

**NEW YORK CITY
WATER HUB:**
Catalyzing an Emerging
Industry



COLUMBIA | SIPA
School of International and Public Affairs

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Acknowledgements

The MPA-ESP team wants to express its appreciation to the New York City Department of Environmental Protection and the New York City Economic Development Corporation, specifically Alan Cohn and Kristin Bell, who have been instrumental in concretizing the ideas put forth in this report. The opportunity to work with these organizations and individuals has been a powerful learning experience. The research team believes the efforts put forth this semester and outputs incorporated into this report can be utilized to forward the establishment of a collaborative water body, in the New York City Water Hub.

We would also like to thank our faculty advisor, Dr. Nancy Degnan, a terrific source of information and feedback, for shaping the direction of this project.

We additionally want to thank the individuals who we interviewed for this report. The information gleaned from these interviews was essential to supplement the research we conducted.

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Executive Summary

Sustainable water management is at the forefront of human concerns, especially in the context of a changing global climate. Providing access to safe, clean drinking water, successfully managing wastewater, and ensuring resiliency to storm water and its damages must all be executed carefully, thoughtfully, and sustainably. Collaboration is necessary to join various economic sectors to optimize these practices, and to ensure the existence of healthy water systems for present and future generations.

A water hub is a central, collaborative network that enables participants to share research and innovation for water technologies, financing opportunities, and implementation mechanisms. Such a network drives economic development linked to the design and implementation of effective water strategies. This report analyzes the successes and limitations of five of water hubs, situated across three continents, in order to understand the important roles the hubs play in the water space, locally, regionally and globally. The hubs are in: 1. Copenhagen, Denmark; 2. Toronto, Canada; 3. Milwaukee, Wisconsin, USA; 4. The Republic of Singapore; and, 5. Boston, Massachusetts (the location of a New England regional hub).

Differences in the hubs stem from inherent difference in the hubs' local geographies and politics, as well as underlying driving forces and aims, choices of management structures, and mechanisms for collaboration. Many commonalities exist across the examined hubs, derived from their platforms of enhanced collaboration. By joining partners from academia, nonprofits, and the public and private sectors, on one hand, and enhancing management and communication on the other, all hubs have been able to capitalize on the opportunities afforded by water to promote economic growth. Major categories of success include improved water supply and distribution, enhanced resiliency, adoption of innovative technologies, financial growth, and job creation.

New York City is well positioned to emerge as a regional, national and global leader in the water space. The City's unique coastal geography, effective water infrastructure, and availability of private investment are all integrated with the City's emphasis on long-term planning and prioritization of climate resiliency.

Ultimately, this report assesses the feasibility of establishing a water hub in New York City and proposes ways forward to do so. Five major recommendations are suggested:

- (1) Define the problem and identify opportunities;
- (2) Establish and communicate an official public stance;
- (3) Assemble a coalition with a centralized management system;
- (4) Pave an avenue for financial success; and
- (5) Promote continuing innovation.

By focusing on these recommendations, New York City can establish a leading water hub, ensuring sustainable water management and bringing about sustained economic development.

Project Overview

This report is the final deliverable for the Workshop in Applied Earth Systems and Policy Analysis course, the capstone requirement for the Master of Public Administration in Environmental Science and Policy (MPA-ESP) at Columbia University's School of International and Public Affairs (SIPA).

The Workshop comprises of a group of graduate students completing a pro bono consultancy assignment for a public-sector client. A team of ten MPA-ESP Program students, led by a faculty advisor from the Program, was asked by the New York City Department of Environmental Protection (DEP) and the New York City Economic Development Corporation (EDC) to research the feasibility of establishing a water sector hub in New York City. This report is a product of the team's inquiry, conducted over the spring semester, 2017. It reflects in-depth primary and secondary research and analysis, as well as frequent meetings and exchange with the clients and water sector experts. The Workshop Team also conducted three briefings, the final of which was presented to the DEP and EDC in May 2017.

Columbia University's MPA-ESP Program is an intensive one-year degree focused on developing future environmental sustainability leaders. Students develop quantitative and qualitative skills required to address current and emerging environmental issues, including climate change, world water shortages, environmental contamination, and renewable energy. The degree emphasizes applied science, project management, economics, and policy analysis both through real-world case studies and simulations. Additionally, the Program facilitates interdisciplinary problem-solving and fosters systems-thinking as well as systems-based approaches to public policy problems, preparing students for careers in government, nonprofit and for-profit sectors. The MPA-ESP degree was created in 2002 and at the publishing of this report in 2017 has over 700 alumni.

The Researchers

Averill Wickland (Manager)

Averill Wickland has had a passion for the environment and sustainability his whole life. From exploring the woods to growing seedlings and flowers, his time growing up in Vermont was a formative experience. He pursued a B.A. in Earth and Environmental Sciences at Wesleyan University and shortly after, joined the Peace Corps. Here, stationed at the base of a mountain, tucked in a remote corner of Malawi, he worked to alleviate deforestation by helping host country nationals establish orchards and woodlots. Since returning to the United States, Averill has been living in New York City, working in environmental education, especially with kids, teens and families. Much of this work focused on the uniqueness of the urban ecosystem in New York City, and the importance of water issues.



Mohammad Umar Ashfaq (Deputy Manager)

Umar has eight years of work experience spanning the investment management and nonprofit sectors in Pakistan and the Middle East. Most recently, Umar was the CEO of Teach for Pakistan, the Pakistan chapter of Teach for America, managing operations in schools across the two cities, Karachi and Lahore. He has consulted for startups and social enterprises at various stages of their life-cycle, working with entrepreneurs and incubators on business planning, valuation and optimization. He has also worked in the asset management industry in South Asia and the Middle East North Africa (MENA) region, focusing on investment due diligence, equity research and portfolio management. Umar has a BSc (Honors) from Lahore University of Management Sciences (Pakistan) in Mathematics and Economics.



Kevin Cheng

Kevin is a graduate research consultant and an associate researcher at the Earth Engineering Center, where he conducts research on waste management policies in China. He collaborates with policymakers, academics, practitioners, and global innovators in China and around the world to promote the exchange of best practices and innovative solutions to global waste management challenges. Previously, Kevin served as the Director of Internal Controls for Winewise Hong Kong Group Limited. He also worked



as an audit associate and financial consultant at Deloitte LLP in Hong Kong. Kevin earned his B.B.A. in Business Administration from Pace University. After graduation, he plans to pursue a career that connects sustainability and social responsibility to global economic development.

Tiara Cunningham

Tiara received her BA in Anthropology and Sociology with a minor in Environmental Studies from Spelman College in 2012. During her undergraduate career, Tiara researched climate change and its health impacts at Emory University Rollins School of Public Health. She also interned with the US Department of Energy, in the Energy Efficiency and Renewable Energy (EERE) office. After working as an English teacher in Shenzhen, China for 2 years and working as a financial consultant for the US Department of Defense, Tiara enrolled in the MPA Environmental Science and Policy Program at Columbia University. After graduation, Tiara plans to pursue an academic research career focusing on the interplay of environmental health, sustainability and policy.



Katie Flahive

Katie is passionate about building equitable climate resiliency, joining her background and experience in sustainable development and geography. Before enrolling in the MPA ESP program, she worked as Sustainability Coordinator with a National Heritage Area in Southeastern Pennsylvania. Here, she worked to bring about sustainable economic development by implementing community recreation and environmental education and mentorship programs in underserved communities. She has previously worked with the Smithsonian Institution, first in environmental education and outreach in the Chesapeake Bay and later conducting geospatial research on tropical deforestation in Eastern Panama. Katie has a B.A. in Environment and Development with a Minor in Geography from McGill University in Montreal, Quebec. After graduation, she plans to pursue a career in urban sustainability, combining her knowledge of both natural and social sciences with her skillset in project management and policy analysis.



Lacey McCarthy

Lacey has over seven years of experience in biological research and high school science education. She taught various science courses, such as biology and chemistry, to at-risk students in a nontraditional school setting for five years. Before becoming a teacher, she interned at the Smithsonian Center for Conservation, Education, and Sustainability where she helped prepare a conservation capacity building workshop in Botswana, and performed research and analysis to support camera trap monitoring in the Peruvian Amazon. She earned her BS in Biological Sciences with a concentration in Ecology, Evolution, and Conservation Biology. While in school she was a field research technician monitoring an endangered butterfly and a lab researcher on pathogens in honey bees for which she is published as a co-author in PLoS ONE. She plans to pursue a career that connects policy, environmental conservation practices, and human development through informed decision making.



Marissa Sterling

Marissa is a policy advisor and research scientist at the Lamont-Doherty Earth Observatory, where she studies the link between water scarcity and conflict in the Middle East. Marissa collaborates with scientists at Columbia to form relationships with activists on the ground in Israel and Jordan to better inform water policy with climate science. Previously, Marissa served on the executive board of Change-Magazine, Inc. as Managing Editor for Development to recruit and establish new branches across the country. She has also worked as a consultant for the Trust for the Public Land's Climate-Smart-Cities Initiative. Marissa earned her B.A. in sustainable development from Columbia University and her B.A. in Jewish Ethics from The Jewish Theological Seminary of America.



Jayson VanBeusichem

Jayson has three and a half years of experience in public policy and international development. At the World Resources Institute, he provided research, writing, and administrative support to the three Directors of the Food, Forests, and Water Programs. Prior to that Jayson was a Junior Legislative Assistant/Legislative Correspondent in the Office of Congresswoman Carol Shea-Porter (NH-01), where his portfolio included the environment and natural resources, transportation, agriculture, and financial services. He also worked at the climate change organization 350 Vermont and



on the 2012 reelection campaign of United States Senator Bernie Sanders (VT). He has his BA in Political Science and Religious Studies from Stonehill College in Easton, Massachusetts. After graduating in May, Jayson plans to pursue a career combining policy, international development, and environmental protection in the fields of water management, food security, or resilience.

Louise Venables

Louise has eight years of experience in professional services, first as a public sector financial auditor and then as a sustainability consultant. She has worked with multinational corporations as well as public sector organizations to design and implement sustainability strategies. Following five years working in London, Louise moved to Abu Dhabi in the United Arab Emirates to establish KPMG's first sustainability consulting practice in the region. She is a chartered accountant and a candidate in the Chartered Financial Analyst program (Level 2). Her skills and passion lie at the intersection of sustainability and finance.



Isaac Wilkins

Isaac received his BA in Political Science and minor in Chemistry from Howard University in 2016. While being a Bill Gates Millennium Scholar, Wilkins also served as an Organic chemistry researcher at Howard and UCLA, both working to help develop more efficient and inexpensive capsules for pharmaceuticals. Matriculating through college he continued doing research serving as a political science researcher, investigating key factors and policy issues related to the lack of diversity in STEM. Inspired to learn more about the public-sector Isaac served as a congressional intern for U.S. Sen. Cory Booker focusing on health and environmental issues. While academically focused Isaac also founded the Men of George Washington Carver Brother-Hood, helping freshmen males matriculate and advance throughout college. Combining his experience in Chemistry and Political Science Wilkins attended COP21 and more recently COP22, serving as a student delegate and researcher. Currently Isaac serves as a sustainability consultant for a small start-up company in Chicago and seeks to continue his mission of bridging the gap between natural and social science solving global and environmental issues.



Advisor: Professor Anne (Nancy) Degnan, Ph.D.

Nancy is a Senior Advisor for Education and Outreach for the Columbia Water Center, Earth Institute, Columbia University, headed by Dr. Upmanu Lall. In this capacity, she works with the Center's research team to help translate, design, develop and implement education on water across the K-12 sector, higher education and professional and executive education. The Center addresses six critical areas of research including: America's Water, Global Floods Initiatives, Data Analytics, Multiscale Predictions, Risk and Financial Instruments, and the Water-Food-Energy Nexus. The ultimate objective is to advance understanding of water as the incipient issue of sustainable development (U. Lall, 2015) and to frame the stewardship and management of water for an increasingly water-stressed 21st century.



During her recent career, Nancy was the Director, Academic Initiatives for the Earth Institute, Columbia University as well as the Executive Director of the Center for Environmental Research and Conservation, also of the Earth Institute. The Earth Institute brings together the people and tools needed to address some of the world's most difficult problems, from climate change and environmental degradation, to poverty, disease and the sustainable use of resources. Nancy also teaches a graduate Workshop in Applied Policy Analysis for Columbia's School of International and Public Affairs (SIPA) in its Environmental Science and Policy MPA Program, or, the ESP-MPA Program.

Nancy received her BA from the College of New Rochelle in International Relations and her MPA and Ph.D. from Columbia University. She is a life-long resident of New York.

The Clients



The New York City Department of Environmental Protection, (DEP) is responsible for managing the City's water supply and treatment systems as well as reducing air, noise, and hazardous waste pollution. The New York City Economic Development Corporation (EDC) is a citywide nonprofit organization that promotes economic growth and development to increase employment opportunities for all New Yorkers, to make neighborhoods more resilient, and to create shared prosperity across the city.

By engaging together on a water hub, the DEP and EDC seek a shared objective of improving water management and promoting economic development through implementation of emerging technologies in New York City. Moreover, to achieve such a goal, the clients also aim to bring together stakeholders with diverse expertise to solve the City's water problem and to capitalize on its business and financial capacities.

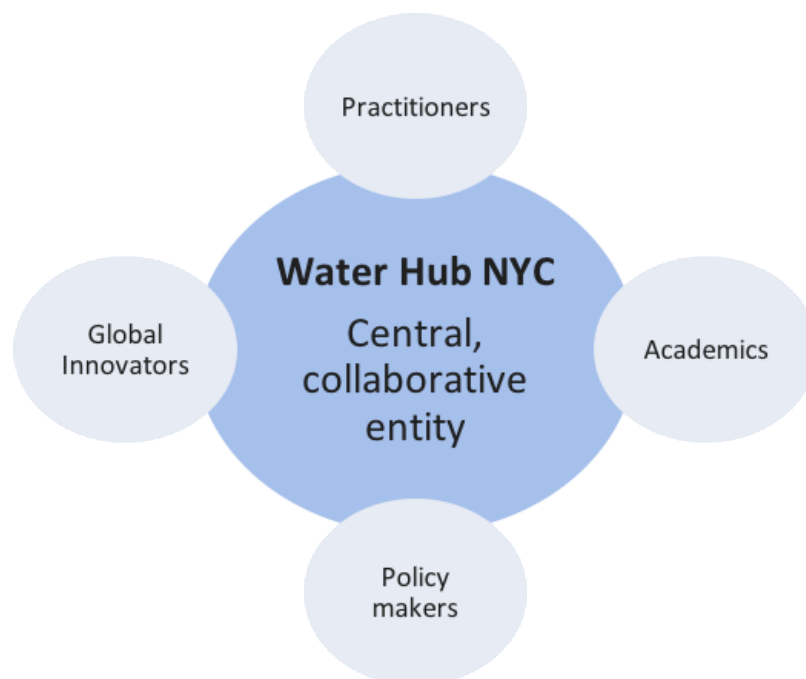
Purpose

Water plays a vital role in the long-term resiliency and sustainability of New York City. The City needs to effectively and efficiently provide clean, potable water and manage wastewater and storm water for nearly 9 million inhabitants. Located on four islands, the City will be deeply affected by climate change and corresponding sea level rise. New York City is uniquely positioned as a national and international leader and sits at the crossroads for trade and commerce, finance, insurance, and real estate transactions.

The DEP and the EDC would like to explore the potential for creating a central, collaborative entity – a Water Hub – to bring together regional, national and global innovators, academics, policymakers, and practitioners to promote novel, cross-sectoral approaches to water management.

A logical next step, that has begun to be conceptualized through discussions between the DEP and EDC, is for the City to become a hub for advancing technology, supporting applied research, and promoting sustainable water management. The hub would be a unique opportunity to promote entrepreneurship and investment in innovation, while working to fulfill the City's sustainability goals and objectives. Finally, a New York City Water Hub – because of the City's role regionally and globally -- holds the promise of being a catalyst for 21st century sustainability and resilience in water, across the nation and around the world.

All of these characteristics are critical, and taken together, help address and tackle the challenges of an increasingly water-stressed world. A water hub will support the goals the DEP and EDC—advancing the sustainability and economic strength of New York City.



Introduction

The term ‘water hub’ is used to describe a collaborative network of participants in the water sector. These participants may come from the private or nonprofit sectors, academic institutions, or government entities. The water hub offers numerous benefits to its participants, which may range from knowledge sharing and networking, to designated office space, product-testing laboratories and opportunities to raise investment to fund new ideas in water technology. A hub requires centralized, coordinating efforts, which may be undertaken by a private, nonprofit, or governmental organization.

The characteristics of each hub are unique and determined by the natural geographies and political landscape of the region where they are located. The motivations for creating each hub also differ. For example, the water hubs discussed in this paper work to reduce water scarcity, improve efficiency and access, increase resilience, and promote economic development.

Despite these differences, water hubs all seek to improve collaboration and cooperation within the water sector. Toward achieving this end, they can remove barriers between the public and private sector, facilitate information sharing, and/or create a physical working space. Ultimately, the hubs enhance collaboration between entities in pursuit of addressing a problem and/or capitalizing on an opportunity presented by the water sector. By doing so, hubs also accrue additional benefits like generating jobs, economic growth, and socio-economic and environmental development.

Research Design

To understand the potential for creating a NYC Water Hub, the Workshop team researched and studied existing water hub projects and assessed the feasibility of applying similar approaches in New York City. The research team performed an extensive literature review and conducted interviews with subject matter experts. They then performed a comparative analysis to develop recommendations for establishing a New York City Water Hub.

The research consisted of the following methodology:

I. Literature Review

A. Researchers studied the features of existing water hubs in Milwaukee, Toronto, Denmark, and Singapore, specifically:

1. Mission statements and objectives for each hub
2. Derived benefits
3. Best practices
4. Existing regulatory framework and governance
5. Stakeholders and partnerships
6. Funding mechanisms
7. Measures of success

B. Researchers examined the current state of New York City's water sector:

1. Key stakeholders responsible for water management
2. Challenges related to water management
3. Organizations and businesses working on innovative water technologies
4. Linkages between public and private sector water innovators
5. Existing water value chain

II. Interviews

Given the multidisciplinary nature of the project, interviewees included individuals from public administration, private industry, and academia. The research team generated a list of general questions for all interviewees and specific questions for each sector. Initial contacts were determined with guidance from the clients and additional contacts were identified throughout the course of the project. To better understand New York City's water sector and existing water hubs, interviewees included:

A. 'Internal' experts, including those at:

1. Affiliated schools at Columbia University, including the Columbia Business School, and the Fu School of Engineering and Applied Sciences
2. Affiliated research institutes, such as the Columbia Water Center, Earth Institute, Lamont-Doherty Earth Observatory, NASA - Center for Climate Systems Research

B. ‘External’ experts, who included personnel at:

1. Government departments, including those at the DEP and EDC
2. The existing water hubs of Copenhagen, Denmark; Toronto, Canada; Milwaukee, WI, US and Boston, MA, US.
3. Nonprofit organizations working in the field of water
4. Business incubators and organizations furthering innovation and entrepreneurship related to water management

III. Comparison and Analysis

Taking into consideration the secondary research and primary information obtained through interviews, the research team identified specific examples of success within each hub and relevant factors that enabled those successes. Though each hub is uniquely influenced by its physical environment, political climate, and specific water challenges, common overarching categories of success emerged for:

- **Economics:** With foci on job creation and growth of new businesses.
- **Education:** With approaches that included awareness raising campaigns and events, to the development of a graduate program specializing in water.
- **Communication:** With events such as annual conferences on topical issues to campaigns designed to widely publicize the achievements of the water hubs through social media and web presence.
- **Resilience:** With strategies to adapt to threats posed by extreme weather events.
- **Treatment:** With incentives that advanced novel and/or enhanced water treatment processes.
- **Efficiency:** With the drivers that catalyzed technological solutions to problems of water wastage and loss.
- **Flexibility:** With a willingness to look ahead to potential challenges, and to adapt current practices according to those future needs.

Comparative analysis also provided an opportunity to learn about the challenges experienced by established water hubs. While not all challenges hold insights for New York City, the research team identified the following set that may be useful when planning for a New York City water hub:

- The entity with the responsibility for coordinating the activities of a water hub often faces resource-constraint challenges. Existing hubs have found it valuable to collaborate with partners for coordination activities and to share the workload. Because the coordinating entity is often a nonprofit, attracting long-term funding is also a challenge.

- Technological innovation often requires low-levels of risk aversion and high levels of financial support. A water hub that focuses on incubating startup companies and helping to bring new technology to market faces the challenge that many start-ups fail and appropriate technology is often difficult to develop, test, and fully implement at scale.
- Policy changes may be slow to develop and even slower to implement. This may mean that, in some cases, the water hub should not be overly dependent on policy development to realize its aims.

Existing Hub Profiles

The researchers evaluated existing hubs that are considered well-established with a wide geographic spread (operating in five locations across three continents). These hubs are concerned with ensuring both water quantity and quality, as well as building resiliency to extreme weather events. These are concerns for New York City, too. The existing hubs have taken different approaches to addressing these challenges, but each offers important insights.

For the purpose of this report, findings from five specific water hubs are presented. The findings are informed by secondary research as well as a number of interviews conducted with experts in the hubs, in academia and in government agencies. Notably, interviews are considered to be to have been conducted with due diligence and “all care taken but no responsibility accepted” by either the interviewer or the interviewee.

At the beginning of each section, key points, or “Learnings” appear. “Learnings” is a colloquial term from the medical field and *means specific items that were newly discovered or learned* (www.grammarist.com). The research team appreciated what the word implies and, therefore, adopted it as a heading for this report.

A. Copenhagen, Denmark



Project Director and
Senior Advisor, Environment



Some Key Learnings:

- *Severe weather is a current and future threat globally*
- *The government can make clear statements and set environmental targets with deadlines. Then, other stakeholders like private businesses can create solutions to achieve these targets.*

Natural Environment and Water Challenges

Denmark consists of the mainland peninsula Jutland and an archipelago of over 400 named islands. The country is almost entirely surrounded by water, with the Kattegat and Baltic Sea to the east and the North Sea to the West. This proximity to the ocean - no location in the country is more than 30 miles away from the sea, has led to the water exerting a significant influence over the country, economy, and culture.¹ The challenges faced by Denmark relate to its proximity to the ocean, including the influence of the ocean on Denmark's climate, the availability of resources, the acquisition of freshwater, and the treatment of wastewater.

As a low-lying country, Denmark faces several immediate and long-term threats from sea level rise, including coastal flooding and saltwater intrusion into freshwater aquifers. The country also must contend with sudden downpours brought on by cloudbursts. These storms and the resultant flooding they generate are a serious threat to the country's people, infrastructure, and economy.

Establishment

Denmark has been engaged in a decades-long effort to promote sustainability. Building on the successes of its energy efficiency standards, the country turned its attention to reducing nutrient loads in wastewater. This focus was two-pronged. On one hand, goals were established for decreasing nitrogen and phosphorus levels, while on the other, goals were simultaneously set to increase energy efficiency used in wastewater treatment plants to the level of 2 percent per year. These goals have been reinforced through public-private partnerships, utilizing the expertise and research and development capability of the private sector to bolster the capacity of plants and utilities.

Two specific examples of how the government of Denmark supports public/private partnerships are The Denmark Climate Consortium and the State of Green Portal.

In 2008, prior to COP15 in Copenhagen, Denmark created The Denmark Climate Consortium. The Consortium connects public and private resources to address climate related issues including energy, water and environmental technology.² Denmark has set an ambitious goal of being fossil fuel independent by 2050. A core part of their strategy is to convert wastewater sludge to natural gas for energy production used in heating and cooling. The clean technology sector is instrumental in designing, testing and implementing the kind of innovation that is required to fulfill the strategy and achieve this goal.³

The State of Green Portal serves to connect all stakeholders in the sustainability space. The Portal provides public access to content, products and contact information that can be used to build and reinforce public/private partnerships. Information on the Portal is supplied at no cost and can be used freely for non-commercial means. Additionally, the Portal has addressed the issue of intellectual property. A set of protocols designed to protect against the improper use of intellectual property for commercial purposes is in place. The architecture and protections afforded by the Portal have catalyzed rapid innovation. Coupled with ongoing government support, partnerships continue to grow and produce the technology required to solve some of the most pressing 21st century sustainability challenges.

One of the important lessons of the Danish experience, however, is that decisions about what stakeholders to engage in the initial stages of policymaking and implementation. Neither energy nor water utilities was part of the policy process at the outset. The absence of expertise from the utilities is cited as one reason why policy for, and implementation of, new technology was slower than anticipated.

Policies

The foundation of Denmark's water hub has been centered around partnerships between corporations and public utilities. Prior to these partnerships, the water utilities in Denmark lacked the capabilities to perform significant research and development in pursuit of enhancing quality. Private firms provided the needed expertise and flexibility for innovation. The Cleantech Hub, which is the outgrowth of public-private partnership, is an effort between the Danish Government and the Confederation of Industry. The Danish Confederation of Industry is a private entity funded and managed by Danish companies in the trade, manufacturing and service industries. The overall mission of the Cleantech Hub is to promote Danish technologies and Danish companies within a global marketplace. Toward this end, the Hub has specifically targeted New York City and Shanghai as entry points.⁴

Additionally, the culture of collaboration in Denmark has been central to expediting the creation of positive environmental initiatives. As an example, the Danish citizenry has overwhelmingly supported these initiatives to reduce nutrient loading (specifically nitrogen and, later, phosphorus) as well as to increase efficiency across multiple sectors⁵. This same collaborative culture is part of an ethos of cooperation and open communication within the governmental sector as well. In effect,

the “flatter” bureaucracy in Denmark affords greater opportunity for the flow of ideas between and among administrative tiers and greater ease in decision-making processes for all functions including public/private partnerships.

Funding

There are many private- and public-sector funding opportunities in Denmark. The private sector recognizes that there are significant benefits to be gained from water innovations, both for business and society. As a result, water is a major component of the technology sphere – a position that is reinforced by the implementation of strict environmental standards at a policy level. The government incentivizes innovation, for example, through the installation of privately developed technologies in public pilot projects. In Copenhagen, there is a climate/storm water neighborhood that was built with the purpose of testing new technologies in “real” community settings. The climate/storm water neighborhood serves as a “living laboratory” in Copenhagen and includes technologies such as:

- Rain-garden - retains rainwater
- Bio-swales
- Green roofs⁶

The government’s drive for the development and testing of these technologies is critical because it provides Danish companies with a competitive advantage. Because the government provides a clear regulatory framework, companies are motivated to take the kinds of risk necessary for innovation; and, for market introduction of their products within an accelerated timeframe. Consequently, these first adopters can benefit from earlier economies of scale.

Successes

As described above, the development of public-private partnerships has been a key feature of success. Klaus Christensen, who was interviewed for this report, notes that the social structure in Denmark plays a major role in the success of these public-private partnerships.⁷ The government is more explorative and less risk-averse, which allows for the implementation of potentially-viable technologies that have not yet been tested at scale. This stands in contrast to some of the New York City behaviors. In NYC, a responsibility to provide high quality drinking water to nearly 9 million inhabitants may impact decisions about technology risk and beta testing.

The establishment of the climate/storm water neighborhood is a success because provided an opportunity to test technologies while also displaying and promoting these technologies to the community and beyond. Some of these technologies - for example, cloud burst identification, monitoring and alarms - have helped Denmark solve or mitigate water-related threats. These technologies may be especially valuable to NYC because cloudbursts, though not as common today as in Denmark, are expected to become more frequent due to climate change.

Development of new wastewater treatment technologies and processes has also been successful. Denmark has a lower nutrient load and less combined sewage overflows than does New York City. Denmark's elimination of contaminated water and mitigation of the subsequent impacts of eutrophication are laudable. The country's approach is likely to be even more critical in the future especially in pursuit of preserving the health and productivity of aquatic systems.⁸

The ways in which Denmark has exported its technologies is also a key area of success. They have been on the forefront of exporting technologies to other countries and getting their foot in the door with international public projects.

Further Opportunities

Going forward, Denmark needs to examine the impacts of climate change beyond cloudbursts, and promote the development of technologies to solve these impacts. Specifically, sea level rise and the effects of storm surges are considered critical. The Danish Coastal Authority oversees all the nation's coastline and spearheads governmental, economic and social conservation and resilience activities⁹. Specifically, the Authority advises the Danish Ministry of the Environment, municipalities, public authorities, the public. It "develops methods and tools for the public, authorities, and others in climate change." An example is the coastal planning tool, which is climate scenario forecasting tool that can be used for decision-making regarding appropriate levels and types of coastal developments.¹⁰

A second area of significant growth, as defined by Danish government, is in wastewater treatment. While eliminating water pollution is still a desirable goal, grey water collection and use for non-potable purposes is a potential new area for innovation, particularly for a growing global market.

Still, another opportunity for growth is achieved by expanding Denmark's international reach. The Danish Cleantech Hub has been in communication with New York City's DEP and EDC for this purpose. The scale and population density of the City pose unique considerations for any partnership. Additionally, questions regarding ease of access for companies, businesses and individuals, types of innovation and scope of competitive restrictions will need to be addressed as a necessary component of effective engagement.

Lessons for New York City

- Developing environmental, conservation and economic efficiency targets from a governmental level can provide the private sector with clear direction. These targets can be based on economic opportunity and/or the opportunity to avoid penalties.
- Educating the public and gaining buy-in on the need to invest in water issues is critical to maintain long-term political drive to accomplish relevant goals.

- An innovative view of waste treatment brought economic benefits to Denmark, while both solving an environmental problem and achieving social targets. The use of filtering sludge from the wastewater system, breaking it down in a bio-reactor and generating natural gas is a great example of solving a problem and simultaneously exploiting an under-utilized resource.
- An initial resistance to the likely higher costs of water efficiency measures due more stringent governmentally imposed standards should be expected. In the case of Denmark, this initial resistance, and idea that goals were too lofty, was overcome through innovation.

B. Toronto, Canada



Senior Manager of Communications



Some Key Learnings:

- *Being innovative doesn't have to be expensive, sometimes it means investing in decentralized systems and operations that can be more nimble*
- *Incentives around R&D, funding for testing and demonstration, showcasing water innovation are all means to support business growth*

Natural Environment and Water Challenges

Located on the largest freshwater network in the world, the City of Toronto has had a long, complex history with water. The Great Lakes network, an avenue for trade and shipping, helped the City grow and establish itself globally, but also faces pollution and other environmental problems. Lake Ontario serves as a reliable source of freshwater for Toronto and its surrounding communities, but wastewater and storm water runoff can contaminate the lake, ultimately causing environmental and public health problems. The City's intimate relationship with the Lake provides challenges in terms of pollution and urban resiliency, but also unique opportunities for success.

Some of Toronto's most significant challenges stem from its heavy use of the waterway. The introduction of untreated waste or industrial contaminants is perhaps the greatest threat to the Great Lakes system, including Lake Ontario. Contamination occurs when wet weather flows exceed treatment plants' capacity and discharge untreated water directly into the lake ¹¹. In 2011, seven tons of toxic metals (cadmium, mercury, lead and nickel) were released into Lake Ontario even after wastewater had passed through Toronto's four treatment plants.¹² In twelve events in 2016, a total of 538 cubic meters of wastewater was discharged into the lake without receiving full treatment.¹³

Additionally, Toronto faces increased severity and frequency of extreme weather events through climate change.¹⁴ The winter weather phenomenon of lake-effect snowfall, especially as it will be exacerbated by climate change, threatens Toronto with heavy storms and flooding events. As these extreme events increase, so could the discharge of contaminants and/or untreated wastewater into Lake Ontario. Hence, building urban resilience by ensuring a safe, sustainable drinking supply and management strategy for Ontarians is an important priority for the province.

Establishment

As problems with contamination of water resources and consequent environmental degradation have negatively affected Ontario, the province has articulated concern for successful water management. For example, thousands of individuals fell ill and seven people died in May 2000 when a dangerous strain of pathogenic *E. coli* contaminated the water supply of Walkerton, Ontario. The Ontario Clean Water Agency made nearly 100 recommendations for improving the water quality and public health, codified in legislation as outlined in the next section.

Under the Water Opportunities and Water Conservation Act of 2010 the Water Technology Acceleration Project, (WaterTAP), a nonprofit organization that works to strengthen and support the Ontario water technology sector. With thirteen staff members and a Board of Directors consisting of nine experienced industry professionals, the organization is mandated to “to help grow globally competitive companies and provide high value jobs in Ontario’s water and wastewater sector.”¹⁵ WaterTAP supports businesses in overcoming strategic, operational and financial challenges to develop a share in the water market and has been instrumental in creating a centralized area for knowledge sharing and networking.¹⁶ More specifically, it provides opportunities for companies to expand their global network by connecting companies to new capital, partners, and customer opportunities. The exemplary Better Best Practices Initiative builds awareness and collaboration, helping businesses develop and implement best practices in water management, leadership, and innovative technologies.

Policies

In the province, all municipal drinking water systems are regulated by the Ontario Ministry of the Environment (MOE). The 2002 Safe Drinking Water Act and 2006 Clean Water Act help protect drinking water from source to tap, with a multi-barrier approach in efforts to stop contaminants from entering lakes, rivers and aquifers, the three main sources of drinking water. The researchers have identified three overarching aspects of Ontario government policies that allow the Water Hub to be successful:

1. Driving adoption of innovation and technologies. Partnering with water industry stakeholders, the Government of Ontario encourages the development, demonstration, commercialization, and adoption of innovative water solutions.
2. Attracting investment and increasing access to global markets, the Government of Ontario is committed to working with stakeholders to expand the reach of Ontario companies in global markets, and in attracting global companies to invest in Ontario.
3. Creating a competitive Ontario advantage. The support of infrastructure partnerships and collaboration to create competitive advantage for businesses, and support financing to accelerate the adoption of water solutions in Ontario.

Funding

WaterTAP provides small businesses with the opportunity to grow by helping them to benefit from the diversity of funding sources available in Ontario. Specifically, the organization spreads awareness to the many federal, provincial, and municipal funding opportunities for water technology firms and has sustained over \$28 million in economic growth. As of 2013, a total of 29 grant and loan programs in the water technology space were funded, summing to approximately CAD 2.13 billion.¹⁷ These programs fund initiatives at various stages, from conceptualization to implementation. For example, the Sustainable Development and Technology Canada, which is a federal program, allots \$590 million to companies with technologies that have been established but are still untested in the market.¹⁸ Programs like these incentivize business creation and establishment in the region, and allow for the successful implementation of new technologies.

Successes

WaterTAP has succeeded establishing successful businesses, yielding financial returns and implementing new technologies. Over 100 businesses participate in one or more of the strategic clusters in Ontario's innovation ecosystem. In one exemplary case, the hub aided ECONSE Water Purification Systems in its transition from its concept to wide scale implementation of a craft brewery wastewater treatment technology called the BruClean System. ECONSE partnered with the BLOOM Centre for Sustainability and members of Ontario Craft Brewers to pilot the technology and optimize its implementation. Domestic and international demand for this technology has skyrocketed in the two years since the WaterTAP partnership, and the business has become well established, profitable, and an important Toronto-based employer.¹⁹

WaterTAP has also had great success in the market. In 2016 alone, CAD 1.8 million was invested in water technology, with a 15x documented return on this investment.²⁰ Looking at earlier returns, WaterTAP President and CEO, Dr. Peter Gallant has stated, "WaterTAP is working. The Province's average annual investment in support of the organization of \$1.5 million has yielded more than \$20 million in economic value, representing an excellent return on investment."²¹ An annual average of 13x return on investment, which includes more than 70% of Ontario water firms, is noteworthy.²²

Further Opportunities

When the government of Ontario passed the Water Opportunities Act in 2010, it committed to making the water technology sector a priority for Ontario. The emergence of many successful Ontario-based companies such as Trojan Technologies, ZENON Environmental, and Pressure Pipe Inspection Company has inspired new entrepreneurs and spurred a new generation of startups with access to Ontario's supportive research and development ecosystem. Ontario's provincial government understands the value of competing on a global scale, and the Water Opportunities Act represents a commitment to supporting that potential.

Lessons for New York City

- The central importance of a comprehensive regional water strategy and water industry growth plan is key. Establishing an overarching strategy and water sector growth plan demonstrates the commitment of government to the water sector and inspires private sector confidence.
- Strengthening water quality regulations and compliance enforcement can drive innovation. After the E Coli outbreak, Ontario, recognizing the importance of water health, strengthened water quality regulations and stepped up compliance testing measures. Much of the innovation from WaterTAP is related to water quality and ultimately, public health and safety.
- Encouraging and supporting diversity within the water sector is essential. One key element of WaterTAP's success is the healthy, growing and diverse private water sector. Ontario's government has fostered an environment that encourages startups and diversity within the water industry.
- Innovation requires strong collaboration between academia and practitioners. At WaterTAP, where there is robust support for, and collaboration between universities and private entities, innovation thrives and consequently, enhances economic growth.
- WaterTAP successfully reduced barriers to market entry that small-scale firms often face by joining municipal, provincial, and federal funds to enhance adoption of water technologies. Although such progressive willingness to adopt new processes is unlikely to be directly exported to New York City, it is important to highlight the important role this has played in the success of the water hub.

C. Milwaukee, WI, US



Membership Manager



Some Key Learnings:

- *Water Council created for business, by business*
- *Being in a physical space with people working on similar projects facilitates organic connections between innovators who might otherwise not connect*

Natural Environment and Water Challenges

The City of Milwaukee is situated on the shores of Lake Michigan, at the confluence the Kinnickinnic, Menomonee and Milwaukee rivers.²³ The natural environment made the city a logical location for water-intensive industries such as brewing, meatpacking, tanning, and transportation.²⁴ For example, the abundant water supply provided these businesses with their main ingredient, in the case of breweries, or the ability to soak and prepare their product, in the case of tanneries.²⁵ Some industries like tanneries have since almost completely declined, but the ancillary industries they gave rise to, those that manufacture water pumps, meters and plumbing fixtures, continue to benefit from Milwaukee's strategic location and water-centric reputation.²⁶

The Great Lakes region faces several water-related threats. Climate change models predict that an increase air temperature in the region will result in a decline in lake levels of half a meter to two meters.²⁷ There are also threats to water quality, in the form of agricultural and industrial runoff, and threats to water quantity from proposals encouraging diversion of water from the Great Lakes to other regions.²⁸ Additionally, the impact of invasive species is a threat to the ecosystem, Eurasian watermilfoil and zebra mussels are examples of an invasive plant and animal whose range is expanding via shipping and transportation.²⁹

Establishment

In the mid-2000s, an economic development study of the local region highlighted the existing track record of water-focused businesses in Milwaukee.³⁰ Recognizing an opportunity to leverage this historical economic strength, Rich Meeusen, CEO of Badger Meter, and Paul Jones, CEO of the A.O. Smith Corporation, came together in 2007 to found The Water Council.³¹ Their idea was to create a "Silicon Valley of water technologies"³² as a means to capitalize on the pre-existing water sector in Milwaukee by formalizing and building upon relationships between companies, research institutions, and government agencies. Meeusen and Jones saw Milwaukee's pre-existing expertise in moving, metering, measuring, managing and monitoring water as unique in enabling Milwaukee

to investigate and invest in collaboration in the water industry. Their goal became to shift Milwaukee water companies away from operating in isolated water silos to a more integrated network of water initiatives and activities.³³

Understanding that cross-sectoral collaboration was key to the growth of Milwaukee's water technology sector, Meeusen and Jones laid the foundations for The Water Council by gathering together representatives from water-related business, universities, economic development agencies and aides to government officials for a conference and inviting friends and colleagues, who were leaders in water-focused businesses into the Council.³⁴ Meeusen and Jones attribute the appeal of the idea of building a water technology hub in Milwaukee to the fact that it would build upon an existing infrastructure and focus on forming connections, rather than introducing new industry.³⁵ Once formed, The Water Council was charged with the objective of leveraging collaboration between public, private and academic sectors to find "innovative solutions to critical global water issues," translating practical expertise in water to research on water management and innovation.³⁶

Over time, the organization grew from collaborations between businesses to involvement with research institutions, such as developing water educational programs, and partnership with local government. This transition classified The Water Council as a true public-private partnership promoting the exchange of know-how, research, and implementation. The organization, which attained nonprofit status in 2009, focuses its efforts on "freshwater research, innovation, education, business development."³⁷

Today, the Water Council identifies its unique niche as aligning regional research and innovation on water with up and coming water industries and technology. The organization strives to link water technology companies, government agencies and NGOs with entrepreneurs, water research and education programs, and professionals in the water industry. Leading companies, such as A.O. Smith and Badger Meter are members of The Water Council because they see the opportunity to collaborate. It is the spirit of collaboration and integration between public, private, and academic institutions that has enabled The Water Council to pioneer water research and education programs, establish dedicated premises for water technology companies, and provide angel investor training to startup businesses, amongst other achievements such as a business accelerator program and a stewardship program.³⁸

Policies

The Water Council is an economic development organization with roots firmly in the private sector. Public policy initiatives have not been a driver in the growth of The Water Council and its mission.³⁹ However, the City's Sustainability Plan does have a goal of making Milwaukee America's Water Centric City.⁴⁰ The Water Council has received helpful financial support from the State of Wisconsin, but the public-private partnerships that have emerged in the regional water industry have not been spurred by particular policy efforts.⁴¹ Instead, the work of The Water Council over the last decade to build a network of water industry participants, host frequent

industry events, Member Meetings, and an annual summit, has assisted in connecting businesses, academic institutions, government, nonprofits and investors without relying on policy initiatives.

However, a strategic aim for The Water Council is to encourage water-focused businesses to set up in or relocate to Milwaukee. In this respect, there are numerous examples of supportive policies, for example:

- Job creation tax incentives: Refundable tax credits for the creation of jobs;
- Relocation credit: Eliminates income tax liability for businesses that relocate to Wisconsin from another state or country provided they have not done business in Wisconsin in the two preceding tax years; and
- Economic Development Credit: Non-refundable tax credits for creating jobs and making significant capital investments.⁴²

Funding

The Water Council, which is at the heart of coordination efforts to establish Milwaukee's status as a "freshwater capital of the world," is a 501(c)(3) nonprofit that is partially funded by the dues of its 180 members worldwide.⁴³ The Wisconsin Economic Development Corporation provides grant funding as well as subsidized rental space for the Council.⁴⁴ The federal government has also provided financial support in the past, in the form of a Regional Innovation Strategies program grant, in 2014.⁴⁵ In addition to membership dues and government grants, corporate sponsorship plays an important role in The Water Council's funding model. The Council has established two accelerator programs (discussed further under 'Successes', below) that are funded by corporate partners such as A.O. Smith.

Successes

The Water Council has a sophisticated communications and messaging platform that publicizes its successes. Two key attainments are the development of dedicated real estate that accommodates water businesses, and the launch of two accelerator programs.

Dedicated Real Estate: The Global Water Center and the Water Technology Park are dedicated facilities and mixed-use buildings for use by water-related companies. The Global Water Center houses more than 40 tenants and includes a special laboratory, the Water Flow Lab, where new products are tested and exhibited in an auditorium with video conferencing technology.⁴⁶ The Water Technology Park is a 17-acre zone in downtown Milwaukee dedicated to educational, research and technology focused water industry participants. The Park has a system of urban bioswales and rain gardens and a 'purple pipe' for rainwater recapture.⁴⁷

Accelerator Programs: The Water Council launched its first accelerator program in 2013 and a second in 2015. The purpose of these accelerator programs is to pair water technology entrepreneurs with the resources they need to take their ideas from concept to revenue-generation.

The first accelerator program was established in Partnership with the Wisconsin Economic Development Corporation (WEDC) and was named ‘Business Research Entrepreneurship in Wisconsin’, or ‘BREW’.⁴⁸ WEDC provides \$50,000 investments for up to six water technology startups that demonstrate commercialization potential.⁴⁹ The WEDC funds are matched by industry representatives and The Water Council.⁵⁰ Entrepreneurs apply through a competitive process to take part in the programs and, if selected, spend 12 months receiving mentorship, training, subsidized access to workspace, access to laboratories and demonstration sites and, at the end of the program, an opportunity to secure capital investment.

As an expansion of the 2013 accelerator, BREW Corporate was launched in 2015 and, through sponsorship by corporations such as A.O. Smith, focuses on developing startups that can provide new technology to address a specific challenge chosen by the corporation.⁵¹ This approach of partnering with corporations to sponsor an accelerator program is an innovative way to attract funding for water technology startups, in a way that is attractive to the corporate sponsor.

The Water Council lists some of the successes of their accelerator programs as:

- Over 65 jobs created
- 115 pilot sites, memoranda of understanding and contracts facilitated
- \$2.6 million additional capital raised by entrepreneurs
- Patents granted or pending for 14 businesses that have graduated the programs⁵²

The Water Council believes the success of their accelerator programs is due to the organic connections that occur when organizations focused around the same entity or resource, water, are working side-by-side.⁵³

Further Opportunities

The Water Council is ambitious in its forward looking strategic direction. It no longer sees itself in a regional or even a national context, but as an international center of freshwater research, innovation, education, and business development. Accordingly, the three-part strategic direction for the Council is:

- Enhance the Council’s leadership position as a global center of water excellence;
- Target research and development to meet global needs in the water technology industry; and
- Increase the readiness of members of The Water Council to enter new, international markets.⁵⁴

It is a decade since The Water Council’s inception. The organization has faced challenges in its mission to establish Milwaukee, and, latterly, the state of Wisconsin, as a global leader in water technology. Some of these challenges are noted below:

- Partnerships with academic institutions are a strength of Milwaukee’s water technology. However, the closest partner, University of Wisconsin-Milwaukee, ranked only 179th in the country for research funding in 2014, and just \$2 million out of university’s \$61 million research funding came from business partnerships.⁵⁵ Without a significant flow of funding, the capacity of academic institutions to contribute to research and development in water technology will be limited.
- In its *Strategic Framework* document, the organization’s leadership recognize that The Water Council “cannot do everything” in its bid to take on an elevated, global role.⁵⁶ Securing the commitment of long-term collaborative partners, across multiple sectors, is a key challenge for a lightly staffed nonprofit with the ambition of The Water Council.
- Funding is an “overarching challenge that relates to every component” of The Water Council’s Leadership Vision.⁵⁷ As any organization, especially a nonprofit, expands and explores new goals, it is a challenge to find funding models that can facilitate growth.

Lessons for New York City

- Understand the breadth and depth of existing water institutions in New York City, including but not limited to academic, business, nonprofit, and government. This stakeholder analysis will assist in determining which partners can be drawn together, which is one of the keys to success enjoyed by The Water Council.
- Identify the existing connections between water institutions in New York City and determine where and how collaboration could be strengthened.
- Evaluate existing city and state tax incentives for new and relocating business, and explore whether these could be augmented to attract water technology companies.
- Determine current academic research on water in New York City and how a hub could foster cooperation between research and business innovation.
- Investigate the feasibility of launching a New York City accelerator program for water technology startups. Establish New York City as a prime location for water industry, including financial incentives and networking and collaborative opportunities.
- Develop accelerator programs early on to lay a foundation for future growth of the industry in the City.
- Identify corporations interested in providing seed funding for accelerator programs.
- Seek public-private partnerships as sources of funding for the hub.
- Analyze public sector building stock to assess whether any facilities in New York City could be repurposed as a water technology research and development hub, in which companies could rent space.
- Explore funding sources for the initiatives and resources required to launch and maintain a collaborative water hub in New York City.

D. The Republic of Singapore

Natural Environment and Water Challenges

Located at the southern tip of the Malaysian peninsula, Singapore is a small island city-state consisting of a mainland and 60 islets. Although surrounded by water, Singapore has always faced water scarcity issues due to the lack of natural lakes, aquifers and reservoirs. Recognizing this as an issue, Singapore constructed its first reservoir, the MacRitchie, in the late 1860s.⁵⁸ Over time, Singapore has managed to capitalize on the abundant rainfall (average rainfall 91 inches) and has made significant investment into research and innovation. Currently, Singapore has 17 reservoirs and “Four Water Taps” – or sources of water and water import agreements with Malaysia which will run-out by 2061 (see next section). Given these time sensitive water import agreements, and constrained water resources because of natural typography and growing population, the Singapore government has prioritized water’s sustainable sourcing and management.

Establishment

Singapore signed a series of four policy agreements (1927, 1961, 1962 and 1990) with its neighboring country Malaysia, to import water to meet its daily demand of 430 million gallons per day. The last of these agreements is set to expire in 2061. Given that deadline, the Public Utilities Board (PUB) - the country’s national water agency - has been pursuing alternate sources of water in the event of a new agreement not being signed. Additionally, the PUB estimates that total water demand in the country will almost double by 2060. As such, Singapore is working to become water self-sufficient, reduce its vulnerability, and become a global leader in water technology. With 180 companies and 26 research centers, the City is already a thriving water industry ecosystem.⁵⁹

Policies

On May 1, 1963, the government established the Public Utilities Board (PUB). The Public Utilities Board is a statutory board under the Ministry of the Environment and Water Resources. The PUB’s mission is to manage Singapore’s water supply, water catchment and used (waste) water in an integrated way. Thus, the PUB ensures an efficient, adequate and sustainable supply of water for the country.

To date PUB has built and diversified its Four National Water Taps: imported water; water from local catchment; NEWater; water from desalination. These are described below.

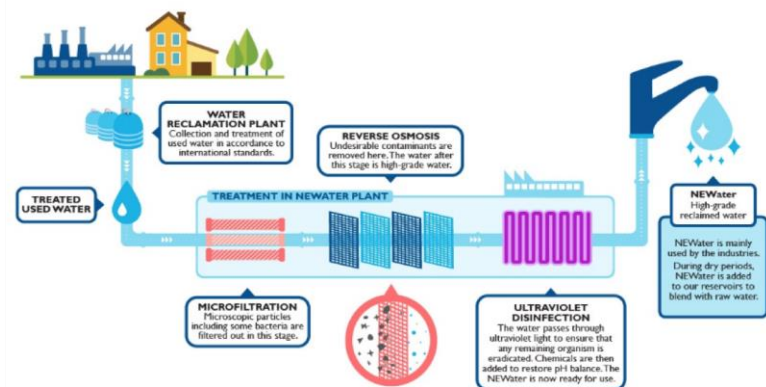
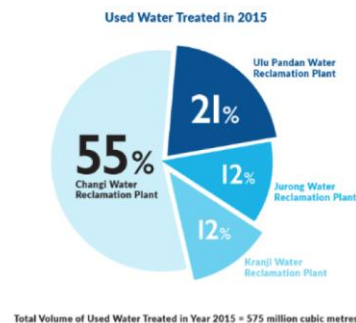
Imported Water: Under the bilateral water agreements with Malaysia, Singapore is permitted to purchase up to 250 million gallons per day. However, with Malaysia experiencing seasons of drought, Singapore has had to decrease the amount of water they purchased from Malaysia. In fact, during Malaysia’s most recent drought, Singapore was able to support their own daily water need without support from Malaysia. That noted, Singapore continues to import water from Malaysia

because it is currently a cheaper approach, particularly when contrasted with desalination which requires significant energy in production.⁶⁰

Water Catchment: Singapore has 17 reservoirs which make-up two-thirds of Singapore's domestic water supply. The country is one of the few in the world that harvests storm water, on a large scale, for consumption, on a large scale. The storm water, separated in an underground sewage system to prevent contamination, flows through local drains, canals, rivers and ponds into the 17 reservoirs.⁶¹

NEWater: Since 1970 Singapore has been researching and developing strategies to make reclaimed water useable for domestic and non-domestic use. The first two NEWater Plants started operating in 2003; and, Singapore now operates four NEWater Plants (see figure below). The NEWater has passed 150,000 international water tests and meets the water quality standards of the U.S. EPA and World Health Organization. The water is treated and put through microfiltration and reverse osmosis to remove bacteria and contaminants. It is then disinfected with UV light. NEWater is mainly used in industrial estates and commercial buildings and in cooling for industrial processes.⁶² The PUB plans for NEWater will meet up to 55% of the country's water needs by 2060.⁶³

Breakdown On Volume Of Used Water Treated
By Various WRPs In Year 2015



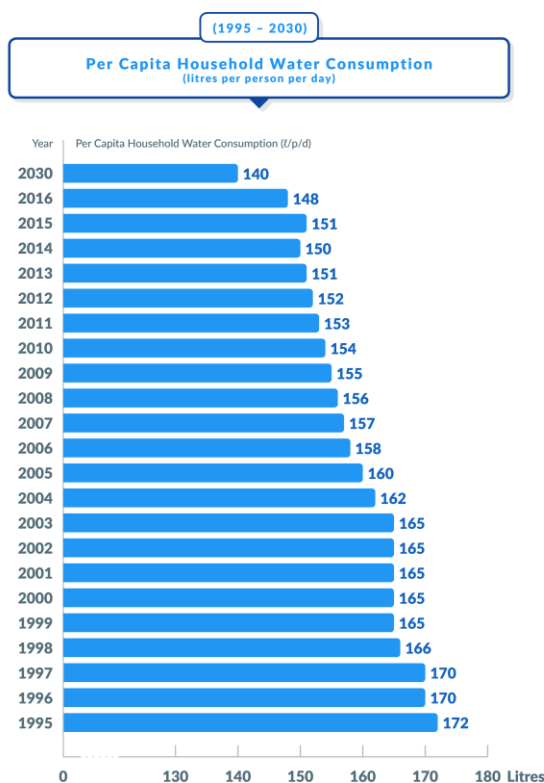
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Desalination: Currently, Singapore has two desalination plants, which produce 25% of Singapore's water (est. 100 million gallon/day). Of the Four Taps, this is the most expensive and energy intensive (3.5 kWh/m^3). The PUB has deployed a pilot program with the U.S using electro-deionization to reduce the energy use of the plant. Plans are in place to try this approach in a larger scale plant. Also, the PUB is piloting the use of biomimicry – mimicking mangroves biological processes - which uses low amounts of energy and produces water of lower salt content. Singapore would like desalination to account for 30% of daily water need by 2060.⁶⁵

Successes

Domestic water programs: Singapore's per capita domestic water consumption was reduced from 165 liters per day in 2003 to 151 liters per day in 2017. The country plans to lower consumption to 147 liters per day by 2020 and 140 liters per day by 2030.⁶⁶ To maintain the current trends, Singapore implemented a variety of domestic programs.

For example, the *Water Closet Replacement Program* provides financial assistance to low income families to replace their water closets with more efficient ones.⁶⁷ Another example is the *Water Efficiency Labelling Scheme Program* which helps consumers choose water efficient products (e.g. washing machine) by placing labels on approved water efficient products.⁶⁸



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Non-Domestic Programs: Currently Singapore's non-domestic water consumption accounts for 55% of the total country's total water usage. It is projected that water demand for the non-domestic sector will increase to 60% in 2030 and 70% by 2060.⁷¹ In order to stay at or below the projected water demand the PUB has provided solutions through multiple programs. These solutions are centered on the strategy of "reduce, replace and reuse". For the "reduce" strategy, the PUB has mandated that companies that use at least 60,000 cubic meters of water submit a *Water Efficiency Management Plan* (WEMP). The Plan outlines the firm's usage as well as how the PUB and the firm can co-develop strategies to reduce water consumption.⁷² For the "replace" strategy, the PUB encourages companies to attend education programs and implement actions that result in *Water*

*Efficient Building Certifications.*⁷³ Lastly, “reuse” strategies are focused on the type of water used in buildings and operations. Rather than purified water use, the PUB will work with companies to provide alternative sources.⁷⁴

Community Programs: To engage citizens around the importance of sustainability and Singapore’s Four Water Taps, the PUB has implemented community programs and projects. For example, the NEWater Visitor Center provides educational programming that promotes water sustainability in Singapore and highlights the importance of their 3rd national tap, NEWater.⁷⁵ Additionally, the Center focuses on the *Active Beautiful, Clean Waters Program*, which has optimized reservoirs, rivers and canals beyond their traditional functions and transformed them into recreational spaces for people to enjoy.⁷⁶

Relevant Water Technologies: Singapore’s Operational Management System (OMS) is a real-time modelling platform designed to: (i) compute short-term rainfall forecasts; (ii) estimate the ensuing water flow in Singapore’s reservoirs; and, (iii) propose operational strategies to handle excess water coming into reservoirs during storms. This system allows operators to upload data to system and visualize and take the appropriate measures to mitigate impacts from storms and major drainage issues.⁷⁷

Singapore also has a series of Smart Sensors to help manage water consumption and water quality. The PUB has partnered with the National University of Singapore to develop “Toxicant Sensors” which are responsible for identifying where there are alarming or dangerous levels of toxicants (i.e. lead) in the water network system. The PUB has also worked private companies and international governments to develop Pressure and Acoustic Sensors. These Sensors are connected wirelessly and offer real-time data to detect and pinpoint leaks quickly for repair, thus conserving water.⁷⁸

Finally, Singapore has deployed 207 “Water Level Sensors” which provide real-time data on water levels in drains and canals, revealing true conditions during heavy storms and thus, supporting more effective decision-making for response and recovery.⁷⁹

Funding

Singapore water success is connected to significant investment by the public and private sector. In fact, the PUB accounts for a quarter of the national operating budget and is projected to increase by 13.1 percent in the coming year, 2018.⁸⁰ Additionally, The National Research Foundation of Singapore, which is part of the Prime Minister’s office, has provided nearly \$670 million (approximately \$475 million U.S. dollars) to water projects. Apart from this government-sponsored financial support, Singapore’s water success is largely due to the establishment of private public partnerships.

Because of the prioritization of water resilience, Singapore has managed to garner capital from many sectors and its liquidity in the water sector has made it the leading place to do business in the Asian market.

Various international public and private partners that have worked with Singapore, providing expertise and financial capital.⁸¹ Current North American Partners:

- General Electric (GE)
- DOW
- U.S EPA
- University of California, Berkeley
- Stanford University
- National Water Research Institute
- American Water Works Association (AWWA)
- University of Waterloo
- Massachusetts Institute of Technology (MIT)

Partnership example: GE and PUB signed a 5-year MOU in 2016 to explore ways to cooperate in the areas of technology, research and development, applied research and training, and in project collaboration. Recognizing the potential scientific and technological benefits of jointly demonstrating new technologies and products, the MOU cites common areas of interest between GE and the PUB. These include water treatment processes, such as reverse electrodialysis and anaerobic membrane reactors; and industrial water processes, such as water recycling.⁸²

Lessons for New York City

- Incorporate policy mandates. Singapore has had great success in promoting water efficiency initiatives spurred by government policies. New York City has offered some similar water efficient devices. For New York City, creating policy that defines targets and standards could help incentivize the wider use of these devices.
- Establish long-term goals backed up by and achieved through incremental change. Water use has gone down steadily in Singapore and is projected to continue dropping, on the path to its 2030 and 2060 goals. New York City might establish a similar approach.
- Implement community programs to educate and engage the public. By capitalizing on activities the public wants to engage in, the opportunity to teach and build public impetus can grow. In New York City, active water education could be formalized under an overarching umbrella that brings together community based and nonprofit organizations engaged in water programming.
- Water efficiency goals will likely be different for New York City than what is seen in Singapore. However, the act of establishing goals can go a long way to encouraging changes in consumption and in promoting greater efficiency.

E. Boston, MA, US



Executive Director



Some Key Learnings:

- *Environmental initiatives must be driven on a state and local level.*
- *New technology has a long waiting period before reaching to market, public-private partnership can help speed up the process of new technology adoption.*
- *Technological advancement could be encouraged by creating a sustainable fund, “water innovation trust”. This could move from the current model of one-off investments to a more long term strategy.*

Natural Environment and Water Challenges

Depletion and degradation of traditional water sources, aging and obsolete infrastructure, population growth and climate change have increased the strain on water resources and water systems throughout New England. Even though Massachusetts has enough surface and groundwater to meet the demand of the state’s water demand, much of the state’s water infrastructure are nearing its end of usefulness.

Establishment

The groundwork for the New England Water Innovation Network (NEWIN) was laid in 2011, and the organization was formally incorporated in January 2014. A Boston-based organization, NEWIN operates along the entire Northeastern United States. By basing itself in Boston, NEWIN benefits from the high concentration of water tech companies in the City - over 300 currently.⁸³ The organization represents New England’s water technology sector, promoting growth within the region and expansion to other markets. Recognizing its expanding reach, the organization announced in March 2017, that it was rebranding itself as the Northeast Water Innovation Network with plans to expand into New York City and surrounding regions.^{84 85}

Policies

In Massachusetts, water and wind/energy innovators are able to obtain grants ranging from \$65,000 for clean-tech and water technology development, to \$350,000 to support protection of drinking water supplies every year through state agents and the Massachusetts Technology Transfer Center, an organization that is, in part, supported by state funding.^{86 87 88} The strong

support for innovative technology and the earmarking of funds for water tech encourages companies to locate to areas in and around Boston. The City provides a central location in New England, a robust business infrastructure and marketability as a water tech center.⁸⁹

Working to influence policy and politicians is an integral part of NEWIN's advocacy focus. The organization maintains a database of relevant managers in federal agencies. NEWIN regularly communicates with these individuals to keep them informed of new developments in water technology in New England. By informing state and federal agencies of water technology work, NEWIN has increased awareness of New England as a water technology as a growing water technology center. Lobbying led to the inclusion of water innovation as an emerging sector to be focused on by the Massachusetts Clean Energy Center, a large (over \$50 million yearly) publically funded agency.^{90 91 92}

Additionally, NEWIN provides the following benefits to its members:

- Promote water innovation through collaboration, sharing of best practices, and advocacy and outreach;
- Assist with business development and make available a technology testing site network to accelerate innovation to market;
- Connect businesses with innovative technologies to reduce treatment cost and improve quality;
- Engage and energize the next generation of water industry professionals; and,
- Provide a common voice for the New England Water sector.⁹³

Successes

New England Startups Incubators and Accelerators:

- Association of Cleantech Incubators of New England (ACTION). The common goals of accelerating the growth and success of early stage companies, strengthening the regional cleantech cluster, and creating more green jobs in New England is what ACTION offers. ACTION is New England's leading network of cleantech incubators.
- Cleantech Open Northeast. As one of the oldest and largest cleantech startup accelerator program in the country, Cleantech Open's mission is to find, fund, and foster entrepreneurs with ideas to address the environmental and energy challenges of today.
- Greentown Labs. Greentown Labs provides prototyping space, shared machines and shop tools, and office event space to startups. Located in Somerville, MA, Greentown leverages the facility, partners, and sponsors to provide entrepreneurs access to the equipment, services, education, and network they need to launch their business.
- MassChallenge. Connecting entrepreneurs with the resources needed to launch and succeed immediately, MassChallenge primary activities include running an annual global accelerator program and startup competition, documenting and organizing key resources,

and organizing training and networking events.

- North Shore InnoVentures - Established in 2008, North Shore InnoVentures (NSIV) is a nonprofit technology incubator committed to help grow innovation startups in the cleantech and biotech sectors. Likewise, NSIV supports economic development in New England by successfully launching new companies and creating high-quality, sustainable jobs.

The partnership of NEWIN and these incubators and accelerators help NEWIN member companies refine their business strategies, conserve capital, build strong teams and achieve development and funding milestones.

Further Opportunities

New England has a strong history of innovation and entrepreneurship and has many long-established water technology firms. With public policy support and targeted investment, alongside NEWIN's assistance, the water sector is well positioned to grow into an important economic engine for the region, while addressing the some of the most critical water problem the world faces. NEWIN has identified expansion opportunities in both New York and New Jersey in support of this vision.⁹⁴

Lessons for New York City

- NEWIN has been very successful in working to frame the Northeast, in general, and Boston, in particular, as a great environment for water tech businesses to (re)locate. This can be contrasted with other regions that may have positive business environments, but do not adequately promote their business-friendly features.
- NEWIN chose to base itself in Massachusetts for its central location in the Northeast and the high number of qualified water tech specialists. Massachusetts does have the opportunity for water and wind/energy innovators to obtain grants ranging from \$65,000 to \$350,000 in each quarter every year.
- Different regions have different capabilities, NEWIN has identified the strong point of the Northeast as the strong intellectual base exemplified by the large number of top-tier institutions concentrated in a relatively small geographic area.
- Invest in measuring impact metrics, rather than throughput metrics is another takeaway. NEWIN, like most similar organizations, focuses on measuring throughput metrics like “how many companies are participating, or how many awards have partner companies received”. They have also focused on measures that support deep assessment of impacts regarding the actual growth of business and jobs creation as well as strides made in solving water problems. These assessments provide greater insight on the dynamics of innovation and the marketplace, than does evaluation on the numbers of companies, alone.

New York City

New York City is an exceptional example of a large municipality supplying clean water and effectively treating and eliminating the waste produced by its citizens and introduced by storms. The success of this system is based upon its high-quality source and infrastructure, as well as the policies and actions of the City's Department of Environmental Protection (DEP), Water Board, and Municipal Water Finance Authority that protect this resource.

In 2015, New York City consumed 1 billion gallons of water per day, or approximately 119 gallons of water per capita.⁹⁵ Most residential water usage occurs in the bathroom, and modern fixtures have reduced flush volume saving water by a two-fold margin (up to four-fold when compared to older fixtures).⁹⁶ ⁹⁷ Other additions, such as faucet aerators also result in significant water reduction. Encouragingly, water usage has been declining since the early 1990s. While the City's population increased by 7% since this time, water distribution (essentially equivalent to consumption) decreased by 25%. This suggests significant success for the various water efficiency programs initiated by the City.

Natural Environment and Water Challenges

The main water source for New York City is the Catskill/Delaware watershed, which lies 125 miles north of the city. A series system of aqueducts conveys water from this source to the City. The land in this watershed is owned by a mixture of private owners, the City, State and local governments, and land conservancies. Development on this land by private individuals is highly regulated to prevent water contamination of the watershed.⁹⁸ Due to the DEP's continual efforts to minimize microbial contamination of the water at its source and throughout transportation, the water originating in the Catskill/Delaware watershed is exempt from EPA filtration requirements.⁹⁹ However, water from the Croton watershed, which supplies roughly 10% of NYC's water, has not been granted this exemption.

Resilience:

Like Denmark, New York City is surrounded and greatly influenced by water. With a total land area of only 304.9 square miles, the City has 520 miles of coastline and 4 of its 5 boroughs are on islands.¹⁰⁰ Some of the City's solid land mass was once wetlands, which provided natural protection from storms and storm surges. With rising sea levels caused at least partially by climate change, the City faces long-term risk of flooding. These dangers were made apparent by Superstorm Sandy. Even under the Paris Agreement, sea level would rise by up to 10 feet, threatening much of the City's coastline, including residential areas on Staten Island and in Brooklyn and economically valuable properties in the Financial District.¹⁰¹ As mentioned in the Denmark profile, climate change is also anticipated to cause an increase in the frequency of cloudbursts, which could overwhelm the City's storm water management capacities.

Water Monitoring, Testing and Treatment:

Water quality is tested at several points along the supply system, with the first point being the Kensico Reservoir.¹⁰² The City also maintains a network of buoys that measures pH, nutrient levels, and turbidity. This data is fed into a centralized computer system, which also considers weather forecasting to predict the daily quality and quantity of water for each of the City's 12 reservoirs. The Hillview Reservoir in Westchester County, with a capacity of 900 million gallons, is the last stop before the City's water mains. An ultra-violet filtration plant in Westchester county treats the water for any microbial contamination before the water is supplied to the City.

An aging infrastructure that supplies water to most New York City residents has been a cause of concern. Corrosion in the pipelines that serve as the final link to residents can be a source of lead contamination. According to the Department of Environmental Protection, all known lead service lines to city-owned properties — including schools, libraries and parks — were replaced from 2008 to 2010. But the City is working to identify and replace any that remain. The results of a federally mandated water testing program for families living in homes at risk for lead contamination raised concerns among some environmental advocates. Of the 350 samples collected in 2015, 6.6 percent exceeded the federal standard of 15 parts per billion. If more than 10 percent of samples exceed this standard, actions must be taken to reduce lead levels.¹⁰³

Wastewater and Storm Water Management:

The City's water and sewer infrastructure play a critical role in promoting public health. There are fourteen wastewater treatment plants serving NYC, which treat approximately 1.4 billion gallons of wastewater and storm water daily.¹⁰⁴ The DEP's Bureau of Wastewater Treatment (BWT) is responsible for the operation and maintenance of all facilities related to the treatment of sewage. The BWT has an annual operating budget of \$262 million, and an annual capital budget of \$114 million.¹⁰⁵ With these resources, the 1.4 billion gallons of wastewater are processed at the treatment plants. After the treatment process is completed, the plants release high quality, treated water into the waterways surrounding New York City.

Funding

There are three primary funding streams that help to maintain and improve New York City's water system. The funding provided to the DEP is appropriated annually in the City Budget. Some of this Budget is specifically earmarked for certain water initiatives. The DEP and the New York City Water Board - and entity composed of members appointed by the Mayor for two-year terms - collects water and sewer usage payments from users. Water supply and sewer rates are set by the Water Board, at levels that allow for sufficient maintenance of the systems while also taking fairness and equity into account. These revenues help to meet the water and sewer system's operating and capital needs, which includes salaries and benefits for more than 6,000 City employees, as well as major initiatives like the construction of aqueducts, filtration plants and

significant upgrades and repairs to treatment plants, sewers, and other water infrastructure.¹⁰⁶ Based on data from the DEP and the American Water Works Association, New York City's water rates as well as consumption are above the national average. The current combined sewer and water rate is \$9.87 per 100 cubic feet of water versus about half that rate nationally.¹⁰⁷

Additional funds for the City's water and sewer system capital program come from the New York Municipal Water Finance Authority (NYW). NYW is administered by a seven-member board, which includes the Commissioner of Environmental Protection of the City, as well as other City and State officials. They can issue bonds, commercial papers, and other debt instruments. Proceeds from these obligations provide the funding necessary to finance large-scale projects to protect the watersheds, perform the necessary treatment, and maintain and improve the transmission and distribution capacity of the City's water supply system.¹⁰⁸ Bond proceeds also fund the capital investments for climate resiliency initiatives, maintenance and improvement of the sewer system, and storm water and green infrastructure development.

In the recently-passed 2018 New York State budget, the State pledged \$2.5 billion over the next five years in the historic Clean Water Infrastructure Act. Highlighting water investment as a state priority, this funding stream allocates around \$200 million for water infrastructure improvements in New York City and is, therefore, an important source of potential funding in the coming years. These funds can specifically be allocated to "address water emergencies, pay for local infrastructure construction projects, underwrite land acquisition for source water protection, and investigate and mitigate emerging contaminants in drinking water."¹⁰⁹

Challenges and Room for Growth

New York City faces several challenges relating to water, including flooding, efficiency and loss issues, and wastewater/storm water management. Local topography, dense urban development, an aging sewer system, and increasing frequency of extreme weather events are some of the biggest contributing factors to flooding. Many communities in Queens, Staten Island, the Bronx, and Brooklyn, have long been prone to flooding and drainage problems. These challenges provide an opportunity for innovative approaches to improving the resilience of these areas. The Rebuild by Design competition following Superstorm Sandy is an example of how smart planning and community involvement can spur economic growth and increase local resilience.

Like many older cities, New York City has a combined sewer drainage system, which means that storm water and wastewater flow through the same network of pipes and treatment plants. During some rain events, when significant amounts of storm water enter the sewers, the total flow can be beyond of the capacity of the system to treat. In these cases, the system directly discharge the excess effluent into New York's waterways at designated combined sewer outflows (CSOs).¹¹⁰ The untreated wastewater adversely impacts the water quality of the adjoining water body and may ultimately impact human health.¹¹¹ The DEP has greatly reduced CSOs over the years, but more

work is needed. Solutions for decreasing CSOs include both grey and green infrastructure projects. Retention facilities collect and store excessive water for treatment after flows return to normal once a storm ends. However, these facilities are very large and costly, so it is also important to the amount of storm water flowing into the system with green infrastructure, such as bioswales, green roofs, and rain gardens. New York City's density and concrete composition makes implementing technologies such as bioswales all the more challenging, but necessary.

New York confronts the legacy of lead pipe usage in the water supply system, as do many American cities established in the same era. While the water is almost lead-free from at its source, lead can leach into the water from pipes, solder, and fixtures in buildings and private homes. To remove all lead pipes in the city would be extremely costly and disruptive to every-day life. The City has chosen to manage this problem by carefully controlling the pH of the City's water and by adding with phosphoric acid to the water, which forms a seal coating the interior of the pipes. Together, these actions limit pipe corrosion and lead leakage into the water supply.¹¹² However, in the future New York City may need to replace corroded pipes. A comprehensive pipe replacement plan will be needed to mitigate disruptions to activity and limit costs.

Successes

Regulatory Measures Aimed at Demand Management:

New York City has taken several initiatives aimed at furthering the sustainable use of water. In 2010, the City passed four laws aimed at water consumption and efficiency. One law required building water tanks to be fitted with high water level alarms, and required many industries and buildings greater than six stories to install sub-meters on all water lines. Another law required that all new water fixtures (e.g. showerheads, toilets, urinals, and faucets) meet the requirements of the EPA's WaterSense program.¹¹³ A third law prohibited the use of water in "once-through" cooling systems, such as ice machines, walk-in freezers, and air conditioning units. The final law removed a plumbing code provision that allowed water vending machines to be used as a substitute for up to 50% of the drinking water requirements in certain facilities. To facilitate reusable water bottle use, the law also required water fountains to have a separate spout to fill up water bottles.^{114 115}

Incentivizing Private Sector Efficiency:

In 2013, the Department of Environmental Protection launched the New York City Water Challenge to promote efficient water usage in the private sector. It was a year-long voluntary program that challenged private sector groups to match the city's goal of 5% water reduction. The City provided resources and opportunities to attend meetings and workshops to learn about water conservation industry experts.¹¹⁶ There were separate challenges for hotels and restaurants. Many hotels achieved a 10% reduction in total water use through this program. These efforts help to reduce overall water consumption, and lower operating costs for water-intensive businesses.

Resiliency Initiatives:

After the catastrophic damage caused by Superstorm Sandy, enhancing resilience to severe weather events became a key motivator for the City and the DEP. A key piece of legislation, the Community Risk and Resiliency Act (CRRA), enacted in 2014, has the following provisions:

- Official sea level rise projections to be adopted into regulation;
- Applicants for permits or funding in certain programs must demonstrate that they have considered sea level rise, storm surge and flooding risks. The New York State Department of Environmental Control (DEC) must consider incorporating these risks into certain facility-siting regulations;
- State public infrastructure agencies must consider mitigation of sea level rise, storm surge and flood risk in list of smart growth criteria. Smart growth concerns minimization of unnecessary cost of sprawl development. Any new infrastructure project in the state must be evaluated to ensure it is consistent with the criteria;
- Requires DEC and New York State Department of State to develop guidance on use of natural resources and natural processes to enhance community resiliency;
- Requires the Department of State, in cooperation with DEC, to develop model local laws that consider risk of sea level rise, storm surge and flooding.¹¹⁷

Further actions include the implementation of the NYC Wastewater Resiliency Plan, which precedes the CRRA and was first published in 2013. The Wastewater Resiliency Plan was enacted to address improvements to the wastewater treatment plants and pumping stations, which are typically located in low-lying areas, vulnerable to sea level rise, storm surge and flooding.

Storm Water Management - Green Infrastructure Development:

To alleviate the impact of storms on public infrastructure, the DEP is working with partner agencies to institutionalize storm water management into the design of public property, including streets, parks, schoolyards, and public housing.¹¹⁸ The NYC Green Infrastructure Program, a multi-agency effort led by the DEP, aims to construct and maintain a variety of sustainable green infrastructure practices such as green roofs, rain gardens, and right-of-way bioswales on City owned property such as streets, sidewalks, schools, and public housing to promote the natural movement of water and reducing the amount of storm water entering the City's sewer system. The overarching objective of the Green Infrastructure Program is to limit contamination of the water bodies around New York by reducing the amount of discharge of untreated effluent.

Recommendations and the Path Forward

After analyzing the information acquired through interviews and secondary research, the research team identified recommendations relevant to the establishment of a water hub. These recommendations are as follows:

1. Define the problem and identify opportunities;
2. Establish and communicate an official public stance;
3. Assemble a coalition with a centralized management system;
4. Pave an avenue for financial success; and,
5. Promote continuing innovation.

For each recommendation, the team determined a course of suggested actions that the City may want to take to assist in pursuit of creating a water hub in New York City. Some of these actions can be taken by the Economic Development Corporation or the Department of Environmental Protection specifically, as indicated.

Define the Problem and Identify Opportunities

Government must identify water issues and prioritize the relevant factors on which to focus. In New York City, specifically in the goals of the Department of Environmental Protection and the New York City Economic Development Corporation, these issues have been identified as:

- Incentivizing water tech businesses in NYC;
- Ensuring supply of safe clean drinking water;
- Increasing resilience to severe weather events;
- Reducing negative environmental impacts;
- Encouraging job growth via increased business activity; and
- Strengthening communities through sustainable economic development.

New York City Specific Action Steps

- Concretize the goals of the DEP and EDC regarding the water hub by establishing specific environmental targets and developing goals in a codified document and MoU.
- Determine the physical presence and location of the water hub in New York City, utilizing open space under DEP control as a potential option. Having a physical presence on a Brownfield site would allow the Hub to benefit from state-level and Federal grants and other economic incentives. Furthermore, DEP's expertise in Brownfield remediation regulation could be leveraged.
- New York State classifies certain businesses as "Qualified Emerging Technology Company." These businesses are thus granted several types of tax credits, incentivizing tech companies to be domiciled in the State.¹¹⁹ Including water-related businesses in this category, and widely publicizing this inclusion, would attract businesses to New York.

Establish and Communicate an Official Public Stance

Public bodies must make an official stance/commitment to pursue solutions. Public buy-in is imperative and should be achieved through educational campaigns and outreach. Additionally, this approach can “place a stake in the ground,” to establish the DEP and EDC as the leaders of this project, a role that has been seized by private interests in other hubs.

- Press conference/release
- Media campaign highlighting why the public should care and the reasons to pursue innovative approaches to water sustainability
- Public demonstrations

New York City Specific Action Steps

- Once a direction has been chosen internally by public bodies, publicize the position and attract private partners with specific incentives and opportunities related to both development grants and pilot projects installations.
- Define goals and targets for the water hub as part of OneNYC, the Mayor’s blueprint for the City, to benefit from the momentum of the vision. Integrate the development of the water-tech sector as part of one of the several existing initiatives.
- Expand existing demonstrations such as the green streets in the Bronx River sewershed that began under the City’s Green Infrastructure Plan with appropriate informative signage.
- Clearly communicate through the websites and digital media of the DEP and EDC the establishment, purpose and goals of the partnership between the two organizations, as well as the advancements that occur, highlighting additional stakeholders as the join in collaboration.

Assemble a Coalition with a Centralized Management System

Successful hubs are achieved by having diverse partners in the public, private and academic sectors. By combining the unique expertise of partners, an organization can be created with more value than the sum of its parts. A New York City Water Hub should capitalize on existing relationships and pursue new connections.

- Consider whether a new organization should be established to manage and oversee the hub. Successful hubs are nimble and able to react to changes and seize opportunities. Utilizing an independent, nonprofit model can allow an organization greater flexibility than a government institution, while at the same time, conducting activities in a manner focused on promoting goals for the public good.
- Codify current partnerships through formal Memorandums of Understanding (MoU's). While not a legally binding agreement, MoU's can promote more structured relationships between organizations, enhancing trust and thus, cooperation.
- Establish relationships with academic institutions who are currently studying water issues and solutions.
- Establish a channel of concept and technology transfer with business leaders including NEWIN and the Danish Cleantech Hub

New York City Specific Action Steps

- Formalize the relationships between existing collaborators, beginning with agents without financial partiality, specifically the DEP, EDC, Columbia University and New York University who have all been in communication on the establishment of New York City Water Hub.
- Expand upon existing partnerships with state-level agencies, such the New York State Department of Environmental Conservation, to develop a mandate for the water hub.¹²⁰
- Start bringing together interested organizations. Release a Request for Proposal (RFP) with the 12-18 month objective of developing a Standard Operating Procedure for the water hub and a plan to convene stakeholders and implement steps to move forward. Organizations to target with the RFP should include stakeholders who do not have interests conflicting with those of the DEP and EDC, for example, the Columbia Water Center.

Pave an Avenue for Financial Success

Business partners need concrete opportunities they can invest in confidently. A New York City Water Hub should take steps to secure private sector investment.

- Support the development of innovative water management techniques through the establishment of water specific incubators
- Invest in the strategic installation of new technologies.
- Issue Requests for Proposals to encourage the further development of innovative water technology installations.

New York City Specific Action Steps

- Facilitate business growth through tax incentives and implementation of pilot projects in pre-secured locations.
- Communicate with leaders of business network groups to determine their needs and work to fulfill these needs. Utilizing existing relationships is a logical place to start, NEWIN can provide insight from the domestic side and the Danish Cleantech Hub can offer an international perspective.
- Obtain state funding for projects through recently signed Clean Water Infrastructure Act, specifically the NYS Water Grant Program and Intermunicipal Grant Program.
- Collaborate with state-level agencies, such as the NY State's Regional Economic Development Council (REDC) to offer "bundled" incentives for the private sector offering water-tech solutions. State-level grants currently offered by the REDC for environmental improvement and economic development¹²¹ must be part of the incentive package.
- Develop a partnership with the EPA to utilize water-tech grant funding opportunities under the Environmental Technology Innovation Clusters Program.¹²²

Promote Continuing Innovation

Water issues and opportunities are complex and will continue to unfold, perpetual learning and adaptation is essential to address a constantly evolving environment.

- Incorporate water in New York City's long term development, public media and educational systems

New York City Specific Action Steps

- Create a long-term innovation community through the establishment of incubators within New York City and the ongoing implementation of publicly funded pilot projects
- Leverage and build upon available knowledge. The New York State Energy Research and Development Authority (NYSERDA) has conducted a comprehensive assessment of the water and wastewater sector of New York, focusing on energy usage and opportunities for improvement.¹²³ Benchmark city and state-level performance as a reference to determine room for innovation.
- The EDC's Urbantech NYC has an ecosystem that fosters entrepreneurship, working with early-stage ventures focused on NYC sustainability and resilience.¹²⁴ EDC can expand its current partnership network to include water-tech experts and water-specific prototyping labs.

Prioritization of Tasks and Division of Responsibilities

The aforementioned goals and recommendations will ultimately be forwarded by the collective assemblage of stakeholders participating in the water hub. The initial steps forward however, will need to be fulfilled by the DEP and EDC.

The first four steps to advance the establishment of a water hub in New York City and the agency, DEP or EDC, who should lead that particular effort are:

1. Formalize the relationships between existing collaborators, beginning with agents without financial partiality, specifically the DEP, EDC, Columbia University and New York University who have all been in communication on the establishment of New York City Water Hub. Define roles and responsibilities specific to the development of the water hub for each collaborating partner based on their area of expertise. **(Both agencies)**
2. Start bringing together interested organizations. Release a Request for Proposal (RFP) with the objective of developing a Standard Operating Procedure for the water hub and a plan to convene stakeholders and implement steps to move forward. Organizations to target with the RFP should include stakeholders who do not have interests conflicting with those of the DEP and EDC, for example, the Columbia Water Center. **(Both agencies)**
3. Communicate with leaders of business network groups to determine their needs and attempt to fulfill these needs. Utilizing existing relationships is a logical place to start, NEWIN can provide insight from the domestic side and the Danish Cleantech Hub can offer an international perspective. **(EDC)**
4. Leverage the technical expertise of DEP to identify NYC-specific water management challenges. Expedite the bidding and contracting process for water-tech ventures with solutions in the domain of priority areas. **(DEP)**

Appendices

I. Abbreviations

<u>Abbreviation</u>	<u>Long Form</u>
BWT	Bureau of Wastewater Treatment
CRRA	Community Risk and Resiliency Act
CSO	Combined Sewage Outflow
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environment Protection
EDC	New York City Economic Development Corporation
EPA	United States Environmental Protection Agency
NEWIN	New England Water Innovation Network
NYC	New York City
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
PUB	Singapore Public Utilities Board
REDC	Regional Economic Development Council

II. Interviewee List

The interview process targeted the highest level and most knowledgeable individual at each organization. While interviews were conducted with all consideration and due diligence, the information included in this report is offered as “all care taken but no responsibility accepted” by both the interviewer or interviewee.

<u>Expert Name</u>	<u>Organization</u>	<u>Title</u>
<i>Isaiah Perez</i>	<i>The Water Council</i>	<i>Membership Manager</i>
Organizing existing businesses can allow them to increase their overall influence regionally, creating an attractive environment which can pull in businesses from other regions.		
<i>Raad Seraj</i>	<i>WaterTAP</i>	<i>Senior Research Associate</i>
- Money can be wasted due to inefficient technologies. In order to improve, we must understand where the leaks are and then how to optimize decision making and assets. - Decision makers need to be made aware of problems and opportunities and empowered to make progressive changes.		
<i>Kate Boicourt</i>	<i>Waterfront Alliance</i>	<i>Program Manager</i>
- Sometimes if government initiatives are too narrowly focused, they might miss opportunities for collaboration with some stakeholders. - Different government funding streams (federal, state, and city) do not have the same timelines, making long-term projects difficult.		
<i>Marcus Gay</i>	<i>Novus Technical Services, New England Water Innovation Network</i>	<i>Principal, Executive Director</i>
- The water sector needs to attract the best entrepreneurs. One way to accomplish this, is by the government focusing of projects that are good investments. - Because political will can change as new administrations are elected, the organizational framework of a water hub should have long-term goals while also being able to capitalize on current opportunities.		

<i>Upmanu Lall</i>	<i>Columbia Water Center, Columbia School of Engineering and Applied Science</i>	<i>Director of the Columbia Water Center, Alan and Carol Silberstein Professor of Engineering</i>
Water issues are not prioritized. This applies to academia, the government and business. There should be more researchers focused on water issues and a greater investment in infrastructure like dams and water mains.		
<i>Kerry Freek</i>	<i>WaterTAP</i>	<i>Senior Manager of Communications</i>
Business development can be facilitated by government actions such as implementing incentives supporting research and development, supplying funding for testing and demonstration and publicly showcasing water innovations.		
<i>Klaus Christensen</i>	<i>Danish Cleantech Hub</i>	<i>Project Director</i>
- Linking the public and private sectors can come with challenges. For instance, there may be a limitations or restrictions to how the private sector can utilize taxpayer dollars. These restrictions may lessen business motivation to pursue publicly determined objectives. - Contrasting Denmark and New York City, government in Denmark supports a market for privately conducted research and development that heavily subsidized with public funds. To promote research and development in the US, more subsidies would be useful.		
<i>Wade McGillis</i>	<i>Lamont-Doherty Earth Observatory</i>	<i>Lamont Associate Research Professor</i>
- There are limited funding options for large-scale non-government water projects. - Although important for safety, some regulations unduly hinder innovative water projects.		

<i>Morten Løber</i>	<i>Confederation of Danish Industry</i>	<i>Senior Advisor, Environment</i>
• Pulling in multiple stakeholders can create a “2+2=5 situation” where the created partnership is stronger than the separate apart. In order to form a viable partnership, a business case must be created that benefits all stakeholders. • A business case that supports public goals can be created by reinterpreting problems as opportunities. For example, in Denmark, the problem of nitrification created the opportunity of unconventional energy production. Nitrogen and phosphorus is extracted from wastewater, the resulting sludge is converted in a bioreactor to form biogas.		
<i>Michael Puma</i>	<i>NASA - Center for Climate Systems Research</i>	<i>Research Scientist - specializing in Hydrology</i>
• There are multiple options to deal with water challenges in New York City, much discussion is centered on government bodies. Another strategy could be reaching directly to consumers using market-based methods, such as water filtration devices or faucet filters.		
<i>Rob Gradoville</i>	<i>IDEO.org</i>	<i>Wastewater Engineer</i>
• Strengthening city-level quality control measures are imperative to avoiding disasters similar to Flint, Michigan. Federal and state-level point source water testing is inadequate without municipal level support.		
<i>Patrick Dunlap</i>	<i>Black and Veatch</i>	<i>Environmental Engineer</i>
• New York City could benefit from establishing partnerships between universities and water technology companies and the bring in the city assets to implement pilot projects, learning from experiments at the sites.		
<i>Kevin Siedlecki</i>	<i>Formerly with EmNet</i>	<i>Infrastructure & Wastewater Engineer</i>
• The water sector tends to be conservative regarding building new infrastructure, and municipalities are slow to adopt new, innovative techniques. Impetus for change is often a reaction to regulation. For example, a municipality works with a consultant to rectify a problem or meet a defined target.		

<i>Luis Montestruque</i>	<i>EmNet</i>	<i>CEO</i>
• The civil procurement process in New York City can be onerous, the average time to get a contract signed is 12-24 months. Private sector utilities and other industries tend to complete this same process in a few months. The elaborate procurement process may deter both utilities and tech providers from pursuing available opportunities.		

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