10 RECOMMENDED PLAN ELEMENTS

10.1 SUMMARY OF THE ALTERNATIVES EVALUATION

This section summarizes the results of the alternatives analysis and presents the rationale for the selected alternative. The alternative evaluation process is designed to select the alternative that represents the best balance among performance, cost, affordability, sustainability, social/ environmental benefits, public support and practical factors such as constructability. The detailed cost and benefit information presented in Section 9 and the screening criteria presented in Section 5 are used to compare the alternatives. Of equal importance to these factors, however, is the opportunity that PWD's selected alternative provides to address modern challenges to managing water resources and infrastructure in a sustainable way. That supports PWD's larger goal of helping the City to recreate itself as a 21st Century Sustainable City. PWD's recommended alternative provides a clear pathway to a sustainable and resilient future while strengthening the utility, broadening its mission and complying with environmental laws and regulations.

10.1.1 Evaluating Within a Watershed Planning Context

PWD developed their concept of regional watershed management planning after recognizing that, as the downstream most entity in each of the watersheds draining to the City of Philadelphia, the necessary long-term sustainable improvements to water quality and habitat within each waterway could not be achieved cost effectively without watershed-wide stakeholder and agency support.

Watershed management fosters the coordinated implementation of programs that address and manage stormwater, while also looking to control sources of pollution, reduce polluted runoff, promote managed growth in the City and surrounding areas, protect the region's drinking water supply, and improve fishing and other recreational opportunities. This must be accomplished while addressing a multitude of overlapping regulatory requirements, including the United States Environmental Protection Agency's (US EPA's) Combined Sewer Overflow (CSO) Control Policy, Phase I and Phase II Stormwater Regulations, PA Act 167 Stormwater Management, Total Maximum Daily Loads (TMDLs), PA Act 537 Sewage Facilities Planning and drinking water source protection programs. The planning must take place within the context of a host of non-regulatory planning processes and initiatives, including existing municipal and conservation planning efforts such as River Conservation Plans, Open Space Plans, and municipal comprehensive plans. Just as important, the planning process must address stakeholder goals. Implementation of this Long Term CSO Plan Update (LTCPU) commitment is just one part of PWD's larger, watershed-based commitment.

PWD has committed to development of Integrated Watershed Management Plans (IWMPs) for each of the five major tributary streams of the Schuylkill and Delaware Rivers that drain through the City of Philadelphia, including the Cobbs, Tookany/Tacony-Frankford (TTF), Wissahickon, Pennypack and Poquessing. Most recently, PWD has committed to developing watershed-based plans for the City of Philadelphia portions of the Schuylkill and Delaware River systems as well. To date, IWMPs have been developed for the Cobbs and TTF Watersheds.

PWD's IWMP development process is based on a carefully crafted approach to meeting the challenges of watershed management in an urban setting. The primary intent of the planning process is to improve the environmental health and safe enjoyment of the watershed on a region-wide scale by sharing resources and through cooperation among residents and other stakeholders. PWD offers the residents and stakeholders a number of resources, as this multifaceted planning

approach requires a tremendous amount of coordination, characterization and planning, which the watershed stakeholders build on through the IWMP process.

The IWMPs are built upon a solid, scientific foundation composed of water quality monitoring (including both wet and dry weather samples), macroinvertebrate and fish bioassessments, physical stream surveys (fluvial geomorphology as well as streamside infrastructure) and computer modeling of stormwater flows and pollutant loading. Based on these extensive physical, chemical and biological assessments, the plans explore the nature, causes, and severity of water quality impairments in the watershed and opportunities for improvement. IWMPs present logical and affordable pathways to restore and protect the beneficial and designated uses of these urban waterways.

10.1.1.1 Environmental Implementation Targets

In an ideal world, flowing streams and rivers would remain in harmony with the surrounding environment. Streambanks would remain stable with lush, vegetative protection. Fish and benthic invertebrates (bugs) would thrive within their in-stream habitat. The floodplains surrounding the streams would be accessible, and within them one would find a mix of wetlands and mature forest cover.

Unfortunately, for the urban waterways of the Philadelphia area, streams have fallen victim to years of the effects of compounding urbanization. As populations and development have increased within and surrounding Philadelphia, so has impervious cover. This has resulted in a significant increase in stormwater runoff to be managed by existing infrastructure, ultimately making its way to these urban streams. This increase has created a "flashy" regime in these urban streams, meaning that they go from very low streamflows during dry weather to extremely high flows during rain events. This effect has ravaged the stream systems, causing erosion and scouring of streambanks such that habitat has been all but destroyed for benthic invertebrate and fish populations.

Development of watershed planning goals through the stakeholder led IWMP process resulted in the establishment of three implementation targets for watershed improvement and restoration based on consideration of ecology and human health. Targets help PWD to break the overwhelming end goal of "significantly improving watershed conditions" into three distinct measurable pieces on which PWD can consistently assess performance during the implementation period.

The targets are used to help in the evaluation of each of the alternatives under consideration.

> ***Target A:*** *Improvement of Stream Quality, Aesthetics and Recreation During "Dry" Weather.* Achievement of this target is focused on meeting water quality standards in the stream during dry weather periods, which is when PWD believes that watershed stakeholders are most likely to be recreating streamside. In a given year, this is observed close to 65% of the time. Achievement of this target would involve the elimination of dry weather discharges to the stream from outfalls as well as removal of trash and litter from the waterway, improvement of public access to the waterways, and enhancement of streamside recreational opportunities including streamside trails and open space.

Each alternative being evaluated includes management options to address dry weather water quality, aesthetics and recreation. Because all the alternatives contain similar measures to address Target A

objectives, there is no clear differentiation between alternatives based on this criterion unless the cost of wet weather controls limits PWD's ability to implement these options due to financial hardship.

> ***Target B:*** *Preservation and Enhancement of Healthy Living Resources.*
> Part of what makes a stream so valuable is its healthy aquatic environment, which results in diverse macroinvertebrate and fish populations. Implementation projects to achieve this target are aimed not only at restoration of habitat, but also measures to provide the opportunity for these organisms to seek refuge and avoid the high velocities of streamflow during storms. Achievement of this target will increase the population, health, and diversity of the benthic invertebrate and fish species within the stream.

Alternatives with green stormwater infrastructure restore a more natural water balance, including increasing the minimum groundwater fed baseflows in creeks and streams. Traditional infrastructure alternatives do not meet goals for restoration of living resources due to hydrologic alterations. The resulting lack of groundwater recharge will reduce dry weather stream baseflows needed for a healthy aquatic community. Additionally, depending on design, a tunnel or treatment system would concentrate remaining overflows at a smaller number of points than does the existing system, resulting in increased channel and bank erosion at those locations. Although it may be possible to design a stream channel to mitigate some of these effects, this lack of hydrologic variation is not conducive to a functioning stream ecosystem. Additionally, for alternatives that include dispersed treatment at consolidated outfalls along the tributary systems, the possibility of a failed dechlorination system could overwhelm the modest baseflow with chlorinated flows, resulting in a fish kill and other related environmental damage.

> ***Target C:*** *Improvement of Wet Weather Water Quality and Quantity.*
> During rainstorms a great deal of stormwater is piped to urban streams – resulting in abrupt changes in water quantity and quality. Alternatives that include green stormwater infrastructure tools will reduce the impact of these abrupt changes by managing stormwater where it hits the ground, thereby reducing the amount of stormwater that reaches the waterways.

The mixes of technologies included in all alternatives are capable of capturing and treating at least 80% of combined sewage in a year representative of long-term climatic conditions when considered on a combined sewer system (CSS)-wide basis. Comparing only capital, operations and maintenance costs of the alternatives does not necessarily lead to a clear choice. Within the range of uncertainty inherent in the analysis, several alternatives may be roughly equivalent in terms of cost-effectiveness when measured as combined sewage overflow avoided per dollar spent once implementation is complete. However, the Green Stormwater Infrastructure with Targeted Traditional Infrastructure Alternative begins to provide benefits immediately as the many small scale projects are continuously added throughout the 20-year implementation period. This ultimately results in greater cumulative benefits over time. Also, there is a minimum constructible size for many of the traditional management options considered. For example, implementing a system of tunnels to serve all four watersheds results in a present value capital cost beginning at approximately $5 billion for tunnels intercepting all trunk sewers and having minimum constructible diameters of 15 ft. Building large-scale transmission and treatment infrastructure is estimated to begin at close to $4 billion in capital and O&M cost dictated by the length of existing interceptor sewers, assuming that at a minimum a new system would double existing wet weather capacity.

10.1.2 Affordability and Financial Capability Limits our Choice

PWD currently spends upwards of $150 million each year renewing and upgrading its existing facilities. In addition to these recurring costs, Philadelphia anticipates spending further funds over the coming years to meet evolving drinking water quality goals and stormwater management criteria under the Clean Water Act. Under the current economic climate, securing capital funding for PWD's existing, on-going programs, much less new initiatives, is a challenge. That is why, when money does become available, it is ever more critical to ensure that every dollar is leveraged to satisfy the myriad of issues facing this water utility.

A financial capability assessment for the LTCPU was prepared using criteria suggested by the US EPA. The US EPA's approach calls for an evaluation of costs of the proposed improvements against Philadelphia residents' median household income. In general, the US EPA considers wastewater costs above two percent of median household income to be an unacceptable cost burden to ratepayers. The affordability and financial capability analysis presented in Section 11 identifies an upper limit on the level of spending that PWD and its rate payers can sustain without severe hardship. Socioeconomic analyses generally point to slow economic growth in the Philadelphia region for the next 20 years. The trends highlighted in the analysis provided in Section 11 are predictive of an increasing burden on ratepayers for wastewater treatment costs prior to the enactment of any CSO compliance measures by the PWD. It is important for PWD, the PADEP and the US EPA to negotiate a level of CSO control and an implementation schedule that recognizes the financial burden on ratepayers and the permittee that will result from CSO compliance measures, and that the affordability of the selected alternative must be one of the considerations in selecting the preferred alternative. Of the alternatives studied, only the Green Stormwater Infrastructure with Targeted Traditional Infrastructure Alternative includes a constructible scenario providing management for all four watersheds that can be implemented within reasonable limits of affordability for the ratepayers of Philadelphia.

Costs for implementing even this most affordable of alternatives are estimated to be $1.6 billion at the end of the twenty year implementation period ($1.0 billion in 2009 dollars). Based on this estimate and implementation schedule, the affordability assessment determined that the LTCPU would result in a cost to City of Philadelphia residents well above the upper limit of US EPA's median household income affordability criteria.

10.1.3 Green Stormwater Infrastructure: An Emerging Trend

In selecting the best alternative for meeting the City's obligations for controlling CSO events, PWD considers it critical to embed the CSO program in the larger context of city-wide objectives for a more livable and sustainable city. Philadelphia, like many major American cities, is faced with an array of economic, social, and environmental challenges. These challenges require that government agencies break out of their traditional roles of providing narrowly defined services and seek to work together toward larger goals. PWD's LTCPU rightly focuses on significantly reducing CSOs, thereby making Philadelphia's creeks and rivers cleaner and healthier. But as the single largest investment of environmental dollars in the City over the next 20 years, it presents a unique opportunity to be much more than just a water quality improvement program. The selected alternative must be part of a larger city-wide effort to reverse the decline in the physical infrastructure of the City. It must be designed to provide additional benefits beyond the reduction of CSOs, so that every dollar spent provides a maximum return in benefits to the City.

To maximize benefits, the LTCPU must be seen in the broader context of Philadelphia's movement to re-invent itself as a more sustainable 21st century city. The current mayor has outlined an

ambitious agenda through the City's GreenWorks initiative aimed at transforming Philadelphia into the "greenest city in America" by reversing years of decline. This will take a transformation in the way city agencies work together, and will need to align city government, non-governmental organizations and residents in a joint effort towards achieving a common goal of a more livable, sustainable city that reduces its energy needs, improves the economic condition of its citizens, and manages its natural resources to the greatest extent possible. PWD's CSO program will become a critical element in achieving this goal.

Of the alternatives considered, only the selected alternative, Green Stormwater Infrastructure with Targeted Traditional Infrastructure, also supports numerous US EPA initiatives at a time when the nation's cities need 21st Century solutions to aging infrastructure problems. US EPA Administrator Lisa Jackson identified five priorities for the administration including:

1. Protecting America's water
2. Improving air quality
3. Reducing greenhouse gas emissions
4. Cleaning up hazardous-waste sites
5. Managing chemical risks

PWD's selected alternative, rolled out to the public under the name *Green City, Clean Waters,* will address four out of five of these priorities.

The City of Philadelphia's LTCPU is being developed under a new, emerging, regulatory context described in recent green stormwater infrastructure guidance and policy documents developed by the US EPA. The US EPA signed the "Green Stormwater Infrastructure Statement of Intent" in April 2007 and followed with the production of two memos including "Using Green Stormwater Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs" and "Use of Green Stormwater Infrastructure in Permits and Enforcement". These US EPA memos strongly support the use of green stormwater infrastructure approaches in lieu of traditional infrastructure when possible by encouraging state and federal policy to integrate green stormwater infrastructure into permitting and enforcement activities.

In March 2009, Administrator Jackson charged the US EPA Office of Water with leading a new Urban Waters initiative. The focus of this program will be to promote stewardship of urban waterways in the communities that surround them, especially in areas not historically targeted by environmental outreach. The goals of the Urban Waters Initiative are to achieve water quality goals of fishable/swimmable/drinkable rivers, improve public health and the environment and quality of life, and sustain community improvements over multiple generations. This initiative will help restore urban waterways in Environmental Justice communities. Only the selected alternative (Green Stormwater Infrastructure with Targeted Traditional Infrastructure) embodies the intent of this new US EPA initiative. PWD will follow this initiative as it develops and will seek opportunities for partnership synergies.

Also, the US EPA has recently joined forces with the US Department of Housing and Urban Development and the Department of Transportation through an Interagency Partnership for Sustainable Communities, focusing national attention to improve access to affordable housing, more transportation options, and lower transportation costs while protecting the environment in communities nationwide. Philadelphia's unique approach to CSO requirements helps promote their goal of livable communities by investing in healthy, safe and walkable neighborhoods and coordinates all levels of policy to support existing communities. This is yet another initiative that

would dovetail with the *Green City, Clean Waters* program, presenting opportunities to partner and where possible, leverage dollars such that both agencies are able to stretch their limited funding further and are able to get more out of each investment.

Seen in this context, selecting the best alternative for the LTCPU provides a unique opportunity to align itself with the larger vision of a sustainable city, broadening PWD's role in the City while leveraging the dollars spent to comply with environmental laws and regulations to reach the wider goals of economic stimulation and the rebuilding of the City's infrastructure.

Clearly the primary benefit of the CSO control program is an improvement in water quality and aquatic ecosystem health meeting both the letter and the spirit of the Clean Water Act. There are, however, differences between the way benefits accrue to the green alternative vs. the traditional infrastructure alternative. Figure 10-1 illustrates these differences over the implementation period. Because of the great expense associated with a storage based program such as the tunnel alternative, it would have to be constructed in phases, by watershed, and affordability would dictate that only a portion of the tunnel alternative could be completed in the first 20 years. The graph illustrates the advantage in performance over time associated with the dispersed, small scale implementation of green stormwater infrastructure, which captures increasing percentages of combined sewage as it is implemented. The tunnel alternative only provides capture upon completion, which is shown here in construction stages to fit within affordability guidelines. If one considers that the cumulative volume of CSOs captured is represented by the area beneath the respective curves, it is clear that the small scale implementation of green stormwater infrastructure results in greater benefit over the implementation period. The traditional infrastructure approach does not capture any additional combined sewage until completion of construction in the last years, while increases in the capture percentage begin to accrue to the green approach from the first year of implementation.

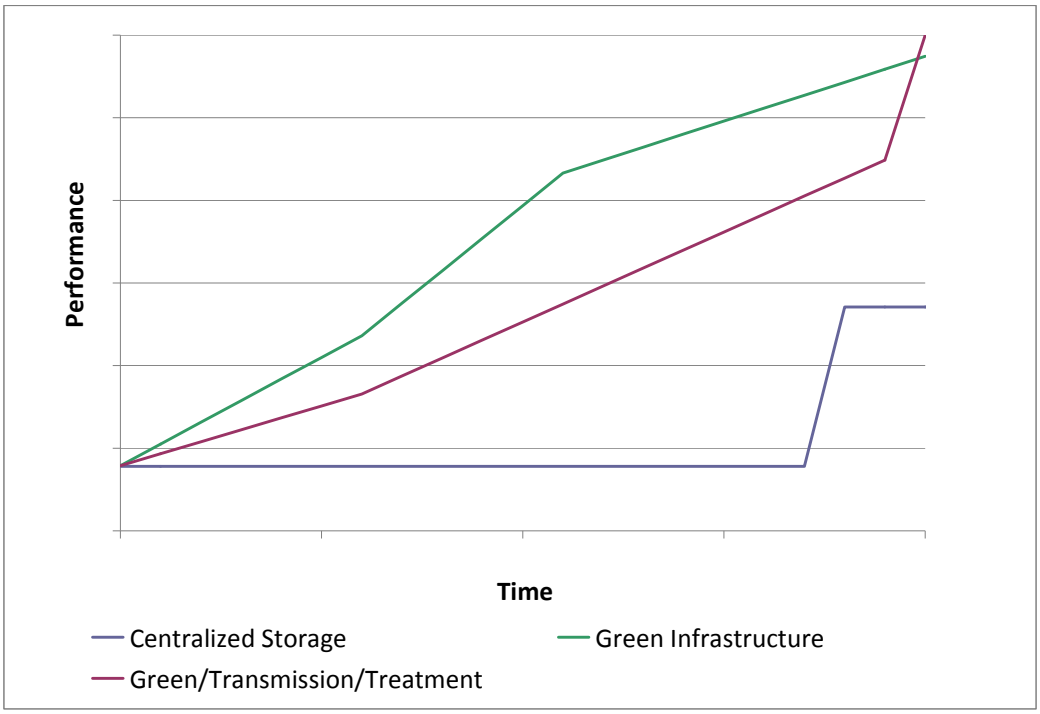


Figure 10-1 Comparison of Performance Over Time of Three Alternative Types Evaluated for the City of Philadelphia

Only the Green Stormwater Infrastructure with Targeted Traditional Infrastructure Alternative will provide improvements in dry weather water quality and aesthetics, stream corridor restoration measures, and significant environmental, social, and economic benefits at an affordable cost. Additionally, this is the only alternative that adapts to climate change by mitigating the urban heat island effect and helps mitigate climate change both by sequestering carbon in trees and by saving energy. Construction and operation of traditional storage, transmission, and treatment systems result in a net increase in energy usage, air pollutant emissions, and greenhouse gases. These alternatives neither mitigate nor adapt to global warming.

10.1.4 Triple Bottom Line: Environmental, Social, and Economic Benefits

The strictly traditional infrastructure-based alternatives all provide no additional benefits outside of the control of CSOs and associated water quality improvements. The green stormwater infrastructure aspect of the selected alternative does provide these important benefits. As described in Section 9, PWD has undertaken a Triple Bottom Line (TBL) analysis of the environmental, social, and economic benefits of the program. This TBL accounting means expanding the traditional financial reporting framework to take into account ecological and social performance so that the total benefits can be evaluated against the financial investment. TBL accounting attempts to describe the social and environmental impact of PWD's proposed infrastructure investment such that they can account for not only the water quality benefit that the infrastructure would produce, but also the additional environmental and societal benefits generated by the various alternatives evaluated.

Although these environmental, social, and health benefits are difficult to quantify, PWD felt it was important to gather information in an attempt to comprehensively compare the green approach with other traditional infrastructure alternatives. Understanding the full societal costs and benefits is important in justifying the program with the ratepayers, who will ultimately pay for this initiative. With the help of leading environmental economists, PWD compared the alternatives to help quantify the social benefits. After 20 years beyond the implementation period, the total net social benefits of PWD's $1.6 billion plan add up to a present value of $2.2 billion (Figure 10-2).

PWD considers the selection of the alternative that relies primarily on green stormwater infrastructure a responsible investment for the City. The benefits associated with the green stormwater infrastructure within the selected alternative Green Stormwater Infrastructure with Targeted Traditional Infrastructure are discussed below.

Green Stormwater Infrastructure Enhances Recreation

Throughout the Fairmount Park system, residents enjoy recreation along Philadelphia's stream corridors and waterfronts, but some areas do not live up to their full potential. Improved access, appearance, and opportunities in these areas will make them more desirable destinations for the public (Figure 10-3). Recreation also will be more desirable along newly greened neighborhood streets and public places. Philadelphians enjoy recreation along stream corridors and waterfronts today such as the Forbidden Drive along the Wissahickon Creek and The Schuylkill River Trail. *Green City, Clean Waters* will improve aquatic habitat and accessibility to the Tacony Creek and the Cobbs Creek and allow them to realize their full potential. Improved access, appearance, and opportunities in these areas will make them more desirable destinations for the public; in fact it is estimated that use of Fairmount Park lands will be increased by 10% due to the implementation of PWD's *Green City, Clean Waters* program. Recreation also will be more desirable along newly greened neighborhood streets and public places.

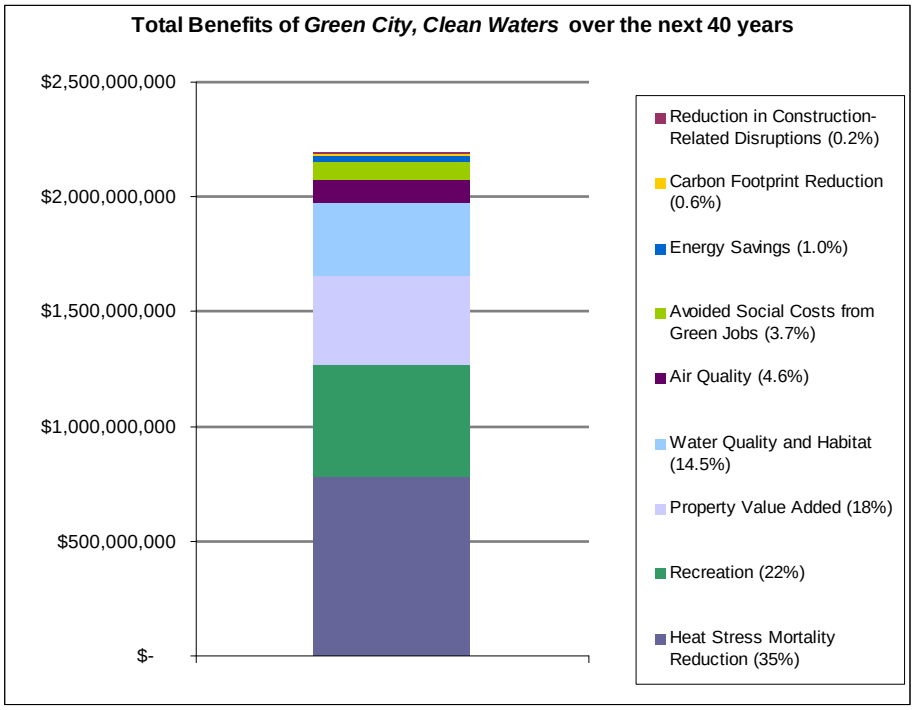


Figure 10-2 After 40 Years, the *Green City, Clean Waters* Program Will Create More Than $2.2 Billion of Social Benefits

Figure 10-3 A Vision of Cobbs Creek Looking Toward Woodland Avenue Dam Illustrating Habitat Restoration and Recreation Enhancements

Green Stormwater Infrastructure Restores Ecosystems

Green stormwater infrastructure improves ecosystems in two ways. First, by allowing rain to soak into the ground and return slowly to streams, green stormwater infrastructure restores a water cycle more similar to a natural watershed. This provides a natural water quality filter and limits erosion of stream channels caused by high flows, both of which benefit aquatic species. Second, PWD's green stormwater infrastructure approach includes physical restoration of stream channels and streamside lands, including wetlands, to restore habitat needed for healthy ecosystems (Figure 10-4).

Figure 10-4 Before and After a Stream Restoration of Exposed Interceptor Pipe Along Marshall Road in the Cobbs Creek Watershed

Improvements to water quality and habitat have been valued at $8.5 million over the next 40 years from:

- 45 ac of wetlands restored
- 148 ac of wetlands created
- 7.7 mi of stream restored in the Cobbs Creek Watershed
- 3.4 mi of stream restored in the TTF Watershed

Green Stormwater Infrastructure Improves Community Quality of Life
Trees and parks are an important part of the recipe that together can make an urban neighborhood into an inviting, exciting place. Residents clearly recognize and value this quality of life effect of urban vegetation. One way to estimate a value is to study property values in areas that are close to parks and greenery. It is estimated that values of homes near parks will be increased by $390 million over the next 40 years.

Green Stormwater Infrastructure Jobs Reduce the Social Cost of Poverty
Governments at all levels incur significant costs in coping with poverty, and Philadelphia is no exception. Green stormwater infrastructure creates jobs which require no prior experience and are therefore suitable for individuals who might be otherwise unemployed and living in poverty; in fact it is estimated that due to the *Green City, Clean Waters* program 250 people will be employed with green jobs each year. These new jobs create a benefit to society in reduced poverty-related costs, in addition to the wages paid to the individual workers. The stabilizing and transforming effects of green stormwater infrastructure in neighborhoods further reinforce and support the benefits of providing employment to a population that is outside the labor force. Green stormwater infrastructure is not by itself the solution to poverty, but it is a valuable tool in the toolbox of poverty reduction.

Green Stormwater Infrastructure Reduces Effects of Excessive Heat
Heat waves are a fixture of summers in Philadelphia, including some severe enough that they have resulted in over 100 premature deaths (for example, the summer of 1993). These events may be more frequent and severe in the future due to climate change. Green stormwater infrastructure (for example, trees, green roofs, and bioretention sidewalks) reduces the severity of extreme heat events in three ways - by creating shade, by reducing the amount of heat absorbing pavement and rooftops,

and by emitting water vapor – all of which cool hot air. This cooling effect will be sufficient to actually reduce heat stress-related fatalities in the City during extreme heat wave events. It is estimated that more than 140 excessive heat related fatalities could be avoided over the next 40 years.

Green Stormwater Infrastructure Improves Air Quality
Like many major cities in the United States, US EPA currently classifies the Philadelphia metropolitan area as exceeding federal air quality standards for both ozone (smog) and fine particles (soot). Known health impacts of these air pollutants include premature death, hospitalization for respiratory diseases, heart attacks, and lost work and school days. Green stormwater infrastructure will improve Philadelphia's air quality in two ways – by reducing emissions of pollutants (such as SO_2) and by removing ozone and particulates from the air. Reductions in energy and vehicle use will reduce emissions of pollutants. Once in the air, some ozone is taken into the leaves of trees as they "breathe." Leaves also trap additional fine particulates, which then wash off in the rain or fall with the autumn leaf drop. When trees are fully grown, improved air quality will reduce on average 1 to 2 premature deaths and 20 asthma attacks per year as well as to reduce up to 250 days of work loss or school absence per year.

Green Stormwater Infrastructure Saves Energy and Offsets Climate Change
Green stormwater infrastructure reduces energy use, fuel use, and carbon emissions in two ways. First, the cooling effects of trees and plants shade and insulate buildings from wide temperature swings, decreasing the energy needed for heating and cooling. Second, rain is managed where it falls in systems of soil and plants, reducing the energy needed for traditional systems to store, pipe, and treat it. Growing trees also act as carbon "sinks", absorbing carbon dioxide from the air and incorporating it into their branches and trunks. Implementation of the *Green City, Clean Waters* program will result in 1.5 billion pounds of carbon dioxide emissions avoided or absorbed over the next 40 years – the equivalent of removing close to 3,400 vehicles from Philadelphia's roadways each year.

10.1.5 Qualitative Evaluation Factors
In addition to the performance, cost, affordability, and TBL considerations previously described, a number of other, more qualitative criteria were used in comparing alternatives.

Public Support
Public feedback expressed the strongest support for alternatives that manage stormwater and CSO primarily through green stormwater infrastructure. Thus far, at the numerous public and stakeholder meetings during which PWD described the various alternatives under consideration for addressing the Clean Water Act requirements, the public has emerged as strongly supportive of measures that included a larger degree of green stormwater infrastructure. For example, the participants in the PWD's *Green City, Clean Waters* public participation program have expressed overwhelming support for green stormwater infrastructure as the preferred approach to reducing CSOs in Philadelphia. Over ninety-two percent of the more than 700 survey respondents responded positively to the green stormwater infrastructure approach. All stakeholders, from suburban watershed partners to City residents living within the CSO drainage area desire an approach that promotes multiple community benefits and creates truly sustainable watersheds and cleaner, safer and more accessible waterways. In addition, the political backing for the green approach is strong, as witnessed in the Mayor's Sustainable City initiative and GreenWorks plan.

Feasibility, Reliability, and Complexity

All alternatives present challenges in terms of feasibility of construction and operation. Technologies needed to construct and operate green stormwater infrastructure are straightforward and use relatively simple technologies, but institutional and political barriers exist that need to be reduced over time. Technologies associated with wastewater collection and treatment are considered more complex but highly reliable. Construction of storage tunnels is technically challenging and risky, although operation is considered reliable.

Each alternative will result in considerable disruption to traffic as well as to residential and commercial areas, although this will be to varying degrees and durations. For example, installation of green stormwater infrastructure techniques on a given block of street could cause a change in traffic pattern for several weeks. Because green stormwater infrastructure will be installed in many locations, the disruptions will be scattered throughout the system, however much of the installation will be carried out in conjunction with other public works such as street paving, sewer repair, and underground utility repairs. Thus the disruption will not be significantly greater than what would already be occurring for other reasons. The building of a large-scale storage tunnel could cause a disruption of traffic patterns and accessibility for a number of years, but in a smaller disturbance area along the rivers and creeks. According to the Triple Bottom Line analysis performed to evaluate various CSO mitigation alternatives for the City of Philadelphia, the difference in vehicle delay from construction and maintenance in hours of delay are roughly 250,000 hours for an alternative managing runoff from one-third of impervious surfaces as opposed to a 620,000,000 hour delay with a 30 foot diameter tunnel alternative.

The technology needed for maintenance of green stormwater infrastructure is simple but needs to be applied frequently on a large scale. Green stormwater infrastructure measures may fail occasionally on a local scale (*e.g.*, clogging of a release structure,) but the consequences of these small-scale failures are low and are easily corrected by routine maintenance.

Coordination and Consistency with other PWD and City Programs

Green stormwater infrastructure complements City of Philadelphia sustainability and redevelopment goals. These programs include redevelopment of vacant and abandoned lands and efforts to both mitigate and adapt to climate change. Traditional infrastructure interferes with many of these goals by occupying waterfront land and increasing air pollution and greenhouse gas emissions.

The green stormwater infrastructure clearly complements some of the larger, regional initiatives such as the East Coast Greenway Trail Network ("the Greenway"). The Greenway is a multi-user trail network connecting urban centers along the East Coast of the United States from Canada to Key West. This spine route consists of a series of locally owned and managed trails, linked to form a continuous greenway, easily identified by the public through signage, maps, and user guides. The Schuylkill River Trail is a multi-use trail that runs from Philadelphia to Pottsville. The downtown Philadelphia portion, called Schuylkill Banks, is managed by the Schuylkill River Development Corporation. The East Coast Greenway will eventually use the proposed extension of the Schuylkill River Trail as the long-term regional trail plan unfolds.

Adaptability and Expandability

Alternatives involving green stormwater infrastructure are more adaptable and expandable than larger scale, traditional storage alternatives. As they are implemented over a long period of time, conditions can be periodically reevaluated to identify design and programmatic changes that are needed. New technologies can be integrated as they are developed because of the small scale of the projects being implemented. One key advantage to green stormwater infrastructure is that as

development accelerates, stormwater control linked to the development also accelerates. Transmission and storage options can only be adapted to some extent. For example, transmission capacity can be initially oversized (at increased cost) to allow for the possibility that future treatment needs may be greater than expected. New treatment capacity can be added in the form of independent treatment trains. The large-scale storage alternative is the most difficult of any of the alternatives to adapt and expand to changing conditions.

10.2 SELECTED ALTERNATIVE

After more than two years of significant engineering and economic analysis and evaluation, the Green Stormwater Infrastructure with Targeted Traditional Infrastructure Alternative was shown to be the clear choice for the City of Philadelphia due to the many environmental, social, and economic benefits that can be realized, its ability to improve all four watersheds and remain within affordability guidelines, and the fact that benefits begin accruing immediately – thereby producing benefits for city residents long before the traditional infrastructure approach would. At the close of the 20 year implementation period, PWD will have invested approximately $1.6 billion ($1.0 billion in 2009 dollars) to initiate the largest green stormwater infrastructure program ever envisioned in this country, thereby providing for the capture of 80% of the mixture of sewage and stormwater that would otherwise flow into portions of the Schuylkill and Delaware Rivers, and the Tacony, Frankford and Cobbs Creeks.

The selected alternative includes the three main elements:

- A commitment to green stormwater infrastructure; converting 34% of the CSS drainage area of the City to greened acres
- Stream corridor restoration and preservation (implementation of Target A and B commitments in each watershed)
- Wet weather treatment plant upgrades

Additional resources will be expended by PWD toward implementing their core mission and could be considered "leveraged" toward addressing this larger *Green City, Clean Waters* program.

This programmatic commitment of $1.6 billion ($1.0 billion in 2009 dollars) is in addition to the numerous commitments already in place, including:

- Approximately $200 million already spent toward 1997 LTCP commitments (including Nine Minimum Controls, capital projects and watershed planning)
- Approximately $2 million dollars committed annually to conducting the Stormwater Plan Review Program
- Approximately $55.8 million dollars committed to relining streamside interceptor pipes in the Cobbs and TTF watersheds – as outlined in the IWMP commitments
- Approximately $2 million dollars committed annually to public outreach and education (including support of the Fairmount Waterworks Interpretive Center, Fairmount Park Commission Environmental Education)

The true value of the *Green City, Clean Waters* program is likely to exceed $3 billion with the addition of leveraged dollars and activities implemented by stakeholders and partners. Of equal importance, even after the close of this 20 year implementation period, the practices put in place will continue to produce greened acres, achieving additional cumulative reductions in combined sewer overflows to the City's rivers and streams.

The Green City, Clean Waters Program:
PWD's *Green City, Clean Waters* program is the much talked about philosophy of the land-water-infrastructure approach made real. We have deemphasized the use of traditional infrastructure as it is cost prohibitive while missing the restoration mark, instead pledging our precious investments into greening the City as a means to provide specific benefits to the residents of the City of Philadelphia while meeting ecological restoration goals.

The PWD's vision *Green City, Clean Waters* is to unite the City of Philadelphia with its water environment, creating a green legacy for future generations while incorporating a balance between ecology, economics, and equity.

This plan commits the City to significantly reducing the negative impacts of stormwater on the effectiveness of PWD's sewer collection system. PWD's strategy will be to reduce the amount of impervious surfaces in the City on an annual basis by changing the way that the landscape interacts with stormwater by enhancing City surfaces with natural features. PWD will measure progress through greened acres that capture and manage the first inch of stormwater.

The basic principles underlying the City's *Green City, Clean Water* approach are:

- Utilizing rainwater as a resource by recycling, re-using, and recharging long neglected groundwater supplies rather than piping it to the streams and rivers
- Maintaining and upgrading one of the nation's oldest water infrastructure system
- Transforming the City's rivers and streams into recreation destinations and green open space for visitors and City residents
- Preserving and restoring habitat for aquatic species within the City's urban stream corridors
- Collaborating to revitalize the City with a focus on sustainability
- Energizing the City's residents, partnerships, public and regulatory partners to adopt and join us in the watershed-wide strategy

PWD's Commitment:
As previously described, PWD's recommended alternative includes three main components:

- A commitment to green stormwater infrastructure
- Stream corridor restoration and preservation
- Wet weather treatment plant upgrades

A detailed description of each component follows.

10.2.1 Green Stormwater Infrastructure

The use of sustainable and natural design that is green stormwater infrastructure will bring about the renewal and expansion of the urban form. Acknowledging the symbiotic relationship between land use and water resources, PWD's definition of green stormwater infrastructure includes a range of soil-water-plant systems that intercept stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air, and in some cases release a portion of it slowly back into the sewer system.

Green stormwater infrastructure examples include bioretention planters in sidewalks and parking lots, green roofs, roof leaders that run off into lawns and rain gardens (Figure 10-5). These vegetated features manage rain where it hits the ground similar to the way a natural system such as a forest or a meadow would handle the rain runoff. PWD sincerely believe in the efficacy of using nature's own

designs in which rainwater is an essential component for a thriving ecosystem. Once rainwater is removed from the natural system, it is only a matter of short time before the natural system fails. This is the unintended consequence of traditional infrastructure that separates rainfall from the earth.

Green stormwater infrastructure also involves the restoration of physical habitats in stream channels, along stream corridors, and on riverfronts. Restoration of stream habitats and riverfronts can also be combined with commitments to improve public access and amenities along the stream corridors. Public stewardship can only be guaranteed when the public is given the opportunity to see, touch and experience the streams healed by PWD's efforts. These practices are critical to PWD's larger restoration vision; without them, the ecosystem damage resulting from two centuries of urbanization will not be reversed.

This approach has been shown to be the most environmentally beneficial and economically favorable way to remediate the effect of more than 200 years of urbanization on the City's waterways. By investing in green stormwater infrastructure and other innovative, cost-saving strategies to manage stormwater, PWD is not only ensuring the rebirth of the City's ecological resources but is also striving to provide a host of other environmental, social and economic benefits that will catalyze PWD's success in achieving the sought after reality of "Greenest City in America."

A robust green stormwater infrastructure based program that commits to greening 34% of the impervious areas within the CSS is the cornerstone of PWD's wet weather water quality program.

An important performance goal used throughout this document is the achievement of a "greened acre." This greened acre includes the area of the stormwater management feature itself and the area that drains to it (or the stormwater feature's own little watershed). Each greened acre will manage the first inch of runoff from one impervious acre of the combined sewer service area. About one million gallons of rain fall on an acre over the course of a typical year. Of this, PWD's designs are intended to remove about 80-90%, or 0.8 to 0.9 million gallons of stormwater, preventing its discharge into the City's waterways.

PWD would like to see more than one third of the CSS drainage's impervious cover included in a green approach to stormwater management within the next 20 years. Ambitious goals call for a program that touches on every aspect of development and redevelopment in the city, and a timeline that envisions a city transforming itself over several decades. This cannot be done by PWD alone, but will require a coordinated effort across all city agencies, as well as the private sector, to achieve the ambitious goals of the program. A significant portion of PWD's $1.6 billion investment over the next 20 years will be invested in green stormwater infrastructure, and will also leverage PWD's ratepayer investment in a way that provides multiple additional community benefits.

Figure 10-5 Graphic of a City Neighborhood with Green Stormwater Infrastructure Components Implemented (Source: WRT Designs)

PWD has developed a number of "Green Programs," each with a number of associated implementation tools – including policy changes, regulatory tools, funding commitments and incentives through which the transformation from impervious acre to greened acre will occur.

PWD's Green Toolbox Includes Eight Green Programs:

- Green Streets
- Green Schools
- Green Public Facilities
- Green Public Open Spaces
- Green Industry, Institutions, Commerce and Business
- Green Driveways and Alleys
- Green Parking
- Green Homes

Key to the success of PWD's strategy is that it focuses on the treatment of publicly-owned land, such as city properties, streets and right-of-ways, which constitute 45% of the impervious land area of the City. With that in mind, the initial approach to achieving management of impervious cover is to focus efforts on publicly owned impervious cover and the larger, more commercial properties, and to use programs addressing impervious cover on smaller private properties to increase the level of control as needed. Over the course of the implementation horizon, additional programmatic elements will be explored and developed.

The Green Stormwater Infrastructure Program can be thought of as a series of individual programs, each targeting a different generator of stormwater (impervious cover category). The target at year 20 is to have put sufficient measures in place to manage the first inch of stormwater for one-third of all impervious cover in the CSS drainage area of the City of Philadelphia. Implementation of the program will need to review progress at a series of decision points, one every five years for the 20 year implementation period, as part of an adaptive management approach. The program will need to be flexibly applied, with targeted impervious cover controls adapting to changing economic, technical, and social conditions.

Figure 10-6 shows the breakdown of impervious cover in the city, organized around the green stormwater infrastructure programs planned for implementation. Of importance is the fact that parking, roads, and sidewalks make up a significant portion of the impervious cover. Much of this impervious cover can be managed through facilities located on public property or public right of way, a critical point in assessing the feasibility of the program and in designing measures to achieve the target of controlling the first inch of rainfall on 34% of all impervious cover in the city. With that in mind, the initial approach to achieving management of 34% of impervious cover is to focus efforts on publically owned impervious cover and the larger, more commercial properties, and to use programs addressing impervious cover on smaller private properties to increase the level of control as needed.

A description of each of the various green programs with their primary implementation tools follows.

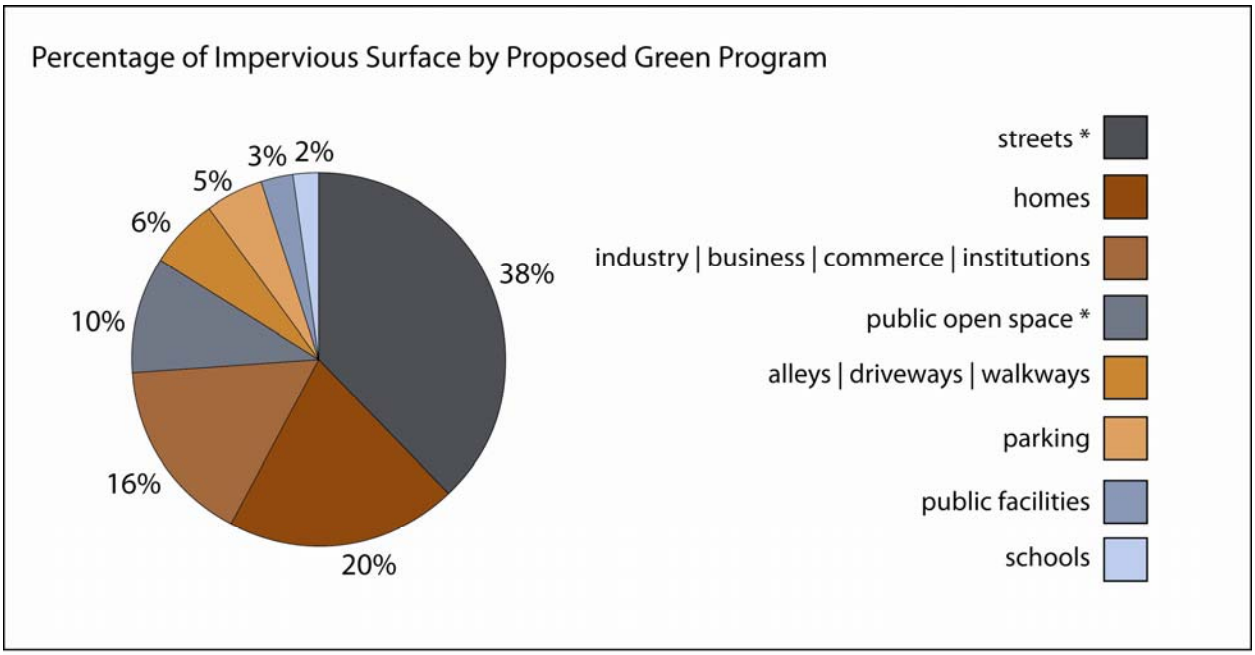


Figure 10-6 Breakdown of Impervious Cover Within the CSS Area of the City by the City's Green Program Implementation Tools

* Please note that the "Streets" category does not include streets adjacent to public open space; these streets are included in the impervious surface percentage associated with "Public Open Space"

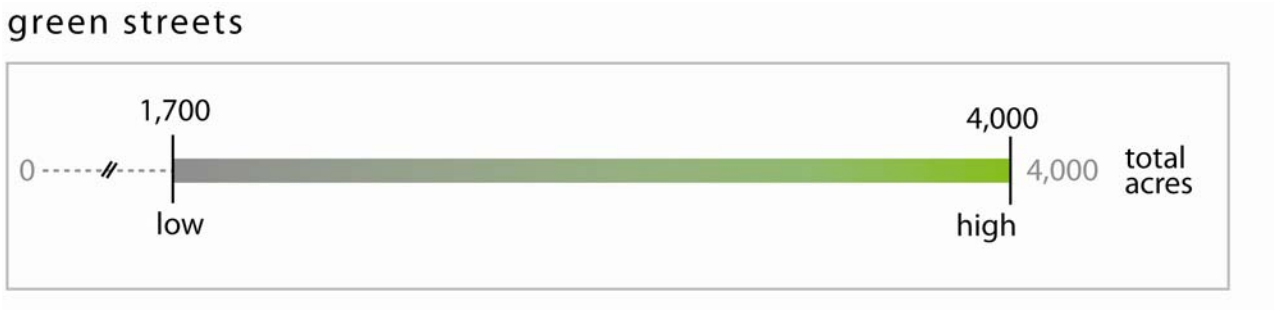


Figure 10-7 Vision of "Before and After Greening" of a South Philadelphia Street (Source: WRT Designs)

Figure 10-8 Examples of Street Greening Elements and Practices

Streets and sidewalks are by far the largest single category of public impervious cover, accounting for roughly 38% of the impervious cover within the combined sewer service area. (Note: impervious cover associated with streets in front of parks was not included in this percentage; these streets will be included in the "Green Public Open Space" Program) A green street acts as a natural stormwater management system, capturing rain or melting snow (runoff), allowing it to soak into soil, filtering it and at the same time, reducing the amount of stormwater that would otherwise go into Philadelphia's combined sewer pipes (Figures 10-7 and 10-8).

PWD is designing stormwater management systems while maintaining the primary function of the street for vehicles and pedestrians. These greened acres will provide additional societal benefits on City streets, such as shading, cooling, traffic calming, and visual enhancement.

Some of the green stormwater infrastructure tools in the green streets tool box include street trees and the "pit" they are planted in, sidewalk trenches, planters, sidewalk bump-outs and bulb-outs (sidewalk extensions), and porous pavement. Street tree pits and trenches capture the flow of stormwater from the street and sidewalk, letting it soak into the soil to water the trees. They provide shade, improve air quality, absorb noise and beautify the neighborhoods.

Through the use of sidewalk planters, stormwater runoff from the street and sidewalk is directed to the planter through a curb opening allowing stormwater to be absorbed by the plant and soil materials. Sidewalk planters help protect the City's waterways by filtering and reducing stormwater runoff.

The use of porous pavement allows the stormwater runoff to soak right through the sidewalks, while providing the same structural support as traditional pavement. This is a tool that at the surface might not look "green" to the eye, but still provides stormwater management benefits.

PWD is working to align its green stormwater infrastructure practices with street greening programs associated with the ambitious greening goals of GreenWorks. Coordination of PWD's program with other city programs will encourage maximum effectiveness. Ultimately, the Green Streets program should result in setting a "green standard" for streets within the City. Partners include PennDOT and the City of Philadelphia Streets Department as well as special districts to help with maintenance.

In developing a concept for rolling out a large-scale green streets program, PWD has begun to evaluate streets in terms of categories by street widths. PWD has begun this process by dividing streets into four categories by width, where a given width has associated with it a set of design considerations. PWD chose four streets in South Philadelphia to serve as the "model" streets for evaluating their street width concept. Streets and widths evaluated are as follows:

- Streets 2-19 ft wide – Iseminger Street
- Streets 20-29 ft wide – Dickinson Street
- Streets 30-49 ft wide – Snyder Street
- Streets 50+ ft wide – Washington Avenue

For each of these "model streets" PWD had a photo-simulation developed (Figures 10-9 through 10-12) so that consideration could be given to things like "street furniture" (*i.e.*, bike racks, utility boxes/poles, trash receptacles, newspaper boxes, etc.) and utility conflicts as various green stormwater infrastructure components are considered for application.

Figure 10-9 Streets 2-19 ft wide – Iseminger Street (Source: WRT Designs)

Figure 10-10 Streets 20-29 ft wide – Dickinson Street (Source: WRT Designs)

Figure 10-11 Streets 30-49 ft wide – Snyder Street (Source: WRT Designs)

Figure 10-12 Streets 50+ ft wide – Washington Avenue (Source: WRT Designs)

PWD then used these pre-defined street widths to evaluate streets throughout the CSS drainage area for applicability of these various green street tools. PWD has begun to map the opportunities for implementing green streets. Maps have been prepared that identify these four categories of street width, and standard designs are being prepared appropriate for each type of street. Figure 10-13 shows an example of a green street planning map for the CSS drainage area of the TTF Watershed.

In addition to the street planning maps, developing and making standard designs for green streets is critical to implementing green stormwater infrastructure on a large scale. PWD has already developed a portfolio of standard details, one of which is shown in Figure 10-14. These standard designs provide a variety of approaches for all types of streets, and will help to make the large scale implementation of green stormwater infrastructure more efficient.

Many standard details are as simple as adding tree trenches to increase tree cover, which provides some measure of stormwater capture. Others are more ambitious redesigns that include tree trenches, planters, and underground infiltration/retention facilities, resulting in a completely new form for Philadelphia's commercial and residential streets.

Because implementation of the *Green City, Clean Waters* program will depend highly on green streets, PWD has already started collaborating with the Streets Department and other utilities so that all projects will become streamlined and coordinated. PWD will design tree trenches and bump-outs to

streets already slated for improvements. When both utility and road work can be done on each street at the same time, it lessens the project costs and the inconvenience to residents.

Additionally, the Fairmount Park Commission already has an extensive street tree program. PWD will build on a successful history of working together with the Fairmount Park Commission by designing street tree trenches to be installed as new street trees are installed. Not only will these trenches increase the life expectancy of the trees, they will capture even more urban runoff in the underground drainage system. The same efficiencies can be realized by installing curbside green stormwater infrastructure such as bump-outs where possible when the City replaces or installs Americans with Disabilities Act mandated ramps on the sidewalks.

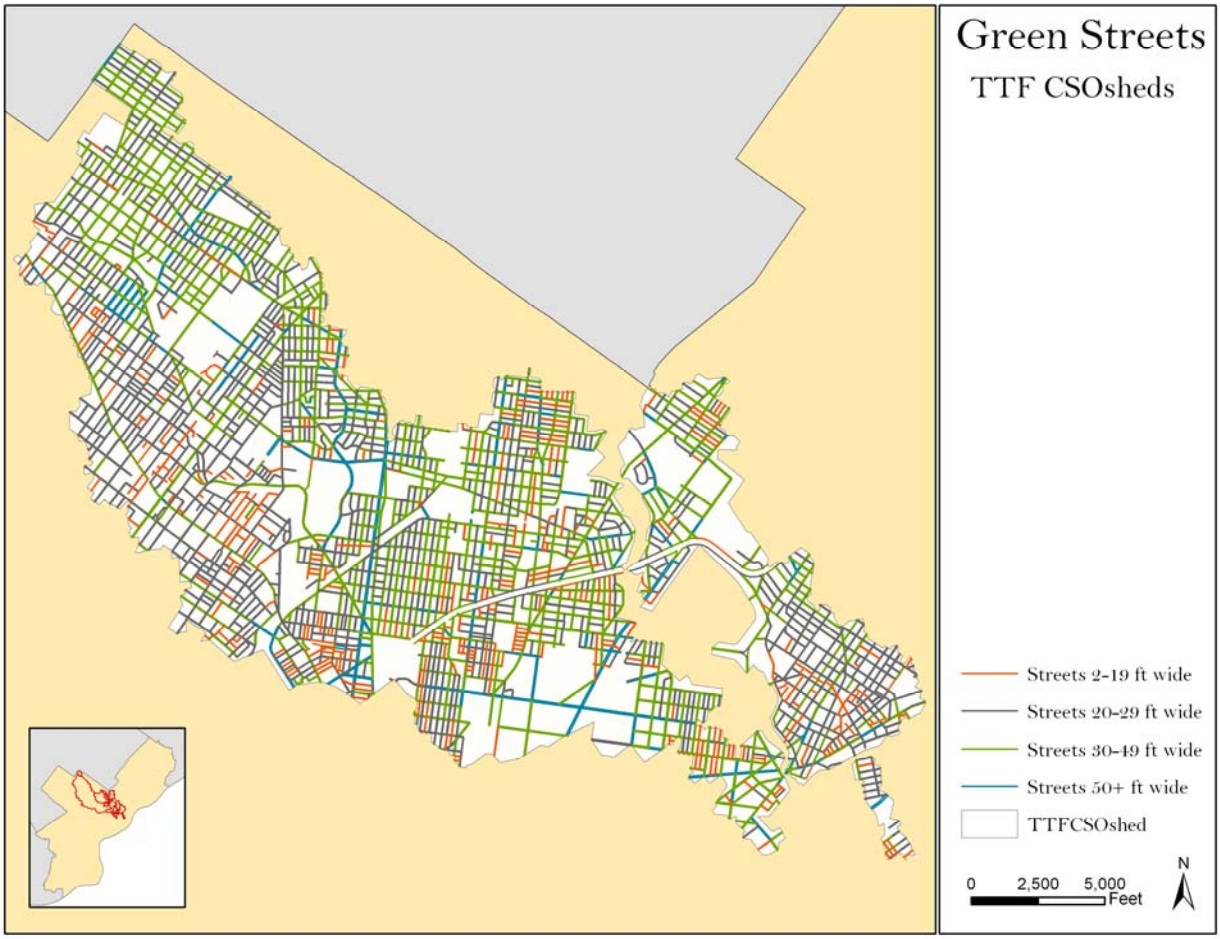


Figure 10-13 Green Street Planning Map Illustrating Different Categories of Street Width within the CSS Drainage of the TTF Watershed

PWD is preparing standard designs, and is working on appropriate regulations and incentives to retrofit streets whenever the opportunity arises such as when the following occur:

- PWD water/sewer infrastructure repair/replacement
- PWD storm flood relief related construction
- Cable/gas/phone infrastructure repair/replacement
- Routine repaving by either the Philadelphia Streets Department or PennDOT

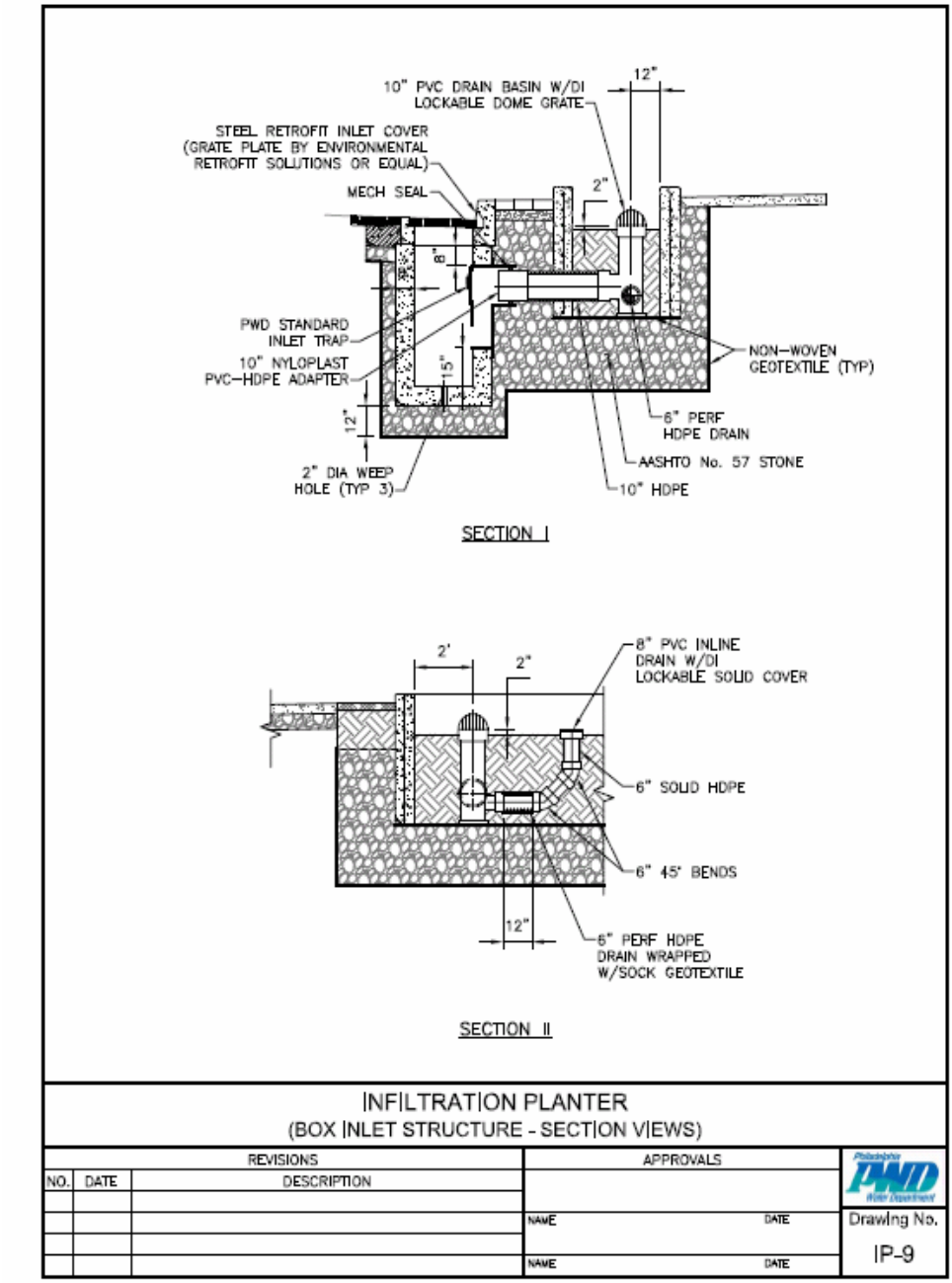


Figure 10-14 Standard Detail for Infiltration Planter

In addition to city streets, discussions are proceeding with PennDOT to take all runoff from Interstate I-95 within the city from its current discharge to the combined sewer system and discharge directly to the Delaware River. This would be a complete separation of the Route 95 corridor runoff, to be implemented as part of the planned Route 95 reconstruction. Further, the infrastructure constructed through this process will be sized such that ample capacity will exist for disconnecting parcels located between I-95 and the Delaware River. As properties are redeveloped over the coming years, they will be able to disconnect from the combined sewer system and connect to this new separate system.

Schools make up 2% of all impervious cover in the City, but because they are highly visible and associated with education, making them critical components in a green stormwater infrastructure program, they present a high priority target for greening. The goal is to retrofit up to half of all schools in the City in the coming 20 years. PWD plans to support the retrofitting of up to 5 school campuses per year, utilizing an array of stormwater measures such as rain gardens, green roofs, rain barrels and cisterns. Perhaps the most important and biggest opportunity here includes the use of pervious pavement and trees on both parking and recreational facilities on school properties, transforming what are now heat trapping asphalt surfaces into more welcoming, cooler, green islands (Figures 10-15 and 10-16).

The greening of schoolyards will require specific designs for each campus. These designs can include green stormwater approaches such as porous pavement, rain gardens, green roofs, and cisterns, but also could be expanded to include improvements to water efficiency that reduce sewage flows.

Figure 10-15 Porous Pavement Examples

The primary tools for this include:

- Providing design services through PWD contractors
- Incentives associated with the new stormwater rates
- Stormwater regulations for new construction
- Potential for funding of green sidewalks and streets around the school property.

Figure 10-16 Visualization of a Potential Schoolyard Greening Project (Source: WRT Designs)

Public parcels make up 3% of impervious cover within the CSS drainage. The value in retrofitting them with green stormwater infrastructure to manage stormwater is primarily to lead by example as envisioned in Figure 10-17. This cannot be underestimated, both for establishing the credibility of the program in the eyes of the public, and to demonstrate the effectiveness of the measures to remaining skeptical individuals within the development community. PWD is leading this initiative by evaluating opportunities for the greening of its own facilities (Figure 10-18). Additionally, PWD also encourages the installation of green streets surrounding major public facilities to maximize the potential stormwater management benefits.

Retrofit of existing facilities will require close coordination with other city agencies to evaluate opportunities for facilities such as Parks & Recreation buildings and structures, and Police and Fire facilities.

Figure 10-17 Photosimulation of Green Stormwater Infrastructures on Public Facilities

Figure 10-18 Examples of Philadelphia Public Property Green Retrofits

Compliance with the stormwater regulations provides the framework for all renovation projects on public property. Every opportunity will be utilized to include green stormwater approaches for all

significant capital improvement work on City property to bring them in compliance with the Stormwater Regulations. To increase the effectiveness of the program associated with city facilities, PWD will encourage the city to refurbish the streets surrounding each of the major facilities undergoing construction using one of the green street designs. This will significantly increase the effectiveness of the retrofit and provide opportunities for public education on stormwater management at each City facility.

Parking lots, at 5% of the impervious cover, present a great opportunity to reduce stormwater runoff. (Please note: The Green Parking Program is composed of free-standing parking lots only; parking associated with retail or other facilities is included as a part of the impervious cover associated with that facility.) Parking lots have a significant visual impact on the city, and green parking lots can contribute to the overall improvement in the appearance of the City's commercial and business districts. A variety of stormwater measures can be used to renovate parking lots, including vegetative strips, infiltration beds, trees, porous pavement, sand filters, and even green roofs on parking garages (Figure 10-19).

The benefits of green parking are just now being realized, including reduced summer temperatures and no loss of parking space during and after storms due to standing water. Parking lots have a significant visual impact on the city, and green parking lots can contribute to the overall improvement in the appearance of the city's commercial and business districts.

Figure 10-19 Examples of Green Retrofit Parking Projects

City-owned parking facilities will be targeted as a demonstration of the City's commitment to green stormwater infrastructure. A city financed program of parking lot retrofits will be evaluated. Private parking lots can be retrofitted through the incentives provided by PWD's Parcel Based Billing Initiative. This program resulted in a reallocation of stormwater fees and should make retrofits aimed at reducing stormwater fees more attractive such that private parking lots might begin to seek opportunities for retrofit. The City may also consider an ordinance that will mandate a green buffer around all parking facilities that can also serve as a stormwater infiltration measure.

Figure 10-20 Photosimulation of Green Stormwater Infrastructure on Public Facilities and Adjacent Streams

Public Open Space is not a large contributor to impervious cover, making up only about 10% of the city's impervious cover. Impervious cover associated with the park lands itself is quite low, but PWD sees opportunities for utilizing the streets surrounding these parcels to route and manage stormwater from the surrounding areas where this can be done without adversely impacting the quality of the public land itself (Figure 10-20 and 10-21).

PWD has worked with greening recreational centers that are already community focal points and often in need of restoration or upgrade.

Figure 10-21 Stormwater Management through Green Practices on Public Land

Vacant land, while not all publicly owned, presents a unique opportunity for stormwater management. There are over 40,000 vacant parcels of land in the City. These present an opportunity both for permanent green redevelopment, as well as for more temporary measures such as the creative use of vacant parcels for management of stormwater from surrounding areas. In addition, there are many areas of the city ready for redevelopment, including areas of abandoned or substandard housing, abandoned industrial areas, or outdated commercial facilities. High priced and ever scarcer energy is changing the way Americans live, making older urban centers more and more attractive places to live and work. As a result, the rate of redevelopment in the city is expected to impact 1% or more of the city's impervious cover each year. Making all redevelopment projects contribute to a greener city will be critical to meeting ambitious green stormwater infrastructure goals.

Figure 10-22 shows a mixed industrial and residential section of a Philadelphia neighborhood with vacant properties highlighted in yellow. This neighborhood has an 11% vacancy rate. Due to the large number of vacant properties, this neighborhood has many opportunities for neighborhood revitalization, which can lead to an expansion of the PWD customer base. The vacancies also provide placement for the installation of green stormwater infrastructure technology.

Figure 10-22 Vacant Property Redevelopment Opportunities

Besides the redevelopment of vacant land, currently used public land also represents an opportunity for improved stormwater management.

- Bikeways/Trails can serve as linear elements in the landscape, and are closely associated with the Green Plan. All bikeways and trails should be designed for zero stormwater discharge (Figure 10-23)

- Parks are often associated with Philadelphia's creeks and rivers. In addition to onsite management of stormwater, they present opportunities for wetland creation/restoration, and stream restoration
- Plazas are central meeting places in the city. Stormwater measures should be designed to aid in the greening of the plazas through the use of planters and tree pits
- Golf courses should all be required to manage stormwater onsite. In addition, they should all participate in the Audubon Cooperative Sanctuary Program for Golf Courses to reduce water use and the use of pesticides and herbicides

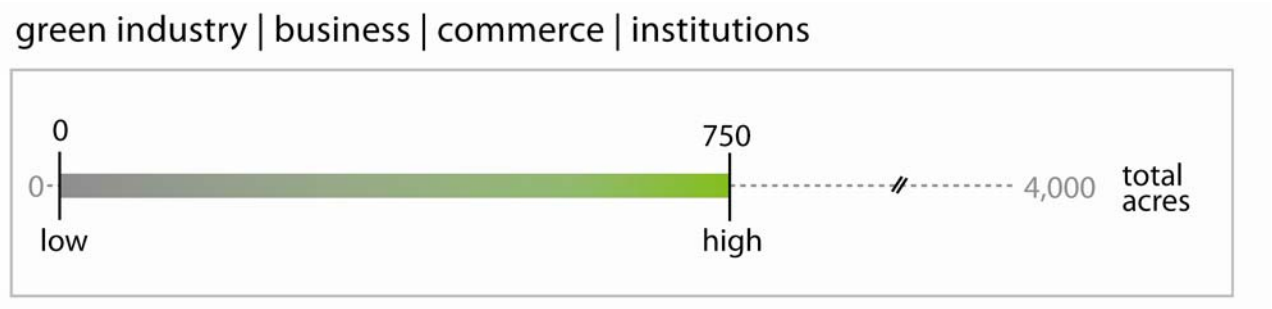
PWD's progressive new stormwater regulations and the restructuring of its stormwater rates to tie fees to impervious cover will play an ever increasing role in the greening of Philadelphia and are the most effective tools for greening private land. The new regulations requiring the first inch of rainfall to be controlled onsite will have a great impact on the city's stormwater and CSO programs by bringing all new development and redevelopment projects in line with the new regulations. However, PWD is considering additional ways to improve and strengthen its stormwater programs by potentially reducing the minimum area to trigger the stormwater regulations to 5000 ft^2.

Figure 10-23 Examples of Green Public Trails, Paths and Bike Routes

Additional incentives are being considered to further stimulate innovative stormwater designs, including:

- Fee in lieu: allowing stormwater controls to be transferred to another location if efficiency is improved
- Green permit expediting: green designs are fast tracked through the permit review process
- Evaluate the potential for linking green stormwater infrastructure to other incentives related to zoning, such as density/setback incentive bonuses for increased stormwater control beyond the minimum requirements

Limited, appropriate, and compatible use of recreation and other open space for the management of stormwater from surrounding areas is also under consideration.



Land subject to the Green Industry, Business, Commerce and Institutions Program makes up about 16% of the City's impervious cover. Philadelphia's industrial, business, commercial and institutional properties hold significant opportunities for green stormwater infrastructure implementation. Generally, because implementation of this program is within the control of private entities, PWD will undertake a supporting role in seeing it developed programmatically. Many industries, businesses and commercial buildings would be expected to face upgrades and renovations within the 20 year time frame, making a high rate of compliance with stormwater regulations a reasonable expectation. Also, one clear incentive for private entities to consider installation of green stormwater infrastructure will be PWD's new stormwater rate structure, which ties impervious cover to the stormwater fee. PWD anticipates that this will result in multiple existing large private, non-residential properties to retrofit their properties with stormwater management infrastructure in order to receive a credit in the stormwater portion of their bill. This could prove particularly effective for parking lots that previously have not received a water bill.

PWD also intends to encourage the use of green stormwater infrastructure, where possible provide tools and incentives to make their use easier and more attractive, and if possible to provide incentives for the retrofit of existing facilities. Additionally, PWD will evaluate LEED certification to see how credits are being allocated to stormwater management features. PWD might consider working with the United States Green Building Council (USGBC) to reevaluate the way that these credits are distributed in order to make the stormwater management component a more integral portion of the program.

A program to target properties and buildings owned by churches, hospitals, universities, and sports stadiums presents another highly visible opportunity for green stormwater infrastructure. Much like large commercial or industrial properties (Figure 10-24), this program will rely on compliance with the City's Stormwater Regulations for new facilities as well as the incentive for retrofit of existing facilities provided by the new stormwater rate structure. In addition, many major universities, including the

Figure 10-24 Green Business Greening Example (Source: WRT Designs)

University of Pennsylvania, have embarked on ambitious sustainability initiatives. Where possible PWD will seek to partner with these entities in order to produce synergies and stretch limited dollars. This may present opportunities to work with each university to separate all stormwater from the sewer system for onsite, green solutions.

Other opportunities might include greening the large areas of impervious cover associated with the sports stadium complexes and the Convention Center, which attract millions of visitors each year. When certain large facilities are renovated or constructed anew, complete separation of the facility's sanitary and storm sewers might be possible, and could even be combined with green measures.

Other incentives are being considered, including:

- Providing design services though PWD contracts
- Evaluating opportunities for public/private partnerships for the management of stormwater runoff from the public right-of-way on private property in exchange for the funding of a green stormwater infrastructure retrofit

Figure 10-25 Before and After Alley Greening and Implementation of Porous Pavement with Underdrain of a Philadelphia Alley (Source: WRT Designs)

Philadelphia has many smaller alleys located behind houses and commercial buildings that are currently impervious and drain to the storm and combined sewers via stormwater inlets. Though land under this program makes up about 6% of all impervious cover in the City, it may offer relatively inexpensive solutions for infiltration or collection of roof runoff. These often underutilized areas present an opportunity to either use the alleys for infiltration, or to convey stormwater to green stormwater infrastructure located at the end of an alley. In addition to the alleys, there are often walkways providing access to backyards of homes, and driveways for single family homes and row houses that present other opportunities for onsite stormwater controls.

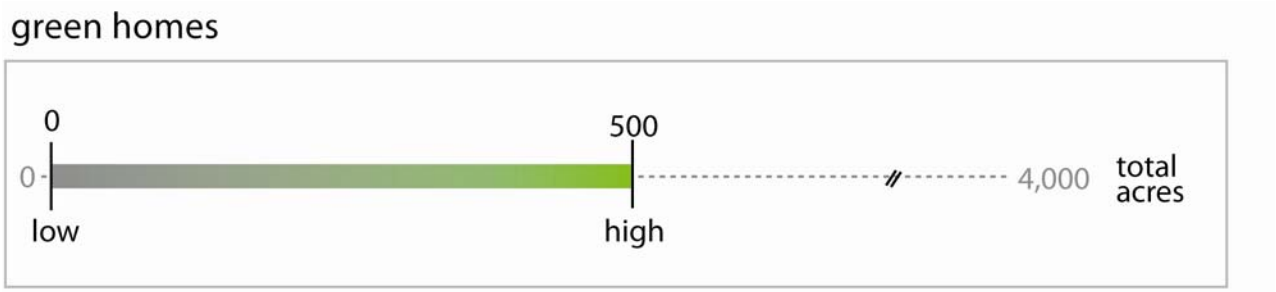


Figure 10-26 Photosimulation of Green Stormwater Infrastructure on Residential Properties (Source: WRT Designs)

Residential roofs make up 20% of all impervious cover in the City. The key to success for this program may lie in the simplicity of smaller scale solutions, many of which can be carried out by the homeowners themselves and can achieve benefits at a minimal cost.

Projects, such as the use of rain barrels, have already proven popular in pilot programs, and if successful on a larger scale, can ultimately affect a significantly larger amount of impervious cover. Additionally, more ambitious and costly measures are also possible, including the installation of a green roof (Figure 10-26) or capturing stormwater in larger cisterns for reuse.

Public education is a key to increasing participation in residential stormwater measures such as:

- Installing rain barrels to collect roof runoff
- Disconnecting downspouts to direct runoff to pervious areas or small, dug drywells
- Using site slopes to direct stormwater runoff to rain gardens

Examples of a couple of these elements are shown in Figure 10-27 and Figure 10-28 below.

To supplement the Green Homes Program, more ambitious and costly measures are also possible, including installing a green roof, or capturing stormwater in larger cisterns for reuse. Stormwater fees are not likely to be effective in stimulating these solutions, and PWD might consider evaluating creation of tools to encourage implementation.

Figure 10-27 Green Stormwater Management Practices for Homeowners

Reductions in the contribution of wastewater from homes to the sewers can also have a significant impact on CSOs. The City is embarking on an ambitious program of energy reduction through weatherization of homes throughout the city.

PWD will also evaluate potential for developing a sidewalk replacement grant program that would share the cost of greening sidewalks in front of private properties, ranging from modest measures such as planters and tree pits, to more ambitious approaches such as the installation of pervious paving and subsurface storage.

Figure 10-28 Examples of a Rain Garden and Disconnected Rain Spout for Residential Areas

Summary
This is how PWD envisions unfolding their Plan. PWD has some clear ideas and has implemented many of the solutions through a variety of demonstration projects with the assistance of their partners, although the precise application of which tools and where they will be applied has not yet been determined. What is truly exciting about this Plan is that it has the power to change forever the way the City renews its streets and neighborhoods. Many of these green technologies have been proven successful, but are untried on such a city-wide scale. This Plan contains built-in milestones that allow PWD to measure progress with each element every few years and adapt as necessary. Where less progress is measured with the use of a given tool, another will be implemented. Because of the numerous possible tools available for greening acres, the Plan is by its very nature adaptive.

10.2.2 Stream Corridor Restoration and Preservation; Achievement of Targets A and B

Restoration and Preservation of riverfronts, stream habitats and corridors can be combined with efforts to improve public access and amenities along the water corridors. Implicit in this effort are aspirations to re-connect Philadelphians with the City's extensive river network. Included in PWD's recommended approach is a commitment to restoration of 7.7 mi of the stream corridor along the Cobbs Creek and 3.4 mi of stream corridor restoration along the Tacony Creek. Where applicable-wetland preservation, enhancement and creation within these corridors will offer the additional benefits of mitigating the adverse impacts of stormwater runoff and increase the ecological connectivity within the region.

The Delaware and Schuylkill Valleys serve as important junctions for anadromous fish and avian migratory activities. As such, efforts by PWD to commit to the restoration of a number of acres of tidal wetlands along the Schuylkill and Delaware Rivers will have ecological impacts that extend beyond the region and into the Delaware Bay and beyond. Additionally, in order to facilitate recreation on the Delaware River, the PWD will support local efforts to increase public riverfront access and recreation by moving or consolidating CSO outfalls to eliminate odors and improve aesthetics. Depending on site-specific conditions at locations, outfalls may be modified by consolidating with another downstream outfall or extending the outfall away from the river's edge further into the Delaware River channel. PWD will seek to identify locations where CSO outfalls may be consolidated or extended in order to enhance recreational opportunities.

What follows is a description of individual commitments made toward achievement of Targets A and B in each of PWD's four watersheds within the CSS drainage area.

10.2.1 Improving Dry Weather Water Quality, Aesthetics and Recreation

Target A addresses water quality requirements of the Clean Water Act in streams and rivers during dry weather conditions, as well as stream and river aesthetics and river related recreation.

10.2.2.1 TTF Creek Watershed

The TTF IWMP, completed in 2005, included a long-term commitment to Target A implementation measures (Table 10-1).

Table 10-1 TTF IWMP Target A Commitments

Tookany/Tacony-Frankford Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Public Education and Volunteer Programs			
AP2 School-Based Education	$370,000 annual	$150,000	
AP3 Public Participation and Volunteer Programs			
Municipal Measures			
AM1-4 Sewer Evaluation, Cleaning, Relining/Rehabilitation	$24,000,000 one-time cost plus $530,000 annual		
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)	$5,000,000 one-time cost plus $210,000 annual		
AM6 Stream Cleanup and Maintenance	$170,000 annual	$30,000	$20,000
AO1 Enhancing Stream Corridor Recreational and Cultural Resources*		$0	$0
Monitoring and Reporting			
AMR Monitoring, Reporting, and Further Study	$20,000 annual		
Target A Total Annual Costs and Operations & Maintenance (2009 Dollars)	$1,090,000	$180,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$3,100,000
Total New One Time Costs for Target A			$20,000
Total Target A Commitment			**$54,600,000**
Total Target A Commitment in LTCPU			**$3,120,000**

* PWD funding has not been allocated for enhancement of recreational and cultural resources, though efforts will be sought to support these initiatives

Public Education

Public Participation and Volunteer Programs

PWD supports the TTF Watershed Partnership, a 501(c)3 organization financially through annual membership dues, and programmatically by offering resources and technical assistance to this group throughout the year. This organization was formed with the mission of implementing the recommendations of the IWMP and leads the efforts to connect the community to the watershed by

engaging volunteers and educating residents on stormwater and watershed management. PWD additionally maintains the http://www.phillyriverinfo.org website for posting of Partnership related information, meeting minutes, presentations, announcements, etc.

Additionally, PWD has launched a robust public outreach and education program through their *Green City, Clean Waters* Campaign called the Model Neighborhood Initiative. This initiative is aimed at transforming neighborhoods of Philadelphia into model green communities that manage stormwater in innovative ways. These neighborhoods will showcase green stormwater infrastructure elements, such as street trees trenches, sidewalk planters, and bump outs/curb extensions.

School-Based Education

PWD will continue to support the Tookany-Tacony/Frankford Watershed Partnership in providing school-based education and volunteer programs. Additionally, the Fairmount Water Works Interpretive Center hosts school groups and teacher trainings to promote watershed concepts. For each watershed, an area-weighted percentage of Water Works funding has been allocated into the Target A commitment. PWD will continue to lead the *Green City, Clean Waters* program to engage the public and receive feedback on issues surrounding the LTCPU implementation and will use this watershed partnership as one of the vehicles for taking this message to the public.

Municipal Measures

Inspection Cleaning and Rehabilitation of Sewers

Sewers are assessed to identify segments in need of rehabilitation, particularly where leakage is directly flowing into the stream. Maintenance of sewers includes activities required to keep the system functioning as it was originally designed and constructed. Any reinvestment in the system, including routine maintenance, capital improvements for repair or rehabilitation, inspection activities, and monitoring activities is classified as maintenance. The single largest component of the Target A commitment in the TTF Watershed is to reline almost seven miles of combined sewer interceptor that runs along the mainstem of the creek.

Illicit Discharge, Detection, and Elimination (IDD&E)

The water quality of the TTF is also impacted by separate sewered areas. In keeping with the watershed approach, the separate sewered area of the TTF watershed has been a priority area for the PWD Defective Lateral Program over the past decade. This commitment to continuation of the program within this watershed is aimed at elimination of dry weather flows to the creek resulting from illicit sewer connections. The program will continue as required in the City of Philadelphia Stormwater Permit.

Stream Cleanup and Maintenance

Stream cleanup and maintenance is performed by the PWD Waterways Restoration Team (WRT). The WRT will continue to inspect and assess the conditions of sewage infrastructure along the Tacony/Frankford and its tributaries, collect litter and large debris, identify, prioritize and maintain a list of obstructions, aesthetic nuisances, and debris removal needs, and investigate right-of-way complaints.

Recreational and Cultural Resources

Enhancing Stream Corridor Recreational and Cultural Resources

PWD will support the enhancement of recreational and cultural resources along the Tacony/Frankford Creek and local initiatives by providing partnership support and technical assistance.

The Frankford Greenway Master Plan:

As part of Target A objectives in the TTF Creek Watershed, PWD supported the development of the Frankford Greenway Master Plan, which is an effort to reconnect residents with the waterway in a very underutilized area. The planning area includes a 2.7 mi stretch of Frankford Creek in Northeast Philadelphia. Unlike the upstream portion of this watershed's drainage area, this portion of the creek is not surrounded by planned or existing park lands. The Frankford Creek has been channelized with large concrete walls and bottom, and is inaccessible due to private land ownership. This plan is intended to improve stream ecology, provide recreational opportunities, preserve the history of the corridor, provide riparian buffer, manage storm water, and provide connectivity for and to surrounding communities (Figures 10-29 through 10-31).

PWD has not committed funding to support implementation of this plan, however as PWD moves forward with implementation of land-based and instream restoration commitments, opportunities to support the vision as laid out by this plan will be evaluated and synergies sought.

Figure 10-29 Before and After Visioning of Aramingo Avenue & Frankford Creek (Source: Frankford Greenway Master Plan, 2008)

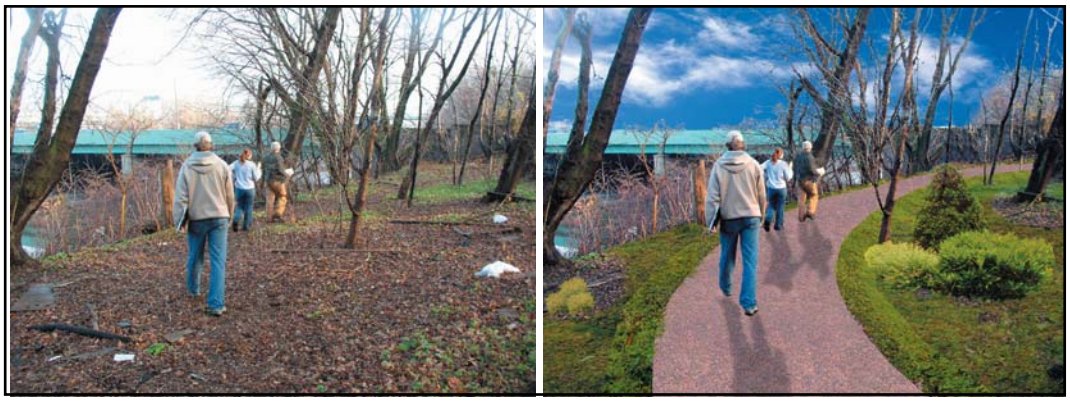


Figure 10-30 Before and After Visioning of Frankford Creek, Just North of Aramingo Avenue (Source: Frankford Greenway Master Plan, 2008)

Figure 10-31 Before and After Visioning of What a Trail Could Look Like Underneath the Interstate Ramps Along Frankford Creek (Source: Frankford Greenway Master Plan, 2008)

10.2.2.2 Cobbs Creek Watershed

The Cobbs Creek IWMP (CC IWMP), completed in 2004, included a long-term commitment to Target A implementation measures (Table 10-2).

Table 10-2 CC IWMP Target A Commitments

Cobbs Creek Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Public Education and Volunteer Programs			
AP2 School-Based Education	$370,000 annual	$150,000	
AP3 Public Participation and Volunteer Programs			
Municipal Measures			
AM1-4 Sewer Evaluation, Cleaning, Relining/Rehabilitation	$10,000,000 one-time cost plus $500,000 annual		
AM6 Stream Cleanup and Maintenance	$170,000 annual	$20,000	$20,000
AO1 Enhancing Stream Corridor Recreational and Cultural Resources*		$0	$0
Monitoring and Reporting			
AMR Monitoring, Reporting, and Further Study	$20,000 annual		
Target A Total Annual Costs and Operations & Maintenance (2009 Dollars)	$1,060,000	$170,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$2,900,000
Total New One Time Costs for Target A			$20,000
Total Target A Commitment			**$34,800,000**
Total Target A Commitment in LTCPU			**$2,920,000**

* PWD funding has not been allocated for enhancement of recreational and cultural resources, though efforts will be sought to support these initiatives

Public Education

School-Based Education

Public education and participation is an important element of the CC IWMP as well as the LTCPU. PWD will continue to support the Darby-Cobbs Watershed Partnership in their school-based watershed education and volunteer programs. Additionally, the Fairmount Water Works Interpretive Center hosts school groups and teacher trainings to promote watershed concepts. For each watershed, an area-weighted percentage of Water Works funding has been allocated into the Target A commitment. PWD will continue to lead the *Green City, Clean Waters* program to engage the public and receive feedback on issues surrounding the LTCPU implementation and will use this watershed partnership as one of the vehicles for taking this message to the public.

Public Participation and Volunteer Programs

PWD supports and continues to convene the Darby-Cobbs Watershed Partnership. This organization leads the efforts to connect the community to the watershed by engaging volunteers and educating residents on stormwater and watershed management. PWD additionally maintains the http://www.phillyriverinfo.org website for posting of Partnership related information, meeting minutes, presentations, announcements, etc.

Additionally, PWD has launched a robust public outreach and education program through their *Green City, Clean Waters* Campaign called the Model Neighborhood Initiative. This initiative is aimed at transforming neighborhoods of Philadelphia into model green communities that manage stormwater in innovative ways. These neighborhoods will showcase green stormwater infrastructure elements, such as street tree trenches, sidewalk planters, and bump outs/curb extensions.

Municipal Measures

Inspection Cleaning and Rehabilitation of Sewers

Sewers are assessed to identify segments in need of rehabilitation, particularly where leakage is directly flowing into the stream. PWD will continue to regularly inspect and clean the combined sewer infrastructure in the Cobbs Creek Watershed to reduce dry weather flows. Maintenance of sewers includes activities required to keep the system functioning as it was originally designed and constructed. Any reinvestment in the system, including routine maintenance, capital improvements for repair or rehabilitation, inspection activities, and monitoring activities is classified as maintenance. The single largest component of the Target A commitment in the Cobbs Creek Watershed is relining of almost six miles of interceptor pipes that run along the mainstem of the creek.

Stream Cleanup and Maintenance

Stream cleanup and maintenance will be conducted by the PWD WRT. The WRT will continue to inspect and assess the conditions of sewage infrastructure along the Cobbs Creek and its tributaries, collect litter and large debris, identify, prioritize and maintain a list of obstructions, aesthetic nuisances, and debris removal needs, develop and maintain a corrective plan, and investigate right of way complaints.

Recreational and Cultural Resources

Enhancing Stream Corridor Recreational and Cultural Resources

PWD will support the enhancement of recreational and cultural resources and local initiatives along Cobbs Creek by providing partnerships support and technical assistance.

10.2.2.3 Delaware Direct Watershed

An IWMP planning process for the portion of the Delaware River Watershed within the City of Philadelphia (also called the Delaware Direct Watershed Drainage) was initiated in winter, 2008. Specific commitments to dry weather water quality improvements have not yet been defined for this watershed, however, numerous visions have been set forth for revitalizing the Delaware Riverfront. The forthcoming IWMP will support these visions and will seek to compliment them where possible.

Target A is defined for the Delaware Direct as focusing on the removal of solids, floatables and large debris in addition to the facilitation of local efforts to increase recreational and cultural opportunities along the river. As the Delaware Waterfront is redeveloped and becomes a local attraction, it should be aesthetically appealing and accessible to the public in order to be an amenity to the community. Commitments set forth to address Target A in the Delaware Direct Watershed are described in Table 10-3.

Table 10-3 Planning-Level Cost Estimates for Target A Options in the Delaware Direct Watershed

Delaware Direct Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Public Education and Volunteer Programs			
AP2 School-Based Education	$370,000 annual	$200,000	
AP3 Public Participation and Volunteer Programs			
Municipal Measures			
AM6 Stream Cleanup and Maintenance		$67,000	$50,000
AM8 CSO Outfall elimination/consolidation			$29,00,000
AO1 Enhancing Stream Corridor Recreational and Cultural Resources*		$0	$0
Target A Total Annual Costs and Operations & Maintenance (2009 Dollars)	$370,000	$267,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$4,600,000
Total New One Time Costs for Target A			$29,050,000
Total Target A Commitment			**$42,250,000**
Total Target A Commitment in LTCPU			**$33,650,000**

* PWD funding has not been allocated for enhancement of recreational and cultural resources, though efforts will be sought to support these initiatives

Public Education

School-Based Education

The Fairmount Water Works Interpretive Center hosts school groups and teacher trainings to promote watershed concepts. Additionally, PWD will continue to lead the *Green City, Clean Waters* program to engage the public and receive feedback on issues surrounding the LTCPU implementation and will use this watershed partnership as one of the vehicles for taking this message to the public.

Public Participation and Volunteer Programs

PWD has launched a robust public outreach and education program through their *Green City, Clean Waters* Campaign called the Model Neighborhood Initiative. This initiative is aimed at transforming neighborhoods of Philadelphia into model green communities that manage stormwater in innovative ways. These neighborhoods will showcase green stormwater infrastructure elements, such as street trees trench, sidewalk planters, and bump outs/curb extensions.

Municipal Measures

Stream Cleanup and Maintenance

Target A in the Delaware Direct IWMP currently will be developed to focus on the removal of litter and floatables in the Delaware River to improve aesthetics and recreation. Staffing of the WRT may need to be expanded to assist removing debris along the banks of the Delaware River.

Floatables Control:

PWD has made a number of significant commitments to control the discharge of solids and floatables within these waterways. The City maintains a robust program for the cleaning of inlets and catch basins, which includes the inspection and cleaning of approximately 79,000 stormwater inlets throughout the City of Philadelphia.

The City also maintains two floatables skimming vessels aimed at reduction of floatables and improvement of both water quality and aesthetics of the receiving streams. The use of a skimmer vessel allows for a mobile control program capable of managing debris at various locations, increasing the effectiveness of this control measure. In addition, the boat is a visible control, and increases the public awareness and education of floatables impacts.

Floatables Skimming Vessel – R.E. Roy is a 39-ft, front-end loader, single hull, shallow draft, debris skimming vessel with a hydraulically controlled grated bucket and a 5.6 cubic yard on-board (Figure 10-32).

The vessel is operated approximately five days per week, 8 months of the year. The vessel's main purpose is to perform general debris collection and removal on both the Delaware and Schuylkill Rivers. The vessel is also used to clean up for and serve as a public relations highlight at events such as the Schuylkill Regatta.

The PWD has also purchased a pontoon vessel that is being used as a workboat on the Upper Schuylkill, Lower Schuylkill, and Delaware Rivers within Philadelphia. The vessel is used to retrieve floating trash and debris from the waterways within the service area. The debris is hand netted from the water surface by employees standing on the vessel deck. The hand nets are emptied into 30-gallon debris containers on the deck, and the containers are offloaded by hand. The pontoon vessel can be utilized in tight spaces found in marinas, among piers, and in near shore areas. This small pontoon vessel is used as a companion vessel to the larger floatables skimming vessel already being operated in Philadelphia.

The operational area of the Pontoon Vessel includes:

1. The Lower Schuylkill above Fairmount Dam up to Flatrock Dam (7.2 mi)
2. The Lower Tidal Schuylkill down to the confluence with the Delaware River (8.1 mi)
3. The Delaware River from the confluence up to the Philadelphia City boundary (18.8 mi)

Figure 10-32 Floatables Skimming Vessel in Operation

Figure 10-33 Floatables Pontoon Vessel in Operation

An additional skimmer vessel will be purchased and staffed twice a week during the nine month outdoor recreational season. These additional resources will remove floatables in the Tidal River and accommodate increased river access along the Delaware Waterfront.

CSO Outfall consolidation and extension

Outfall consolidation/extension is the most expensive Target A option in the Delaware Direct and likely to occur as the riverfront is re-developed. In order to facilitate recreation on the Delaware River, the Philadelphia Water Department will support local efforts to increase public riverfront access and recreation by moving CSO outfalls to eliminate odors and improve aesthetics. Depending on site-specific conditions at locations, outfalls may be consolidated with another downstream outfall or extending the outfall away from the river's edge further into the Delaware River channel.

Outfall consolidation projects will be conducted as conflicts with recreation or access to the river arise. Each consolidation project will include a different number of outfalls consolidated, typically

ranging from two to four and will cost $10-$12 million. The LTCPU commitment includes a total of $29 million to implement outfall relocation/consolidation, which would support two major consolidation projects along the Delaware Waterfront. The more outfalls that can be consolidated in each project, the greater the savings. Based on planning level costs estimates, up to 10 outfalls can be consolidated, eliminating up to 7 CSO outfalls, or 11% of the CSO outfalls on the Delaware River. These eliminated outfalls represent nearly half of the highest priority outfalls based on conflicts with recreational use. Specific outfalls to be consolidated or relocated have not been determined; this level of planning and assessment will take place over the coming years.

Enhancing Stream Corridor Recreational and Cultural Resources
Strategies to protect water-based historic structures are currently outlined in the Civic Vision and North Delaware planning efforts. These plans will become more fully developed through further local planning efforts. In addition to consolidating outfalls as described above, PWD will continue to support the enhancement of recreational and cultural resources along the Delaware River by providing partnership support and technical assistance.

The City of Philadelphia maintains a strong commitment to supporting implementation of the visions set forth by other stakeholder initiatives focused on enhancing recreational opportunities along the Schuylkill and Delaware Rivers. PWD has evaluated the following plans for the Schuylkill and Delaware riverfront areas and will seek to complement these efforts where possible:

- North Delaware Riverfront, Philadelphia: A Long-Term Vision for Renewal and Redevelopment – 2001
- North Delaware Riverfront Greenway Master Plan – 2005
- New Kensington CDC Community Plan – 2008
- A Civic Vision for the Central Delaware (Figure 10-34) – 2007
- An Action Plan for the Central Delaware – 2008
- Northern Liberties Waterfront Plan – 2007
- Northern Liberties Neighborhood Plan – 2005
- Neighbors Allied for the Best Riverfront – Ongoing
- Navy Yard Master Plan – 2004
- Tidal Schuylkill River Master Plan – 2003
- Schuylkill River Heritage Area Planning - Ongoing

PWD has not committed funding to support implementation of these plans, however as PWD moves forward with implementation of land-based and instream restoration commitments, opportunities to support the vision as laid out by these plans will be evaluated and synergies sought.

Figure 10-34 Visions of a "Greened" Delaware Riverfront with Ample Public Recreational Facilities (Source: Civic Vision for the Central Delaware, 2007)

10.2.2.4 Tidal Schuylkill

An IWMP planning process for the portion of the Schuylkill River Watershed within the City of Philadelphia was initiated in winter, 2008. Specific commitments to dry weather water quality improvements have not yet been defined for this watershed, however, numerous visions have been set forth for revitalizing the riverfront. The forthcoming IWMP will support these visions and will seek to compliment them where possible.

Target A is defined for the Tidal Schuylkill watershed as focusing on the removal of solids, floatables and large debris in addition to the facilitation of local efforts to increase recreation along the Schuylkill River. Commitments set forth to address Target A in the Tidal Schuylkill Watershed are described in Table 10-4.

Table 10-4 Planning-Level Cost Estimates for Target A Options in the Tidal Schuylkill River Watershed

Tidal Schuylkill Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Public Education and Volunteer Programs			
AP2 School-Based Education	$370,000 annual	$200,000	
AP3 Public Participation and Volunteer Programs			
Municipal Measures			
AM6 Stream Cleanup and Maintenance		$67,000	$50,000
AO1 Enhancing Stream Corridor Recreational and Cultural Resources*		$0	$0
AM8 CSO Outfall elimination/consolidation			$29,000,000
Target A Total Annual Costs and Operations & Maintenance (2009 Dollars)	$370,000	$267,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$4,600,000
Total New One Time Costs for Target A			$29,050,000
Total Target A Commitment			**$42,250,000**
Total Target A Commitment in LTCPU			**$33,650,000**

* PWD funding has not been allocated for enhancement of recreational and cultural resources, though efforts will be sought to support these initiatives

Public Education

School-Based Education

The Fairmount Water Works Interpretive Center hosts school groups and teacher trainings to promote watershed concepts. For each watershed, an area-weighted percentage of Water Works funding has been allocated into the Target A commitment. PWD will continue to lead the *Green City, Clean Waters* program to engage the public and receive feedback on issues surrounding the LTCPU implementation and will use this watershed partnership as one of the vehicles for taking this message to the public.

Public Participation and Volunteer Programs

PWD has launched a robust public outreach and education program through their *Green City, Clean Waters* Campaign called the Model Neighborhood Initiative. This initiative is aimed at transforming neighborhoods of Philadelphia into model green communities that manage stormwater in innovative ways. These neighborhoods will showcase green stormwater infrastructure elements, such as street trees trenches, sidewalk planters, and bump outs/curb extensions.

Municipal Measures

Stream Cleanup and Maintenance

While the implementation of wet weather controls will reduce the sources of floatable debris, Target A of the Schuylkill River IWMP will focus on the removal of litter and floatables in the Schuylkill River to improve aesthetics and recreation. An additional pontoon skimmer vessel will be purchased and staffed twice a week during the nine month outdoor recreational season. These additional resources will remove floatables in the Tidal Schuylkill River and accommodate for the

increased river access and recreational use as the banks of the Schuylkill River are developed. Additionally, the WRT may also need to be expanded to assist removing debris along the edges of the Tidal Schuylkill River.

CSO Outfall consolidation and extension

Outfall consolidation/extension is the most expensive Target A option and likely to occur as The Tidal Schuylkill Master Plan is further developed and realized. In order to facilitate recreation on the Schuylkill River, the Philadelphia Water Department will support local efforts to increase public riverfront access and recreation by moving CSO outfalls to eliminate odors and improve aesthetics. Depending on site-specific conditions at each location, outfalls may be consolidated by piping flow downstream to the next outfall to the following outfall or extending the outfall away from the river's edge further into the Schuylkill River channel.

Outfall consolidation projects will be conducted as conflicts with recreation or access to the river arise. Each consolidation project will include a different number of outfalls consolidated, typically ranging from two to four and will costs $10-$12 Million. The LTCPU commitment includes a total of $29 Million for the Schuylkill River to implement outfall relocation/consolidation, which would support two major consolidation projects to take place. The more outfalls that can be consolidated in each project, the greater the savings. Based on planning level costs estimates, up to 10 outfalls can be consolidated, eliminating up to 7 CSO outfalls, or 18% of the CSO outfalls on the Schuylkill River. These eliminated outfalls represent a majority of the highest priority outfalls based on conflicts with recreational use. Specific outfalls to be consolidated or relocated have not been determined; this level of planning and assessment will take place over the coming years.

Enhancing River Corridor Recreational and Cultural Resources

Strategies to provide access to cultural and water resources for recreational purposes, as proposed in the Tidal Schuylkill River Master Plan, encourage appreciation for and stewardship of these areas. PWD will support the enhancement of recreational and cultural resources along the Schuylkill River and local initiatives by providing partnership support and technical assistance. PWD has not committed funding to support implementation of this plan; however, as PWD moves forward with implementation of land-based and instream restoration commitments, opportunities to support the vision as laid out by this plan will be evaluated and synergies sought.

10.2.3 Restoring Living Resources

Target B addresses improvements to the number, health, and diversity of benthic macroinvertebrate and fish species in Philadelphia's waterways. Achieving Target B objectives will require investment in habitat improvement and measures to provide the opportunity for organisms to avoid high velocities during storms. Improving the ability of an urban stream to support viable habitat and fish populations must focus primarily on the elimination or remediation of the more obvious impacts of urbanization (Figure 10-35). These include loss of riparian habitat, eroding and undercut banks, scoured streambed or excessive silt deposits, channelized and armored stream sections, trash buildup, and invasive species.

Restoration and Preservation of riverfronts, stream habitats and corridors can be combined with efforts to improve public access and amenities along the water corridors. Implicit in this effort are aspirations to re-connect Philadelphians as well as the landscape- with the City's vast river network. The Delaware and Schuylkill Valleys serve as important junctions for anadromous fish and avian migratory activities.

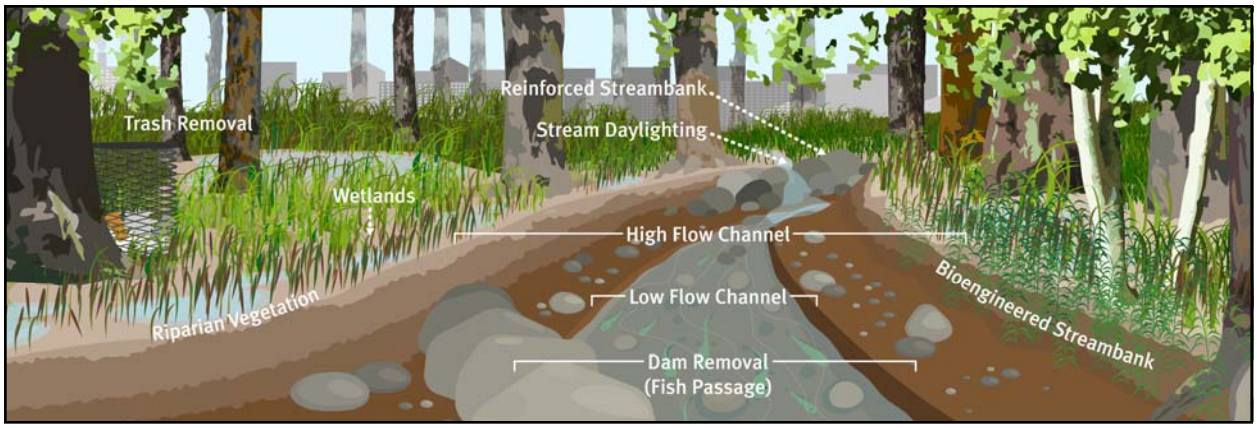


Figure 10-35 Vision for a Restored Stream Corridor (Source: WRT Designs)

PWD is currently assembling a Watershed Project Registry to identify and study areas for future stream restoration, wetland creation, wetland enhancement (including invasive plant management), tidal wetland creation/restoration, stream daylighting and preservation projects (Figure 10-36). This effort will ensure a steady progression towards the greater goal of making Philadelphia one of the greenest cities in the country as well as realizing the full ecological potential of the Fairmount Park system, which could one day serve as the model for urban forestry and river management.

In the tidal rivers, impairment of living resources has not been identified as a problem, but the opportunity for the restoration of lost habitat will be key elements of the IWMPs.

As defined by the IWMPs, Target B measures include the following:

Channel Stability and Aquatic Habitat Restoration

BM1	Bed Stabilization and Habitat Restoration
BM2	Bank Stabilization and Habitat Restoration
BM3	Channel Realignment and Relocation
BM4	Plunge Pool Removal
BM5	Improvement of Fish Passage

Lowland and Upland Restoration and Enhancement

BM6	Wetland Creation and Enhancement
BM7	Invasive Species Management
BM8	Biofiltration
BM9	Reforestation

Measure to achieve Target B objectives are discussed below by watershed.

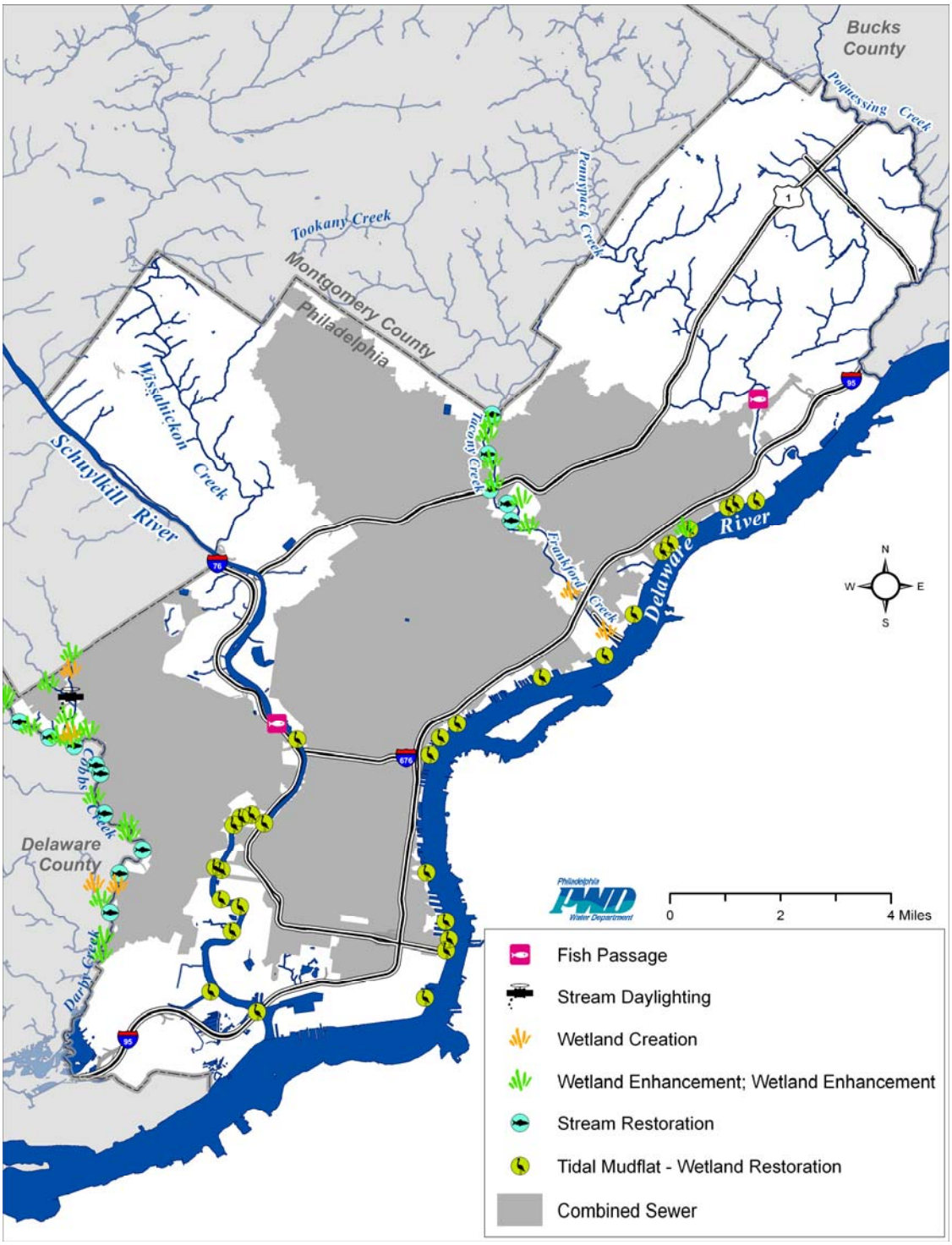


Figure 10-36 PWD's Proposed Stream Corridor Preservation and Restoration Sites

10.2.3.1 TTF Creek Watershed

The TTF IWMP, completed in 2005, included a long-term commitment to Target B implementation measures (Table 10-5).

Table 10-5 TTF IWMP Target B Commitments

Tookany/Tacony-Frankford Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Channel Stability and Aquatic Habitat Restoration			
BM1-BM3, BM6-9 Bed and Bank Stabilization and Habitat Restoration Wetland Creation and Enhancement		$9,300	$25,000,000
Monitoring and Reporting			
BMR Monitoring, Reporting, and Further Study	$23,400 Annual		
Target B Total Annual Costs and Operations & Maintenance (2009 Dollars)	$23,400	$9,300	
Total Present Value of New Annual Costs and O&M (20 Years)			$160,000
Total New One Time Costs for Target B			$25,000,000
Total Target B Commitment			**$25,700,000**
Total Target B Commitment in LTCPU			**$25,160,000**

Stream and Habitat Restoration Planning (BM1- BM9)

PWD has committed to implementing stream and habitat restoration along the TTF Creek from the Montgomery County boundary to the Juniata Golf Course, the beginning of the channelized portion of the waterway. This amounts to a roughly 3.4 mi length of stream to be evaluated for restoration.

In 2008, PWD contracted with an engineering firm to guide the long-term vision of aquatic ecological restoration work planned in the Tacony Creek Watershed. Over the next 20 years, PWD intends to implement natural stream channel and wetland design work along the 3.4 mi of the main stem of Tacony Creek within the City of Philadelphia. The anticipated benefits of this riparian corridor work will include reduced stream bank erosion, channel deposition and scour, restoring the natural functions of aquatic habitat and ecosystems to the greatest degree possible.

Additionally, in 2009 PWD worked with consultants to develop a vision for the TTF Creek Watershed as "Fertile Ground for a Destination Watershed: Laying the groundwork for restoring the TTF Creek corridor toward a vision of creek health and community wealth" (available online at http://www.phillyriverinfo.org). This vision covers the entire TTF Creek from its headwaters in Montgomery County through the confluence with the Delaware River.

Plunge Pool Removal (BM4)

In addition to Target A initiatives, the WRT also performs instream habitat restoration and plunge pool removal.

10.2.3.2 Cobbs Creek Watershed

The CC IWMP, completed in 2004, included a long-term commitment to Target B implementation measures (Table 10-6).

Table 10-6 The CCIWMP Commitment to Target B

Cobbs Creek Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Channel Stability and Aquatic Habitat Restoration			
BM1-BM3, BM6-9 Bed and Bank Stabilization and Habitat Restoration Wetland Creation and Enhancement		$41,000	$53,000,000
BM5 Improvement of Fish Passage			$150,000
Monitoring and Reporting			
BMR Monitoring, Reporting, and Further Study	$23,400 Annual		
Target B Total Annual Costs and Operations & Maintenance (2009 Dollars)	$23,400	$41,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$700,000
Total New One Time Costs for Target B			$53,000,000
Total Target B Commitment			**$54,300,000**
Total Target B Commitment in LTCPU			**$53,700,000**

Stream and Habitat Restoration Planning (BM1- BM9)

PWD has committed to implementing stream and habitat restoration along the Cobbs Creek from the Montgomery County boundary to the confluence of the Cobbs Creek with the Darby Creek. Though the Cobbs Creek forms the Philadelphia County boundary, PWD has committed to restoring both banks of the creek as it would not support habitat establishment to only implement restoration practices on the Philadelphia side of the creek. This amounts to a roughly 7.1 mi length of stream to be evaluated for restoration.

In 2008, PWD contracted with a team of consulting firms to guide the long-term vision of aquatic ecological restoration work planned in the Cobbs Creek Watershed. Over the next 20 years, PWD intends to implement natural stream channel and wetland design work along the main stem of the Cobbs Creek within the City of Philadelphia. The anticipated benefits of this riparian corridor work will include reduced stream bank erosion, channel deposition and scour and restoring the natural functions of aquatic habitat and ecosystems to the greatest degree possible.

Additionally, in 2008 PWD worked with consultants to develop a vision for the Cobbs Creek Watershed as "A Gateway to Many Places and to Cleaner Water" (available online at http://www.phillyriverinfo.org). This vision evaluated the Cobbs Creek corridor from the northern-most portion of the watershed within the City of Philadelphia including the East and West branches of Indian Creek all the way down to the confluence of the Cobbs Creek with the Darby Creek. This corridor was broken into seven segments – and each was evaluated for its own opportunities for habitat and recreational creation and enhancement.

Fish Passage on Cobbs Creek

The PWD is investigating the option of a project to create fish passage on the Cobbs Creek. The purpose of the Cobbs Creek Fish Passage Restoration Project would be to investigate, select, design and construct the best alternative to reestablish fish passage on Cobbs Creek. Two small dams represent opportunities to improve fish passage on Cobbs Creek. The lower dam, Woodland Dam, located close to the Cobbs Creek Parkway and Woodland Avenue, is the first impediment to fish passage on Cobbs Creek. It is a low concrete structure below which the creek is tidal. The upper dam, Millbourne Dam, situated on Cobbs Creek near 65th and Race Streets is a rock structure. Both dams are managed by the Fairmount Park. This currently is a potential project and will become an active project depending on available funding from sources including the U.S. Army Corps of Engineers.

10.2.3.3 Delaware and Schuylkill Rivers

Commitments set forth to address Target B in the Delaware Direct and Tidal Schuylkill Watersheds are described in Tables 10-7 and 10-8.

Table 10-7 Planning-Level Costs for Target B Options in the Delaware Direct Watershed

Delaware Direct Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Lowland Restoration and Enhancement			
BM6 Wetland Creation and Enhancement		$212,000	$25,000,000
Target B Total Annual Costs and Operations & Maintenance (2009 Dollars)		$212,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$3,700,000
Total New One Time Costs for Target B			$25,000,000
Total Target B Commitment			**$28,700,000**
Total Target B Commitment in LTCPU			**$28,700,000**

Table 10-8 Planning-Level Costs for Target B Options in the Tidal Schuylkill River

Tidal Schuylkill Watershed			
	Included in PWD Base Program	**New Annual Cost**	**One-Time cost**
Channel Stability and Aquatic Habitat Restoration			
BM5 Improvement of Fish Passage	$140,450		$300,000
BM6 Wetland Creation and Enhancement		$112,000	$14,200,000
Target B Total Annual Costs and Operations & Maintenance (2009 Dollars)	$140,450	$112,000	
Total Present Value of New Annual Costs and O&M (20 Years)			$2,000,000
Total New One Time Costs for Target B			$14,500,000
Total Target B Commitment			**$19,700,000**
Total Target B Commitment in LTCPU			**$16,500,000**

Tidal Wetland Restoration

Both the Delaware and Schuylkill Rivers are tidally influenced within Philadelphia's combined sewer area. Since there are few tributaries in the extremely urban drainage areas to the Delaware and Schuylkill Rivers, Target B focuses on habitat restoration along the main stem of these tidal rivers. Historically, freshwater tidal wetlands extended from Trenton, New Jersey to Chester, Pennsylvania, but urbanization has reduced the tidal wetland area by 95%, with only small remnants of freshwater tidal wetlands on the Pennsylvania side of the Delaware River.

In 2006 and 2007, aquatic biologists from the PWD conducted a field assessment of the inter-tidal areas in the Delaware and Schuylkill Rivers. Existing tidal wetlands and areas with potential for habitat enhancement and restoration were mapped. Existing vegetation within each of these areas was identified and recorded in a geo-spatial database. The locations for potential tidal wetland restoration and creation were selected when the following criteria were found in the tidal shores of the Delaware and Schuylkill Rivers:

1. Gradual slope to littoral shelf and appropriate depth range
2. Appropriate sediment characteristics
3. Ability for wave/wake attenuation

The inter-tidal assessment identified approximately 27 ac in the Delaware that need vegetative enhancement or invasive species removal. Another 61 ac in the Delaware and 30 ac in the Schuylkill have been identified as locations where conditions support creation or restoration. The identified sites are exposed during low tide as unvegetated mudflats and partially inundated during high tide. Restoration will entail introducing appropriate wetland vegetation into areas flooded to a maximum of 3 ft during high tide. The restoration of tidal wetlands and shoreline protection will improve the quality of water, as well as create vital habitat for aquatic life, herpifauna and migratory birds. Shoreline protection and wave attenuation is essential for the success of establishing tidal wetlands in this area. Additional studies will need to be conducted to assess the wave energy at each site. PWD will commit to creation/restoration of up to 60% of potential shoreline wetlands identified by PWD Aquatic Biologists.

Fairmount Dam Fishway

In addition to the tidal wetland restoration in the tidal Schuylkill River, habitat for fish species, especial migratory fishes, continues to be enhanced through the improvements of the Fairmount Dam fishway. The Fairmount Dam is situated within the Philadelphia City limits on Fairmount Park property. The fish ladder was constructed between 1977 and 1979 on the western side of the Fairmount Dam. The fish ladder has been maintained historically by the voluntary efforts of the Friends of the Fairmount Fish Ladder. The effects of time and natural forces damaged the fish ladder and the degradation severely limits the ladder's efficiency at passing migratory fish species. In 2002, the PWD partnered with the Philadelphia District Army Corps of Engineers to improve and revitalize the Fairmount Dam Fish Ladder, pursuant to Section 1135 of the Water Resources Development Act of 1986. By 2009, the fish ladder restoration project was completed, including the creation of an outdoor educational area adjacent to the fishway. The PWD will continue to monitor fish in the tidal Schuylkill River and passage through the Fairmount Dam fishway.

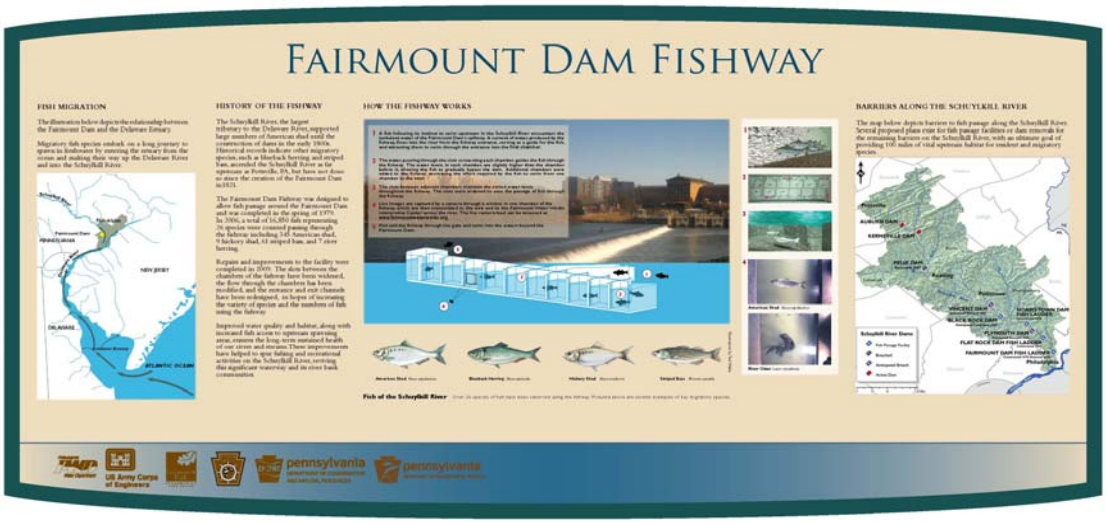


Figure 10-37 Fairmount Dam Fishway Interpretive Sign

10.2.3 Expansion of Wet Weather Treatment Capacity at WPCPs

The City's recommended alternative includes some traditional infrastructure to maximize the combined sewer overflow reduction benefits of the program. The expansion of wet weather treatment capacity at all three of PWD's existing water pollution control plants is recommended and includes the following commitments:

- Expansion of the Northeast Water Pollution Control Plant to include a 215 million gallon/day secondary treatment bypass
- Expansion of the Southwest Water Pollution Control Plant to include a 60 million gallon/day increase in secondary treatment capacity
- Expansion of the Southeast Water Pollution Control Plant to include a 50 million gallon/day increase in the secondary treatment capacity through process and hydraulic improvements

These plant upgrades will allow PWD to better utilize existing transmission capacity to capture and treat sewage.

These are complex projects that PWD has spent several years evaluating through the use of hydraulic and hydrologic computer modeling and facilities planning. Thus far PWD has obtained preliminary designs for these upgrades, but will work over the coming years to develop the necessary final designs, including detailed surveying and geotechnical investigations in order to move forward with construction of these upgrades. Results of preliminary planning are discussed in detail in Section 6.

Figure 10-38 Image of PWD's Southwest Water Pollution Control Plant

10.3 PERFORMANCE OF THE SELECTED ALTERNATIVE

Green stormwater infrastructure is efficient at reducing the volume of CSO and increasing percent capture of combined sewage. The selected alternative will result in both immediate and continuous progress in increasing percent capture, resulting in approximately 80% capture after 20 years. Figure 10-39 shows the percent capture by watershed after implementation of the recommended program, with percent capture ranging from a low of 79.4% for the Schuylkill watershed to a high of 80.3% for the TTF and Delaware watersheds.

The 80% capture represents a reduction in volume of CSOs of between 5.2 and 8.0 billion gallons per year, a significant decrease in the amount of combined sewage discharged to Philadelphia's waterways (Figure 10-40). This also represents a mean reduction in the duration of overflows of between 37 to 44 hours per year across all outfalls in the city, a one third reduction in duration of CSOs.

CSO frequency (average annual number of overflows per year) is best characterized as a range across all outfalls in a system. Figure 10-41 is an explanatory figure for box plots of this range, showing the percentiles represented by the symbols in the plot. Figure 10-42 shows the expected distribution of the frequency of overflows across all outfalls in the city's CSO system, by watershed, upon reaching the 20-year milestone of 34% of impervious cover managing the first inch of rainfall.

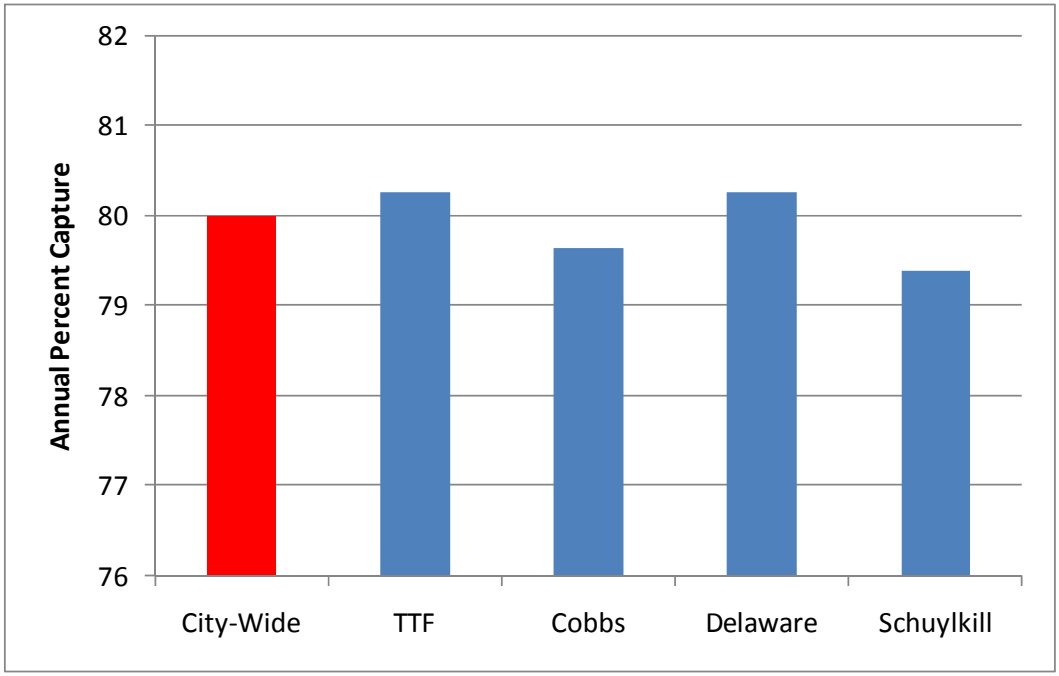


Figure 10-39 Selected Alternative Average Annual Percent Capture

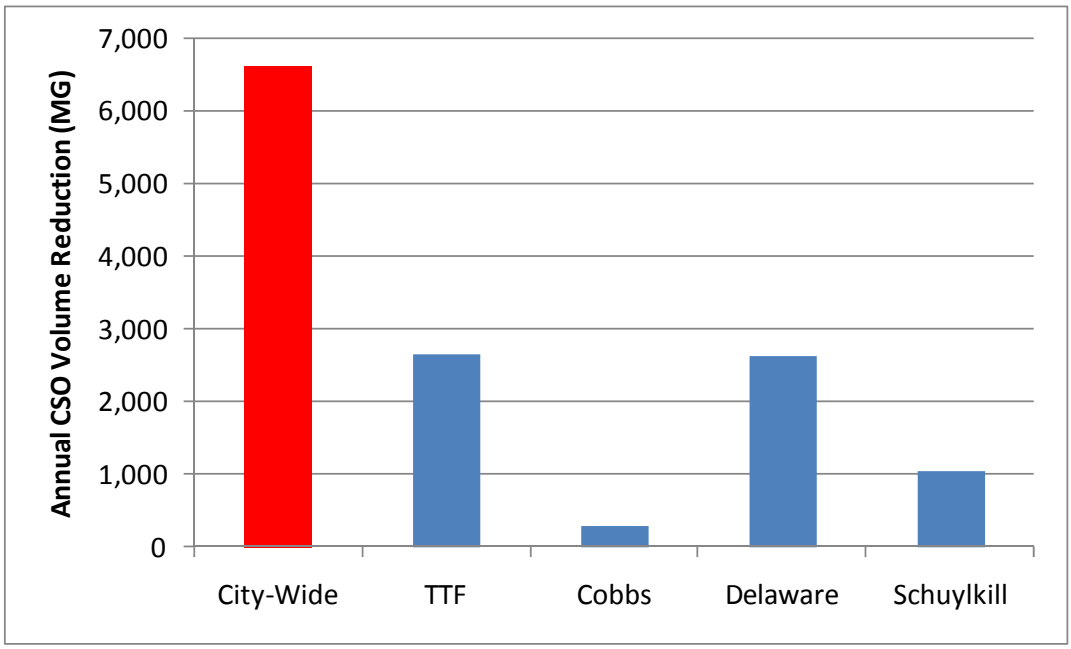


Figure 10-40 Selected Alternative Average Annual CSO Volume Reduction Relative to Baseline

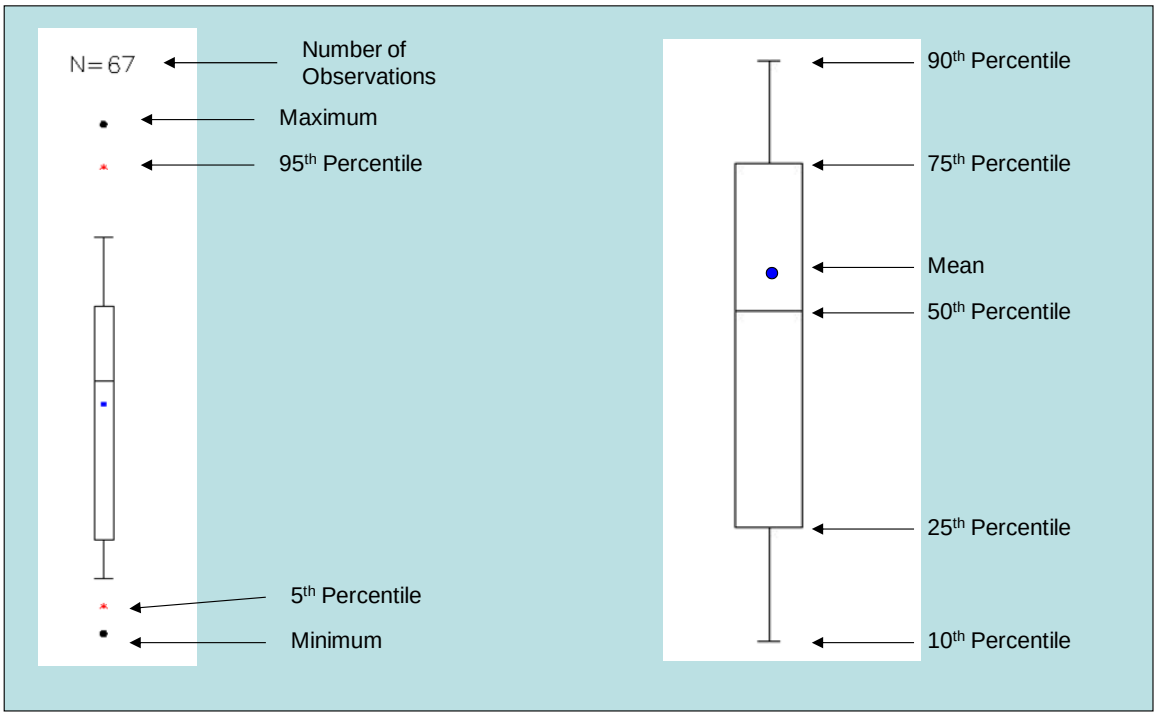


Figure 10-41 Explanation of Symbols Used on CSO Frequency Box Plots

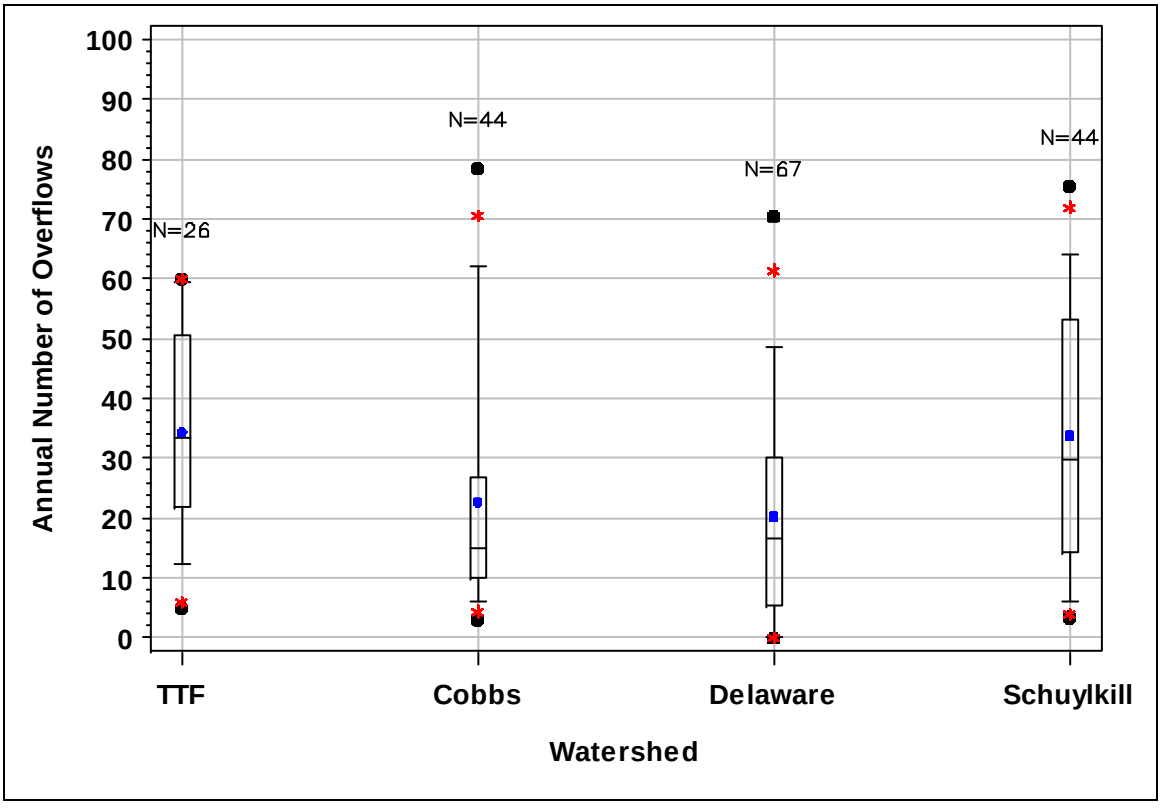


Figure 10-42 Selected Alternative Average Annual CSO Frequency at all Outfalls

10.4 INITIATING THE GREEN STORMWATER INFRASTRUCTURE PROGRAM

The Water Department will play a critical role in helping the City of Philadelphia achieve its goal to be the Greenest City in America. The City currently has the necessary building blocks for a greener future; it is a city of neighborhoods with walkable streets, a regional transit structure, a huge park system, success in revitalization of vacant lands and historically significant and ecologically valuable rivers. Fortunately, this plan coincides with and can support recommendations coming from a variety of city initiatives such as:

- A new Zoning Reform Commission Report to rethink the zoning that has trapped the city in 20th century development patterns
- New stormwater regulations that redefine the way the city addresses stormwater
- A community-driven vision and a series of plans to redevelop the waterfronts of the Schuylkill and Delaware Rivers to attract visitors and residents
- An ambitious GreenWorks program that recognizes the many benefits of green urban space and the need for city agencies to collaborate
- Numerous smaller scale initiatives focusing on sustainability, green jobs creation, neighborhood beautification, and urban agriculture

Together these inter-related initiatives will help realize Philadelphia's ambitious green vision. The co-benefit of these programs – human health, aesthetics, ecological restoration, economic growth and a more vibrant city – are significant and real. PWD's challenge is to instill green stormwater infrastructure into design, construction, operation and maintenance of the City's systems (transit, streets, universities, schools); to grow and nurture the City's natural systems (parks, rivers, streams, wetlands); and to protect public health systems.

The first five years of implementation of the *Green City, Clean Waters* program will prove to be the most critical in terms of putting the mechanisms in place that will support the program over the years to come. These first years will focus on establishing the framework and building the momentum that will launch innovative programs that cross city agencies as an everyday standard. In the initial 5-year period, PWD intends to meet a 5-year benchmark for converting impervious cover to greened acres of between 1600 and 1700 ac of the combined sewer drainage area. This will require a significant effort, and will include many "organizational" steps.

LEED Certification

PWD will evaluate LEED Certification and their allocation of credits to the various components of the certification program in order to assess whether they believe that enough weight is being given to the stormwater component. If determined insufficient, PWD will consider working with the United States Green Building Council (USGBC) to evaluate the potential for redistributing these credits in order to make stormwater management a more important component of this certification.

Watershed Partnerships

One of the benefits of having watershed partnerships already established is that PWD already has trusted relationships with their suburban neighbors. This should prove beneficial as the City begins to explore opportunities for regional cooperation and permitted/contractual relations are updated. Another component might involve further evaluation of the City's wholesale contracts with outside communities in light of potential Infiltration & Inflow issues.

Risk Analysis

Ensuring the health of Philadelphia's citizens is paramount. Within this initial 5 years of the implementation period, PWD will investigate the risk associated with recreational use of the City's waterways as they relate to CSO discharges. The City will not only evaluate currently utilized recreational locations, but also areas likely to become recreational locations in the future as the riverfronts are redeveloped and public access is improved. Related to this investigation, PWD may initiate a Water Quality Standards Attainment Review, but do this in a way that respects the public's very basic desire for streams that look good and are without odor.

Regulatory and Policy Roadblocks

PWD will also begin to evaluate the regulatory and policy related changes that will be needed over the coming years in order to support the greening of the City that is envisioned. This includes the evaluation of the City's Plumbing Code, Zoning Code, Licenses and Inspections and Planning Department requirements. PWD will also consider working closely with the development community to better understand current obstacles to green development within the City.

Interagency Cooperation

PWD is laying the groundwork for partnerships with the Philadelphia Housing Authority, The Office of Housing and Commercial Development and private developers. At minimum, the current stormwater regulations ensure all new large development will move towards PWD's goal of green acres, but building partnerships will help us exceed minimal standards and look for cost-effective opportunities to maximize green elements. With each new development, opportunities to increase the amount of green stormwater infrastructure can be evaluated. Assuming a redevelopment rate of 1% per year, 5,000 to 6,000 ac within the combined sewer system drainage will be converted from impervious acres to greened acres during the 20 year program.

Another important partnership that will develop as a result of this program is between PWD, Philadelphia Industrial Development Corporation (PIDC), Department of Commerce and Special Districts such as Center City District. These partnerships will help transform the commercial corridors and business parks in the City. Adding stormwater management to the existing beautification projects could reduce overall maintenance costs, calm traffic and add beauty to corridors. The greener, safer corridors could draw new customers and retailers, creating additional local and green jobs which would in turn promote safety in the City.

Some of the largest landowners in Philadelphia include Institutions of health, learning, and worship. Many of these campuses such as hospitals, universities and churches have already been leading the field of environmental sustainability. Not only can they easily incorporate greening into their mission, they are often willing to go far beyond required stormwater management. This means a few property owners can transform the City in a big way.

These are just a few examples of the many exciting developments and synergistic relationships budding in Philadelphia. As the city grows its green identity, more residents will be drawn to move into Philadelphia. When the City flourishes, it will increase base revenue for PWD to support more greening, drive up property values, and enhance awareness of the benefits of green stormwater infrastructure, creating a positive feedback loop that helps the program thrive. The greening of Philadelphia benefits the environment as a whole. Since existing cities can provide homes to a greater number of people with an overall smaller ecological footprint, this approach protects further development in areas in the headwaters of the City's watersheds.

10.5 MEETING THE PROGRAM COST

As previously described, a financial capability assessment for the City of Philadelphia's Long Term Control Plan Update was prepared using criteria suggested by the US EPA (see Section 11). The US EPA's approach calls for an evaluation of costs of the proposed improvements against Philadelphia citizen's median household income. In general, the US EPA considers wastewater costs above two percent of median household income to be an unacceptable cost burden to ratepayers. Implementing the LTCPU selected alternative will require PWD to spend an estimated $1.6 billion at the end of the twenty year implementation period ($1.0 billion in 2009 dollars). Based on this estimate and implementation schedule, the affordability assessment determined that the LTCPU would result in a cost to City of Philadelphia residents well above the upper limit of US EPA's median household income economic burden criterion.

In order to maximize effectiveness of this PWD investment, preliminary policy structures have been put in place over the past 10 years since the original LTCP was adopted by the City of Philadelphia to help leverage a great deal of additional funding toward its Clean Water Act commitments. These are structures that PWD instituted and programmatically supports, but for which the majority of greened acres will not be paid for by PWD's rate payers.

The first and most significant source of leveraged dollars comes from the development community. Because of the City's updated stormwater regulations adopted in January, 2006, every development/redevelopment project initiated within the City limits with an area of disturbance greater than 15,000 ft^2 must manage the first inch of runoff from the site – which is the same measure that PWD is utilizing for their greened acres concept. There are many areas of the city ready for redevelopment, including areas of abandoned or substandard housing, abandoned industrial areas, or outdated commercial facilities. High priced and ever scarcer energy is changing the way Americans live, making older urban centers more and more attractive places to live and work. As a result, the rate of redevelopment in the city is expected to impact 1% or more of the city's impervious cover each year. Making all redevelopment projects contribute to a greener city will be critical to meeting ambitious green stormwater infrastructure goals. With a city-wide redevelopment rate of roughly 1% annually, PWD sees an additional roughly $1.1 Billion dollar investment in 2009 dollars being applied toward the City's greening goals.

Another policy related tool that will help to achieve additional greened acres city-wide is the new Parcel Based Billing Initiative, which has resulted in a stormwater rate reallocation, to be phased in over the coming years. This reallocation has impacted some customers much more than others – at times causing the monthly water bill to increase 4-fold or more. PWD has been targeting these customers with a program aimed at evaluating the Top 50 parcels affected by the rate reallocation in order to evaluate them for potential achievement of "stormwater credits" on their utility bill resulting from retrofits on the property to manage the first inch of runoff. This program involves the offer of free design assistance and site evaluation by a PWD contractor in order to identify potential stormwater management opportunities that might exist on the site – and to perform a cost-benefit analysis in order to help the property owner to weigh the cost of the retrofit against the annual savings on the water bill. PWD believes that the rate reallocation will result many of these large parcels being retrofitted to manage the first inch of runoff – producing additional greened acres.

10.6 ADAPTIVE MANAGEMENT WITH DECISION POINTS

PWD's selected alternative is an innovative, decentralized approach to CSO control. As such, it will need to be carefully monitored and adjusted as needed to ensure success. Thus, the proposed approach for implementation is adaptive management of the program, with specified decision points where course corrections are possible. PWD's proposed adaptive management includes:

- Taking near term actions to improve water quality
- Experimenting with a variety of green stormwater infrastructure tools aimed at meeting water quality objectives
- Data collection and analysis on initial projects
- Reassessment of appropriate actions and adaptation of the program to improve effectiveness at pre-determined decision points

The recommended plan elements have preliminary milestones – including percentage of impervious cover within the CSS drainage area managed utilizing the various green program elements. These implementation tools will be periodically adapted, as needed, based on information about these elements of the program as implementation proceeds. PWD will utilize newly acquired information to steadily increase the cost-effectiveness of the program to achieve CSO control objectives.

10.6.1 Adaptive Management Rationale

A traditional CSO approach based solely on tanks and tunnels can often be completed within a 20-year timeframe to achieve the targeted number of overflows per year. With a limited number of large scale projects, this approach does not warrant adaptive management implementation, but would rely on more standard project management techniques. PWD believes, however, that the traditional approach no longer meets today's environmental and social goals, nor is it affordable and cost effective. Some of the most obvious shortcomings of the traditional approach when applied to Philadelphia are:

- Even at a cost of more than twice the affordability limit for the city, it only represents a partial solution that will not address water quality in all the watersheds
- Does not allow the city to simultaneously address water quality in the non-CSO areas in an integrated program
- Does not coincide with social programs focusing on the creation of entry level green collar jobs
- No longer matches with US EPA's broader goals of sustainability, consuming significant energy on an annual basis for as long as the tunnels and tanks are used
- Reduces stream baseflow, thus damaging the very habitat the program is designed to protect
- Does not offer the significant secondary benefits associated with a Triple Bottom Line accounting that a green stormwater infrastructure program would offer
- Benefits to water quality only start at the completion of the projects (15 to 20 years in the future)
- Once completed, it is a static solution with fixed benefits which cannot be easily adapted to changing conditions or the challenges imposed by climate change

As an alternative, the mixed approach of combining green stormwater infrastructure with targeted traditional infrastructure provides numerous benefits and advantages, including:

- Improving the natural resources of the city
- Enhancing the community through the development of new standards in sustainable urban design
- Providing significant improvements to air quality, waste product reuse, urban heat island mitigation, carbon sequestration, and energy conservation
- Offering the flexibility for continuous improvement and change to meet the challenges of climate change as new technologies are developed and existing approaches are refined through experience
- Immediate benefits from the start of the program, with benefits continuously increasing over time
- Offsets the considerable cost of the program with significant social and environmental benefits that have almost comparable dollar value to the cost

Because the program is innovative, based on multiple, small scale projects carried out by a variety of responsible agencies and parties, it will need to be implemented using the principles of adaptive management, as discussed in Section 5.

10.6.2 Adaptive Management Action Plan and Interim Milestones

The adaptive management action plan provides for progress tracking and reporting every 5 years, with actual progress compared to expected progress at each 5-year decision point. This is shown in Figure 10-43. Overall, the program is expected to control runoff on 34% of impervious cover after 20 years.

At each 5-year assessment point, progress will be compared to the following expected milestones:

Year 5:

- A target of 5.5% impervious cover managed, including design and construction of at least one project in each of the green program categories
    - 144 ac of impervious cover transformed to greened acres by PWD
    - A plan update for the most efficient green stormwater infrastructure projects to achieve the year 10 milestone
- 6 mi of interceptor rehabilitated/relined
- 2 mi of streams restored
- 10% of water pollution control plant treatment upgrades completed
- Budgeted dollars expended by target date: $47.2 million

Year 10:

- A target of 13.3% impervious cover managed through green stormwater infrastructure projects using projects in each of the green program categories deemed cost effective
    - 804 ac of impervious cover transformed to greened acres by PWD
    - A plan update for the most efficient green stormwater infrastructure projects to achieve the year 15 milestone.
- 7 mi of interceptor rehabilitated/relined
- 4 mi of streams restored
- 30% of water pollution control plant treatment upgrades completed
- Budgeted dollars expended by target date: $382.7 million

Year 15:

- A target of 22% impervious cover managed through green stormwater infrastructure projects using projects in each of the green program categories deemed cost effective
    - 1,064 ac of impervious cover transformed to greened acres by PWD
    - A plan update for the most efficient green stormwater infrastructure projects to achieve the year 20 milestone
- 4.5 mi of streams restored
- 65% of water pollution control plant treatment upgrades completed
- Budgeted dollars expended by target date: $862.1 million

Year 20:

- A target of 34% impervious cover managed through green stormwater infrastructure projects using projects in each of the green program categories deemed cost effective
    - 2,012 ac of impervious cover transformed to greened acres by PWD
- 100% of water pollution control plant treatment upgrades completed
- Budgeted dollars expended by target date: $1.621 billion

In addition to the 5-year reporting periods, PWD will leave open the possibility to incorporate smaller adaptive management changes within each annual report to suggest and implement minor adjustments to the program by re-setting the percentages of targeted impervious cover within the individual green program elements, by considering design changes to increase storage at some of the green stormwater infrastructure sites, or adjustments to the stream restoration and dry weather flow options.

10.6.3 Meeting the Affordability Challenge

Over time, factors such as household incomes; energy, raw material and labor costs; and the cost of capital tend to revert to long-term trends. However, history shows that economic conditions and financial markets can be extremely volatile from year to year. In a given year, this volatility can have a significant impact on the financial capability of a community to finance public infrastructure improvements without economic hardship. In Combined Sewer Overflows: Guidance for Long Term Control Plan, US EPA provides a prescriptive formula for calculation of financial capability. By fixing assumptions for economic and financial variables over the planning period, this guidance does not allow a utility any flexibility to adapt to changing economic circumstances.

A flexible, adaptive approach to financial capability analysis will be considered to maximize PWD's chances of success in implementing its chosen program. Periodically, PWD proposes to reassess its affordability and financial capability analysis in light of any new information. Local economic conditions will be assessed including changes in household income, revenue, capital spending in response to new regulations or requirements, construction and operating costs, and PWD's financial position and cost of capital. Adjustments to the program will be considered to either increase the rate of progress toward goals or decrease spending to avoid economic hardship.

10.6.4 Monitoring and Evaluation Plan

In order to carry out the reassessments every five years, data and information on the progress of the selected alternative will be gathered, with the information provided in annual reports. The data and information will be analyzed and compared to expected benchmarks every 5 years, with the results used to adjust the program as needed and to provide the plan update for the following 5-year period.

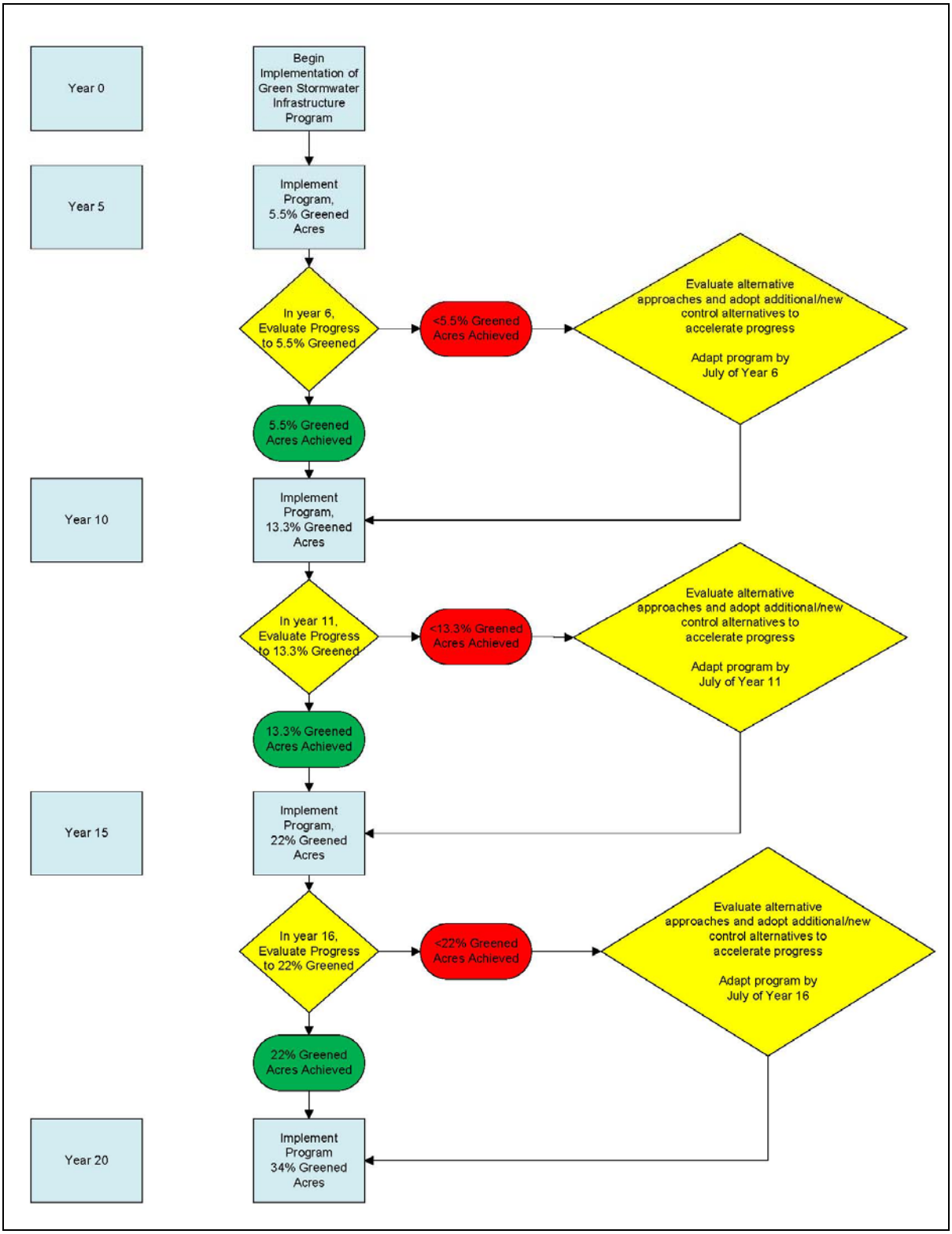


Figure 10-43 Flow Path of Decision Points

10.6.4.1 Project Progress Monitoring

Long-term monitoring of combined sewer flows is the key to verifying that green stormwater infrastructure is performing as expected. When implemented on a large scale, green stormwater infrastructure is intended to alter the urban water budget to a state more similar to a natural system such as a forest or meadow. Rain that falls on this altered system can take one of three main pathways – interception by vegetation or depression storage on impervious surfaces, leading to eventual evaporation; infiltration into soil, leading to eventual uptake and transpiration by plants, or continuation to groundwater recharge; or direct runoff to the combined sewer system. Of these three pathways, stormwater flows in the combined sewer system are the easiest to monitor. Evapotranspiration and infiltration are difficult to measure in the field, particularly on a large scale.

The process for verification of long-term green stormwater infrastructure performance compares measured stormwater volumes to those predicted by PWD's calibrated hydrologic and hydraulic model. A model is necessary to estimate what the runoff volume would have been during the monitored period if no controls had been implemented. First, sewer flows are monitored downstream of a catchment containing significant green stormwater infrastructure. These flows are separated into their components – base wastewater flow, groundwater inflow, and stormwater – using the tools described in Section 5. This process establishes an estimate of stormwater runoff that occurred during the monitored period. Second, PWD's calibrated hydrologic and hydraulic combined sewer system model is run using measured precipitation for the same period covered by the sewer monitoring data. A simulation is run with a condition that matches the amount of green stormwater infrastructure actually implemented to date. To determine the effectiveness of the controls, measured runoff is compared to runoff predicted by the model. Controls are performing as expected when the measured water budget is similar to the water budget predicted by the model, within a reasonable range of uncertainty inherent in both the measured and modeled results.

In addition to using the models to assess green stormwater infrastructure effectiveness, PWD will monitor the progress of planned projects covering the entire range of green stormwater infrastructure projects, as well as any traditional storage and treatment capacity projects planned as part of the selected alternative. General categories of information to be collected to monitor project progress include:

- Lists of completed stormwater control projects, types of controls implemented, and area of impervious cover managed by each project
- Expenditures and maintenance actions carried out during the 5-year periods including miles of sewers relined
- Maps of stream channel, riparian corridor, or other ecological restorations carried out, including acreage improved and expected habitat improvements
- Total acres of impervious cover managed by watershed, compared to the expected acres from the prior 5-year Plan update
- Miles of streams restored compared to the schedule and target number of miles restored within each watershed

PWD will provide an Evaluation Plan every 5 years. The Evaluation Plan will review monitoring results and milestone attainment every year, list projects completed, and acreage of impervious cover managed. The Plan will discuss any revisions to the original implementation schedule including which planned actions were not implemented and why they were not implemented. The Evaluation Plan will then provide alternative directions and adaptation strategies for those projects and measures that are proving less effective or more difficult to implement than originally anticipated.

With eight green programs to choose from at differing levels of implementation, the distribution of projects, types of projects, and designs will be adjusted to meet the next milestone as needed.

10.6.5 Green Stormwater Infrastructure Maintenance

Because of the dispersed nature of the green stormwater infrastructure, it will be important to develop a maintenance plan to ensure that the green stormwater infrastructure projects operate according to design and that they continue to operate and provide the storage, infiltration, and evapotranspiration for their useable life. Maintenance of green stormwater infrastructure is relatively simple, but is specific to the type design. PWD has developed a BMP manual that provides guidance for maintenance of urban stormwater best management practices. This manual, and subsequent updates, will provide the guidance for maintenance of all green stormwater infrastructure practices that are part of the LTCPU.

Typical maintenance activities might include:

- Mowing and/or trimming of vegetation
- Periodic inspection of vegetated planters or strip components expected to receive and/or trap debris and sediment for clogging and excessive debris and sediment accumulation;
- Periodic inspection of vegetated areas for erosion, scour, and unwanted growth. Unwanted growth (*i.e.*, invasive species) should be removed with minimum disruption to the planting soil bed and remaining vegetation.
- Inspection of level spreading devices or inlets for trapped sediment or other flow impeding conditions
- Raking of filter media surface for the removal of trash and debris from control openings
- Inspection of filter media for standing water (filter drainage is not optimal) and discoloration (organics or debris have clogged filter surface)
- Removal of the top few inches of filter media and cultivation of the surface when filter bed is clogged
- Cleaning out accumulated sediment from storm inlets

PWD has planned for over $100 million in operation and maintenance expenditures for green stormwater infrastructure as part of the overall cost of the program. This money will be used to fund maintenance activities over the 20 year implementation period and establish mechanisms for this to continue far beyond. But PWD's green stormwater infrastructure program is a composite of public and private initiatives, and its plans for maintenance should take advantage of this. To this end, a neighborhood approach to maintaining green stormwater infrastructure such as rain gardens, street trees, planters, porous pavement, and green roofs is proposed and will be evaluated. PWD will work with existing and to be formed special, neighborhood service districts to develop, train, and keep staff for these important tasks. These districts can also include cooperation of major universities for certain areas of the city.

A critical link in integrating the green stormwater infrastructure program with Philadelphia's ambitious sustainability goals is to use green stormwater infrastructure to stimulate the creation of Green Collar jobs to perform these maintenance functions. This will entail working with City Government job creation programs, as well as NGOs such as the American Cities Foundation.

10.6.6 Assessment of Attainability of Water Quality Standards

PWD's *Green City, Clean Waters* program is not just aimed at achievement of water quality standards compliance, but also to achieve the true end goals of the Clean Water Act: to have healthy streams where aquatic life can prosper; to make these streams pleasant, accessible and safe when people are recreating in and around them; to protect, preserve and maintain these streams against the challenges of sedimentation, erosion and the careless disposal of trash; to improve the riparian habitat and to make stream corridors a great asset for everyone to enjoy.

The watershed approach, recommended by the National CSO Control Policy, addresses all these issues confronting urban streams - in dry and wet weather - whether they fall within or outside the direct control of the Clean Water Act. The approach allows PWD to consider all of the societal and environmental benefits and impacts. In Combined Sewer Overflows: Guidance for Long Term Control Plan, US EPA encourages permittees "to consider innovative and alternate approaches and technologies that achieve the objectives of the Policy and the Act." PWD's watershed-based, green stormwater infrastructure-focused approach to address CSOs accomplishes exactly that.

Therefore, PWD has viewed its CSO LTCPU, as it has all of its Non-Point Discharge Elimination System (NPDES) permits and other obligations, as elements within the context of a far broader integrated watershed management approach. The IWMPs were crafted after extensive input from the community and numerous stakeholders. The goals, and the strategies employed to achieve them, go well beyond nominal compliance with Water Quality Standards and look to achieve a broad array of environmental and societal goals that the community values and respects.

The National CSO Control Policy recognizes the site specific nature of CSOs and their impacts and provides the necessary flexibility to tailor controls to local situations. PWD believes it will be able to demonstrate that after the LTCPU has been implemented it will have achieved not only the broader endpoints of the ambitious goals contained in the IWMPs but also the more narrowly focused compliance with the health risk goals of Water Quality Standards. PWD believes that after implementation of the LTCPU it will be able to demonstrate that the level of protection provided by the Water Quality Standards has been achieved.

PWD has begun a preliminary study to document recreation occurring along waterways and potential health implications of that recreation. PWD would like to develop this data in a more comprehensive fashion and looks forward to working with US EPA, PADEP and local Health Department authorities in planning and conducting further studies.

While PWD believes that the protective goal of the Water Quality Standards can be achieved, it recognizes that there is a possibility that achieving this goal may take longer than 20 years. Should additional time be needed to achieve wet weather water quality goals, PWD will work with PADEP in developing a Water Quality Standards Attainment Review to review and possibly revise the Water Quality Standards.

10.7 IMPLEMENTATION SCHEDULING

A number of factors are considered in deciding how watershed and combined sewer overflow management measures will be implemented over the long term. Factors include continuing implementation of the Nine Minimum Controls, high-priority areas and activities, public input, financial capability, and logistical factors. Implementation is phased to begin realizing environmental, social, and economic benefits as early in the program as possible. Finally, it is important to identify all the entities involved in implementation and define the role that each will play.

The scheduling approach first considers priorities expressed by PWD, regulatory agencies, public, and watershed partners as follows:

- Priorities expressed by the public, by watershed partnerships, or in IWMPs will be considered
- Implementation of measures to improve water quality, aesthetics, and recreational opportunities in dry weather will begin early in the process
- Restoration of living resources (including stream and stream corridor restoration) will begin early in the process
- Implementation of green stormwater infrastructure will begin immediately. Environmental, social, and economic benefits of these investments in Philadelphia's neighborhoods will begin to accrue from the first day of program implementation
- Projects will be scheduled to complement other urban greening and redevelopment projects occurring throughout the drainage area. For example, green stormwater infrastructure might be installed at a school when the school district is conducting major renovations or landscaping
- Relocation of a PWD outfall might take place concurrently with construction of a waterfront trail or development by another entity

For each management option, implementation is broken down into a number of steps:

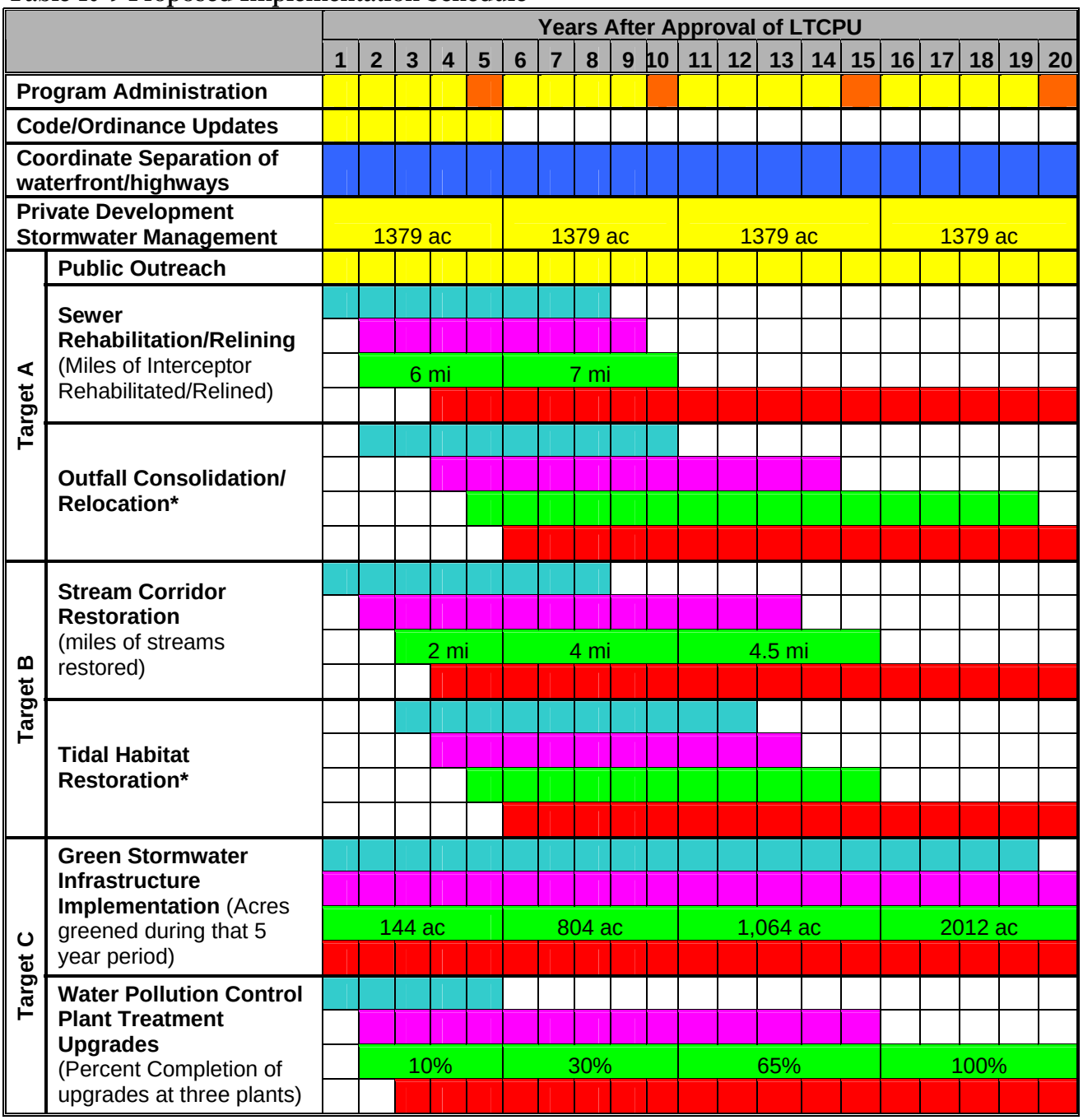
- Research, development, and demonstration: For green stormwater infrastructure and other innovative technologies, research best practices and examples from peer cities nationally and internationally. Design, construct, build, and monitor projects on a small scale, then apply lessons learned on a larger scale
- Develop standard details and specifications: For green stormwater infrastructure, develop standard details and specifications that can be replicated on a large scale with only minor modifications
- Review and revise local codes, ordinances, and policies: Review codes and ordinances that present unnecessary barriers to green stormwater infrastructure. Examples may include plumbing and building codes and ordinances governing the public right-of-way. Identify and work to resolve barriers to green stormwater infrastructure implementation on private land or through public-private partnerships. Develop interagency agreements between relevant public agencies and authorities
- Facility planning and site investigation: For traditional infrastructure, acquire more highly detailed information needed for detailed design. Examples include geotechnical investigations, detailed modeling of hydraulics and siting of structures
- Site-specific design: For infrastructure projects, develop detailed plans and specifications needed to construct a system. For green stormwater infrastructure, this step may consist of modification of standard details and specifications

- Permitting and land acquisition: For structural projects and stream restoration, acquire necessary environmental permits. Acquire land for structures if necessary
- Construction: For structural projects, oversee the bidding process, arrange financing, give notice to proceed, and oversee construction
- Operation: For structural facilities, operation begins after completion of construction. For many nonstructural practices, operation is ongoing throughout the life of the project
- Review of private redevelopment plans and enforcement of stormwater ordinance: Throughout the implementation period, PWD will continue to oversee implementation of its stormwater regulations following redevelopment of private lands

A proposed schedule of implementation for the structural elements of the LTCPU is presented in Table 10-9. The implementation schedule sets Philadelphia on a path to achieve the goals of the IWMPs. Along this path, unexpected events will occur and the schedule may have to be adjusted accordingly. The following list summarizes a range of uncertainties that may affect the implementation schedule:

- Changes to the Clean Water Act, National CSO policy; US EPA, PADEP, or Delaware River Basin Commission rules, regulations, or water quality standards
- Changes to PWD's CSO NPDES permits
- Additional regulatory requirements imposed on PWD, and funded by its rate payers, such as Safe Drinking Water Act regulations, TMDLs, changes to the NPDES MS4 Permit, or capacity management requirements
- Consent orders or agreements
- Economic conditions, changes in rate payer income, changes in the financial condition or bond rating of PWD, borrowing costs
- Construction cost escalation
- Timing of permits and land acquisition for construction of facilities
- Additional findings of the facilities planning or detailed design stages

Table 10-9 Proposed Implementation Schedule



* Implementation schedule subject to coordination with riverfront redevelopment

- On-going Implementation
- Reporting Milestones
- Coordinate and Schedule with other entities
- Facility Planning and Site Investigation
- Design
- Construction
- Operations & Maintenance