PREVENTING THE OVER-CONSUMPTION OF LONG ISLAND'S SOLE SOURCE AQUIFER

Developing Water Conservation Strategies for the Town of North Hempstead

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FOREWORD

Graduate students, within Columbia University's M.S. Sustainability Management program, developed this report for the capstone workshop requirement. The capstone workshop is a client-based consulting project that students undertake to address critical sustainability management issues. The project is the culmination of the program's studies and is a requirement to graduate. Through this experience, students receive hands-on sustainability management experience and increase their understanding of the real-world constraints under which sustainability managers operate. This report includes analysis and recommendations authored by the group members of the Columbia Capstone Workshop: Preventing the Over-consumption of Long Island's Sole Source Aquifer, under the direction of Kizzy Charles-Guzman.

DEFINITIONS

Terms	Definitions
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.
Peak period	Time of the year during which demand is highest. For the purposes of this paper, we define the peak for the ToNH as encompassing May to October.
Public water supply	Water withdrawn by public and private water suppliers and delivered to users. Public water suppliers provide water to domestic, commercial, and industrial users, for public use, and irrigation.
Pumpage	Synonymous with water withdrawals. Most commonly found in reporting data by water suppliers to the DEC.
Saltwater intrusion	The movement of saline water into freshwater aquifers, which can lead to contamination of drinking water sources and other consequences. Water extraction drops the level of fresh groundwater (i.e. water tables), reducing its water pressure and allowing saltwater to flow further inland. Saltwater intrusion can also be worsened by extreme events like hurricane storm surges and by sea level rise.
Water usage	As used in the analysis for this report, water usage consists of water resources that are delivered and billed by the water suppliers to end users. It differs from water withdrawals as it precludes water used for various public services (i.e. firefighting, main/hydrant flushing, street cleaners, etc.) and which is lost through leakage during distribution. Sometimes referred to as unaccounted water.
Water withdrawal	Freshwater taken from ground or surface water sources, either permanently or temporarily, and conveyed to a place of use.

LIST OF ABBREVIATIONS

Abbreviation	Definition
DEC	(New York State) Department of Environmental Conservation
IANY	Irrigation Association of New York
LICAP	Long Island Commission on Aquifer Protection
LISSA	Long Island's Sole Source Aquifer
MGD	Million gallons per day
NOAA	National Oceanic and Atmospheric Administration
NYIT	New York Institute of Technology
NYS	New York State
ToNH	Town of North Hempstead
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WA	Water Authority
WD	Water District

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EXECUTIVE SUMMARY

Nassau County is presently at risk of over-drawing water resources from its single source of freshwater, Long Island's Sole Source Aquifer. The Office of Sustainability, in the Town of North Hempstead (Nassau County) seeks to help reduce the potential for the overconsumption of this shared resource and serve as an example to its neighboring towns by implementing effective water conservation practices.

Defining the Problem

Water management within the ToNH is complicated by the fact that water services are provided by a decentralized system of 15 water suppliers and the Town is comprised of 47 villages, each with their own jurisdictions and local codes. The Town receives 100% of its water supplies from an aquifer system that is currently facing a cycle of reinforcing threats; overconsumption reduces water levels in the aquifer system which exacerbates water quality issues, including salt-water intrusion and water pollution, which contributes to reduced freshwater supplies. While there are many different stakeholders involved in water issues on LI, local water management for the ToNH is further constrained by a lack of data on water resources and usage patterns and by a lack of regional coordination for water management planning.

Methodology

In order to recommend a holistic and applicable set of policy alternatives to the ToNH, a multi-pronged research approach was adopted. This approach included a Supply and Demand Assessment focusing on various users (i.e. residential, commercial, etc.) and regulators (i.e. state, federal, local) of water resources; stakeholder and expert interviews to identify key trends, opportunities and needs; and a comparative analysis of best practices and case studies relevant to the ToNH's profile and situation.

Main Findings

1. ***The ToNH mainly faces a seasonal water issue***

This report's analysis of water withdrawal and usage rates within the ToNH revealed that annual water consumption is fairly stable around 17 billion gallons, but the summer months (June through September) are critical periods for water consumption, representing historically ~50% of annual water usage. This period coincides with low groundwater recharge rates, creating a seasonal imbalance within the aquifer system.

2. ***Outdoor irrigation is driving the seasonal water issue and is ripe for conservation***

The research findings show that outdoor irrigation activities, particularly for landscaping, are the main component of water usage (estimated at ~56% of total usage from May to October). Additionally, outdoor irrigation has the potential to include significant waste (up to 50% according to the US EPA), and has fewer existing federal mandates and incentive programs targeting it (compared to indoor water usage), making it a prime area of focus for conservation.

3. *Challenges for addressing water issues can vary widely by user segment*

Water conservation within the residential sector is challenged by several factors including weak pricing signals, a lack of consumer awareness of water issues and conservation practices, weak enforcement of existing water usage regulations and the lack of a comprehensive water management strategy. Alternatively, while the commercial sector tends to be aware of water issues and generally in advance of regulations, it does face low return-on-investment (ROI) for water efficiency projects due to the low cost of water and the high costs for measuring detailed water usage. There is also some conflict in existing building codes and regulations that inhibit conservation practices to be adopted.

Recommendations & Next Steps

The development of recommendations was tailored to address the main opportunities and needs for the ToNH as identified during the research process. The prioritization and ultimate selection of our final recommendations was targeted towards actions specifically under the Town's control. Additional factors of consideration were (1) ease of implementation, (2) cost efficiency and equity, and (3) opportunity and timing of overall water conservation.
Key recommendations proposed in this report that the ToNH can implement include:

[1] Implement an irrigation infringement request feature in its 311 telephone system • Nassau County has existing lawn watering code applicable to ToNH but unevenly enforced • Applicable to both residential and commercial properties	**[2] Pursue licensing certifications for its irrigation installers** • Implement at County level for cost efficiency • Certification includes water conservation technology and practices so targets reducing outdoor water waste
[3] Coordinate a collaborative cost-avoidance study with stakeholders • Necessary to create defensible policies to incentivize and offset conservation investment costs • Work with NGOs and water suppliers; potentially fund through grants	**[4] Host an annual workshop on water conservation to share best management practices and coordinate conservation efforts** • Leveraging existing industry groups but targeted towards the ToNH • Agenda could include elevating public awareness, water pricing, smart irrigation technology, greywater reuse opportunities, etc.

Additionally, this report provides 7 additional recommendations that the ToNH can implement depending on its future conservation planning. To support the ongoing management of water resources, this project also designed a toolkit for the ToNH that includes:

1. A score card for evaluating and selecting future initiatives;
2. A GIS mapping tool to visualize water use characteristics;
3. A water database of currently available water data (2010 – 2014) that provides an updated profile of North Hempstead's water usage and withdrawal trends.

1. Project Overview

1.1 Project Background

Nassau County is presently at risk of over-drawing water resources from its single source of freshwater, Long Island's Sole Source Aquifer (LISSA). To prevent the overconsumption of this resource, the New York State Department of Environmental Conservation (DEC) has implemented withdrawal caps for the majority of towns in Nassau County. While towns with DEC caps continue to remain under their annual water withdrawal caps, towns without limitations are periodically over-drawing the aquifer exacerbating significant stressors to LISSA.

Main stressors on the LISSA:

- Spikes in outdoor water usage during summer months when the natural recharge rate of the aquifer is at a minimum can cause salt-water intrusion and other contamination
- Renewed competition for water resources from New York City
- Climate change induced sea-level rise can decrease aquifer reserves by exacerbating salt-water intrusion
- Climate change induced drought can decrease aquifer reserves through evapotranspiration

The client for this project, the Office of Sustainability, in the Town of North Hempstead (Nassau County), seeks to help reduce the potential of overconsumption of this shared resource and serve as an example to its neighboring towns by implementing effective water conservation practices.

The town serves a population of 240,000 that divides into 31 incorporated villages and 16 unincorporated hamlets of approximately 100,000 residents that are within the town's jurisdictions. These villages typically receive their water supply from a decentralized system of 15 water suppliers.

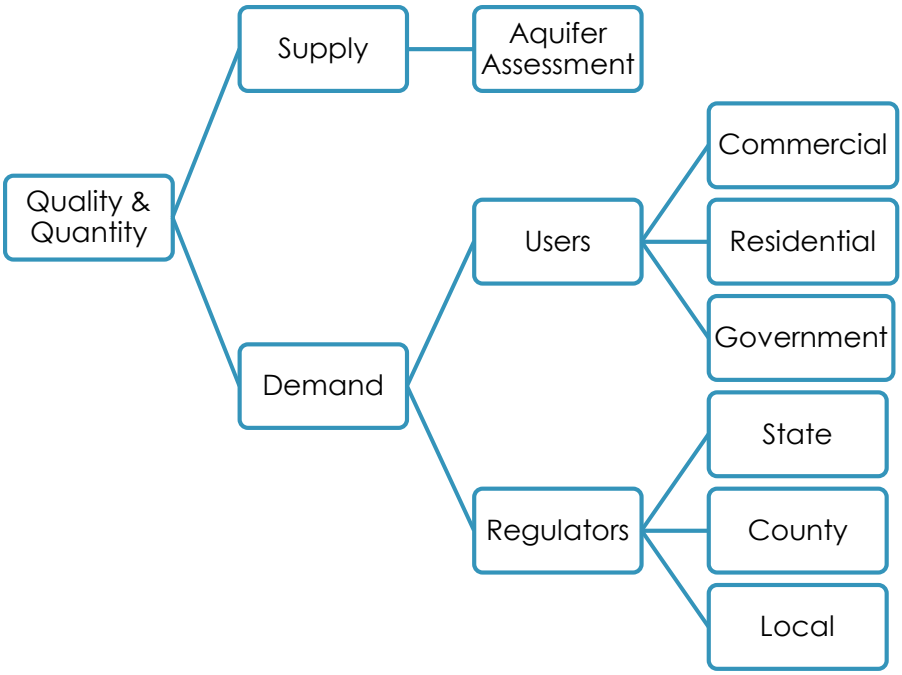
To provide a clear context of the issue, this report starts by providing a detailed overview of the key components of water management in Nassau County (LI). In the following section (Section 3), this report discusses the hydrogeology of the LISSA and the variety of factors that influence the availability of clean groundwater within the aquifer system. Section 4 proceeds through the lens of groundwater demand, providing an in-depth discussion on the many variables influencing water withdrawal and consumption patterns within the Town. The report culminates with the recommendations for the Office of Sustainability in the Town of North Hempstead to integrate into its mission of reducing the overconsumption of the LISSA.

1.2 Methodology

In order to recommend a holistic and applicable set of policy alternatives to the ToNH, a thorough analysis of the town's water usage was conducted. Using a multi-pronged approach and multiple data collection methods, the project's research focused on identifying the diverse variables that influence the state of the sole source aquifer. The research and analysis were conducted in three phases:

1. **Supply and Demand Assessment**
   Analysis was conducted on the supply and demand of groundwater in order to assess relevant recommendations. As demonstrated by Figure 1, this research included (1) conducting an evaluation of the aquifer system, (2) profiling the different users of water in the Town, and (3) identifying current laws and regulations on the federal, state, and town level that are pertinent to water usage in the ToNH.

FIGURE 1: RESEARCH APPROACH



2. **Expert and Stakeholder Interviews**
   Primary research was conducted through phone interviews and emails to gather qualitative and quantitative professional insight on the current trends, challenges, and future of the town's source of water. Professionals interviewed included sustainability experts, local water suppliers, and higher-level policymakers from the ToNH and NY State. The interviews also provided much needed information that was not publicly available through published research and organization/department websites. A complete list of all the interviews is available in Appendix 1: Expert & Stakeholders Interviews.

3. **Comparative Analysis**
   Case study analysis and technical research were conducted for benchmarking and comparison to the ToNH. Specifically, the research focused on sustainability plans or projects that have been implemented with specific water conservation efforts. The combination of these methods provided insight on best water management practices and technological solutions that are applicable to the town.

With the support of extensive research mentioned above, the recommendations for the client were identified and evaluated based on 3 selection criteria themes: ease of implementation, cost implications and water conservation potential. Section 5 of this paper further explains the methodology and rationale for the development and application of the recommendation criteria.

2. Water Management In Nassau County, Long Island

2.1 History of Water Management Activities on LI

Modern efforts to manage water systems on Long Island elevated dramatically in the 1970's due to a convergence of factors. This included a sharp increase in population in Nassau and Suffolk Counties[1] and the introduction of federal drinking water standards (i.e. Clean Water Act (1972) and Safe Drinking Water Act (1974)). Historically, water management on LI has been managed independently by Nassau and Suffolk Counties, with each legislature responsible for enacting programs to meet federally mandated requirements. In 2014, as described in Section 2.2 below, the recent step towards developing an integrated approach to water management was taken by both counties through the creation of the Long Island Committee on Aquifer Protection (LICAP). Many water experts still continue to emphasize the need for the creation of one over-arching body or 'compact' with the powers to regulate all aspects of the water system as is used throughout most of NY State.[2]

Nassau County's proximity to New York City (NYC) and the potential for competition for water resources is a particularly relevant concern for the ToNH. While NYC relies on an extensive system of surface water storage in Upstate New York for its drinking water needs, it has frequently looked to groundwater resources on LI as a potential backup or alternative supply for its growing needs. For instance, in 2004 NYC proposed setting up an Aquifer Storage & Recovery system (or ASR) to store water resources during "wet" periods for later recovery, but this idea was later abandoned.[3] More recently, as part of NYC's Water for the Future Program, NYC once again raised the possibility of using LI groundwater. These actions continue to be a driver for developing stronger conservation and integrated water management plans across LI, but particularly for Nassau County. More information on select water-related events influencing water management on LI is available in Appendix 2: Select Water-Related Events Impacting Water Management in LI.

2.2 Stakeholders Involved in LI Water Issues

A significant complication to creating water conservation strategies for the ToNH is the number of stakeholders that are involved directly and indirectly in different elements of water management on Long Island (see Table 1). This includes stakeholders from federal, state and local levels, including participants from both public and private sectors. The large variety of stakeholders unfortunately does not equate into a clear system for managing water or even understanding the current state of water systems on the island. One of the most influential groups are the water suppliers, both individually through their operating practices and collectively through the lobbying and activities of their various industry organizations. Additionally, the DEC plays a critical role in managing groundwater resources on LI, but has been hampered in its ability to create a truly comprehensive integrated water management system due to lack of funding and staff, including over 100 staff reductions (representing ~30% of total staff) from its Water Division since 1990.[4] The DEC has also faced several lawsuits from various water suppliers on LI which have further limited its ability to effectively manage water resources, including setting or enforcing effective caps on some withdrawals. Overall, while there are a variety of stakeholders that the ToNH can leverage

for developing water conservation strategies, particularly for raising public awareness and coordinating efforts of water suppliers, there are significant challenges to overcome in terms of data availability, regulatory authority and financing to support more complex conservation efforts.

TABLE 1: STAKEHOLDERS IN WATER MANAGEMENT ON LONG ISLAND

Stakeholder	Level	Role in LI Water Management
US Environmental Protection Agency (EPA)	Federal	Regulate water suppliers through Clean Water Act and Safe Drinking Water Act regulations focusing mainly on water quality issues. More focus on surface water than groundwater. Also sponsoring programs on storm water management, stream and wetland area management, etc.
US Geological Survey (USGS)	Federal	Main scientific body studying aquifer health and performing research on water issues (groundwater monitoring, saltwater intrusion, etc.). Recent funding issues with NYC & Nassau County has limited efforts.[5]
Federal Emergency Management Agency (FEMA)	Federal	Providing $729 million in funding for water infrastructure repair (mainly wastewater systems) and resiliency following Hurricane Sandy damage in 2012[6].
NY Department of Environmental Conservation (DEC)	State	Founded in 1970, through passage of NY Environmental Conservation Law; regulates permitting of all groundwater withdrawals over 45 gallons per minute as well as discharges through state pollution discharge elimination system. Sets safe withdrawal levels or 'caps' for public water suppliers and monitors compliance.
NY Department of Health (DOH)	State	Regulates protections for drinking water quality through part 5 of NY State Sanitary Code. Also regulates irrigation systems to have backflow devices.
Long Island Water Districts (WD) & Water Authorities (WA)	Local	Almost 50 different suppliers provide water services on LI including 15 within the ToNH, which have significant power in establishing water conservation methods, influencing legislation and effecting overall water management.
Long Island Commission on Aquifer Protection (LICAP)	Local	Water management body created in 2014 by Nassau & Suffolk County legislatures though with limited funding or no clear regulatory powers; 9-member board is from various government agencies supported by various ex-oficio members (non-voting) from industry; main objective is to create Groundwater Resources Management Plan by 2017
Long Island Water Workshop (LIWC)	Local	Association of public and private water suppliers on LI created in 1951. Structured in multiple committees focusing on topics like regulatory coordination, water supply coordination, drinking water standards, etc.

Nassau County Water Resources Board (NWRB)	Local	Long defunct agency originally started in 1970's, but resurrected in 2014 with main objective to monitor potential threats to Nassau County groundwater resources; serves as Nassau County's interface to other water focused organizations.[7]
Nassau Suffolk Water Commissioners' Association (NSWCA)	Local	Association of water commissioners from 21 water districts (including 7 within ToNH) created in 1986. Promote environmental excellence and best practice management for water suppliers.
Long Island Clean Water Partnership (LICWP)	Local	Partnership of several prominent NGOs and local groups advocating on LI water issues including the Nature Conservancy, Peconic Bay Keeper, Citizen's Campaign, and over 30 others. Focus on raising public awareness of issues, mobilizing citizens to take action and represent community on water issues.

2.3 Water Services Delivery in the ToNH

Water services are delivered in the ToNH through a decentralized system of 15 main public water suppliers (Table 2). The majority of these suppliers are water districts (13), which are quasi-government agencies that are funded through a mix of taxes and billed services, while two of the larger providers are water authorities, which are business organizations funded purely by billed services (see Appendix 3: Water Districts & Water Authorities for more differences between the two types of suppliers). The average water supplier in the ToNH is small, typically with a service area of several square miles, serving a population of 10,000 to 30,000 people and utilizing 3 to 6 wells to generate their supply of water. Two suppliers, the Water Authority of Western Nassau and the Manhasset-Lakeville Water District accounted for 38% of total water withdrawals between 2010 and 2014. These two suppliers would be key stakeholders for targeting conservation efforts. Suppliers typically withdraw water resources directly from the aquifer system, though two suppliers purchase water wholesale from other water districts to serve their constituents (*highlighted in Table* 2). Capital expenditures for water system upgrades and expansions plans are typically funded through municipal bonds issued directly or under-written by the ToNH.[8] Wastewater services for all residences (100% metered and on sewer system) is provided outside the confines of the ToNH.

TABLE 2: OVERVIEW OF WATER SUPPLIERS IN THE TOWN OF NORTH HEMPSTEAD

#	Water District	Number of Wells	Population Served	Number of Services	5-Yr Average Pumpage (2010-2014) [MGD]	% of Total Water Pumpage
1	Albertson WD	4	13,500	4,054	2.07	**4%**
2	Carle Place WD	4	9,038	2,901	1.61	**3%**
3	Garden City Park WD	6	18,000	7,088	3.29	**7%**
4	Glenwood WD	-	1,000	195	0.15	**0.3%**
5	Manhasset-Lakeville WD	18	44,600	10,700	6.83	**14%**
6	Mineola WD	5	20,500	5,840	2.85	**6%**
7	Old Westbury WD	6	4,624	1,372	2.08	**4%**
8	Plandome WD	-	1,350	441	0.26	**1%**
9	Port Washington WD	13	30,000	10,000	3.80	**8%**
10	Roslyn WD	8	-	-	3.45	**7%**
11	Sands Point WD	3	2,900	1,573	1.14	**2%**
12	WA of Great Neck North	11	32,400	9,097	4.36	**9%**
13	WA of Western Nassau	24	120,000		11.62	**24%**
14	Westbury WD	10	20,500	6,018	3.36	**7%**
15	Williston Park WD	3	10,000	2,400	1.14	**2%**
	Total	112	328,412	61,679	48.01	**100%**

2.4 Water Conservation Efforts in the ToNH

Water conservation measures are an important component of water management strategies. The following are the different programs and initiatives implemented within the Town.

Rainwater Harvesting Program

In 2012, the ToNH began an initiative called "Recycle the Rain" run by the Office of Sustainability. The Office offers a discounted price of $50 for fifty-gallon rain barrels to residents to collect rainwater that can be used for outdoor irrigation as a conservation incentive.[9] The barrels are made out of recycled materials and can collect up to 1,800 gallons of water in one summer.[10] Residents are required to watch a 25-minute instructional video on the accurate ways of using a rain barrel prior to purchasing.

Educational Campaigns

The educational outreach program by the Office of Sustainability is directed toward the Town's public school students as follows:

- For all grades, the ToNH's Environmental Outreach Team delivers a 45-60 minute presentation to public schools in the town on water conservation, including recycling and consumption reduction. The community can also access the presentations online.
- From 6th to 12th grade, the Office of Sustainability can arrange classroom visits to conduct presentations on climate change. Students can also arrange field trips to North Hempstead Beach Park to learn more about residents' role in sustaining the environment, conserving and protecting water in the community.

Efficiency Initiatives

The Water Authority of Great Neck North, within the ToNH, provides free showerhead trade-in and leak inspection audits to their customers. Prior initiatives included ensuring water services applications met standards set by the DEC and suggesting a water conservation educational program within the Great Neck Public School System.[11]

3. State Of The Sole Source Aquifer

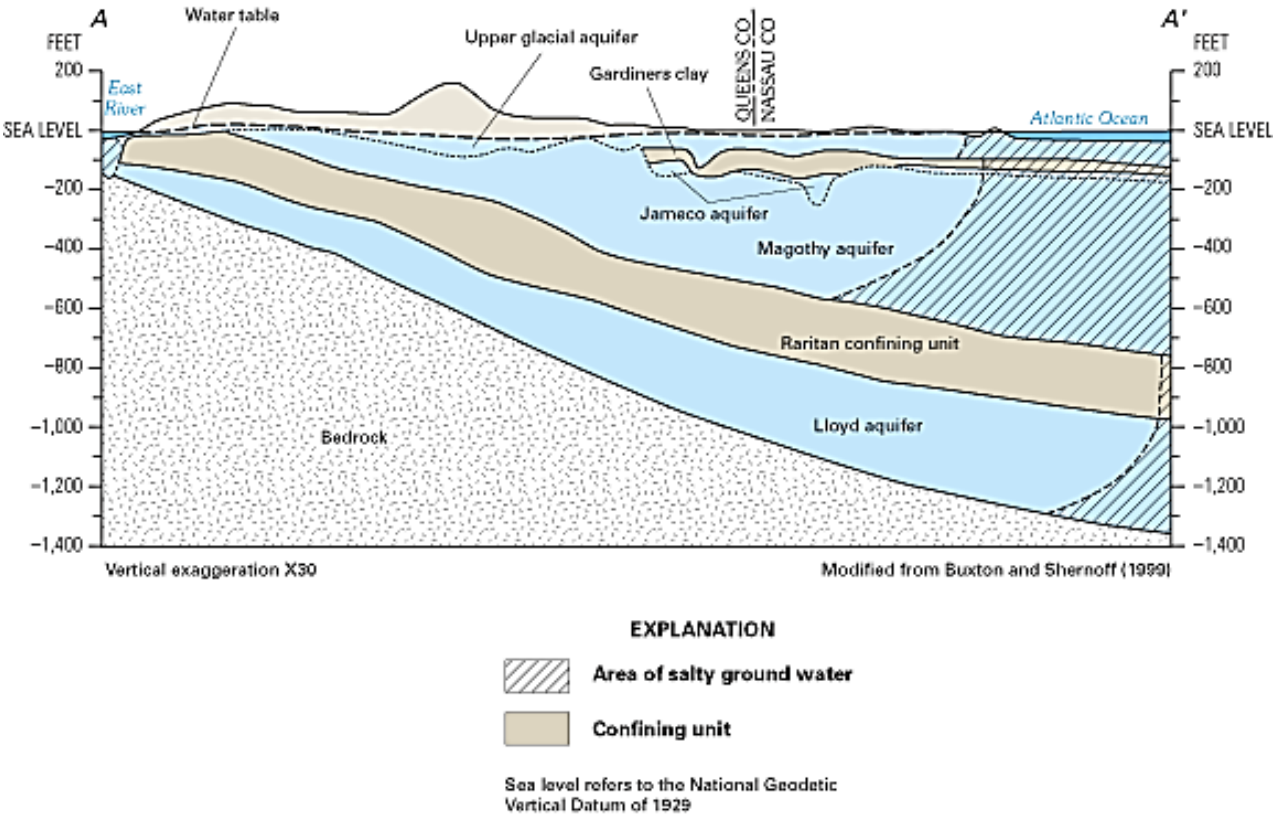
3.1 Overview of the Long Island Sole Source Aquifer System

A sole source aquifer or SSA is a federally defined designation that applies to any aquifer that provides 50% or more of the drinking water to an overlying population.[12] The main implication of an aquifer receiving the SSA designation is that it establishes some limited federal protection, mainly focused on enhanced scrutiny of any projects that could endanger the water quality of the SSA. More information on SSA is available in Appendix 4: What is a Sole Source Aquifer?

On Long Island, Suffolk and Nassau counties depend entirely on the region's groundwater to supply all their water needs. Groundwater reserves are stored in three main aquifers – (1) the Upper Glacial (UG), (2) the Magothy (MG) and (3) the Lloyd (LD). There are also several smaller, localized water bodies in the system including the Jameco and the North Shore aquifers, each hydrologically connected to one of the three main aquifers.[13]

Figure 2 shows the UG closest to the surface, the MG in the middle and the LD below. Clay, silt, gravel and sand are the primary sediments and act as confining units separating the flow of water between the aquifers. Beneath the layers; Gardiners Clay (separating the UG and the MG in the eastern part of island) and the Raritan Clay (separating the MG and LD) at a depth of 2,700 feet, bedrock forms the base of the combined aquifer system.[14]

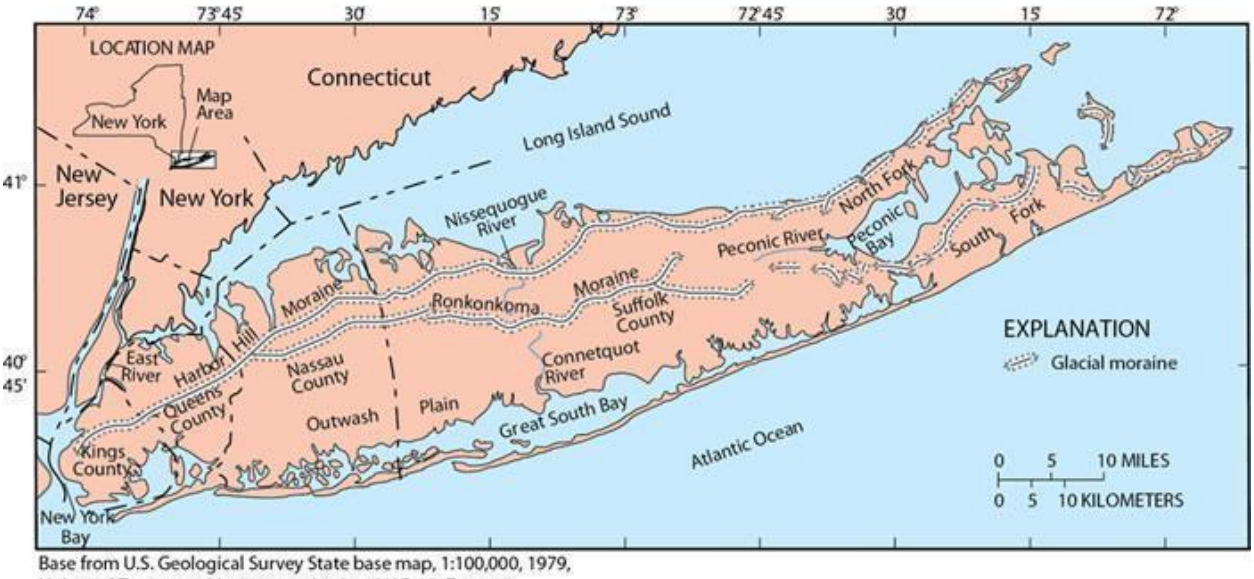
Figure 2: Cross Sectional View of the Long Island Aquifer System
Source: USGS[15]



Near the surface, the UG aquifer contains the water table for most of LI, and is most susceptible to pollution from anthropogenic sources. As a result, the UG aquifer is used less as a source of freshwater.[16] The MG aquifer is the largest source of freshwater in the system with a thickness that can reach 1,000 feet. The LD aquifer has a thickness up to 500 feet and is the deepest below ground (1,500 feet) excluding areas in northern Nassau County where the MG no longer extends. NY State established a moratorium on the development of new wells tapping the LD in 2013 in order to protect the water resource, which is essential for coastal communities.[17]

This aquifer system is surrounded by saltwater on all sides with the Long Island Sound to the north, the Atlantic Ocean to the east and south, and New York Bay and the East River to the west (Figure 3). This feature classifies the water bodies in the LI aquifer system as coastal aquifers, where the interaction between the freshwater and saltwater layers is in constant flux.[18]

FIGURE 3: LONG ISLAND MAP



3.2 Threats to the Long Island Sole Source Aquifer System

3.2.1 Climate Change

Consequences of climate change are higher temperatures, increased precipitation, increased likelihood of drought and sea level rise. An increase in average temperatures will accelerate evapotranspiration loss from the system and increase customer demand for water service, particularly during the warmer summer months, exacerbating temporal water availability issues during peak periods. Extreme heat events and droughts will also increase water demand during peak periods contributing to water availability issues; decreases in extreme cold events and snow levels could increase surface water runoff and thus lower

groundwater recharge rates during winter months. Increased precipitation to the region will also come in higher intensities, which will lead to a higher percent of runoff and thus potentially less recharge.

Table 3 provides an overview of the main climate change models referenced in terms of potential impacts for New York State. The models provide predictions using three scenarios modeled across different periods up to 2100 for Region 4 (NYC and LI). The complexity of modeling such a dynamic system leads to wide bands of potential impact, but there is a clear upward trend in the intensity, variability, or occurrence rate of all environmental conditions evaluated.

TABLE 3: EXTREME WEATHER EVENT PROJECTIONS

Climate Change Projections
Mean Annual Changes

Region 4 - TEMPERATURE

Baseline (1971-2000) 54.6F	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	+1.5 F	+2.0 to 2.9 F	+3.2 F
2050s	+3.1 F	+4.1 to 5.7 F	+6.6 F
2080s	+3.8 F	+5.3 to 8.8 F	+10.3 F
2100	+4.2 F	+5.8 to 10.4 F	+12.1 F

Region 4 - PRECIPITATION

Baseline (1971-2000) 49.7 inches	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	-1%	+1 to 8%	+10%
2050s	+1%	+4 to 11%	+13%
2080s	+2%	+5 to 13%	+19%
2100	-6%	-1 to +19 %	+25%

Region 4 - SEA LEVEL RISE

Baseline (1971-2000)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	2 in	4 to 8 in	10 in
2050s	8 in	11 to 21 in	30 in
2080s	13 in	18 to 39 in	58 in
2100	15 in	22 to 50 in	75 in

Source: "Climate Change in New York State – Updating the 2011 ClimAID Climate Risk Information". NYSERDA, 2014.

It is likely that precipitation will rise given that almost all climate models project some level of increase varying from -1% to 25% on Long Island by 2100.[19] An increase in precipitation will likely increase groundwater recharge rates and surface water stream flow rates, expanding overall freshwater supplies and lowering customer demand. However, much of this precipitation may be in the form of more severe storms that can decrease the rate of recharge and pose risks of increased flooding and higher runoff flows.

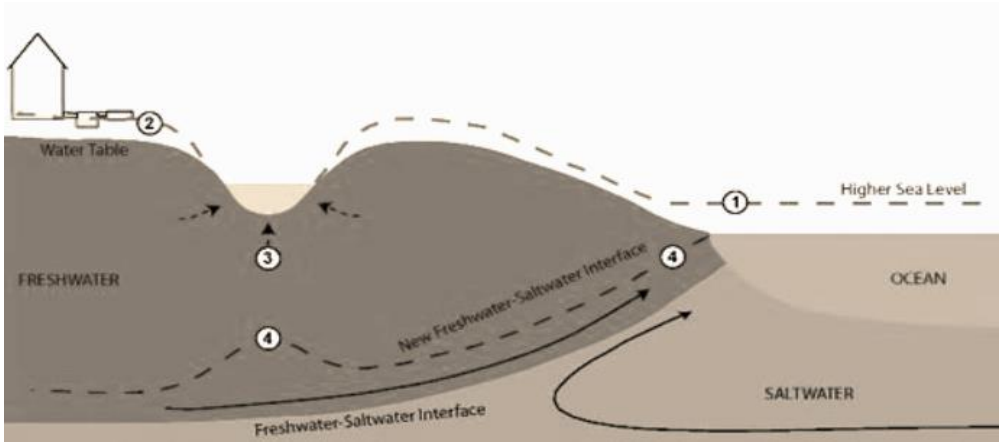
Rising sea levels, as depicted in Figure 4, will raise the water table in North Hempstead, increasing streamflow, but will also lead to expanded saltwater intrusion, necessitating well

closures or replacements. Overall, the availability of fresh groundwater supplies on Long Island will decrease with rising sea levels.

The rate of sea-level rise ranges from about 2.4 to 3.9 mm/year based on long term trend data.[20] Sea level rise can erode beaches and bluffs, leading to shoreline retreat and diminished areas of aquifer recharge. Landward movement of the sea results in the overall rise in the position of the freshwater-saltwater interface below ground and increases coastal groundwater levels.[21] Rising sea level also causes upstream migration of saltwater in coastal estuaries, inundation of low-lying areas including wetlands and marshes, and submergence of coastal aquifers.[22] Sea level rise pushes saltwater zones in coastal aquifers landward and upward, accelerating rates of saltwater intrusion into aquifers already experiencing saltwater contamination.

FIGURE 4: IMPACT OF SEA LEVEL RISE ON LI AQUIFER

Freshwater is underlain by denser saltwater in the shallow (water table) aquifer system of Long Island.
1: Conceptualized position of higher sea level.
2: Corresponding position of higher water table.
3: Resulting increase in hydraulic gradient and flow to streams.
4: Associated decrease in the depth to freshwater-saltwater interface. As this interface moves, higher drinking water supplies may be affected. Credit: Ben Gutierrez, USGS.



The overall impact of climate change on the water cycle in North Hempstead is likely to be varied in terms of overall water supply, but there is a strong likelihood that water demand behavior will be impacted, particularly during the summer period. The increased variability will lead to more extreme disparities between supply and demand levels. Water suppliers will need to evaluate long-term capital budgets to anticipate potential needs related to storage capacity, number of supply wells, and other infrastructure adaptation. Conservation measures may also prove as an effective resiliency measure.

3.2.2 Contamination

Another threat to the LISSA is the contamination of groundwater resources, which result in the degradation of drinking water supplies and coastal waters. Although overuse and contamination of groundwater are common throughout the United States, the proximity of coastal aquifers to saltwater creates unique issues with respect to the ToNH's groundwater sustainability. These issues are primarily those of saltwater intrusion into freshwater aquifers and changes in the amount and quality of fresh groundwater discharge to coastal saltwater ecosystems. The most salient threat for the ToNH is saltwater intrusion, information on other contaminates is available in Appendix 5: Other Pollution Concerns.

Saltwater Intrusion

Saltwater intrusion is the movement of saline water into freshwater aquifers and is exacerbated by the over pumping of groundwater. Because saltwater has high concentrations of total dissolved solids and certain inorganic constituents, it is unfit for human consumption and requires costly desalination treatments. Saltwater intrusion reduces fresh groundwater storage and, in extreme cases, leads to the abandonment of supply wells when concentrations of dissolved ions exceed drinking water standards. The problem of saltwater intrusion was recognized as early as 1854 on Long Island, New York, thus predating many other types of known drinking-water contamination issues.[26]

The Jameco Aquifer, which exists locally along the northern and southern parts of Nassau County, is no longer usable due to saltwater intrusion. Continuous monitoring is required as saltwater intrusion is indicated by analyzing water samples collected periodically over time.[23]

On Long Island, over pumping of the Lloyd, North Shore, and Upper Glacial aquifers on Great Neck has caused extensive saltwater intrusion.[24] Seven public-supply wells have either been shut down or are currently being affected.[25]

Many states and communities along the Atlantic Coast are taking actions to manage and prevent saltwater intrusion to ensure a sustainable source of groundwater for the future. For more information on actions taken to manage saltwater intrusion, refer to Appendix 6: Solutions to Saltwater Intrusion. Considering alternative water sources to water-stressed regions can also relieve pressure from traditional water sources and allows for better hydrologic recuperation of these areas. A comprehensive set of alternative water sources is available in Appendix 7: Alternative Water Resources - Circumventing the Sole Source Aquifer.

3.3 Water Budget of Long Island

The water budget of Long Island is well studied and is an important context to have when reviewing water management measures. Since the water budget is not generally reported at the town level, it is summarized here for the Long Island land mass as a whole from the United States Geological Survey (USGS) review. All figures in this section are reported for Long Island as a whole and it is assumed that the ToNH water budget is roughly proportional

to the Long Island region. The major flows of water in and out of the aquifer on Long Island are summarized in Table 4. Figures reflect annual sums but are reported using daily averages of Million Gallons per Day (MGD) per most reports.

TABLE 4: ESTIMATED SOURCES AND DAILY AVERAGES OF MAJOR INFLOWS AND OUTFLOWS OF LONG ISLAND'S GROUNDWATER PER USGS STATE OF THE AQUIFER SUMMARY

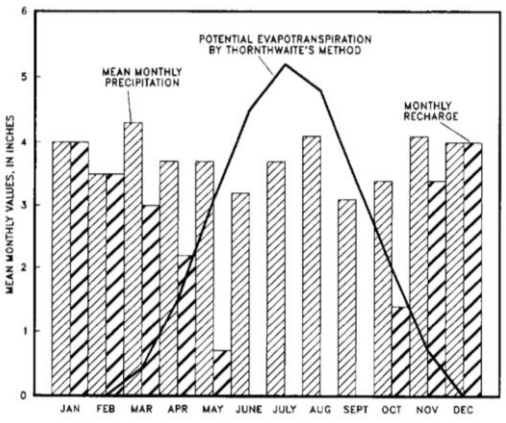
Inflow (+)	MGD	Outflows (-)	MGD
Precipitation recharge	1,180	Groundwater pumped withdrawals	500
Recharge basins	100	Stream flow	220
Infrastructure leaks	42	Subsurface outflow	690
On-site septic systems	74		
Total Inflow	**1,400**	**Total Outflow**	**1,400**

3.3.1 Inflow

Precipitation

Although Long Island enjoys a healthy natural supply of precipitation recharge of about 1,180 MGD, it is not evenly distributed throughout the year. Previous studies of the aquifer indicate that precipitation recharge is actually zero in the June, July, August and September due to increased natural evapotranspiration losses (Figure 5).[27] This has potentially important consequences as these low-recharge months coincide exactly with high usage periods as explored in Section 4.2.

FIGURE 5: TYPICAL ANNUAL PROFILE OF NASSAU'S AQUIFER IN TERMS OF (1) MEAN MONTHLY PRECIPITATION, (2) POTENTIAL EVAPOTRANSPIRATION, AND (3) MONTHLY RECHARGE LEVELS. NOTE THE MONTHLY RECHARGE TO THE AQUIFER IS EFFECTIVELY ZERO IN SUMMER MONTHS. SOURCED FROM KU ET AL[28]



3.3.2 Outflows

Water suppliers throughout the region withdraw groundwater from the aquifer through a network of wells. This aggregated pumped withdrawal is the major non-natural form of outflow. Overall, groundwater withdrawal throughout Long Island is over 500 MGD, averaged over the 2005--2010 period.[29] This average rate will vary depending on the season. Although the inflow of water to the aquifer is adequate on an annual basis for the current consumption levels, there are consequences to seasonal over-extraction.

Water suppliers' withdrawals reduces other natural outflows of the aquifer. In the absence of groundwater withdrawal, there are two main natural outflow paths from the aquifer from both (1) surface stream-flows and (2) subsurface outflows. The USGS states that most of Long Island surface outflow, about 220 MGD, is an outflow from groundwater.[30] As large amounts of groundwater are withdrawn, the water table is locally depressed reducing discharge to streams and saltwater bays thus affecting the ecosystem.

All the remaining outflow levels are attributed to subsurface discharge. Therefore, a majority of the annual water inflow to the aquifer, about 690 MGD, was discharged to the shoreline as subsea discharge in the 2005-2010 period.[31] However, this annual estimate is not evenly distributed over the entire year. Depending on the season, subsurface discharge may be greater than this figure or even zero. If the pumping outflow is greater than natural inflows to the aquifer, saltwater intrusion may even contaminate groundwater resources in some coastal areas.

3.4 Key Takeaways

Just looking at the groundwater budget for LI from a regional and annualized perspective, it does not appear that there is a significant risk of LI running out of freshwater resources anytime soon. This does not mean though that there could be no issues related to localized or seasonal over extraction that must be understood and mitigated. These types of over extraction issues can lead to less subsurface water outflows (effecting salinity levels of surrounding saltwater bodies) and surface outflows (effecting streamflow levels throughout the ToNH). Both of these situations can produce environmental impacts that can effect freshwater supplies and water infrastructure systems.

This then is not simply a problem of how much water is being extracted. Instead, the concern should focus around when and where the water is extracted and how the water is being used. Since the literature on the aquifer does not capture this relationship in much detail, the capstone team conducted a seasonal analysis of groundwater withdrawal within the ToNH. The results of this analysis is discussed further in Section 4.1.

4. Groundwater Demand Assessment

4.1 Water Usage Overview

4.1.1 Seasonal Analysis of Water Suppliers

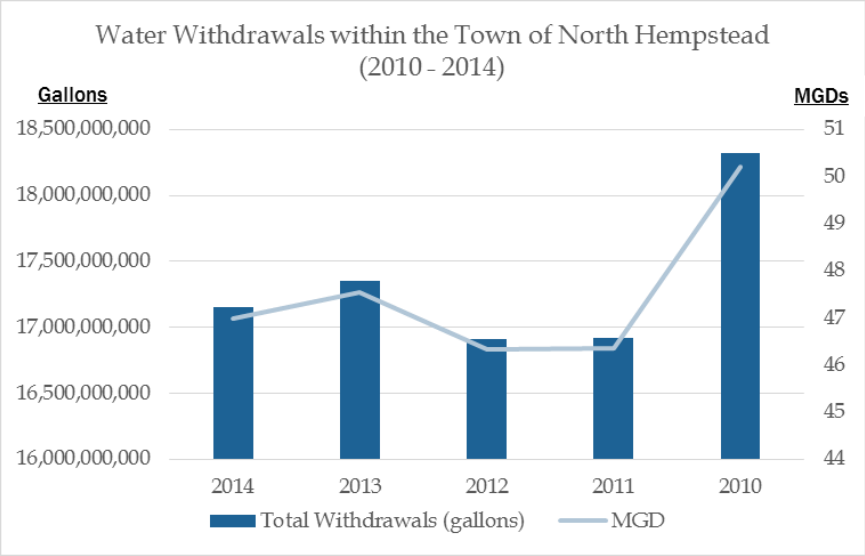
There is a significant seasonal component to water usage within North Hempstead. In Section 2, the water budget was explored as an annual aggregate for the whole of LI. However, it was insightful for the ToNH to quantify water demand at a more local level, both in higher spatial and temporal resolution, in order to identify effective conservation measures. Understanding that consumer water demand has a seasonal, non-constant quality motivated a breakdown of the ToNH water withdrawals in a resolution absent from literature reviews.

Public Supply of water usage represents approximately 92% of overall water supply in Nassau.[32] It is therefore presumed that a similar proportion of the Town of North Hempstead's water withdrawals follow this pattern. Public water supply refers to water withdrawn by public and private water suppliers and delivered to domestic and commercial users. Accounting for the ToNH public suppliers then proved the most critical to characterize the water usage for the region.

Since actual demand and consumption data of water usage is not readily available in the ToNH, water withdrawals or pumpage of each of the water suppliers was used as a proxy for actual demand. To develop this understanding, a request for 5 years of DEC pumpage records for the relevant water utilities operating within the ToNH was requested under the New York State Freedom of Information Law (FOIL). Monthly well withdrawal levels are reported for each utility over five years and have been consolidated into a single database that can be seen in Appendix 8: Town of North Hempstead Water Database.[33]

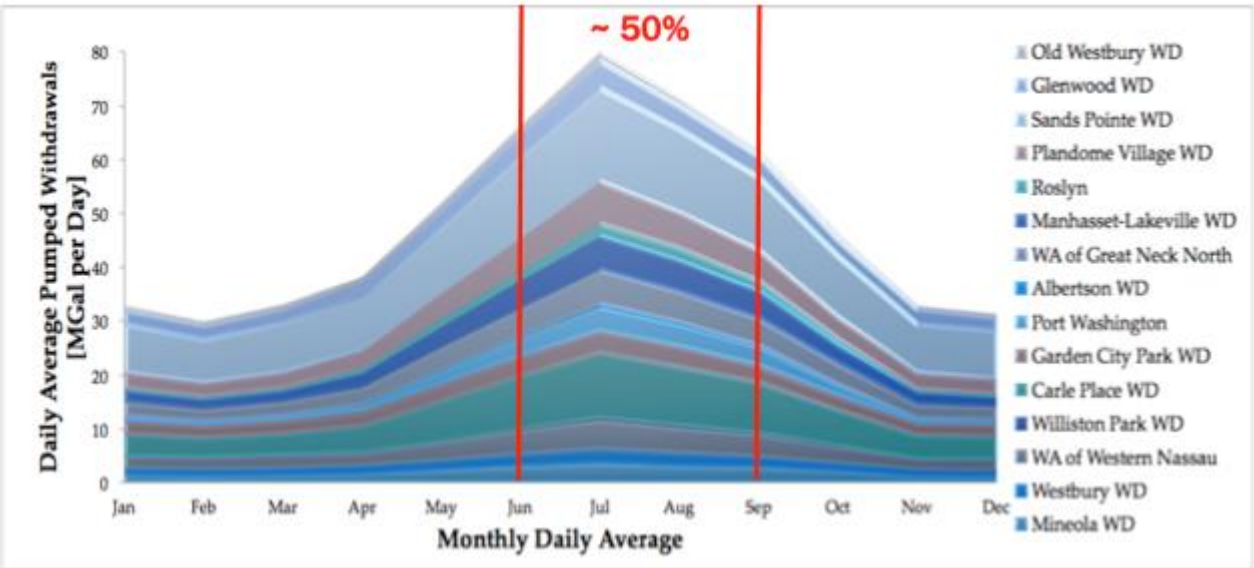
Evaluating this data at an annual level, we can see in Figure 6 that overall withdrawals have been fairly stable at ~17 billion gallons a year, with 2010 being an exception as it is recognized as having been an unusually very dry and hot year.

FIGURE 6: ANNUAL WATER WITHDRAWALS IN TONH, 2010-2014. IMAGE CREATED BY THE CAPSTONE TEAM, 2015.



As seen in Figure 7, evaluating water withdrawals at the monthly level demonstrates a clear seasonal variation within the calendar year with usage cresting between June and September. Just these four months represent an estimated 50% of the total annual water withdrawals. This period occurs at the same time that precipitation recharge is at its lowest as outlined in Section 3.3.1, putting additional strain on the aquifer's health which can lead to degraded environmental conditions that can impact water supplies even further.

FIGURE 7: MONTHLY WATER WITHDRAWALS OF TONH BY WATER SUPPLIERS 2010-2014. IMAGE CREATED BY THE CAPSTONE TEAM, 2015.



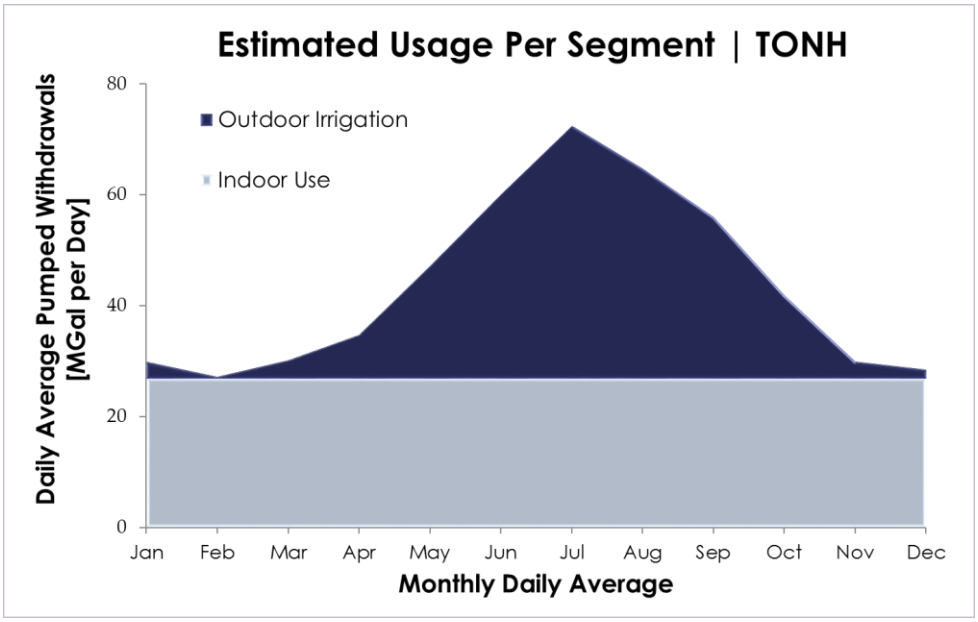
4.2 Seasonal Modeling of Water Withdrawals in the ToNH

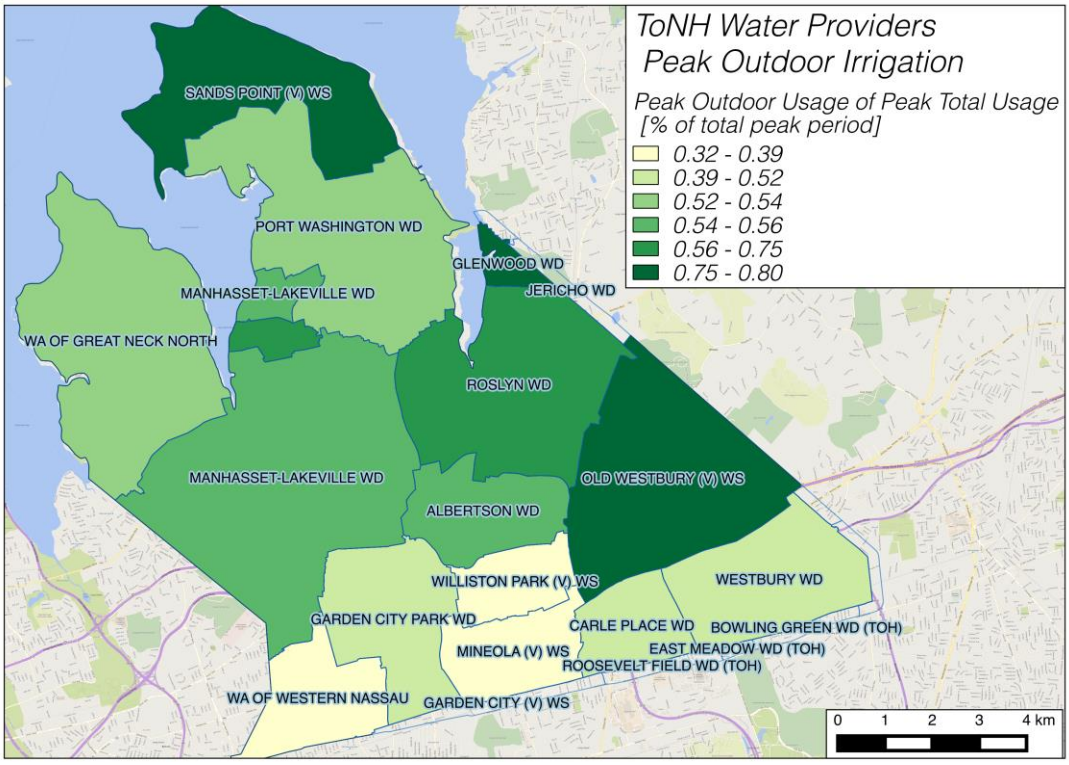
In order to evaluate potential conservation, it was critical to characterize water demand by end use. Extensive interviews and literature review of water consumption revealed that a key component of the seasonality of water demand variation is due to the increase of outdoor irrigation during the 'peak' summer period. Peak period is defined in this report as all months inclusive from May through October since review of the data revealed that these months (May/October) exhibited a clear shift in usage patterns. On the contrary, the base period comprises all other months in the year, explicitly from November through April.

Reducing peak water consumption levels presents both a high potential impact for conservation reductions while also reducing the greatest seasonal risk to the aquifer given current demand patterns. Peak usage poses the greatest risk to the aquifer since it coincides with when the recharge of the aquifer system is at an effective zero. The aquifer recharge is nearly zero in the June through September timeframe due to elevated evapotranspiration rates and higher intensity rainfall, which both prevent natural aquifer recharge (see Figure 5).[34] Therefore, the imperative to reduce public supply extraction rates during this seasonal period directly addresses the biggest risk to the aquifer health in terms of protecting the quantity and quality of its water supply.

A 'minimum month method' approach[35] was used to estimate the impact of outdoor irrigation on total water withdrawals within North Hempstead. This approach is based on a similar analysis used by the Pacific Institute, a well-known water think tank located in Oakland, California that is headed by renowned water expert Peter Gleick.[36] The base assumption of this approach is that there are no significant differences in indoor use during different seasons, as tested by the Residential End Uses of Water Study[37]. Comparing the month with lowest total withdrawals (December selected for our analysis which is assumed to be all indoor usage) to the other months in the year allows for indoor and outdoor usage to be estimated. This indoor/outdoor calculation was performed for each water provider individually and then averaged together. Using this method, approximately 42 percent of total annual use or *56 percent of peak water use is for outdoor purposes* (Figure 8).

FIGURE 8: (TOP) MONTHLY WATER WITHDRAWALS ESTIMATED CONSUMPTION BY SECTOR AND (BOTTOM) A MAP SHOWING THE PERCENT OF PEAK OUTDOOR IRRIGATION IN TONH. IMAGES WERE CREATED BY THE CAPSTONE TEAM, 2015.

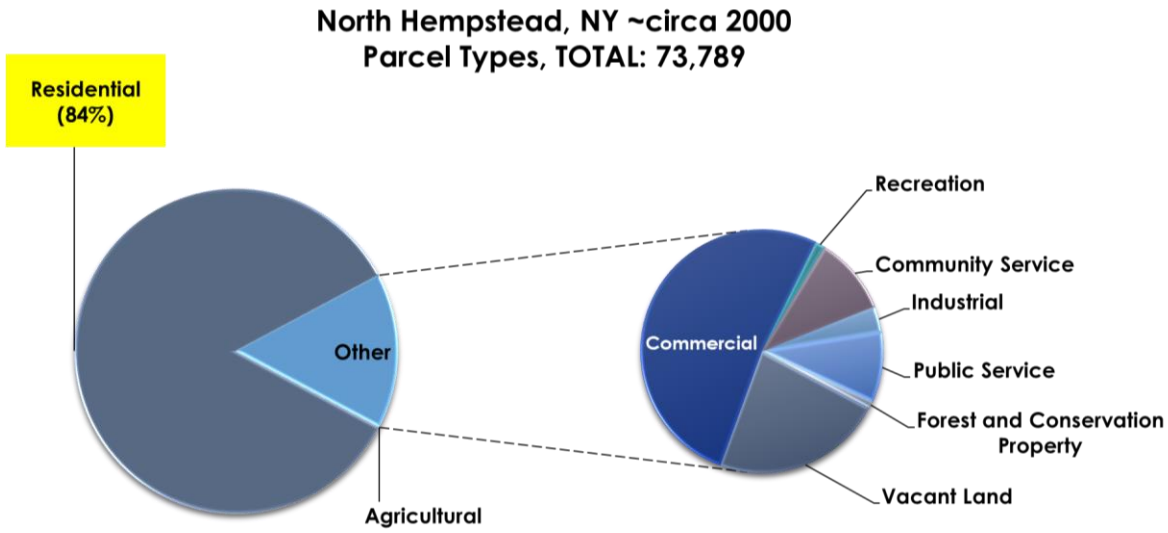




4.3 Overview of Water Consumption by Sector in the ToNH

Water consumption was further evaluated by segmenting it into its respective sectors, residential and commercial properties. Water usage by sector is not readily available for all the water suppliers. Therefore, the team evaluated several methods for estimating the split of usage across sectors. The first assumption was that water consumption is fairly proportional to land use or parcel type.

FIGURE 9: A BRIEF REVIEW OF THE LAND USE OF NORTH HEMPSTEAD SHOWS A RESIDENTIAL CLASS PARCEL TYPES DOMINATE WITH 84%. IMAGE WAS CREATED BY THE CAPSTONE TEAM, 2015.



Residential properties dominate parcel types, with 84%[38], suggesting that they comprise the biggest water user class (Figure 9). It is unlikely though that an average residential property uses the same amount of water as an average non-residential property. If the average non-residential property consumption in North Hempstead is double that of a residential property, then roughly 68% of all water demand would be attributable to residential properties alone. This estimate is in line with United States Geological Survey (USGS) research, which estimated domestic water use within public water supplies of 58% across the U.S. in 2005 and 68% in New York State.[39]

4.3.1 Residential Water Use Characteristics

Understanding residential consumption habits is necessary to evaluate suitable demand management recommendations. Overall, indoor usage is a major component within the residential sector but outdoor usage drives the seasonal imbalance in usage patterns. Residential usage, particularly outdoor irrigation practices, is highest during the summer.

According to US EPA WaterSense program literature -

> "The typical single-family suburban household uses at least 30% of their water outdoors for irrigation during the peak months. Residential landscapes include front,

side and backyard lawns and swimming pools. Some experts estimate that more than 50% of landscape water use goes to waste due to evaporation or runoff caused by overwatering."[40]

Residential Water Rate Structure

Within each sector, there are independent regulations that influence and govern consumption. All water supplied to residents within individual villages are distributed and metered by varying public water suppliers. Although rates are not standard throughout the ToNH, there is a common pattern to pricing (Table 5). It is useful to note that while rates vary between villages, water rate structures imposed by water suppliers are consistent throughout the year and do not have seasonal pricing components to reflect the increase of demand and lower supply. It is also important to note that the WA of Western Nassau, the largest water supplier in the ToNH, uses a *decreasing* rate structure for its pricing structure.

TABLE 5: INCREASING WATER RATES FOR SELECT WATER SUPPLIERS IN THE TOWN OF NORTH HEMPSTEAD

Water District	Base price per Gallon	Top Tier Price per Gallon	Overall Increase to Top Tier
Roslyn WD	$0.88	$2.36	168%
Westbury WD	$1.00	$2.40	140%
Garden City Park WD	$1.10	$1.20	9%
Manhasset-Lakeville WD	$1.35	$4.05	200%
Sands Point WD	$1.45	$3.00	107%
Old Westbury WD	$1.75	$5.00	186%
Mineola WD	$1.85	$3.25	76%
Williston Park WD	$3.92	$4.09	4%
WA of Western Nassau	$4.25	$2.53	-40%
WA of Great Neck North	$5.27	n/a	n/a

Codes and Regulations

Nassau County currently has codes in place to regulate outdoor water use, which apply to the ToNH as well. Specifically, Nassau County Water Authority Rule 4.1 establishes lawn irrigation restrictions for particular days, times, seasons, and sprinklers (Table 6). For instance, all residents are prohibited from outside water usage between 10 a.m. and 4 p.m. all year round. The rule also prohibits driveway watering with violators subject to fines.[41]

TABLE 6: NASSAU COUNTY RESIDENTIAL OUTDOOR IRRIGATION REGULATIONS

Customers	Designated Lawn Irrigation Days
With Odd-Numbered Addresses	Odd-Numbered Days
With Even-Numbered Addresses	Even-Numbered Days
Premises Without a Numbered Address	Even-Numbered Days

To drive compliance with Rule 4.1 or other codes enacted by the water suppliers, a fine system is sometimes used. Table 7 demonstrates fines for the Water Authority of Western Nassau, but it should be highlighted that many water suppliers do not have a fine system in place or are hesitant to enforce fines.[42]

TABLE 7: RESIDENTIAL WATER REGULATION FINES FOR THE WATER AUTHORITY OF WESTERN NASSAU

Occurrences after initial notification	Penalty
1st	$50
2nd	$75
3rd	$150
Each additional	$300

Rule 4.1 established the minimum requirements regulating water use, but individual water suppliers can also set additional, stronger restrictions as needed. Enforcement and penalties for offenses are set by the Code Enforcement Officer of each town, who are responsible for the supervision and compliance of the water provisions for the town. Water meter service foremen possess the authority to issue citations for non-compliance. The Department's Division of Code administers and enforces Town laws, ordinances and regulations in North Hempstead's' unincorporated areas. Residents are encouraged to call the Department's Division of Code if they observe violations of Town Code. Any offenses risk discontinued service, while certain offense may bring a fine exceeding no more than $1,000 or imprisonment for a period not exceeding one year.[43]

Challenges

The following were the major issues identified through our research or specifically highlighted by interviewees as barriers to greater residential water conservation in the ToNH:

1. **Weak pricing signal**
   The price of water in North Hempstead is very low, allowing most residents to use a higher quantity of water without being financially impacted. Apart from that, the low cost of water creates very little incentive for consumers to practice good water usage behaviors.
2. **Minimal consumer awareness**
   The low water rates in town give people no reason to be concerned about water consumption and therefore lack general awareness.
3. **Weak enforcement of regulations**
   Although residential water regulations exist, weak enforcement has hindered water conservation efforts. In addition, the town is not able to enforce additional water regulations upon unconsolidated areas of its township, which is relatively large.
4. **Lack of comprehensive water management strategy**
   Only one water supplier (WA of Great Neck North) has consistent incentive program for water efficient technology that is free to their customers. The remaining water

suppliers limited or no incentive programs and provide limited public information on water conservation for the consumer. Many water suppliers are lacking a comprehensive water management strategy with clear water conservation goals, and even for those that do, there is no coordination amount strategies that would improve overall effectiveness.

These challenges contributed directly to the development of recommendations discussed in Section 5.

4.3.2 Commercial Water Use

The commercial user profile in the ToNH provides a localized context of water usage and water management practices of businesses, thus enabling decision-makers to make targeted and relevant improvements. The largest industry in the ToNH is in the healthcare industry, particularly hospital facilities. Even though the commercial sector plays a smaller role in overall water usage compared to the residential sector, research and interviews showed that businesses are aware of their water consumption habits and are held to strict plumbing codes at the time of construction. Large organizations still have room for considerable retrofit improvements in areas of operations that have significant impact on their water footprint. Such improvements include plumbing infrastructure upgrades, conversion of cooling water systems, landscaping improvements, and other water conservation programs.

Water Usage

There was no sector specific usage data available at the town level but the previous land use data analysis suggests it comprises about 30-40% of total usage. However, it is evident that commercial users behave very differently than residential consumers. Interviews with local government and commercial sector representatives suggest that non-residential properties are cognizant of their consumption, and are already implementing mechanisms that maximize water usage efficiency. Currently, water suppliers influence water conservation practices only for town residents but not businesses. Businesses however, have alternative motives that have acted as incentives to conserve water from their operations, and thus can frequently be ahead of local ordinances targeted towards water conservation.

One of the commercial users examined for this research was the hospital and health care provider, North Shore-LIJ Health Systems. With 12,529 employees in 2014, it is the largest employer in the ToNH.[44] By upgrading its heating and cooling systems, as well as flush fixtures throughout its multiple facilities, North Shore-LIJ was able to significantly reduce its consumption of water well below the threshold set by regulators. The interview also revealed that despite the lack of high ROI of water efficiency upgrades, hospitals specifically are interested in implementing water efficiency measures to ensure future availability of this important resource. Most non-residential buildings have backup generators, which can help them to continue to operate in extreme weather events such

as Hurricane Sandy. However, if the municipal water supply were to become unavailable, the hospitals do not have an alternative source of water. Therefore, ensuring efficient operations is a critical component for organizations invested in the long-term sustainability and resiliency of their community and operations.

Codes and Regulations

The following are codes and regulations, across multiple levels of hierarchy, which have been found to motivate or guide water conservation initiatives undertaken by commercial water consumers (Table 8).

TABLE 8: WATER REGULATIONS AND CODES PERTINENT TO THE COMMERCIAL USER

Federal	State	Town
Energy Policy Act of 1992/2005	New York State Plumbing Code	Plumbing Codes
	New York State Health Department	Restrictions imposed by Water District/Water Authority

EPAct of 1992

The national efficiency standards and specifications for commercial water-using fixtures and appliances are outlined by the Federal Energy Policy Act of 1992. This Act requires certain standards for commercial toilets, urinals and faucets. Businesses are required to remain below 1.6 gallons per flush, 1.0 gallons per flush, or 2.2 gallons per minute at 60 psi (private) and 0.5 gallons per minute at 60 psi (public) respectively in order to remain compliant with EPAct 1992 and 2005.[45]

NYS Plumbing Code

In Section 608 of 2010 Plumbing code of NYS, the supply lines and fittings for every plumbing fixture are to be installed to prevent back flow. Plumbing fixture fittings shall provide back flow protection in accordance with ASME A112.18.1, the American Society of Mechanical Engineer's standard on plumbing fixtures.[46]

Stringency

Building water management requirements differ within each village of the ToNH. Additionally, hospital buildings have more stringent requirements than regular office buildings. For instance, hospital buildings are required to have vacuum breakers at every faucet, double check valves and reduce pressure zones to prevent backflow. Installation details require approval from a licensed plumber, an engineer and the DEP. Penalties can be as strict as shutting of the hospital's water supply, however, the reality is that these penalties are not enforced.

Enforcement of Regulations

The building construction codes are enforced very heavily. Permit holders are required to have their plumbing infrastructure undergo several tests in order to be deemed compliant with the NYS Code. In contrast, water usage regulations of the commercial sector are not enforced by most of the water suppliers. In an interview with Italo J. Vacchio of the Port Washington District, it appears that even if a commercial entity exceeds its usage limit, the district would only issue a warning but would not likely impose fines or shut down water services to the building.[47]

Challenges

The following were the main issues hindering the advancement in water management initiatives.

1. **Measurement is expensive**
   Total water use by individual departments within an organization can only be estimated based on equipment specifications such as gallons per flush or faucet flow rate. It is difficult to accurately track whether a department reduced its water use through lower flow rate faucets, unless meters are installed. Internal sub-metering is expensive and prevents organizations from taking the most fundamental step in bringing about change: measurement.
2. **Low ROI on water efficiency projects**
   The low water tariffs cause water expenses to be only a small portion of the commercial utility bill. While cost savings are the main motivation behind projects in the energy efficiency space, lack of high savings opportunities disincentives investment in water efficiency upgrades.
3. **Conflict of regulations**
   Due to strict regulations on healthcare and sanitation factors, the hospital is not able to expand its sustainable water management initiatives such as the usage of greywater for their toilets. This presents a familiar conflict where existing regulatory obstacles discourage the pursuit of environmental solutions.
4. **Lack of infrastructure compatibility within existing buildings**
   Water savings solutions often involve infrastructure retrofits and/or upgrades. In the case of North Shore-LIJ, utilizing alternatives to potable water in non-patient toilet units was not feasible due to the existing plumbing systems that provide very little room for changes.

These challenges contributed directly to the development of recommendations discussed in Section 5. However, from the discussion above, it can be concluded that commercial water consumption practices in the ToNH pose less of a pressing threat to the sole source aquifer, compared to residential usage. This can be attributed to:

- The external pressures of regulations from the federal and state level and
- The internal pressure within commercial entities in identifying risks to their businesses.

4.4 Key Takeaways

Outdoor water usage within both the residential and commercial sectors should be a key target for conservation because of several factors;

1. Key driver of seasonal water imbalance – our analysis estimates that 56% of water usage during peak period is for outdoor irrigation and can be even higher for specific areas and during specific times of the year
2. High potential for waste – many sources estimate waste of up to 50% for certain outdoor water use activities, including timed irrigation systems, which are highly prevalent in the ToNH
3. Less awareness and programs targeting outdoor water use – public awareness campaigns around reducing indoor usage are more prevalent (ie. shorter showers, turn off water during brushing, etc.); existing government mandates and incentives for adopting water efficient technology (appliances, etc.) are fairly well established

Stricter enforcement of existing regulations coupled with effective penalties can only encourage compliance and motivate innovation and awareness among water users, especially in the residential sector. Existing regulations can be reinforced to promote improved compliance and a shift in behavior around appropriate water usage. Commercial entities tend to be more advanced than residential homeowners in their adoption of water efficient systems and practices, particularly for those businesses where these costs are a significant line item in their cost structures. Many entities have also already identified the need to promote resilience within their water systems for the long-term sustainability of their operations and the community that they serve. However, for many businesses, low water prices continue to inhibit economic decisions around long-term conservation investments that can be addressed by developing prices around the true economic cost of sustaining effective water supplies in the future.

5. RECOMMENDATIONS

Overview of Recommendations

Outdoor water usage in the summer months is a significant lever to reduce the overconsumption of the LISSA. A set of 15 recommendations were created, evaluated and ranked, focusing specifically on controlling outdoor water usage. These recommendations were evaluated and selected based on their ability to provide the strongest water conservation benefits, particularly during the summer period, while considering the potential financial implications to the Office of Sustainability and the broader acceptance rates within the villages of the town. Reviews of this initial list of recommendations condensed them to a final list of 11. These recommendations were evaluated by a multi-tiered decision matrix that scored potential actions based on a holistic outcome.

The top four recommendations as per the scoring method applied were to:

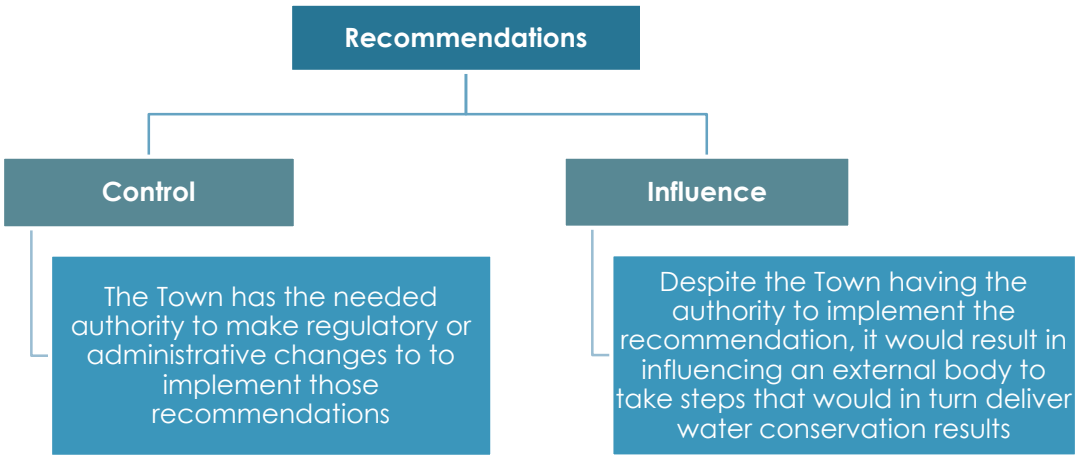
1. Implement an Irrigation Infringement Request Feature via the Town's 311 system
2. Pursue Licensing Certification for Irrigation Installers
3. Coordinate a Collaborative Cost-Avoidance Study on Water Conservation Programs
4. Host an Annual Water Workshop on Best Practices

Methodology and Selection Criteria

The proposed recommendations were evaluated through a standardized scoring and selection process. The process began by developing an initial set of 15 recommendations based on the findings from the research phase of the project including literature reviews, interviews with key stakeholders and evaluation of similar efforts undertaken in other locations. Upon review of these initial recommendations with the client, it was decided to prioritize solutions that are within in the ToNH's jurisdiction, leading to several recommendations being de-prioritized or re-defined.

Recommendations were prioritized based on whether the Office of Sustainability could exert control over implementation (Figure 10) of the recommendation. These were tagged as Control or Influence in the following recommendations.

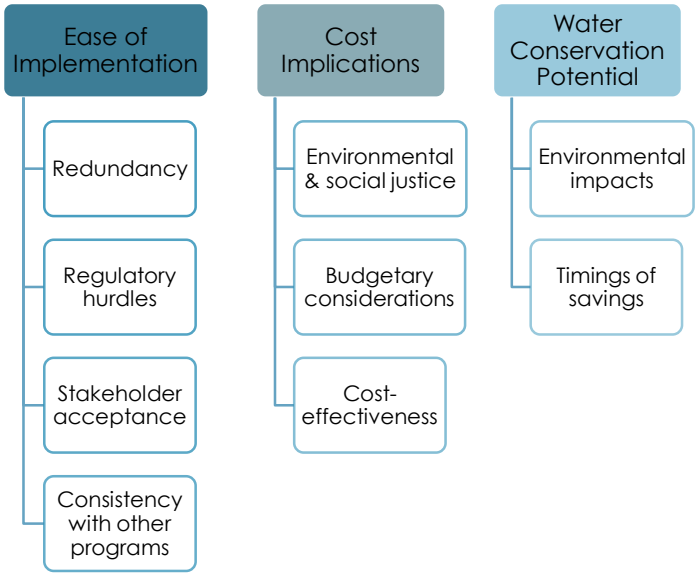
FIGURE 10



Key influence recommendations have been combined into a single idea that can result in communicating with and influencing multiple parties, at once. These are featured in the next section as part of the potential agenda for discussion at the annual water workshop (See Recommendation 4). The next step was to develop the scoring mechanism for selecting the most effective recommendations. The scoring criterion was developed in part by using US EPA Water Conservation Plan Guidelines (Appendix 9: EPA Selection Criteria for Water Conservation) for selecting conservation measures.

The final selection criteria chosen evaluates nine (9) performance criteria, spanning three (3) major category themes as demonstrated in Figure 11.

FIGURE 11



A grading scale was created to assign value to the recommendations with one of three scoring possibilities as seen in Table 9. Each set of recommendation was analyzed and scored using the scoring matrix available in Appendix 10: Scoring Criteria Matrix. The total score for each recommendation was the simple average of the combined scores of the three category themes (i.e. all category themes were weighted equally regardless of how many criteria were evaluated in each).

TABLE 9: STANDARDIZED SCORING CRITERIA FOR RECOMMENDATION EVALUATION

Rubric	Scoring
Negative: sub-factor likely to be barrier to success of recommendation (or low impact)	**-1**
Neutral: sub-factor not applicable or not significantly impacting success of recommendation	**0**
Positive: sub-factor supports the success of the recommendation or provides strong benefit	**1**

Through this process, in alignment with the client, four (4) final recommendations were identified as those with the highest potential to pursue. The full list of all the recommendations and their scoring can be found in Appendix 11: Recommendations & Scoring of Final Recommendations.

1. Implement an Irrigation Infringement Request Feature via the Town's 311 System

Type: Control
Category: Policy & Code

Description: Improve enforcement of outdoor watering codes by leveraging the existing 311 system in ToNH to include a 'Service Request' function for infringements to the outdoor watering regulations; calls would be sent to individual water suppliers for enforcement/fines.

Rationale

As mentioned in Section 4.2, the ToNH residents are expected to follow the Nassau County Water Authority Rule 4.1 which restricts lawn irrigation for particular days, times, seasons, and sprinklers. This watering ordinance was created to address the high water usage during peak summer months. More than half of the total peak withdrawals from the water suppliers in North Hempstead are attributed to outdoor irrigation (Figure 8). Interviews conducted with water authority superintendents revealed an absence of a monitoring system that would allow the water suppliers to penalize violators. This issue was then flagged as a fundamental barrier to controlling or limiting outdoor water consumption during peak summer months.

By implementing a water violation hotline, the ToNH is not only upholding the required legal statue from Nassau County, but also proactively taking a major step in encouraging water conservation behavior change among its residents. The ToNH 311 Call Center is a staffed hotline through which "requests for services that are entered into a work-order format and sent to the appropriate department for review and immediate processing".[48] This system is already in place with more than one million calls received since 2005.[49] As of 2014, residents can also submit requests online and through the "My North Hempstead" mobile application.[50]

Scoring Overview

Implementation	Cost Implications	Water Conservation	Total
50%	**67%**	**100%**	**72%**

The recommendation scores the highest out of the four recommendations by performing well in all scoring criteria categories. The implementation score is the lowest due to its dependence on approval and cooperation by other town officials and residents within the

town. By leveraging the existing 311 system, this recommendation will not necessarily impose additional costs on the Office of Sustainability's budget.

Expected Impact

Water conservation hotlines have been used for enforcement across the country from Massachusetts, Hawaii, California, to Colorado along with many other states.[51] Several towns in California have shown that customers have decreased their water consumption in the last few years due to Water Conservation program efforts.[52] Denver Water has an entire marketing campaign with yard signs and slogans around watering wisely and has a hotline for reporting watering violators.[53] Colorado State University and The Colorado Water Resources Research Institute's study found that across the Front-range in Colorado, mandatory water use restrictions have resulted in 18-56% water conservation savings.[54] Their research also highlighted that in Cary, North Carolina, introducing alternate day watering resulted in 6-10% water savings.[55] For more details on the California case study please refer to Appendix 12: Case Study – Success of Watering Violation Hotline.

The impact from the program could be tracked and measured through the revenues raised from increased issuances of fines. This additional fund could then be used for individual water supplier's water conservation programs with the funds supporting incentives for water efficient irrigation technology. The water suppliers can also measure benefit from cost avoidance experienced due to reduced stress on wells in peak summer months.

Implementation

This recommendation would require an approval from the ToNH Supervisor, Judi Bosworth and relevant 311 staff would need to determine human resource requirements (if any). Next, ToNH would need to collaborate with water suppliers to set up guidelines that would determine duration of response time and protocol to verify violation, issue fines and stop the violation.

At a systems level, the program should be designed to allow residents to report violators on all three platforms: phone, online or on their mobile app with the "My North Hempstead Application" with convenience. Offering multiple reporting options could also increase adoption as people may have varied preferences. The platforms should be leveraged so that complainants would be required to take a timestamped photo to include in the citation.

Messages would be sourced through the 311 channels and distributed to individual water suppliers for determining and distributing fines. In order to track progress of the program, the ToNH must monitor how many calls they receive and track the households. With that list it could determine how many households should be receiving fines and which water supplier is responsible for handling the violators. These records could then be compared to the number of fines distributed by the individual water suppliers.

A Water Violation Hotline recording would prompt the caller to leave a detailed voicemail with the following required fields:

1. The address of the violator.
2. The time of the violation occurred and the day of the week
   For additional Verification Purposes a reporter of violation could also:
3. Submit a picture of proof of violator via a ToNH 311 email system with address if possible (separate email address for watering violations)
4. Timestamped photo

A marketing campaign must accompany this initiative so that customers are continually reminded of their role in water conservation. The campaign messaging must convey that aquifers will only continue to be more stressed with climate change in the future and taking small steps towards water conservation will reap large rewards for those who depend on them.

2. Pursue Licensing Certification for Irrigation Installers

Type: Control
Category: Policy & Code

Description: Lobby at county level to establish a license or certification requirement for all irrigation installers, operating within the ToNH.

Rationale

As discussed, US EPA estimates that up to 50% of water applied for outdoor irrigation during hot summer months is 'wasted' due to losses from evaporation, wind and runoff.[56] This waste magnifies the sharp increase in water usage during peak periods and helps to drive the seasonal water usage imbalance within the ToNH that discussed in Section 4.2. A key driver of this waste factor is improperly designed and/or installed irrigation systems. Currently, US EPA's WaterSense Program provides a certification program for the irrigation industry and recommends that homeowners and businesses only use certified irrigation contractors. In addition, multiple states have moved forward with either licensing or certification requirements for irrigation contractors that require a base level of experience and the completion of an exam testing knowledge of the field in order to be certified.[57] Locally, New Jersey and Connecticut have established certification requirements for irrigation contractors, setting a clear precedent supporting the establishment of this recommendation.[58] Efforts to establish this requirement at the state-level in New York have been ongoing, but unsuccessful since 1999,[59] but could be easier to justify and establish at a local level.

While it appears possible for the ToNH to adopt this certification requirement within its own jurisdiction, it would be costly to set up and administer all the components of this program (i.e an Exam Board to manage the certification process, etc.) so would likely be more cost effective to do at a county-level. Also, the ToNH's ability to impose this certification requirement in unconsolidated areas of the township is questionable, which would not be the case if this requirement was imposed by the County.

Scoring Overview

Implementation	Cost Implications	Water Conservation	Total
75%	**67%**	**50%**	**64%**

This recommendation scores consistently well across all three categories. The water conservation score is the lowest of the group mainly due to the fact that the time to impact

is likely to be at least 12 to 24 months, as it will require time to lobby and pass this legislation and contractors will need to be given time in order to comply.

Expected Impact

The use of certified irrigation contractors is expected to have a measurable impact on both residential and commercial outdoor water usage by helping to ensure that irrigation systems are;

1. Designed to efficiently use water based on local environmental conditions
2. Installed correctly including the usage of water conservation technologies where appropriate
3. Maintained and audited periodically to ensure efficient performance.[60]

Based on the analysis of the water usage profile for the ToNH, we estimate that approximately 6.5 billion gallons per year are used for outdoor watering. At this level, each 1% improvement in water efficiency could save 65 million gallons per year within the ToNH. If we further assume a conservative estimate that 20% of this total amount is 'wasted' through inefficiently installed or maintained irrigation systems due to the under-utilization of certified irrigation contractors, then the total potential water that could be conserved is ~1.3 billion gallons or about 8.4% of total usage.

The successful implementation of this recommendation would take some time to generate the potential water savings discussed above though as irrigation professionals would need sufficient time to complete the certification process before the mandate went into effect. We estimate that 12 to 18 months would likely be a sufficient timeframe for implementing this certification requirement as some irrigation professionals in Nassau County are already certified by either the EPA's WaterSense Program or the Irrigation Association of NY (IANY), which could potentially be given reciprocal certification under a system set up for Nassau County. The majority of the impact on water conservation from this recommendation would come from the installation of more efficient outdoor irrigation systems (both in terms of technology and design) for both new customers and those upgrading outdated systems.

The cost implications of this recommendation are fairly limited for the ToNH. The main expenditure would be in staff resources to educate and convince Nassau County officials of the benefits of this certification requirement. The ToNH could partner with relevant stakeholders, such as the IANY or the Long Island Commission on Aquifer Protection (LICAP), and with other towns/villages in the region to expedite these efforts.

Irrigation businesses would face financial costs in order to complete and maintain the certification process, though these costs are fairly minimal (See Table 11). While these increased costs could lead to higher prices for irrigation services for both residential and commercial property owners in the short term, this impact may be limited since-

1. The costs are balanced by savings from reduced water usage
2. As the certification requirement becomes standard across the industry, normal competition will help to limit any cost increases due to this requirement (i.e. become a cost of doing business).

Table 11 – Fee table for Irrigation Association Certification[61]

Certified Irrigation Contractor (CIC) Exam Fees	IA Member	Non-member
Irrigation Contractor Exam Fee	$250	$495
Exam Retake Fee	$200	$325
Annual Renewal Fee (one certification)	$50	$100
Annual Renewal Fee (two or more certifications)	$100	$150

Implementation

In order to implement this recommendation, the Office of Sustainability within the ToNH should take the following actions:

- Contact relevant stakeholders such as the IANY, LICAP and other towns / villages within Nassau County to coordinate efforts and/or build a coalition to support lobbying efforts.
- Review similar actions implemented in the region, including New Jersey's Landscape Irrigation Contractor Certification Act (N.J.S.A. 45:5AA-1 et seq.)[62]
- Lobby Nassau County officials to modify the business licensing code for irrigation contractors currently covered by Local Law 6-1970 Home Improvement Business.[63]

3. Coordinate a Collaborative Cost-Avoidance Study on Water Conservation Programs

Type: Control
Category: Management

Description: Work with WDs and NGOs to develop a cost-avoidance study on water conservation programs and water efficiency initiatives to gain public support.

Rationale

A successful cost-avoidance study will provide an unbiased view that evaluates water savings opportunities available to the town. This will allow the Office of Sustainability to allocate public resources optimally and gain public support for investments made in water conservation programs. Therefore, the ToNH should commission a cost-avoidance research report evaluating the costs and benefits of a suite of water conservation investments. The study will quantify economic benefits that offset rate increases, reduce consumer bills, and impart environmental benefits improving aquifer health.

A partnership with an NGO will bolster the report's credibility, help secure collaborative grant funds, and save limited ToNH resources. This study will need to offer a multi-perspective review by both government and non-government experts on all high-potential conservation efforts elaborated on in previous sections. The ideal NGO partner or consultant will lead conservation impact assessments from the perspective of the end-consumers, water utilities, society (environmental, etc.), and political level (villages, Town, County). Findings of the analysis will present the cost-benefit of potential programs. Specific costs to be considered should cover direct installations, giveaways, rebates, or water utilities operational investments alongside legislative, regulatory reform.

Scoring Overview

Implementation	Cost Implications	Water Conservation	Total
75%	**67%**	**50%**	**64%**

Overall, this recommendation has a favorable performance for its implementation, neutral in terms of cost implications, and is an average performer in terms of improving water conservation efforts.

For the Implementation category, conducting this type of research effort is within the Town's ability to control, organize, and manage. The public perception will likely not require political capital from the Town Supervisor to gain approval. In fact, it may afford the office

more political capital if undertaken successfully. Most importantly, there is a precedent for neighboring counties to undertake such efforts. Specifically, the ToNH is currently working on a collaborative DEC grant with 21 villages to conduct a stormwater management study. Given the rapport and outcomes of this DEC engagement, it is reasonable to expand the storm-water study towards a cost avoidance review. Additionally, the ToNH worked with the Army Corps of Engineers and DEC to study resiliency measures.[64]

The cost implications of undertaking this study are positive. The ToNH is very familiar with State and Federal grant procedures and they could be leveraged to implement relevant studies. This effort, in time, will help address any resistance to future policy changes to help protect the sole source aquifer, thereby reducing costs to future policy campaigns.

The recommendation holds an average score of 50% for water conservation because the study is a precursor to larger conservation programs and can indirectly promote unofficial campaigns too. The report would at best lead to water conservation in a mid-term time frame.

Expected Impact

A cost avoidance study will build awareness and lead to additional regulatory reform. The value of such a study may be similar to the case study of a Colorado water utility undertaking a retroactive review of conservation benefits. Although ToNH water suppliers are unique, similar water conservation findings of the Colorado water utility alleged '[the] least expensive infrastructure to build, operate and maintain is the infrastructure that isn't needed in the first place.'[65] Therefore, it is a reasonable expectation that many water conservation efforts for ToNH will result in a net societal benefit by reducing the total costs of water delivery, preventing behaviors that can lead to the overconsumption of the aquifer, and potentially improving the Town's resiliency future droughts.

The provision of a cost avoidance study is expected to be a necessary precursor to more measurable improvements to water efficiency in the Town.

More specifically, a successful cost-avoidance study will:

- Quantify water conservation plan impacts
- Measure local economic impacts of business as usual
- Evaluate cost/benefits per property
- Calculate the average payback

Implementation

The report could draw from frameworks developed by the Pacific Institute's Cost Effectiveness of Water Conservation and Efficiency (CE2) Model. Broadly, their CE2 tools help to evaluate the economic desirability of water conservation, efficiency measures and explore how costs and benefits can be shared among customers, water utilities, and other entities.[66] Similarly, the AWE Water Conservation Tracking Tool evaluates the water savings, costs, and benefits of conservation programs for a specific water utility.[67] Such a model would help frame conservation investments' potential in North Hempstead.

In order to implement this recommendation, the Office of Sustainability within the ToNH should take the following actions:

- Approach the water utilities and key village partners to notify them of this new initiative and solicit volunteers to lead an advisory committee;
- Identify an NGO or consultant
- Reach out to DEC for potential grant eligibility and partnership opportunity[68] and put forth a formal proposal;
- Outcomes of the study should trigger a feasibility study for green infrastructure projects. Application should be developed to secure study resources. Specifically, the town will ask for resources that support 'water quality and environmental justice' submitted for EFC *Green Grants* fund[69] or EPA *2015/2016 Urban Waters Small Grants Request for Proposals.*[70]

4. Host an Annual Water Workshop on Best Practices

Type: Control
Category: Management

Description: Establish a ToNH water workshop to promote collaboration between water suppliers on best practices, common issues (e.g. develop a shared water loss assessment), joint campaigns to promote water conservation (e.g. financial incentives, standardizing rate structures and seasonal pricing).

Rationale

The decentralized water delivery system in ToNH has been acknowledged to have advantages in terms of improved public service delivery, and it is assumed that a locally designed institution will be more efficient in managing a common-pool resource (CPR) such as groundwater, than a central authority that might enforce a groundwater quota.[71] However, in practice it can be said to have some disadvantages arising out of water suppliers lacking access to a single leadership and vision, especially one related to groundwater conservation when all water suppliers draw from the same limited aquifer.

During peak season, water suppliers tend to utilize well capacities to the maximum. In the event of technical problems that might require well closures water suppliers need to rely on resources from other water suppliers to avoid supply disruptions. An interview with DEC confirmed that the local and seasonal peak withdrawal issue is considered to be the main reason for the need to collaborate. In the recent Long Island Water Conference, the commissioner of Port Washington Water District is said to have proposed collaboration among the northern water suppliers that are affected by saltwater intrusion in wells close to the shore.

In addition to resource sharing, collectively addressing the need for conservation in general will require some level of consistency in initiatives by the 15 water suppliers in ToNH. For instance, initiatives such as seasonal pricing & audit requirements and communication messages when consistent can have a more pronounced impact. It could potentially prevent a situation in which the efforts of one water supplier are offset by lack of efforts by another.

An annual water workshop, while providing a chance for all relevant stakeholders to come together to share water conservation best practices, can create a sense of collective responsibility towards the LISSA. Meeting annually can act as a way to hold water suppliers accountable towards commitments made during the workshops. Overall, this platform will be able to help Office of Sustainability achieve improved water conservation by promoting stakeholder collaboration and knowledge sharing.

Scoring Overview

Implementation	Cost Implications	Water Conservation	Total
50%	**100%**	**50%**	**67%**

This recommendation is well within the control of the Office of Sustainability and requires no specific authority. The implementation scores 50% due to the uncertainty of stakeholder participation and since this has not been done before by the Office of Sustainability. The cost implications are low since it presents opportunities for co-sponsorship by participating stakeholders. Water conservation impacts will be apparent in the long term as this recommendation only indirectly impacts aquifer conservation.

Expected Impact

This workshop can create a knowledge sharing platform between the 15 water suppliers, various villages, as well as other stakeholders such as the regional DEC, county level representatives, prominent water related NGOs and new water efficient technology providers. Some potential outcomes of collaboration promoted via these workshops are:

- Reduction in new well drilling in order to meet unprecedented peak in water withdrawal, due to trading or sharing of water resources across water district boundaries
- Protection of the aquifer from plumes and salt water intrusion due to peak shaving
- Knowledge sharing regarding demand control such as peak water use rates, seasonal pricing and local awareness campaigns
- Standardized audit mechanisms for water use efficiency
- Consistent plumbing codes owing to common knowledge on available technology

The Office of Sustainability may have to find sponsorship to host this workshop each year or allocate a portion of their budget on communication and set up of the event. While the initial expense may be borne by the ToNH, the value of the impact can be estimated by reduction in over-consumption of the water resources in the town and how sustainably the town's utilities operate. The success of this annual workshop initiative will be apparent over time as the management of the various water districts and authorities begin communicating even outside the workshop. It can also be measured in terms of the number of instances successful partnership occurs between water suppliers, protecting water infrastructure from structural stress due to peak demand. More importantly, the success of this workshop series can be measured in growing consistency in water management practices such as pricing and code enforcement in addition to actual reduction in peak water withdrawals.

Implementation

Great Neck -Port Washington Water Committee currently addresses the need for collaboration. Our implementation strategy involves leveraging this platform and expanding the participants.

Below is a sample of stakeholders that could form part of this workshop:

1. Office of Sustainability Town of North Hempstead
2. Water District Commissioners & Superintendents
3. Water Authority Commissioners
4. Village water department heads (self-supply)
5. Rate-payer representatives
6. Water efficient technology provider such as artificial turf and residential greywater system
7. Regional DEC
8. Nassau County legislators
9. Department of Planning & Environmental Protection
10. Groundwater policy reform expert

Below is a proposed agenda that can be used for the first annual water workshop and can be refined based on response and interest levels in subsequent workshops.

1. Keynote by Mindy Germain, Port Washington Water District about overarching groundwater issues in Long Island's Sole Source Aquifer
2. Regional DEC: Best practices in groundwater management from around the world
3. Roundtable discussions:
   a. Potential impacts of standardized peak pricing for water during peak withdrawal months of May to October across water suppliers
   b. Inclusion of rainwater sensor requirement in lawn sprinklers and inclusion of this in audit processes
   c. Costs and benefits of Nassau County adopting Home Energy Renovation Opportunity (HERO), a leading energy efficiency-financing program that partners with local governments to make energy efficient and water efficient products affordable to homeowners
   d. Ways to improve public awareness on water conservation
4. Breakout panel discussions
   a. Saltwater intrusion and water demand management
   b. Greywater reuse and building, plumbing and health codes

6. Conclusion

SUMMARY

Ultimately, an effective water management strategy requires a strategic, collaborative effort by key stakeholders, guided by robust information of the water issues. For the case of the Town of North Hempstead, water conservation will be a key component of its water management strategy. This report argues that the most effective area of conservation lies in reducing outdoor irrigation, which is a strong driver of the seasonal water usage imbalance that is affecting the health of the overall aquifer system.

This report compiled a list of recommendations for the Chief Sustainability Officer of North Hempstead to pursue in order to help mitigate future harmful depletion of the aquifer. The development of recommendations was tailored to address the main opportunities and needs for the Town of North Hempstead, as identified during the research process. The prioritization and ultimate selection of the final recommendations were targeted towards actions specifically under the Town's control. These recommendations were created by analyzing various data sets, conducting interviews, and referring to applicable case studies. Upon applying the scorecard selection process, the most viable recommendations include:

1. Implement an irrigation infringement request feature in its 311 telephone system;
2. Pursue licensing certifications for its irrigation installers;
3. Coordinate a collaborative cost-avoidance study with stakeholders;
4. Host an annual water workshop on water conservation to share best management practices and coordinate conservation efforts

In addition to the recommendations developed in this report, the capstone team also developed a set of tools to support the ongoing management of water resources that includes:

1. A score card for evaluating and selecting future initiatives;
2. A GIS mapping tool to visualize water use characteristics;
3. A water database of currently available water data (2010 – 2014) that provides an updated profile of the Town of North Hempstead's water usage and withdrawal trends.

With these tools, the Town of North Hempstead can progressively manage its water use in a way that is financially achievable and can be easily adopted by its various villages.

Ultimately, this report sought to present the most holistic recommendations on water conservation in the Town of North Hempstead that can be incorporated by the Office of Sustainability in the near future. North Hempstead has the potential to serve as an example for neighboring towns and cities that will inevitably face similar water challenges since they draw from the same aquifer.

APPENDICES

Appendix 1: Expert & Stakeholders Interviews

Organization	Organization Type	Title	Contact Name
Planning and Environmental Protection Department of North Hempstead	Government	Commissioner	Michael Levine
Town of North Hempstead	Government	Director of Sustainability	Erin Reilley
DEC	Government	Regional Director	Carrie Meek Gallagher
Parks Department of North Hempstead	Government	Commissioner	Jill Weber
Water Authority of Western Nassau County	Business	Chief Engineer	Bob Swartz
Port Washington Water District	Business	Superintendent	Italo J. Vacchio
Water Authority of Great Neck North	Business	Superintendent	Greg Graziano
North Shore-LIJ Health Systems	Business	Director of Sustainability	Neil Rosen
Irrigation Association of New York	Industry Groups	President	Tom Tracey
NYIT Water Center	Industry Groups	Director	Sarah J. Meyland

Appendix 2: Select Water-Related Events Impacting Water Management in LI

Date	Water-Related Action
1978	Long Island designated a Sole Source Aquifer (SSA) by US EPA providing it some limited federal protections to decrease risks of contamination.
1978	*LI Comprehensive Waste Treatment Management Plan* ("208 Study") completed; first comprehensive study of groundwater; used by water professionals as key reference today
1990	NPDES Storm Water Program initiated by US EPA requiring municipalities across LI to create storm water management plans to control discharges to ground and surface water systems
1999	Source Water Assessment Program (SWAP) launched to evaluate water quality of public well systems across LI; completed in 2003
2005	Nassau Groundwater Monitoring Program report completed by Nassau Department of Public Works; details quality and quantity issues as of 2003
2011	NY Water Resources Law (Article 15 of NY Environmental Conservation Law) is expanded giving the DEC permitting oversight for all withdrawals (public & private) from LI aquifer system[72]
2011	NYC introduces its Water for the Future Plan to enhance its drinking water system; includes strategy to "…develop cost-effective groundwater & other supplemental water supply alternatives" including re-activating Jamaica Water system in SE Queens[73]
2012	Hurricane Sandy hits Long Island causing extensive damage to water infrastructure including to the Bay Park Sewage Treatment Plant
2014	Long Island Water Quality Control Act, a bill introduced to expand efforts to protect LI water systems, passes the NY Assembly but is failed to be voted on by NY Senate[74]
2015	NYC plans to re-activate wells in Queens put on hold, though city still going through process to re-permit the wells for future use

Appendix 3: Water Districts & Water Authorities

Public water services are provided in Nassau County through a decentralized system of 47 water suppliers[75]. These suppliers come in two main varieties, water districts and water authorities, which each have unique characteristics and capabilities.

Water Authority[76]

- Non-profit, public benefit corporation operating by virtue of Public Authorities Law of New York
- Funding is done purely through billed services to users
- Coordinated by Board of Directors, consisting of representatives of villages / Towns receiving services (ie. State appointees)
- Officers of the Authority are appointed by the Board of Directors

Water District[77]

- Taxing authority that has ability to raise taxes to partially pay for water services
  - Manhasset-Lakeville WD 2015 budgeted revenues are split into Billed services ($6.44m) and tax levies ($3.5m)[78]
- Managed by a 3-person Board of Water Commissioners and a Superintendent that are elected to their positions (typically 3 year terms)
- Service area is typically focused on one Village or specific service area with a Village, but can cover multi-jurisdictions as well

Overall, water districts are much more common than water authorities, representing over 85% of the suppliers in Nassau County.

Water Districts and Authorities in ToNH:

- Albertson WD
- Carle Place WD
- Garden City Park
- Glenwood WD
- Manhasset-Lakeville WD
- Mineola WD
- Old Westbury WD
- Plandome WD
- Roslyn WD
- Sands Point WD
- WA of Great Neck North
- WA of Western Nassau
- Westbury WD
- Williston Park WD

Appendix 4: What is a Sole Source Aquifer?

A sole source aquifer or SSA is a federally defined designation that applies to any aquifer that provides 50% or more of the drinking water to an overlying population. The main implication of an aquifer receiving the SSA designation is that it establishes some limited federal protection, mainly focused on enhanced scrutiny of any projects that could endanger the water quality of the SSA, especially federally-funded programs like roads, etc. The SSA protection program is authorized by section 1424(e) of the Safe Drinking Water Act of 1974 (Public Law 93-523, 42 U.S.C. 300 et seq.). It states the following:

> *"If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the Federal Register. After the publication of any such notice, no commitment for federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for federal assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer."*[79]

Long Island was one of the first designated SSAs in the United States, receiving this designation by the US EPA in 1978. The SSA designation is further regulated under the New York State Environmental Conservation Law, Article 55 – Sole Source Aquifer Protection. The main requirement of this article is to establish Special Groundwater Protection Areas (SPGAs) within an SSA where human development is limited to protect the quality of the watershed. There is also a requirement to develop groundwater management plans to coordinate efforts to protect the SSA. There are currently nine (9) SPGA's designated within the Long Island SSA, including one in the North Hills area of the Town of North Hempstead.

Appendix 5: Other Pollution Concerns

The UG Aquifer is unconfined and more vulnerable to contamination than the other confined aquifers. Two of the factors that have the greatest effect on groundwater quality are the land-use practices in the recharge area above the aquifer(s) and the groundwater-flow patterns within the aquifers.[80,81]

Long Island has an estimated 6,800 brownfield sites, the highest compared to other regions within the state.[82] The brownfields are land that "stand undeveloped or abandoned because of real or perceived contamination".[83] This presents a major threat to groundwater quality as they result in contamination even when not adjacent to waterfront areas or significant bodies of water.[84] One particularly concerning instance is the Unisys/ Lockheed Martin Site.

In 1985, the U.S. Geological Survey (USGS), in cooperation with Nassau County Department of Health (NCDH) and the Long Island Regional Planning Board (LIRPB), began a study to define the relation between land use and ground water quality. This study was one of 14 studies conducted nationwide by the USGS to evaluate regional groundwater quality in relation to land use[85,86]. Nassau and Suffolk Counties were selected for evaluation because they have a wide variety of land uses that range from highly developed suburban areas to agricultural and relatively undeveloped, pristine land and because extensive data on land use and groundwater quality were available.

Groundwater in Nassau and Suffolk Counties remains contaminated by Volatile Organic Compounds (VOCs) from a variety of sources, including industrial discharges, landfills, municipal wastewater discharges, leaks and spills, and domestic cesspool effluent. Contamination by VOCs was first recognized as a problem in public-water supplies on Long Island by Myott (1980)[87]. The compounds of concern are mainly low-molecular weight chlorinated hydrocarbons used as industrial and commercial solvents[88]. The mitigating effect of regional sewers in the highly developed areas of Long Island probably are obscured by the prevalent use of VOCs in these areas, sources of VOCs that have bypassed sewers, such as leaks, spills, and illegal disposal, and the persistence of VOCs in groundwater prior to sewer installation.[122]

Nitrate contamination was recognized as a problem on Long Island in the 1940s, when several water supply wells in the UG aquifer of Nassau County were abandoned because the water contained excessive nitrates, primarily from cesspool effluent.[89] Nitrate nitrogen in groundwater on Long Island has two main sources: fertilizers for crops and residential lawns and gardens, and septic waste of domestic and animal origin.[123]

Although many types of chemical constituents have contaminated coastal ground-water systems, much of the concern to date has focused on the discharge of excess nutrients, particularly nitrogen, to coastal ecosystems. Nutrient contamination of coastal groundwater occurs as a consequence of activities such as wastewater disposal from septic systems and agricultural and urban uses of fertilizers. One of the most common effects of large inputs of

nutrients to coastal waters is acceleration of the process of eutrophication, which is the enrichment of an ecosystem by organic material formed by primary productivity (that is, photosynthetic activity). Nutrient over enrichment can lead to excessive production of algal biomass, loss of important habitats such as seagrass beds and coral reefs, changes in marine biodiversity and distribution of species, and depletion of dissolved oxygen and associated die-offs of marine life.[90]

Appendix 6: Solutions to Saltwater Intrusion

The State of Georgia has established a multicomponent approach for managing saltwater intrusion. This approach restricts withdrawals in some coastal areas, encourages water conservation, and relies on hydrologic studies and water-quality monitoring. These help to better understand saltwater movement in the State's aquifers and to evaluate alternative sources of freshwater. The regional scale of many of the aquifers along the Atlantic coast means that several communities and political jurisdictions often share a single aquifer or aquifer system, and, therefore, ground-water development in one community can affect the water resources of neighboring communities.[91]

A common approach for managing saltwater intrusion has been to reduce the rate of pumping from coastal wells or to move the locations of withdrawals further inland. [92] Reductions in coastal withdrawals allow ground-water levels to recover from their lowered (or stressed) levels, and fresh ground water to displace the intruded saltwater. In New Jersey, for example, State-mandated reductions in ground-water withdrawals in some coastal counties have resulted in groundwater-level increases in aquifers that have been affected by saltwater intrusion.[93] An alternative to reducing ground-water withdrawals is to artificially recharge freshwater into an aquifer to increase ground-water levels and hydraulically control the movement of the intruding saltwater. Artificial recharge can be accomplished through injection wells or by infiltration of freshwater at the land surface. In either case, the recharged water creates hydraulic barriers to saltwater intrusion. Perhaps the most prominent example of the use of artificial recharge to control saltwater intrusion on the East Coast of the United States is in Southeastern Florida. In that area, an extensive network of surface-water canals is used to convey freshwater from inland water conservation (storage) areas during the dry season to coastal areas, where the water is recharged through the canals to the underlying Biscayne aquifer to slow saltwater intrusion.[94]

In addition to more conventional methods, innovative approaches are now being used to manage saltwater intrusion along the Atlantic Coast. These include aquifer storage and recovery systems, desalination systems, and blending of waters of different quality. Aquifer storage and recovery (ASR) is a process by which water is recharged through wells into a suitable aquifer, stored for a period of time, and then extracted from the same wells when needed. Typically, water is stored during wet seasons and extracted during dry seasons. ASR systems have been developed in Wildwood (Cape May County), New Jersey, the town of Chesapeake, Virginia, and at several locations in Florida.[95]

Appendix 7: Alternative Water Resources - Circumventing the Sole Source Aquifer

Alternative Water Sources

Considering alternative water sources to water-stressed regions relieves pressure from traditional water sources and allows for better hydrologic recuperation of these areas. The following are examples of alternative water sources that are pertinent to the research.

Rainwater Harvesting

Rainwater harvesting can be used for potable and non-potable use. With the exception of areas plagued by acid-rain, rainwater is one of the purest water sources. Contamination typically results from the container itself or storage as stored water will eventually host microorganisms and algae. Rain-barrel irrigation systems are very simple, often a covered container connected to the downspout beneath the eaves of a house, with an overflow and a spigot attached to a hose.[96]

According to the "Building Green Association" using rain-barrels for potable water requires a capture surface that neither leaches chemicals nor traps organic matter, a first-flush system, as well as a filter and treatment system. UV light is the most common filtration process.[97] An average rainfall of at least 24 inches is needed for this technology to function at optimal levels.[98]

Rainwater capture can be used for groundwater injection in places where recharge basins have been taken over by pavement, construction or other human activity.[99] It can also help keep waterways free of storm runoff, avoid estuary and stream contamination, as well as protect the aquifers.

Stormwater Harvesting

Stormwater harvesting focuses water toward large holding ponds which can be used to satisfy landscaping or cooling towers at the building scale.[100] Recharge basins that help capture rainfall collected from impervious surface runoffs prevent flooding on key infrastructure such as highways and developments by directing collected rainwater into the ground.

Wastewater Reclamation: Wastewater Recharge

Using reclaimed water from sewage treatment plants to inject back into coastal aquifers has been successful in California.[101] In Nassau County, the Department of Public Works (with grants from the EPA and others) designed a program to investigate the feasibility of recharging the aquifer with wastewaters that would normally be treated and released into the Atlantic Ocean. Under the program, water that has been completely filtered and treated at Cedar Creek Sewage Treatment Plant is piped to a recharge site in East Meadow, near the center of Nassau County. This pilot was unsuccessful because the tertiary treatment process involved chlorination.[102] Although it met EPA standards for drinking water, samples from the recharge site contained trihalomethanes (THMs) which form as a consequence of the chlorination process when disinfected water is stored for long periods

of time in the presence of organic carbon (i.e. underground).[103] Concentrations in violation of EPA standards result from a reaction of residual disinfectants with ambient organic carbon when reclaimed water is recharged. According to the EPA, prolonged consumption of drinking water containing concentrations of trihalomethanes may cause liver, kidney, or central nervous system problems and may increase the risk of cancer.[104] This presents a serious obstacle to the recharge process, though a feasibility project which uses existing infrastructure with an alternative final treatment process (UV-light) should be investigated.

Greywater for Irrigation

Defined as wastewater from showers, clothes washers and sinks, greywater is separated from other wastewater and allows for irrigation during water-stressed seasons but would require plumbing modifications in existing buildings.[105]

Easily designed for new construction, greywater does not contain sewage (black-water). However, microorganisms still multiply quickly so use must be restricted to landscaping and irrigation with no chance of being mistaken for potable water.[106] According to water conservation expert, John Koeller, P.E., greywater reuse is set to be the "next big thing" in water conservation. With the market for such systems steadily growing, he predicts that presence of this practice should slowly become common in commercial buildings as well as residential water systems.[107] The use of greywater for irrigation reduces pressure on septic systems with decreased water flow allowing for more complete decomposition.[108] This practice also prevents lawns from being water-stressed during warmer months without the need to increase groundwater extraction at the same time. The primary challenges to greywater recycling are regulatory. Some states have banned this practice pending further research and standards that can be mandated to ensure compliance. Water-stressed California is one of the states that have legalized reuse after extensive research in 1994.[109]

Alternative Water Sources Continued

Source	Definition	Typical Uses	Requirements	Pros & Cons
Greywater	Wastewater collected in buildings from showers, bathtubs, clothes washers, and lavatory faucets (but never from toilets and usually not kitchen sinks or dishwashers)	Non-potable: usually used for subsurface irrigation	Separate wastewater drainage lines for greywater & blackwater, a filtration system, and usually a storage; sometimes fed directly into subsurface irrigation piping	+Reduces demand for freshwater + Water volumes can be large + can provide irrigation during droughts - Difficulties with permits - Cost of dual piping - Risk of smell - Maintenance requirement
Rooftop rainwater harvesting	Rainfall collected from a roof surface	Non-potable: used for toilet flushing, irrigation, makeup water for cooling equipment; potable if adequately treated	A gutter system to channel rainwater into a cistern or rain barrel; often first-flush and filtration systems; treatment for potable uses. Most practical in climates that receive at least 20" of rain per year	+ Reduces demand for freshwater + Rainwater is generally softer than well water + Avoided energy for pumping (if gravity-fed from a cistern) - When rainwater relied on as sole potable water system, adequate storage is expensive
Landscape-scale storm water harvesting	Storm water collected on parking areas or other low permeability landscape surfaces and	Non-potable: used for toilet flushing, makeup water for	Topography that channels storm water into retention ponds, mechanism for	+ Reduces demand for freshwater + Fairly low cost - Difficult to manage stored water due to

	stored in retention ponds	cooling equipment	withdrawal and use	evaporation, vegetation
Air-conditioner condensate	Condensate captured from the evaporator coils of air-conditioning equipment or dehumidifiers; the condensate is moisture removed from indoor air	Non-potable: used for toilet flushing, irrigation, makeup water for cooling equipment	Drainage of condensate lines into storage for later reuse; only feasible in areas with adequate indoor humidity levels (not as feasible in much of the western US)	+ Reduces demand for freshwater + as distilled water, condensate is initially very pure + Water volumes can be large - Potential for contamination of stored condensate and condensate lines
Mechanical equipment blowdown	Onsite treated wastewater (greywater and blackwater) producing non-potable water	Non-potable: depending on dissolved minerals and contaminants, may be used for irrigation	Collection and storage components integrated with cooling towers or other sources of blowdown water	+ Reduces demand for freshwater + Water volumes can be large - Most blowdown water has high mineral content or other contaminants
Treated wastewater (building scale)	Outflow treated wastewater (greywater and blackwater) producing non-potable water	Non-potable: used for toilet flushing, irrigation, makeup water for cooling equipment	A sophisticated onsite treatment system employing biological action, microfiltatrion, sometimes reverse osmosis, UV or chemical purification; ecological wastewater treatment may be employed	+ Reduces demand for freshwater - High installation costs - Sludge disposal remains - Can be energy intensive

Treated wastewater (municipal)	Outflow from a sewage treatment plant after tertiary treatment and purification; distributed from water utility through separate piping for non-potable uses	Non-potable: used for toilet flushing, irrigation, makeup water for cooling equipment; may someday become acceptable as potable water	Separate supply plumbing for potable and non-potable water; some water utilities provide such piping- most commonly tied to dedicated landscape irrigation systems	+ Reduces demand for freshwater + Energy savings compared with potable water use - Perception that treated wastewater is unsanitary or dirty
Desalinated water	Freshwater produced by removing salts from seawater or brackish water	Potable: generally too expensive for non-potable uses	Most desalination plants use reverse osmosis- forcing saltwater through a specialized membrane that exclude salts	+ Reduces demand for freshwater + Virtually unlimited supply - Energy intensive - Potential for increasing salinity in bays or evaporated ponds where desalination backwash is deposited

State Approaches for Greywater Use

State Approaches	
Arizona	The state uses a tiered approach: Tier 1 applies to residential greywater use for less than 400gal/day (existing homes do not require a permit); Tier 2 applies to greywater use between 400 and 3,000gal/day; Tier 3 applies to greywater use of more than 3,000gal/day (flood irrigation permitted)
California	A 1995 appendix to the state plumbing code makes it legal to use greywater in subsurface irrigation for single-family residences as well as commercial, industrial, and multifamily projects.
Idaho	The state looks to Appendix C of the International Plumbing Code for guidance regarding greywater in subsurface irrigation projects.
Massachusetts	Title 5 provides specific regulations permitting greywater systems for new residential and commercial construction (with respective nitrogen loading requirements) and composting toilet provisions.
Montana	Currently writing rules to implement a 2007 law that allows greywater to be collected, stored, and redistributed for specific purposes such as underground irrigation systems.
New Mexico	A tiered approach similar to Arizona's except that single family residences must have a permit for systems using over 250 gal/day.
New York	A statewide regulation is scheduled to be in place by 2010; greywater reuse is currently allowed in certain areas with permission typically provided by the local health department.
Oregon	An external rule advisory committee is set to consider greywater reuse as part of the state's onsite wastewater treatment rules.
South Dakota	Following certain design criteria, greywater may be reused for toilet flushing and irrigation (without pooling or runoff) on lawns or areas not intended for food production.
Texas	The state uses a tiered approach modeled after Arizona's system.
Utah	Up to 5,000gal/day of greywater resue permitted for subsurface irrigation in single-family residences with approval from the local health department; if greywater is collected, stored, dyed, and treated within a building, that building is allowed to reuse it for toilet flushing and fire protection.
Washington	A statewide regulation is scheduled to be in place by 2010; local county health departments currently regulate greywater reuse.

City Approaches	
Malibu, California	The city has its own greywater handbook for use after obtaining city approval and permits; it contains design criteria for both small and large volume systems as well as systems specific to beachfront homes
Savannah, Georgia	A March 2008 ordinance allows greywater for flushing toilets and urinals; disinfection and dyeing are required

Appendix 8: Town of North Hempstead Water Database

Water Database for the Town of North Hempstead

Prepared by - Columbia University Capstone Team - Fall 2015

Intro

This database was created by a team of Columbia University graduate students in the Sustainabiltiy Management program as part of a Capstone project tasked with supporting the Town of North Hempstead in developing recommendations for conserving water and protecting the Sole Source Aquifer serving Long Island.

Data Sources

Data sources used to compile this database include ;

- pumpage information received from the DEC under a FOIL request,
  a link to the raw pdf files can be found here: **https://www.dropbox.com/s/dzjl9z66z4nz9ed/Foil%20Data.zip?dl=0** FOIL Source
  the data has been transposed to the '0. raw_data' sheet

- data received directly from the WA of Great Neck North and the WA of Western Nassau
- information collected from water provider websites (particularly annual water quality reports)
  most of this is aggregated in sheet '1-Water Supplier Overview'
- DEC cap information provided by Sarah Meyland, Director of the Water Center at the NY Institute of Technology. Most of this data with some annotations can be found in sheet 'Appendix - DEC Cap Analysis'

Note, data inputs are primarily denoted as sheet tabs with gray-scale coloring

Analysis

All assumptions made as part of this analysis were made solely by the Columbia team referencing commonly defined reference targets and methods. All mistakes are attributable to the team.
Sheels 2, 3, 4, and 5 include analyses and modeling of the current water usage situation in the North Hempstead area and are based on assumptions per research findings

Note, analysis calculations are primarily denoted as sheet tabs with white-scale coloring

Water Provider Overview for the Town of North Hempstead Region

#	Water District	Number of Wells	Population Served	Number of Services	Residential Services	Non-billed Water % (2014)	IRB Use	Price Range (per thousand gallons)	DEC Annual CAP (gallons)	DEC 5-Yr Avg CAP (gallons)	5-Yr Average Pumpage (2010-2014)	% of Total Water Pumpage
1	Albertson WD	4	13,500	4,054	3,872	23.0%	Yes		807,000,000	727,000,000	**756,801,200**	**4%**
2	Carle Place WD	4	9,038	2,901					581,000,000	551,000,000	**586,612,600**	**3%**
3	Garden City Park WD	6	18,000	7,088	6,430	7.0%	Yes	$1.10 to $1.20	1,200,000,000	1,150,000,000	**1,201,331,800**	**7%**
4	Glenwood WD	-	1,000	195					none	none	**55,606,000**	**0%**
5	Manhasset-Lakeville WD	18	44,600	10,700	10,000	7.6%	Yes	$1.35 to $4.05	2,851,000,000	2,600,000,000	**2,491,262,400**	**14%**
6	Mineola WD	5	20,500	5,840		9.1%	Yes	$1.85 to $3.25	1,124,000,000	1,106,000,000	**1,038,505,200**	**6%**
7	Old Westbury WD	6	4,624	1,372		7.0%	Yes	$1.75 to $5.00	562,000,000	510,000,000	**759,435,200**	**4%**
8	Plandome WD	-	1,350	441					109,000,000	99,000,000	**94,646,800**	**1%**
9	Port Washington WD	13	30,000	10,000		5.7%	No		1,464,000,000	1,415,000,000	**1,387,211,800**	**8%**
10	Roslyn WD	8	-	-	-	5.7%	Yes	$0.88 to $2.36	1,436,000,000	1,344,000,000	**1,258,876,600**	**7%**
11	Sands Point WD	3	2,900	1,573		7.9%	Yes	$1.45 to $3.00	345,000,000	302,000,000	**414,813,200**	**2%**
12	WA of Great Neck North	11	32,400	9,097		8.3%	Yes	$5.27 to ??	1,753,000,000	1,693,000,000	**1,590,733,333**	**9%**
13	WA of Wester Nassau	24	120,000		28,000	20.7%	No - declining	$4.25 to $2.53	6,180,000,000	5,803,000,000	**4,243,080,965**	**24%**
14	Westbury WD	10	20,500	6,018		8.0%	Yes	$1.00 to $2.40	1,185,000,000	1,117,000,000	**1,226,296,400**	**7%**
15	Williston Park WD	3	10,000	2,400		4.6%	Yes	$3.92 to $4.09	516,000,000	491,000,000	**417,747,400**	**2%**

Water Provider Analysis - Usage

#	Water District	Population Served	DEC Annual CAP (gallons)	DEC 5-Yr Avg CAP (gallons)	5-Yr Average Pumpage (2010-2014)	Unaccounted Water % (Estimated)	5-Yr Average Water Usage (Gallons)	Weight of Water Use per Provider	5-Yr Average Water Usage (MGD)	Water Usage per Pop (g/day)
1	Albertson WD	13,500	807,000,000	727,000,000	**756,801,200**	**15.7%**	637,848,040	4%	1.7	129
2	Carle Place WD	9,038	581,000,000	551,000,000	**586,612,600**	**9.4%**	531,568,066	3%	1.5	161
3	Garden City Park WD	18,000	1,200,000,000	1,150,000,000	**1,201,331,800**	**7.0%**	1,117,238,574	7%	3.1	170
4	Glenwood WD	1,000	none	none	**55,606,000**	**9.4%**	50,388,236	0%	0.1	138
5	Manhasset-Lakeville WD	44,600	2,851,000,000	2,600,000,000	**2,491,262,400**	**8.8%**	2,271,350,565	15%	6.2	140
6	Mineola WD	20,500	1,124,000,000	1,106,000,000	**1,038,505,200**	**8.0%**	954,999,123	6%	2.6	128
7	Old Westbury WD	4,624	562,000,000	510,000,000	**759,435,200**	**7.0%**	706,274,736	5%	1.9	**418**
8	Plandome WD	1,350	109,000,000	99,000,000	**94,646,800**	**9.4%**	85,765,659	1%	0.2	174
9	Port Washington WD	30,000	1,464,000,000	1,415,000,000	**1,387,211,800**	**6.6%**	1,295,600,333	8%	3.5	118
10	Roslyn WD	-	1,436,000,000	1,344,000,000	**1,258,876,600**	**7.0%**	1,170,229,956	8%	3.2	-
11	Sands Point WD	2,900	345,000,000	302,000,000	**414,813,200**	**8.8%**	378,187,087	2%	1.0	**357**
12	WA of Great Neck North	32,400	1,753,000,000	1,693,000,000	**1,590,733,333**	**15.8%**	1,339,397,467	9%	3.7	113
13	WA of Wester Nassau	120,000	6,180,000,000	5,803,000,000	**4,243,080,965**	**16.8%**	3,528,546,130	23%	9.7	81
14	Westbury WD	20,500	1,185,000,000	1,117,000,000	**1,226,296,400**	**6.3%**	1,149,039,727	7%	3.1	154
15	Williston Park WD	10,000	516,000,000	491,000,000	**417,747,400**	**4.6%**	398,531,020	3%	1.1	109

Appendix 9: EPA Selection Criteria for Water Conservation

Selection criteria used in evaluating water conservation recommendations was based on EPA guidelines.[110]

7. SELECT CONSERVATION MEASURES

Selection Criteria

Describe the process by which conservation measures were selected for implementation, including identification of selection criteria. Summarize the selected measures and total anticipated program costs for implementation.

The first step in the selection process is to identify criteria for evaluating the conservation measures. The cost-effectiveness of the measures (from Section 6) is one criterion, but other factors should be considered as well. Planners are free to consider as many selection criteria as they believe are appropriate, but the relevance of the criteria should be explained in the conservation plan.

Criteria that can be used in selecting conservation measures for implementation include:

- ❒ Program costs
- ❒ Cost-effectiveness
- ❒ Ease of implementation
- ❒ Budgetary considerations
- ❒ Staff resources and capability
- ❒ Environmental impacts
- ❒ Ratepayer impacts
- ❒ Environmental and social justice
- ❒ Water rights and permits
- ❒ Legal issues or constraints
- ❒ Regulatory approvals
- ❒ Public acceptance
- ❒ Timeliness of savings
- ❒ Consistency with other programs

For each selection criterion used, planners should identify whether, how, and why the factor affects the feasibility of implementing one or more conservation measures. Different factors might be assigned different weights. Planners also may want to bear in mind that techniques can be used to mitigate adverse effects and improve acceptance of measures. A cost-effective conservation measure should not be dismissed without careful consideration of how barriers to implementation might be overcome.

Selecting the Measures

Worksheet 4-11 provides a simple format for summarizing the selection of measures. For each measure, planners should indicate whether the measure was selected for implementation. Planners also should identify the primary reason or reasons for selecting or rejecting the measure. Special conditions or actions that are required before a selected measure can be implemented (such as an approval from regulators) should be noted.

In some cases, planners may conclude that a measure (or measures) cannot be implemented because of a constraint that exists in the short term. Conservation measures that might be planned for future implementation, once constraints are resolved, should be discussed in the plan. Planners should briefly discuss their implementation strategies with respect to such measures.

Appendix 10: Scoring Criteria Matrix

Evaluation Category	Question	Negative: sub-factor likely to be barrier to success of recommendation (or low impact) -1	Neutral: sub-factor not applicable or not significantly impacting success of recommendations 0	Positive: sub-factors the success of the recommendation or provides strong benefit 1
Redundancy	Are there efforts already being undertaken by outside stakeholders that parallel this recommendation?	Yes, the town is already doing efforts in the same line with the recommendation. Redundancy exists.	The town has an existing program that shares some similarities with the proposed recommendation.	No redundancies and the town has the ability to enact the recommendation without outside actors.
Regulatory	Is there an existing regulatory framework that supports the implementation of this recommendation?	No, new regulatory or legal measure would be needed to put forth recommendation.	Some existing regulatory framework supports implementation of recommendation.	Yes, the recommendation can be implemented given existing regulatory frameworks.
Stakeholder Acceptance	Will the rate-payers, land owners, related NGOs and other stakeholders be in favor of the measure?	No, the stakeholders are unlikely to accept the measure either initially or in the long-term.	Maybe, the stakeholders may object to the measure but not without large efforts.	Yes, the stakeholders and constituents will not object to the measure and may in fact be in favor of it.
Consistency with other programs	Is there a precedent for the respective party to enact the recommendation?	No, the Town has not acted on similar recommendation before and it is unclear if they can.	The Town has acted on similar activities that can open way for the proposed recommendation.	Yes, the Town has done things like this before meaning it has certain capacities to implement the recommendation.
Environmental and Social Justice	Are the recommendation fiscal costs fairly borne by the benefactors? (ex. ratepayer vs. public budget vs. land owners)	No, the cost of the recommendation is unfairly borne by the implementer.	It is unclear as to how the financing and cost distribution of the recommendation are borne.	Yes, the cost of the recommendation Is fairly borne by the benefactors.
Budgetary Considerations	Are the costs associated with the recommendation fundable in current market?	Unclear how to sustainably finance the initiative.	Some funds may be available from grants or reasonable Town budget allocations.	Yes, there is an existing fund or financing pathways for the recommendation.
Cost-Effectiveness	Is the magnitude of the recommendation fundable in current market?	No, the economic and environmental savings are negligible per costs.	The recommendation may be worth the cost, but other ways may prove to be more cost effective.	Yes, the recommendation saves financial and natural resources effectively relative to the initial cost.
Environmental Impacts	Does the recommendation improve the aquifer water quantity and/or quality issues?	No, the recommendation will not have a direct or indirect impact at conserving water withdrawals.	Yes, the recommendation will have a minor direct or indirect impact at conserving water withdrawals.	Yes, the recommendation will have a meaningful direct or indirect impact at conserving water withdrawals.
Timing (of savings)	Does the recommendation represent a near term, mid-term or long-term conservation improvement measure or will it have no benefit to conserving water?	The recommendation is a long-term effort of conserving effort.	Unclear if the recommendation will provide near term savings, there may be many variables in play to determine its impact.	The recommendation will result in water savings in the near term.

Appendix 11: Recommendations & Scoring of Final Recommendations

1. **MANAGEMENT:** Establish a ToNH water conference to promote collaboration between WDs / WAs on best practices, common issues (e.g. develop a shared water loss assessment), joint campaigns to promote water conservation (e.g. financial incentives, standardizing rate structures and seasonal pricing)
2. **POLICY & CODE:** Lobby at county level to establish a license or certification requirement for irrigation installers, in partnership with WaterSense program and Irrigation Association of New York
3. **MANAGEMENT:** Work with WDs and NGOs to develop a cost avoidance study on water conservation to gain public support for conservation programs and develop water efficiency incentives
4. **POLICY & CODE:** Improve enforcement of outdoor watering codes by leveraging the existing 311 system in ToNH to include a 'Service Request' function for infringements to the outdoor watering regulations; calls would be sent to individual WDs / WAs for enforcement / fines
5. **MANAGEMENT:** Expand school education program with specific focus on importance of outdoor irrigation and seasonal water consumption issue
6. **MANAGEMENT:** Create community outreach program with water related non-profits to implement broader education on water conservation
7. **MANAGEMENT:** Study opportunity and business case around aquifer injection (Aquifer Storage & Recovery) of greywater and wastewater from WWTP in ToNH. Evaluate broader uses of rainwater to recharge aquifer, particularly in coastal areas (mainly commercial / government)
8. **POLICY & CODE:** Lobby at county level to implement codes and incentives to ensure increased adoption of LEED (as in the Yes We Can Commnity Center) and greywater technologies in new construction of both commercial and government buildings
9. **POLICY & CODE:** Expand rainwater sensor requirement and annual audit of rainwater sensor (integrated into backflow audit required by DOH) using existing code from Great Neck North WD
10. **MANAGEMENT:** Work with partners (WD, NYIA) to lobby at county level to leverage tax revenues to implement programs such as HERO PACE, incentivize and campaign for adoption of water efficient lawn technology (rain sensors, smart meters, drip irrigation), particularly for older, grandfathered systems.
11. **MANAGEMENT:** Create collateral materials for conservation (ie. Watersense) that water suppliers (WA/WD) can integrate into bills

Scoring of Final Recommendations

#	RECOMMENDATION	C	ToNH Control	IMPLEMENTATION: Redundancy	Regulatory	Stakeholder Acceptance	Consistency	I	COST IMPLICATION: Total - Implementation	Env. & Social Justice	Budget Considerations	Cost effectiveness	CI	WATER CONSERVATION: Total - Cost	Environmental Impacts	WC	Timing of savings	T	Total - Conservation	R	Total	Rank
1	MANAGEMENT: Establish a ToNH water conference to promote collaboration between WDs / WAs on best practices, common issues (e.g. develop a shared water loss assessment), joint campaigns to promote water conservation (e.g. financial incentives, standardizing rate structures and seasonal pricing)	Control	1	1	0	0	50%	1	1	1	100%	1	0	50%			67%		1		
2	POLICY & CODE: Lobby at county level to establish a license or certification requirement for irrigation installers, in partnership with WaterSense program and Irrigation Association of New York	Control	1	0	1	1	75%	1	0	1	67%	1	0	50%			64%		2		
3	MANAGEMENT: Work with WDs and NGOs to develop a cost avoidance study on water conservation to gain public support for conservation programs and develop water efficiency incentives	Control	1	1	1	0	75%	1	0	1	67%	1	0	50%			64%		2		
4	POLICY & CODE: Improve enforcement of outdoor watering codes by leveraging the existing 311 system in ToNH to include a 'Service Request' function for infringements to the outdoor watering regulations; calls would be sent to individual WDs / WAs for enforcement / fines	Control	1	0	0	1	50%	1	-1	1	33%	1	1	100%			61%		3		
8	MANAGEMENT: Expand school education program with specific focus on importance of outdoor irrigation and seasonal water consumption issue	Control	0	1	1	1	75%	1	1	1	100%	0	-1	-50%			42%		4		
9	MANAGEMENT: Create community outreach program with water related non-profits to implement broader education on water conservation	Control	0	1	1	1	75%	1	0	0	33%	0	0	0%			36%		5		
10	MANAGEMENT: Study opportunity and business case around aquifer injection (Aquifer Storage & Recovery) of greywater and wastewater from WWTP in ToNH. Evaluate broader uses of rainwater to recharge aquifer, particularly in coastal areas (mainly commercial / government)	Control	1	0	-1	1	25%	-1	0	-1	-67%	1	1	100%			19%		6		
11	POLICY & CODE: Lobby at county level to implement codes and incentives to ensure increased adoption of LEED (as in the Yes We Can Commnity Center) and greywater technologies in new construction of both commercial and government buildings	Control	1	1	-1	1	50%	0	-1	-1	-67%	0	-1	-50%			-22%		7		
5	POLICY & CODE: Expand rainwater sensor requirement and annual audit of rainwater sensor (integrated into backflow audit required by DOH) using existing code from Great Neck North WD	Influence	1	0	1	1	75%	1	0	1	67%	1	1	100%			81%		1		
6	MANAGEMENT: Work with partners (WD, NYIA) to lobby at county level to leverage tax revenues to implement programs such as HERO PACE, incentivize and campaign for adoption of water efficient lawn technology (rain sensors, smart meters, drip irrigation), particularly for older, grandfathered systems.	Influence	0	1	-1	1	25%	1	1	0	67%	1	0	50%			47%		2		
7	MANAGEMENT: Create collateral materials for conservation (ie. Watersense) that water suppliers (WA/WD) can integrate into bills	Influence	-1	1	0	0	0%	0	0	0	0%	-1	-1	-1			-33%		3		

Appendix 12: Case Study – Success of Watering Violation Hotline

Mandatory water use restrictions and enforcement have returned dramatic water savings in California. In June of 2015, the state introduced mandatory watering restrictions set by the Governor to reduce potable urban water usage by 25%.[111] The State Water Resources Control Board for California also determined the price of a $500 fine for violators of the watering restrictions.[112] At least six major cities in California have been utilizing water hotlines as their main form of enforcement including Los Angeles, San Diego, Sacramento, Monterey, Ventura, and Lakefield along with smaller water suppliers across the state.[113] Water savings have come with enforcement and as Heather Cooley at the Pacific Institute states "without it, you aren't getting the same amount of water savings."[114] Mark Gold of UCLA's Institute of the Environment and Sustainability says "fines become the most critical financial tool to motivate water consumption reductions."[115]

The water conservation mandatory goals have proved extremely effective and successful: "The data shows that the state, as a whole, exceeded the 25% reduction goal, saving more than 27% in June 2015 (the hottest June on record) compared to that of 2013". According to the Pacific Institute, "Californians saved over 182,000 acre feet of water, or about 15% of the total 1.2 million acre feet goal". Further evidence is that conservation occurred at a localized level: "Of the 405 water suppliers reporting, 266 suppliers (66%) met or exceeded their conservation standard. More than 40% of all urban water suppliers reduced their water use by 30% or more." Suppliers that did not meet their targets by 15% or greater are required to increase their enforcement.[116] The case in California demonstrates the effectiveness of a watering ordinance that is enforced at the local level through water hotlines.

The Colorado State research study also highlighted that public awareness is a critical component to the success of any water conservation policy and regulation strategy. "The relative success of both policy and regulation strategies is highly dependent on the level of public awareness and cooperation, which is directly a result of the outreach and education measures used to promote water conservation."

REFERENCES

[1] USGS. "State of the Aquifer". Web. Nov 2015. <http://ny.water.usgs.gov/projects/SOTA/location.html

[2] Wallace, George. "Lawmakers: 'LI Compact' Needed to Manage Water". Great Neck Patch. Dec 2012. Web. Oct 2015. <http://patch.com/new-york/greatneck/advocates-call-for-li-compact-to-manage-regions-water-resources>

[3] Hendrick, Daniel. "Water Flowing Underground". The New York Times. May 16, 2004. Web. Oct 2015. <http://www.nytimes.com/2004/05/16/nyregion/water-flowing-underground.html?_r=0>

[4] "Protecting and Managing Long Island's Groundwater – Presentation to LICAP, July 1st 2015", Sarah Meyland, NY Institute of Technology Water Center, 2015

[5] Dooley, E. C. "Funding cuts eliminate water monitoring program in city, Nassau". Newsday. May 1, 2013. Web. Oct 2015. <http://www.newsday.com/long-island/nassau/funding-cuts-eliminate-water-monitoring-program-in-city-nassau-1.5180543>

[6] Mian, Rashed. "FEMA Delivers $1.6B to Long Island for Sandy Damage". Long Island Press. Sept 20, 2014. Web. Oct 2015. <http://www.longislandpress.com/2014/09/20/fema-delivers-1-6b-to-long-island-for-sandy-damage/>

[7] Barrios, J. "Nassau lawmakers revive water board to keep an eye on NYC wells". Newsday. July 14, 2014. Web. Oct 2015. <http://www.newsday.com/long-island/nassau/nassau-lawmakers-want-water-board-to-keep-an-eye-on-nyc-wells-1.8798605>

[8] "Town of North Hempstead 2014 Comprehensive Annual Financial Report", Office of Town of North Hempstead Comptroller, 2015

[9] (Shared Vision, Port Washington Peninsula)

[10] Town of North Hempstead. "Recycle the Rain Program". *Town of North Hempstead.* September. 2015. Web.< http://www.northhempstead.com/content/7352/7123/4435/11006.aspx>

[11] Water Authority of Great Neck North. "Water Use and Conservation Plan", July 2013, p. 24. 1 October 2015.

[12] United States Code 2012 Edition Vol. 26United States Code. Print. 2012 Edition

[13] "Nassau County Groundwater Monitoring Program 2000-2003", Department of Public Works,Section 2 – pg 6, 2005) Print.

[14] State of the Aquifer – Long Island : Freshwater : Groundwater, USGS, Web. Sept 2015. <http://ny.water.usgs.gov/projects/SOTA/fresh.html>

[15] Barlow P. M. "Ground Water in Freshwater-Saltwater Environments of the Atlantic Coast" United States Geological Survey. Circular 1262. 2003. Web. October 2015. <http://pubs.usgs.gov/circ/2003/circ1262/pdf/circ1262.pdf>

[16] Monti, J., Como, M., Busciolano, R."Water-Table and Potentiometric-Surface Altitudes in the Upper Glacial, Magothy, and Lloyd Aquifers beneath Long Island, New York, April-May 2010", USGS, 2013. Print. Sept 2015.

[17] N.Y. ENV. LAW § 15-1528 : NY Code - Section 15-1528: Moratorium on the drilling of new wells in the Lloyd Sands. Web. Sept 2015. <http://codes.lp.findlaw.com/nycode/ENV/15/15/15-1528#sthash.DDAOIVSL.dpuf>

[18] Ground Water in Freshwater-Saltwater Environments of the Atlantic Coast", Barlow, P., USGS, Circular 1262; pg.7, 2003. Print. Sept. 2015.

[19] Rosenzweig et al. "Climate Change in New York State- Updating the 2011 ClimAID Climate Risk Information". NYSERDA, 2014. Web. Oct 2015. <http://ntrs.nasa.gov/search.jsp?R=20150002144>

[20] NOAA. "Tides and Currents- Sea Level Trends". Web. Oct 2015. <http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml>

[21] Sherif, M.M., and Singh, V.P., 1999, Effect of climate change on seawater intrusion in coastal aquifers: Hydrological Processes, v. 13, p. 1277–1287.

[22] Ibid

[23] Ibid

[24] Stumm, Frederick. "Hydrogeology and extent of Saltwater Intrusion of the Great Neck Peninsula, Great Neck, Long Island, New York". Water Resources Investigations Report 99-4280. U.S Geological Survey. p.33. 2001. Web. <http://ny.water.usgs.gov/pubs/wri/wri994280/wrir99-4280.pdf > Oct 2015.

[25] Reilly, T.E., 1993, Analysis of ground-water systems in freshwater-saltwater environments, *in* Alley, W.M., ed., Regional ground-water quality: New York, Van Nostrand Reinhold, p. 443–469.

[26] Ibid

[27] Ku et. al., "Effects of Urban Storm-Runoff Control on Ground-Water Recharge in Nassau County, New York". Groundwater. Volume 30, Issue 4, pages 507–514, July 1992 <https://info.ngwa.org/GWOL/pdf/922056380.PDF>

[28] Ibid

[29] State of the Aquifer System, Water Availability > Groundwater Budget > Outflow from the Groundwater System > Groundwater Withdrawals. USGS. Web. Sept 2015. <http://ny.water.usgs.gov/projects/SOTA/index.html>

[30] Spinello et. al. Base flow of 10 south-shore streams, Long Island, New York, 1976-85, and the effects of urbanization on base flow and flow duration. Water-Resources Investigations Report 90-4205 <http://pubs.er.usgs.gov/publication/wri904205>

[31] USGS. State of the Aquifer System, Water Availability > Groundwater Budget > Outflow from the Groundwater System > Coastline and Sub-Sea Discharge. Web. Sept 2015. <http://ny.water.usgs.gov/projects/SOTA/index.html>

[32] Fresh Groundwater Use Comparison between 1985 and 2005, Long Island. USGS. <https://www.arcgis.com/home/item.html?id=7b15c9688bc2472db14a138f32cc6328>

[33] Monthly withdrawal rates for Port Washington WD and the Water Authority of Western Nassau were received directly from providers; Roslyn water data - <http://www.roslynwater.org/conservation.html>

[34] "Effects of Urban Storm-Runoff Control on Ground-water Recharge in Nassau County, New York", Ku, H., Hagelin, N., Buxton, H., Ground Water, July-August 1992, Vol 30, No.4, pg 508

[35] "Waste Not, Want Not: The Potential for Urban Water Conservation in California", Gleick et. al., Pacific Institute, Appendix B - Outdoor Water Use, 2003 <http://pacinst.org/publication/waste-not-want-not/>

[36] Pacific Institute. Web. Oct 2015. <www.pacinst.org>

[37] Mayer, P.W., W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. 1999. Residential End Uses of Water. Final Report. AWWA Research Foundation. Denver, Colorado.

[38] Parcel Counts By Type By Municipality: Beginning Roll Year 2000. New York State. Office of Information Technology Services. Retrieved November 4, 2015 <https://data.ny.gov/Government-Finance/Parcel-Counts-By-Type-By-Municipality-Beginning-Ro/tnwc-mx3q >

[39] Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.

[40] Environmental Protection Agency. "Save water in the yard this summer". Infographic. Web. Oct 2015. <http://www3.epa.gov/watersense/outdoor/images/summer-infographic.jpg>

[41] Water Authority of Western Nassau County. "Outside Water Usage". Web. October 1, 2015. <http://www.wawnc.org/cm/index.php?option=com_content&task=view&id=57&Itemid=103>

[42] Ibid

[43] Reilley, Erin. Town of North Hempstead Sustainability Office. "Long Island/Nassau County Water Use Information for PSA". Print.

[44] Town of North Hempstead New York, "Comprehensive Annual Financial Report Year Ended December 31, 2014". Web. Oct 2015. <http://www.northhempsteadny.gov/filestorage/7350/7121/7237/4383/9812/20803/Town_of_North_Hempstead_-_12-31-2014.pdf>

[45] International Code Council. "2010 Plumbing Code of New York State". Web. Oct 2015. <http://publicecodes.cyberregs.com/st/ny/st/b900v10/st_ny_st_b900v10_6_sec008.html>

[46] International Code Council. "2010 Plumbing Code of New York State". Web. Oct 2015. <http://publicecodes.cyberregs.com/st/ny/st/b900v10/st_ny_st_b900v10_6_sec008.html >

[47] Italo J. Vacchio. Superintendent. Port Washington Water District. Oct 20, 2015.

[48] Town of North Hempstead's 311 Call Center. <http://www.northhempstead.com/311online>

[49] Ibid

[50] Ibid

[51] Board of Water Supply. City and County of Honolulu. <http://www.hbws.org/cssweb/display.cfm?sid=1097 >

[52] NBC News. "Drought Shaming: Californians Snitch on Neighbors Who Waste Water". <http://www.nbcnews.com/news/us-news/drought-shaming-californians-snitch-neighbors-who-waste-water-n157451>

[53]DenverWater. <http://www.denverwater.org/Conservation/WaterUseRulesRegulations/SummerWateringRules/ReportWaterWaste/ >

[54] Barta, Rachel et. Al. Colorado Water Resources Research Institute "Stretching Urban Water Supplies in Colorado: Strategies for Landscape Water Conservation", Policy and Regulation Conservation Measure Effectiveness Table 3, 24, 2004. <http://www.cwi.colostate.edu/publications/SR/13.pdf>

[55] Barta, Rachel et. Al.Colorado Water Resources Research Institute "Stretching Urban Water Supplies in Colorado: Strategies for Landscape Water Conservation", Policy and Regulation Conservation Measure Effectiveness Table 3, 24, 2004. <http://www.cwi.colostate.edu/publications/SR/13.pdf>

[56] US EPA website - <http://www3.epa.gov/watersense/our_water/when_its_hot.html>

[57] Irrigation Association. "Landscape Irrigation Contractor State Licensing Guide". Web. Nov 2015. <http://www.irrigation.org/Policy/Landscape_Irrigation_Contractor_State_Licensing_Guide.aspx>

[58] Ibid

[59] Interview with Tom Tracey, President, Irrigation Association of NY, 11/19/2015

[60] US EPA. "Landscape Irrigation Professionals". Web. Nov 2015. <http://www3.epa.gov/watersense/outdoor/irrigation_professionals.html>

[61] Irrigation Association. "Landscape Certifications". Web. Nov 2015. <http://www.irrigation.org/cic/>

[62] State of New Jersey, Department of Environmental Protection. "Landscape Irrigation Contractor". Web. Nov 2015. <http://www.nj.gov/dep/exams/lic.htm>

[63] Nassau County. "Local Law 6-1970". Web. Nov 2015. <http://www.nassaucountyny.gov/3360/Local-Law-6-1970 >

[64] Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet, Long Beach Island, NY Hurricane Sandy Limited Reevaluation Report (HSLRR) for Coastal Storm Risk Management. 6 March 2014. Web. Nov 2015.

<http://www.nan.usace.army.mil/Missions/CivilWorks/ProjectsinNewYork/JonesInlettoEastRockawayInlet(LongBeach).aspx>

[65] Alliance for Water Efficiency. "Conservation Limits Rate Increases for a Colorado Utility". November 2013. Web. Oct 2015. <http://www.financingsustainablewater.org/resource-search/conservation-helps-limit-rate-increases-colorado-utility>

[66] CE2 Model: Evaluating the Costs and Benefits of Urban Water Conservation and Efficiency Measures. Pacific Institute. April 2012. Web. Nov 2015. <http://pacinst.org/publication/573/>

[67] Alliance for Water Efficiency. "AWE Water Conservation Tracking Tool". Web. Nov 2015. <http://www.allianceforwaterefficiency.org/Tracking-Tool.aspx>

[68]New York State Department of Environmental Conservation. "Grant Applications". Web. Nov 2015. <http://www.dec.ny.gov/pubs/grants.html>

[69] The New York State Environmental Facilities Corporation (EFC). The Green Innovation Grant Program (GIGP). Web. Nov 2015. <http://www.efc.ny.gov/Default.aspx?tabid=461>

[70] <http://www2.epa.gov/grants >

[71] Figureau et al. « Decentralization and Economic Incentives to Manage Groundwater Withdrawals for Irrigation: from Theory to Practice". Sept 2013. Web. Nov 2015. <http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=40167637CCFFC9DA307B1A7CF901DD45?doi=10.1.1.411.3217&rep=rep1&type=pdf>

[72] NYSDEC. "Water Withdrawal, Conservation & Drought". Web. Oct 2015. <http://www.dec.ny.gov/lands/313.html>

[73] NYCEP. "Queens Groundwater Rehabilitation". Web. Oct 2015. <http://www.nyc.gov/html/waterforthefuture/queens_groundwater_rehabilitation.shtml>

[74] Miller, Carrie. "Clean water legislation fails to make it to Senate floor". The Suffolk Times. Jun 27, 2014. Web. Oct 2015. <http://suffolktimes.timesreview.com/2014/06/49642/legislation-fails-to-make-it-to-senate-floor/>

[75] "Basis of Design Report for the Construction of a Public Water Supply System", H2M architects+engineers, March 2013, pg. 95

[76] "Public Authorities Law Article 5. Public Utility Authorities. Title 8-B. Water Authority of Great Neck North", 1985, downloaded from WAGNN website <http://www.waterauthorityofgreatnecknorth.com/EnablingStatue.pdf>

[77] Italo J. Vacchio. Port Washington Water District. Interview. Oct 20, 2015.

[78] Manhasset-Lakeville WD 2015 annual budget. Web. Nov 2015. <http://www.mlwd.net/pdf/2015MLWDBudgetinPDF.pdf >

[79] United States Code 2012 Edition Vol. 26United States Code. Print. 2012 Edition

[80] Back, William, and Freeze, R.A., eds., 1983, Chemical hydrogeology: Benchmark Papers in Geology, 73, Hutchinson Ross Publication Company, Stroudsburg, Pa., 416 p.

[81] USGS. "Contaminants Found in Groundwater". Web. Nov 2015. <http://water.usgs.gov/edu/groundwater-contaminants.html>

[82] Sustainable Long Island. 'Long Island's brownfields: An urgent Problem". September 2008. Web. Oct 2015. <http://sustainableli.org/uploaded_files/pages/attach/f_d015377718180ba7a0f5db38e725f68aSLI08_Brownfields_Web.pdf>

[83] Ibid

[84] Environmental Protection Agency. "Addressing Water Contamination through Brownfields Cleanup and Redevelopment". Solid Waste and Emergency Response. EPA 560-F-10-212. July 2010. Web. Oct 2015. <http://nepis.epa.gov/Adobe/PDF/P1009IXT.PDF>

[85]Ayers, Mark A., Jonathan G. Kennen, Paul E. Stackelberg, 2000 Geological Survey (U.S.), National Water-Quality Assessment Program (U.S.) U.S. Dept. of the Interior, U.S. Geological Survey,- Nature - 40 pages

[86] Johnson,Tyler D., Kenneth Belitz, .2009 Assigning land use to supply wells for the statistical characterization of regional groundwater quality: Correlating urban land use and VOC occurrence, Journal of Hydrology, Volume 370, Issues 1–4, 30 May 2009, Pages 100-108. Web. Oct 2015. <http://www.sciencedirect.com/science/article/pii/S0022169409001462>

[87] Eckhardt, David AV, and Kenneth A. Pearsall. *Chlorinated organic compounds in ground water at Roosevelt Field, Nassau County, Long Island, New York*. Department of the Interior, US Geological Survey, 1989.

[88]Eckhardt, D. A. V. and Stackelberg, P. E. (1995), Relation of Ground-Water Quality to Land Use on Long Island, New York. Groundwater, 33: 1019–1033

[89] Katz, Sandra M. Eberts, Leon J. Kauffman, 2011, Using Cl/Br ratios and other indicators to assess potential impacts on groundwater quality from septic systems: A review and examples from principal aquifers in the United States, Journal of Hydrology. Print. Volume 397, Issues 3–4, 3 Feb 2011, 151-166.

[90] National Research Council, 2000, Clean coastal waters—Understanding and reducing the effects of nutrient pollution: Washington, D.C. Print. National Academy Press.

[91] Barlow, P. (2003). *Ground water in freshwater-saltwater environments of the Atlantic Coast* (p. 36). Reston, VA: U.S. Dept. of the Interior, U.S. Geological Survey. Print.

[92] Barlow, P. (Ed.). (2013, January 11). Ground Water in Freshwater-Saltwater Environments of the Atlantic Coast. Web. Nov 2015. <http://pubs.usgs.gov/circ/2003/circ1262>

[93] Ibid

[94] Barlow, P. (2013, January 11). Ground Water in Freshwater-Saltwater Environments of the Atlantic Coast. Web. Dec 2015. <http://pubs.usgs.gov/circ/2003/circ1262/ CHAPTER 2. CAUSES, MODES, AND MANAGEMENT OF SALTWATER INTRUSION>

[95] Barlow, P.M., and Wild, E.C., 2002, Bibliography on the occurrence and intrusion of saltwater in aquifers along the Atlantic coast of the United States: U.S. Geological Survey Open-File Report 02–235. Print.

[96] Wilson et al. "Alternative Water Sources: Supply-Side Solutions for Green Buildings". Environmental Building News. Building Green. Web. Oct 2015. <https://www2.buildinggreen.com/article/alternative-water-sources-supply-side-solutions-green-buildings >

[97]Ibid

[98] Wilson, Alex. "Rainwater Harvesting". Environmental Building News. Building Green. Web. Oct 2015. <https://www2.buildinggreen.com/article/rainwater-harvesting>

[99]Rayaan Harb Thesis pp.1

[100] Wilson et al. "Alternative Water Sources: Supply-Side Solutions for Green Buildings". Environmental Building News. Building Green. Web. Oct 2015. <https://www2.buildinggreen.com/article/alternative-water-sources-supply-side-solutions-green-buildings>

[101] "Waste Not, Want Not: The Potential for Urban Water Conservation in California", Gleick et. al., Pacific Institute, Appendix B - Outdoor Water Use, 2003

[102](Wood 06) <http://dujs.dartmouth.edu/wp-content/uploads/2008/04/wastewater.pdf >

[103] U.S. Environmental Protection Agency, 2002b, Drinking water advisory—Consumer acceptability advice and health effects analysis on sodium: U.S. Environmental Protection Agency EPA 822–R–02–032 (April 2002), accessed March 13, 2003, at <http://www.epa.gov/safewater/ccl/pdf/sodium.pdf>, 34 p.

[104] Ibid

[105] Wilson, Alex. "Using greywater for Landscape Irrigation". Environmental Building News. Building Green. Web. Oct 2015. <https://www2.buildinggreen.com/article/using-greywater-landscape-irrigation>

[106] Ibid

[107] Wilson et al. "Alternative Water Sources: Supply-Side Solutions for Green Buildings". Environmental Building News. Building Green. Web. Oct 2015.

[108] Wilson, Alex. "Using greywater for Landscape Irrigation". Environmental Building News. Building Green. Web. Oct 2015. <https://www2.buildinggreen.com/article/using-greywater-landscape-irrigation>

[109] Ibid

[110] Water Conservation Plan Guidelines: Part 4 Intermediate Guidelines for Preparing Water Conservation Plans. USEPA. August 1998. pg 87 <http://www3.epa.gov/watersense/pubs/guide.html>

[111] Donnelly, Kristina. Pacific Institute. "New Data Show California Cities' Progress towards State-Mandated Conservation Requirements". 4, August, 2015. <http://pacinst.org/new-data-show-california-cities-progress-towards-state-mandated-conservation-requirements/>

[112] Nirappil, Fenit. "California water-wasters elude fines as drought persists". 14, March, 2015. <http://www.dailynews.com/general-news/20150314/california-water-wasters-elude-fines-as-drought-persists>

[113] California American Water. "Report Water Waste". <http://www.amwater.com/caaw/learning-center/page25286.html>

[114] Nirappil, Fenit. "California water-wasters elude fines as drought persists". 14, March, 2015. <http://www.dailynews.com/general-news/20150314/california-water-wasters-elude-fines-as-drought-persists>

[115] Stevens, Matt. The Los Angeles Times. "$10,000 fines a potent PR tool against water waste". 30, April, 2015. <http://www.latimes.com/local/california/la-me-drought-psyche-20150430-story.html>

[116] Donnelly, Kristina. Pacific Institute. "New Data Show California Cities' Progress towards State-Mandated Conservation Requirements". 4, August, 2015. <http://pacinst.org/new-data-show-california-cities-progress-towards-state-mandated-conservation-requirements/>