial or industrial setting. This is also known as water harvesting. During a one-inch rain storm, a flat 10,000 square foot flat-roofed retail building can produce over 6,000 gallons of water. This water can replace potable water in such uses as irrigation, industrial cooling, and flushing toilets. Small cisterns holding 50-100 gallons are cheaply readily available for residential use, which easily rest under or attach to gutter drain spouts. Larger systems holding several hundred to thousands of gallons are available as well, albeit at higher cost and with more involved installation.

If pursued extensively in Connecticut, capture and use of stormwater would not be a comprehensive solution for multiple properties or neighborhoods. It would likely be used case-by-case to reduce the use of potable water supply through individual service connections to individual properties. Several examples of LEED-certified buildings that use stormwater for toilets and irrigation can be identified, including Kroon Hall at Yale University and the Milone & MAcBroom, Inc. office in New Paltz, NY. The potable water needs of these buildings are therefore limited to drinking, cooking, etc.

2.12 Desalination

Desalination is the removal of salts from water to produce a water of lesser salinity than the source water. Other terms that are interchangeable with desalination include seawater or saline water conversion, desalting, demineralization, and desalinization. For consistency, "desalination" will be used in this chapter.

Desalination can be used to reduce salinity in many sources of water. The term source water is used to identify the body of water from which water is taken for beneficial purposes. On a national scale, source water for desalination can include surface water, groundwater, and municipal wastewater. Desalinated water can be used for potable uses, such as municipal drinking water, or non-potable applications, such as agricultural irrigation or industrial processes. The focus of this chapter is on desalination of surface water or groundwater for potable uses.

Sources of Water for Desalination

Typically, raw water sources must meet basic municipal water supply development criteria for quality and quantity. Municipal source waters should be capable of providing an adequate and sustainable amount of water for an intended beneficial use. Potential sources include oceans, bays, rivers, lakes, and groundwater aquifers. The determination of the safe yield from a water body is necessary for desalination as well as many other types of water supply projects. Oftentimes, ocean and other saline open-water environments afford the greatest safe yield potential for desalination.

Potential Benefits

Desalination can improve a water supplier's ability to provide safe and reliable drinking water to its customers. When adopted as part of a diversified resource portfolio, desalination can provide many potential benefits, including:

- Expanding local water supply.
- Improving overall supply reliability by diversifying resource portfolios.
- Providing emergency supplies during drought periods and after extraordinary events.

Major Implementation Issues

The major implementation issues associated with desalination as a viable resource management strategy can be placed in the following categories:

- Permitting and Regulatory framework.
- Energy use and sources.
- Climate change.
- Funding and perhaps more specifically, significant costs that must be paid by someone.
- Intakes and ocean and freshwater ecosystems.
- Concentrate (brine) management and disposal.
- Subsurface extraction.
- Planning and growth.

Desalination in Connecticut

Generally speaking, desalination has not been as popular in northeastern states as in the west because northeastern states have had more abundant water sources while water demand has not grown rapidly. There are not any desalination plants in Connecticut. In fact, the first desalination plant in New England was not completed until 2008 in Brockton, Massachusetts. This desalination plant provides more than 4 million gallons per day of potable water from the Taunton River. CT DEEP notes desalination may become more prevalent as technology improves and costs drop. However, desalination capabilities have yet to be pursued in Connecticut. Currently due to 22a-417 desalination is not a legal option for potable water supply since it is waste receiving, poses public health concerns, lacks protection of landuse control and water quality control.

The Town of East Lyme reportedly evaluated desalination several years ago as a potential source of water prior to pursuing the water banking arrangement with New London. East Lyme could be contacted for additional information if the State Water Plan process determines that desalination should be further explores.