Water Conservation Plan

University of Connecticut

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1.0 INTRODUCTION

1.1 General

This 2020 *Water Conservation Plan* has been prepared for the University of Connecticut (UConn) to promote long term water conservation and to ensure an adequate supply of water to meet essential needs.

This 2020 *Water Conservation Plan* has been prepared in accordance with existing statutes and regulations currently in effect. The State guidelines for water conservation planning, prepared by the Connecticut Department of Public Health (DPH), Public Utility Regulatory Authority (PURA), Department of Energy and Environmental Protection (DEEP), the Office of Policy and Management (OPM), and Office of Consumer Counsel have also been consulted and utilized, where appropriate. These guidelines, as well as other fact sheets have been used in the preparation of this Plan. Portions of these documents have been incorporated where appropriate.

1.2 Regulatory Overview

Although UConn is not considered a "water company" as set forth in Connecticut General Statute (CGS) Section 25-32a, UConn views its *Water Supply Plan* as an integral device in planning for a safe and adequate water supply system through the foreseeable future. Thus, UConn's *Water Supply Plan* addresses (when possible) the requirements of CGS Section 25-32d and UConn distributes the plan to reviewing agencies and interested parties for review and comment.

This 2020 *Water Conservation Plan* is intended to meet the requirements of CGS Section 25-32d (the Water Supply Planning Regulations). Section 19-13-B102(s) of the Connecticut Public Health Code requires conservation practices, including a program to reduce the amount of water that cannot be accounted for. This Plan is consistent with the Public Health Code requirements.

UConn developed its initial *Water Conservation Plan* in 2000 as part of the revisions to its 1999 *Water Supply Plan*. That initial Plan was revised in 2000, 2001, 2004, and 2011 concurrent with the previous *Water Supply Plan* updates. This Plan is a revision and update of the 2011 *Water Conservation Plan*.

1.3 Goals & Objectives

It is the objective of the State of Connecticut and of the University in developing this plan to manage and conserve the University's water resources through the following goals and policies:

- To make water resource conservation a priority in policy setting and in practice;
- To conserve water resources through technology, methods and procedures designed to promote efficient use of water, and to eliminate the waste of water;
- To balance competing and conflicting needs for water equitably at a reasonable cost to all;
- To reduce or eliminate the waste of water through water supply management practices; and
- To prevent contamination of water supply sources or reduction in the availability of future water supplies.

These goals and objectives are reflected in the strategies and practices set forth in this document.

1.4 Overview of the System

Table 1-1 is a system fact sheet for the UConn water supply system.

TABLE 1-1
System Fact Sheet

Are you currently under agency order or consent agreement? If yes, describe No

Number of service connections: 350 Estimated population in service area[1]: 27,199

Number of new service connections added over the last year: <5

Annual demand: 264.04 MG (2019) Annual average day demand: 0.72 mgd (2019)

Max. month average day demand: 1.01 mgd (9/2019) Max. one day (peak) demand: 1.44 mgd (9/2019)

Max. month-to-average-day ratio: 1.40(2019) Peak day-to-average-day ratio: 2.30 (2018)

System safe yield and available supply or treatment capacity: Safe Yield of 4.3441 mgd,

Available Supply of 3.6475 mgd

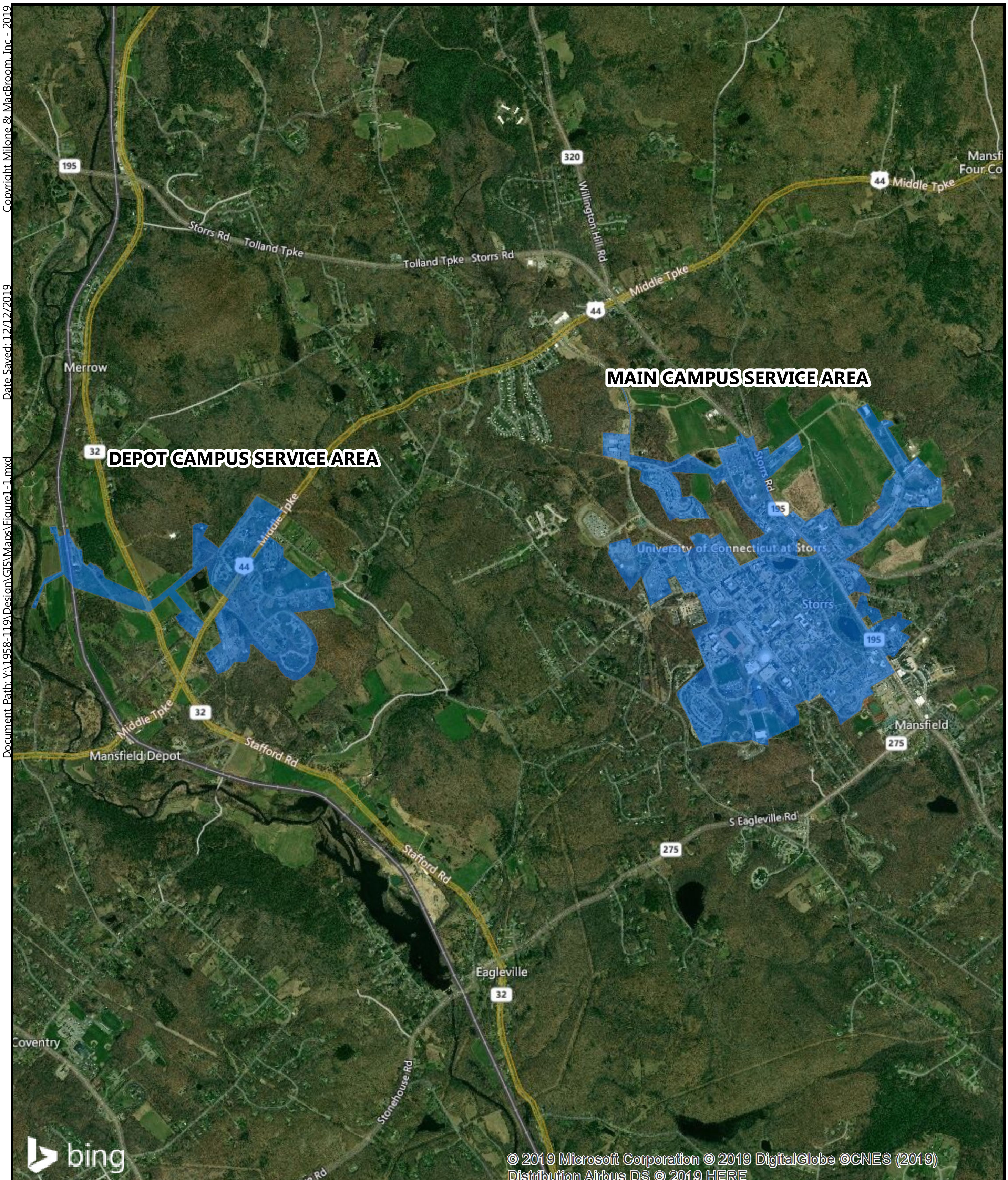
Estimate non-metered water for each of the last five years:

	Year: 2019	Year: 2018	Year: 2017	Year: 2016	Year: 2015
Non-Metered:	0.027 mgd	0.059 mgd	0.245 mgd	N/A[2]	N/A[2]
Percentage:	4%	8%	27%	N/A[2]	N/A[2]

2019 Specification	On Campus Residential	On Campus Non-Residential	Off-Campus	Non-metered	Total
Average day demand (mgd)	0.255	0.439	0.002	0.027	0.723
% of total water use	35%	61%	<1%	4%	100%[3]
No. of service connections	83	258	9	N/A	350
No. of connections metered	82	107	9	N/A	198

1. Estimated service population including resident students, commuting students, faculty, and staff.
2. The Connecticut Water Company (CWC) interconnection came online in late 2016 and former off-campus customers transferred to CWC. Earlier numbers do not reflect current system conditions.
3. Totals do not sum to 100% exactly due to rounding.

Water is supplied to the UConn water system from seven active wells located at two wellfields (Wells B, C, and D at the Fenton River Wellfield and Wells #1, #2, #3, and #4 at the Willimantic River Wellfield). Refer to Figure 1-1 for the locations of key system features. Figure 1-2 represents the schematic plan of the system from the *Water Supply Plan*.



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UCONN WATER SERVICE AREA

WATER SUPPLY PLAN
UNIVERSITY OF CONNECTICUT
MAIN AND DEPOT CAMPUSES
MANSFIELD, CT

N

0 1,000 2,000
Feet

SCALE	1 " = 3,000 '
DATE	12/12/2019
PROJ. NO.	1958-119

FIG. 1-1

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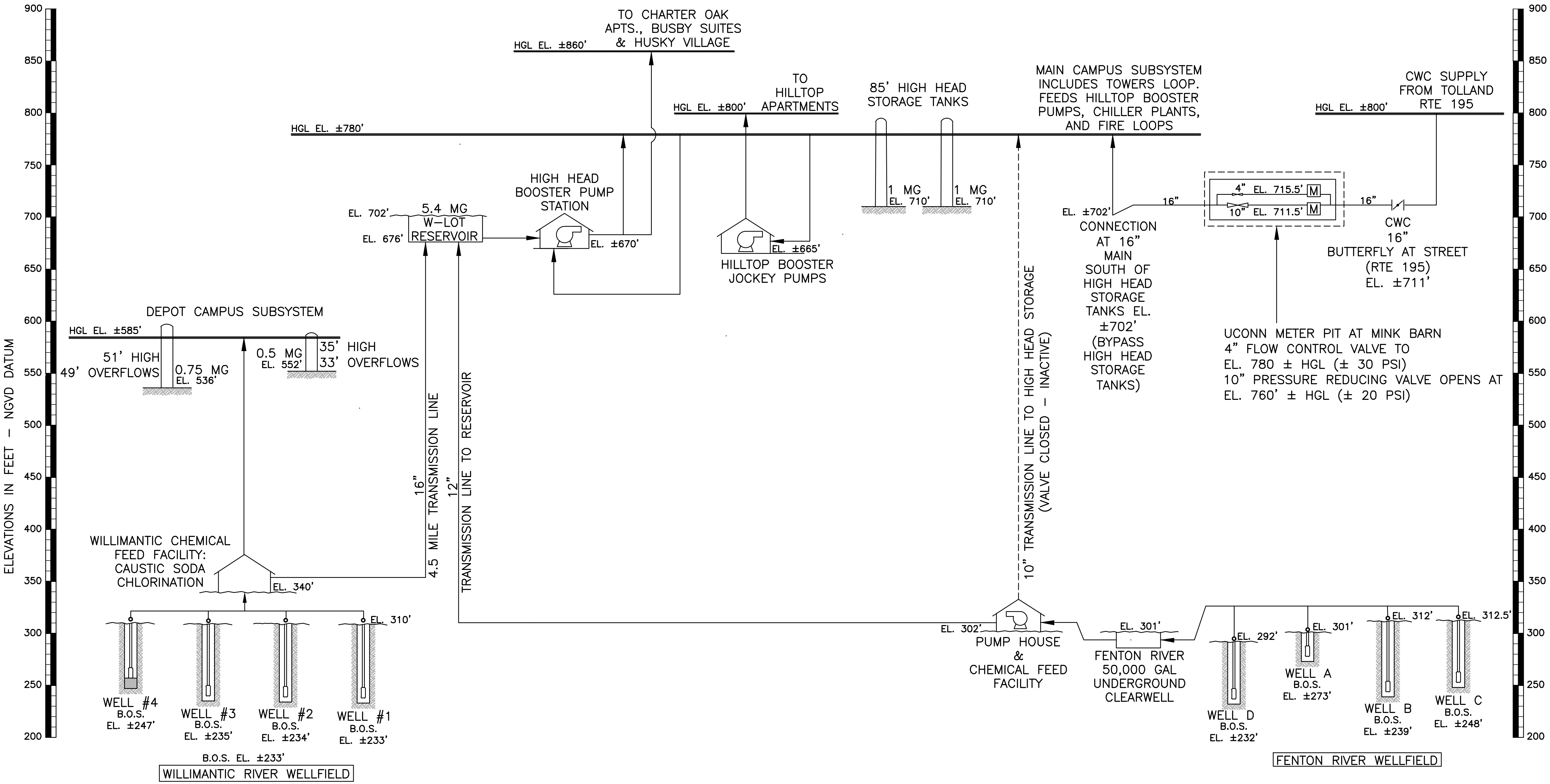

NOTES:
1. DIAGRAM IS FOR SCHEMATIC PURPOSES ONLY. BUILDINGS, TANKS, PUMPS AND DISTANCE BETWEEN STRUCTURES NOT TO SCALE.
2. B.O.S.: BOTTOM OF SCREEN

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REVISIONS
UPDATES 11/22/2019

SCHEMATIC DIAGRAM
UNIVERSITY OF CONNECTICUT
WATER SUPPLY PLAN
STORRS CAMPUS
MANSIELD, CONNECTICUT

DESIGNED	DRAWN	CHECKED
SJB	CME	SJB

SCALE: NTS

DATE: DECEMBER 2019

PROJECT NO. 1958-119-04

SHEET NO. FIG. 1-2

Other water system components include five distribution storage tanks, one transmission storage tank (clearwell), four booster pumping stations, two treatment facilities, and approximately 31 miles of water transmission and distribution mains. UConn is interconnected with The Connecticut Water Company (CWC) Western system which provides an important increment of available supply as well as redundant supply for the active wellfields.

1.5 Evaluation of Present and Future Water Demands

Total water demands have declined steadily since the previous *Water Supply Plan* in 2011. Significant reductions in demand are attributable to the completion of the Reclaimed Water Facility (RWF) in 2013 (which reduced potable water demands by providing non-potable water supply for uses such as the Central Utility Plant) and the CWC interconnection in 2016 (which transferred former off-campus customers served by UConn to CWC).

Based on an examination of consumption data in Section 5.2 of the *Water Supply Plan*, the breakdown of water uses by user category for the last three years (2017-2019) is presented in Table 1-2 (as reprinted from Table 5-14. The average daily water production from the wells was 0.791 mgd for the period 2017 to 2019. On-campus demands accounted for nearly 100% of the overall usage during this period, with 14% of demands (including unmetered users and lost water) remaining unmetered.

TABLE 1-2
Water Usage

Year	Wellfield Production (mgd)	On-Campus Residential Metered Consumption (mgd)	On-Campus Non-Residential Metered Consumption (mgd)	Off-Campus Consumption (mgd)	Non-Metered Water (mgd)	Non-Metered as % of Wellfield Production
2017	0.897	0.270	0.380	0.002	0.245	27%
2018	0.752	0.272	0.419	0.002	0.059	8%
2019	0.723	0.255	0.439	0.002	0.027	4%
Average	**0.791**	**0.266**	**0.413**	**0.002**	**0.110**	**14%**

Future water demands have been estimated in the *Water Supply Plan*. UConn plans to service additional developments on the Main Campus as envisioned in the 2015 Campus Master Plan as well as potential future redevelopment at the Depot Campus.

Table 1-3 presents a summary of projected monthly water demand (reprinted from Table 6-7 of the *Water Supply Plan*. The projections suggest that monthly water demands will average around 1.7 mgd in February, April, September, and October, with a noticeable drop-off in demand for the remaining months. These peaks equate to the return of students (February and September) from semester break as well as higher water needs at the Central Utility Plant (CUP). The September and October months are also two of the months when available supply is restricted due to environmental concerns.

TABLE 1-3
Summary of ADD, MMADD, and PDD Projections

Year	Projected ADD (mgd)	Projected MMADD (mgd)	Projected PDD (MG)
2025	0.929	1.301	2.137
2030*	1.005	1.407	2.312
2040	1.157	1.620	2.661
2070	1.199	1.679	2.758

*Note: 2030 (10-year) demands interpolated from 2025 and 2040 projected demands.

The above demands do not account for seasonality or peaking factors. Any future water consumption at UConn will exhibit seasonality similar to that already experienced by the UConn water system. Monthly projected demands are presented in Table 1-4 in the next subsection.

1.6 System Margin of Safety

Table 1-4 presents the monthly margins of safety for the 5-year planning horizon with existing supplies (reprinted from Table 7-2 of the *Water Supply Plan*). Monthly margins of safety are expected to remain above 1.15 for all monthly average day demands within the 5-year planning period. Similarly, peak day margin of safety is projected to remain above 1.15 in the 5-year planning period (projected margin of safety of 1.71 in 2025).

TABLE 1-4
Projected Monthly Margins of Safety, 2025

Month	Projected Water Demand (mgd)	Total Available Supply (mgd)	Margin of Safety
January	0.703	4.512	6.42
February	0.997	4.512	4.52
March	1.004	4.512	4.50
April	1.086	4.512	4.16
May	0.709	4.512	6.36
June	0.571	3.648	6.39
July	0.848	3.648	4.30
August	1.031	3.648	3.54
September	1.299	3.648	2.81
October	1.188	3.648	3.07
November	0.859	4.512	5.25
December	0.643	4.512	7.02

These margin of safety projections are based on the current DPH worksheet for calculation of available water and margin of safety, as modified in the *Water Supply Plan* for monthly use. The methodology on the DPH worksheet for calculating peak day margin of safety differs greatly from historical DPH guidance. Nevertheless, UConn's margin of safety (with all sources operating normally) is adequate as presented in Section 7.0 of the 2020 *Water Supply Plan*.

2.0 DEMAND MANAGEMENT

Demand management serves as a means of improving efficiency of water use and reducing waste. Water conservation measures involving demand are generally based on providing incentives and technical assistance for customers or end users to reduce water use.

2.1 Summary of Recent Demand Management

The last two decades have seen a significant increase in water conservation by UConn. The UConn 2000, NextGen, and other building programs have resulted in the installation of water-saving fixtures in new UConn buildings and renovations. For example, high-efficiency front loading washing machines have been used throughout campus for more than 10 years. The new washers use 15 to 18 gallons per load compared to the 30 to 32 gallons per load used by top loading machines, saving an estimated 2.6 million gallons of water annually. Furthermore, new State buildings must be constructed to the LEED Silver certification at the very least. This will continue to encourage installation of efficient fixtures and appliances.

In 2006, the University commissioned a water conservation audit by the firm Water Management, Inc. of Virginia. The study report entitled "Water Conservation Opportunities" was published the following year and recommended a number of methods for reducing water consumption. A copy is attached as Appendix A. The report addresses the following sectors of water use and potential savings:

- Domestic Residential;
- Domestic Academic;
- Central Utility Plant;
- Agricultural and Livestock Operations;
- Dining;
- Process Cooling;
- Irrigation;
- Off Main Campus Users; and
- Unaccounted/Miscellaneous such as leakage, water main flushing, etc.

One of the main recommendations of the study was to pursue the construction of the RWF to produce high-quality effluent for use in non-potable facilities such as the CUP. Construction of the RWF was completed in 2013 and the facility was brought online in June 2013. In addition to providing non-potable cooling and process water to the CUP, the RWF provides grey water for toilet flushing in recently constructed campus buildings such as the Innovation Partnership Building (IPB).

Where possible, various UConn departments have instituted water conservation. The University's Poultry Unit switched from continuously running bubbler-drinkers for the chickens to a system of "nipple drinkers" that the chickens utilize when thirsty. It has been estimated that this saves one million gallons of water on an annual basis.

UConn’s infirmary replaced its water-intensive X-ray processor with digital type processors that have no corresponding water use. Estimates are that this change will save 300,000 gallons of water on an annual basis. Future replacement of this facility with a new building (as proposed in the 2015 Campus Master Plan) is expected to result in further water savings.

Irrigation nozzle retrofits at Morrone Field were made to better match nozzle size to delivered water pressure. With the nozzle change-out, distribution uniformity of irrigation spray improved by over 100 % and allowed overall water use to decrease. The recent Athletic District improvements (scheduled for completion in Fall 2020) will utilize synthetic turf which will eliminate the need for irrigation watering (note that some surface cooling water will still be necessary).

Another major ongoing initiative has been the programmatic maintenance and renovations to the aged steam and condensate systems throughout campus. Leakage rates have been reduced with each project resulting in water savings.

Finally, a single-block rate schedule was established in 2006 that replaced the previous declining-block rate for off-campus customers. The new rate structure increased awareness and accountability, and lead to more efficient use of water in recent years prior to the majority of off-campus customers being transferred to CWC.

2.2 Demand Management Goals & Objectives

The following goals and objectives have been incorporated into UConn's demand management strategies to reduce maximum month and peak day demands; these strategies are essentially continuations of prior efforts described above:

- Continue to promote the installation of water-saving fixtures: Older buildings are prone to water leakage and inefficient water use devices. Demolishing or renovating older buildings and their plumbing lowers water demands. The use of water-saving fixtures in new construction associated with the various building programs greatly reduces overall consumption as compared to older, similarly used buildings. Considerable water savings has resulted from the installation of more efficient clothes washing machines and dishwashers on campus, as well as more water efficient research equipment and distribution systems at agricultural facilities.

- Reduce make-up water demands for heating and cooling: The CUP facility has replaced many independent furnaces and facilities throughout campus, resulting in a more energy- and water-efficient system. A similar impact has occurred with the replacement of smaller air-cooling systems into the centralized chiller facility. The recent completion of the RWF has enabled the use of reclaimed water for these non-potable demands, and recent repairs to leaking steam and condensate return lines has resulted in noticeable reductions in potable water use.

- Utilize voluntary conservation measures and mandatory conservation measures when environmental conditions mandate: These measures are triggered based on specific criteria outlined in UConn's 2020 *Wellfield Management Plan*.

- Educate students, staff, and customers with regard to the wise use of water and ways to conserve water outdoors and within the home: Public education constitutes a desirable and necessary component of water conservation programs, and it is a cornerstone of the short-term conservation methods employed in the UConn's *Wellfield Management Plan* to address low streamflows. UConn publishes a "Consumer Confidence Report" for its users each year which contains a segment on water conservation. It encourages all water customers to conserve water and provides suggestions on how best to lower water demands. UConn also maintains a Water Conservation webpage on the Office of Sustainability website[1] that includes frequently asked questions, a Resident Assistant training program to increase awareness, public service announcements on the HuskyVision channel and other signage including "Stop the Drop" signage at sinks, showers, and laundry rooms, and collaboration with student organizations and other administrative departments.

Within these goals, UConn recognizes two important categories of demand-side conservation: (1) methods available each year to guide UConn through the various protocols of the Drought Response Plan, and (2) long-term methods of reducing water usage. These two categories are discussed in the ensuing sections.

2.3 Short-Term Demand Management

Short-term demand-side conservation methods are necessary to respond to the Alert, Advisory, Watch, Warning, and Emergency stages of the low-flow operation procedures included in the *Wellfield Management Plan*. The methods of conservation employed to navigate through the various stages are considered short-term because they can be ceased or relaxed when streamflows recover to higher levels each fall or winter. Short-term conservation was necessary most recently in 2007, 2010, 2014, 2015, 2016, and 2017.

Some short-term methods of conservation are akin to the long-term methods discussed later in this plan, such as increased control on the outdoor use of water for irrigation and washing vehicles. However, some are quite unique and are only meant to be used for short-term responses, such as the use of paper plates in dining halls. The following is a list of the voluntary and mandatory short-term conservation methods used during dry periods:

Voluntary Water Conservation Measures

- Reduce use by taking shorter showers and condensing washing of dishes and laundry into full loads;
- Be more conscious of use by not letting water run to warm up or cool down, and not letting faucets run while brushing teeth, shaving, etc.;
- Avoid power washing buildings and washing vehicles with public water;
- Eliminate non-essential consumption of water (lawn watering, garden watering at night only, car washing)
- Raise air conditioning thermostats for centrally chilled buildings to 75 degrees, particularly when leaving at night; and
- Immediately report leaky fixtures in UConn buildings to Facilities Operations.

Mandatory Water Conservation Measures

- No routine maintenance flushing of hydrants, pipes and sewer lines allowed, and will only be performed to address water quality issues;
- No fleet vehicle washing allowed, and the vehicle wash bay is closed;
- Lawn watering is limited to four hours or less per day, and only between the hours of 5 am and 9 am and 7 pm to 9 pm. Athletic fields are allowed up to two hours of water per day during the same hours;
- Curtail running of lasers, autoclaves and other research lab devices that consume water for once-through cooling;

[1] https://ecohusky.uconn.edu/water-conservation/

- No use of UConn water for construction site dust control or rinsing activities, with contractors required to provide dust control water from off-site;
- No use of UConn water for washing and wetting down streets, sidewalks, driveways, or parking areas unless requested by the local public health authority;
- No water use by ornamental or display fountains;
- The use of hydrant sprinkler caps is banned;
- No pool filling using UConn water; and
- Thermostats set to 78 degrees for centrally cooled buildings.

2.4 Long-Term Demand Management

2.4.1 Controlling Growth in Water Consumption

In water supply systems where supplies are limited or deficient, aggressive water conservation that limits or prohibits growth in water consumption is sometimes instituted as a water saving measure. This option has been utilized by UConn. Indeed, UConn previously elected in its 2011 *Water Supply Plan* to focus on providing water to only four committed demands: North Campus, Depot Campus, Storrs Center, and King Hill Road. Once the CWC interconnection was installed in 2016, UConn transferred nearly all of its former off-campus customers to CWC and no longer needs to make water service commitments as was done in the past. Off-campus areas in the Town of Mansfield that require public water service will be provided with such service by CWC or other entities and not by UConn..

UConn's relationship with its water system inherently promotes water conservation relative to growth concerns. UConn does not need to rely on the sale of water to remain in business and cover all expenses. Thus, it does not need to be concerned with increasing the amount of water produced and distributed in order to generate an increase in water sales and revenues. Instead, UConn only needs to produce enough water to serve itself and its few remaining off-campus customers (<1% of demand as shown in Table 1-1). UConn will continue to aggressively promote water conservation activities in order to ensure that sufficient supplies are available to accommodate planned campus growth.

2.4.2 Water Pricing

Pricing has been used as a water conservation practice by a number of utilities throughout the country. Water pricing strategies may be effective in reducing peak demands due to outdoor or seasonal uses. It may also be effective in reducing long term average demands. The three typical fee structures for water supply are inclining block structure, uniform structure, and declining block structure. These are described below:

Inclining Block Structure

Under an inclining block pricing structure, water becomes more expensive as consumption increases. Inclining or increasing block rates assume that heavy users are responsible for increasing the need for expansion of a system and should therefore pay a higher unit price. Therefore, under this system, the unit price increases as the user enters increasing volume blocks. This structure will tend to promote conservation if rates are high enough in the higher price blocks.

Uniform Rate Structure

Uniform rates assume that every unit of water is of equal value. Thus, the unit price of water is constant so that the more water you use, the more you pay. Conservation may be promoted with this rate structure, although not necessarily to the degree of the inclining structure.

Declining Block Structure

Declining or decreasing block rates were developed under the assumption that the first water used is more expensive to deliver than successive units. Water is priced in blocks of consumption with a decrease in unit price as the user enters a larger consumption block. Consequently, if enough water is consumed such that the customer enters a higher block, the unit price of water will decrease. This structure is not believed to encourage conservation practices.

UConn Rate Structure

UConn does not bill any on-campus users for water, but historically utilized a declining block structure for off-campus commercial customers and a flat rate for unmetered residential customers. This policy did not encourage conservation. A uniform rate structure was adopted for commercial and metered residential customers in 2006 as shown in Table 2-1. The change was made in part to encourage conservation. The uniform rate structure continues to apply to the few remaining off-campus customers connected to the system.

Table 2-1
Summary of Water Rates

Year	Residential	Commercial		
	Single-Family Unmetered	*First 1,200 cf*	*Next 10,000 cf*	*Over 11,200 cf*
1985-1986	$25.00	$25.00	$1.50/hcf	$1.00/hcf
1987-1988	$150.00	$25.00	$1.50/hcf	$1.00/hcf
1989	$160.00	$50.00	$1.75/hcf	$1.35/hcf
1990	$176.00	$55.00	$1.93/hcf	$1.48/hcf
1991	$185.00	$60.00	$2.03/hcf	$1.56/hcf
1992-1993	$185.00	$60.00	$2.03/hcf	$1.56/hcf
1994	$195.00	$63.00	$2.13/hcf	$1.64/hcf
1995	$225.00	$72.00	$2.45/hcf	$1.89/hcf
1996-1998	$270.00	$108.00	$2.54/hcf	$2.03/hcf
1999-2003	$300.00	$108.00	$2.54/hcf	$2.03/hcf
2003-2006	$315.00	$113.00	$2.54/hcf	$2.03/hcf
2006-Present	$340.00	$3.05/hcf		

The UConn water system is funded through operating and capital funds. Operating funds are taken from the Facilities Operations budget which is generated from tuition. Capital funds include funding from the "UConn 2000", "21st Century UConn", and “NextGen” programs for particular water-related projects. The UConn water system is also minimally funded by water revenues from its off-campus customers.

On-campus meters are recorded continuously and reviewed on a daily basis, while off-campus meters are read quarterly. The basic service fee for off-campus customers ($100 per year) covers meter reading, billing expenses, and related administrative costs related to overseeing the customer metering program. Monthly meter reading of on-campus users serves an important function with regard to water conservation, as detection of sudden increases in water use can be indicative of leakage and can be corrected quickly.

UConn recognizes that its current rate structure is still not optimized to encourage maximum conservation. An inclining rate structure may be considered in the future if necessary to reduce wasteful consumption. However, given that off-campus customers now represent a minimal percentage of overall demand, such a change in the rate structure would be of negligible value and is unlikely to occur.

2.4.3 Local Regulations and Ordinances

As the controller of its own water system, UConn does not face the same problems faced by municipal water departments or private water companies that struggle with identifying methods of regulating and enforcing conservation. For example, if vehicle washing is prohibited by UConn administration, then vehicle washing does not occur.

UConn is committed to ensuring that water conservation is an important component of all projects. UConn's Design Guidelines and Performance Standards (DGPS) must be adhered to by designers that are hired by UConn for all new buildings and major renovations of existing buildings. The DGPS documents are available on the University Planning Design and Construction (UPDC) webpage under the Contractors and Consultants tab. UPDC oversees all major construction and renovation projects and enforces the DGPS requirements by detailed review and approval of design drawings and specifications prior to construction. The DGPS require the use of water efficient fixtures in new buildings and renovations as part of its overall goal of meeting LEED Silver design standards, at a minimum, as part of all projects. UPDC staff and UConn construction managers conduct oversight of all new building projects and major renovations throughout the design and construction process to ensure water conservation measures are being employed. By utilizing the DGPS and the environmental sustainability framework mandated by UPDC, newly constructed and renovated buildings are more efficient in water use.

Water conservation is monitored by the UConn Office of Sustainability (formerly the Office of Environmental Policy prior to 2020) and steady decreases in water demand have been seen since 2011. The Office of Environmental Policy 2018 annual report indicates average daily potable water use per campus user has decreased some 51% since 2005. Recent demand data indicates a reduction in ADD for potable water from some 1.29 mgd in 2011, to approximately 1.19 mgd in 2015 (prior to the CWC Interconnection), and to approximately 0.72 mgd in 2019.

Decreases in demand overall, and on a per user basis, can be attributed in large part to water conservation and building efficiency measures instituted by UConn, as noted above. Recent decreases in demand between 2015 and 2017 are also likely due to increased efficiency and conservation but are significantly enhanced by the disconnection of Town and other private properties from the UConn water system since the CWC Interconnection. The water efficiency of new and renovated buildings is highlighted by the fact that student enrollment has increased by some 2,500 students from 2011 to 2017, yet overall water usage declined during this period.

2.4.4 Water Use Audits

Water use audits are a form of technical assistance that can be offered to users. To be effective, there must be a collaborative goal between system operators and end users towards conserving water. Potential recommendations of a water use audit might include recycling, reuse, process changes, replacement or retrofitting, and other efficiency measures. Typically, the audit evaluates areas in which peak demands can be reduced and estimates the amount of the reductions. Leak detection services may also be offered by the water utility and a written report may be provided that summarizes projected water savings, implementation cost estimates, and payback period estimates.

Major water users have been identified for the UConn water supply system. These are summarized in Table 2-2 and include the 20 buildings (or groups of buildings) with the greatest volume of water use.

TABLE 2-2
Major Water Users

Name	Type or Use	Typical Usage, 2011-2019 gpd	Per-Capita or Per-Unit Demand	Water Conservation Potential
Central Utility Plant (Potable)	Utility	119,000	N/A	Low
RWF Potable Water Usage	Utility	87,900	N/A	Low
Pharmacy / Biology Building	Academic / Research	54,200	N/A	Moderate
North Campus	Residential / Dining	67,900	51.5	High
McMahon Hall	Residential / Dining	34,200	56.8	High
Hilltop Apartments	Residential	34,000	31.6	Moderate
Towers Quadrangle	Residential / Dining	28,200	30.1	Moderate
Alumni Quadrangle	Residential	22,700	23.5	Low
Northwest Quadrangle	Residential / Dining	22,000	21.5	Low
Charter Oak Apartments	Residential	21,700	35.0	Moderate
East Campus	Residential / Dining	20,900	37.2	Moderate
Hilltop (Ellsworth, Hale, Putnam)	Residential / Dining	20,000	35.7	Moderate
South Campus	Residential / Dining	18,900	28.8	Low
Burton Football & Shenkman	Athletics	18,400	N/A	Moderate
Institute of Materials Science	Academic / Research	17,500	N/A	Low
Physics Gant Complex	Academic / Research	16,500	N/A	Low
Busby Suites	Residential	16,000	32.6	Moderate
Student Union	Other / Dining	16,000	N/A	Low
Buckley Hall	Residential / Dining	15,700	40.3	Moderate
Garrigus Suites	Residential	15,500	32.4	Low

The highest volume "user," the CUP, represents approximately 16% of the UConn's 2019 average daily demand. The second and third largest "users", the RWF and the Pharmacy / Biology building, represent 12% and 7% of average daily demand, respectively. The CUP water uses have a lower potential for water conservation than identified previously due to the water conservation achieved by the RWF project and the repair and replacement of steam and condensate return lines.

Due to a few recent renovations and the prevalence of recent construction projects in Table 2-2, many of the top 20 users have limited potential for additional water conservation measures. However, older buildings on campus that have had limited or no recent renovations represent a greater potential for water conservation. In particular, East Campus and North Campus include buildings that are greater than 50 years old, and therefore renovations to these structures would provide a higher potential for water conservation.

UConn will consider providing water audit services to any of its major users in the future if necessary. The following components will be considered for incorporation in the audit program:

- Identifying, for each major user, the categories of water use including process, sanitary, domestic, heating, cooling, and outdoor uses.
- Identifying areas in which overall efficiency of water use can be improved and providing an estimate of water savings if improvements are made. Consideration will be given to recycling, reuse, process changes, replacement or retrofit, and other efficiency measures.
- Identifying areas in which peak demands can be reduced and estimating of the amount of demand reductions.
- Leak detection services along service laterals and within buildings.
- Installing retrofit kits in certain applicable buildings (see next section).
- Submittal of written reports to identified major users with recommendations, projected water savings, and implementation cost estimates.

When audits are conducted, water booklets available through the DEEP will be consulted. Additional copies of the State Guidelines for Industrial and Commercial Water Users and the appropriate DEEP water audit booklet will be made available to the major water users during the course of an audit. Each major user will be encouraged to develop its own water conservation plan.

It should be noted that the 2007 water conservation study completed by Water Management, Inc. included cursory audits of many facilities of interest. While some aspects of the report are out of date, the report (Appendix A) may be used as a starting point to conduct individual audits of older buildings present in 2006 that have not yet been upgraded with new water fixtures.

2.4.5 Retrofit Program

Public Act 89-266, An Act Establishing a Residential Water Saving Program, was passed in Connecticut in 1989. The act required each public water supply company serving 1,000 or more persons or 250 or more consumers to make available to all residential consumers, without charge, a residential retrofit kit. By January 15, 1991, and annually thereafter for a three-year period, each non-priority (i.e. non-deficit) public water supplier was required to send a notice to each residential consumer, informing them of the availability of the water saving devices.

Residential retrofitting either replaces or modifies existing toilets, showers, and faucets to reduce water use. Retrofitted plumbing fixtures use less water than original non-conserving fixtures and, once in place, the retrofit devices require no conscious effort on the part of the user to save water.

Retrofitting is accomplished by providing households with a kit that generally consists of a low flow shower head, two faucet aerators (one for the kitchen and one for the bathroom), a pair of toilet tank flush dams, toilet leak detection tablets, installation instructions, and other water conservation literature. The shower heads and faucet aerators are high quality chrome-plated brass and meet State plumbing fixture efficiency standards. By law, up to two kits per dwelling unit were to be provided free of charge upon request.

As UConn previously had less than 250 off-campus residential connections, it is unlikely that it participated in the residential retrofit program. However, the kits could also potentially help with certain smaller on-campus buildings and UConn-owned rental properties. UConn should purchase a small supply of retrofit kits each year for distribution and installation. The availability of the kits should be noted in the annual Consumer Confidence Report.

2.4.6 Public Education Program

Public education constitutes a desirable and necessary component in water conservation programs, and as discussed previously it is a cornerstone of the short-term conservation methods employed to address low streamflow conditions. From a broader perspective, UConn complies with Connecticut General Statute Section 25-32(k) and 25-32(l) that requires each water company to annually provide residential customers, without charge, educational materials or information on water conservation.

UConn also desires for a component of public education to address and encourage long-term water conservation. The challenge will be to generate and sustain an interest for long-term conservation techniques when the majority of UConn's users, including Resident Assistants who assist with dissemination of water conservation materials and guidance, are only typically present for four years. Furthermore, users have become accustomed to reminders to conserve water whenever the Fenton River and/or Willimantic River triggers are reached.

The key to providing education of this nature continues to be to target the longer-term work force that are served by the water system, namely UConn's permanent employees, to serve as leadership and to set an example for conservation behavior. This will ensure that UConn's water conservation messaging (such as through the Office of Sustainability) will be better realized by the more temporary student population. The Implementation Table in Section 4.0 includes a line item for continuing UConn's program of long-term public education subsequent to submittal of this plan.

2.5 Anticipated Water Savings

It can be difficult to calculate or project anticipated savings in water as a result of the above described programs, since actual savings will be heavily dependent upon user participation that is almost impossible to predict. Actual savings can be tracked by means of the periodic water system evaluations and examination of annual production and consumption numbers.

Short-Term Conservation Efforts

As an example of short-term conservation measures, the operational recommendations of the 2011 *Wellfield Management Plan* were put into effect in the late summer of 2016, when drought conditions were experienced at the Storrs Campus. The Fenton River Wellfield was taken offline on June 23, 2016 in response to low flows in the Fenton River, leaving the Willimantic River Wellfield as UConn's sole source of supply. Similar to 2010, UConn had no problems with storage or with wellfield hydraulics in 2016, and again environmental triggers overrode the operational triggers.

UConn notified customers of a *Stage IA - Water Conservation Alert* by letter dated June 28, 2016 and requested that system users voluntarily limit their water use. This action, triggered by the onset of seasonally low surface water flows in both the Fenton and Willimantic Rivers, was consistent with the 2011 *Wellfield Management Plan*. The following water conservation measures were suggested:

- Taking short showers.
- Running dishwashers and clothes washing machines with full loads.
- Shutting off water while washing dishes, shaving, brushing teeth, and lathering up to wash hands, rather than running the water continuously.
- Avoiding vehicle washing or power-washing homes and other buildings.
- Not using water to clean sidewalks, driveways, and roads.
- Reducing, to the extent possible, the water of lawns, recreational and athletic fields, gardens, or other landscaped areas (if watering is essential, late-evening hours are best).
- Not using public water to fill residential swimming pools.

On August 29, 2016, UConn issued a *Stage IB - Water Supply Advisory*, reminding users of the need to conserve water and repeated the request that system users voluntarily limit their water use using the same methods described in the Stage IA letter.

On September 1, 2016, UConn issued a *Stage II - Water Supply Watch* that included mandatory and voluntary water conservation measures. The Stage II notification was issued when flows in the Willimantic River hit triggers established in the Willimantic River Study. Voluntary conservation measures that were requested included:

- Take shorter showers.
- Run dishwashers and washing machines with full loads.
- Use water only as needed when washing dishes, shaving, and brushing teeth.
- Avoid power washing buildings and washing vehicles with public water.
- Raise the thermostat in UConn buildings, particularly when leaving at night.
- Immediately report leaky fixtures in UConn buildings to Facilities Operations (486-3113)

Also, UConn implemented certain mandatory conservation restrictions including:

- Lawn watering for all users is limited to four hours or less per day and only between the hours of 5 a.m. to 9 a.m. and 7 p.m. to 9 p.m. Athletic fields will be allowed up two hours of water per day during the same hours.
- Filling of public or private pools must be provided via water delivered from another source.
- Washing of motor vehicles is banned. The UConn's wash bay will be closed until further notice.
- The use of ornamental or display fountains is banned.
- The use of water for washing and wetting down streets, sidewalks, driveways, or parking areas is banned unless required by the local public health authority.
- The use of UConn water for dust control at construction sites is banned. Contractors are required to provide water for dust control from off-site.
- The use of hydrant sprinkler caps is banned.
- Water main flushing will only be used to address water quality issues.

On September 7, 2016, UConn issued a *Stage III - Water Supply Watch* as flows in the Willimantic River continued to recede and hit persistent low-flow triggers established in the Willimantic River Study. The Stage III request reinforced the need to conserve water and reiterated those voluntary and mandatory restrictions identified during the prior Phase II advisory communication.

On September 15, 2016 UConn issued a *Stage IV - Water Supply Emergency* due to the continued decrease in flows at the Willimantic River. The mandatory and voluntary water conservation measures outlined in the Stage III notification were repeated in the Stage IV notification.

The *Stage IV - Water Supply Emergency* restrictions were lifted in November 2016, but a letter issued November 17, 2016 indicated Stage III mandatory and voluntary conservation measures would remain in effect. On December 21, 2016, a letter was issued rescinding Stage III and II restrictions but noting that the Storrs Campus remained in a Stage IA condition and voluntary water conservation measures were still necessary. Residents and businesses in the community were requested to continue to conserve water by reducing demand by 15%. Finally, on March 3, 2017, flows in the Willimantic River were such that the Stage IA alert was rescinded, but UConn noted Tolland County was still under a Drought Watch issued by the State of Connecticut, and residents and businesses were asked to continue water conservation measures that would reduce their use by some 15%.

System production in August 2016, up to August 29, was 0.92 mgd, which was slightly higher than the production in July 2016 (0.86 mgd), and consistent with production levels in 2015 (0.96 mgd) and 2014 (1.05 mgd). In spite of this slight increase, the 2016 figures compare favorably with prior years. While it is difficult to quantify the impact conservation measures had on water usage in 2016, the data suggest that UConn's conservation efforts reduced water consumption below what would otherwise be expected for similar conditions.

<u>Long-Term Conservation Efforts</u>

UConn has experienced growth in its on-campus uses in the last decade through the UConn 2000, 21st Century UConn, and NextGen initiatives. During this time, average daily production steadily decreased from 1.49 mgd in 2005 to 1.26 mgd in 2012. The maximum month average day demand (typically September) also decreased over those years from 1.95 mgd in 2005 to 1.53 mgd in 2012. The trends demonstrate that long-term conservation efforts have resulted in overall water savings. These efforts have included leak detection surveys and repairs, installation of more efficient fixtures in new construction and renovations, and continued metering and charging for actual water usage.

The RWF came online in 2013 and resulted in the demand for potable water at the CUP to be reduced by half. Demands in 2014 (the first full year of RWF use) averaged 1.16 mgd, down 0.10 mgd from 2012. With the construction of the CWC interconnection in 2016, the majority of off-campus users were transferred to CWC. The result of this was that demands in 2017 were much lower (0.88 mgd) than seen previously. The past two full years have continued to see decreasing trends in water use (0.75 mgd in 2018 and 0.72 mgd in 2019).

UConn will continue to track how average day production and average monthly production figures change from year to year. This will help evaluate whether future conservation efforts are having their intended effects even as seasonal conditions vary from year to year. At the same time, metering of all new connections from this point forward will provide vital information about how much water is being used.

3.0 SUPPLY MANAGEMENT

Supply management is aimed at reducing losses of water and increasing system efficiencies. In many systems, supply management practices are generally considered preferable to demand management practices because they are not dependent upon the cooperation of users. However, UConn has had significant success with both methods of management.

3.1 Summary of Recent Supply Management

As of 2007, only half of the University's facilities were metered to record water consumption. The Board of Trustees authorized $2.4 million to continue metering to the point that the majority of water using facilities were metered. A similar goal was set for off-campus users, and the majority of users were metered by 2010.

Source meters have also been upgraded. New meters were installed at the Fenton River wells approximately 10 years ago. All source meters are regularly evaluated and calibrated to ensure that withdrawals are accurately tracked. New England Water Utility Services (NEWUS) conducted the most recent formal calibration of the production well meters in January 2019 (see Appendix L of the 2020 *Water Supply Plan*). All meters that were tested that were not within approved limits were recalibrated. Note that the meter for Willimantic Well #1 is scheduled to be replaced in June 2020.

In an effort to reduce overproduction and water waste, automated pump and tank controls with alarms were installed in 2006 and 2007. By controlling well operation based on tank water levels, the wells now run only in response to system demand and tank overflows no longer occur. Tank levels are tracked electronically from the Facilities Operations office.

Beginning in 2005, leak detection surveys have been scheduled to take place every two years. The most recent leak detection survey was completed in 2019, and the report is included as Appendix K to the 2020 *Water Supply Plan*.

It is noteworthy that UConn not only owns and controls the operation of its water sources, but also owns and controls a considerable portion of its distribution system as well as pipes that would otherwise be considered laterals in many other water systems. Therefore, UConn is in a strong position to make physical changes to the transmission and distribution systems in order to optimize water use and reduce loss. For example, a new fire loop system installed from 1997 through 2002 allowed for the abandonment of the older fire protection system that was prone to leaks, and the 16-inch transmission main from the Willimantic River Wellfield to the Main Campus was replaced in 2015-2017, and the 20-inch transmission main from the W-Lot reservoir to the Towers storage tanks was replaced in 2016-2017 to reduce leakage and waste.

3.2 Supply Management Goals and Objectives

Although UConn recognizes two categories of demand-side conservation, a logical division is neither appropriate nor recognized for supply management techniques. The following goals and objectives have been incorporated into UConn's supply management strategy to reduce demands:

- Continued metering of sources of supply.
- Continuation of the ongoing metering program to meter some of the remaining on-campus users that are not currently metered.

- Conducting an ongoing program of meter calibration, testing, and repair of source meters and major facilities meters.
- Conducting ongoing evaluations of the transmission and distribution systems to determine the extent and causes of leakage or unauthorized use.
- Continued monitoring of pressure and periodic evaluation of the appropriateness of pressure reduction.
- Leak detection surveys conducted every two years.

3.3 Meter Management

Sources of supply at the Fenton River Wellfield and the Willimantic River Wellfield are presently metered prior to distribution in compliance with Section 19-13-B102(n) of the Public Health Code. Meters are read and recorded on a daily basis. Routine calibrations are performed on all source meters as needed but not less than once every year.

An active repair/replacement program is currently in place for service connection meters in the service area, with a budget allowance that is allocated each year. The PURA guidelines are used by UConn with regard to meter testing and replacement schedule.

The document "The University of Connecticut Water System – Rules and Regulations" (Appendix N of the 2020 *Water Supply Plan*) discusses the service protocols that have been in place since October 2006 with regard to metering. Each new service connection is required to be separately metered. In general, UConn meters its customers in the following ways, although there are many exceptions due to the variety of water users:

- On-campus residential: Each building in a complex is individually metered, with a few exceptions. Some complexes may have additional meters to separate flow at dining facilities from residential use.
- On-campus non-residential: Each building is individually metered, with a few exceptions where groups of buildings sharing a common service lateral share a meter.
- Off-campus users: Single family and multi-family residential structures have one meter per structure. Other building types have one meter.

An annual budget has been allocated in the improvement schedules for water meter testing, calibration, repair, and replacement. Identification of faulty meters or unmetered connections will be largely monitored by the meter reader staff, as is currently done.

Although only approximately 55% of all campus buildings are presently metered, approximately 86% of water production is currently metered as consumption. Unmetered uses include various on campus non-residential buildings, a few off-campus customers, unauthorized water use, frost bleeders, firefighting, street cleaning, tank cleaning, and water line flushing.

Many of the low water use campus buildings remain unmetered, with a higher number in the Depot Campus as compared to the Main Campus. However, only a few large buildings remain that are not metered, and these are suspected to have low water usage consisting only of sanitation needs. It will not be cost-effective for UConn to provide 100% metering for all buildings, especially in the Depot Campus area where water usage is negligible in several of the underutilized buildings. Nevertheless, UConn wishes to continue accurately characterizing unaccounted-for water to the extent possible. The following plan is proposed for continuation of the metering program:

- Buildings that will be demolished in the near future will not be metered.
- When buildings are constructed, refurbished, or renovated, they will be fitted with a meter.
- Where several buildings are grouped together and share a common water main, there may be opportunities for installing a common meter. The meter would then record consumption for the group of buildings.

UConn's long-term goal is to continue to meter a minimum of 85% of production. This will allow UConn to ensure that unaccounted-for water use remains below 15% of production.

3.4 Water System Evaluation

Typically, "non-revenue water" is the difference between total water produced at the source and metered water consumption. Some of the traditional non-revenue uses include tank flushing, main flushing and blow-offs, firefighting, main breaks, and unauthorized water use; and these do occur throughout the UConn water system. However, UConn is not a traditional revenue-producing entity, so the term is a misnomer in this context. While UConn produces some water that results in the collection of "revenue," the majority of its water production is to provide itself with water. Therefore, a better term for discussing the non-metered consumption is simply "non-metered" water.

Unaccounted-for water is the result of conditions such as leaks, unauthorized water use (i.e., use of non-metered recreation, tank filling, etc.), frost bleeders, firefighting, street cleaning, and inaccurate meters. Improvement programs and water conservation measures are targeted at reducing and then maintaining the percentage of unaccounted-for water to below 15%. UConn has attempted to minimize unaccounted-for water by installing temporary meters for as many of these types of uses as possible.

UConn has attempted to calculate non-metered water usage as a result of its ongoing intensive metering program. Thus, the average daily metered water demand from 2007-2009 was approximately equal to 85% of average daily production over that same time frame, and average daily metered water demand from 2018-2019 was approximately equal to 86% of production over that period. The metering data from these periods confirm that approximately 14-15% of UConn's produced water is a combination of (1) distributed water that is consumed by unmetered uses, and (2) transmitted/distributed water that is truly unaccounted-for or lost. Thus, it is believed that UConn's true "unaccounted-for water" amounts to much less than 15% of total production. The continuation of the metering program will allow UConn to continue to assess of unaccounted-for water in this manner in future water supply plans.

Water system evaluations are conducted on an annual basis to track trends of water usage. Future water system evaluations will be able to track unaccounted-for water more precisely as buildings are renovated, water mains are repaired, and metering increased. Estimates of the amount, location, and use of water will be made in conjunction with the annual evaluation. If usage trends indicate that goals will not be met, the following options will be examined:

- Working with appropriate personnel to establish water use logs;
- Installation of taps for in-line meter testing in all services over three inches;
- Establishment of a more rigorous replacement program for older water mains;
- Flagging water uses above or below the normal range for the water user or the user type;
- Locking or removal of meters not in use; and
- Conducting additional leak detection surveys.

3.5 Leak Detection and Repair

Like all water supply systems, it is anticipated that UConn's transmission and distribution systems lose some water due to leaks. Water that is leaked through the transmission and distribution system causes the water supply sources to be drawn upon in an equivalent incremental amount. Repair of leaks can recover the costs of obtaining, treating, and pumping wasted water. Maintenance carried out due to leak detection and repair programs can also avert major problems and property damage.

UConn conducted leak detection surveys at the former Mansfield Training School and corrected deficiencies in 1991 and 1993. In 1996, UConn contracted a firm to conduct a leak detection survey at the Depot Campus and at problem areas associated with the main campus. Noted deficiencies were repaired. A leak detection survey performed between November 1 and December 30, 2005 located four leaks in the UConn water distribution system totaling 11 gpm (15,840 gallons per day) of water loss. Those leaks were repaired.

NEWUS currently conducts leak detection surveys every five years, targeting specific areas of the system. This is consistent with the schedule required by the water diversion permit for the CWC interconnection. The most recent leak detection survey was conducted from August 23, 2016 through September 1, 2016. The survey found that 6 hydrants were not completely closed. They hydrants were closed and resurveyed. A copy of the most recent leak detection report is included in Appendix K of the 2020 *Water Supply Plan*.

Major water main breaks do sometimes occur, and they are repaired immediately. In July 2010, approximately 40 linear feet of the Willimantic River Wellfield transmission pipeline to the Main Campus ruptured north of the prison in the Depot Campus and was repaired. The entire 16-inch transmission main was subsequently replaced. Recent leaks and repairs include the following:

- July 2017 and October 2017 – connection to Lakeside Building on North Eagleville Road.
- December 2017 – 6-inch cast iron main near White Building (East Campus); 8-inch fire main near North Campus Residence Halls; 4-inch cast iron main near Tasker Admissions Building; 6-inch main near Jorgensen Auditorium, 1-inch main near West Campus / Hillside Road; main and service connection to Lakeside Building.
- January 2018 – main on North Eagleville Road
- January 2020 – 8-inch cast iron main near Student Recreation Center; 4-inch cast iron main on Fairfield Way; 12-inch diameter main near Fine Arts Building.

To help prevent future breaks and leakage, UConn retained BVH and CDM Smith to update the mapping of the Main Campus distribution system in 2019. This project is ongoing, and when completed will provide an updated summary of pipe lengths, sizes, and conditions. This information will inform UConn's water main cleaning, relining, and replacement program for underground infrastructure over the next several years. This program will be informed as needed by the system hydraulic model developed by CDM Smith in 2016.

3.6 Pressure Reduction

System pressures fluctuate with the time of day, as would be expected. Maximum pressures generally occur at night when demand is low. Minimum system pressures typically occur during the peak demand periods, between 6:00 a.m. and 8:00 a.m. and between 6:00 p.m. and 8:00 p.m. Industry standards recommend pressures in the range of 35 psi to 125 psi.

According to hydraulic modeling completed in 2016 by CDM Smith, the majority of the distribution system on the Main Campus experiences pressures in the range of 29 psi to 170 psi, with approximately 80% of the service area having pressures between 35 psi and 100 psi. Areas of the highest pressure occur at each wellfield. The fire protection system has static pressures ranging from 130 to 180 psi. The Towers Loop pressure zone is operated at a range of 120 psi to 160 psi, with pressure averaging 140 psi in order to maintain appropriate pressure on the discharge side of the booster station. Areas of low pressure (below 35 psi) occur in less than 1% of the service area and occur directly around the Towers standpipes and along Route 195 near Horsebarn Hill Road and Tower Loop Road due to higher elevations in these areas. Although the Depot Campus was not analyzed by CDM Smith, pressures in the Depot Campus service zone typically range from 30 psi to 85 psi.

Based on the current pressure ranges, pressure reduction may be a feasible means of reducing some water loss through leakage and/or unintentional waste at fixtures that run wide open. While the installation of pressure reducing devices has been considered as a way to reduce demands, an overall reduction of system pressure in the UConn's water system is not considered to be practical due to system configuration and hydraulic limitations. Pressure is regulated from water levels in the storage tanks. Lowering tank levels to lower system pressure would be contrary to the goal of maintaining as much water in storage as possible to help sustain system demands and fire flows when the wellfields are taxed or otherwise limited due to instream flow concerns.

At the current time, pressure reduction is not a high priority relative to the other means of supply management and demand management described in this plan. This will be periodically reevaluated in the future.

4.0 WATER CONSERVATION PLAN IMPLEMENTATION

The first step in implementing a sound water conservation plan is to educate those individuals affected by the policies and practices developed in it. Therefore, copies of this Plan will be disseminated to all UConn divisions that make decisions affecting water consumption, such as Facilities, Residence Life, Athletics, etc., as well as departments with buildings on the Top 20 Users list.

Implementation budgets and schedules for ongoing and future water conservation efforts are presented in Section 7.3 of the *Water Supply Plan*. Table 4-1 reprints those planned efforts herein.

TABLE 4-1
Water Conservation Plan Implementation Schedule

Item	Estimated Cost	When	Funding Source
Conduct additional leak detection surveys	$5,000	Every 2 Years	OB*
Repair leaking services as needed	$2,500 ea.	As needed	OB*
Long-term public education program	$0	Annually	OB
Residential retrofit program	$1,000	Annually	OB
Meter testing, calibration, repair, and replacement program.	$50,000/yr.	Ongoing	OB*
Continue metering of service connections and groups of buildings	TBD	2020	CI*
Conduct water audits of major users as needed	$0	As needed	OB*
Continue to conduct monthly (or more frequent) evaluations of water savings during dry years when following the Drought Response Plan.	$0	As needed	OB*
Annual water audit	$0	Annually	OB*
Evaluate the need for pressure reduction for conservation.	$0	As needed	OB

Notes: Cost estimates are for planning purposes only; costs of $0 will have associated UConn labor costs that are not estimated or may be built into the contract operations fees. Costs of TBD will be included in other capital projects.
* May be completed by the Contract Operator

APPENDIX A

Water Conservation Opportunities, 2007

Water Conservation Opportunities

UCONN

Water Management, Inc.
117 Clermont Ave.
Alexandria, VA 22304
703-370-9070
www.watermgt.com

Amy Vickers & Associates, Inc.
441 West Street, Suite G
Amherst, MA 01002 USA
413-253-1520
www.waterplowpress.com

Resource Wise
6716 Astair Ave NW
Albuquerque, NM 87120
505-259-7102
www.resource-wise.com

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Executive Summary

After several months of survey and analysis, Water Management, Inc. with specialized help from Amy Vickers & Associates, Inc. and Resource Wise has completed the water consumption audit at University of Connecticut's main campus in Storrs. This report presents the results of the detailed analysis of existing water consuming equipment and processes and the anticipated savings opportunities that are available to the University through the application of several water and related energy conservation strategies.

Water use for the University of Connecticut's (UConn) main campus water system is approximately 498 million gallons per year. For the purposes of this report, we have linked the water use at UConn to one of nine categories:

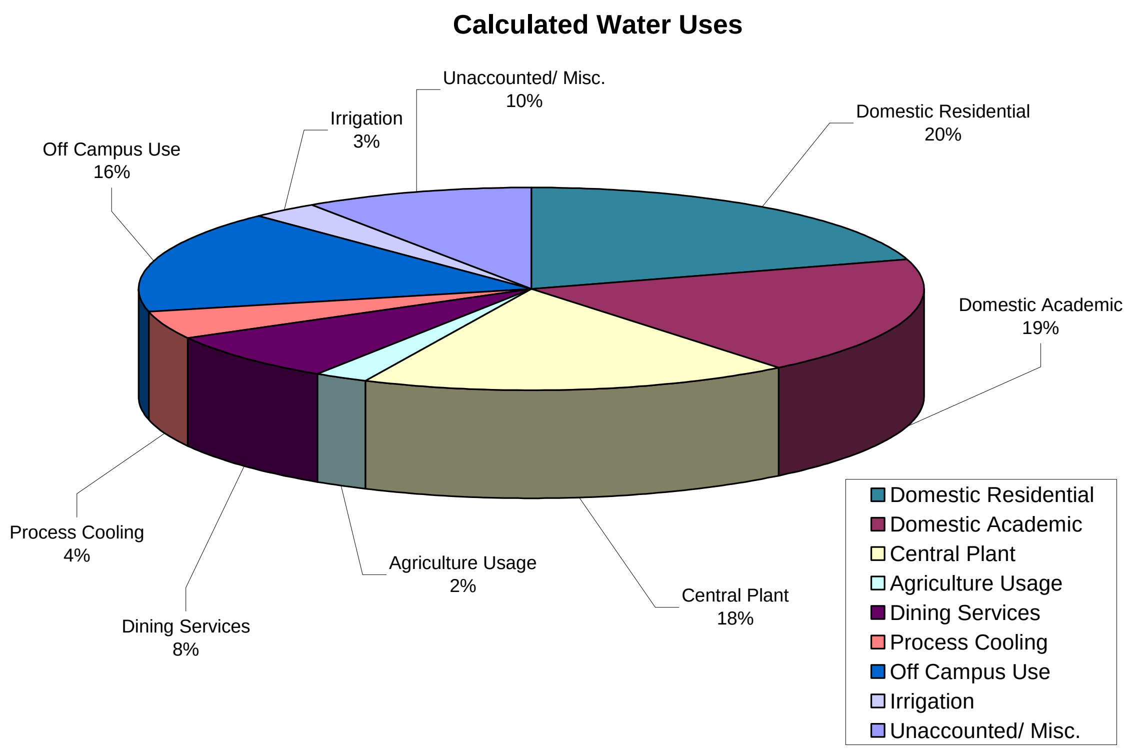


Table 1:

Area		Gallons / year
Domestic Residential	20%	101,237,206
Domestic Academic	19%	94,000,000
Central Plant	18%	87,921,168
Agriculture Usage	2%	12,000,000
Dining Services	8%	38,320,065
Process Cooling	4%	21,500,000
Off Campus Use	16%	81,820,755
Irrigation	3%	13,357,126
Unaccounted/ Misc.	10%	47,696,680
Total	100%	497,853,000

1. **Domestic Use Residential:** On-campus domestic use for the 12,000 students that live in the residence halls relates to toilets, urinals, faucets, showers and laundry. This category of use makes up the largest water use category at UConn. **Total usage for the residential buildings is 101 million gallons per year**, representing 20% of the total water use.

2. **Domestic Use Academic/Non Residential:** Domestic use for the 24,000 students, faculty and other related staff that utilize the campus facilities each day make up the second largest water use category at UConn. **Total domestic usage for the academic and other non residential buildings is 94 million gallons per year**, representing 19% of the total water use.

3. **Central Plant Usage:** The Central Plant uses **88 million gallons of water per year –** 45 million gallons of water for make up to the steam system and 43 million gallons for make up to the cooling towers, representing 18% of the total water use. The central plant provides steam year round to buildings on the main campus.

4. **Agricultural:** Agricultural usage is **estimated to be about 12 million gallons per year**, or 2% of the total water use. This usage does not include the water used for domestic use or the water used for process cooling. The majority of the water used in agriculture is for the care and cleaning of the animals and their respective living spaces. Dairy cows are milked three times per day and the milking area is completely cleaned after each use. Chicken, cattle and swine areas are also cleaned every day as are the cages for the mice and rabbits. Various bottle and cage washers make up the largest users in this category.

5. **Dining:** Dining services use **38 million gallons per year**, or 8% of total water use. There are 8 dining units, 5 retail eateries and 7 café locations on the UConn campus. The water that is accounted for in this category is for food preparation and sanitation and includes equipment such as: garbage disposers, pot washers, tray conveyers, pulpers, pre-rinse spray nozzles and dish machines.

6. **Process Cooling:** Process cooling accounts for **21.5 million gallons of water per year**, or 4% of the total water use. This water use is connected to equipment such as: steamers, sterilizers, lasers, ice makers, heat presses and many other pieces of equipment typically found in either science buildings or dining facilities.

7. **Irrigation:** Approximately **13.3 million gallons of water per year** is applied to 18 acres of turf, including one field with artificial turf. Even though irrigation only accounts for 3% of water used at the University, much of the use occurs during the late summer and early fall – which is the time period when the greatest amount of water is used at the University.

8. **Off Main Campus Use:** The University of Connecticut provides water and sewer services for a variety of residential and commercial consumers in the Town of Mansfield, Connecticut. **Total off-campus water usage is 82 million gallons**, which makes up 16% of the total usage.

Several Mansfield public buildings depend on UConn water and sewer services, including the Mansfield Community Center, Mansfield Town Offices, and E.O. Smith High School. The facilities surrounding the Depot campus (State Department of Corrections, Department of Mental Retardation, and Depot Day Care / Nursery) are also in this category and account for roughly 50% of the off-campus use.

9. **Unaccounted/Miscellaneous:** By completing our overall analysis first, we were able to gain a better understanding of where water is currently being used – the remaining **48 million gallons** is accounted for in this category. This water use category accounts for 10% of the total water usage.

The estimated cost to implement the water conservation measures (WCM's) identified in this report is $3,245,786. If all of the measures recommended in this report are implemented, **the resultant savings will be approximately 167 million gallons per year** (a 34% reduction in water use). If this same level of savings (34%) is generated on the off-campus accounts then an additional savings of 28 million gallons per year will be realized.

Below is a listing of the water conservation measures and their associated savings that are addressed in this report.

Table 2:

Calculated Water Savings						
Water Conservation Measures		**Cost**	**Annual Savings (kgal/year)**	**Annual Savings**		**Simple Payback**
Domestic Upgrades Dormitories		$770,956	38,010	$	114,030	6.8
Domestic Upgrades Academics		$889,000	22,000	$	66,000	13.5
Central Plant		$1,190,000	88,000	$	264,000	4.5
Agricultural	Equipment	$1,350	1,100	$	3,400	0.4
	Scheduling Improvement	$1,000	5,000	$	15,000	0.1
Dining		$261,980	8,600	$	25,800	10.2
Process Cooling		$42,500	1,400	$	4,200	10.1
Soil Based Irrigation Control System		$89,000	3,500	$	10,500	8.5
Total Water Conservation Measures		**$3,245,786**	**167,610**	**$**	**502,930**	**6.5**

* A rate of $3.00 per thousand gallons was used to calculate Simple Payback.

Domestic

The largest water use category at UConn is on-campus domestic use, consuming a total of 195 million gallons in both the Residential Life Buildings and Academic Areas. Based on building data provided by UConn, the total square footage of the Storrs campus is a little over 11 million square feet. The square footage is roughly divided as follows: 5.3 million square feet for the academic buildings, 3 million square feet for the residential buildings, 1 million for the garages and support buildings, 1 million for the Depot campus and the balance for Agriculture buildings and approximately 30 houses on campus.

Domestic water use relates to toilets, urinals, faucets, showers and laundry. The water use for this category is divided almost evenly between the domestic use in the Residential Life buildings and the domestic use in the Academic/Non-Residential buildings.

- **Residential Life buildings (ResLife)**: 12,000 students are housed each year on campus in one of the many residence halls. All of the ResLife complexes on campus (approximately 3.1 million square feet) were surveyed and the University provided per building population statistics and other building use information. Each survey gathered approximate fixture counts with associated flow rates. Based on the information gathered in the survey, **the total calculated water use for domestic usage within the ResLife buildings is 101 million gallons of water per year**.

  When compared to metered data from October 2006 to January 2007, the calculated usage was quite close – the annualized usage for those four months was 114 million gallons. **A savings potential of 37 million gallons per year could be available if the older faucets, showers and toilets in the ResLife buildings are upgraded.**

  Table 3: ResLife Fixture Counts and Annual Savings Potential.

Total Annual Savings in gallons (ResLife)		
Water Conservation Measure	Savings	% of ResLife Usage
Aerators	4,157,618	4%
Showerheads	13,719,474	14%
Toilets	19,899,910	20%
Total of all measures	**37,777,002**	**37%**

  The savings calculations in Table 3 above are based on the following assumptions:

  Days: Students are estimated to be on campus approximately 219 days per year (the 2007 fall schedule will have 111 days from 8/27 to 12/16, and the 2008 spring schedule will have 108 days from 1/22 to 5/10).

  Toilets: Each toilet is flushed approximately 4.8 times per resident, per day (3.8 times per resident, per day in buildings/bathrooms where there are urinals) and approximately 1 time per day by visitors.

Urinals: 45% of the residents of each building are male. When urinals are available, men will use them 50% of the time.

Lavatory Sink: The lavatory sink is used approximately 12 minutes per person per day, approximately 219 days per year.

Shower: Each resident takes an 8 minute shower approximately 75% of the time.

Laundry: The new Maytag washing machines are using 17 gallons per load. Students are doing approximately 1 load per week – 50 loads per school year (219 days divided by 7 days per week).

- **Academic buildings/Non-Residential**: During the day, 12,000 students housed in the residence halls leave their dormitories to go to class. They, along with 8,000 commuter students and 4,000 faculty and support staff, use the toilets, urinals, faucets and showers in the academic and other support facilities. This category of use includes academic buildings, offices, support facilities, libraries, and the domestic usage in the agricultural buildings. **The total calculated water use for domestic usage within the academic buildings is 94 million gallons of water per year** or the equivalent of 18 gallons of water per person per day for a 219 day period. This water usage also accounts for visitors' use during athletic events as well as summer students.

  An estimated 94 million gallons of water is consumed for domestic use in the academic buildings. This usage is greater than the metered usage provided by the University. Based on 2006 metered data, the annualized usage for the buildings in this category was 78 million gallons; however, this usage was only for 2.2 million square feet of the facilities, whereas the actual square footage of the buildings in this sector is 5.3 million square feet. At of the end of the 2006 calendar year approximately 3.1 million square feet of academic/non-residential space did not have meters.

  Based on the building list provided by UConn, the square footage for the academic sector has increased by 21% since 1996. This would mean that only 1.1 million square feet of the academic buildings have newer bathroom fixtures. Based on site surveys and engineering calculations, there are approximately 1,800 toilets in this sector of which almost 400 have already been replaced with low flush technology.

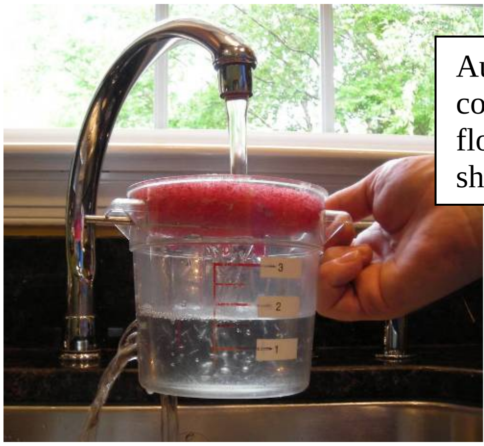
  Because the population is so mobile, calculation of the potential savings for any specific academic building is difficult; however, the average savings per toilet is conservatively estimated at 1.7 gallons per toilet per flush and 1.0 gallon per minute of use for the faucets. Total potential savings, if all of the domestic equipment is upgraded in the academic buildings, is 23% or 22 million gallons. The cost to perform these upgrades would be approximately $720,000. Individual costs for the various domestic use conservation measures are listed in Table 4 in the end of this section.

Domestic Water Fixtures

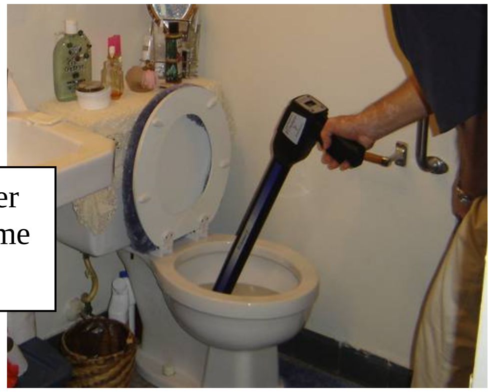
Auditing techniques:

Sanitary water use is calculated for each fixture type: toilets, urinals, faucets and showerheads. This was determined by measuring the flow rates and gallons per flush of a sample of each fixture type. Faucet and showerhead flow rates were measured using a calibrated flow container. Faucet flow rates are taken by turning the valve a quarter turn. Tank type toilets are measured by using a t-5 flushmeter or by using a water meter connected to the supply line. Diaphragm valve type toilets are measured by flushing the contents into a calibrated bucket, or by using the t-5 flushmeter.

The most reliable device for measuring toilet flush volumes is the t-5 flushmeter; the most reliable tool for determining flow rates for showers and faucets is the Micro weir.



Auditor uses a Micro-weir container to measure the flow rate of faucets and showers



Auditor uses t-5 flushmeter to measure the flush volume of the toilet

The average flow rate and flush volume for each fixture type is then used to represent the baseline flow rate. Usage profiles for these domestic sanitary fixtures are based on three parameters: population, female-to-male ratio, and the frequency of use of these fixtures. The population includes all personnel and visitors. On average, employees are in the building for eight hours per workday all year round.

Based on industry standards for commercial and industrial buildings, employees use the restrooms 4 times per day or 1 use per 2 hours. The number of uses per day (NUPD) for female staff is 4. Males use the urinals 50 percent of the time and the toilets 50 percent. It is assumed that with each toilet or urinal use, all people wash their hands for at least 6 seconds per use.

In ResLife buildings, toilets are used 4.8 times per day, and people wash their hands with each toilet use for an average duration of 6 seconds per use. Two additional minutes per day of sink use per student were added for other uses. Shower use per day is .75 for an average duration of 8 minutes per use. In academic/non-residential buildings, commuter students use the bathroom 2 times each day, while it is estimated that the on-campus students use the bathroom 4 times per day.

The number of uses per day (NUPD) for staff and visitors is totaled by each fixture type and each group of users to give total uses per day (TUPD). The TUPD for toilets and urinals is multiplied by the average sampled flow and occupancy to give baseline water consumption. Similarly, the TUPD for lavatories and showers are multiplied by the average sampled flow rates, minutes per use and occupancy.

Toilets

There are three main types of toilet fixtures found at UConn: gravity tank and bowl, pressure tank and bowl, and diaphragm valve and bowl (commercial). The most common fixture in ResLife is the diaphragm valve and bowl toilet, primarily found in dormitory style buildings, such as the South Campus complex, Towers complex, and McMahon Hall. Hilltop and Charter Oak Apartments contain gravity tank and bowl toilets, while Hilltop Suites and Charter Oak Suites contain pressure tank and bowl toilets.

Residential buildings constructed after 1994 and commercial buildings constructed after 1996 are required by federal law to have low-flow 1.6 gallon per flush (gpf) domestic fixtures. Most tank and bowl and pressure tank and bowl toilets encountered in ResLife were rated as a 1.6 gpf toilet, although many of those toilets were not flushing on 1.6 gpf. The majority of commercial valve fixtures in ResLife buildings were rated at 3.5 gpf; however, many flushed at volumes of up to 5 or 6 gpf.

There were a significant number of low-flush commercial valve toilets in ResLife buildings, but not all low-flush fixtures were flushing at 1.6 gpf. There are a variety of reasons a low-flush toilet would use more than 1.6 gallons. The most common reasons are: 1) maintenance departments only stock higher flow replacement parts; 2) debris can infiltrate the valves causing malfunction and increased flush volume; or 3) china is a poor design and needs more water to properly evacuate.

Valve Toilets:

Use of toilets and flush valves from the same manufacturer is generally recommended to assure that flush performance is optimized as well as to address any performance or quality problems with any one particular manufacturer. Certain combinations of fixtures and flush valves yield a less satisfactory flush. Many poor flushing Crane and American Standard commercial toilets were seen on the campus.

Essentially there are two types of flush valves – diaphragm types and piston types. Descriptions of each are listed below:

- Diaphragm types:
    - 30-80 psi range of operation
    - Discharge varies
    - 30% over range
    - Diaphragm material variations cause variations in discharge curve
    - Easily clog when debris is in the water
    - Very susceptible to harsh chemical treatments
- Piston types:
    - 15-125 psi range of operation
    - Discharge varies <6% over pressure range
    - Piston travel is controlled by a fixed diameter hole
    - Self-cleaning feature reduces run-on operation
    - Piston valves have less vulnerability to chemical treatments in the water.

This toilet and many other low flush toilets at UConn need to be flushed twice to properly clear the bowl

Older diaphragms can wear over time and begin leaking, usually undetected causing "silent leaks." These "silent leaks" can create significant water losses.

Most of the commercial toilets at UConn use diaphragm valves (Sloan or Delaney) – the existing diaphragm valves present a maintenance challenge: debris in the water line can clog the equalization port as well as decrease the life span of the rubber diaphragm. Both of these situations require the disassembly of the valve and cleaning or replacement of the diaphragm. They can also cause the valve to stick open causing a continuous flush, making the situation worse, or an increase of flow per flush.

Until recently, it was better, from a water conservation perspective, to use piston actuated flush valves over diaphragm actuated flush valves. Experience has shown that piston actuated valves have a mean time between maintenance of five to seven years, compared to two years for the traditional diaphragm valve. New dual filtered diaphragm valves that eliminate most of the problems typically seen with the traditional diaphragm valves are now available. Existing diaphragm valves should be replaced with the dual filtered diaphragm or with a piston valve.

Tank Toilets:

Tank toilets are very problematic and require constant maintenance to the handle, fill valve and flush valve. These toilets are prone to significant leakage. The toilet pictured to the right is located in the Infirmary, and there is evidence that the toilet has had a long-term leak.

For this reason, it is recommended that existing tank toilets be rebuilt or replaced. If the toilets are rebuilt, it is recommended that anti-siphon fill valves be used with flappers made from chloramine resistant materials. If the toilets are replaced, it is recommended that they be replaced with high efficiency toilets (HET's) that can flush at least 400 grams. HET toilets flush on 1.28 gallons – a 20% savings over the traditional 1.6 gpf toilets.

For a listing of the best toilets refer to the MaP (Maximum Performance Testing) report that can be found at the following link http://www.cuwcc.org/MapTesting.lasso

The pressure tank toilet energizes the water within its tank. When the water supply line is connected to the closed, sealed tank that is full of air, it flows into the tank. The air inside the tank, with no means of escaping, becomes more and more compressed until its compression produces a counter pressure equal to the force from the supply line. When these forces become equal, the water flow stops.

Thousands of pressurized flush toilets have been installed around the nation. Studies show that pressurized tank toilets perform excellently and have better drain line carry. UConn has already replaced over 30% of the tank toilets in the dormitories with pressure assist toilets.

The pressure flush system requires very little maintenance and the manufacturer provides a parts warranty for 10 years from the date of installation. Pressure toilets eliminate the need to replace deteriorating flush and fill valves or seals every 18-24 months. New pressure flush toilets are even able to effectively operate using 1.0 gpf.

Urinals

In addition to toilets, urinals in the dormitory buildings were evaluated for water use. Approximately 125 urinals are in the dormitory buildings on campus. Since urinals use less water than toilets (the average urinal in the ResLife building uses 1.2 gpf), the projected water use for those buildings would be less. Studies have shown that when urinals are present, men will use them 50% of the time.

This urinal was closed off because the diaphragm valve continued to run. Valve needs to be replaced.

Flush volume on trough-like urinals above can not be reduced to less than 1.5 gpf. Water use can only be lowered to 1.0 gpf or less by replacing the china.

Typically, urinal water consumption can be reduced by replacing only the flush valve. For this reason, there is no need to replace anything other than the flush valve for most of the urinals found on campus. Many wall mounted urinals can operate effectively on only 0.5 gpf.

<u>A note about waterless urinals:</u> Because of the high cost of replacement fluids and problems with odor and salt mineral build-up in the drain lines, installation of waterless urinals is not recommended.

Faucet Aerators

Water flowed from kitchen and lavatory faucets at an average of 2.3 gpm. The restrictors on some of the aerators have been removed because of clogging, causing the flow rate to increase considerably. For example, during the water audits that were performed as part of this study, it was documented that some faucets had flow rates in excess of 5 gallons per minute (gpm).

Low-flow lavatory faucet flow controls direct the water with conical screens to isolate debris and prevent clogging. Flow controls are available at flow rates between 0.5 and 1.0 gpm. Kitchen faucet flow controls are available with a flow rate of 1.5 gpm. Four (4) million gallons of water can be saved annually by just upgrading the faucet aerators in ResLife buildings. Faucet flow controls are available in vandal proof models but because newer flow controls have a pleasant flow and do not clog, it is not usually necessary to install vandal proof models.

Shower Heads

With the exception of Hale and Ellsworth, the showerheads in ResLife buildings were found to be in good condition and operating at an average of 2.4 gpm, a relatively low flow rate. The majority of showerheads noted during the survey are of the low flow spray variety and changing them would not result in significant water savings. Many of the existing showerheads, however, have a very poor spray while others are malfunctioning and are beginning to clog with debris – these fixtures should be changed. All of the residential showerheads should be standardized and replaced with an adjustable spray selection showerhead that offers massage and combo settings. A model with an efficient non-aerating spray would reduce heat loss, increase comfort, and could not be altered to increase flow indiscriminately. Flow rates of 2.0 gpm could be selected that would save on average 0.5 gpm per showerhead changed.

This type of shower system is present at both Hale and Ellsworth (Hilltop Residence Halls). The two buildings are identical – each with 9 floors and 3 showers per floor.

The water pressure in the buildings averages 70 psi while the flow rate on the showers is in excess of 10 gallons per minute.

Upgrading the showerheads at Hale and Ellsworth will require a little innovation because the manufacturer's suggestion is extremely expensive (approximately $200 each); however, by making a slight design change to the shower systems in these two residence halls the existing showers can be converted to low flow units for approximately $50 per unit. Since these showerheads have extremely high flow rates (in excess of 10 gpm) the replacement of these 54 showerheads, will save approximately six (6) million gallons of water annually.

Laundry Facilities: In 2005, five hundred and twenty-two (522) Maytag Neptune high efficiency front load washing machines were installed throughout the campus. The new washers use 15-18 gallons per load compared to the 30-32 gallons per load used by top loading machines. The replacement of these washing machines has saved the University approximately 2.6 million gallons of water annually. Currently, there are no other significant water savings potential for the laundry facilities at UConn as the savings are already in place.

Summary of Water Conservation Opportunities for Domestic Use

1. Replace existing aerators on all faucets (savings of 4 million gallons / year in the ResLife buildings and 2.5 million gallons in academic buildings)
2. Upgrade shower systems for Hale and Ellsworth (savings potential of 6 million gallons / year). Test remaining showerheads and replace if needed.
3. Replace all gravity tank toilets with HET toilets. If gravity toilets are not replaced, then upgrade the fill and flush valves and calibrate to use 1.6 gpf. Tank toilets are much more likely to leak than flush valve toilets. Upgrading the tank toilets will minimize maintenance cost and eliminate these leaks (savings potential of 1.5 million gallons / year is projected).
4. Replace the old Sloan 1.6 gpf flushmate pressure tanks with 1.0 gpf flushmate vessels. Doing this will reduce flush volume of existing 1.6 gpf pressure toilets by 40% and will reduce maintenance costs because the current vessels are out of warranty and the new vessels have a 10 year warranty.
5. Replace diaphragm valves with adjustable piston valves for urinals and valve toilets.
6. Replace older high volume valve toilets with 1.6 gpf bowls.

Note: Many of the newer toilets are out of adjustment and need maintenance, upgrading these fixtures will save some water and will also save on maintenance.

Table 4: **Approximate cost in labor and material to replace specific fixtures**

Domestic Fixture Retrofits (ResLife)				
Measure	**Unit Cost**	**Counts**	**Total Cost**	**Water Saved Per Unit (gal)**
3.5 Commercial Toilet Replacement	$515.00	1,026	$528,390	16,317,926
1.6 Commercial Valve Retrofit	$175.00	337	$58,975	1,081,656
1.0 Pressure Tank Toilet Upgrade	$150.00	251	$37,650	989,442
Gravity Toilet Tank Upgrade	$75.00	528	$39,600	1,510,885
Urinal Valve Retrofit	$175.00	133	$23,275	232,477
Faucet Flow Control	$14.00	2,669	$37,366	4,157,618
Showerhead Upgrade	$20.00	2,150	$43,000	7,884,000
Showerhead Retrofit	$50.00	54	$2,700	5,835,474
		TOTAL:	**$770,956**	**38,009,479**

Domestic Fixture Retrofits (Academic)				
Measure	**Unit Cost**	**Counts**	**Total Cost**	**Water Saved Per Unit (gal)**
3.5 Commercial Toilet Replacement	$515.00	1,400	$721,000	15,610,000
1.6 Commercial Valve Retrofit	$175.00	400	$70,000	700,000
Urinal Valve Retrofit	$175.00	280	$49,000	490,000
Faucet Flow Control	$14.00	3,500	$49,000	5,200,000
		TOTAL:	**$889,000**	**22,000,000**

Central Plant

The Central Plant uses **approximately 88 million gallons of water per year –** 45 million gallons of water for make up to the steam system and 43 million gallons for make up to the cooling towers. Table 5 shows the monthly water use in the central plant broken out by equipment. Water use per day in the Central Plant was determined to be 241 thousand gallons.

Table 5:

Make-up Water Central Plant						
Month	**Total Water Use UConn Gallons**	**Boiler use**	**Chilled Water**	**Old Cooling Tower**	**New Cooling Tower**	**Total Central Plant Usage**
January-06	36,977,000	4,630,300	329	347,942	485,272	5,463,843
February-06	42,961,000	4,165,100	1,220	256,080	1,107,054	5,529,454
March-06	44,276,000	4,106,400	2,220	415,680	1,303,281	5,827,581
April-06	45,681,000	3,514,300	540	636,280	1,260,381	5,411,501
May-06	33,492,000	2,905,300	60,980	1,160,620	2,678,010	6,804,910
June-06	32,432,000	1,854,800	27,040	1,328,000	4,029,529	7,239,369
July-06	42,516,000	3,473,729	11,160	1,404,220	7,574,083	12,463,192
August-06	45,066,000	3,598,700	16,640	373,300	7,383,477	11,372,117
September-06	49,683,000	3,113,000	3,500	960,380	3,902,169	7,979,049
October-06	49,185,000	4,173,769	3,100	12,980	2,963,390	7,153,239
November-06	41,928,000	5,387,307	3,500	26,560	1,747,865	7,165,232
December-06	33,656,000	4,424,820	15,200	316,600	755,061	5,511,681
usage per year	497,853,000	45,347,525	145,429	7,238,642	35,189,572	87,921,168
usage per day	1,363,981	124,240	398	19,832	96,410	240,880

Cooling Towers

The Central Plant also provides cooling year-round for the Cogeneration plant, for space cooling, or for process cooling to the buildings on the main campus. Cooling towers are used to dissipate heat from water-cooled refrigeration, air-conditioning and industrial process systems. Cooling towers are very effective at economically cooling water, but as a result, they use water through evaporation. Essentially, cooling towers operate on the principal that when a fluid evaporates, there is a cooling effect. The purpose of the tower is to evaporate water to create cooling. This water must be made up by supplying fresh water to the system.

Water must also be made up in cooling towers because water is lost as the result of blow down. Blow down is defined by water that is exhausted from the system due to poor water quality. Because cooling towers are an open system, the water used must be protected from airborne contaminants. Additionally, there are minerals that are naturally present in the water; when the water evaporates the minerals remain in the water. All of the above contribute to the need to chemically treat the water as well as routinely dump the water (or blow-down) at regular intervals and replace it with fresh water. The water for evaporation and blow-down is equal to approximately 116,500 gallons per day (43 million gallons per year) and must be made up by supplying fresh water to the system.

Steam System

The central plant provides steam year-round to the buildings on the main campus. The steam lines run underground inside of a pipe tunnel or are direct-buried. It is estimated that approximately 50% of the condensate is not returning to the central plant and is being lost into the ground. This could be the result of broken condensate lines, steam trap failures or steam provided to process equipment. Current trap maintenance focuses on replacing traps upon failure. Failures are detected in one of two ways: by visual observation of steam venting to the atmosphere or by receiving a call of a building shut down.

Based on information from the Facilities Department, the average amount of steam that is being produced is 80,000 lbs / hour. It was also determined that the approximate amount of condensate that is being returned is 50%. Based on this, daily condensate loss is estimated at 118,500 gpd.

Table 6:

Steam Production lbs/hr	Conversion Water lbs/gallon	Steam Production gallons/hour	Condensate Loss %	Condensate Loss gallons/hour	Condensate Loss gallons/day	Condensate Loss gallons/year
80,000	8.10	9,877	50%	4,938	118,519	43,259,259

The above data is very close to the metered data presented in Table 6. The meter data indicates that the water needed by the boilers as make up for the steam system is 124,000 gallons per day (45 million gallons per year). Reducing the condensate losses by half (i.e.: increasing condensate recovery from 50% to 75%) would reduce new water needs for the steam system by 62,000 gallons per day.

Steam System Losses

In summary, the existing steam system is losing an estimated 124,000 gallons of condensate per day. Leaks in the piping system, condensate lines that go to sanitary waste, and steam trap problems are some of the reasons that the losses are this high. The Department of Energy estimates that 25% of the energy needed to produce steam is still in the condensate water. If steam traps have not been maintained for three to five years, 15 to 30 percent of traps will likely be mal-functioning. If the steam traps discharge into a sanitary waste line or leak directly into the ground, significant amounts of water and energy are lost.

Table CG-3. Cost of Various Sized Steam Leaks at 100 psi (Assuming steam costs $5.00/1,000 lbs)

Size of Orifice (in)	Lbs Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/2	835,000	$4,175.00	$50,100.00
7/16	637,000	3,185.00	38,220.00
3/8	470,000	2,350.00	28,200.00
5/16	325,000	1,625.00	19,500.00
1/4	210,000	1,050.00	12,600.00
3/16	117,000	585.00	7,020.00
1/8	52,500	262.50	3,150.00

The steam loss values assume clean, dry steam flowing through a sharp-edged orifice to atmospheric pressure with no condensate present. Condensate would normally reduce these losses due to the flashing effect when a pressure drop is experienced.

Source: Armstrong International

Efforts need to be taken to increase the percentage of condensate that is returning to the Central Plant. A cost effective method to identify problem areas is to perform predictive testing using infrared technology. Infrared surveys can be accomplished from the ground or from the air. Infrared inspection finds the hot spots produced by leaks and deteriorated insulation. Aerial surveys are best done by helicopter and are very effective in identifying leaks in an underground steam system. The approximate cost for an aerial infrared survey would be $10,000.

<u>Steam Trap Audit:</u>

In addition, a steam trap audit needs to be completed at UConn. Typically trap maintenance focuses on replacing traps upon failure. Failures are detected in one of two ways: by visual observation of steam venting to the atmosphere or by receiving a call of a building shut down. Principle steam traps are designed to remove condensate from the steam distribution piping and heat exchange equipment. They also remove non-condensable gases, which impede heat transfer and result in corrosion. System debris, improper sizing, and improper application are common causes of steam trap failure. A May 2002 DOE "Steam System Survey Guide" report explains that steam traps can fail in different modes (open or closed). Both failure modes result in significant economic impact.

Traps that fail open result in:
- Increased fuel bills
- Higher emissions
- Water hammer
- Increased water and effluent charges

Traps that fail closed result in:
- Water hammer and wet steam
- Increased maintenance
- Longer start-up times
- Reduction in process performance

Historical steam trap surveys indicate that at other large facilities where there is not an active steam trap management program, as many as 30-50% of the traps are oversized, blowing, leaking or are plugged with dirt. As it has been years since a comprehensive audit has been completed on the steam traps at UConn, it is quite possible that the failures could be very significant. A comprehensive steam trap audit will likely cost $20,000 - $30,000.

Professional steam trap audits use visual, thermal and acoustic methods to evaluate steam trap performance. Ultrasonic testing can quickly reveal the condition of each steam trap. An ultrasonic test is a "positive" test in that a user can hear what is happening within a steam system as it is being tested. A contact probe used to localize the sound coming from the trap will not pick up the other pipe noises since ultrasound intensity falls off rapidly as it moves away from its source. After the ultrasonic test is completed, infrared temperature readings need to be taken at the inlet and outlet of the trap. This data is then documented for calculation of the losses.

The goal of the steam trap audit will be to determine, as closely as possible, the level of losses that are occurring on the campus and what the cost will be to make the appropriate repairs. The audit should be the beginning of a comprehensive steam trap management program. The software used in the audit should be made available to UConn so that it will be easy to record the location and identity of every trap at UConn, assess the operating condition of every trap, develop a complete trap database, and provide a comprehensive steam trap assessment report. Each trap's number, location, application, size, manufacturer and model number will be part of the report.

Water Re-use for Central Plant

Because of the large need for new water for the Central Plant (Cooling and Steam Systems), there is a big opportunity to reduce this requirement and reduce overall consumption by 18% with the implementation of one measure.

Reuse of waste water as a source of make up water for Central Plant: There are several hundred microfiltration and ultrafiltration (MF/UF) systems in operation for municipal drinking water systems throughout the world, with capacities that are evenly distributed between MF and UF exceeding 200 mgd (million gallons per day). The proliferation of MF/UF systems in the municipal market place is the result of increasingly stringent water quality requirements being mandated for potable water derived from surface water sources. In the United States, MF/UF technology has been readily accepted to achieve potable drinking water quality in terms of controlling pathogenic microorganisms and potentially carcinogenic Disinfection By-Products (DBP).

Capital cost estimates for MF/UF range from $1.50 to $2.00 per gallon per day (gpd) of filtrate (for the purposes of this report, $1.50 will be used in the calculations). The central plant uses on average 240,000 gpd. This means that the capital cost for using MF/UF for providing treated waste water to the WWTP for reuse at the Central Plant would be approximately $360,000.

The other significant capital cost that would be incurred before water could be supplied from the WWTP to the central plant would be the cost of the pipeline. Approximate cost for this would be $35 per diameter (inches), per length (foot) of pipeline. Using a mile (5,280 feet) as the distance from the wastewater treatment plant (WWTP) to the central plant – the cost for a mile of 4" pipeline would be approximately $740,000. In addition, engineering costs, approximated at $90,000 should be factored in for a total of $830,000.

Therefore, for a capital cost of $1,190,000 water use to the central plant could be reduced by 88 million gallons per year.

Water Conservation Opportunities for Central Plant

1. Conduct audit of steam system ($20,000 to $30,000)
2. Repairs to steam system

Table 7.1:

Reduction in Condensate Loss	Units	Unit Cost	Total Cost	Water Savings (kgal/yr)
Steam trap audit			$20,000 - $30,000	
Steam loss aerial survey			$10,000 - $15,000	
Repairs to steam system			N/A	
Reduce loss by 25%*				**22,630**

*Assumes savings of 62,000 gallons per day.

3. Install point of use reuse system for Central Plant

Table 7.2:

Reuse of Effluent Water	Units	Unit Cost	Total Cost	Water Savings (kgal/yr)
Initial cost for filtration system of effluent for reuse at Central Plant	240,000 gpd*	$1.50/gpd**	$360,000	
Piping of effluent from WWTP to Central Plant	21,120 ft.	$35/ft	$739,200	
Engineering costs for design of reuse system of effluent water from WWTP			$90,000	
Total Cost of Reuse System			**$1,189,200**	**88,000**

*Assumes that no upgrades were done to the steam system.

**Does not include pumping costs or the cost to replace filters.

Agricultural and Livestock Operations

Agricultural usage at UConn is difficult to quantify. A considerable amount of water is consumed (for instance based on studies done at New Mexico State University, a dairy cow drinks an average of 11,680 gallons of water per year) but the majority of the water that is used in agriculture is used for the care and cleaning of the animals and their respective living spaces. Dairy cows are milked three times per day and the milking area is completely cleaned after each use. Chicken, cattle and swine areas are also cleaned every day as are the cages for mice and rabbits. The largest user in this category is for the various bottle and cage washers.

Agricultural Usage is estimated to be 12 million gallons per year.

Agricultural animal and livestock facilities at UConn include the Kellogg Dairy Center, Horse Barns, Cattle (and sheep) Resources Unit, Poultry Unit, and Swine Unit. Research mice are housed at the Biotechnology Laboratory. Water use at each of these facilities is primarily for animal watering and cleaning of cages and the dairy barn. This usage does not include the water used for domestic purposes or the water used for process cooling.

Water Use

At present, most of the UConn agricultural animal and livestock operations are not metered. Given the size and complexity of animal operations at UConn, it is difficult to estimate water usage, particularly as the animal population varies throughout the year.

Agricultural facility managers are acutely aware of the university's concern about water use. During site visits, it was evident that they try to report leaks and water-using equipment malfunctions quickly and that Facilities is typically prompt in making repairs. One area of concern is the apparent persistent leak that frequently creates large puddles and runoff behind the Horse Barns. It is important to note that UConn has conducted at least two leak detection surveys of this area, with the most recent investigation completed in June 2007. The results of these analyses are that the surfacing water is due to groundwater seepage and is not from a pipe leak.

Water-efficient automatic water drinkers are used for nearly all the dairy cow, horse, beef cattle, sheep, swine and poultry units, with a few exceptions such as horse stalls and some outdoor horse paddock areas that have manual-fill troughs. Automatic water drinkers provide animals with water on demand (e.g., nipple and round cup types for chickens) or refill a trough to a set point (e.g., float-type). These labor-saving drinkers help ensure that water is always available for animals and they are more water efficient than manual watering troughs, since less water is dumped at cleaning time.

Water used for cleaning non-equipment work areas and floors is done with hoses. Typically, these hoses were observed to have working automatic shut-off nozzles. In some cases, walkways and animal areas with manure (e.g., barn floors) that are washed down with hoses might be cleaned more quickly and effectively using hoses attached to water brooms.

Large water-using equipment is difficult to evaluate for water efficiency without metered water use records, but these large volume uses can and should be tracked for efficiency. For example, large equipment such as the horse arena misting system used for dust control and the milk sterilization and storage unit (discussed in the Process water section of this report) are clearly essential. Metered records of these major end uses could better quantify the opportunities for future water savings through such measures as schedule modifications, retrofit and/or reuse.

Kellogg Dairy Center & Cattle/Swine Units: Water Brooms

High-pressure wash-down hoses are used for cleaning walls, removing manure and cleaning floors in the milking parlor (left) and the cow barn (right). A potential water and labor-saving alternative is a high-pressure water broom (bottom) that can reduce water use by up to 60%. Several manufacturers offer industrial water brooms in various sizes and designs, including brooms that roll on castors to easily move waste and debris, as shown below. Water brooms can also reduce labor steps for leaning and lifting while cleaning.

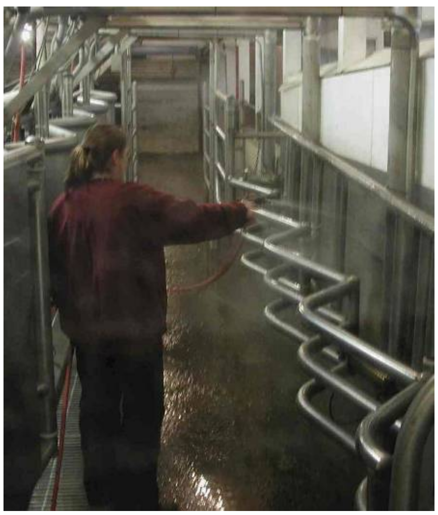


Photo source: City of Pasadena (CA) Water & Power, Water Broom Rebate Program

http://www.waterbrooms.com/waterbroomInfo.html

Table 8: Agricultural Equipment Usage and Upgrades

Measures	Site	Est. Water Use			Current water use	Measure Units Needed	Measure Cost/unit	Cost	Est. Annual Cost Savings	Est. Annual Water Savings
		Current	Measure	Rate						
Water Broom	Dairy milking parlor, barn	8 gpm	2.8 gpm	180 min/day	1,051,200	2	$300	$600	$2,050	683,280
	Cattle & Swine Units	8 gpm	2.8 gpm	120 min/day	700,800	2	$300	$600	$1,367	455,520
Automatic Hose Shut-off Nozzles	Horse Barns, Cattle, Sheep, Swine & Units	5 gpm	1.8 gpm	20 horse/ month	24,000	15	$15	$225	$46	15,360
				Total	1,776,000	19	$615	$1,425	$3,462	1,154,160

Over 300 cages are washed daily. This process takes over two hours, not including time spent washing other animal equipment. We estimate there is potential for an additional 5 mg/yr savings if just one hour of cage washing can be saved per day by washing only full loads. Are all wash loads completely full? Could they save one hour of washing per day? The answer is most likely yes.

Table 9: Scheduling Changes for Largest Agricultural water user with/ Potential Savings

Measures	Site	Estimated Water Use			Current Water Use	Est. Annual Water Cost Savings	Est. Annual Water Savings Gallons
		Current	Measure	Rate			
Wash full loads only	Agricultural Biotechnology, mice water bottle and cage washing	230 gpm	0 gpm	2 hr/day for 7 days/ week	10,074,000	$15,111	5,037,000

Recent Success in the Poultry Unit: Two years ago, the Poultry Unit switched from continuously running bubbler-drinkers for the chickens to a system of "nipple drinkers" that the chickens peck at when they're thirsty, as shown in the picture on the right.

It has been determined that this innovative water conservation measure is saving 1 million gallons (mg) of water per year.

The new drinkers work by attaching a rubber nipple to containers of water, where a droplet forms. A light bulb casts light on the droplet, attracting the chickens, which peck at the drinker until their thirst is quenched.

Potential Water Savings, Benefits and Costs

Estimates of potential water savings and related costs and benefits from the measures identified above are shown on Table 8 and 9.

Of the estimated 11,850,000 gallons used by agriculture in a year, approximately 6 million gallons per year could be saved through equipment upgrades and scheduling modification changes to water using equipment. For the cages and bottle washers, the combined water savings of 5,037,000 gallons would be realized if one hour could be eliminated through a concentrated effort to wash full loads only. The estimated costs to implement these changes are low ($1,425) and the annual avoided water and sewer treatment costs associated with the water savings upgrades are estimated at $15,000.

Summary of Water Conservation Opportunities for Agriculture

1. Purchase water brooms and high pressure automatic shut-off valves for agricultural sites, dairy milking parlor and cattle and swine units.
2. Analyze opportunities for washing full loads.
3. Inspect automatic watering (drinking) systems for leaks.

Dining

Dining services use **38 million gallons per year**. There are eight dining units as shown in the map below, five retail eateries and seven café locations on the UConn campus. The water that is accounted for in this category is for food preparation and sanitation and includes equipment such as: garbage disposers, pot washers, tray conveyers, pulpers, pre-rinse spray nozzles, and dish machines, which are summarized in Table 10.

Map of Resident Dining Locations
(http://www.dining.uconn.edu/resident_dining_locations.html)

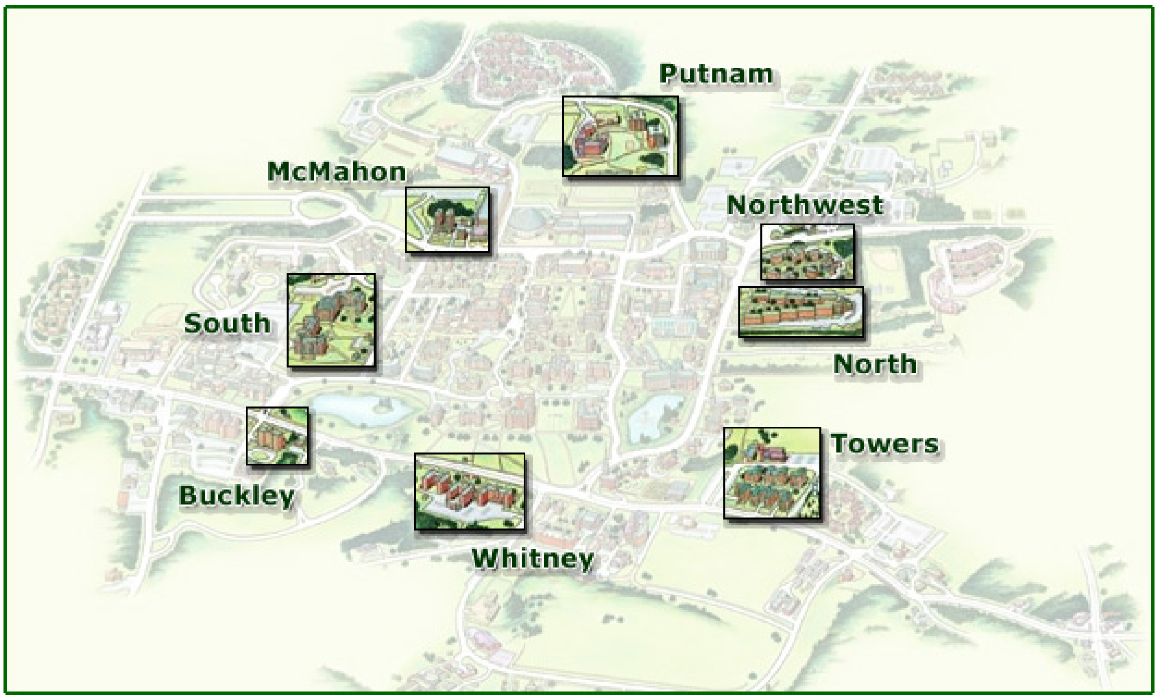


Table 10: Individual Equipment Locations

Facility Name	# of Meals per Day	Steamer	Dish Machine	Pre-Rinse Sprayer	Garbage Disposal	Pulper	Food Tray Washing	Tray Conveyer
Whitney	895	X	1	7	1			
Buckley	1,553	X	1	2			1	
McMahon	1,977	X	2	3	1			
Putnam	1,749	X	2	4				1
North	2,525	X	2	4	1		1	2
NorthWest	2,029	X	1	1	3			
Towers	2,112	X	1	1	1			
South	3,348	X	1	2	1	1		
Union St. Market	3,000	X	2	4	1			
Total	**19,188**	**30**	**13**	**28**	**9**	**1**	**2**	**3**

Water use attributed to dining facilities was calculated based on the number of existing fixtures, multiplied by fixture flow rate, multiplied by daily operating hours and then multiplied by 245 days per year of operation. Our water use model indicates that **approximately 38,000,000 gallons per year** is used in kitchen equipment, 50% of which is being used by dish machines.

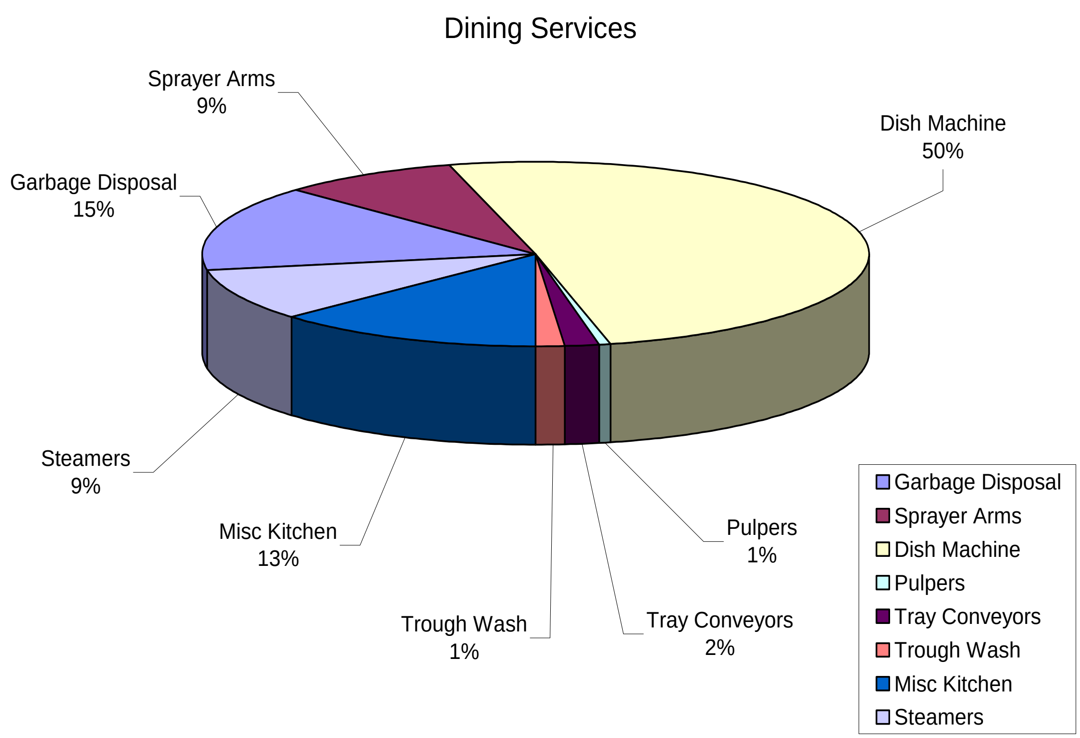


Table 11:

Dining Services:		Usage (gal/year)
Garbage Disposal	15%	5,715,528
Sprayer Arms	9%	3,372,600
Dish Machine	50%	19,293,900
Pulpers	1%	262,080
Tray Conveyors	2%	611,520
Trough Washers	1%	559,104
Misc Kitchen	13%	5,000,000
Steamers	9%	3,505,333
Total	100%	38,320,065

<u>Large Dining Units</u>

Located in **Whitney, Buckley, McMahon and Putnam**, the large dining units offer a traditional comfort style menu. These units serve between 250 and 1,000 customers per meal. A variety of foods are served at each unit depending on the season and the daily chef specialties.

Northwest Dining Hall, seating 450 people, offers a variety of cuisines prepared by a professional staff and offered in a marketplace style dining facility. Northwest also has a comfort station, pizza/pasta station, Panini grille and a dessert bar with all desserts prepared on campus by a team of pastry chefs.

North Dining Unit has a newly renovated serving area. Designed to handle a large student population, this unit offers a variety of made-to-order foods and a large and well-lit dining room.

South Campus Marketplace is the contemporary food court on campus. The location is very accessible for students just getting out of classes, and it is also near several resident complexes and staff offices. South has a broad selection of menu options. The menu varies daily but offers a selection of comfort foods, grill specialties, deli sandwiches, pastas, pizzas, salads, soup du jour, rotisseries, international specialties and desserts.

The Towers Dining Unit, now called Roger A. Gelfenbien Common, offers seating for 450 and a diverse range of food options, including kosher meals. The kosher kitchen is certified by Kashrut Commission of Greater Hartford and all kosher dishes are prepared under the close supervision of the resident Mashgiachs. All of the kosher offerings in the unit are mainstreamed with other menu alternatives so that anyone may choose to eat kosher at no additional cost. In addition to kosher, Halal menu offerings are available for lunch and dinner Monday through Friday for students who prefer this option. Traditional service at Towers is seven days a week, providing dining options for breakfast, lunch and dinner as well as some late night service.

Union Street Market is part of the retail food service operations on campus and consists of six separate eateries. They are all located in the Student Union Food Court, along with Wendy’s, Panda Express, and Blimpies.

DESCRIPTION OF USAGE AND SAVINGS METHODS

<u>“Connectionless” Food Steamers</u>

There are over 30 kitchen steamer/combo units on the UConn campus. The units are primarily Groen or Vulcan multi-chamber units.

Atmospheric compartment steamers are a primary appliance in many commercial kitchens. The typical kitchen steamers utilize a steam boiler or generator that injects steam in the cavity at a constant rate during the cooking event. In order to maintain the compartment at atmospheric pressure (i.e., pressureless condition), steam that does not immediately condense on the food product escapes through the drain. Not only is water wasted in the rejected steam, additional condensate cooling water is required by code to reduce the temperature of the effluent to below 140º F. Thus, conventional compartment steamers are inherently water (and energy) inefficient.

Water consumption ranging from 20-40 gal/hour for three-pan steamers under controlled American Society for Testing and Materials (ASTM) cooking tests is typical for conventional technology models. The consumption for “connectionless” steamers or boiler-based steamers with more sophisticated controls is below 3 gallons/hour. The annual water savings resulting from the replacement of a single conventional steamer with the typical connectionless type will range up to 325,000 gallons per year.

As noted above, water savings that result from the replacement of the typical conventional (non-efficient) plumbed food steamer with an efficient connectionless steamer are estimated at approximately 325,000 gallons per year per steamer for the larger capacity units. (Variations from this estimate occur based upon the capacity of the equipment and the hours of use.)

In the UConn Dining Units, steamers are typically turned on by 5:30 AM each morning and are shut off between 10:00 to 11:00 PM each night. The units are in standby mode a majority of the time, limiting the amount of steam entering the chamber. Full flow experienced during actual cooking time is approximately six to eight hours per day in most applications. A good rule of thumb is that the unit will flow approximately 10 gallons per hour per pan capacity while in the steam mode. The units, theoretically speaking, should not flow water during the standby mode. Many of the units at UConn, however, have no solenoid to shut off flow and many with solenoid valves are not working properly. Half of the unit’s water consumption is condensate cooling water and the other half is actual condensate. In standby mode, the expected flow rate for a three-pan unit with a malfunctioning solenoid is about 0.25gpm.

In addition to considerable water savings, “connectionless” steamers offer fairly significant energy savings, approximately 30%, with the reduced need for heating water. A typical 8 to10 kW heater is most often used on the common sized units; therefore, the energy consumption will be reduced significantly with the “connectionless” technology.

Dish Machines

Dish machines are used to wash plates, silverware, cups, bowls, and plastic food carrying trays while pot washers are used primarily for pots and pans. The dish machine operates like a carwash where dirty dishes are placed on a moving rack which proceeds through pre-wash, wash and rinse zones in the dish machine. Hot water is used in these different zones. Public health regulations require that the dishware leaving the rinse zone must be heated to at least 160°F. Because normal domestic hot water is 130˚F, this water must be heated to a higher temperature (180°F preferred) to be used in the rinse zone. Every dish machine has a specification that indicates the required hot water flow rate (gpm) in the rinse zone. In the dish machines surveyed at UConn, the flow of water in the rinse zone is greater than the required specification; therefore, water and energy are being wasted. For these machines, water and energy can be saved by reducing the rinse water flow rate.

By reducing the hot water supplied to the rinse zone to the manufacturer's specification, water and energy can be saved in these dish machines. One excellent benefit is that the dishes will come out dry instead of wet. In machines that are using too much water in the rinse zone, the hot water temperature will be less than the desired 180°F but should be at least 160°F. The reason for this is that a steam heat exchanger is used to heat the domestic hot water from 130-140°F to 180°F; however, if too much rinse water is used, the heat exchanger does not have the capacity to heat the water to 180°F.

After water flow is reduced to the proper level, the heat exchanger can operate as it was designed, and the hot water temperature will rise to about 180°F. This will cause the dishware to be hotter and will evaporate the water on the dishware surface faster. A sure sign of a dish machine that is using too much water is wet dishware that must be hand dried.

UConn has 13 dish machines manufactured by 8 different makers including Hobart, Stero, Automation, Champion, Metal Wash, Insinger, and Vulcan, which surely create challenges for preventive maintenance. The existing machines can be tuned up and flow controls can be installed for a price of $1,200 per dish machine. Savings of 9% (1,700,000 gallons) will be saved from the total calculated dish machine usage of 19,294,000 gallons.

<u>Pre Rinse Sprayers</u>

Kitchen pre-rinse spray nozzles are used throughout the day for rinsing food off dishware or trays before entering a dishwasher. Approximately 35% of the water used in the kitchen is from this pre-rinse spray nozzle. Newer spray nozzles are more efficient and do a better job rinsing dishes than old nozzles. The installed cost per kitchen sprayer is approximately $165 with savings of 200-300 gallons and 1-2 therms per day. These sprayers come complete with back flow prevention devices.

The existing pre-rinse spray valves have a flow rate in excess of 2.5 gpm. New pre-rinse spray valves have higher pressure and therefore rinse dishes faster, but the flow rates are lower – typically 1.2 to 1.6 gpm. It has been assumed that the spray valves in the Dining Units at UConn are used a minimum of 2.2 hours per day for 365 days a year. Annual savings per valve of hot water is 43,000 gallons. During the audit we located 28 spray nozzles throughout the campus – potential savings is greater than 1 million gallons per year.

Garbage Disposals

There are three different manufacturers of garbage disposal units on the UConn campus: Hobart, Salvijor & Waste King. These units are used to dispose of food waste, similar to a residential application, but on a much larger scale. The existing units range in horse power from 3 horse power to 10 horse power per unit. There are generally one or two nozzles that spray water around the walls of the basin and into the disposal. The disposal also has a direct water supply line into the base of the disposal unit. Between the two water supplies, most of the existing units receive more than twice the water needed for proper operation.

Food washing stations for trays and pots are similar; the only difference is that instead of a long trough with a garbage disposal at the end, there is a round trough (typically 2-3 ft. in diameter) with a garbage disposal in the center. The round trough has 1 or 2 nozzles that shoot water around the walls of the trough and into the disposal. The garbage disposal has a dedicated water supply line which puts water into the grinding zone. The trough nozzles usually use 1-2 gpm each and the garbage disposal about 2 gpm. An overhead hand water spray is often provided. These types of stations are usually staffed for 3-5 hrs/day and water either runs continuously or is controlled by a push button timer.

An audit of the nine waste disposals at UConn determined that on average they use approximately 600,000 gallons each per year. The least expensive water savings approach would include the following items: installation of flow restriction devices to ensure the appropriate amount of water volume is supplied; installation of new controls on the trough nozzles and on the feed water line to the garbage disposal; and installation of a timer system to shut off the water supply to the system if no timer exists. Some of the disposals are broken or at the end of their useful life and should be replaced. If the waste disposal units need to be replaced then the most water efficient thing to do would be to replace the waste disposals with pulpers.

Pulpers

A pulping system consists of a pulper that grinds or cuts up food waste materials in water to create a slurry and an extractor that separates the liquids from the solids. The solids are discharged into a waste container, and the liquid is sent back to the pulper to carry more waste materials to the extractor. Pulpers differ from the typical waste disposer in that the resultant slurry is not discharge to the sanitary sewer but instead is captured for discharge into a standard container. This process reduces the volume of waste 10-fold and saves significant amounts of water (60% or more) over a typical waste disposer.

There is one pulping unit located in the South Kitchen that is manufactured by Hobart that is used for waste disposal. The unit is partially recycled with roughly 6.5 gallons recycled per minute and 2 gpm going to the drain. Some adjustments could be made to this system that would further reduce the water that is going to the drain. Typical features of pulpers are:

- Usually connected at the end of a food tray wash station trough, in place of a garbage disposal
- Designed to process and dispose of food, paper, plastic and foil
- Waste from the food trays is scraped into the trough
- The waste in the trough is washed down into the pulper with water
- The pulper will first shred the waste and then separate the waste from the wastewater
- The waste is discarded into a trash can
- The wastewater is usually re-circulated to the beginning of the trough and is used to wash the waste in the trough to the pulper.

Pulpers cost substantially more than waste disposal systems but the savings in water, labor and trash hauling typically result in a return on investment of less than 3 years. Pulpers usually do not make sense for dining units that serve less than 1,500 meals per day, because the prices range from $10,000 to $15,000 for small units and to more than $125,000 for large engineered systems. Installing a timer control system to reduce water waste would cost approximately $1,100.

Tray Conveyor

As the name implies, the cafeteria tray conveyor is the moving belt on which people place their dirty cafeteria trays. Underneath the conveyor is a washing system that sprays water on the underside of the conveyor belt to keep it clean. This washing system is about 4 feet long and is covered by a stainless steel door. A spray nozzle attached to copper tubing sprays water on the underside of the conveyor. Water is sprayed either continuously or when the conveyor is moving. Typical flow rate is 1-2 gpm.

The installation of a timer system that controls when the water is sprayed can save significant amounts of water. This achieves a water savings of more than 50% for existing systems. Tray washing systems usually operate for about 2 hours for each meal served; however, the water spraying can be continuous from opening to closing if it is not regulated by conveyor movement. There are three tray conveyors on campus, two at North Dining and one at Putnam. Together the tray conveyers are using over 600,000 gallons of water per year. Installing a timer control system to reduce water waste would cost approximately $1,100 each.

<u>Miscellaneous Kitchen:</u>

Throughout the eight dining units, there are a number of faucets used for hand washing that have minimum flow control. Reducing the flow rate on these faucets by just 0.5 gallons per minute will save approximately 500,000 gallons per year. This assumes that each dining unit is in operation 245 days per year and has at least three hand washing sinks that are used for an average of three hours per day. Table 12 allows for $100 for installation of flow controls on all of the hand washing sinks; this amount is likely more than necessary.

Summary of Water Conservation Opportunities for Dining

The cost involved with upgrading or changing equipment in dining can have a quick return on investment. Below is a table showing the amount of current water savings along with total cost of upgrades that UConn can realize from upgrading specific kitchen equipment.

Table 12:

Equipment	# of units	Unit Cost	Total Cost	Usage (gal/year)	Water Savings (gal/year)	Annual Savings
Garbage Disposals	9	$1,040	$9,360	5,715,528	1,528,800	$4,586
Pre Rinse Sprayer Arms	28	$165	$4,620	3,372,600	1,214,136	$3,642
Dish Machines	13	$1,200	$15,600	19,293,900	1,744,883	$5,235
Pulpers	1	$1,100	$1,100	262,080	131,040	$393
Tray Conveyers	3	$1,100	$3,300	611,520	611,520	$1,835
Tray Washing Stations	2	$1,100	$2,200	559,104	279,552	$839
Steamers	30	$7,500	$225,000	3,505,333	2,629,000	$7,887
Misc. Kitchen	8	$100	$800	5,000,000	500,000	$1,500
Total			**$261,980**	**38,320,065**	**8,638,930**	**$25,917**

Additional Ideas for Kitchen & Cafeteria Savings:

1. Pre-soak utensils and dishes in a basin rather than in running water.
2. Conduct semi-annual training on water efficiency.
3. Reduce flow to devices like dipper wells or troughs for ice cream scoops.
4. Consider installing foot triggers in food prep areas to prevent constant flow.
5. Run only full loads in rack machines.
6. Consider scrape only systems and remove disposals and troughs.
7. Ensure only air cooled ice machines are used.
8. Change specification for dish machines to standardized units that are water and energy efficient. This will produce not only water and energy savings but operations and maintenance savings. This will also allow the staff to better understand the unit operations to consistently provide tune up services.
9. Repair leaks in steam, hot water and cold water lines as quickly as possible.
10. Analyze the benefits of replacing old and broken waste disposal systems with pulper systems.

Process Cooling

Process cooling, or "once-thru cooling," accounts for **21.5 million gallons of water** per year. This water use is connected to all sorts of equipment such as: sterilizers, lasers, ice makers, heat presses and many other pieces of equipment typically found in either science buildings or dining facilities. The buildings with the highest amount of process water use are:

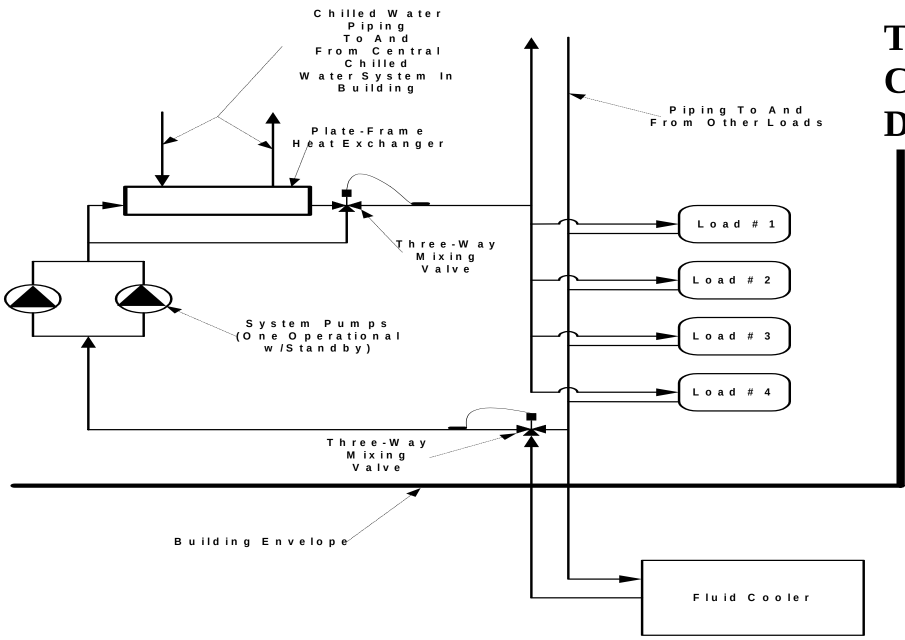
- Bio Physics - Houses labs and offices for Department of Molecular and Cell Biology and laser facility for Department of Physics; greenhouses; facility for biological collections (birds, mammals, fish, parasites).
- Engineering 2 - Building of Department of Chemical, Materials, Biomolecular, Optics, Fuel Cell Engineering, etc.
- IMS - Institute of Material Science, houses laboratories & lasers
- Pharmacy - Pharmacy School, houses chemical research laboratories
- Kellogg Dairy Center

Process cooling refers to any systems such as refrigeration compressors and air conditioning units that have water-cooled condensers, condensate vacuum pumps, medical vacuum pumps, medical air compressors, steam quenching at high quality water stills, steam sterilization equipment cooling, and photo processing units. All can use water one time before draining.

Often, these systems are older and water may have been the only cooling option available at the time the technology was introduced or the decision was made to use water-cooled equipment because of lower installed cost. If the cost of operation was taken into account at the time of installation, water costs were not a major consideration in the past. In general, water cooled systems have performed well and an "out of sight – out of mind" mentality was developed over the years of operation. The consumption of one unit may only be one gallon per minute (525,600 gallons per year), but the actual water consumption through several units can reach into the millions of gallons per year when looked at as a group.

A once-thru cooling system was found at the **Kellogg Dairy Center**. While running, approximately 3 to 15 gpm of water passes through a heat exchanger to cool the milk from the dairy cows before it is stored. Potable water empties into a sink drain for about nine hours per day, totaling about 3,780 gallons per day or approximately 1.4 million gallons per year. Installing an air cooled system at the Dairy Center would cost approximately $42,500.

Typical "Once-Thru" Closed Loop System Diaphragm



The diagram above shows a common approach in providing a closed loop solution. A plate-frame heat exchanger is required to reject excess heat to a chilled water loop or pre-existing condenser water loop. An expansion tank and a make-up line to the tank are added to the system to add cooling water when required.

Identifying the amount of process water used for BioPhysics, Engineering 2, IMS and Pharmacy was determined by subtracting the calculated domestic water usage from the buildings actual meter usage.

Table 13:

Process Usage in Selected Academic Buildings					
Building	Square Footage *	Average Monthly Usage	Est. Monthly Domestic Usage	Est. Monthly Process Usage	Yearly Process Usage
BioPhysics	157,109	372,819	314,218	58,601	703,212
Engineering 2	57,907	433,361	115,814	317,547	3,810,568
Institute of Material Science	86,308	1,225,456	172,616	1,052,840	12,634,077
Pharmacy	221,243	799,679	442,486	357,193	4,286,311
* Assume 2 gallons per sq. ft per month for domestic usage				**Total**	**21,434,168**

To confirm that this was an accurate approach, a transit time flow meter was installed on the main water line of a few of the buildings. In the Pharmacy building, nighttime flow rarely dropped below 10 gpm (gallons per minute) and every 10 minutes for a period of approximately 30 seconds increased to approximately 20 gpm. Projecting a flow rate of 10 gpm for an entire month is equal to 437,000 gallons. This level of usage is slightly higher than the usage identified in the table above, but does confirm the high level of process water usage.

At the IMS building where over one million gallons of water is used for process cooling, nighttime flow rates (flow with equipment in standby mode) varied between 7 gpm and 21 gpm. Using an average nighttime flow of 14 gallons per minute suggests that the monthly usage for IMS at just the nighttime flow rate for the month would be equal to 612,000 gallons.

The IMS building has over 50 pieces of equipment that requires water for cooling. Below is a listing of some of the items that require water on a continuous basis.

Table 14: Select IMS Lab Equipment Listing and Water Usage

Room	Equipment	Usage
216	Solvent still cooling through condenser	Unknown
313	Edwards (306)	75 litres/hr
313	Light scattering laser	2.5 GPM, 70 psi
7	Still	Unknown
9B	Amray SEM (1000)	15 gph
14	2 lasers	2-4 GPM
14	2 lasers	1 liter/min
16	Haskris/TEM (2010)	20 gph
16	Haskris/ FESEM (6335)	20 gph
16	Haskris/TEM	20 gph
17	D5005 Diffractometer	Unknown
17	D8 Advance	Unknown

There is a chilled water line for domestic cooling that runs underneath the IMS building. It is possible that this line could be tapped into for some of the larger pieces of equipment. Estimates for tapping into this line for the above equipment in the IMS building were not available, but the cost would likely be considerably less than installing air cooled equipment for each of the major pieces of equipment.

Sterilizers

Steam sterilizers are utilized to disinfect laboratory and surgical equipment and instruments. Low-pressure steam is utilized to render bacteria and other microbial organisms harmless. So that instruments can be sterilized in short order situations, many facilities never shut the units off, with the exception of approximately eight hours once a week for cool down and subsequent cleaning.

All manufactures utilize the same basic technologies to accomplish the sterilization task: first by injecting low pressure steam into the chamber when the sterilization process is taking place and next by creating a vacuum in the sterilization chamber during the dry phase cycle. Additionally, all manufacturers pass some steam into the chamber when the unit is in the standby mode in order to keep the unit ready to go at a moment's notice.

The vacuum is created by one of two methodologies: 1) vacuum pump; or 2) ejector method (venturi). The vacuum pump method is effective, but has a high maintenance component relative to the ejector method and is considered to be somewhat less reliable. The ejector or venturi method is the most commonly used method – it is simple and reliable, but consumes large amounts of water. Cold city water is passed through a venturi thus creating high velocity and corresponding low static pressure. Generally speaking, the colder the water, the better the vacuum created. Flow rates vary by chamber size but generally are between 3 and 6 gpm when the unit is in the dry phase cycle. Typical dry phase lasts for approximately 20 to 30 minutes.

Most sterilizer units are kept in a ready mode for long periods of time and many units never shut off. When the unit is in standby (ready) mode, small amounts of steam are passed into the chamber to maintain a specific temperature. As this steam condenses, it is bled off to a floor drain. Code prohibits temperatures in the plumbing drain to exceed 140º F. To lower the temperature, cold city water is mixed with the condensate. Overall, flow rates range from 1 to as much as 6 gpm in this portion of the process. Opening the sterilizer doors takes time (approximately 3 minutes) because to do so the vacuum seal needs to be released and the unit needs to purge itself of any remaining steam. As a result, most of the sterilizer doors are left open – even overnight. Closing these doors after each use as per manufacturer's recommendations would minimize the condensate losses and reduce the cooling load for the building. The amount of water savings from closing the doors is not known.

In order to lower the water consumed in the vacuum process, it is generally not recommended to replace the ejector system with a vacuum pump because of the increase in maintenance and reliability issues. Systems are available that can recover 100% of the water by utilizing a tank and cooling coil which is piped into the building's central chilled water system to cool re-circulated water used in the ejector. This system requires about 6-8 sq. ft., electric power for a small recirculation pump and connection into the central chilled water system. The system is simple and reliable and is engineered to switch back to city water in case of system failure.

The second measure is to reduce the water consumed during standby mode, which is the mode of operation during the vast majority of the time that the sterilizer is on. During standby mode, the sterilizer is kept at an elevated temperature by periodically introducing steam to keep the chamber sterile so that it can be utilized at a moment's notice without having to go through a "flash" cycle. The chamber jacket must be cooled to prevent overheating and subsequent damage. This is done with cold city water. Condensate is constantly formed from the steam introduced into the chamber. To prevent temperatures above 140º F from entering the city sewers, water in the jacket condensate trap and in the chamber trapway are cooled by city water. This water runs 24 hours a day at the flow rates set during start up. Most new models ship with this control technology from the factory.

By adding a very simple control system which senses actual trapway temperatures, water can be sent to the trapways only when needed. An additional fixed orifice limits the overall flow when the system is running. Flows can be reduced from levels as high as 60 gallons per hour to approximately 23 gallons per hour. These flow rates will vary from site to site depending upon specific parameters.

Note: The temperature of materials discharged into sanitary sewer systems is most often legally limited to less than 140°F. Such temperature restrictions can be seen in local ordinances, as a part of industrial pretreatment requirements and as a part of plumbing codes.

There are a number of reasons for limiting the temperature of sewer system inflows.

- First, conventional wastewater treatment facilities utilize biological treatment as an integral part of the overall wastewater treatment process. Biological treatment occurs when bacteria and other microorganisms consume, breakdown and thereby eliminate organics in the wastewater. High temperature discharges can seriously upset treatment efforts by killing bacteria and other organisms essential for proper treatment.
- Second, microorganisms responsible for treatment require oxygen to breakdown the organics. As water temperature increases, the amount of dissolved oxygen (DO) in the water decreases thus reducing the amount of oxygen available to the microorganisms. In addition to lowering treatment efficiency, this reduction in DO can also cause problems in the collection system. Lowered DO levels increase the likelihood that anaerobic conditions will occur. This in turn can cause excess amounts of undesirable odor and damage causing sewer gasses to be produced in the collection system.
- Third, high temperatures can cause problems with the treatment of fats and oils. Domestic wastewater by nature contains a variable amount of fats and oils. These substances are relatively difficult to treat using biological means. Biological treatment of fats and oils requires extended treatment time, a greater amount of oxygen and consequently higher treatment costs.

Recent Success:

Until the fall of 2007, the Infirmary had an x-ray processor. This technology uses a great deal of water, but the x-ray equipment was recently replaced with digital type processors that do not use water.

Water is used in x-ray processors for two purposes: first to rinse processing chemicals off of the film prior to entering the dryer section and secondly to cool the machine. The manufactures of these types of x-ray processors specify the water flow rates required for high quality photo imaging with flow rates ranging from 0.2 gpm to a high flow of 2.5 gpm. This water passes through the photo processor one time and goes to the drain. If flow is reduced below the specified rate, photo quality diminishes thus elevating contingent liability to the hospital.

It is estimated that this measure will save the Infirmary 300,000 gallons this next year.

Summary of Water Conservation Opportunities for Process Cooling

1. Conduct detailed audit of Bio-Physics, Engineering 2, IMS and Pharmacy to identify all of the equipment that is using once-thru cooling. Identify which systems can be upgraded to use less “once-thru” water.
2. Perform engineering analysis to identify the cost of tapping into the chilled water line that runs under the IMS building for use for some of the larger pieces of equipment that require “once thru cooling”.
3. Close sterilizer doors if unit will be in stand-by mode for more than an hour.
4. Inspect sterilizers to make sure that automatic control systems are in place – reduce flows to trapway as appropriate.
5. Install a closed loop air cooled chiller and other mechanical equipment at the Kellogg Dairy Center.
6. Instruct custodial staff to close doors to sterilizer units when they are in the “stand-by” mode.

Irrigation

Based on sub-metered data and engineering irrigation audit testing of all areas of turf which are irrigated on campus, approximately **13.3 million gallons** of water per year is applied to 18 acres of turf.

Eight athletic fields and the Lodewick Visitors Center are the only areas of the University actively irrigated. A few other areas on campus have irrigation systems, but the systems are in such disrepair that they are not used. The current irrigation systems and components are old and antiquated. Controllers are the easiest to upgrade. The most important function in water management for an automatic irrigation system is the amount of time an area is irrigated. Obviously water needs change based on the weather and amount of traffic across turf areas.

Typical sprinkler control systems consist of automatic valves connected to a multi-station clock controller. Watering is based on preset schedules regardless of weather or soil conditions. These systems are generally not effective at delivering water to the turf roots in an efficient manner because they are open-looped. They also require human intervention to turn the system on and off. Most irrigation managers do not have the time to turn off the system within five minutes of outburst rainfall. Adding rain sensors and automatic controllers that are tied to the weather create closed-loop systems allowing for feedback to the irrigation system to turn on and off at a moments notice. The implementation of such devices gives irrigation managers the chance to spend time on turf maintenance and upkeep rather than irrigating the turf.

Table 15: Athletic Fields

Athletic Field and Buidling Names	Estimate Irrigated Area (acres)	Estimate Precip. (in/hr)	Estimate Cycles per Week	Irrigation Time (min)	Estimate Irrigation Weeks per Season	Gallons Used per Year
Morrone Soccer	2.18	0.29	8	30	14	961,270
Practice Soccer	3.77	0.29	4	30	14	830,833
J.O. Christian Baseball	2.57	0.44	4	24	21	818,182
Conn. Softball Stadium	0.64	0.66	3	30	18	307,482
Memorial Football	1.88	0.28	6	30	22	940,898
Sherman Astro Turf Field	1.81	0.34	6	180	21	6,329,687
Two Practice Football	4.74	0.43	6	30	18	2,987,800
Lodewick Visitors Center	0.34	0.27	3	60	24	180,975
Total	18					13,357,126

Newer control systems utilize Evapotranspiration (ET) and real-time rainfall data for the basis of watering. These technologies change the watering schedules continuously based on changing weather data, such as temperature, wind, humidity, solar radiation, or historical ET rates. While this system is more accurate than typical control systems, the irrigation systems connected to the weather or soil moisture require additional knowledge to operate and understand.

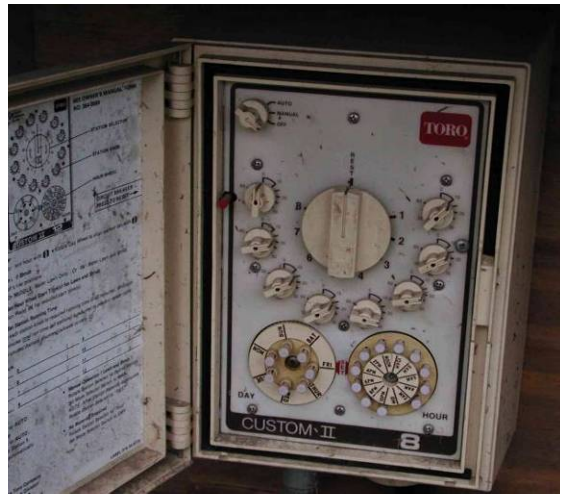
The greatest advances in irrigation technology have come in the field of **moisture sensors and better understanding of the effect of distribution uniformity**.

Parts of the sports turf and artificial astro turf field at the Sherman Complex are irrigated with "big gun" or "water cannon" type traveling sprinklers that are manually started by grounds people. The area encompasses a total of four acres. Since the application rate is fixed by the flow rate (gpm) of the nozzle and the travel speed of the cannon, the only way to adjust water usage is by the frequency of manually starting the sprinkler. Applying water only when needed could result in a significant decrease in usage.

Water Use

The volume of irrigation water used at UConn's nine athletic fields is unknown. Meters are reported to exist at each field but only three meters were found during an initial site visit on December 6, 2006. One of these meters is unreadable due to an improper installation, although it appears to be connected to the school's AMR system. The other two meters show volume figures on their dials, but because the irrigation systems were turned off for the season and no historical meter records exist for these meters, it is unclear if they are working and/or accurate. Historical records of metered water use for the athletic fields are not available with the exception of one month of metered water usage at Storrs for October 2006. In that month, it was reported that 16,200 gallons were used at the "batting cages" (includes the J.O. Christian baseball field) and 160,610 gallons were used by the soccer field (Morrone).

The water meter for the J.O. Christian Baseball Field is installed less than 6 inches under its protective metal cover. As a consequence, visual readings of metered water use are impossible. This meter appears to be connected to UConn's AMR system, but historical meter reading data is not available.



This worn Toro irrigation controller at Memorial Stadium was found to have only six of the seven zones set**.**

The estimate of water used is shown in Table 15, although these estimates do not include regular adjustments to the irrigation schedule that are necessary due to weather, climate, and playing field conditions. Many irrigation runs are controlled manually (the irrigation controller is overridden) for those reasons. According to UConn's athletic field irrigation manager, when irrigated, fields are given 15 minutes for the first run and 15 minutes for the second run, for a total of 30 minutes per day.

Two water cannons used to flood the Sherman Astro Turf for field hockey are estimated to use over 18,000 gallons per day (over 3,000 gallons per hour), not including leakage. The synthetic surfaces used at some field hockey surfaces like the one at UConn require water to improve playing conditions and minimize abrasions from the synthetic fibers. The new (artificial) field turf that is expected to be installed in 2007 or 2008 will require considerably less water.

Table 16: Existing Irrigation System

Athletic Field	**Meter**		**Rotors/Sprinkler heads (1)**			No. Zones	Controller	Notes
	Type	Reading 12/6/06, gallons	Size	Rotor Number	Fequency			
Baseball (J.O. Christian)	1.5" ?	Unreadable meter. AMR?	Hunter I-25, I-40	61	2x/day, total 30 mins	12	Toro 1200	Faulty meter installation.
Softball (Stadium Rd)	meter?		Hunter I-25	26	2x/day, total 30 mins	7	(broken)	Zones not coordinated with controller.
Football (Memorial Stadium)	meter?		Toro	31	2x/day, total 30 mins	7	Toro 8	Only 6 of 7 zones working
Soccer (Morrone Stadium)	1.5" Istec	1,529,000	Hunter I-40	52	2x/day, total 30 mins	12	Irritrol	Controller is old.
Two Practice Football	meter?		Hunter I-25	103	2x/day, total 30 mins	21	Irritrol	No zone 13, 23, 24.
Practice Field 1 (Morrone)	1.5"?	962,000	Hunter I-25	54	2x/day, total 30 mins	7	Irritrol	Very wet. Irrigated infrequently.
Sherman Artificial Turf Field	meter?	2 water reels with movable cannons for field hockey use, 3 hrs/day, 6 days/wk				2		To be replaced with field turf in 2007.

<u>Notes</u>
1. Source: Casey Erven, Athletic Fields Manager, field schematics, Dec. 6, 2006.

Water losses due to leakage in the irrigation systems are unknown because the pipes have not been surveyed for leaks. The irrigation systems for each field are believed to have their original pipes. The baseball field irrigation system may have been put in about five years ago, but the age of the other systems is unknown.

Several examples of spray heads that should be replaced, repaired, or reinstalled were found during the audit. The photo on the left shows a spray head that was installed too close to the sidewalk fence, which causes overspray to the nearby bleachers and pavement (right).

Distribution uniformity testing was done at all of the fields listed in Table 17. The results range from a low of 13% for Memorial Football Stadium field to a high of 83% at the practice football fields. As a result, the turf on the practice fields is noticeably better established. The Memorial football field has bare spots in the middle of the field, and the turf is doing poorly.

Table 17: Distribution Uniformity and Application Rate

Athletic Field and Buidling Names	Estimate Irrigated Area (acres)	Average Precip. (in/hr)	DU	Hour:Minute Apply 1/2 Inch Depth Irrigation Water	Current Schedule Application Irrigation Depth (in/hr)	Percentage of 1/2 inch currently applied each Irrigation
Morrone Soccer	2.18	0.29	30%	1 hour 44 minutes	0.07	15%
Practice Soccer	3.77	0.29	30%	1 hour 44 minutes	0.07	15%
J.O. Christian Baseball	2.57	0.57	76%	53 minutes	0.14	29%
Conn. Softball Stadium	0.64	0.66	71%	45 minutes	0.17	33%
Memorial Football	1.88	0.28	13%	1 hour 49 minutes	0.07	14%
Sherman Astro Turf Field	1.81	0.34	53%	1 hour 28 minutes	1.02	204%
Two Practice Football	4.74	0.43	83%	1 hour 10 minutes	0.11	22%
Lodewick Visitors Center	0.34	0.27	40%	1 hour 51 minutes	0.07	14%
Total	18				0.21	43%

The sixth column on Table 17 shows actual application amount based on current irrigation watering times. The last column puts that number into a percentage of the recommended amount of water that should be applied anytime the irrigation system is used. The amount of water applied translates into about two inches of infiltration well below the needed eight inches required for healthy drought tolerant turfgrass. If the water doesn't infiltrate down eight inches the roots of the turf aren't going to grow down that far either.

Proper spacing, pressure and the right combination of equipment at the Connecticut Softball Stadium show the time of apply ½ inch of water at 45 minutes. An example of an old dilapidated system with worn rotors and an old controller at Memorial Football field, the time to apply a similar amount of water would take 109 minutes. Clearly, having an irrigation system designed well with proper spacing, pressure and nozzle size greatly decreases the amount of time an irrigation system has to run and decreases maintenance and additional problems associated with bare spots on an athletic sports field.

UConn's weather plays a big part in amount of irrigation water needed by the turfgrass during the year. Climate characteristics for the state as reported by the Connecticut State Climate Center reflect that precipitation is evenly distributed during the four seasons throughout all parts of the state. Precipitation can be measured an average of one day in three, with a yearly total of approximately 120 days. Periods of five days or more of successive daily precipitation occur a few times during most years.

The percentage of possible sunshine averages 55 to 60 percent. An average of 140 cloudy days occurs per year. Heavy or dense fog is observed on an average of about 25 days per year and is most common during the late summer and fall. The humidity tends to be lowest in the spring and highest in the late summer and early fall. The topography of the campus plays a big part in how fast water evaporates from the athletic fields as does the amount of wind present – for instance Memorial Football Stadium receives a concentrated amount of wind, while the other fields are more protected from the wind and not affected as much.

What this all means is that the turfgrass at UConn needs less water than is currently being applied. To realize this savings new control systems that automatically adjust the irrigation schedule based on the turfgrass needs will need to be installed.

There are two main ways to automatically manage irrigation systems: by soil-moisture sensor data or by weather station data. The trend by many in the industry in making irrigation systems more water efficient has been to install a weather based system. Weather based systems can be very effective but they require a greater level of commitment to make sure everything is working correctly. Without trained technicians to maintain the system, problems can occur. As a result of recent advances in the soil-moisture sensor field, we recommend the installation of a soil-moisture sensor system over a weather based system for UConn. The savings for both systems is the same, but the cost for a weather based system is approximately $40,000 more than a soil-moisture system.

Soil-moisture sensor control is recommended at UConn because each field has great differences in irrigation needs. For example, the practice soccer field has been built on a wetland area and is often quite swampy. As mentioned above, Memorial Field has a wind tunnel effect drying that field faster. Some of the fields have clay soil and some have sandy soil. In the soil-based irrigation control system, soil moisture sensors are placed in two areas of each field to capture irrigation requirements depending on levels of compaction or traffic an area receives. Once the soil moisture sensors are calibrated the control clocks automatically turn the irrigation system on and off without any human intervention. This will allow the field manager time to concentrate on other aspects of turf maintenance.

A weather based system would be connected to a weather station on campus. Signals would be sent via radio transmission to tell the irrigation systems when to operate depending on the amount of evapotranspiration of the turfgrass where the weather station is located. The type of weather station that would be installed at UConn would likely monitor and record the following parameters: 1) air temperature; 2) soil temperature; 3) wind speed; 4) wind direction; 5) barometric pressure; 6) rainfall; 7) humidity; and 8) solar radiation. This data is then inputted into an equation to obtain the total amount of evapotranspiration in a given time period. With this additional control comes an additional fee for transmission of the signals between controllers and a central office. This fee over the life of the system can actually cost more than the system's original cost. This system has many perks, but also has more sensors that may fall out of calibration due to dust and grime. This level of knowledge is not usually known by field managers, but only by the manufacturer. Having this maintenance requires additional resources, time and money for the upkeep.

Potential Water Savings and Costs

Table 18: New Irrigation System Upgrade Recommendations

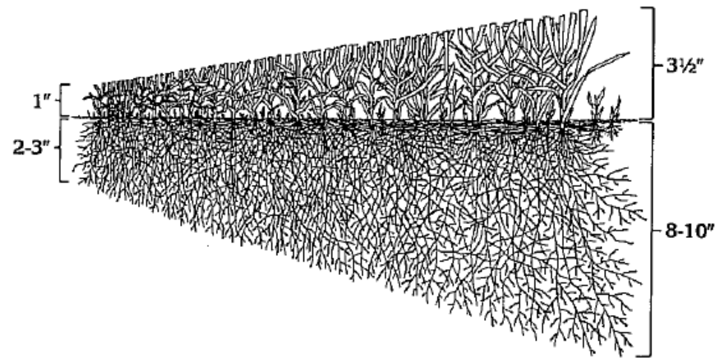
Athletic Field and Buidling Names	Gallons Used per Year	Gallons Required	Annual Gallons Saved	Cost (Soil Based)	Cost (Weather Based)
Morrone Soccer	961,270	475,503	485,767	$13,578	$19,309
Practice Soccer	830,833	821,962	8,871	$13,799	$19,437
J.O. Christian Baseball	818,182	560,173	258,009	$15,680	$20,600
Conn. Softball Stadium	307,482	138,614	168,868	$7,517	$15,808
Memorial Football	940,898	409,010	531,887	$8,717	$16,480
Sherman Astro Turf Field*	6,329,687	(395,644)	0	$0	$0
Two Practice Football	2,987,800	1,033,673	1,954,127	$26,302	$29,482
Lodewick Visitors Center	180,975	74,785	106,190	$3,647	$12,912
Total	**13,357,126**	**3,513,721**	**3,513,718**	**$89,240**	**$134,028**

* Sherman Astro Turf Field – Estimated gallons required listed above is the amount of water that would be needed if this were a natural turf field.

Additional Comments on UConn Irrigation System

Irrigation and Weather Controllers: Controllers are present at all fields, but not all appeared to be in working order. No rain shut-off devices or moisture sensors are used. Often, the "look and feel" method is used to determine irrigation. The new field manager has identified many of these problems and for now, setting irrigation runs manually may be the best practice until irrigation equipment repairs and upgrades can be made. Long-term improved controllers, rain shut-offs and moisture sensors are simple tools that can save water.

Turf grass and Mowing: Field grass types are primarily Kentucky bluegrass with about 20% perennial ryegrass. Fields are seeded on an as-needed basis, which can be quite often as fields are constantly getting torn up by practices and games. Mowing heights are about one to one-and-a-quarter inches. These may be adjustable upwards to reduce evaporative water losses.



(Drawing by J.M. Lenaham)

Mowing heights have a direct correlation to how deep the turf roots grow. Even with proper watering to a depth of six to eight inches, turf grass roots will not grow deeper than the corresponding height of their leaves. The drawing above shows that the mowing height of one inch produces a root system only two to three inches deep. The lower the mowing height, the greater the stress, making the turf less drought resistant. The soil is more prone to compaction due to heavy traffic. As a result, turf grass managers have to water more frequently to prevent wilting from occurring.

Soils and Fertilizer: Field soils are generally a sandy loam or silty clay loam with some having a thin (2") clay layer on the surface. Some variations in soils were found from field soil probe tests done during the May 2007 audit that may explain some of the variations in irrigation requirements (see photo).

The J.O. Christian Baseball field was found to have a sandy soil with clay thatch. The nearby softball Stadium Road field is a clay loam soil. The softball field needs less water because water evaporates out of clay soil more slowly than out of sandy soil.

As per UConn landscape manager - fertilizer is applied at about 6-7 pounds per 1000 square feet. All gravel and practice fields are fertilized. Fertilizer is applied before it rains, about every six weeks. A granular fertilizer product is used, not a watering-in type. Organic soils have been found to have improved soil moisture retention compared to conventional soils. Pesticides for grubs are applied twice annually. Herbicides and fungicides are used as needed, and the entire field is covered to minimize spread. Non-synthetic natural and organic materials, such as those now used by some professional sport fields, are options and reduce hazards posed by field chemicals to local water sources.

A Comment about "Cow-Trails":

Under current water restrictions, the only areas on campus being watered are the athletic fields and the Lodewick Visitors Center. At the Lodewick Visitors Center and at other places on campus, students have found an easier way to make it to where they want to go, and trails across turfgrass can be seen. These areas slowly become compacted and the turf begins to die. No amount of water applied to this area will cause the turf to continue to live. The soil structure has been compromised. Most plants including turf need three things to survive: water, oxygen and sunlight. Compaction eliminates oxygen and slows infiltration of water.

No turf will grow in these areas without extensive maintenance and time on part of the maintenance crew. Looking at the return on investment, a best management practice may be to stop watering any area where "cow trails" start to appear. Another is to stop students from crossing that area all together. This will be more of an issue when other areas on campus again are irrigated.

"Cow-trails" are trails where people naturally walk to get from one building to the next. A trail like this is located near the Visitor's Center and is often irrigated even though no grass or planting will grow in this area because of compaction.

Recent Success:

In May of 2007, it was noted that the distribution uniformity (DU) at Morrone Field was very low, thus requiring much more water to keep the grass alive. It was determined that the nozzle in the rotor was the wrong size. Notice that there are just two sprays: one for short distance and one for long distance.

It was determined that the I-40 rotors on Morrone Field had size 41 nozzles and that those nozzles do best when the pressure is around 70 psi. Pressure measured at this field was 40 psi; therefore, it was decided to change the 41 nozzle to a 40 nozzle during the audit. It made a significant difference – in fact now you can see that the nozzle has three distinct sprays: one for short, medium and long.

Distribution uniformity improved by over 100% by simply changing to a nozzle that matches the pressure delivered. UConn's irrigation manager was very helpful and interested in identifying ways to improve the system. Extra supplies were left with him so that he could change some additional nozzles and recheck the DU afterwards.

Summary of Water Conservation Opportunities for Irrigation

1. Replace all of the irrigation controllers with smart controllers.
2. Audit entire irrigation system and replace or repair all broken and misdirected spray heads.
3. Survey athletic fields' irrigation pipes, connections and fittings for leakage.
4. Check sizing and replace or fix broken rotors and sprinkler heads.
5. Develop models/graphs of historical and real-time weather data to determine water evapotranspiration (ET), which is the water loss from soil and leaves of turf, and to determine worst-case scenarios for amount of water needed by turf grass under heavy traffic condition in a season past, present, and future.
6. Install rain sensors to shut-off irrigation clocks when raining and for a few days after the storm.
7. Install soil moisture sensor devices and related soil moisture sensor controllers.
8. Record and meter irrigation and other water use on all athletic fields.
9. Link irrigation controllers to irrigation manager's office for easier control and troubleshooting purposes.
10. Install new pumps if adequate system pressures can not be maintained.

Off Main Campus Users:

The University of Connecticut provides water and sewer services to several residential and commercial consumers in the Town of Mansfield, Connecticut. **Total off-campus water usage is calculated to be 82 million gallons annually.** Below is a listing of the off-campus accounts and the calculated water usage for these accounts.

Table 19: Off-campus Uses

Off-Campus Users	Census	Water Management Inc.'s calculations				CWS reported usage	
Commerical Account Name		Gallons per Person	Daily Total in gallons	Days of Operation	Yearly Total in gallons	Yearly Total in CF	Yearly Total in gallons
Alumni House	20	7	140	280	39,200	45,063	337,071
B and B Associates - 13 Dog Ln.	100	7	700	365	255,500	15,797	118,162
Celeron Square	392	75	29,400	365	10,731,000	2,375,830	17,771,208
College Square	200	4	800	365	292,000	157,342	1,176,918
Dept. of Corrections	1175	100	117,500	365	42,887,500	1,451,124	10,854,408
Nathan Hale Inn	150	60	9,000	365	3,285,000	238,492	1,783,920
Phil's	30	3	90	300	27,000	4,167	31,169
R.C. White Co. / Courtyard at Storrs	80	75	6,000	365	2,190,000	303,431	2,269,664
Single Family Residential Homes	250	75	18,750	365	6,843,750		6,843,750
Southern New England Telephone	35	3	105	280	29,400	14,722	110,121
Storrs Associates Meter A and Meter B	200	5	1000	365	365,000	33,601	251,335
Town of Mansfield - Beck Building	75	15	1,125	280	315,000	21,310	159,399
Town of Mansfield - Community Center	100	10	1,000	280	280,000	26,306	196,769
Town of Mansfield - Ctr. For Rehab	120	50	6,000	365	2,190,000	473,394	3,540,987
Town of Mansfield - E. O. Smith HS	1400	10	14,000	220	3,080,000	185,718	1,389,171
Town of Mansfield - Glen Ridge	75	75	5,625	365	2,053,125	123,049	920,407
Town of Mansfield - Holinko Estates	88	75	6,600	365	2,409,000	101,660	760,417
Town of Mansfield - Juniper Hill	100	75	7,500	365	2,737,500	810,684	6,063,916
Town of Mansfield - Mansfield Day Care	25	15	375	250	93,750	47,712	356,886
Town of Mansfield - Wright's Village A/B	50	75	3,750	365	1,368,750	186,627	1,395,970
U.S. Post Office	60	3	180	280	50,400	7,928	59,301
UConn Foundation	103	7	721	280	201,880	77,415	579,064
UCPEA - 18 Dog Ln.	10	3	30	280	8,400	8,791	65,757
Uni-Plaza Stores	80	3	240	365	87,600	304,630	2,278,632
Annual usage					**81,820,755**		**59,314,402**
Daily usage					**224,166**		**162,505**

Most of the off-campus accounts were audited, and there are significant opportunities for water savings; however, because many of the meters are older technologically, few of the off-campus customers have had any incentive to implement water conservation programs. Meter under-reporting is a problem that is being faced by water utilities across the country. Many water utilities are realizing that by upgrading their meters they are able to account for a much greater portion of their water, and customers are then faced with either paying more for their water or implementing conservation measures.

Note: Charter Oaks Apts, Charter Oak Suites, Greek Village, and Hilltop Apartments are listed in some prior reports as off-campus accounts – for the purposes of this report they are listed in the on-campus residential sector and not in the off-campus category.

The facilities surrounding the Depot Campus (State Department of Corrections, Department of Mental Retardation, and Depot Day Care / Nursery) account for roughly 50% of the off-campus use.

Several public buildings in the Town of Mansfield are using UConn water, including the Mansfield Community Center, Mansfield Town Offices, and E.O. Smith High School. The Town of Mansfield is focused on conserving the University's water, and they have signed a performance contract with Siemens Building Technologies to implement a water and energy performance contract to save water in many of Mansfield's public buildings.

There are many opportunities for savings on the off-campus accounts. Below are some of the opportunities identified at the Bergin Correctional Facility and Nathan Hale Hotel.

Bergin Correctional Facility

The largest public sector customer using UConn water is the Bergin Correctional Facility. The minimum-security prison borders the Depot Campus along Rt. 44 just southwest of campus proper. While the population of the facility does fluctuate, it houses an average of 1,000 inmates and is staffed by 218 state employees. Inmates use community bathrooms and shower stalls. The prison prepares its meals on-site in a full service kitchen and inmates are responsible for the laundry operation in each of the three dormitories. We toured the prison in early December of 2006, guided by Corrections Officer and Staff Plumber Richard Paro.

Table 20:

Daily Water Balance - Bergin Correctional Facility				
User	**Population / Occurrence**	**Usage per Occurrence (gallons)**	**Total Use Per day (gallons)**	**Usage Index**
Inmates	1,000	100	100,000	100 gallons daily per inmate
Staff	218	40	8,720	40 gallons daily per staff
Laundry (pounds/day)	321	3	963	3 gallons per pound of laundry
Cafeteria (meals/day)	2700	3	8,100	3 gallons per meal prepared
		Totals	**117,783**	

Most of the fixtures in the prison were commercial valve toilets made of porcelain china. This contrasts to most prison settings where stainless steel fixtures are more common.

Footnote regarding Bergin Correctional Facility:

- Stainless steel toilets frequently use much greater amounts of water than porcelain fixtures. Bergin has some stainless steel toilets and urinals in Campbell Dormitory.
- There are no group showers at Bergin, rather individual shower stalls where showers are often longer in duration.
- The porcelain china at the prison was in generally good condition. The fixtures included some low-flow fixtures and some high-flow fixtures, but replacement diaphragms are for 3.5 gpf toilets. This effectively causes any low flow fixture to use higher flows.
- Each dormitory building contained two to three commercial, cold-water only, washing machines. Inmates were responsible for washing approximate 321 lbs. of laundry a day across the prison in three shifts. The prison cafeteria had very little water consuming equipment, save for a commercial dishwasher and food steamer. Water use calculations for the prison laundry and cafeteria are based on standardized indices.
- The overall condition of the water meters at the prison was poor. There are a total of six meters: two 4" ISTEC meters, three 4" Hersey MCT II meters, and one 3" Hersey meter. The meters are located in the basements of these buildings. WMI's survey indicates a majority of Bergin's meters are underreporting or not registering at all.
- The meter located in the kitchen basement (Campbell K-1) was replaced within the last year. The meter is a Hersey MCT II compound magnetic drive meter. At the time of the site visit, this new meter was not working properly. None of the prison meters were installed with the required manufacturer and AWWA recommendations.

Nathan Hale Inn

The Nathan Hale Inn & Conference Center was opened in the fall of 2001, and even though it is located on the grounds of the main campus – it is considered an off-campus account. The building is five stories high with 100 guest rooms, 17 suites and 1 presidential suite. The Inn is a full service hotel, which includes a restaurant, lounge, business center, meeting rooms, indoor pool, hot tub and fitness center. The Conference Center can hold meetings for up to 750 people.

Toilets are 1.6 American Standard gravity tank toilets. These toilets flush poorly and are prone to clogging. The fill and flush valves typically begin leaking after 18-24 months.

Showerheads are low flow pressure compensating units from Symmons. The flow has reduced since installation and in many units it takes a long time to rinse off.

Many tub spout diverters have begun to leak or are difficult to operate. This spout was leaking 2 gpm when the shower was in operation.

Summary of Water Conservation Opportunities for Off Campus Use

1. Install new meters and automatic meter reading systems for all off-campus accounts. This would include the homes that are receiving free water from UConn.
2. Replace toilets and conduct leak inspection audits in the residential homes that are receiving free water.
3. Increase regularity of issuing water bills (preferably monthly). Provide water meter readings and water usage on each bill.
4. Use usage numbers in this report to set water budget for off-campus accounts.
5. Perform detailed water audits for each of large off-campus accounts.
6. Alert Bergin prison that water meters have been under-registering so that they will be prepared for sharply increased water bills.

Unaccounted/Miscellaneous

Approximately **48 million gallons of the water that is treated is unaccounted for in our model**. This unaccounted-for-water (UFW) is equal to 10% of the total water usage. American Water Works Association sets a goal for water providers of less than 10% as a target for UFW. High UFW is because of one or a combination of the following reasons:

1. Leakage in the main distributions system
2. Additional lab and miscellaneous uses
3. Conservative water use estimates in our model
4. Under-estimation of the fixture leakage
5. Flushing of fire systems
6. Fleet washing at the Motor Pool

Main line Leakage

The United States has 53,000 community water systems serving over 280 million people. Some of the pipes installed over 100 years ago are still in use today. As pipes age, various corrosion mechanisms lead to the degradation of the pipe. The situation with the underground piping at UConn is very similar to what is happening in the rest of the country. Within the past year, Connecticut Water performed leak detection testing on most of the main distribution lines at UConn. Some leaks were identified and repaired.

As part of the repair process, it is recommended that galvanic anodes be installed on the cast and ductile iron water piping. Installing a leak clamp in corrosive soils without the benefit of cathodic protection often results in future leaks. Cathodic protection systems are very cost effective – cathodic protection systems can be installed for approximately $10 per foot for lines 10” in diameter.

Under Estimation of Fixture Leakage

Below, Table 21 shows the significant impact that a toilet or other type of leak can have on water usage. Many locations on the UConn water system are not metered and some of the current meters have oversized small leaks and are not accounted for in our model. The table below demonstrates how just one toilet with a flapper stuck open can use over 2 million gallons of water in a year.

Table 21:

Rate	gal / mth		gallons / year
1 drip / second	263		3,154
5 drips / second	1,314		15,768
1 cup (8oz) / minute	5,472		65,664
1 gallon / minute	43,776		525,312
4 gallon / minute	175,104		2,101,248

Eco-Husky (http://www.ecohusky.uconn.edu/) has instituted a "STOP THE DROP" program in all of the residence halls – this program needs to be implemented for the entire campus. Consideration should be given to providing free leak repair service to off-campus users that are not metered.

We learned during the course of this study that UConn is currently expanding its metering efforts**.** We recommend that UConn immediately begin metering all off-campus billed accounts with a drive by or an automatic radio-read metering system. Total cost for upgrading the water meters on the off-campus accounts would be less than $250,000. The increase in revenue that would be realized by replacing these old meters would be approximately $80,000 per year. The off-campus metering problems fall into one of three main categories:

- Meters missing, as is the case in a number of single family homes;
- Oversized meters; or
- Non-functioning meters.

The following considerations must be given to the new system:

- One type of meter should be used and all of the meters should either read in 100's of gallons or in 1,000's of gallons.
- Meters should be read and billed more frequently than once every quarter – one time per month is preferred.
- Meter readings should be listed on customer bills. Currently, only the usage and rate structure appear on UConn's water and sewer bills making investigation of meter accuracy and functionality extraordinarily difficult.

Upgrading the off-campus metering system will save water. Numerous studies have shown that if you accurately measure and bill for consumption, end users will save water. As shown above, even small leaks can add up to considerable amounts of water in a year's time.

Fire Protection Systems

We did not determine how much water was being used by the fire protection system, but we were able to determine the following fire hydrant counts:

- 112 hydrants on the Main Campus
- 28 hydrants off-campus
- 22 hydrants at Depot Campus

The default used for fire protection systems by the American Waterworks Association is 1.25%.

Fleet Vehicle Washing

UConn's fleet of approximately 525 cars, trucks and buses is managed by Motor Pool. Vehicle operators and other staff wash vehicles on an as-needed basis. The volume of water used for fleet vehicle washing at UConn is unknown but is estimated to be small. Water used for vehicle washing is not metered. A remote-read water meter was installed in the Motor Pool garage in 2006 but was placed more than 15 feet above the floor in the car wash bay and cannot be read visually without a ladder.

On average, approximately 700 gallons of water are used monthly to wash 29 vehicles at UConn (See Table 22). This estimate is based on the number of vehicle washes reported and the type of self-serve manual vehicle washing system in place at Motor Pool. Self-serve manual vehicle (non-bus) washing is estimated to use about 16 gallons per vehicle, according to the International Car Wash Association – "Water Use in the Professional Car Wash Industry". Because UConn's vehicle fleet includes large buses, the 700 gal/mo estimate assumes a per-vehicle water use factor that was adjusted upward to 24 gallons to account for the extra water required to wash buses.

Vehicle washing at UConn appears to be relatively water efficient based on the method and equipment it employs for washing. Self-serve manual vehicle washing methods like that used by Motor Pool typically use less water compared to other types of water-based systems, such as in-bay automatic and conveyor vehicle washes. The siphon detergent hose and the clean water rinse hose in Motor Pool's wash bay were both equipped with automatic shut-off nozzles. No leaks were observed during a site visit. Wash and rinse wastewater drains to the facility's oil-grease separator.

Table 22:

Month	# of Vehicles (1)	Estimate Water Use (gallons) (2)	Estimate Water Use (gallons) (3)
Oct-01	12	288	768
Nov-01	34	816	2176
Dec-01	28	672	1792
Jan-02	47	1128	3008
Feb-02	54	1296	3456
Mar-02	65	1560	4160
Apr-02	44	1056	2816
May-02	12	288	768
Jun-02	29	696	1856
Jul-02	12	288	768
Aug-02	18	432	1152
Sep-02	13	312	832
Oct-02	5	120	320
Total	373	8952	23872

Notes

1. Source: Wayne P. Landry, Central Stores Manager, UConn, Dec. 14, 2006.

2. Assumes 24 gallons used per vehicle washed.

3. Assumes 64 gallons used per vehicle washed. Hose at 8 gpm X 8 minutes to wash car or bus

The Motor Pool garage maintains a dedicated wash bay for vehicle washing that is equipped with self-serve detergent, brushes, bucket and automatic shut-off hoses. This type of manual vehicle washing is typically more water-efficient than automatic washing systems. No water-saving measures for fleet vehicle washing are recommended for the Motor Pool facility at this time. Manual washing of vehicles with automatic shut-off hoses on an as-needed basis, as currently practiced at UConn, is one of the best ways to minimize water use for this activity.

Staff is encouraged to continue their existing maintenance practices with these reminders and minor enhancements:

1. Check regularly for leaks and broken hoses, nozzles, and fittings; repair promptly.
2. Select high-pressure spray nozzles with automatic shut-offs for nozzle replacements.
3. Spot check staff that are washing their vehicles to make sure they note their wash bay usage on the vehicle wash log sheet so that accurate wash counts are recorded.
4. Require staff to note the type of vehicle washed (i.e., car, truck or bus) on the wash log sheet so that more accurate estimates of water use can be made.
5. Ensure that Motor Pool receives a regular report on its metered water use so staff can monitor facility water use for efficiency.

Future Considerations for Fleet Washing

If future vehicle washing activity increases at Motor Pool such that an automatic vehicle washing or other system is desired to replace the current manual method, other water-efficient options include automatic washing water with reclamation (recycling) systems, off-site washing, and waterless chemical foam vehicle cleaning agents. In terms of benefits and costs, each option is different:

- Automatic vehicle wash and ultra-efficient reclamation systems may provide some small water savings compared to manual washing, but they require more maintenance and energy and could cost over $100,000 (not including remodeling of wash bay) to install. Automatic and conveyor type vehicle washing systems can be cost-effective when washing hundreds of vehicles daily ("U.S. Postal Service Water Conservation Program" August 20, 2003). Currently UConn averages only one vehicle washing per day;
- Off-site washing will cost more and may require additional employee time than the current manual washing system, and
- Waterless vehicle cleaning methods using chemicals produce a clean and shiny vehicle appearance but take three to four times longer to complete than conventional washing and waxing.

Off-System Wells, Ponds and Rainwater Harvesting

There are several alternative water supply sources that could be tapped to help meet UConn's water demands for athletic field irrigation, landscape irrigation, horticultural nurseries, dust control, and other non-potable water uses such as make-up water for cooling and heating systems. Several potential off-system alternative water sources exist at UConn, in addition to wastewater reuse – but the option with the greatest potential for success is rainwater harvesting.

1. Rainwater harvesting - based on data collected rainwater harvesting (cistern and rooftop methods) have the potential of harvesting 2.8 million gallons of water per year:
    - The below sample rainfall collection potential for UConn is based on The Texas Manual of Rainwater Harvesting 3rd Ed (Brown, Chris, Gerston, Jan, Colley, Stephen). Table 23 shows site specific adjustments including local evapotranspiration and rainfall data for the town of Storrs.
    - Collect from rooftops adjacent to fields only, limit piping costs.
    - Collect in cisterns and/or water storage tanks for later reuse, e.g., dust control and street cleaning.
    - Natural ground systems (e.g., bio-swales). For example at Shenkman Training Center, because of the shallow ground table, there is bio-swale on the side of the building. As there are no gutters on the roof, it is likely that this bio-swale is larger than planned. There is potential to tap the bio-swale for athletic field irrigation.
2. Off-system wells
    - Connecticut DEP, DPH, and other state and federal water and wastewater regulations may limit the development of alternative water supply sources.
3. Ponds
    - Swan Lake and Mirror Lake – currently used as retention ponds were last dredged in the early 70's. Original capacity of Mirror Lake is approximately 2.5 million gallons and Swan is 1.5 million gallons. More information about the health of these ponds is available upon request. A suggested area for an additional retention basin / constructed pond could be near the "W" lot, this is a good location because there is an abundance of clay soil and it would be easy to divert rainwater to it.

Table 23:

Adjacent Building for Rainwater Harvesting	Usage Reason	Estimate Gallons Used for Irrigation or processes after WCM's Implemented (2)	Water Cost with WCM's Implemented (3)	Roof Surface for Rainwater Harvesting (sq. ft.) (4)	Amount of Rain Collected (gallons per season) (5)	Rainwater Harvesting Tanks Size (gallons) (1)	Irrigation Water needed in addition to Rainwater Harvesting (gallons) (6)	Cost of needed water after harvesting rainwater tanks are full (7)	Approx. Rainwater Harvesting Tank Cost parts and installation included (8)	Simple Pay back (years) (9)
Freitas Ice Forum	Morrone Soccer	480,635	$1,442	34,456	278,609	5,000	195,876	$588	$13,000	15.2
Shenkman Training Center	Practice Soccer J.O. Christian Baseball Conn. Softball Stadium	978,249	$2,935	80,697	652,511	10,000	751,207	$2,254	$19,000	27.9
Gampel Pavilion & Greer Field House	Memorial Football Sherman Astro Turf Field Two Practice Football	8,294,036	$24,882	130,796	1,057,802	30,000	2,218,684	$6,656	$51,000	2.8
Lodewick Visitors Center	Lodewick Visitors Center	90,487	$271	4,691	37,931	1,000	21,817	$65	$7,000	34.0
Kellogg Dairy Center	Once through cooling for milk	367,720	$1,103	28,235	228,306	10,000	0	$0	$16,000	14.5
Cattle Resources Unit	Wash down and Trough	245,280	$736	16,101	157,634	5,000	0	$0	$12,000	16.3
HorseBarn Hill Arena	Wet down water for Arena	8,640	$26	34,519	337,953	250	0	$0	$4,000	154.3
MotorPool	Vehicle Washing	23,872	$72	5,421	53,073	500	0	$0	$4,000	55.9
Total		10,488,919	$31,467	334,916	2,803,820	61,750	3,187,584	$9,563	$126,000	5.8

Notes:

1. Rainwater tank size could be one tank or several tanks of equal volume.
2. Evapotranspiration - Rainfall = Supplemental Irrigation needed. If more evapotranspiration occurs in one month than rain falls, then supplemental irrigation water is needed to keep the turf healthy.
3. Reduced costs after new control clocks, rain sensors, rotors, nozzles and soil moisture sensors are installed on existing irrigation systems.
4. Roof Surface was calculated by scaling area on aerial maps. A roof square footage is found by taking length X width. Roof pitch does not matter, it's only the straight down footprint of the roof which makes the catchment area.
5. Collection surface size sq.ft. X average monthly rainfall inches X gallon/sq.ft. collection coefficient = .62 gallons/sq.ft. X efficiency factor of 85%. Efficiency factor is used to account for rainfall events which don't capture all the rainfall due to splashing, overflowing gutters, first flush water removal and anything else which stops rain from entering the cistern or water tank.
6. Certain months of the year, more evapotranspiration occurs than amount of rainfall. The supplemental irrigation required exceeds the amount collected from previous month rainfall held in water tank. Larger tanks could be installed, but in this case the discrepancy is so large that a larger tank wouldn't be economical. The tank size is adequate for the other months' irrigation purposes, potable water is more economical to buy, than it is to buy a larger tank for only a couple of months of supplemental irrigation.
7. Some months, usually the hottest months of the year require additional supplemental irrigation water to be supplied by the potable water system. Although much more water than required by the turf is collected, the frequency at which it falls on the collection area can be sporadic from month to month.
8. Water tanks are priced at approximately $1.00 per gallons for first 10,000 gallons, $.70 cents per gallon over 10,000 gallons. Additional costs for a rainwater harvesting system include: delivery charge @ $1.50 per mile, filtration, roof washers, gutters, trenching, pumps, controls, connection to irrigation system, floats, tank foundations, and engineering services for structural planning.
9. Pay back = estimate gallons used for irrigation - additional amount required when rainfall is lower than evapotranspiration divided by cost of water storage tank and parts and labor.