2012

Building a Rain Garden to Address Stormwater Management in the English Park Section of the Morris Arboretum

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An independent study project report by The Alice and J. Liddon Pennock, Jr. Endowed Horticulture Intern (2011-2012)

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Abstract

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The first objective of this project is to provide infiltration of stormwater runoff near the Hillcrest building by installing a rain garden. The rain garden will reduce erosion, flooding, and revitalize the aesthetic value of the area while providing an education component to incorporate learning opportunities. Currently, stormwater enters the garden along Hillcrest Avenue near the Hillcrest building and moves over the pavilion driveway and down the hill washing out the garden beds along the way. Erosion and flood control are the main objectives that will be met by this project. Cleanup from floods calls for many hours of work by maintenance and horticulture staff in addition to outside contractors. Diverting some of this stormwater runoff to a rain garden would reduce impact and damage, thereby decreasing the amount of time spent cleaning up after large rain events.

The second aspect of this project is improving the aesthetic value of the area near the Hillcrest building. Revitalizing the garden beds and installing a rain garden will bring new interest to this vicinity. I plan to use low maintenance native plants appropriate for the ephemeral waves of flooding. Furthermore, I will repeat the plantings in the surrounding beds to create a node of unified plants.

Finally, I would like to tie in an educational component highlighting the rain garden's capacity to reduce runoff and demonstrate a passive technique for addressing stormwater runoff. This will include interpretive signage and an educational lesson to be used by the volunteer guides.

Disciplines

Horticulture

Comments

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Date: **March 2012**

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INTRODUCTION

The Wissahickon Creek watershed includes 64 square miles, covering 15 municipalities in Montgomery County and Philadelphia County. The Creek originates in Montgomery Township and flows for 27 miles to the Schuylkill River (Philadelphia Water Department [PWD] Office of Watersheds, 2011). The Morris Arboretum, located within the Wissahickon watershed, is situated in one of the lowest points of the watershed basin [Figure 1]. Naturally, during rain events, water moves to the lower points of the watershed. In developed areas, this surge of water often exceeds the amount of water able to naturally infiltrate the ground. As a result, street drains and sewer systems are overwhelmed and excess water overflows into nearby streams (Stormwater PA, 2011). The Environmental Protection Agency defines stormwater runoff as excess water generated when precipitation flows over land or impervious surfaces and does not percolate the ground (Environmental Protection Agency [EPA] Office of Wastewater Management, 2011). A majority of stormwater runoff can be traced to a specific place (e.g. a building rooftop, paved parking lot, etc) where it's considered point source runoff. In situations where a considerable amount of runoff is generated, a National Pollutant Discharge Elimination System permit (NPDES) is required. An NPDES permit holder can allow a designated amount of storm water flowing off their permitted property. Generally, NPDES permit holders are limited to municipal separate storm sewer systems, construction activities, and industrial activities such as large scale agriculture, mining, landfills, waste management facilities, and power plants. While residential locations and most business operations do not require this permit, a recent addition of a specific stormwater fee was implemented by Philadelphia Water Department in 2010. Prior to 2010 the stormwater fee was lumped together as part of the sewer service charge.

Beginning in fiscal year 2010, PWD designated a revised stormwater fee to all customers' bills. The money from this added charge goes toward funding grants and loans in a stormwater incentive program**.** Originally based on meter usage, the fee is transitioning to a parcel size based cost to be fully implemented by 2014. The new system takes into account the gross area and impervious area of a property. This fee revision provides a more accurate system of billing based on impervious surface. Before the revision, a residential property was being charged the same amount in stormwater fees as a large, paved parking lot for example. Based on just size and amount of paved surface, the parking lot is producing significantly more runoff and is now billed accordingly. For example, of the 45 inches of average rainfall in Philadelphia, undisturbed land has 8 inches of runoff while paved land has 43 inches of runoff (Pennsylvania Department of Environmental Protection, 2006). This represents the great deal of stormwater runoff the city is required to handle within the sewer systems.

With the stormwater fee, residential properties are charged a uniform amount of $13.66 based on a city wide average of residential lot size and impervious characteristics. Non residential properties are charged based on property size. From July 1, 2011 to June 30, 2012, the Arboretum is expected to pay $2,887.72 in stormwater fees. By June 30, 2014, that fee will level out to $5,775.44 per year. Based on the Water Department's records, the Arboretum includes a gross area of 3,583,479 square feet and an impervious area of only 238,199 square feet (PWD, 2011). Fortunately, PWD offers a stormwater crediting program, as part of the new stormwater fee program, which incentivizes property owners to manage and retain stormwater running off their properties.

The Arboretum has utilized stormwater best management practices for many years. Some of the stormwater best management practices already in place at the Arboretum include the pervious parking lot with recharge bed, green roofs and cistern capturing system at the Horticulture Center, pervious pathways and water capturing and recharge system at the Pennock Garden, and the underground infrastructure managing stormwater from the driveway and Meadowbrook Ave. In December 2011, the Arboretum hired an engineer to evaluate the garden's stormwater management techniques in order to apply for stormwater credits. The report was submitted to PWD in December 2011 for review [Figure 2]. PWD will determine what measures are sufficiently mitigating the effects of stormwater on the garden's property and issue credits, reducing the annual stormwater fees.

STORMWATER PROBLEM

At the Arboretum, stormwater flowing into the garden does not stem from a point source [Figure 3]. While there are multiple points where water flows into the garden via natural waterways, there are several unintended entrance points along Hillcrest Avenue. Tracking stormwater from its original source and managing its flow is not always possible. Hillcrest Avenue, on the southeast boundary of the garden, serves as a channel for large amounts of stormwater flowing from many different outputs. Additionally, Hillcrest Avenue has been repaved several times over the past decades. Each time the road is repaved, the ratio of the street to gutter diminishes. With a reduced gutter, stormwater has less space to be moved into the street storm drains. This excess stormwater enters the garden in several spots along the road, including at the Hillcrest building, creating numerous problems as a result.

Some of the problems caused by stormwater runoff near the Hillcrest building include flooding in the building and damage to garden beds from channeling water. In 2011, Hurricane Irene and Tropical Storm Lee hit the Arboretum within two weeks of each other. While these two instances are extreme cases, the Arboretum sustained considerable damage from stormwater, essentially. The total insurance claim from both storms totaled approximately $218,000. About $97,000 of that was associated with stream work rebuilding, $87,000 for streambed stonework, and $10,000 for cleanup at the Hillcrest building.

The garden area around the Hillcrest building suffers from significant stormwater runoff. As precipitation averages increase, the problems associated with stormwater are also amplified. Hourly rainfall depths have gradually increased in frequency over the past decade [Figure 4]. In 2011 the greater Philadelphia area experienced a surge in heavy rain events at 64.33 inches making it the wettest year in recorded history. From 1981 to 2010 the annual average was 41.49 inches. August 2011 set the record for the wettest month with 19.31 inches (National Oceanic and Atmospheric Administration, 2012). As rain events intensify and become more frequent, best management practices need to be in place to address the stormwater runoff to come. One method of mitigating runoff is by installing a rain garden. Rain gardens are flexible in design and can be incorporated into a variety of landscapes.

HISTORY

While management of rain water was not the intended purpose of early "water gardens" at the Morris Arboretum, these varied habitats provided a unique approach to ornamental horticulture. Early records of water gardens in the Morris Arboretum date back to 1959. In the Morris Arboretum Bulletin (Vol. 10 Number 2) a reference was made to a new bog garden. It stated, "Preparation of a small bog garden where for the first time we shall be able to grow plants which require acid bog conditions" (Arboretum Activities, 1959). The bog garden was also referenced in a 1965 issue of the Morris Arboretum Bulletin (Fogg, 1965). It stated, "One small area has been developed as a bog garden, enabling us to display plants of moist, acid habitats, such as *Ledum groenlandicum, Anromeda glaucophylla, Rhododendron canadense, Nemopanthes mucronata, Viburnum nudum, V. alnifolium,* etc." The bog garden was located in the English Park section northeast of the key fountain. While this garden wasn't installed with the purpose to mitigate stormwater, it was a unique approach to showcase a variety of water loving species. Plants documented in the bog garden included: *Aronia arbutifolia* (red chokeberry), *Aronia prunifolia* (black chokeberry), *Chamaecyparis thyoidesI (*Atlantic white cedar), *Ilex glabra* (inkberry), *Ilex verticillata* (winterberry), *Kalmia angustifolia* (sheep laurel), *Nemopanthus mucronatus* (mountain holly), *Rhododendron viscosum* (swamp azalea), *Viburnum cassinoides* (witherod viburnum) and *Viburnum nudum* (possumhaw). Based on plant records with removal dates, the bog garden existed for nearly 15 years. The *Viburnum* nudum was noted as being dead as early as 1963 and the *Viburnum cassinoides* was dead by 1978. In March 1984 the rest of the plants in the bog garden were removed and the area was relandscaped.

The proposed location of the rain garden is contained in quadrants G21 and F21 near the Hillcrest building [Figure 5]. The topography of the area around the Hillcrest building was altered in the early 1900s as the excavation of the Swan pond occurred [Figure 6]. The soil removed from the pond was used to build up mounds near the Gardener's cottage. From very early on the topography of this area has been altered and has directly influenced the flow patterns of stormwater in this area of the garden.

After the bog garden was removed and up until the construction of the Horticulture Center, rain and water gardens were nonexistent at the Arboretum. In 2010, three rain gardens were created with the completion of the Horticulture Center. These rain gardens are located between parking lots A and B, along the back side of the 4 bay garage, and along the southwest side of the office building. Planted as mostly native meadow rain gardens, they serve to capture rain water from the roofs and parking lots. The rain gardens at the Horticulture Center have been a fairly simple and successful method to manage stormwater. Repeating this stormwater technique on the public side of the Arboretum will prove to be an effective approach for addressing the stormwater runoff problem near the Hillcrest building.

PURPOSE

By managing stormwater runoff in the garden several side effects can be prevented such as soil erosion and gully formation, wash-out of garden beds, reduced water logging, and runoff infiltration. The garden beds around the hillcrest building have suffered significantly from stormwater runoff and are limited to the planting opportunities here. In January 2012, Philadelphia experienced 2.96 inches of rainfall and 3.4 inches of snowfall (National Oceanic and Atmospheric Administration, 2012). As the trend of increased rain events continues, steps need to be taken in order to diminish the negative effects.

Rain gardens are designed to capture, absorb, and filter stormwater runoff. Because they replicate natural hydrologic processes, rain gardens are an ideal solution for managing stormwater. In addition to minimizing the amount of runoff from impervious surfaces, rain gardens provide habitat for water loving plants, animals, and insects. Rain gardens are generally planted with native plants to attract beneficial insects in addition to contributing native habitat. Native plants are better suited to handle the variable weather of the region. Generally, rain gardens capture and treat 80 to 90% of the stormwater runoff from surfaces draining in to the garden (Cooper, 2011). Installing a rain garden will not solve all of the problems with stormwater runoff around the Hillcrest building, however, it will be the first in hopefully a series of management techniques to address the problem in this area of the Arboretum. Furthermore, the rain garden will bring more attention to the problem and serve as an educational tool for garden visitors. With interpretive signage about the rain garden and stormwater, visitors can better understand the relationships with these natural cycles.

PROCESS

There are several components to consider when planning and constructing a rain garden that include flow entrance, ponding area, organic layer of mulch, planting soil and filter media (such as a diatomaceous material), native plantings, and a positive overflow point for when the garden is at maximum capacity (PWD, 2011). The first part of the planning process required selecting an appropriate location for the rain garden. A location near the Hillcrest building in the English Park [Figure 5] was selected as the most adequate area for a rain garden. Steep slopes from the pathways moving down into a bowl-shape make up the proposed vicinity. The topography has changed over the past several decades and most recently new pathways and a reconfigured Gardener's Cottage driveway were added in the 1990s. The ground was raised and lowered to accommodate that construction and in turn changed and redirected the flow of stormwater.

Our percolation test confirmed that this area would serve as a good site for a rain garden. The test involved digging a hole at the lowest point of the rain garden area and filling it with water. By dividing the distance the water dropped by the amount of time it took for it to drop, the absorption rate was determined. An ideal infiltration rate is between a ½ inch per hour and 12 inches per hour. The percolation test yielded approximately 3 inches per hour, which falls well within the ideal range.

We then had to determine the type of rain garden to build. One option was to install a pre-made system called SustainRain™ by Complete Aquatics. This system uses interlocking crates to hold the captured water underground. Using a pump, the water is re-circulated through a fixture, such as a fountain, used for irrigation, or moved into a discharge pipe. While this system is effective, especially for capturing large quantities of stormwater, it wasn't the ideal system for the Arboretum site. Installing the SustainRain™ system would have required significantly more excavating, putting rare tree species located nearby at risk for stress and damage. We decided to excavate the rain garden area without installing any kind of underground system.

The next step involved establishing the boundaries for the garden. Creating a berm on the north and northeast side of the garden was included in order to slow down the flow of water. While redirecting water is not the objective, creating a barrier with the berm will allow stormwater to collect in the rain garden. The boundaries were also influenced by the surrounding trees including *Abies cilicica,* a rare fir tree accessioned in 1932.

The garden construction will be done by Arboretum staff with potential consultation from an engineer with Complete Aquatics. Once the garden is excavated, the soil will be amended with a diatomaceous material, such as Axis®, to give the soil optimal percolation capabilities. Generally, the planting soil depth will be at least 18 inches where herbaceous plants will be used. When planting woody plants, the soil depth will be increased depending on the species. The planting soil should be loamy and amended with composted organic material. According to the Philadelphia Stormwater Best Management Practices Manual, generally the soil is combined with 20-30% organic material (compost) and 70-80% soil base (preferably topsoil). The planting soil should be approximately 4 inches deeper than the bottom of the largest root ball. Once the native species are planted, a maximum of 2 to 3 inches of shredded mulch or leaf compost should be evenly spread out over the garden to prevent erosion. Wood chips should not be used as they will float during heavy rain events.

PLANTING CONSIDERATIONS

Rain gardens are generally divided into three planting zones. The wet zone (lowest zone) will contain species that do well in short periods of standing water as well as dry periods. The mesic zone (middle or moist zone) will contain plants that can tolerate extreme conditions of very wet or very dry. The transition zone (high zone and berm) will include plants that withstand more normal to drier conditions. Considerations for determining the planting schematic include:

- How much shade and sun the garden will receive
- Potential removal of a tree, *Zelkova sinica,* (accession number 95-174*A) located in the middle of the planned rain garden
- Prevent viewshed obstruction (Currently the viewshed consists of the Swan Pond and Love Temple from the pathway along the south side of the rain garden site)
- Deer browsing (Use deer tolerant plant species)
- Drought and water tolerance (a variety of native species meet these criteria)
- Repeat the plantings in nearby beds to create a node of a consistent theme

The following is a list of plant species native to the Mid-Atlantic and the U.S. that are suitable for planting in the wet-to-moist conditions of a rain garden:

Campanulastrum americanum (bellflower)
Lobelia siphilitica (great blue lobelia)
Ruellia humilis (fringeleaf wild petunia)
Baptisia australis (wild blue indigo)
Solidago (goldenrod)
Vernonia fasciculata (ironweed)
Lobelia cardinalis (cardinal flower)
Eupatorium dubium (dwarf Joe Pye weed)
Phlox divaricata (wild blue phlox)
Liatris spicata (blazing star)
Tradescantia virginiana (spiderwort)
Helenium autumnale (sneezeweed)

Asclepias incarnata (swamp milkweed)
Asclepias tuberosa (butterflyweed)
Eupatorium coelestinum (hardy ageratum)
Onoclea sensibilis (sensitive fern)
Carex pensylvanica (oak sedge)
Iris versicolor (blue flag)
Aster novae-angliae (New England aster)
Cornus sericea (red twig dogwood)
Viburnum nudum (possumhaw)
Ilex glabra (inkberry)
Monarda didyma (bee balm)
Rudbeckia fulgida (black-eyed susan)
Hibiscus moscheutos (marsh mallow)
Osmunda claytoniana (interrupted fern)
Schizachyrium scoparium (little bluestem)
Rhododendron viscosum (swamp azalea)
Kalmia angustifolia (sheep laurel)
Lindera benzoin (spicebush)
Cornus amomum (silky dogwood)
Photinia melanocarpa (black chokeberry)

The following list will be used for the rain garden in the Arboretum. While there are numerous native plants to select from, only a handful of woody and herbaceous plants will be used. By planting large masses of a few plants, an overall unity will be achieved. Additionally, these same plants will be repeated in the surrounding beds to create a cohesive area around the rain garden.

Woody plants:
Viburnum cassinoides, *Itea virginica*, *Chamaecyparis thyoides*, *Physocarpus opulifolius*, *Salix gracilistyla*, *Cornus sericea*

Herbaceous plants:
Asclepias tuberosa, *Lobelia cardinalis*, *Lobelia siphilitica*, *Carex flaccosperma*, *Polystichum acrostichoides*, *Osmunda regalis*

MAINTENANCE

Planting native species in the rain garden minimizes the amount of maintenance required. However, some attention is needed, particularly in the initial phases of the newly established rain garden. The following chart from the Philadelphia Stormwater Manual v2.0 represents general maintenance routines that should be carried out in order to ensure the rain garden is successfully retaining stormwater runoff (PWD, 2011).

Maintenance Guidelines	
Activity	***Schedule***
• Water vegetation at the end of each day for two weeks after planting is completed. • Water vegetation regularly to ensure successful establishment.	First year after installed
• Re-mulch void areas. • Treat diseased trees and shrubs. • Keep overflow free and clear of leaves.	As needed
• Inspect soil and repair eroded areas. • Remove litter and debris. • Clear leaves and debris from overflow.	Monthly
• Inspect trees and shrubs to evaluate health, replace if necessary.	Biannually

• Add additional mulch. • Inspect for sediment buildup, erosion, vegetative conditions, etc.	Annually
• Maintain records of all inspections and maintenance activity.	Ongoing

BENEFITS OF A RAIN GARDEN

Rain gardens enhance, naturalize, and improve native habitat attracting beneficial insects and animals. Because rain gardens mimic natural hydrologic patterns, they are well suited for managing stormwater. By capturing stormwater runoff, they prevent stream degradation and limit the amount of non-point source pollutants entering waterways. Rain gardens reduce facility maintenance and more effectively control runoff from small frequent storms (Pennsylvania Environmental Council, 2006). They also filter sediment and pollutants by nutrient cycling and by removing pollutants through the soil and in the plants. Some other benefits of rain gardens are that they conserve water, reduce mosquito breeding, recharge local groundwater, reduce potential of flooding, reduce garden maintenance (once rain garden is established), and increase garden appeal.

EDUCATION COMPONENT

Currently, the Arboretum education guides maintain a wetland lesson plan for teaching visitors about wetland ecosystems. Because the wetland at the Arboretum is not as accessible as other areas of the garden, creating a supplementary lesson plan for the new rain garden would be beneficial. In addition to being an easier location to visit, due to its proximity to the Visitor Center and other parts of the public garden, the lesson would provide a small scale learning tool for understanding the problems associated with stormwater runoff. Additionally, the rain garden will offer another opportunity to see the benefits of using native plants. For people not visiting as part of a guided group, interpretive signage will present visitors with a brief explanation of the rain garden including ways the rain garden helps reduce the negative impacts of stormwater runoff.

CONCLUSION

Stormwater runoff is an ongoing problem in the city of Philadelphia. Fortunately, steps are being taken to address this major issue such as the PWD stormwater fees and incentive program. The Arboretum is clearly dedicated to maintaining environmental responsibility and will continue to make every effort in order to minimize stormwater damage. One of the challenges is finding the best method for managing runoff while attempting to provide aesthetic and environmental benefits in the garden. Rain gardens meet both of these parameters and are becoming an important landscape tool for land-use planners. While the installation of a rain garden in the English Park section is not going to solve all stormwater problems, it is a step in, hopefully, a larger plan to mitigate the negative effects of stormwater in this area. The Morris Arboretum has been committed to sustainability for decades and this project will help to continue that mission.

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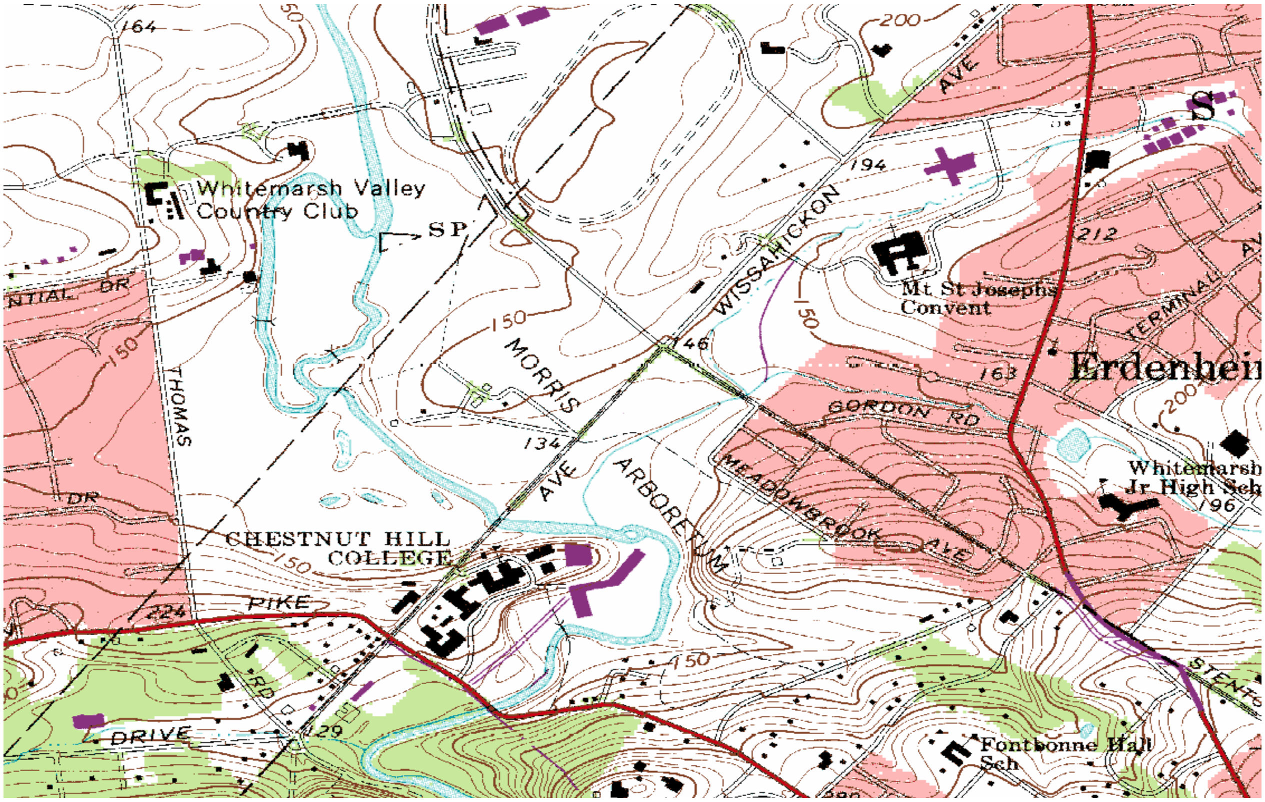
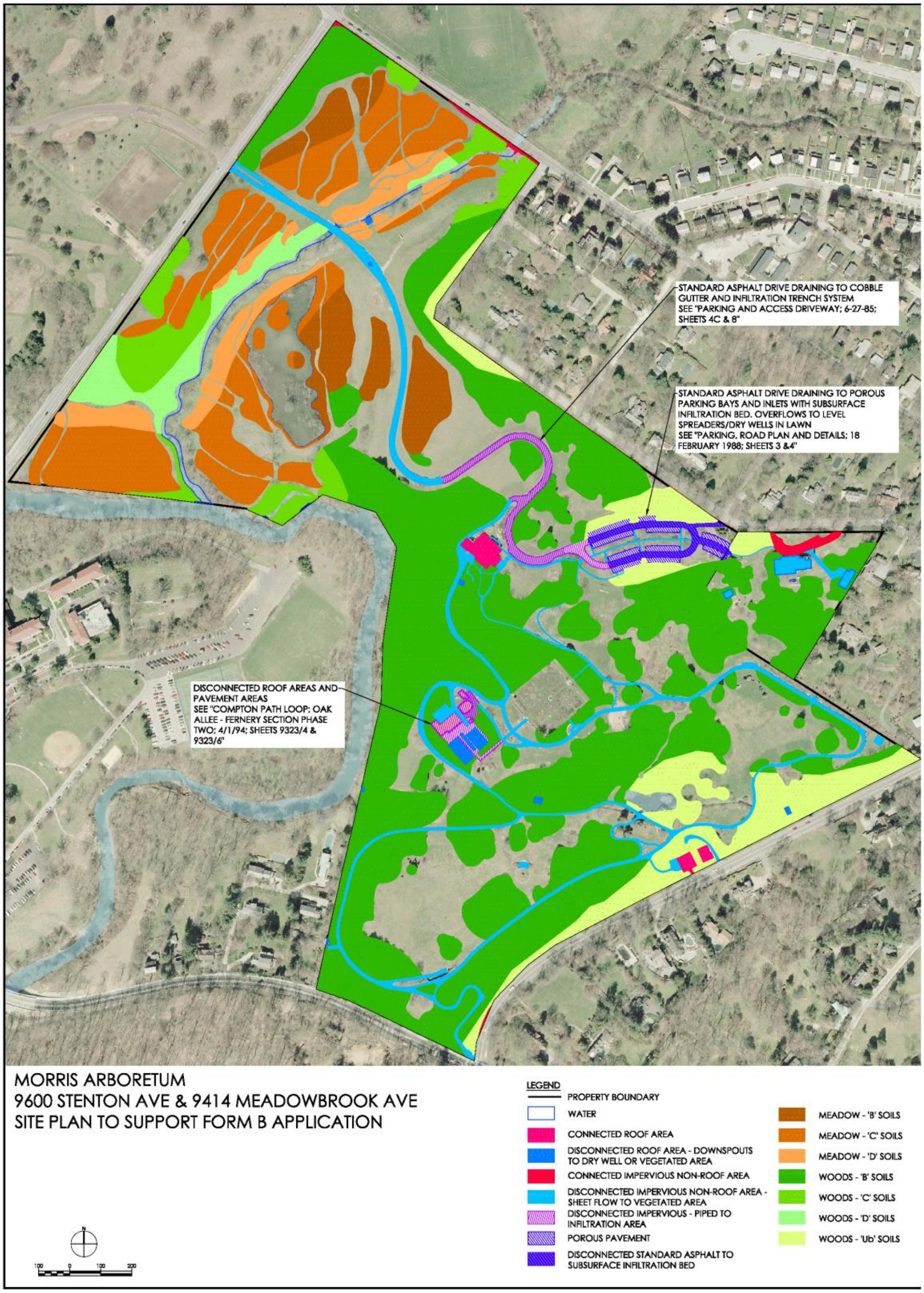
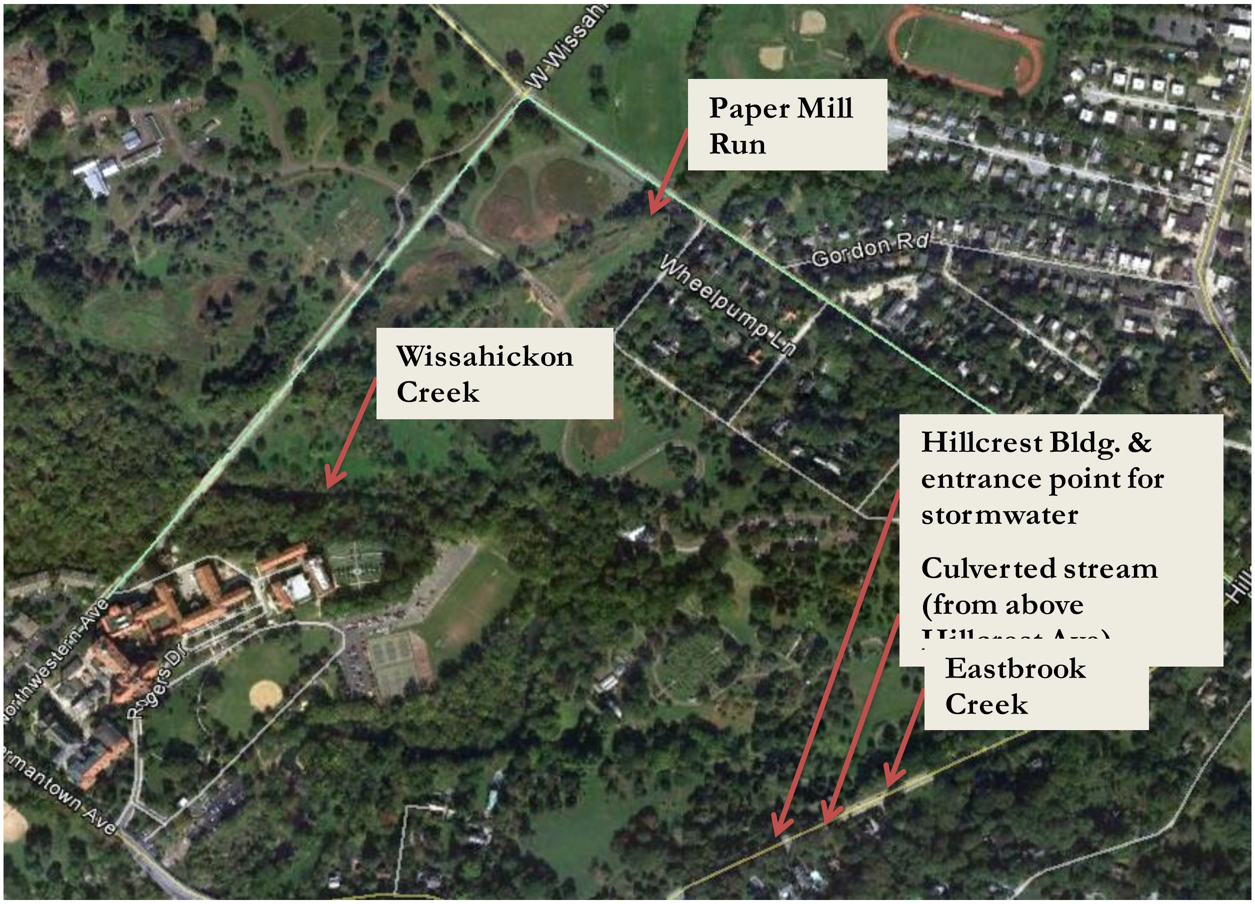
APPENDIX



[Figure 1] Topographic map of the Morris Arboretum
The topo map shows the steep elevation in and around the south and southeast part of the Arboretum.



[Figure 2] Stormwater runoff map by Meliora Engineering
This map illustrates the Arboretum's parcels within Philadelphia and the pervious and impervious surface coverage. The map was included in the stormwater credit application to the Philadelphia Water Department.



[Figure 3] An aerial view of the Morris Arboretum
The red arrows represent incoming water sources. These sources include:
Wissahickon Creek, Paper Mill Run, Eastbrook, underground stream diverted to Eastbrook, and stormwater runoff from Hillcrest Avenue

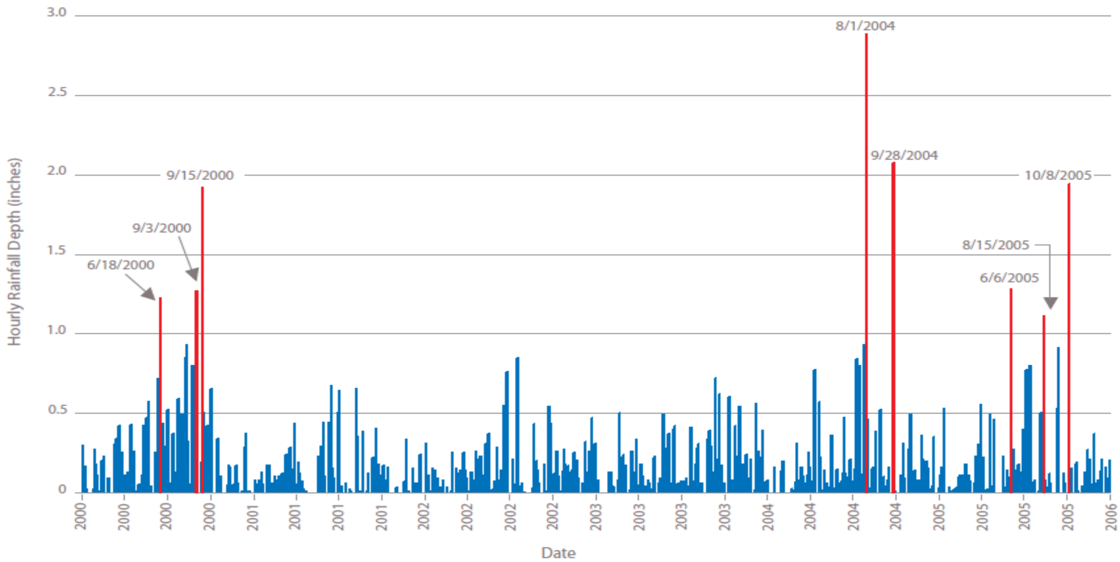
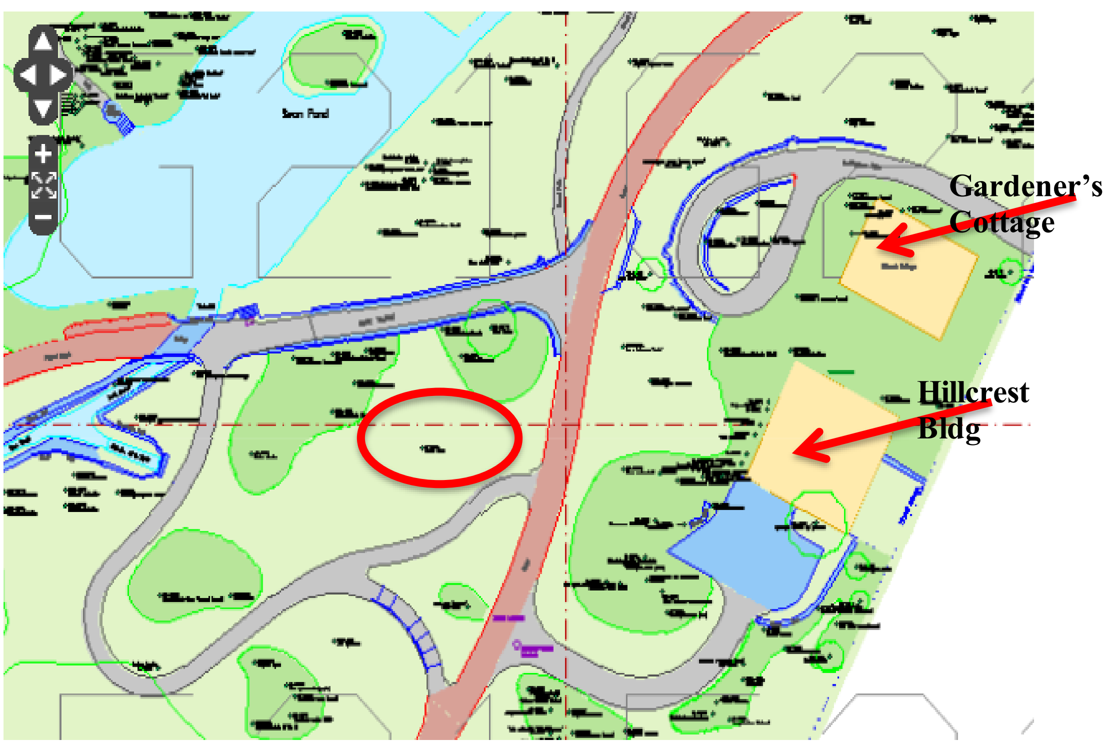


FIGURE 1: Hourly rainfall depths recorded at PWD Rain Gage #05 (South Philadelphia), 2000–August 28, 2006

[Figure 4] Philadelphia Water Department Graph
Represents the increase in hourly rainfall depth from 2000 to 2006



[Figure 5] The red circle represents the proposed location of the rain garden

[Figure 6] Looking toward Hillcrest Avenue at Gardener's Cottage
The mounds were created by the soil excavated from the Swan Pond