Sustainability in Philadelphia: Community Gardens and Their Role in Stormwater Management

Photo courtesy of Domenic Vitiello

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Abstract:

As part of a larger trend of creating more sustainable cities by assessing their triple bottom line, this paper examines the role of community gardens in managing stormwater runoff using the case study of the City of Philadelphia. This paper first defines sustainability and the importance of addressing water management systems and food management systems when addressing sustainability. It then provides background information about both community gardens and stormwater management within the City of Philadelphia. Because the current literature does not discuss the potential for community gardens to assist in stormwater management, I pose the question that my research answers: to what extent do community gardens in Philadelphia mitigate stormwater runoff?

After describing the method by which I answer this question, this study finds that alternative uses of land have rates of water runoff that are 1.2 to 4.9 times higher than that of community garden-occupied land; gardens are therefore useful in reducing combined sewer overflows. Before describing the effects of this outcome on the environmental aspect of sustainability throughout the entire city, my research assesses the triple bottom line at the local level at two gardens: Mill Creek Farm and Brown Street Garden. This paper concludes that because of their social, economic, and environmental benefits, the latter being the focus of this study, community gardens are a successful means for achieving sustainable development within the city of Philadelphia.

Table of Contents

1. Preface…………………………………………………………. 4
2. Introduction……………………………………………………. 5
3. Community Gardens: Background ………………………………. 11
4. Stormwater Management: Background…………………………. 17
5. Stormwater Management and Community Gardens……………. 25
6. Methodology…………………………………………………….. 27
    a. Community Garden Data………………………………… 27
    b. Measuring Stormwater Runoff…………………………… 29
        i. "C" the Runoff Coefficient
        ii. "I" the Rainfall Intensity
        iii. "A" the Drainage Area
    c. Applying the Rational Method…………………………….. 33
        i. Vacant Land
        ii. Community Gardens
        iii. New Developments
7. Data……………………………………………………………….. 37
8. Discussion/Analysis…………………………………………….. 41
    a. Micro-level Decisions: Case Study of Mill Creek Farm and Brown Street Garden………………………………….. 41
    b. Macro-level Decisions: Sustainability in Philadelphia……. 47
9. Conclusion………………………………………………………. 49
10. Bibliography……………………………………………………. 52

1. Preface

This research stems from a project on which I worked this past summer related to community gardens and the role they play in food security in the City of Philadelphia. I originally became involved in the project because of my interest in the environment, and I wanted to see if community gardens were a viable means of reducing the distance food travels and the chemicals normally used to grow this food. At the end of this study though, many vital questions about the role community gardens play in environmental sustainability remained unclear. The data we had gathered about organic gardening was inconclusive, and calculating food miles seemed a daunting task. I began to look for alternative environmental problems that community gardens were also addressing. Finally, after many talks with some of my coworkers, I decided that one of the most vital environmental issues left unaddressed was the issue of stormwater management. Thus, my project was born.

Before delving into the rest of the paper, I would like to thank first and foremost Michael Nairn. In addition to guiding me through the process of writing my paper, and ensuring that I met deadlines, he also allowed me to contact many key government officials. Without him, this research would not have been possible. I would also like to thank Domenic Vitiello and Sarah Zuckerman, who along with Michael worked alongside me this summer to gather and discuss data we collected. In the early stages of my project, Domenic also helped define and refine my project idea. Finally, I would like to thank all of the classmates in my Senior Seminar Group and Elaine Simon who provided valuable feedback on drafts of my paper throughout the past semester.

Once again, thank you to everyone who helped me develop and write this paper. I hope the outcome of this paper matches my gratitude.

Kevin Levy

2. Introduction

In 1987, a report from the World Commission on Environment and Development, also known as the Brundtland Commission, defined sustainable development as "'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'" (Novotny and Brown xvi). However, the report did not outline specific methods by which people could implement sustainable development practices. Especially in developed nations that face the constraint of an already existent built environment, how can sustainable development take place?

One criterion for evaluating sustainable development is through the use of the triple bottom line. This approach believes in "delivering bottom line environmental, economic, and social returns…from every institution and agency in our society" (Brown, Paul R. 3). According to this philosophy then, even the most technical infrastructure must not only prove economically viable, but must also provide some additional benefits to the people living in society and to the environment as a whole. Such a solution must take into account the variety of urban problems that modern cities face: large populations requiring food and producing waste, global climate change, and an increase in the amount of impervious surfaces that both retain heat and increase water runoff (Novotny and Brown 2007). It would seem logical, then, to begin addressing these challenges cities face by addressing an inherent trait of cities: their infrastructure.

Traditionally, this infrastructure has included streets, roads, and even power lines. However, equally important parts of this infrastructure are the water management systems and food delivery systems that serve cities. Recently, these systems have been strained. The World Water Council believes that “the water to produce food for human consumption, industrial processes and all the other uses is becoming scarce” due to an increased competition for water’s uses, a rising urban population, and changing cultural lifestyles (World Water Council 2008). The absence of such water supplies means that cities will be faced with “the threat of fire, disease, social unrest, and material impoverishment” (Gandy 22). Furthermore, factors such as urbanization, population growth, rising fuel prices, and global warming have contributed to an insecurity in global food security. Not only has “world grain production…fallen short of consumption in seven of the last eight years” (Brown, L. 176), but also, as a result of the high cost of food that a lack of supply creates, people who face the risk of starvation have begun to riot (Dyer 2007). Thus, while both systems are critical to life, both systems face problems whose consequences are tremendous. While the United States and other developed countries have been able to handle many of these problems associated with water management and food distribution, at least temporarily, through a complex system of distribution and management, the consequences of leaving such issues unaddressed are antithetical to the idea of sustainable development.

Understanding how to address these two problems requires an understanding of the relationship between water management systems and food distribution systems. To understand the current state of water management systems, it is important to investigate the history of these systems. In the first stage of water management in early cities, people relied on surface water such as streams and rivers for sewage removal. With the growth of cities, people began relying on engineering to divert sewage out of cities. Many times this new infrastructure relied on combined sewer systems to carry sewage away with stormwater in underground pipes.[1] At the third stage in the 20th Century, cities began to build infrastructure that would treat water from point sources to remove pollutants or kill harmful bacteria. In the fourth stage, also in the 20th Century, cities began to treat water from non-point sources, such as dispersed roadways, to further reduce pollution in water. Only recently, in the 21st Century, have cities begun to adopt a new "fifth paradigm" that "adopts a holistic, systems approach to the urban watershed, rather than a functionally discrete focus on individual components (drinking water, sewage, stormwater) characteristic of earlier models" (Novotny and Brown xvii). Cities have just begun to understand that the water-dependent waste removal systems they use are inefficient because they "require[] tones of water to move what becomes very dilute waste," and the addition of chemicals for treating such water diminishes the quality of the effluent[2] (Speers 24). Cities have begun to recognize that "distributed [sewer-management] systems may offer better services" than the traditional, expensive infrastructure that carries water and sewage into and out of cities (Marsalek et al. 341). As the costly infrastructure they once built deteriorates, they have the opportunity to redevelop the water-management infrastructure of cities in a sustainable, decentralized way.

While experts have debated many different approaches for managing stormwater in such a way, perhaps one of the most promising has been the suggestion to use some type of garden to absorb water before it enters into the traditional infrastructure. Doing so appeals both politically and economically to many because it requires relatively low capital input, and relatively low governmental oversight, further reducing costs (Marsalek et al. 350-351). Despite claims that this very decentralization will give large amounts of

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[1] Because this point is particularly germane to my research, I will return to this point later in this paper.
[2] Effluent is the fluid that is released back into the natural environment after treatment.

responsibility to "unqualified personnel," resulting in system failure and larger health impacts (Marsalek et al. 350), such a proposal deserves a more thorough analysis before being either accepted or dismissed. More research is required to see if using gardens and other green spaces as an effective means for managing urban stormwater is in fact environmentally sustainable. Does this proposed, decentralized system provide environmental, economic and social benefits without compromising the needs of future generations?

Much research has already supported the fact that gardens do in fact provide economic and social benefits, two of three pillars of sustainability. Many studies have documented their ability to improve neighborhoods' home property values (Wachter 19, Been and Voicu), build social capital (Glover, Kingsley and Townsend, Warman 7), and provide local, healthy food to urban citizens (Blair et al., Bellows, Kate Brown) who may not otherwise be able to afford food. Most recently, I have helped in a study that documents community gardens' role in food security (Vitiello et al. forthcoming).

In fact, people in cities around the world are increasingly realizing that decentralized, regional food systems that urban agriculture can help create can have positive impacts not only on people but also on the environment. As part of Lester Brown's proposal for more sustainable cities, he cites urban agriculture and local farmers' markets within Tanzania, Vietnam, Venezuela, and India as a means for reducing the fuel used in transporting food while addressing issues of poverty and food insecurity (Brown, L. 205-207). Likewise, within the United States, local, organic food production "eliminates the use of fossil fuel-based pesticides and fertilizers, limits the need for long-distance transportation, and typically requires much less processing, packaging, and refrigeration" (Vitello 254). While community gardens may "not be a panacea or a quick-fix" (Nairn and Vitiello 8), they do provide benefits to the community, not the least of which are the larger environmental benefits. Thus, just as the "fifth paradigm" of water management provides the opportunity for a more holistic approach to water management, so too do community gardens allow people in cities to address several issues simultaneously.

However, the environmental benefits, the third pillar of sustainability, at this point are merely presumed and uncalculated. People have only assumed that locally grown food reduces fuel consumption in the transportation process; though some have begun to quantify and include this concept in carbon footprints, generally speaking, they have not calculated the amount of energy saved. Likewise, while community gardens' positive "green" and environmental impacts have been acknowledged, there are currently no studies on the specific impacts that these gardens make on the environment, particularly stormwater management, within cities. However, as cities around the country begin to integrate environmental management policies with "green" practices, these environmental impacts become increasingly important. Because of the problem in all cities of large amounts of impermeable ground cover, the issue of stormwater management is of particular environmental importance to cities.

To assess more fully the environmental benefits of using these community gardens as a means of decentralizing stormwater management and developing more sustainable cities, I hope to investigate their importance in the City of Philadelphia. More specifically, I aim to answer the question: to what extent do community gardens in Philadelphia mitigate stormwater runoff? In doing so, I will be addressing a broader question of how cities can become sustainable by providing holistic solutions to economic, social, and environmental problems. Thus, this paper is an analysis of one tool that city governments have at their disposal for creating more sustainable cities. Before describing the process by which I aim to achieve this answer, and describing and analyzing the results of this research, I provide, as background, information about the history of community gardens, stormwater management, and their recent relationship within the City of Philadelphia.

3. Community Gardens: Background

Until very recently, planners both nationally and in Philadelphia have always viewed community gardens as temporary installments, and have subsequently paid little attention to them as long-range solutions to urban problems (Lawson 151). Having their roots in the depression of 1893-1897, community gardens began as a way for cities to help the poor. In Philadelphia, the organization responsible for distributing land and helping people farm was known as the Philadelphia Vacant Lot Cultivation Association (Goldstein 1997). As the depression waned, people began to see community gardens not as a means for overcoming poverty, but as an extracurricular activity for students to encourage a strong work ethic (Lawson 155). Thus at this point, gardens were popular only within a small subgroup of the population. However, as World War I began, the government began to encourage community gardens by marketing them as a way to help the war effort; by producing their own food, Americans would allow more food to be exported to Europe (Lawson 158). Widespread use of community gardens continued through the Great Depression as a means of subsistence for individuals, but returned to serving more social and economic purposes during World War II when Americans used community gardens, then called “Victory Gardens,” as a way of decreasing demand for food to support the war effort (Lawson 160-162).

World War II-era posters celebrating community gardens, then known as "victory gardens." These posters emphasize the social and economic benefits of growing food by highlighting their importance to the war effort. (Vitiello and Nairn).

After the war, community gardens fell out of vogue as the patriotism and hype surrounding them fell and settlement patterns changed. Nevertheless, they experienced a resurgence in the 1970s and 1980s as a way to build community in cities that were losing or had lost population due to the white flight and suburbanization of the population during the 1950s through the 1970s (Vitello and Nairn). Throughout the country in the

1990s, with a robust economy, many affluent citizens took up gardening within cities for recreational purposes as well as for the health benefits that fruits and vegetables provide (Nairn and Vitiello). Though perhaps different throughout the rest of the country, in Philadelphia, after this economic boom, in the early 2000s, due to Philadelphia's growing real estate market, many community gardens closed down. While the City of Philadelphia acquired some of this land through its Neighborhood Transformation Initiative (NTI) in order to redevelop the land, individuals or companies used some of the land for private development as neighborhoods changed and became more affluent. In other circumstances, many of these gardens were simply abandoned as people left the city or as their circumstances changed (Nairn and Vitiello). Nevertheless, in Philadelphia, and throughout the country as a whole, gardens in the past have been a tool used to support larger social missions or individual needs.

Most recently, as noted earlier, researchers have documented these benefits of community gardens within their communities and within the City of Philadelphia as a whole. Many studies have documented their ability to improve neighborhoods' home property values (Wachter 19, Been and Voicu), build social capital (Glover, Kingsley and Townsend, Warman 7), and provide local, healthy food to urban citizens (Blair et al., Bellows et al.).[3] Organizations now see community gardens as a way to manage the 30,900 vacant lots within the city and thus reduce the burden of the city to clean and maintain these lots (Pennsylvania Horticultural Society "Managing Vacant Land…", Foreward).

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[3] Some examples: Wachter notes an "immediate 64% rise and a longer run rise of 30% in price to the neighbors of vacant lots" that were later "cleaned and greened." Warman notes that "through the simple act of gardening people form alliances." Finally, Bellows et al. note that "gardeners report that they increase their fresh produce consumption because the same foods they grow are not…accessible to them…"

In fact, many people within the city now see community gardens as a way to manage vacant land *and* develop a "greener," more environmentally-friendly city. In 2005-2006, a competition entitled Urban Voids challenged designers to create "compelling ideas for Philadelphia's vacant land and imagine fantastic long-term solutions" for the "crisis of vacancy." Most of the finalists in this competition included environmental sustainability as their cornerstone. One proposal, entitled Farmadelphia, recommended using vacant lots for agriculture. Another suggested allowing formerly buried urban streams to reappear above ground to take advantage of "bioremediation processes" that can clean water and land (Urban Voids). Thus, designers have begun to combine gardening, water management, and environmental sustainability into visions for the future of Philadelphia.

However, using gardening as a means for creating an environmentally sustainable city has gone beyond theory. The Pennsylvania Horticultural Society (PHS) launched its "The Green City Strategy," which "promotes the enhancement of community gardens…" among other things to revitalize the city both socially and economically. In 2003, the city's NTI program, the main program responsible for revitalizing neighborhoods in Philadelphia, adopted the Green City Strategy, and granted a $4 million contract to PHS to begin its implementation (Pennsylvania Horticultural Society *Launching the Green City Strategy)*. While PHS has been working to "green" the city by protecting open lands and community gardens, and planting more trees through a PHS program called Philadelphia Green for over 30 years now, the cooperation between PHS and the city reflects the growing importance of "green," sustainable initiatives within the city.

Furthermore, the Philadelphia Water Department (PWD) has recently supported two urban farms as pilot projects to realize the potential of urban agriculture to mitigate stormwater runoff. The first, Somerton Tanks Farm, operated by the Institute for Innovations in Local Farming, began in 2003, sells its food to caterers, restaurants, and other citizens through farm stands, farmers markets, and other buying clubs. It "demonstrates that stormwater management can take profitable forms" (Vitiello 270). The second, Mill Creek Farm, a non-profit farm which sells its produce to co-ops and through its own farm stand began in 2005 "as a stormwater management project supported by the PWD." This farm is situated in an area of the city that has had to deal with subsidence and home damage due to a buried stream (Vitiello 271-272, Spirn 398). Even though these are not technically community gardens because of the fact that they sell their produce (The definition of community gardens that this paper uses is in the "Methodology" section), and even though Somerton Tanks Farm has since closed, and housing development threatens to remove Mill Creek Farm from the land (Nairn and Vitiello) each farm reflects people's commitment and belief in gardening as a means for promoting environmental sustainability.

In light of the problems that these two farms have faced, research that produces evidence of the ability of gardens or farms to reduce stormwater runoff becomes increasingly important; the value or lack thereof of gardens must be assessed before the city can make informed decisions about which vacant lands to develop and which to use for stormwater mitigation. Such a decision then directly dictates the extent to which Philadelphia will develop in a sustainable manner. However, before evaluating the ability of gardens to reduce stormwater runoff, we must first understand the history and importance of stormwater runoff mitigation within the City of Philadelphia.

4. Stormwater Management: Background

In order to maintain a sustainable lifestyle within cities, stormwater management practices in Philadelphia have developed over time to protect surface water from pollutants that stormwater normally carries after hitting the ground. Newer cities generally rely on separate systems for managing stormwater (ie rainfall) and wastewater (ie sewage). Thus, stormwater runoff drains directly into receiving bodies while wastewater is first piped to treatment stations before being returned to receiving waters. Older cities including Philadelphia built systems in the 19th and early 20th century using systems called combined sewers, which channeled both stormwater and wastewater in the same pipes directly to receiving waters (eg rivers and streams). Generally, cities laid these pipes in natural stream courses and then filled with material such as coal ash or other available material before building houses and other structures on top. These pipes provided easily accessible ways for cities to remove sewage and protect the public health (PWD *History*). Contrary to the natural environmental system where plants and soils filter out pollutants from water before returning water to receiving waters, in combined sewer systems, water was not filtered and thus concentrated many of the city’s pollutants and sewage at discharge points in receiving waters. Thus, the protection of public health came at the expense of the environment, as the formerly “green” environment was replaced by “grey” infrastructure. The extent to which these combined sewers replaced streams and therefore bypassed “green” infrastructure in Philadelphia is shown in Figure 1.

Figure 1(a)

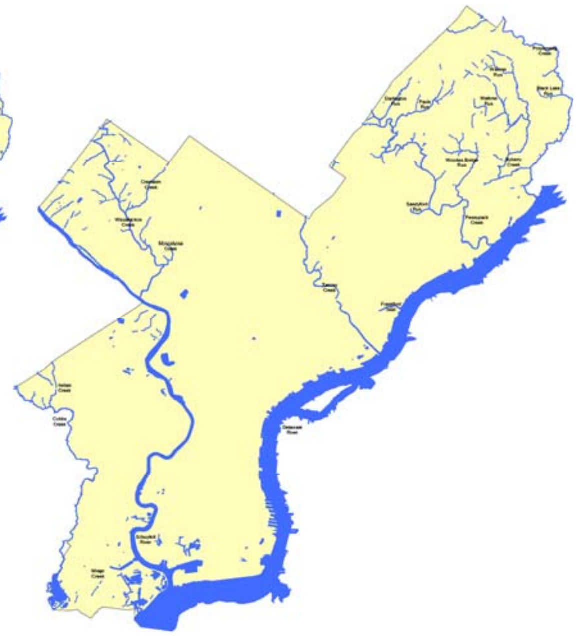

Figure 1(b)

Figure 1. This time series shows the extent to which streams in Philadelphia have been put underground. The blue lines represent the streams and rivers that were or are above ground. Notice that the purple lines in Figure 1(a) show the combined sewers by 1940 that were built in the 19th and 20th century to use streams to carry sewage and stormwater directly into the rivers. Figure 1(b) shows the current streams and rivers that are above ground as of 2004 (PWD *History*).

However, in the 1970s, the Environmental Protection Agency (EPA) began to realize that these types of sewer systems made the receiving waterways in which many people swam, fished, and drank into virtual cesspools. Their wastewater management practices were unsustainable. To combat this problem, Congress enacted the Clean Water

Act, which “establishe[d] the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters” (EPA *Summary of Clean Water Act*). Likewise, beginning in the 1930s, Pennsylvania passed and amended several versions of the Pennsylvania Clean Streams Law to “preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation” (Pennsylvania Clean Streams Law).

To accomplish these mandated goals, Philadelphia in particular created “interceptor” sewers, which catch the outflow from combined sewers, and send this liquid to a water treatment facility where harmful bacteria and pollutants are removed, and the clean water is released into the waterways. However, problems occur during heavy storm events. In these situations, the capacity of the combined sewers is exceeded so that they either overflow or the treatment facility is overwhelmed and cannot handle all of the liquid from the interceptor (Cammarata). To prevent this mixture from backing up into houses or onto streets, this mixture is diverted to a combined sewer overflow outfall during heavy rains and is discharged directly into the receiving waters (Asher 174). There are more than 70 CSO outfalls along the Delaware and Schuylkill rivers as well as others along Cobbs, Tacony, Frankford, and Pennypack creeks (see figure 2) (Cammarata).

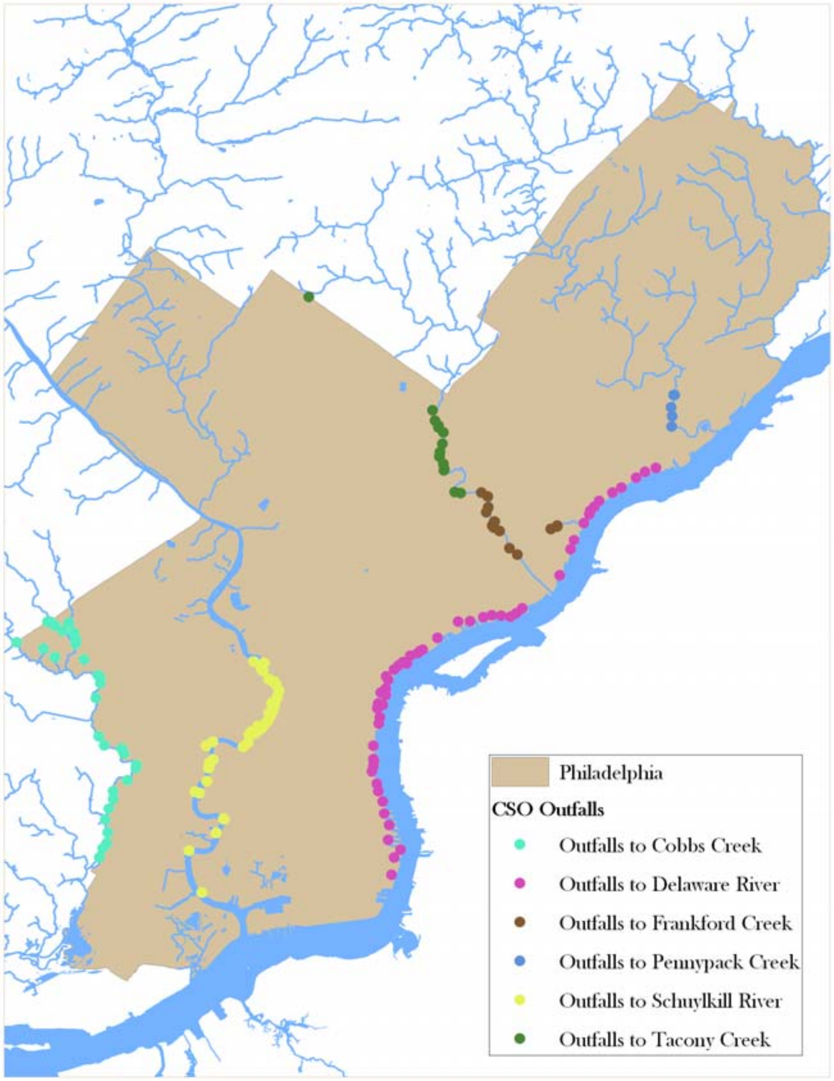

Figure 2. CSO outfall locations in Philadelphia. Each colored dot represents a location for a CSO outfall. At each outfall, a host of environmental issues can arise including eutrophication increased Biological Oxygen Demand, and streambank erosion. Allowing such outfalls decreases water quality downstream. There are more than 70 outfalls in the City of Philadelphia (PWD *Maps*).

Thus, CSOs become an environmental concern, as more nutrients can lead to eutrophication[4] and increased Biological Oxygen Demand (BOD).[5] Increased water outflow can lead to streambank erosion, as well as threaten drinking water supplies of municipalities located downstream. It can also lead to general lifestyle concerns, as people who enjoy fishing, swimming, and other water activities can no longer use the water. The problems caused by CSOs have reduced the ability for both current and future generations to meet their needs; CSOs are unsustainable.

To address these problems, Philadelphia passed new stormwater regulations that recognized that “improperly managed storm water” carries pollutants into river systems and increases the velocity of runoff which have the effects of “degrading water quality” and may “increase the incidence and severity of flooding” respectively. Furthermore, the legislation recognized that “[e]ighty to ninety-five percent of the total annual loading of most storm water pollutants that discharge into receiving waters are concentrated in the runoff created by the first one inch of rainfall, and carried off-site in the first one-half inch of runoff” (City of Philadelphia, §14-1603.1). Thus to mitigate these problems, these new codes regulate development and redevelopment that impact 15,000 square feet or more of surface area, or alter storm water management facilities (City of Philadelphia, §14-1601.1(4)(a)) in part by requiring that 2-year and 100-year storm events are managed

[4] According to the United States Department of the Interior, eutrophication “is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth…This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die. Nutrients can come from many sources, such as fertilizers…deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges” (United States Department of the Interior).

[5] Biological Oxygen Demand (BOD) is a qualitative measure of dissolved oxygen in receiving waters available for biological life.

appropriately.[6] Furthermore, after new developments are constructed “storm sewers must be able to convey post-development runoff from a 10-year storm without surcharging inlets” (City of Philadelphia, §14-1603.1(6)(c)(.4)).

Thus, two standards are developed for mitigating stormwater runoff: one that requires mitigation of 2-year and 100-year storm events, and one that requires mitigation of 10-year storm events. The 2-year storm events are storms that have a probability of occurring once every 2 years, or more accurately, a 50% chance of happening in any given year. The 100-year storm has a probably of occurring once every 100 years, or more accurately, a 1% chance of happening in any given year (Weiler, 25). Note that the Code only specifies the frequency with which storms occur, and not the duration of these storms (ie how long these storms last).[7]

To further address the problems of CSOs on both a large and small scale, The EPA mandated that Philadelphia, through its Water Department (PWD), develop a Combined Sewer Overflow Long Term Control Plan (CSOLTCP). This plan’s primary goal is to reduce the rate at which stormwater enters the “grey” infrastructure of combined sewers. As part of the CSOLTCP, the Philadelphia Water Department (PWD), the department in charge of managing drinking water, stormwater, wastewater, and water quality, has developed stormwater management techniques that operate on three levels:

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[6] The Philadelphia City Code requires “the maximum rate of storm water runoff [to] be no greater after earthmoving or development than prior to earthmoving or development activities. The determination of the maximum rate of storm water runoff shall be obtained from statistical analyses of historical rainfall data and/or the application of hydraulic methodology generally accepted as good engineering practice. Storm events ranging from the 2 year through the 100 year storm-frequency-duration shall be attenuated. Design of retention facilities shall also accommodate the storage volume necessary to contain first flush runoff as required by subsection (6)(c)(.5) (City of Philadelphia, §14-1603.1(6)(a)(.1)). Furthermore, Subsection (6)(c)(.5) requires that: The proposed storm water management system shall be designed with a minimum storage volume equivalent to the first flush of runoff [which] contains the majority of the pollutants. Treatment volume shall be based on the first inch of runoff generated from the development or earthmoving project…(City of Philadelphia, §14-1603.1(6)(c)(.5))

[7] While I will describe my exact methodology later, I choose to use the 2- and 100-yr storm events because it provides a greater variation in the type of storms studied.

water, infrastructure, and land. Of particular interest to this paper, is the focus on land-based water management techniques. These management techniques focus on "Low Impact Development (LID) and other structural and non-structural controls to reduce CSO volume…" Unlike past practices based on traditional civil engineering standards, "[t]he goal of [the] LID program…is to keep stormwater runoff out of our sewer systems" by promoting "green, attractive measures to manage stormwater" on public and private land to "reduce demands on sewer infrastructure" (PWD, *Our Land-Based Program*). Community gardens fit into these "green" measures because they fill formerly vacant lots with more foliage that can absorb water, and they provide highly porous soil through which water can infiltrate into natural underground aquifers. Thus, PWD has committed to the "fifth paradigm" of sustainable development of the stormwater management system.

As with all three of their management techniques, PWD developed three general planning and implementation targets for their land-based water management techniques named Target A, B, and C. The last target, Target C, is meant to address wet weather and flooding issues by "reducing wet-weather pollutant loads and stormwater flows" (Maimone et al., 304). Thus, PWD has emphasized the need to reduce stormwater flows into the sewers because of the negative impacts that such runoff can have on public health and the general environment. Many times, these impacts can be felt for generations.

Despite the advances in stormwater management regulations and techniques in Philadelphia and around the country, CSOs remain a large problem for older urban cities. Current management techniques focus on integrating "green" and "grey"stormwater management to reduce two aspects of stormwater runoff: the pollutant load and the rate of runoff. These techniques and the focus of these techniques have important implications for assessing the extent to which green spaces, specifically community gardens, have on mitigating stormwater runoff and creating more sustainable cities.

5. Stormwater Management and Community Gardens

Because community gardens are porous, they offer a change from the impervious surfaces that dominate cities in the form of roads, parking lots, and buildings. Gardens' naturally pervious surface allows water to infiltrate the ground, recharge the ground water, and reduce stormwater runoff. In fact, recent stormwater efforts in United States' cities such as Chicago, Washington DC and others have highlighted other "green" areas such as biofiltration rain gardens, natural landscaping, "green roofs," and other permeable surfaces as integral to the development of stormwater management in the future (Lanyon 14; NRDC 6). As noted earlier, the Philadelphia Water Department has begun to realize this potential of "green" spaces as well. However, because these PWD programs are relatively new, most assessments of programs such as the LID program are based on models provided by EPA or PWD. Likewise, most of the emphasis has been focused only on assessing the ability of LID to reduce runoff rates and pollutants on large, new developments (Maimone 314). Because these "green" techniques are so new, no one has done extensive studies about their impacts.

Thus, the current literature suggests that assessment of LID and other "green" initiatives are needed to assess the effectiveness of some of PWD's water management strategies. Furthermore, this literature suggests that the most problematic concerns for PWD are water pollutants and runoff rates. While ideally, this study would address both of these concerns, it is only feasible within this study to focus on the latter concern: runoff rates.

Even after determining community gardens' abilities to reduce runoff rates though, to fully analyze the effectiveness of such gardens, their contributions must be measured against other land uses to determine the *relative* ability to reduce runoff rates. In keeping with this idea, My project will compare the rate at which stormwater runs off of the total land area in the city occupied by community gardens to the rate at which stormwater runs off of a similar amount of land that is either vacant or converted to new housing development. My project will discuss some of the implications of this data by looking specifically at two adjacent gardens, Brown Street Garden and Mill Creek Farm, and qualitatively weighing the triple bottom line factors (economic, social, and environmental) that go into determining whether or not this land should be developed. While technically Mill Creek farm is not a community garden as defined by Vitiello et al., it possesses many of the same environmental benefits that community gardens do, and because it faces development pressures, it becomes an interesting study with potential impacts on public policy decisions. Finally, my analysis will attempt to reconnect the role of community gardens as a stormwater mitigation technique back to environmental sustainability.

In the following section, I will outline both the process by which I will assess the overall impact that community gardens have on mitigating stormwater runoff throughout the entire city, and compare such an impact to the water runoff that would be generated if the land were used for either housing developments or vacant land. In doing so, we will be able to answer the question “to what extent do community gardens in Philadelphia mitigate stormwater runoff?”

5. Methodology

In answering this question, I first needed to obtain data about community gardens, then I needed to determine a framework by which to measure stormwater runoff, and finally I needed to combine this information into a process by which I could eventually analyze my data. It is this process that I outline in the sections below:

Community Garden Data

This past summer, a team of other researchers and I developed and completed a survey of all of the community gardens within the City of Philadelphia. We defined a "community garden" as a food-producing garden whose gardeners or gardener either: 1) gardened on land that was owned by a city or other governmental agency, or a not-for-profit or other community organization, or gardened on land that was owned privately but not by one or more of the gardeners; or 2) privately owned by one or more of the gardeners who distributes food to members of the surrounding community outside of his/her/their family. In both circumstances, there would be either a positive or negative interaction with the community and thus would provide the "community" aspect of the community garden. We also chose to look only at food-producing gardens because these gardens are the only ones that play a direct social benefit in providing food to people, and were thus in keeping with the original use of urban gardens (see Background section on community gardens) and with the idea of the triple bottom line (see Introduction section).

After defining our population of gardens, we developed a list of possible gardens in the City of Philadelphia. We developed this list of possible garden sites from two sources: 1) the Philadelphia Horticultural Society that keeps track of green spaces in the city, including both community gardens and other gardens that they have supported in the past; and 2) the former Urban Gardening Program of the Pennsylvania State University that was ended in the late 1990s. During the process of investigating these sites, we found several other community gardens en route. To our knowledge, our research reflects the most up-to-date information about community garden locations within the city.

At each community garden, we filled out, among other things, a survey form (see Figure 3 below).

<u>Garden Site Survey</u>

1. Name: ______________________________

2. Location:
   a. Neighborhood: ______________________________
   b. Address: ______________________________
   c. OR: Addresses of adjacent properties: ______________
      i. AND # of parcels from cross-street: ______________
      ii. AND Cross streets: ______________
   d. Side of street (N, S, E, W): ______________

3. Size, layout, & organization:
   a. Size
      i. Front: ______________ ft.
      ii. Length: ______________ ft.
   b. Number of Plots: ______________
   c. Size of one plot
      i. Length: ______________ ft.
      ii. Width: ______________ ft.
   d. Apparent level of use - % of plots:
      i. Well-used/maintained: ________
      ii. Some maintenance: ________
      iii. Unused/vacant: ________
   e. Posted rule on organic: Y [ ] N [ ]
      i. No posted rules: [ ]
   f. Water
      i. City water source/hoses [ ]
      ii. Barrels/collection systems [ ]
      iii. No apparent water source [ ]
   g. Evidence of support organizations (checklist – PHS, PSU, UTC, others?):
   ____

4. Trees:
   a. Fruit & nut trees:
      i. Number of trees: ______________
      ii. Size (diameter of entire canopy): ______________ ft.
   b. Other trees (not fruit-bearing):
      i. Number of trees: ______________

Figure 3. Community Garden Survey Form. Of particular importance to this paper is Section 3 "Size, layout, & organization" of the gardens.

Of particular importance is the data under Section 3: Size, layout & organization. This data provides information about the amount of ground cover for the entire garden ("Size" as measured by the "front" and "length"). This data was collected for each garden. Data was then aggregated to find the total amount of land used for gardens within the city.

Measuring Stormwater Runoff

To develop a theoretical model for measuring stormwater runoff from gardens, I used the Rational Method. The Rational Method is a mathematical equation developed and accepted by civil engineers used to evaluate the peak rate of storm-water runoff from different surfaces. The Rational Method measures the peak flow of water off a site where the peak flow equals the area of the land, multiplied by the rainfall intensity, and a coefficient of permeability (where 1 represents completely impermeable surfaces and 0 represents entirely permeable surfaces). Rainfall intensity is a region-specific number determined by the storm frequency and time of concentration of the storm. For example, a 2-year (frequency) 24-hour (time of concentration) storm event will be a storm that has a probability of occurring once every two years and lasts for 24 hours. For each region of the country, the National Oceanic and Atmospheric Administration estimates the amount of storm-water for many rainfall intensities.

While engineers have to begun to use a different, more precise model when designing specific systems (PWD, *Stormwater Management Guidance Manual*) I chose to use this model because I am comparing the relative runoff rates. In comparing relative runoff rates, any peculiarities that make the Rational Method too imprecise for engineering standards, particularly sizing drainage pipes, will not only be small, but will also be the same across all tests, and thus acceptable for my purposes. For these reasons, and because the Rational Method is easier to use, I preferred to use the Rational Method.

Below is a summary of the Rational Method:

$$Q=CIA$$

Q= Peak runoff rate (cubic feet/second)

C= Runoff coefficient (0 is completely pervious, 1 is completely impervious)

I= Rainfall intensity (inches/hour)

A= Area of the drainage area (acres)

Thus, to determine peak runoff rates from any piece of land, three variables must be defined: a runoff coefficient, rainfall intensity, and the area of the land. Defining these three variables within the context of my study is where we must next direct our attention.

“C” the Runoff Coefficient

The runoff coefficient is a value that denotes how permeable different surfaces are. As noted above, a value of 0 indicates that the surface is completely pervious, and has no peak runoff; a value of 1 indicates that the surface is completely impervious, and has a peak runoff rate equal to that of the rate of rainfall. Runoff coefficients for this project were taken from McCuen and the State of North Carolina's *Stormwater BMP Manual*. A list of relevant Runoff coefficients used for this project are listed below:

Type of Soil[8]	**Runoff Coefficient (C)**
Lawns, heavy soil, flat (<2%) (Vacant Land)	.15
Inclined roof	1.00
Asphalt	.95
Cultivated Land	.08

Because vacant lands usually occur on compressed, flat, urban soil (eg after the Neighborhood Transformation Initiative bulldozed homes) and grow mostly if not solely grass, I used a definition of "Lawns" that occur on heavy, flat (less than 2% grade) soil as a proxy for vacant land runoff coefficients. I used "Inclined Roof" to describe the runoff coefficients for homes, which all had inclined roofs as opposed to the flat roofs normally associated with Philadelphia rowhomes. I used "Asphalt" to describe any sort of

[8]All coefficients come from the following source: State of North Carolina. *NCDENR Stormwater BMP Manual*. 28 September. <http://h2o.enr.state.nc.us/su/documents/BMPManual_WholeDocument_CoverRevisedDec2007.pdf>. The one exception is the coefficient for "cultivated land" which was taken from McCuen, Richard H. *Hydrologic Analysis and Design.* 3rd Edition. Pearson Prentice Hall: New Jersey, 2005. pg 378. Also important to note is that while McCuen believes the .08 coefficient value for cultivated should be .14 for storm events including and beyond the 25-year event, I have chosen to use the .08 value for the 100-yr storm event because I assume that the soil will retain its porosity.

pavement on the property, and I used cultivated land to represent any land that was used for community gardens.

"I" the Rainfall Intensity

Data for rainfall intensity is gathered by the National Oceanic and Atmospheric Administration (NOAA) and published for public use. Because all of these gardens are located in Philadelphia, I chose to use data gathered near Drexel University (National Oceanic Atmospheric Administration) since this is a central location within Philadelphia, and would thus best reflect weather patterns throughout the entire city. However, I still needed to decide what the frequency and intensity of the storm events were. To do so, I used information gathered about the type of storm events that the city was currently trying to fix. As noted in Philadelphia's city code, "Storm events ranging from the 2 year through the 100 year storm-frequency-duration shall be attenuated" by new developments (6)(c)(.5) (City of Philadelphia, §14-1603.1(6)(a)(.1)). While another stipulation stated that "storm sewers must be able to convey post-development runoff from a 10-year storm without surcharging inlets" (City of Philadelphia, §14-1603.1(6)(c)(.4)), I chose to measure the 2- and 100-year storm events because it reflected a wider probability of storm events and thus allows a more comprehensive analysis of storm events in the City of Philadelphia. Thus, the upper and lower bounds for frequency were set at 2 and 100 years. I decided to use a 24-hour duration time for rainfall because this seemed to be a common duration that I encountered at various agencies' and organizations' websites when investigating examples of using the rational method.

“A” the Drainage Area

The drainage area I used for the Rational Method calculations were taken from the garden data collected over the summer. To determine the total area that would absorb water, I multiplied the “front” and “length” of the gardens (under the category “Size” in Figure 3) to get the “Total Sq. Ft,” which represents the total area of the community garden in square feet. For gardens where inadequate data existed on the total area of the community garden, I used the information on “size of plot” and “apparent level of use (%)” to estimate the total area of the community garden by taking the product of the “length,” “width,” “# of plots,” and “apparent level of use (%)” expressed as a fraction of 100 (ie 100%=1, 90%=.9, etc.). For example, a garden with 2 plots, each with length 4 and width 6 and 100% used would have a total area of 48sq ft (2x4x6x100/100=48) I then converted the total area from square feet (sq. ft.) into acres using the proportion 1 acre=43560 sq. ft. The area (in acres) that these calculations provided, allowed me to further analyze each piece of land as described below.

Applying the Rational Method

While the above section (“A” the Drainage Area) briefly explained the process for determining the total amount of land that community gardens occupy, this process does not take into account the varying characteristics of different land uses. For example, what happens if some of the community garden land is used for a storage shed? Because each land-use has a different percentage of land dedicated to different characteristics, I needed to address such characteristics on each piece of land. The goal of this sub-section of the Methodology section is to more specifically define how I combined the garden data and

Rational Method to estimate peak runoff rates on the three different land-uses I studied: vacant land, community garden land, and developed land. Note that I give consideration only to the area (A) and coefficient (C) because the rainfall intensity (I) is independent of land use and is therefore constant across all three land-uses.

Vacant Land

Because vacant land is predominantly covered in grass, and is relatively flat, I choose to use a C value of .15 for the entire land area, and chose to use an area identical to the total land area used for community gardens (as noted in '"A" the Drainage Area' above).

Community Gardens

Because community gardens receive a large amount of care from gardeners, the ground is relatively porous. While most of the land for each community garden is under production of food, even the land that is not producing food is usually producing flowers or is covered by highly permeable layers of soil such as mulch. Furthermore, on some land that is not growing anything, the ground still remains porous because of the fact that gardeners either till the soil or because of the fact that no machines are ever compressing the soil. Thus, for 95% of the land, I chose to use a C value equal to .08 (cultivated land). The other 5% I count as impervious soil because of the fact that many gardens have storage sheds, stone pathways, and other impervious surfaces within the total area of the garden.

New Developments

Because each new development has three different characteristics (Roof area, asphalt area, and grassy/lawn area), I used C values of 1, .95, and .15 respectively for roofs, asphalt, and grass/lawn areas. To determine the land area reserved for each characteristic, I used GoogleEarth's ruler feature to measure the total area allotted for each characteristic within each property on the new development. After finding the total area of each characteristic within the given property area, I found the percentage of land used for each characteristic (area of land used for each characteristic/total land of the property). Once I found these percentages, I was able to find the total land area used for each purpose by multiplying the percentage by the total land area on which I was measuring water runoff (this value is equivalent to the total amount of land that community gardens occupy). I used this procedure for two types of new developments. The first was a Redevelopment Authority's (RDA's) new housing development on Berks and Franklin Streets. The second is a Philadelphia Housing Authority (PHA) new housing development called Lucien E. Blackwell Homes whose offices are located on Fairmount and 4th Streets. Both housing developments are two-family attached housing units.

Thus my calculations for determining the peak runoff for each land use are as follows:

$$Q_{(use)}=I_{(yr,\ 24\text{-}hr)}*((C_1*A_1)+(C_2*A_2)+\ldots(C_i*A_i))$$

Where:

$Q_{(use)}$ is the peak runoff rate for a certain land use (cu ft/sec)

$I_{(yr,\ 24\text{-}hr)}$ is the rainfall intensity (in/hr given for a certain frequency (2 or 100 years) with a 24-hour duration

C_i is the coefficient for each characteristic of land use (e.g. lawn, roof, etc.), and

A_i is the area that each characteristic occupies (acres), and where the sum of all areas should be equal to the total area that community gardens occupy

6. Data

As a result of this methodology, I generated data that represents the rate of peak runoff that comes off of the land in Philadelphia currently used for community gardens, and the hypothetical runoff rates if this land was used for other vacant land or new developments. The raw data is summarized below to give a sense of the types of calculations used for this research:

COMMUNITY GARDEN			
Total CG Area (acres)	44.6778191		
Percent Cultivated	0.95		
Percent Impervious	0.05		
Total CG Cultivated Area (acres)	42.44392815	Cultivated Coeff	0.08
Total CG Impervioius Area (Acres)	2.233890955	Impervious Coeff.	1
I (2yr, 24 hr)=	3.25		
I (100yr, 24hr)	7.72		
Q (cu ft/sec)=CI(2yr)A	18.29556692		
Q (cu ft/sec)=CI(100yr)A	43.4590082		

VACANT LAND			
I (2yr, 24hr)=	3.25		
I (100yr, 24hr)	7.72		
A=	44.6778191	Vacant Coeff	0.15
Q (cu ft/sec)=CI(2yr)A	21.78043681		
Q (cu ft/sec)=CI(100yr)A	51.73691452		

NEW DEVELOPMENT (RDA)

Percent Roof	0.375841751		
Percent Asphalt	0.187710438		
Percent Grassy	0.436447811		
Total Area (CG acres equivalent)	44.6778191		
Total Roof Area if all Devp (acres)	16.79178975	Roof Coeff	1
Total Asphalt area if all devp (acres)	8.386492979	Asphalt Coeff	0.95
Total Grassy area if all devp (acres)	19.49953637	Grass Coeff	0.15
I (2yr, 24 hr)	3.25		
I (100yr, 24 hr)	7.72		
Q (cu ft/sec)=CI(2yr)A	89.97263775		
Q (cu ft/sec)=CI(100yr)A	213.7196195		

NEW DEVELOPMENT (PHA)

Percent Roof	0.27148289		
Percent Asphalt	0.161723701		
Percent Grassy	0.566793409		
Total Area (CG acres equivalent)	44.6778191		
Total Roof Area if all Devp (acres)	12.12926344	Roof Coeff	1
Total Asphalt area if all devp (acres)	7.225462252	Asphalt Coeff	0.95
Total Grassy area if all devp (acres)	25.32309341	Grass Coeff	0.15
I (2yr, 24 hr)	3.25		
I (100yr, 24 hr)	7.72		
Q (cu ft/sec)=CI(2yr)A	74.07372891		
Q (cu ft/sec)=CI(100yr)A	175.9535961		

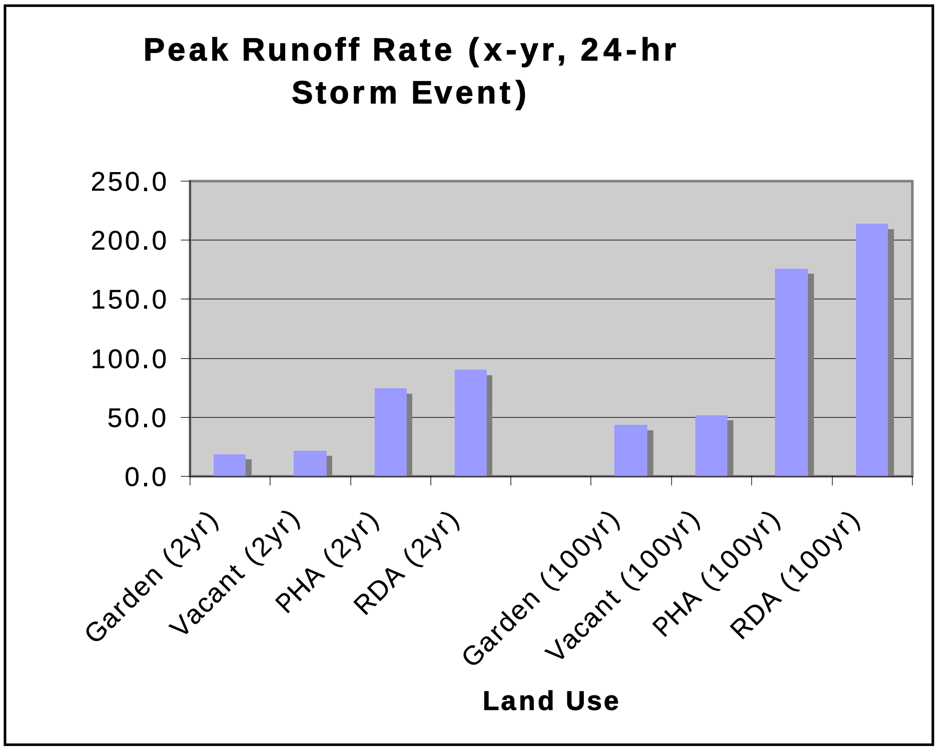
The summary of Peak Runoff Rates for each land use, organized by storm event follows:

Peak Runoff Rates

(Q=CIA)

Land Use (x-yr, 24-hr Storm Event)	**Peak Runoff Rate (cu ft/sec)**
Garden (2yr)	18.3
Vacant (2yr)	21.8
PHA (2yr)	74.1
RDA (2yr)	90.0
Garden (100yr)	43.5
Vacant (100yr)	51.7
PHA (100yr)	176.0
RDA (100yr)	213.7

Finally, a graph of this data for each land use, organized by storm event follows:



As we see from this data, gardens have the lowest peak-runoff rates; the vacant land has the next highest runoff rates (1.2x garden runoff rate). These are followed by the PHA housing development (4x garden runoff rate) and RDA Development (4.9x garden runoff rate).

7. Discussion/Analysis

As noted in the "Data" section: gardens have the lowest peak runoff rates, and the vacant land has the next highest runoff rate (1.2x garden runoff rate). These are followed by the PHA housing development (4x garden runoff rate) and RDA Development (4.9x garden runoff rate). Clearly, community gardens reduce the rate of runoff, and thereby mitigate CSOs to a certain extent. However, normative questions still exist: Should this land be used for community gardens? Should it be left vacant? Or should housing be built upon this land? This section aims to answer these questions by analyzing the data and placing it within the larger context of sustainable development that I addressed in the Introduction. To analyze these questions, I will 1) focus my discussion around two particular food-producing gardens in the city, and then 2) expand the focus of my analysis to include the entire city. In doing so, I hope to address at both the micro and macro levels the ability of community gardens to address urban problems such as stormwater management in a holistic, decentralized way.

Micro-level Decisions: Case Study of Mill Creek Farm and Brown Street Garden

Because of the decentralized manner in which this proposed solution would be implemented, understanding the circumstances surrounding the decision to use individual gardens as a means for stormwater mitigation becomes an important part of any public policy decision. The two individual gardens I have chosen to investigate are Mill Creek

Farm and Brown Street Garden. These two gardens are adjacent to each other and while Mill Creek Farm is not technically a community garden as I have defined them, it does provide many of the same attributes that community gardens provide to the neighborhood, namely, fresh produce in an area with few if any supermarkets. In addition, it also provides educational programs, and a venue for community building. Because of these similarities, Mill Creek Farm is considered by many to be a community garden. These two gardens are located at 4901 Brown Street and 4907-49 Brown Street respectively on land that is owned by the Redevelopment Authority (RDA). Together, they represent approximately 32,800 square feet (about .75 acres) of land that is used for food production. However, the Philadelphia Housing Authority (PHA) has petitioned RDA for transfer of ownership so it can develop the combined parcel for housing (Vitiello and Nairn).

Based purely on the previous stormwater mitigation evaluation, the conversion of land from cultivated land to housing, given average impervious coverage in previous RDA developments, would increase the stormwater runoff by approximately 5 times the amount of the current land use. Thus, from the standpoint of PWD and its environmental goals, developing the land would be an inefficient use. Moreover, in an area located within an older part of the city (West Philadelphia) with large numbers of combined sewers, CSO mitigation efforts are especially valuable. As one can see from Figure 4, the area around these two gardens has one of the largest discharge rates as measured by volume per year.[9] Thus, developing this land would hurt PWD's goal and would not help the current problems of CSOs.

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[9] Also, see Figure 1(a) in the Stormwater Management: Background Section for a map of the combined sewer systems.

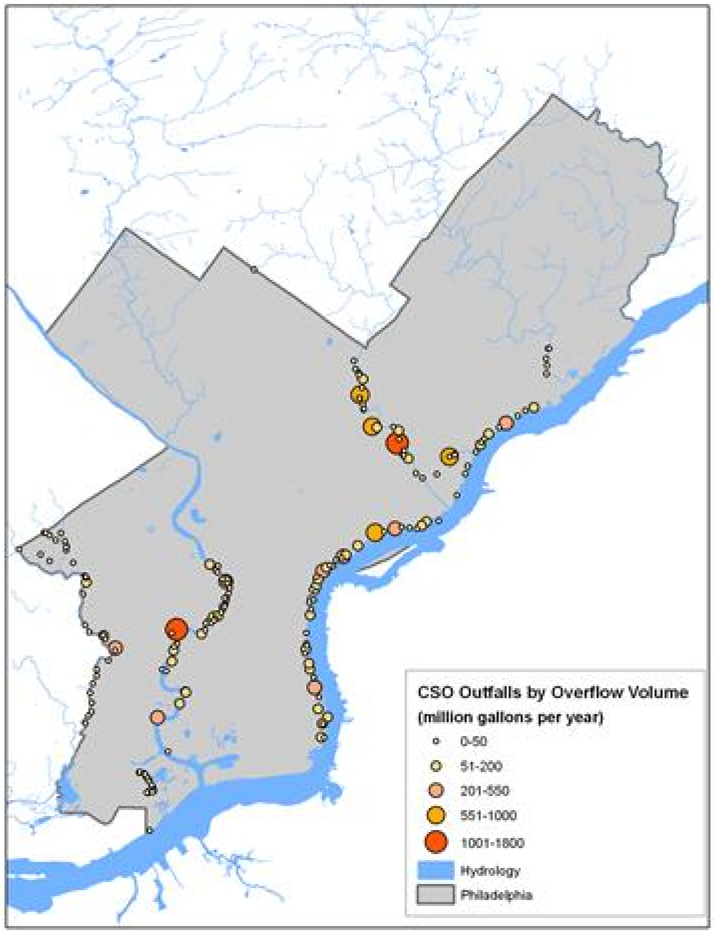

*Figure 4. This map shows the overflow volume per year at each CSO outfall location in the City of Philadelphia. The two main receiving bodies are the Delaware River (east, right) and the Schuylkill River (just left of center). Important to note is the large red dot on the Schuylkill River (one of two in the entire city), which is the discharge point associated with the runoff from Mill Creek Farm and Brown Street Garden. This dot indicates a large volume of overflow from this area (*PWD *Maps).*

However, stormwater management must be balanced according to other needs of the city and of the people living in the city. While stormwater management is important, housing needs and tax revenue are equally as valuable. Thus, the city needs to balance the costs and benefits of changing land uses. If the revenue generated from the developed land amortized into present day value were more than an expansion of the sewer system would cost, perhaps the city would be well advised to develop the land. Unfortunately, in general, the City is required to spend money to subsidize low-income housing production. A normal rowhouse costs a minimum of $130,000 to build, but normally the market value is between $35,000-$65,000 in “neighborhoods that have not experienced high appreciation and private market investment.” Thus, if the city wants to entice private development, it must subsidize the investment by about $65,000-$95,000 per home (Black 2008). In this particular neighborhood, the houses are listed for sale at $150,000 but it is unclear given the subsidy structure for homebuyers what the actual selling prices are (Nairn).[10] A web search for selling prices for homes in the surrounding area reveal selling prices for existing homes range from $55,000 to $90,000 with a high number of foreclosed properties with far lower selling prices. [11] The Neighborhood Information System at the Cartographic Modeling Laboratory of the University of Pennsylvania notes that the 2007 median selling price for homes in the neighborhood is $30,300. These values would support Black’s assertion that the city would have to subsidize the construction of homes in this neighborhood. From the purely financial perspective, then, because the continuation of the farm and garden are beneficial, but require little to no cost, while housing requires significant capital costs, the city would be well-advised to allow the garden to continue to occupy the land.

[10] The Lucien Blackwell Homes, of which this development would be a part, is a Hope VI project, a cooperative effort by Housing and Urban Development (HUD) and its local partner PHA to introduce affordable middle class housing into distressed neighborhoods.

[11] I reference here prices from <www.frontdoor.com> as of 18 Dec 2008.

Because of the high vacancy rates in the area of West Philadelphia in which Mill Creek Farm and Brown Street Garden are located (see Figure 5 on next page), there has likely been little private investment in the area, and probably little if any appreciation. Especially with the mortgage crisis, housing values are probably in decline. Moreover, even with private investment, the city is not even likely to gain significant revenue from the project if previous construction is any indication. Finally, as noted earlier, green spaces, such as gardens have even had the effect of raising property values in areas of Philadelphia .The economic benefits of replacing these gardens with new low-income housing are non-existent, if not negative.

Regardless of the social capital that community gardens are known to generate (Glover, Kingsley and Townsend, Warman 7), because the environmental and economic costs of creating such a development are so high, it would appear that the benefits of retaining this garden as a community garden would outweigh the costs of doing so. Nevertheless, this result is not generally applicable to other areas of the city since each neighborhood faces a different economic situation. Thus, in areas that have low vacancy rates, and high private investment, community gardens may not make sense.

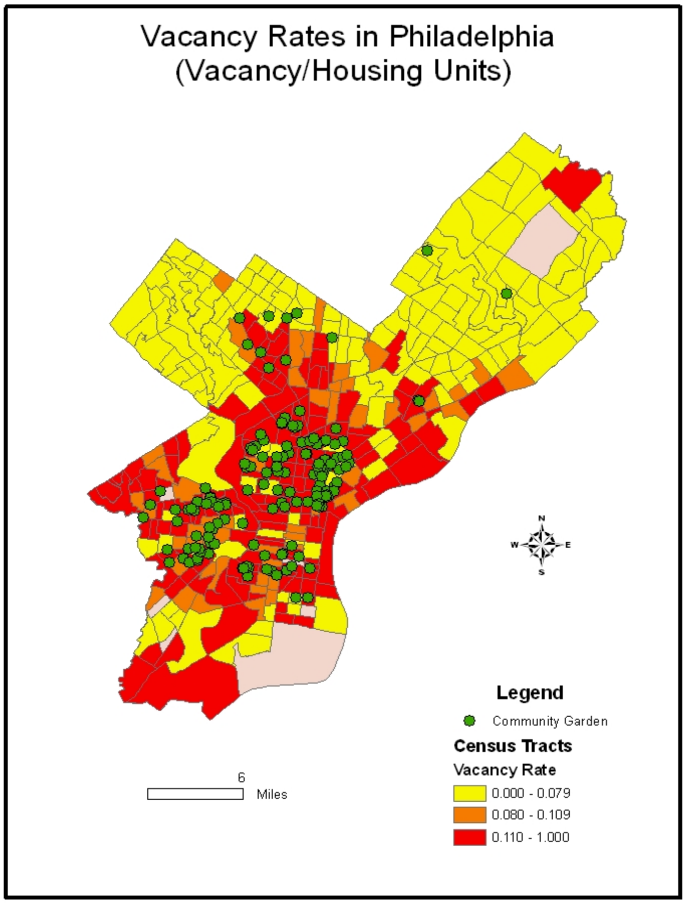

Figure 5. Vacancy Rates (Vacancy/Housing Units) and Community Gardens in the City of Philadelphia. Red areas indicate high vacancy rates, orange areas indicate medium vacancy rates, and yellow areas indicate low vacancy rates. Green dots indicate community garden locations. Note that Mill Creek Farm and Brown Street Garden are located in West Philadelphia, in the northernmost cluster of green dots. This graphic was developed using GIS with data from the 2000 US Census Data (vacancy/housing units) and from data collected this past summer during which my co-workers and I verified garden locations throughout the entire city (Levy and Zuckerman 2008*).*

Macro-level Decisions: Sustainability in Philadelphia

As noted earlier, environmental sustainability can be defined as a way to pass on high standards of living to all future generations by incorporating the three pillars of sustainability, environmental, social and economic reasoning, into every decision. In particular, stormwater management plays a large role in making a city sustainable; without stormwater management, sewage from Philadelphia runs into the rivers causing significant health and environmental impacts. Viewed in this light, community gardens provide a valuable service to the city by reducing the amount of stormwater runoff, and thus reducing the amount of pollution that enters the water system. Likewise, as noted earlier, community gardens play a valuable role in building social capital within communities (Glover, Kingsley and Townsend, Warman 7) as well as providing a valuable source of local, healthy food that acts as an income supplement for both high- and low-income individuals (Blair et al., Bellows, Brown, and Vitiello et al, forthcoming). This local sourcing is also assumed to have positive environmental impacts. Finally, researchers have shown that green spaces such as community gardens provide valuable economic benefits to the surrounding community (Wachter 19, Been and Voicu).

Thus, community gardens play an active role in the “triple bottom line” approach for developing sustainable cities. By allowing these gardens to exist in the city, Philadelphia is not only adding to its ability to manage stormwater, but also to promote a sustainable lifestyle within the city and surrounding areas. While individual gardens may have to be removed as land values increase, overall, the city should strive to maintain or even create gardens in areas of the city, especially when these areas have high vacancy rates and/or are located near combined sewers (see Figures 1(a), 4, and 5).

8. Conclusion

This paper has investigated the role that community gardens play in making the City of Philadelphia sustainable by assessing their role in one particular environmental issue: stormwater management. After defining sustainability and one measurement of sustainability, the triple bottom line, this paper examined current problems in water management and food management system that stand in the way not only of people's livelihoods, but also of sustainable cities. To understand these issues as they exist at a city level, I described the historic role that community gardens and stormwater management have played within Philadelphia, and further examined the role that community gardens play in improving the economic and social situations of communities. Finally, my research analyzed one part of the role that community gardens play in the third and final pillar of the triple bottom line, the environment, at both the neighborhood and city level.

This study has found that community gardens are a viable means for promoting the city's decentralization of stormwater management. Because they reduce water runoff anywhere between 17-80% from alternative uses (alternative uses produce 1.2-4.9 times the amount of water runoff), community gardens are one effective tool of many in managing CSOs. Moreover, as the local example of Mill Creek Farm and Brown Street Garden illustrate, these gardens in parts of the city that have high vacancy rates and low investment rates, offer one of the best uses of land when valued by the triple bottom line. At both community and citywide levels, these gardens provide the city not only with social and economic benefits, but also with some level of environmental sustainability.

Though the implication of this information would suggest that the city should build community gardens as a positive step toward sustainability, in reality, simply creating community gardens is easier said than done. They face strong competition from housing developers and commercial developers; simply creating gardens in lieu of housing would leave many people homeless, or would not capitalize on high demand, and create further problems at both the neighborhood and city levels. Moreover, they require a strong sense of community or at least a few strong community leaders to develop and maintain such gardens. Thus, public policy must take a measured approach to promoting community gardens if they hope to promote sustainability within the city. While the city should continue to build low-income housing, and other commercial developments, they should do so with regard to the community gardens that currently exist. Where at all possible such developments should be built around these gardens so that the economic value, social capital, and environmental value that these gardeners have created can be harnessed.

While community gardens are a valuable tool in the city's arsenal of methods to create a sustainable city, they are by no means a solution to all of the cities problems. This study adds only one piece of knowledge to an ongoing discussion and debate about ideas and solutions that the City of Philadelphia can pursue as it strives for sustainability. Nevertheless, to the extent that the City of Philadelphia represents other industrial cities and cities around the world, community gardens may come to play an integral role in allowing these cities to become more sustainable by managing the stormwater runoff of the cities. This "fifth paradigm" of water management in cities appears to be an effective means of creating sustainable cities. While no one is sure what sustainable cities of the future will look like, undoubtedly their built environment will address problems holistically in much the same way that community gardens achieve success through the triple bottom line.

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