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Rain Garden Revitalization at Bloomfield Farm

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An independent study project report by The Hay Honey Farm Endowed Natural Lands Intern (2014-2015)

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Abstract
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In order to redesign the rain gardens I considered the original planting plan, assessed the existing conditions, and determined what native plant species could be added or removed for a rain garden that will better comply with the Horticultural Center's LEED Platinum rating. I made several visits to nearby rain gardens, discussed maintenance regimes and challenges with staff members and took photographs to note plant species and general construction techniques that could be applied to improve the Arboretum's rain garden basins. This information was used to draft site plans for the individual rain gardens that included a species list, quantities needed, and any additional construction supplies such as rocks, landscape fabric, and signage. My design recommendations will be implemented in April 2015 when the rain gardens will be planted with the help of the horticulture volunteers.

Disciplines
Horticulture

Comments
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DATE: March 2015

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INTRODUCTION

Properly designed stormwater management features significantly reduce damaging effects of excess water in a built environment. Runoff from impervious surfaces such as roofs or parking lots can be collected into rain gardens, bioswales, retention basins, and rain barrels. These systems, used alone or in combination, reduce flooding and erosion risks by holding water in designed basins before slowly releasing it to recharge the groundwater system (Strom & Nathan, 1998). Rain gardens are vegetated basins with a mix of plant species that are tolerant to varying levels of inundation. Basins vary in size and rain gardens can be built to serve the homeowner by taking water from driveways and roofs; or can be constructed on a larger scale to collect runoff from an entire parking lot. Rain gardens differ from bioswales and retention basins because water is contained at the site and does not flow away under normal water inundation. During a high water event, rain gardens may reach capacity and flow into an outlet drain or overtake an established berm.

Vegetation in rain gardens provides valuable ecosystem services by filtering out excess nutrients and pollutants, taking up water and releasing it through evapotranspiration, reducing flood and erosion risks, and providing pollinator and animal habitat. Rain gardens are planted with a mixture of species that can endure varying periods of stormwater inundation. Usually, wetland species that tolerate high moisture levels are planted at the bottom of the basin, those that are waterlogged briefly but dry out in-between storm events are placed on the middle layer, and drought tolerant upland species are located on the upper edges of the rain garden. Species are also chosen for their extensive root systems that allow water to percolate into the ground thirty to fifty percent more than a typical lawn (Dunnett and Clayden, 2007 & Strom and Nathan, 1998).

This project focuses on stormwater management in the Wissahickon Watershed in the Philadelphia region. The Wissahickon Creek, which runs through the Morris Arboretum, is fed mostly from sewage treatment effluent discharge and stormwater from heavy rain events. Historically, the majority of water flowing in this creek came from groundwater inputs. Because thirty percent of the watershed is currently covered in impervious surfaces, the Wissahickon becomes flooded quickly and easily during large storm events (Figary & Pennington, 2014). As a result, the creek experiences increased bank erosion and siltation, and significantly less groundwater is recharged. The Morris Arboretum has several rain gardens at the Horticulture Center complex on the Bloomfield Farm property that were designed by Andropogon Associates, Ltd. in 2009/2010. Two rain gardens collect stormwater from the roofs of the office building and 4-bay garage via rain chains. This project focuses on a second set of rain gardens located in-between the parking lot area east of the Horticulture Center (see Fig.1). Here, two rain gardens were installed to redirect stormwater from the paved surfaces into vegetated basins. For the purposes of this paper, the more northern rain garden will be referred to as RG North and the more southern rain garden will be referred to as RG South.

SITE ANALYSIS

The purpose of this project was to make improvements to the rain gardens at the Horticulture Center parking lot at the Bloomfield Farm property in order to maintain functionality and improve visual interest. Rain gardens often need to be reconfigured after 3-4 years of installation because sites require regrading, vegetative assemblages need to be redesigned, and accumulated silt must be removed (C. West, personal communication, October 7, 2014). The two rain gardens in the parking lot exhibit a need for revitalization and attention after their installation four years ago, especially in regard to plant community and edge alterations to allow for more efficient stormwater infiltration. Before redesigning the rain gardens, I completed a site analysis to establish a baseline for making improvements similar to Messervy (2009). I surveyed both rain gardens and recorded what species were growing, and performed sheet flow tests in the parking lot to determine which direction stormwater flowed.

The following lists the original plantings in the two rain gardens. Edge plants are located around the perimeter of the basin and the basin/plug mix lists what was planted or seeded in the rain garden depression. Unsuccessful plantings are highlighted in bold. See Table 1 for an expanded plant list from the preliminary September 2014 survey and common names.

RG North Edge Plants: *Acer rubrum* 'Brandywine,' *Amsonia tabernaemontana, Ilex verticillata* 'Winter Red' and 'Southern Gentleman,' *Nyssa sylvatica, Panicum virgatum, Physocarpus opulifolius* 'Center Glow,' *Prunus maritima, Rhus aromatica* 'Gro-Low,' *Ulmus americana* 'Princeton'

RG South Edge Plants: *Acer rubrum* 'Sun Valley,' *Amelanchier laevis, Baccharis halimifolia, Calycanthus* 'Venus,' *Ilex verticillata* 'Winter Red' and 'Jim Dandy,' *Physocarpus opulifolius* 'Center Glow,' *Pterostyrax psiliphylla, Quercus montana, Quercus muehlenbergii, Sinocalycanthus* 'Hartlage Wine'

Rain Garden North/South Basin Plug Mix: ***Andropogon glomeratus***, *Elymus riparius, Eupatorium* 'Little Joe,' ***Iris versicolor***, ***Liatris spicata***, *Panicum virgatum,* 'Rehbraun,' *Solidago* 'Fireworks'

Since the installation in 2009/2010, both native and introduced species have seeded into the parking lot rain gardens. Overall, RG North exhibited more invasive and introduced species than RG South. For purposes of this report, introduced species refers to all species that were not part of the original planting. This includes native and non-native species that seeded in from the nearby meadows and green roofs; see the list below. Invasive species are highlighted in bold (PA DCNR, 2002). See Table 1 for more information, including common names.

Introduced/Invasive Species: *Ambrosia artemisiifolia, Artemisia vulgaris, Bouteloua curtipendula, Cichorium intybus,* ***Cirsium arvense***, *Conyza canadensis, Daucus carota, Echinochloa muricata, Lactuca serriola,* ***Microstegium vimineum***, *Oenothera biennis,*

Persicaria sp., *Schizachyrium scoparium*, *Setaria faberi*, *Setaria pumila*, *Solidago canadensis*, *Xanthium strumarium*, *Zelkova serrata*

According to the preliminary survey, many original species planted in the rain gardens did not survive. Plugs were installed in December 2009 and due to widespread failure; a mixture of grasses was overseeded by Arboretum staff later that spring. Plants sustained rodent damage the following year and failed to return. Second, a few of the woody plants added later were placed in inconvenient areas and are subject to snowplow damage or are easily injured from string trimmer maintenance regimes. In RG North, Prunus maritima (beach plum) exhibits snowplow damage because it was situated too close to the edge. In RG South, Calycanthus 'Venus' (Venus sweetshrub) and Sinocalycanthus 'Hartlage Wine' (Hartlage Wine hybrid sweetshrub) suffer extensive deer and string trimmer injury. These cultivars are located elsewhere in the Arboretum and could be removed from the site. Third, there are a few invasive plants that need to be kept under control. In RG North, Artemisia vulgaris (mugwort) continues to expand along the southern edge of the basin and controlling its spread will be an ongoing goal. Both rain gardens have noxious weeds including Cirsium arvense (Canada thistle) and Microstegium vimineum (Japanese stilt grass) probably due to deer traffic through the basins.

In addition to a vegetative analysis, functionality of both rain gardens was examined especially in regard to stormwater infiltration capabilities. According to construction documents, both parking lots were graded 2% to the north and runoff flows in the same direction (Andropogon Associates Ltd., 2008). Results from sheet flow tests and observations during rain events confirm the northern parking lot is graded away from RG North. Thus, little stormwater runs into the basin from the paved surfaces and instead flows away from the rain garden and into the turf. In contrast, the southern parking lot contributes water to RG South because it is graded correctly. However, stormwater tends to flow towards the rain garden but hits the raised thatch edge and fails to percolate into the basin (Fig. 1). Instead, it runs down the pedestrian pathway and into the road or puddles in a low spot in the turf. Future plans for the Horticulture Center site include adding a third parking lot in between the existing parking areas. Until then, RG North is not functional as a stormwater management feature.

RESEARCH AND INTERVIEWS

As part of research for the project I conducted site visits to several gardens, completed online research, and read several books and regional rain garden guides. My goals were to gather information about maintenance challenges, plant palette, and rain garden construction; and to apply what I learned to the Arboretum's rain gardens.

Temple University's Ambler Arboretum

I met with Anne Brennan, Garden and Greenhouse Supervisor for the Department of Landscape Architecture and Horticulture at Temple University. Anne maintains a wetland garden and vegetated swale on the Ambler, PA campus. Runoff from the roof and sidewalk is directed into these stormwater management systems and both feature overflow areas that allow excess stormwater to overtake an established berm to percolate into a grassy area. I observed plant species used in the garden and took photos of the construction techniques around the inlets and outlets of the swales. Most included rocks as a means to slow the velocity of water. The wetland garden featured a recirculating pump for a fountain and plants in this area were well suited to growing in standing water. The vegetated swale was planted with native shrubs, trees, and meadow grasses and forbs. According to Anne, maintenance is minimal in the rain garden/bioswale areas. There are two full-time gardeners for the entire Ambler Arboretum and some seasonal help from students. Meadow plants and perennials are cut back once a year or not at all and invasive species are removed a few times per year (A. Brennan, personal communication, September 24, 2014). I noted the following species in the rain garden areas: Carex stricta (tussock sedge), Equisetum sp. (horsetail), Eutrochium purpureum (Joe-Pye weed), Hibiscus moscheutos (swamp rose mallow), Quercus rubra (red oak), Rudbeckia sp. (coneflower), Solidago sp. (goldenrod), and Woodwardia virginica (Virginia wood fern).

Northcreek Nurseries

I spoke with Claudia West, Ecological Sales Manager for Northcreek Nurseries in Landenberg, PA. Northcreek is a leading provider of native plant plugs in the nursery trade and I was given a tour of their stormwater management practices. This included their examples of working bioswales, detention basins, and a rain garden where they trial plants for sale. Northcreek Nurseries also provides a guide for rain garden installation categorized by moisture zones (Wiles, 2012). They have a rain garden that receives overland flow from the road. Once the rain garden reaches capacity, the water flows over a gravel bag into a bioswale that is connected to three detention basins before the water reaches a creek. Very rarely do the detention basins fill completely. I discussed plant selection and the importance of having erosion control in the winter, when most plants die back. Claudia advocates the use of evergreen grasses or perennials with basal leaves to reduce erosion and provide winter interest when not many other plants are growing. Maintenance of their stormwater gardens is minimal. Staff members cut down tall stalks once a year and weed the garden a few times during the spring and summer. Any low growing, non-invasive weeds are left, as long as they are not too aggressive, because they

still provide the service of stormwater infiltration through their roots. There had been problems with sediment buildup in the rain garden from the gravel roadway and overland flow is slowed using rocks before it enters the vegetated section (C. West, personal communication, October 7, 2014). Some notable plant species I noticed were: Juncus tenuis (poverty rush), Sisyrinchium angustifolium 'Lucerne' (Lucerne narrow-leaf blue-eyed grass), Liatris spicata (dense blazing star), Scirpus validus (soft-stemmed bullrush), Solidago graminifolia (grass-leaved goldenrod), Pycnanthemum muticum (short-toothed mountain mint), Iris versicolor (blueflag), Verbena hastata (swamp verbena), Juncus effusus (soft rush), Acorus americanus (American sweetflag), Carex emoryi (Emory's sedge), Carex amphibola (creek sedge), Carex cherokeensis (Cherokee sedge) and Panicum 'Cape Breeze' (Cape Breeze switchgrass). The rain gardens were planted with plugs and did not contain any woody vegetation.

Duke Farms

I met with Charles Barreca, Manager of Ecological Stewardship, and Thom Almendinger, Director of Natural Resources and AgroEcology, at Duke Farms in Hillsborough, NJ. Duke Farms was a former private estate that recently opened to the public in 2012 as an example of environmental stewardship. Andropogon Associates, Ltd. also designed their new visitors' center and parking area and their infrastructure looked similar to the Horticulture Center at Bloomfield Farm. Runoff from the parking lot drains into two bioswales that direct stormwater into a large rain garden at the west end of the parking area. The bioswales and rain garden at Duke Farms contained a mixture of woody plants and seeded in perennials from Ernst Conservation Seeds. Notable species included Oligoneuron rigidum (stiff goldenrod), Solidago nemoralis (gray goldenrod), Solidago speciosa (showy goldenrod), Solidago bicolor (white goldenrod), Monarda fistulosa (wild bergamot), Solidago gigantea (giant goldenrod), Nyssa sylvatica (black tupelo), Magnolia virginiana (sweetbay magnolia), Cornus sericea (red-osier dogwood), Cornus amomum (silky dogwood), Cornus racemosa (gray dogwood), and Aronia arbutifolia (red chokeberry). Charles recommended using less invasive goldenrod species other than Solidago canandensis (Canada goldenrod), which tends to spread quickly via underground rhizomes (personal communication, December 8, 2014). One unique feature of the bioswales at Duke Farms was that the beds come directly up to the pervious parking lot edge. In order to increase visibility, maintenance crews cut the vegetation to a height of two feet so drivers can see around the corners. I took pictures of the interpretive signage as well.

Stroud Water Research Center

I visited the Stroud Water Research Center in Avondale, PA and spoke with David Arscott, Ph.D, Vice President and Assistant Director and Melinda Daniels, Ph.D, Associate Research Scientist. Their LEED Platinum Moorhead Environmental Complex, built in 2012, houses rain gardens, bioswales, a green roof, a wetland wastewater treatment system, and composting toilets in addition to other green building components. Their rain gardens hold runoff from the sidewalks, roofs, and gravel roadways and allow it to percolate into the groundwater before it reaches the White Clay Creek. I noticed several features including rain chains from the roof to inlets lined with large native stone pieces and river jacks, outlet drains for overflow to

supplementary basins, simple mass plantings. I also observed, similar to Northcreek Nurseries, that rain gardens adjacent to the gravel driveways had a lot of accumulated sediment. Staff informed me that two employees spend part of their time on rain garden maintenance in addition to indoor maintenance tasks (D. Arscott and M. Daniels, personal communication, March 28, 2015). The basins appeared mulched and all the perennials and grasses had been cut back for spring. Plants in the rain gardens included: Acer rubrum (red maple), Amelanchier laevis (Allegheny serviceberry), Amsonia 'Blue Ice' (Blue Ice bluestar), Chelone glabra (white turtlehead), Coreopsis rosea (pink tickseed), Crocus sp. (crocus), Fothergilla gardenii (dwarf fothergilla), Hydrangea quercifolia 'Pee Wee,' (Pee Wee oakleaf hydrangea), Ilex glabra (inkberry), Iris versicolor (blueflag), Juncus effusus (common rush), Liatris spicata (blazing star), Lobelia siphilitica (great blue lobelia), Magnolia virginiana (sweetbay magnolia), Osmunda claytoniana (interrupted fern), Panicum virgatum 'Shenandoah' (Shenandoah switchgrass), Penstemon digitalis 'Husker Red' (Husker Red beardtongue), Phlox 'Minnie Pearl' (Minnie Pearl garden phlox), Sporobolus heterolepis (prairie dropseed), Symphyotrichum oblongifolium 'Raydon's Favorite' (Raydon's Favorite aromatic aster), Vernonia noveboracensis (New York ironweed), and Waldsteinia ternata (barren strawberry).

Additional Rain Gardens

I also conducted more informal visits and online research of other rain gardens where I did not speak with maintenance staff. Visits included Shoemaker Green at the University of Pennsylvania, Villanova University's Biofiltration Rain Gardens, and Rutgers Gardens in New Brunswick, New Jersey. Shoemaker Green features trench drains in the sidewalk that divert water from nearby roofs and paved surfaces to a rain garden. The garden features native plants exclusively, including Taxodium distichum (bald cypress), Ilex glabra (inkberry), Carex sp., Magnolia virginiana (sweetbay magnolia), Rudbeckia sp., and Iris versicolor (blueflag). A variety of rocks are placed to direct and slow the velocity of water, and to create pathways through the garden (University of Pennsylvania, 2015). Second, Villanova University retrofitted an existing traffic island to create a biofiltration rain garden. Soil was removed, mixed with sand, and replaced to increase the basin's infiltration capacity. Parking lot runoff patterns were observed in order to cut slices out of the existing curb to allow water to flow into the basin. In the event of a large storm, excess water flows into a dry detention basin. Plant species include Ammophila breviligulata (American beach grass), Panicum virgatum (switchgrass), Panicum amarum (coastal panic grass), Schizachyrium scoparium (little bluestem), Solidago sempervirens (seaside goldenrod), Aronia melanocarpa (black chokeberry), Baccharis halimifolia (eastern baccharis), Ilex verticillata (winterberry), Iva frutescens (marsh elder), and Prunus maritima (beach plum) (Villanova, 2013). Third, Rutgers Gardens in New Jersey has a garden with multiple components featuring two bogs, a fern section, and a rain garden that are fed from recirculating stormwater held in a cistern. The rain garden is located on one end and features plants such as Carex stricta (tussock sedge), Carex grayi (Gray's sedge), Iris versicolor (blueflag), and Iris virginica (Virginia iris). A full list of shrubs, trees, grasses, perennials, and ferns can be found on their website (Rutgers Gardens, 2012). Many of the species are already found in the Morris Arboretum's rain gardens.

DESIGN RECOMMENDATIONS

After completing a site analysis, researching rain gardens, and checking nursery availability, I compiled a set of design recommendations for the two rain gardens at the Horticulture Center. All plantings will be native and deer resistant, with the exception of C. sericea (red-osier dogwood). I was given a budget of 2-3,000 dollars for new plants and construction supplies. Both rain gardens will receive low growing, groundcover grass species along the edges to control for broadleaf weeds with a selective herbicide, if needed. Until Canada thistle and mugwort can be controlled, few broadleaf perennials will be planted. At time of publication, I plan on ordering plant material from Pleasant Run Nursery, Northcreek Nurseries, and Kurt Bluemel, Inc. The rain gardens will be planted on April 29, 2015 using horticulture volunteer help.

RG North will receive plants more suited to a dry basin environment since it does not act as a rain garden due to the direction of the parking lot grading. New drought tolerant plants will include: Sporobolus heterolepis (prairie dropseed) along the parking lot edge, with Panicum 'Cape Breeze' (Cape Breeze switchgrass), Andropogon virginicus (broomsedge), and Schizachyrium scoparium 'Blue Heaven' (Blue Heaven little bluestem) in the basin mix. Removals include Prunus maritima (beach plum), Physocarpus opulifolius 'Center Glow' (Center Glow ninebark), and Amsonia tabernaemontana (common bluestar). P. maritima and A. tabernaemontana will be relocated within the same rain garden to areas protected from snowplow damage. P. opulifolius 'Center Glow' will be moved to RG South to join the mass of its own species. See Fig. 2 for a more detailed planting schematic. While analyzing this site, I noticed a pedestrian pathway had formed on the western edge of the rain garden basin where people take a shortcut to the parking lot. To prevent further damage, this traffic area should be acknowledged with a small rock pathway.

RG South, the functional rain garden, will receive plant species suited to an area that may experience sudden inundation and long periods of drought. Along the edge closest to the parking area Carex amphibola (creek sedge) and Cornus sericea (red-osier dogwood) will be planted. C. amphibola is a semi-evergreen grass and C. sericea will provide winter interest with its red stems. Similar to the basin mix in RG North, Panicum 'Cape Breeze' (Cape Breeze switchgrass), Andropogon virginicus (broomsedge), Schizachyrium scoparium (little bluestem) and will be added with the addition of Vernonia noveboracensis (New York ironweed). Calycanthus 'Venus' (Venus sweetshrub) and Sinocalycanthus 'Hartlage Wine' (Hartlage Wine eastern sweetshrub) will be removed from the rain garden edge and Physocarpus opulifolius 'Center Glow' (Center Glow ninebark) will be added from RG North. See Fig. 3 for a more detailed planting schematic. In addition to vegetation adjustments, this rain garden will be altered to improve runoff infiltration from the southern parking lot. The turf edge along the walking path will be regraded and partially removed to allow surface flow to spill over the paved edge onto a rock border. Larger limestone accent rocks and river jack stone will be added on top of landscape fabric around the parking signs to reduce string trimmer maintenance.

The third component of the rain garden design will be an interpretive panel similar to nearby signage that details the green roofs and Horticulture Center. The sign will explain how a

rain garden functions, why it is important for stormwater management, and what plant species are there. Hopefully, this informative sign and the rain garden can be incorporated into training for the Arboretum's guides and during tours of the Bloomfield Farm property. The sign will be located in front of RG South along the pedestrian walkway so visitors can see it as they walk from the parking lot.

MAINTENANCE

Newly planted rain gardens require the most maintenance. Because RG North and South will be planted in the spring, they will require supplemental summer watering to ensure establishment of new landscape plugs and woody plants. Weeds will be an issue particularly in areas of soil disturbance or exposure. Handpulling and selective herbicide application for broadleaf weeds can provide control. RG North has a patch of mugwort along the southern edge that will need ongoing attention. This can be mowed repeatedly throughout the summer to weaken the plant and then sprayed with an herbicide (C. Barreca, personal communication, December 8, 2014). Confront® and Transline® are recommended selective herbicides for mugwort and Canada thistle control (Koepke-Hill et al., 2011). Areas with extensive mugwort or thistle patches should not be planted until populations are diminished. Japanese stilt grass will also need to be monitored and weeded out. It cannot be sprayed because of its proximity to other desirable grass species. Instead, patches will have to be weeded annually and plugs can be planted more aggressively in these areas. If possible, it would be beneficial to discourage deer from entering the rain garden. The following table outlines seasonal tasks for the rain garden maintenance.

Season	**Maintenance Tasks**
Spring	• Monitor site for weeds and invasive plants- control using a selective herbicide, weed wrench, or hand weeding • Mow mugwort in RG North • Cut back *Carex* and *Sporobolus*
Summer	• Monitor site for weeds and invasive plants- control using a selective herbicide, weed wrench, or hand weeding • Water newly planted plugs to ensure establishment, especially in the first year • Mow mugwort throughout the season, spray with selective herbicide at the end of the season • Replace woodchip mulch as needed around woody plants • Replace or fix deer protection around trees and shrubs • String trim in areas missed by the mower
Fall	• Monitor site for weeds and invasive plants- control using a selective herbicide, weed wrench, or hand weeding • Cut/mow meadow basin mix in late fall or winter • Keep fallen leaves out of the rain garden • Replace rocks or plants as necessary
Winter	• Place markers along edges accessible by the snow plow • Prune: rejuvenate woody plants, especially *C. sericea* in late winter to encourage bright red stems • Keep overflow drains clear of debris and sediment • Monitor deer protection to discourage buck rub/winter browse

CONCLUSIONS

After extensive rain garden analysis, both on-site and at local gardens and nurseries, I have created a site plan for improving the rain gardens at the Morris Arboretum's Horticulture Center. Regrading and addition of stones will allow for more efficient stormwater infiltration. New plants will provide much needed winter interest, erosion control, and will act as a weed barrier by covering previously exposed soil. Once invasive and aggressive plants are controlled, broadleaf perennials can be added for more visual interest and diversity. The area could be designated as an official Monarch Waystation with the addition of Asclepias sp. (milkweed) (Monarch Watch, 2015). Interpretive signage will encourage visitors to learn the benefits of rain gardens and they might consider adding one in their yard. There are many region-specific guides for installing stormwater management gardens available and hopefully the rain gardens at the Morris Arboretum can serve as an example of sustainable gardening for the Wissahickon Watershed.

REFERENCES

Andropogon Associates, Ltd. (2008) *Construction Documents: Horticulture Center at the Morris Arboretum.* Overland Architects, PLLC.

Dunnett, N. & Clayden, A. (2007). *Rain gardens: Managing water sustainably in the garden and designed landscape*. Portland, OR: Timber Press.

Figary, S. & Pennington, D. (2014). *Creek watch: Program manual*. Wissahickon Valley Watershed Association.

Koepke-Hill, R. M., Armel, G. R., Klingeman, W. E., Halcomb, M. A., Vargas, J. J., & Flanagan, P. C. (2011). Mugwort control in an abandoned nursery using herbicides that mimic indole-3-acetic acid. *HortTechnology*, *21*(5), 558-562.

Messervy, J.M. (2009). *Home outside: Creating the landscape you love*. Newtown, CT: Taunton Press.

Monarch Watch. (2015). *Monarch waystation program*. Retrieved from http://www.monarchwatch.org/waystations/.

Pennsylvania Department of Conservation and Natural Resources. (2002). *DNCR invasive plants.* Retrieved from http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20026634.pdf.

Rutgers Gardens. (2012). *Rain garden*. Retrieved from http://rutgersgardens.rutgers.edu/raingarden.html.

Strom, S. & Nathan, K. (1998). *Site engineering for landscape architects*. 3rd ed. New York, NY: John Wiley & Sons, Inc.

University of Pennsylvania. (2015). *Penn connects: Shoemaker green*. Retrieved from http://www.pennconnects.upenn.edu/find_a_project/completed/completed_2012/shoemaker_green_overview.php.

Villanova College of Engineering. (2013). *Bio-filtration rain garden*. Retrieved from http://www1.villanova.edu/villanova/engineering/research/centers/vcase/vusp1/research/bio-infiltration-rain-garden.html#.

Wiles, C. (2012). *Rain gardens: Species recommendations for water wise gardens*. Retrieved from http://www.northcreeknurseries.com/_ccLib/attachments/links/Rain_Gardens_2012_FINAL.pdf.

APPENDIX

Table 1. Existing rain garden plant species from September 12, 2014 survey.

Woody Plants

Botanical Name	Common Name	Original Planting	Introduced/Native
Acer rubrum 'Brandywine"	Brandywine red maple	x	N
Acer rubrum 'Sun Valley'	Sun Valley red maple	x	N
Amelanchier laevis	Allegheny serviceberry	x	N
Baccharis halimifolia	eastern baccharis	x	N
Calycanthus 'Venus'	Venus sweetshrub	x	Hybrid
Ilex verticillata 'Jim Dandy'	Jim Dandy winterberry holly	x	N
Ilex verticillata 'Southern Gentleman'	Southern Gentleman winterberry holly	x	N
Ilex verticillata 'Winter Red'	Winter Red winterberry holly	x	N
Nyssa sylvatica	blackgum	x	N
Physocarpus opulifolius 'Center Glow'	Center Glow ninebark	x	N
Prunus maritima	beach plum	x	N
Quercus montana	chestnut oak	x	N
Quercus muehlenbergii	chinkapin oak	x	N
Rhus aromatica 'Gro-Low'	Gro-Low fragrant sumac	x	N
Sinocalycanthus 'Hartlage Wine'	Hartlage Wine eastern sweetshrub	x	Hybrid
Ulmus americana 'Princeton'	Princeton American elm	x	N
Zelkova serrata	Japanese zelkova		I

Grasses

Botanical Name	Common Name	Original Planting	Introduced/Native
Bouteloua curtipendula	sideoats grama		N
Echinochloa muricata	rough barnyard grass		N
Elymus riparius	riverbank wild rye	x	N
Eragrostis spectabilis	purple love grass	x	N
Microstegium vimineum	Japanese stilt grass		I
Panicum virgatum	switch grass	x	N
Panicum virgatum 'Rehbraun'	Rehbraun switch grass	x	N
Schizachyrium scoparium	little bluestem		N
Setaria faberi	green foxtail		I
Setaria pumila	yellow foxtail		I
Tridens flavus	purpletop	x	N

Perennials

Botanical Name	Common Name	Original Planting	Introduced/Native
Ambrosia artemisiifolia	common ragweed		I
Amsonia tabernaemontana	eastern bluestar	x	N
Artemisia vulgaris	mugwort		I
Cichorium intybus	chicory		I
Cirsium arvense	Canada thistle		I
Conyza canadensis	Canadian horseweed		N
Daucus carota	Queen Anne's lace		I
Eupatorium dubium 'Little Joe'	Little Joe Dwarf Joe Pye weed	x	N
Lactuca serriola	prickly lettuce		I
Oenothera biennis	evening primrose		N
Persicaria sp.	smartweed		N
Solidago 'Fireworks'	Fireworks goldenrod	x	N
Solidago canadensis	common goldenrod		N
Xanthium strumarium	rough cocklebur		N

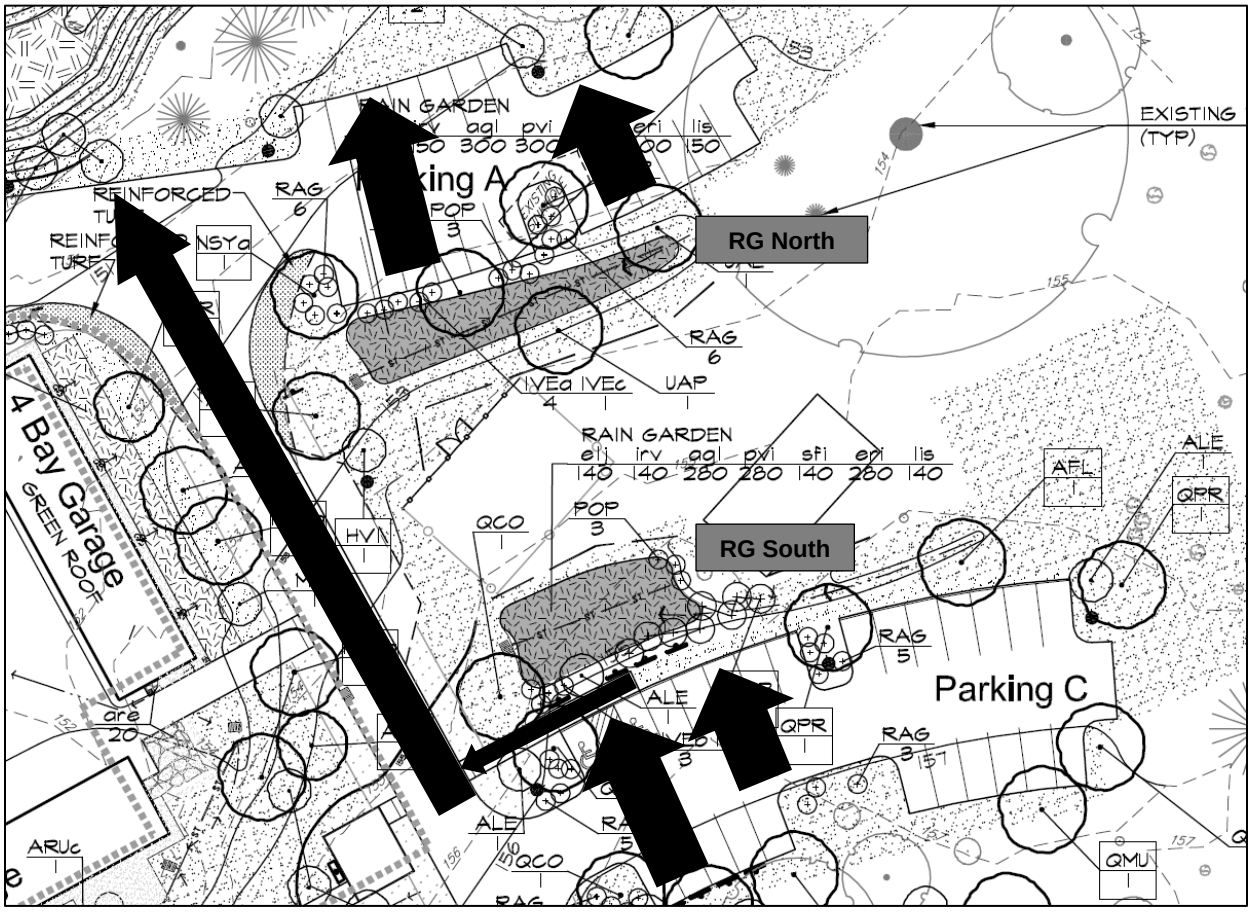

Figure 1. Detail of rain garden location from as-built plans from Andropogon Associates Ltd. (2008). Rain Gardens North and South are highlighted in green. Blue arrows indicate stormwater flow direction.

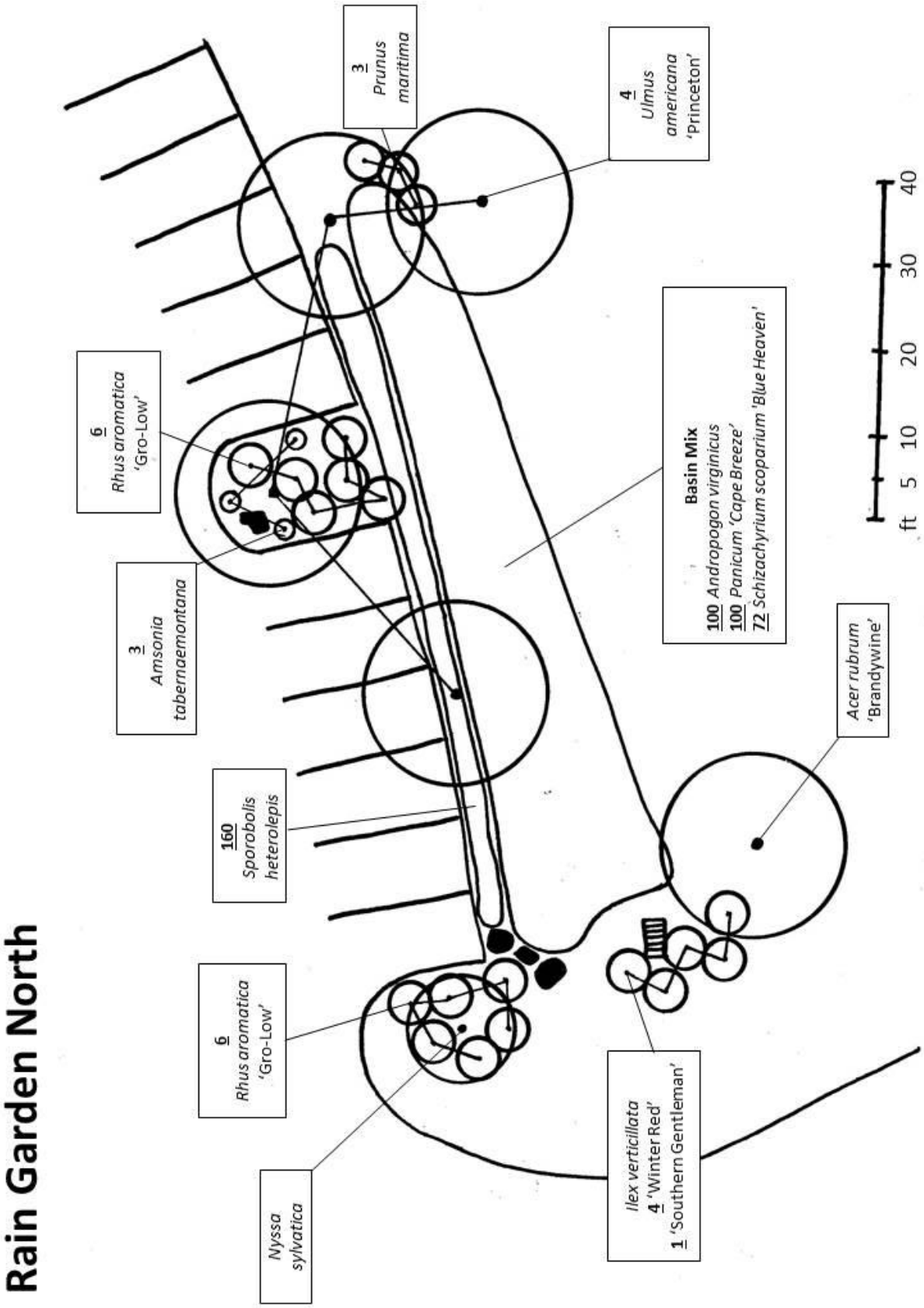

Figure 2. Proposed design for Rain Garden North. The basin is 1,300 sq. ft.

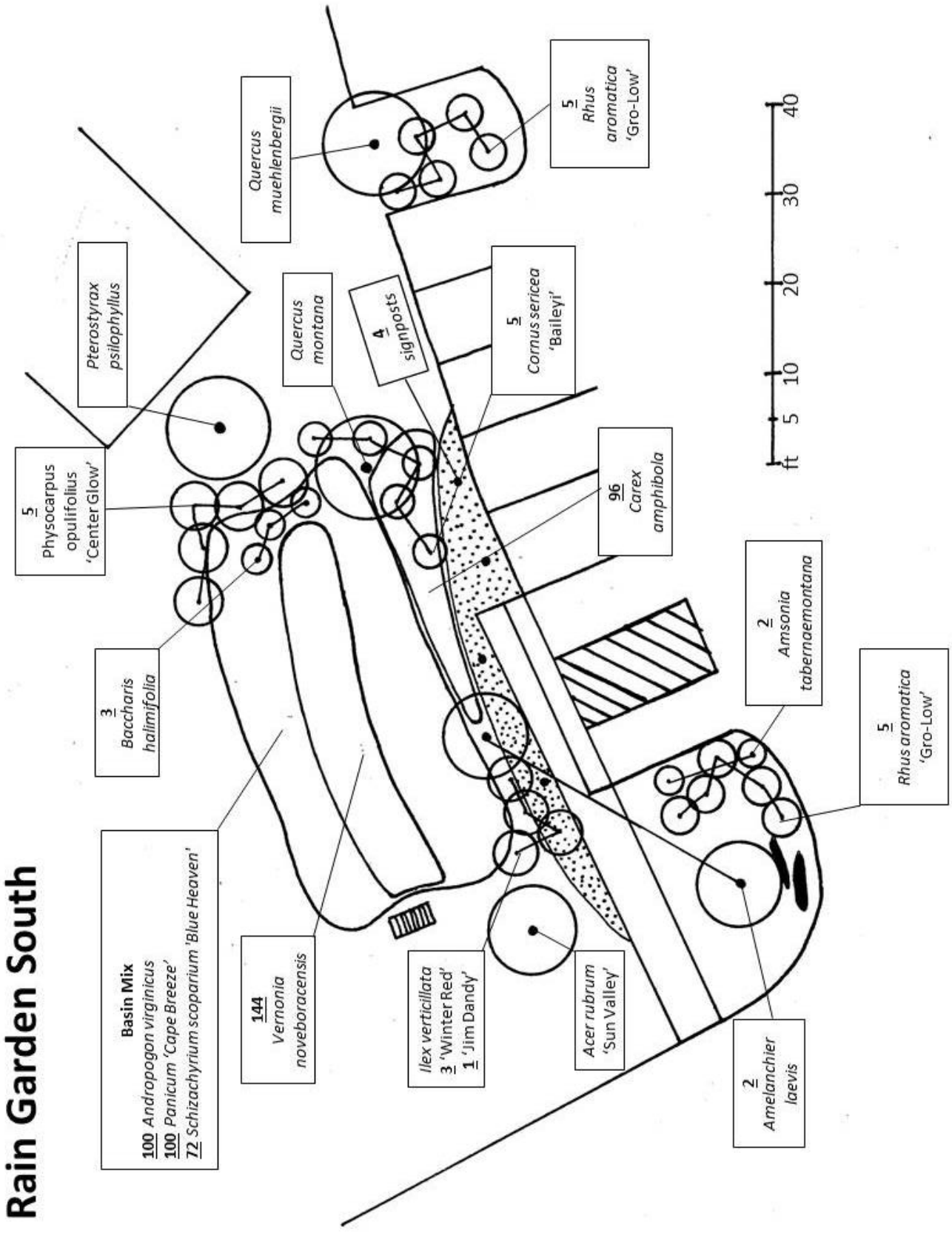

Figure 3. Proposed design for Rain Garden South. The basin is 1,200 sq. ft.

ADDITIONAL RESOURCES

The following is a list of additional resources for rain garden installation and planting suggestions:

Bannerman, R. & Considine, E. (2003). *Rain gardens: A how-to manual for homeowners*. Wisconsin Department of Natural Resources. DNR Publication PUB-WT-776 2003.

Low Impact Development Center. (2007). *Rain Garden Design Templates.* Retrieved from http://www.lowimpactdevelopment.org/raingarden_design/templates.htm.

McCarthy, J. (2012). *New Hampshire homeowner's guide to stormwater management: Do-it yourself stormwater solutions for your home.* NHDES (New Hampshire Department of Environmental Services). Retrieved from http://des.nh.gov/organization/divisions/water/stormwater.

Obropta, C.C., Bergstrom, J.D., Boyajian, A.C., Higgins, C. S. Salisbury, K.V., & Young, W.E. (2011*). Rain garden manual of New Jersey*. Retrieved from http://www.npsnj.org/pages/nativeplants_Rain_Gardens.html.

Philadelphia Water Department. (2006).*A homeowner's guide to stormwater management*. Office of Watersheds.

Schmidt, R., Shaw, D. & Dods, D. (2007). *The blue thumb guide to rain gardens: Design and installation for homeowners in the upper Midwest*. Minneapolis, MN: Waterdrop Innovations, LLC.

Wallace, T. (2009). *The rain garden planner*. Atglen, PA: Schiffer Publishing Company.