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Abstract
This paper focuses on the Philadelphia, Pennsylvania water supply – past, present, and future – and makes the case that stakeholder collaboration is essential to preserve and enhance this important resource. I argue that without proper planning and funding allocations, the water supply of Philadelphia could be compromised, and by 2050 Philadelphians could learn that an inexpensive, seemingly endless supply of water is substantially diminished. Public awareness is critical as Philadelphia and the United States are both likely to move into an era of water scarcity and onerous water pricing models. The more stakeholders work together to prepare for future strains on their key natural resource, the better the quality of life will be for people and for the other inhabitants of our natural world.

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PHILADELPHIA'S WATER SUPPLY: HOW HUMAN CAPITAL AND COLLABORATION CAN OVERCOME SIGNIFICANT MAN-MADE CHALLENGES

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My central argument is that Philadelphians must change their mindsets and their relationships with water. I believe they must value water as *the* vital natural resource that sustains life. If residents hold this premise and if they use citywide collaboration to make change, then our water supply will flourish for generations to come. If we fail to alter our current thinking and practices about water, we will be responsible for terrible and preventable outcomes.

How can residents and organizations become more knowledgeable about the City's water issues and needs? How will they change their behavior toward water? What measures can induce residents, organizations, and visitors to help the water utility and municipal government realize their sustainability goals? These are the critical questions answered in this paper.

History of Philadelphia's Water Services

When the well's dry, we know the worth of water. **~** Benjamin Franklin, *Poor Richard's Almanac*

The Delaware and Schuylkill rivers were essential in establishing the trade and manufacturing economies of 17th century Philadelphia, with the Schuylkill serving as the source of drinking water during the initial development of the City. Without the rivers, Philadelphia would not likely have become the fifth most populous U.S. metropolis with an estimated population of 1.5 million ("Quick Facts," 2012, p. 1).

The Schuylkill river of William Penn's day seemed destined to remain a placid, bucolic course until anthracite coal was discovered beneath its headwaters in 1790 (Nolan, 1951). Abandoned mines continued to leak acid long after the coal industry's peak in the 1910s. Combined with the harm done by industrial growth and dams, severe pollution and damage to animal habitats resulted. Attempts to repair the damage included the adoption of environmental laws to govern sewage disposal and the pursuit of solutions to reduce pollution from agriculture and urban runoff ("Schuylkill Watershed Conservation Plan," 2001, p. 6).

Coal was not the only culprit in the demise of Schuylkill purity. Like many large cities worldwide, Philadelphia dumped raw sewage into the rivers from the mid-19th to mid-20th centuries, which caused severe illness and death to a multitude of residents. Other results were also well-known:

> Pollution became so severe in many places, including Philadelphia, that the rivers and lakes became dead zones, devoid of the dissolved oxygen needed to support aquatic life. Dockworkers were sickened by the fumes of hydrogen sulfide, a byproduct of the decomposition of sewage. The same fumes also tarnished the silver coins in sailors' pockets and rusted any metal buildings along the riverfronts (Levine, 2010, p. 14).

Citizens made strong demands for municipal government to clean the water and as a result of public protest, filtration plants were built. Unfortunately, once disease rates fell to "normal levels," the interest in stopping pollution at its source diminished. When Benjamin Franklin died in 1790, he left funds to construct a public water supply system. In 1801, the city opened its first water works with water supplied from the Centre Square and Schuylkill Works operations. [Note: The Fairmount Water Works later became an international tourist attraction, one of the most visited sites in the United States between 1820 and 1840 ("About the Fairmount Water Works," 2012, p. 1).]

According to Philadelphia Water Department (PWD) historian and engineer, Drew Brown, at the beginning of the 19th

century, PWD engineers began installing water meters and built drinking water treatment plants on the city's high ground and water pollution control plants on the low ground. Engineers and chemists saved lives by installing filters and applying chlorination to municipal water systems. As a bonus, gravity flow systems like Philadelphia's do not require electrical energy, which we now recognize has reduced Philadelphia's "carbon footprint" (D. Brown, personal communication, August 4, 2011).

In 1822, the Philadelphia Water Works installed water wheels to replace steam engines, which saved money that had previously been expended on fuel. In 1844, the purchase of the Lemon Hill Estate was another "Philadelphia first" – the first U.S. real estate purchase to protect a significant watershed by preventing industry from locating on the land (Gibson, 1990, p. 1). By the 1890s, there was enough scientific evidence of pollution and its causes to support the case to build filtration plants in other locations (Gibson, 1988, p. 7).

In the late 1800s, City officials considered creating a water supply system in the Delaware Water Gap region to improve drinking water's taste and odor. Kramek and Loh (2007) noted that "Problems such as outdated technology, industrial pollution, corruption, inadequate finances and political machinations challenged Philadelphia's water managers" (p. 5). Kramek and Loh attribute much of the successful development of Philadelphia's water system to "public pressure and grass-roots advocacy" for health concerns. The authors provide examples of the early obstacles to change, as well as the power of the people and the necessity and evolution of organizations, all of which can also be observed today:

> To coordinate efforts [and to combat a typhoid rate that was out of control], the citizen groups created a Filtration Committee . . . working outside of the established system . . . which drew members from a diverse group of stake-holders, ranging from residents of afflicted areas, professionals from the Engineers Club and the County Medical Society, editors and owners of local newspapers, and influential university presidents.
>
> This elaborate public organization was needed to counter not only the bureaucratic delays inherent in most large cities at the time, but also Philadelphia's notorious political maneuverings.
>
> Attempts to improve drinking water and build a sewage system became victims of politics: any proposal from the mayor met with immediate opposition from the other party. Because citywide water supply was expensive, government officials found that debate on any potential changes was a highly effective way to get public attention.
>
> To break the impasse, the mayor (Mayor Samuel Howell Ashbridge) commissioned a third-party expert report. . . . Their [recommendation] was no surprise: filtration was necessary for disease prevention. The city accepted the report; in 1899 and 1900 it approved funds for a filtration system and so 'water reform, controversial for so long, quietly became a reality.'
>
> The financial, legal, and engineering obstacles to preventing pollution shifted public and governmental attention to treating the water after it was removed from the river, rather than relying on the river as a natural filter. Yet rivers' health was still equated with public health: in 1905, the Pennsylvania Public Health Department was created, with the sole purpose of cleaning up rivers. (pp. 20-21, 24).

The citizens of Philadelphia and the surrounding region have benefited from three sets of state and federal legislation which forced officials to clean up the rivers and tributaries.

The Pennsylvania Distilling and Clean Streams Acts of 1945 helped transform the Schuylkill River from a dying river into a river that today is filled with dozens of species of fish

and is rich in recreational use. The Clean Water Act of 1972 (a/k/a Federal Water Pollution Control Act) enabled regulation of river and stream pollution. The Act provided funding to assist communities to build sewage treatment plants and regulated the discharge of pollutants into the water by either banning or requiring permits for questionable discharges. The Safe Drinking Water Act (SDWA) of 1974, the primary Federal safe-water act, established national standards for drinking water and provided oversight of all organizations involved in delivering water to consumers ("Summaries of Environmental Laws," 2012, p. 1).

The Delaware River, which supplies drinking water to residents of New York City, New Jersey, and Delaware and provides 60 percent of Philadelphia's water via the Baxter Water Treatment Plant, has also been an area of concern. There was a tense period during the 1960s and 1970s when the free-flowing Delaware was nearly dammed. In *Damming the Delaware*, which presents the history of the Tocks Island Dam project, Richard Albert (2005) raised an "either-or" question: Was the value of the river to serve mankind, or to remain free flowing? President Nixon played a role in the fate of the River when he signed the National Environmental Policy Act on January 1, 1970. The Act required federal agencies to prepare environmental impact statements for proposed public works projects. Albert (2005) noted,

> Tocks Island was the Vietnam War of the Delaware Valley. Tocks had its U.S. Army, spiraling costs, dogmatic supporters, opposition protestors. . . . In 1975 both the dam and the war collapsed from weakened political support and rising public pressure" (p. 175).

The dam was never built; the project was eliminated.

In the early- and mid-1980s, the Philadelphia region experienced periods of drought. In 2010, the non-governmental organization (NGO) American Rivers (americanrivers.org) named the Upper Delaware River the most endangered river in the U.S. Although the Delaware did not appear on the organization's 2011 "top 10" list, the Delaware has remained threatened by man-made intrusions. [Note: Another Pennsylvania river, the Susquehanna, did appear on the 2011 top 10 endangered river list due to the threat of natural gas extraction.] *Appendix A* presents a detailed chronology of the Delaware River's history from 1842 to 1985.

Philadelphia's Current Water Management System

Failure on water, as individuals and communities, and little else we get right will matter. ~ Chris Wood, *Dry Spring: The Coming Water Crisis of North America*

Water supplies cannot be transported long distances inexpensively. For this reason, and short of widespread drought and inter-country conflicts, water resource issues are local. Because of consistent rainfall and the benefit of two abundant river sources, Philadelphia's water supply and water access continue to be advantageous.

Philadelphia's water supply is monitored, treated, and delivered by the municipal authority, the Philadelphia Water Department (PWD) and by the Water Revenue Bureau (WRB). PWD's primary mission is

> to plan for, operate, and maintain both the infrastructure and the organization necessary to purvey high quality drinking water, to provide an adequate and reliable water supply for all household, commercial, and community needs, and to sustain and enhance the region's watersheds and quality of life by managing wastewater and storm water effectively ("Water Infrastructure Management," 2012, discussion of Traditional Infrastructure Basics, para. 2).

The nucleus of PWD's strategy to control combined sewer overflows (CSOs) is the current initiative called "Green City, Clean

Waters." The 25-year strategic plan of this initiative is designed to satisfy federal environmental laws and regulations, and enhance Philadelphia's watersheds. Specifically, it is to unite the City with its water environment, creating a green legacy for future generations while incorporating a balance among ecology, economics, and equity; integrate combined sewer and water resources management into the socioeconomic fabric of the City; and manage Philadelphia's watersheds so that expenditures provide a maximum return in benefits to the public and the environment ("Water Infrastructure Management," 2012, para.2).

Historically, Philadelphia has relied on a combined sewer system that has pumped sewage and pollution into the rivers during heavy rainfall. Green stormwater infrastructure, by contrast, uses systems that assist or mimic natural processes to manage stormwater runoff, reduce flooding, reduce combined sewer overflows, and improve water quality. For instance, green roofs retain rainwater and filter water runoff. They can enhance the Leadership in Energy and Environmental Design (LEED) rating for building owners. A green roof system adds vegetation, a drainage system, and water proofing to residential, commercial, or institutional buildings ("Green Roof Benefits," 2012, p. 1). A number of Philadelphia public and private organizations are currently creating and implementing these and other green applications for managing Philadelphia's water system. Examples are

PA Horticultural Society (PHS)

The PHS Philadelphia Green program joined forces with the Philadelphia Water Department to minimize stormwater runoff through "Low Impact Development" to detain, filter, and infiltrate runoff by mimicking natural processes. By relying more on landscaping than on infrastructure, this approach is intended to enhance open space in urban neighborhoods "Green Initiatives," 2011, para. 3). PHS advocates for green roof technology. Carroll (2011) notes, "Green roofs offer big benefits to the environment: they absorb and retain large quantities of rainwater, reducing runoff that contributes to flooding. They filter pollution from rainfall and keep it from entering rivers and streams" (p. 1).

Kensington Creative and Performing Arts School

Kensington is a former industrial, inner city neighborhood located between the lower Northeast and North Philadelphia. PWD has collaborated with the School District of Philadelphia at the Kensington Creative and Performing Arts School to install a porous pavement parking lot, rain gardens, rainwater cisterns, and green roofs covering 50 percent of the roof area.

University of Pennsylvania

The University of Pennsylvania (Penn) is located in the University City section on the eastern, or "Center City," side of West Philadelphia. Penn Park, which the University opened in 2011, is located near the banks of the Schuylkill and is an outstanding example of design for sustainability. The Park's drainage system captures rainwater, which is used for irrigation and to reduce both runoff and water demand.

"Penn Connects" is the plan to guide the University's sustainable development http://www.pennconnects.upenn.edu). Highlights of the plan related to Penn Park include a long-term plan for carbon reduction; smart land use planning and increased open space; and mitigating stormwater issues. Much of the green infrastructure built to manage the Park's stormwater benefits wildlife habitat and air quality. Penn's green space is now 20 percent larger because of the 24-acre park.

Once classified as a grey field, where stormwater is problematic, Penn's Shoemaker Green is designed to "improve water quality, minimize runoff, and restore biomass to the site and increase local biodiversity with habitat planting and use of living soils" ("Shoemaker Green," p. 1). The Green, an $8 million project located on 3.5 acres, will be a model for sustainable landscape design and is a pilot project to test the Sustainable Sites Initiative ratings systems for landscapes (McWilliams, 2010), which could serve a similar purpose as the U.S. Green Building Council's LEED Green

Building ratings ("Penn's Shoemaker Green Project," 2010, para. 1). In addition

> In cooperation with the Philadelphia Water Department Office of Watersheds, Penn is exhibiting best practices in sustainability by installing green roofs on a number of buildings. By capturing rainwater and reducing it slowly over time, Penn's green roofs lessen the burden on the West Philadelphia sewer system. In addition, green roofs can provide a habitat for a number of insect and bird species, increasing urban biodiversity and creating a healthier ecosystem ("Designing Green," 2012, para. 2).

Dilworth Plaza

In 2014, the west side of Philadelphia's City Hall will re-open as a green space with 38 percent less impermeable paving and 27,600 square feet more lawn and plantings area. A fountain, which will reuse its own water and capture stormwater runoff, will become an ice rink in the winter (climate permitting). Funding is provided by the Federal Transit Administration, Commonwealth of Pennsylvania, SEPTA, the City of Philadelphia, the Center City District (a private organization), the William Penn Foundation, the John S. and James L. Knight Foundation, and by individuals ("Daniel J. Keating Company Selected," 2011, November 17, p. 1).

Philadelphia's Current Water Resources Issues

The great Dust Bowl of the 1930s . . . might turn out to have been only an early warning.
~ Edward and Robert Ayres,
Crossing the Energy Divide

A common water utility issue is how to stem the hemorrhaging of water from aged, inefficient distribution systems. Consider the sobering national statistics that Charles Fishman (2011) presents in *The Big Thirst*: "One of every six gallons of water pumped into water mains by U.S. utilities simply leaks away, back into the ground. Sixteen percent of the water disappears from the pipes before it makes it to a home or business or factory" (p. 5).

To understand the critical water resources issues facing the City now and in the future, I asked opinions of several Philadelphia water experts. I catalogued their opinions in a SWOT (Humphrey, 2005) in *Appendix B.* In addition, E-mail communications, in-person or telephone interviews, research, and personal observation revealed a number of pressing issues. Despite adequate water supplies and a respected water management, those I interviewed believe that Philadelphia faces problems that could become critical by 2050. They include the following:

1. Climate Change

Climate change is likely to impact Philadelphia with multiple consequences. Many in the scientific community predict that global warming will cause the Atlantic Ocean to continue to rise ("Climate Change," 2012, p. 1). As the ocean rises, the Delaware's salt line will travel northward closer to water supply intake points. The Delaware intake point is located in the Torresdale section of Northeast Philadelphia at the Baxter Water Treatment Plant. Should the salt line reach the Baxter location, the plant would be forced to shut down ("Delaware River Watershed Source Water Protection Plan," 2007, June, p. iv). Because the current water treatment process does not address salt, treatment plants will need to be redesigned and/or the current intake point will need to be moved upstream – "either of which would carry a significant cost" ("Regional & Global Trends," 2012, para. 2).

On December 4, 2011 the Global Carbon Project (www.globalcarbonproject.com) claimed that global emissions of carbon dioxide from fossil-fuel burning increased by the largest amount on record during 2010. Gillis (2011) noted in *The New York Times* that

> Scientists with the [Global Carbon Project] group . . . said the increase, a half-billion extra tons of carbon pumped into the air, was almost certainly the largest absolute jump in any year since the Industrial

> Revolution, and the largest percentage increase (5.9 percent) since 2003. . . . The increase solidified a trend of ever-rising emissions that scientists fear will make it difficult, if not impossible, to forestall severe climate change in coming decades (para. 2).

In *The Philadelphia Inquirer* article about Dr. Benjamin P. Horton, director of Penn's Sea-level Research Laboratory, Bauers (2011) says, "In the most detailed look yet at sea-level change, scientists Monday reported that waters along the East Coast have risen faster over the last century than at any time in the previous 2,000 years. . . . Where the temperature picks up in the 20th century, so does sea-level," (para. 1, 3). Horton's research project was partially funded by the U.S. Geological Survey. His $1.5 million grant will be used to improve the prediction of coastal flooding caused by hurricanes and rising sea-levels (Watkins, 2011, September 16, para. 1).

Another danger attributable to climate change is flooding. In recent years, there has been an increase in precipitation and frequency of heavier rains. According to The Partnership for the Delaware Estuary, whose sponsors include energy companies ConocoPhillips and Sunoco, these meteorological conditions will continue for "decades due to the impacts of carbon already in the atmosphere" (Adkins, 2011, p. 2). Carol Collier, executive director of the Delaware River Basin Commission (DRBC) said that in the past her agency has managed for droughts and must now manage for floods as well. Between 2004 and 2006 three significant floods swamped the Philadelphia region. Collier noted, "I believe in climate change. We need to enlarge the flood plains and build more data systems" (C. Collier, personal communication, July 27, 2011).

Due to environmental impact associated with the manufacture and transportation of plastic, Philadelphia residents' consumption of plastic bottled water contributes indirectly to climate change. Consider that the manufacture of all plastic water bottles sold in the U.S. in 2007 emitted over 2.5 million tons of carbon dioxide, or the equivalent of emissions from 400,000 passenger cars a year ("Bottled Water" p. 1). As well, the Pacific Institute finds that it took approximately 17 million barrels of oil equivalent to produce plastic for bottled water consumed by Americans in 2006—enough energy to fuel more than 1 million American cars and light trucks for a year ("New Case Study," 2007, December 12, para. 1).

2. Drought

Drought causes problems similar to those caused by general climate change, discussed above, and the 1960s drought experience is cause for alarm. In 1965, in the midst of the drought, New York City cut back on the amount of water it allowed to flow past New York to supply Philadelphia and other points south. The resulting lack of flowing fresh water created a possibility of salt water being drawn into the intakes instead of fresh water ("Regional Entities," 2012, p. 10).

According to Collier, during the 1960s drought, the mayor of New York City turned off the reservoir flow to the Delaware River. She adds

> If we had a multi-year drought in 2050 like we had in the 1960s, the salt line would be four miles above Philadelphia's water intake point. In 2100, it would be seven miles above the point (C. Collier, personal communication, July 27, 2011).

3. Water-Energy Nexus

In "The Sustainability Challenge: Meeting the Needs of the Water-Energy Nexus" (2011), Dow Chemical Director of Global Marketing Snehal Desai argues that water and energy are inseparable for the following reasons:

> Water is required to make use of energy. Water is used directly in the generation of most forms of turbine-generated electricity, either directly (hydropower, geothermal) or indirectly (steam to turn turbines, cooling). Energy is required to make use of water. In order to take advantage of water resources, energy is needed to extract, move, treat, deliver, use and dispose of water (p. 1).

In the report, Desai explained that the nexus can become a

> vicious cycle, as lack of technology, poor management or inefficiencies in use in one area can affect the sustainability of the other. For instance, power plant inefficiencies can result in increased water use to generate the needed amounts of electricity (p. 2).

4. Impervious Land Causes Stormwater Runoff

Although 10 percent of Philadelphia is made up of one of the largest urban parks in the country, the majority of Philadelphia's land is paved, developed, or unnatural and contains a high number of residential structures, such as row homes. These factors cause massive volumes of water to pour into waterways during rainstorms. According to PWD, 80 percent of pollution in the rivers currently comes from contaminants moved by stormwater runoff. Philadelphia's combined sewer system has 164 "overflow locations" where, after heavy rain, stormwater runoff contaminated with untreated sewage flows directly into local waterways, as has occurred for centuries in the City.

5. Toxins

According to Fishman (2011), "What we don't understand, such as impact of micropollutants, we can't regulate. The Safe Drinking Water Act is outdated" (p. 176). Bauers (2011) reported in *The Philadelphia Inquirer* that a water division chief at the State Department of Environmental Protection found Iodine-131 in water samples taken from the Wissahickon Creek near Green Lane. That point is located upstream from the Belmont Water Treatment Plant in the Wynnefield section of West Philadelphia, which draws water from the Schuylkill. Iodine-131, used to treat thyroid cancer, is radioactive (para. 6).

The *Inquirer* account was confirmed by PWD Project Engineer Julia Rockwell in the Fall, 2011 issue of *Estuary News*. Based on samples taken downstream of wastewater treatment plants on the Schuylkill, the city's surface waters appear to be affected by "detectable and highly variable levels of I-131." According to Rockwell, PWD has initiated a national discussion on radioactive contaminants in water supplies (p. 3). Current treatment systems do a fine job with the contaminants they were designed to eliminate, but they cannot detect and eliminate the myriad drugs that have come into being subsequently.

> Pharmaceuticals get into drinking water because people now take more medication than ever. . . [some of which] passes through the body, eventually making its way into the rivers and streams that serve as our nation's drinking water sources. These compounds are at such low concentrations that they cannot be detected unless the most advanced methods are used, and there is currently no indication that such small concentrations pose any public health risk. Studies do show impacts to fish, however, which have constant exposure to these substances ("Source Water Quality: Pharmaceuticals," 2012).

NGOs throughout the United States and local governments are partnering to offer prescription drug collection boxes to control the disposal of medication. The Drug Enforcement Administration (DEA) hosted a National Drug Take Back Day on April 30, 2011 *("*"Another Huge Turnout," 2011, May 6, p. 1). In support of the April 30th collection effort, Philadelphia's city council passed Resolution 110324 which references the U.S. Geological Survey's position that that improper disposal of prescription drugs contaminates the environment and pollutes water sources.

With regard to other well-known toxins, if the Delaware Riverkeeper is correct, companies continue to discharge chemicals including polychlorinated biphenyls (PCBs), with minimal oversight or enforcement, into the Delaware. This disgraceful practice can kill wildlife. PCBs also contaminate multiple links in the food chain, which ultimately can alter human health.

6. Population

Although the Philadelphia City Planning Commission's analysis predicts a population increase of only 100,000 for Philadelphia by 2035 ("Philadelphia2035," 2011, p. 33), I believe a severe spike in gasoline prices could cause a tipping point and drive a wave of migration into the City. In an energy-challenged world, people will seek housing located in close proximity to public transportation systems, such as Philadelphia's Southeastern Pennsylvania Transportation Authority (SEPTA), to reduce their transportation costs.

Advances in medical science could also cause Philadelphia's population to rise. With an increase in the median mortality rate, and without a corresponding reduction in the City's annual birth rate, more senior citizens would consume water. In time, senior citizens alone could impact the availability of water for all age groups.

7. Upstream and Watershed Conditions

Deforestation and impervious surfaces cause watersheds to become fragile. Excessive stormwater runoff can lead to severe flooding. In eastern Pennsylvania, watershed damage can impact millions of downstream residents. Human meddling can change the life of a river, radically. In spite of today's greater environmental awareness, there are those who continue to propose industrial, commercial, and residential development in and near the banks of Philadelphia's rivers.

Hydraulic fracturing, referred to as fracking, is a drilling process using chemicals to extract natural resources such as natural gas from great distances beneath the earth's surface. Upstream from Philadelphia, commercial interests currently clash with community activists and environmental NGOs over the property and drilling rights to natural gas. The related issue for Philadelphians is whether this type of natural gas drilling can be regulated effectively near Philadelphia's water supply. On November 18, 2011, the executive director of the Washington, D.C.-based Food & Water Watch declared a tentative victory against fracking when the Delaware River Basin Commission announced it cancelled the vote to proceed with regulations that would pave the way for 20,000 wells in the region ("Anti-Fracking Advocates," 2011, November 18, p. 1).

Solutions

Unlike oil, there are no substitutes for water.
~ Peter Rogers and Susan Leal,
Running out of Water: The Looming Crisis and Solutions to Conserve Our Most Precious Resource

Does a multilateral approach to water management work better than a "uniform environmental code" which may be designed, implemented, and enforced by one governmental agency? One way to understand water policymaking and governance is to examine potential solutions.

Governmental agencies, non-profit organizations, and the media play important roles in sustaining water supplies for future use by people and by the natural world. One of Philadelphia Mayor Michael Nutter's goals is for Philadelphia to be the "greenest city in America" by 2015. The mayor's Office of Sustainability tracks sustainability targets established in the multi-year plan, "Greenworks Philadelphia." The initiative could raise awareness about how environmental conditions affect the quality of life for city residents and workers.

Based on independent, environmental "report cards" issued by the National Resource Defense Council, Philadelphia is considered to be a leader in prudent and progressive water resources management. Devine (2011) tells us that Philadelphia is the only U. S. city achieving a score of 6 out of 6 using "Emerald City" criteria and Philadelphia is the first city in the nation officially committed to using green infrastructure as the primary means to satisfy its CSO obligations (p. 1).

A bold plan such as Green City, Clean Waters could prove to be the solution to the City's stormwater problem. This green infrastructure project, with a projected cost of $1.6 billion over the next 20 years, will be implemented instead of the traditional method, which would have required the construction of large storm water storage tunnels with a

projected cost of $10 billion. The green project will be funded by water fees, government grants and loans, private investors, and foundations. To fund the tunnel project, PWD would need to collect exorbitant storm water fees ("Green City Clean Waters," 2012).

The City projects that green infrastructure will reduce storm water flow in Philadelphia by 80 percent bringing it very close to full compliance with Clean Water Act requirements. Still, questions remain about Philadelphia's plan. For example, on the Penn Law School's Weblog, Gillard (2011) asks, is green infrastructure durable? What will be its maintenance costs? Will City departments collaborate to "green" the city further? Will budgets allow the Philadelphia Department of Streets to pave significant city acreage with pervious pavement too? (p. 25).

With city government's effectiveness limited by financial constraints and finite influence, I argue that all stakeholders must join together to sustain Philadelphia's water supply. The most effective planning is collaborative, integrative, and holistic – in short, planning that follows a systemic approach – because the water supply problem is a systems problem.

Formed in 2008 to study water resource scarcity, the 2030 Water Resources Group is comprised of the World Bank Group, McKinsey & Co., and a business consortium including Coca-Cola and Nestlé. The report's findings include:

> A lack of transparency on the economics of water resources makes it difficult to answer a series of fundamental questions: What will the total demand for water be in the coming decades? How much supply will there still be? What technical options for supply and water productivity exist to close the "water gap"? What resources are needed to implement them? Do users have the right incentives to change their behaviors and invest in water saving? What part of the investment backlog must be closed by private sector efforts, and what part does the public sector play in ensuring that water scarcity does not derail either economic or environmental health ("Charting Our Water Future," 2009, p. 10).

Philadelphians are fortunate that its municipal water utility functions very well compared to other authorities across the country. To help ensure that agencies such as PWD continue to be forward-looking and remain accountable, the City released its comprehensive plan, "Citywide Vision," in June, 2011. The City had last updated its comprehensive plan in 1960 (C. Randall, personal communication, August 30, 2011).

Corporate Citizens: The New Era of Transparency

The good news is that Corporate America is reversing years of past abuse of U.S. environments, such as waterways. Businesses are partnering with governments and NGOs to find solutions to protect natural resources such as water supplies. They are recording and then publicly reporting their own water usage.

Philadelphia-based companies are practicing sustainability in their respective supply chains and throughout their operations. With current technology and stakeholder encouragement, Philadelphia companies and institutions are reducing their water usage by thousands of gallons each month. When an organization's ethos is green, the ripple effect is powerful. Employees learn the importance of conserving and reusing natural resources, such as seemingly ubiquitous water, which can influence their personal usage and relationship with water. For example, the power generation company PECO, an Exelon subsidiary, has installed a green roof on its Philadelphia company headquarters and proudly reports that the 45,000 square foot roof will "reduce stormwater runoff by absorbing 60 to 70 percent of the approximate 1.5 million gallons of annual rainwater that falls on the Main Office Building." The roof also will save on heating and cooling costs by reducing the summertime peak roof temperature by 60 to 80 degrees Fahrenheit ("Enhancing our Environment," 2012). By using fewer fossil fuels and emitting less carbon into the atmosphere, utilities like

PECO can help curtail global warming, which indirectly impacts Philadelphia's water supply. PECO has claimed many sustainability contributions including reduced greenhouse gas emissions by 54 percent between 2001 and 2010; reduced stormwater runoff up to 50 percent due to the 45,000 square foot green roof on its center city headquarters building; and increased energy efficiency improvements in 10 of the largest company buildings in the Philadelphia region with a goal to reduce water usage by 35 percent ("PECO," 2009, p. 1).

Another successful example of partnering for sustainability is the operation of Dow Chemical, which acquired Rohm and Haas in 2009. The Bristol, Pennsylvania plant, which manufactures coating materials, is located near the Delaware River. Rohm and Haas and Dow strive to be recognized as good corporate citizens, and they have collaborated with The Natural Step (http://www.naturalstep.org/), an NGO dedicated to creating systemic, sustainable change, by providing a science-based understanding of sustainability to decision makers. Through this collaboration, Dow aspires to make sustainable development a priority for the chemical industry. Indeed, Dow created a Sustainability External Advisory Council (SEAC) to help establish sustainability goals. SEAC includes members from NGOs, academia, and the business community.

In January 2011, Dow and The Nature Conservancy launched a collaboration to help Dow "incorporate nature into global business goals, decisions, and strategies." The following credo describes the collaboration in detail:

> This collaboration is designed to help us innovate new approaches to critical world challenges while demonstrating that environmental conservation is not just good for nature – it is good for business. . . . As the world population surges, it will take public and private sector collaboration like this to make the health of the environment not just an afterthought, but a fundamental consideration in everything we do in every part of our society ("Investing in Nature," 2012, p. 1).

Environmental NGOs Protecting Philadelphia's Water and Land

Environmental NGOs are non-profit organizations whose missions are to protect natural resources and open space. The Greater Philly Environmental Network (GPEN) lists dozens of such NGOs in the Philadelphia area.

Non-profit conservancies and land trusts, which either acquire or administer easement, play important roles in protecting watersheds and waterways. Working with local property owners, these organizations identify land that offers critical natural habitat as well as land offering recreational, agricultural and other conservation value. They either purchase such properties or work to convince owners to use their land with conservation in mind. By limiting unbridled land development, they help create natural buffers and they preserve natural habitats, which helps retain biodiversity in ecosystems.

The following are leading, Philadelphia-area organizations, recognized by the Network, that are doing exemplary advocacy and educational work to protect Philadelphia's water supply:

Natural Lands Trust conserves land from development in eastern Pennsylvania. The Pennsylvania Land Trust Association (PALTA) is an umbrella organization including 80 dues-paying state conservation organizations. PALTA's strategies are to support land trusts and governments to conserve land and achieve their conservation objectives and to advocate for public policies that impact land and water conservation. In 2006, PALTA lobbied legislators to pass Act 154, which "empowers local governments to give land, easements and cash to land trusts in support of conservation" ("Public Policy Accomplishments," 2006, p. 1).

Delaware Riverkeeper Network (DRN) serves as the voice of the Delaware, and is managed by Maya van Rossum, an environmental lawyer. The Network challenges lawmakers and regulators to protect the natural state of the Delaware. On November 2, 2006, the *Green City Journal*'s Caryn Hunt (2012) reported the following disturbing incident that allegedly occurred (circa 2004) and was reported in an interview with Tracy Carluccio of DRN.

The U. S. Army sought places to dump 1,200 tons of VX nerve agent waste. (VX is a potent chemical weapon.) They tried sending the waste from Indiana to Ohio, but public opposition defeated that plan. Then the Army considered the Delaware Estuary at the Dupont Chambers Works facility in Careny's Point, Salem County, New Jersey for its toxic disposal. The result could be fatal to fish, horseshoe crabs, and migrating shore birds that feed on crabs' eggs. The drinking water of people living in the state of Delaware could be jeopardized.

DRN campaigned against the New Jersey dumping and filed a complaint against the Army. In part through DRN's campaign, people learned of the Army's plan and spoke out in public hearings. They wrote letters by the thousands to elected officials. Apparently, protests such as "letters to the editor" are still effective in causing politicians to act in the public's best interest (Hunt, 2012, p. 10).

Another issue for DRN is that of fracking. In a 2011 media interview, von Rossum said, "There is no sane, credible, sensible argument for going forward with drilling [for natural gas in or near a watershed] based on what we know" (Kulesza, 2012, p. 1). In August, 2011, DRN filed a lawsuit against the Army Corps of Engineers and other federal agencies alleging that any drilling near the Delaware without an impact assessment violates the 1969 National Environmental Policy Act. DRN reasons that industrial shale gas drilling causes pollution, which causes people to get sick.

Tookany/Tacony-Frankford (TTF) Watershed Partnership The Tookany /Tacony Creek flows from Montgomery County into Northeast Philadelphia and into the Delaware River, south of the Betsy Ross Bridge. The TTF connects residents, businesses, and government to steward this impaired but vital watershed in the Philadelphia metro region. Through educational programming, community outreach, and project coordination, TTF facilitates, supports, and initiates efforts to restore the health of the watershed and to mobilize its communities as watershed stewards.

Friends of Wissahickon (FOW) The Wissahickon Creek is a 23-mile tributary of the Schuylkill with a watershed that stretches for 64 square miles in Montgomery County and Northwest Philadelphia. The Wissahickon Valley has earned National Natural Landmark status, and the Wissahickon Park Trail System is a National Recreation Trail. According to Jim Harris in his 1993 documentary *The Gentle Wissahickon*, industry polluted the creek severely during the 19th century. A key lesson from the film is the narrator's warning that the survival of the Wissahickon is dependent on the involvement of a concerned public.

For generations, the FOW has mobilized residents of Northwest Philadelphia to remove invasive plants from and monitor discharges into the Creek. With the ever-increasing limitations on Philadelphia Parks and Recreation's budget, non-profit organizations like FOW are vital to monitor watershed management. FOW's strength was demonstrated on March 29, 2012 when Springside Chestnut Hill Academy in Northwest Philadelphia hosted a town meeting to discuss the health of the Wissahickon Creek and over 300 people attended, hearing panelists discuss the importance of conserving water, creating rain gardens, and using rain barrels (Everline, 2012, April 5, p. 1).

William Penn Foundation (WPF) Private foundations such as WPF serve important roles in the stewardship of Philadelphia's water supply. They provide financial capital and capacity building to non-profits, including City government. WPF is a champion of environmental needs.

A priority of the Foundation's Environment and Communities program is the "protection and restoration of watersheds, with a focus on key waterways." WPF funded "Financing Stormwater Retrofits in Philadelphia and Beyond," a 2012 report by The Natural Resources Defense Council, which highlights Philadelphia as a case study.

The Foundation awarded grants from 2005 - 2009, totaling more than $14 million through its water policy priority. Grantmaking included stormwater policy and practice and drinking water for Philadelphia region ("Strategy Review," 2011).

These progressive organizations play vital roles in keeping regulators "honest" and educating the public. Their stewardship contributions are immeasurable. A more visible,

unified consortium of environmental NGOs could help design sophisticated water supply solutions to address future shortages and increased demand.

Summary and Conclusions

Synergy: a mutually advantageous conjunction or compatibility of distinct business participants or elements (as resources or efforts). *~ Merriam-Webster Dictionary*

As noted by Rogers and Leal (2010), "Water is finite, but fortunately there is no limit to human ingenuity and creativity" (p. ix). Leaders need to continue to articulate their visions of water distribution that are equitable for all ecosystem members, and to act with courage to implement solutions that outlive themselves. To ensure that Philadelphia's freshwater remains abundant and affordable, citizens need to organize and present solutions to policymakers.

Given the history of water resources management and PWD's current talent, I believe that Philadelphia's present public utility model is the appropriate framework to address the City's water needs in the 21st century. That said, stakeholders must further develop and nurture the public forum for addressing water resources to ensure multiple perspectives and creative solutions. One caveat: Given economic pressures, I believe that municipalities like Philadelphia are reluctant to challenge revenue-generating corporations on their use of water and discharge of wastewater. Politicians and bureaucrats steward the corporate tax base and strive to entice more businesses to open shop within City borders. Therefore, I do not envision municipal officials pressing our corporate citizens enough to act progressively regarding their water usage.

When Philadelphia's governmental agencies, scientists, businesses, environmental NGOs, and citizen activists collaborate effectively, the City will realize a more sustainable water supply system. Such a system would deploy technology to limit infrastructure leakage; would minimize over-usage without rationing; and would protect biodiversity. Working together, rather than independently, stakeholders will be more successful in preserving Philadelphia waterways and watersheds.

As well-designed, well-intentioned, and promising as the Green City, Clean Waters plan is, time will tell how the Philadelphia community will respond to the "call for action." Philadelphians and Philadelphia's private enterprises must embrace PWD's vision to incorporate green infrastructure on a city-wide basis – for environmental and financial reasons. All water consumers must contribute to the water supply's future by reducing their water consumption per capita and per operation. Philadelphia's history shows that community activism can move policymakers to act, especially when public health is at stake.

The City's comprehensive plan, Philadelphia2035, is a good step toward developing an Integrated Water Resources Management system that shares views from stakeholders without compromising the sustainability of ecosystems. The active participation of stakeholders will solve inevitable water challenges and will create sound water policies. My recommendations for creating a sustainable water supply system for future generations of Philadelphians are as follows:

Pricing Model Changes

When residential water bills are less than half of monthly cable TV or cell phone bills, many fail to appreciate the value of protecting water. Based on climate change trends, salt water lines on the Delaware and Schuylkill Rivers may travel north and pose a significant threat to City water intake points by 2050. Philadelphia is also likely to experience population gain, which impacts the consumption drain of the water supply.

To prepare for these contingencies and to maintain miles of pipes, PWD needs additional funds. A tiered pricing system would help the utility raise the revenue that is needed for actual costs and for contingency funds to operate the City's water system. A pricing model that surcharges residents and businesses for gross over-consumption of public water and that subsidizes low-income residents to satisfy their fundamental needs may be needed.

Technology

As funding allows, I believe that retrofitting the Philadelphia water system with sensors and other monitoring devices, to ensure that the distribution and treatment of water is as energy efficient as possible and that the water leakage is minimal, may be valuable. I also believe that supporting the development of low-cost, digital instruments for residential water faucets that display gallon usage can encourage conservation.

Organizational Contributions

In addition to preventing water scarcity and water price-gouging, organizations can contribute to protecting the environment – in short, they can behave as good, green citizens – by committing to:

Adopt and follow a "corporate social responsibility" strategy vis-à-vis the environment. Install a Chief Sustainability Officer, or designate a position within operations or facilities departments to be accountable for executing the Green strategy.

Partner with environmental NGOs financially and participate in community projects to protect waterways.

Promote stewardship support in altruistic, not in "greenwashing," ways.

Participate in environmental forums such as the March 22, 2011 conference "Valuing Water: Business Challenges and Opportunities for Innovation," hosted by Penn's Initiative for Global Environmental Leadership (IGEL).

Be vigilant and active in motivating myopic CEOs to evaluate their use of natural resources. This is particularly true of Federal regulators, such as the EPA, and NGOs, such as the Delaware Riverkeeper Network**.**

Environmental progress must continue to occur – for the benefit of consumers and businesses alike. As an optimist, I believe that industry and the business community will continue to partner with Philadelphia stakeholders to sustain the water supply.

Education

Educate citizens through multiple touch points (such as through radio and TV public service announcements, social media, environmental group websites and newsletters, and school trips to the Fairmount Water Works Interpretive Center) on why it is important to consume less water for personal needs. Encourage Philadelphia residents to limit showers to four minutes, to turn potable water off while shaving, washing hands, or brushing teeth, and to water lawns only when absolutely necessary.

Promote Philadelphia's greenness as a community movement by marketing the Green City, Clean Waters initiative through multiple channels, including community associations, and tax accountants. The public needs to know, for example, that green roofs improve air quality, reduce stormwater runoff, and can lower utility bills.

Encourage thought leaders at Philadelphia institutions of higher learning to study Philadelphia water resources issues. For instance, Penn's Organizational Dynamics program could assign a team of students to consult with PWD or the Mayor's Office of Sustainability on how to design a systems-thinking approach to water conservation. Encourage high schools and colleges to host ideas tournaments on how to manage Philadelphia's water resources system.

Incentives

The City should partner with the business community to pay public tribute to companies and institutions that reduce their water usage substantially throughout their operations and their supply chains. Everyone likes a "pat on the back" once in a while. The Philadelphia Global Water Initiative (http://pgwi.org/) can identify water experts and establish a "blue ribbon" panel of judges to recognize publicly Philadelphia's green companies and institutions.

Make it fun. Reward contest winners with cash prizes and "honor roll" status. In addition, water problem-solvers could receive media coverage, letters of commendation, and invitations to special events, including award ceremonies.

Society can encourage individuals to act prudently to conserve resources for future generations. With proper leadership and innovation, Philadelphia's water supply system

will be less vulnerable to man-made threats and will sustain the needs of present and future generations. Action by multiple stakeholders will truly steward and enhance the water supply.

High community awareness about Philadelphia's fragile water supply will help provide better public health for the City's residents – humans, animals, fish, birds, and plants. The media, educational system, municipal governmental agencies, business community, citizen activists, environmental NGOs, and other City stakeholders must pool their human capital to ensure a continued high level of water resources management.

This paper has examined man-made challenges that threatened the safety of Philadelphia's water supply – that therefore threaten life. Cross-sector and multi-generational collaboration will ensure that the water supply remains abundant and reliable. The key is to find bold, effective leaders who will coordinate the necessary collaboration amongst varied, and at times competing, interests to overcome these challenges.

With proper leadership and innovation, Philadelphia's water supply system will be less vulnerable to man-made threats and will sustain the needs of present and future generations. Action by multiple stakeholders will truly steward and enhance the water supply.

This paper was based on an independent study project supervised by Alan Barstow, Ph.D. and completed in 2011 in partial fulfillment of requirements within the Sustainable Development concentration of the Master of Science in Organizational Dynamics degree program. The project and the concentration examine problems in environmental sustainability, including how to change thinking and practices within organizations in order to meet sustainability goals.

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Appendix A
Chronology of Delaware River Projects

1842	Start of the New York City water system
1850	First Philadelphia intake on the Delaware
1852	First Supreme Court case involving the Delaware
1900-20	Delaware examined for hydropower
1908	First meeting of New Jersey, New York, and Pennsylvania concerning the Delaware
1925	First Tri-State Delaware River compact
1928	New York City decides to tap the Delaware
1931	U.S. Supreme Court affirms New York City's right to divert water from the Delaware based on the principle of equitable apportionment
1930-34	Corps of Engineers produces the first comprehensive water-resources plan for the Delaware; Tocks Island Dam (TID) is first proposed
1956	Mayor Clark helps form the Delaware River Basin Advisory Committee, comprised of "politically influential citizens to study the Delaware"
1959	The Committee establishes a "non profit, impartial, educational organization" named the Water Research Foundation for the Delaware River Basin
1960	Corps reservoir plan is finalized (Tocks Island is the largest dam in the plan)
1961-67	Record drought hits Delaware River region
1962	Tocks Island Dam Project authorized by Congress
1965	Delaware Water Gap National Recreation Area is established around Tocks Island Reservoir; Delaware Valley Conservation Association forms to fight dam and recreation-area projects
1970	National Environmental Policy Act becomes law
1971	Corps delays start of TID because of incomplete environmental impact statement; Save the Delaware Coalition forms to fight the dam
1975	Delaware River Basin Commission votes 3 to 1 against the construction of TID
1978	Middle Delaware Scenic and Recreational River is created in Tocks Island region
1980-81	Drought declared
1985	Drought declared

Source: Albert, Richard: *Damming the Delaware: The Rise and Fall of Tocks Island Dam*, 2005.

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Appendix B
SWOT Analysis of Water Experts' Opinions of Philadelphia Water Systems

Strengths	**Weaknesses**
▪ Abundant resources - Schuylkill and Delaware[1] ▪ History of watershed protection[1] ▪ High values – economic and recreational[1] ▪ Long term improvements planned under the Clean Water Act[1] ▪ Climate – not arid[2] ▪ Few water restrictions – allocation not an issue[2] ▪ Infrastructure – good base to improve on[2] ▪ Human capital – highly-trained and well-regarded PWD staff, plus volunteer support from community[2] ▪ PWD – excellent organization that has a very good planning department that looks at all potential impacts of what could affect delivery of high quality drinking water[4] ▪ PWD Office of Watersheds programs[5] ▪ PWD's willingness to try new approaches[5] ▪ PWD Water Commissioner Howard Neukrug[5] ▪ Outstanding academic institutions in Philadelphia region[5]	▪ Philadelphia is downstream[1] ▪ Urbanization and development/stormwater management issues[1] ▪ Limited access to sections of our rivers[1] ▪ Combined Sewer Overflows (CSOs)[2] ▪ Aging infrastructure – costly to repair and replace with many pipes located under roadways[2] ▪ DRBC less environmentally-friendly lately[3] ▪ Current water protection laws are not written strongly enough – e.g., lack of legislation making pollution illegal.[3] ▪ Army Corps of Engineers do not capture climate change in their analyses of projects and therefore their outcomes are skewed and fail to consider a future climate-changed situation in our region.[3] ▪ Deepening the Port of Philadelphia will threaten Delaware River's natural ecosystem.[3] ▪ Aged infrastructure makes it difficult to depend on water that is delivered through pipes that are 80 to 100 years old.[4] ▪ Old infrastructure[5] ▪ Bureaucracy in agencies[5] ▪ Economy – less revenue for public projects[5] ▪ Current Pennsylvania government's approaches and new programs[5]
Opportunities	**Threats**
▪ PWD's "Green City, Clean Waters" plan[1] ▪ Convergence of multiple interests to take advantage and appreciate our rivers: riverfront planning with public use in mind; partner projects such as The Schuylkill Project; planned greenways/bike trails; public desire to get on the river[1] ▪ Interest in emerging issue regarding the protection of drinking water quality[1] ▪ Stronger legislation and regulation[3] ▪ Public officials willing to say "no"[3] ▪ Citizen activity to direct governments to stop development near watersheds and waterways[3] ▪ Move homeowners living near rivers to restore flood plains[3] ▪ USGS Water Smart Program piloting Delaware River for watershed study[5] ▪ Existing coordination of agencies and partners through PDE, DRBC, DVRPC, etc.[5] ▪ Recognition by some that we need to act through adaptive management and not by following previous play books[5]	▪ Reliance on regulations to protect drinking water quality/political influence, e.g., Marcellus Shale drilling[1] ▪ Economy/impacts to ratepayers on stepped-up schedule for improvements[1] ▪ Limited state and other funding available to leverage projects[1] ▪ Intake water quality – NYC and NJ usage could impact Philadelphia's water[2] ▪ Low-level toxins (i.e., pharmaceuticals) not regulated adequately by federal government[2] ▪ Perception that Philadelphia tap water is not clean – if enough residents use bottled water, then could lead to decrease in drinking water standards[2] ▪ Commercial and residential development along rivers and in watersheds – loss of vegetation and other natural buffers and destruction of flood plain soil diminishes water quality for downstream users[3] ▪ Sea-level rise – bigger risk for Delaware River than other waterways and increased flooding exposures[3] ▪ Pollution – Discharge of toxins is a big and growing problem. The discharge of PCBs is one example of how even known toxins are allowed to continue to be discharged, not to mention all the new pollution discharges allowed every day.[3] ▪ Fracking (natural gas hydraulic fracturing) – gas drillers knowingly poison our environment in a way that poisons water, air, land, and communities[3] ▪ Climate – extreme drought and flood conditions could be the norm in the future[3] ▪ Impacts of climate change on water quantity – salt water could impact the water intake points and low-flow on the Schuylkill River could impact water intakes[4] ▪ Changing land use and loss of forests upstream[4] ▪ Sea-level rise – threat to Delaware River intakes[4] ▪ Changing precipitation and temperature patterns can cause droughts, floods, and changes in water quality[4] ▪ Upstream problems due to spills, terrorist attacks, or natural processes could adversely affect Philadelphia's water supply[4] ▪ Increasing micro-pollutants, endocrine disruptors, and bioaccumulatives[4]

Sources: [1]Joanne Dahme, PWD Public Affairs Manager; [2]Niva Kramek, University of Pennsylvania Researcher; [3]Maya K. van Rossum, Delaware Riverkeeper; [4] U.S. EPA Region III Representative; [5]Carol Collier, Executive Director, Delaware River Basin Commission