Pennswood Village Regional Stormwater Management System – Newtown, PA
Methodology for Landscape Performance Benefits
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Environmental

Reduced the rate of peak stormwater runoff by 53%, 64%, and 69% for the 2, 10, and 100 year storms.

The pre- and post-construction stormwater management report was completed by Pickering, Corts & Summerson, the project's civil engineer. Standard TR-55 methodologies were utilized to calculate the discharges. The predevelopment discharges, calculated to be 55.39 cubic feet per second (cfs), 133.11 cfs, and 249.38 cfs for the 2, 10, and 100-year storm events respectively were reduced in the post development condition to 25.79 cfs, 40.74 cfs, and 80.20 cfs. The resultant reductions were 53% for the 2-year event, 64% for the 10-year event, and 69% for the 100-year event. These results were accomplished by the stormwater management system design that consists of a system of swales, basins, and wetlands.

	2-Year Storm	10-Year Storm	100-Year Storm
Predevelopment	55.39 cfs	133.11 cfs	249.38 cfs
Post Development	25.79 cfs	40.74 cfs	80.20 cfs
Reductions	53%	64%	69%

Sequesters 11,700 lbs of carbon dioxide annually in the 205 new trees planted onsite.

This benefit was calculated using the plant list provided by the landscape architect and the National Tree Benefit Calculator.

The Tree Benefit Calculator is not as precise of scientific as other forest assessment tools and this is mentioned on the www.treebenefits.com website. Patterson and Coelho (2009) write about but do not critically assess iTree as the calculating tool of National Tree Benefits Calculator. Bonnfaci (2009) identifies STRATUM software as the basis for the National Tree Benefits Calculator. But after examining both STRATUM and UFORE (another tree calculating program) she ended up using the Tree Benefits Calculator to assess trees in Somerville, Massachusetts, Her attempt to use UFORE yielded little information. Because she was hindered by lack of data acquisition tools to accurately measure attributes such as crown size and tree height necessary for the more precise modeling offered by UFORE.

McPherson (2010) works for the National Forestry Service, the branch of government that developed STRATUM. He writes about the thinking behind iTrees noting that STRATUM was the foundation for what is now referred to as iTree Streets and was "based upon 20 years of urban forest science (McPherson, p. 230)." McPherson notes specifically that the software was developed with landscape architects (and others) in mind who might be interested in analyzing the benefits and costs of municipal forests. Presumed to be an author of the software, he makes a strong case for the logic behind its methodology.

> "The approach was to first divide the US into 16 climate zones (based upon length of growing season, minimum temperature, building energy use patterns), then select a representative city within each zone to study intensively. The representative cities had to have updated tree inventories (20,000-100,000 trees); accurate information on planting dates for aging a sample of approx. 900 trees; and large old trees present in the community. In each reference city, 30 to 60 trees from each of the 22 major tree species were ages and measured. Then linear regression was used to fit predictive models with diameter at breast height (dbh) as a function of age for each species. Predictions of leaf surface area, crown diameter, and height metrics were modeled as a function of dbh using best-fit models. Geographic data were collected for use in iTree Streets' numerical models. That data included temperature, precipitation, air pollutant concentrations, and fuel mix for energy production (McPherson, p. 231)."

While it is not possible to be absolutely precise using iTree, it is certainly one of the most convenient software models to use. What it lacks in precision is made up for with ease. It is possible that this software tool will become more precise over time, as additional data related to urban forests and specific tree types/benefits are developed by the USFS and others. Previously an asphalt parking area with all runoff flowing into the city storm sewers, the Central Wharf Plaza now captures 100% of the stormwater that falls on the site, except in the case of extreme precipitation events. If a storm event occurred that exceeded the infiltration ability of the site, some stormwater would overflow into the city's combined sewer system. However, due to the storage capacity of the structural soil layer and the amount of time it would take to fill, peak flows would be greatly reduced and delayed. This helps decrease the volume of discharge from combined sewer overflows, reducing the amount of pollution entering the harbor and other bodies of water.

Achieved ecological quality 13.8 times that of a standard stormwater detention/ retention basin, as measured by the Plant Stewardship Index.

The Plant Stewardship Index (PSI) was used to calculate the benefit of using a wetland planted with native species versus detention basin planted with non-native species. The PSI calculator was obtained free from Bowman's Hill Wildflower Preserve www.bhwp.org.psi.

> The Plant Stewardship Index, (PSI) is a thermometer reading of the ecological quality of open land by seeing what plants live there. The index is calculated based on averaging numbers assigned to each plant by a group of leading botanists and ecologists in the state. These numbers are referred to as "CC" or coefficients of conservatism.
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> They range from 0 to 10 with zero being those "generalist" plants that can be found in any area (including parking lots, plowed fields and other highly disturbed land sites) to ten being "specialist" plants that the botanists have agreed can be found naturally in very specific habitats. Many (although not all) of our threatened and endangered plants have been assigned a 10 because they are so specialized and their required habitats are disappearing. The average of all these numbers is called the Mean C. The calculation also takes in to account the total diversity of plants on a site www.bhwp.org.psi.

The Pennswood stormwater wetland PSI was compared with a nearby detention basin visited by the research team and observed to be mowed grass. Temple University Horticulture professor, Dr. Michael Olszewski, is knowledgeable about turfgrass indicated that 3 main species: Festuca elatior, Fescue; Lolium Perenne, Perennial Rye; Poa pratensis, Bluegrass.

In 2005 botanists from Bowman's Hill Wildlife Preserve reported data for Pennswood stormwater landscape in the Plant Stewardship Index. According to those findings, the site contained 132 plant species (both native and non-native) and has a PSI of 13.8.

	Standard Detention Basin 3 non native species	Pennswood Stormwater System 132 native and non native species
Plant Stewardship Index (PSI)	0	13.8

Provides habitat for at least 73 bird species, based on cumulative data from counts by residents.

Based on cumulative data provided by residents of Pennswood Village. Residents have shown a consistent effort in bird counts over the past decade. Counts were mainly taken from path in wetland area.

American Coot	Goldfinch	Red-tailed Hawk
American Crow	Great Blue Heron	Redwing Blackbird
Bald Eagle	Great Egret	Ringbill Gull
Baltimore Oriole	Great Horned Owl	Robin
Barn Swallow	Hair Woodpecker	Rock Dove
Belted Kingfisher	Harrier	Rose-breasted Grosbeak
Black-capped Chickadee	Herring Gull	Rough-winged Swallow
Blue Jay	House Finch	Ruby-throated Hummingbird
Bluebird	House Sparrow	Rusty Blackbird
Broad-winged Hawk	House Wren	Sharp-shinned Hawk
Brown-headed Cowbird	Kestrel	Song Sparrow
Canada Goose	Killdeer	Starling
Cardinal	Lesser Sandpiper	Tree Sparrow
Carolina Wren	Mallard Duck	Tree Swallow
Catbird	Marsh Hawk	Tufted Titmouse
Cedar Waxwing	Mockingbird	Turkey Vulture
Chipping Sparrow	Mourning Dove	White-breasted Nuthatch
Common Crow	Myrtle Warbler	White-throated Sparrow
Common Flicker	Northern Flicker	White-crowned Sparrow
Common Grackle	Purple Finch	White-throated Sparrow
Cooper's Hawk	Purple Grackle	Wild Turkey
Cormorant	Red-breasted Nuthatch	Wood Thrush
Dark-eyed Junco	Red-headed Woodpecker	Yellow Warbler
Downy Woodpecker	Red Knot	
Eastern Kingbird	Red-bellied Woodpecker	

Social

Increased satisfaction with Pennswood as a home or workplace, with 63% of survey respondents saying that the wetland landscape increased their satisfaction.

Improves the mood of residents and staff, with 61%, of survey respondents saying that their mood was more positive after being in the wetland landscape.

Serves as an educational tool for residents and staff, with 79% of survey respondents saying that they were aware that the wetland landscape captures and treats stormwater from on and off site, greatly reducing impacts to Neshaminy Creek.

A survey was developed to quantify the possible social benefit of the Pennswood stormwater landscape. Residents and staff were surveyed using a questionnaire comprised of demographic, self rated health and experiential questions. The survey was based on measures developed by Barbosa et.al.(1999); Sherman, Varni, Ulrich and Malcarne (2005); Grahn and Stigsdotter (2010) and others. The survey questionnaire included 4 questions related to demographics; 5 health related questions; 13 questions related to wetland experience and 2 questions rating landscape photos for attractiveness. The photos were of a standard "manicured" lawn landscape and a "wilder" wetland landscape.

The survey questionnaire was reviewed by the Institutional Review Board of Temple University and exempted from further review (June 29, 2012 IRB Protocol communication for project 20746).

This was a convenience survey in which respondents voluntarily agreed to fill in the questionnaire. The survey was administered by the LAF Fellow and LAF Research Assistant on two days: July 16, 2012 from 10 a.m. – 2:30 p.m.: and July 18, 2012 from noon to 6:00 p.m. A desk was set up in the Pennswood Village main lobby, adjacent to the café and mailbox area, with a sign asking people to "Tell us how you feel about the Pennswood Wetland Landscape" nearby. Both staff and residents were invited to take the survey. The The Pennswood manager also emailed staff a digital version of the questionnaire and some staff chose to fill that out and turned it in via electronic mail. The questionnaire took between 10 – 20 minutes to complete. A total of 74 respondents, 10.66% of the total combined resident/employee population completed the questionnaire. The total population is comprised of 389 residents and approximately 400 employees. 210 employees are fulltime equivalent. 190 employees are part-time.

Not all answers were completed by all respondents. Sixty-two (n=62) respondents answered the question about affiliation. 78% (n=55) were residents; 18% (n=14) were employees; 4% (n=3) answered "other". The questions use "wetland landscape" or "wetland park", or "wetland park landscape" as interchangeable terms to describe the wetland.

Responses were tabulated and made into Excel charts. Some responses were entered into SPSS (Statistical Program for Social Sciences) and cross tabulated. We were particularly interested in the impact of the wetland landscape on emotional well being. However, the crosstab findings were not strong. We also wished to know whether respondents understood that the wetland was a "designed" landscape with a stormwater mitigation function. The raw data provided clear answers to these questions.

> A majority, 63%, (n=42) of respondents said that the wetland landscape definitely increased their satisfaction with Pennswood as a home/workplace. 15% (n=10) indicated that it probably increased their satisfaction with Pennswood as a home/workplace.
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> A majority, 61% (n=34) of respondents said that their mood was more positive after being in the wetland landscape. 25% (n=14) said that their mood was fairly positive after being in the wetland landscape.
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> A majority, 65% (n=45) indicated that they were definitely aware that the wetland landscape was designed by a landscape architect. 23% (n=16) said that they were probably aware that the wetland landscape was designed by a landscape architect.

A large majority, 79% (n=52) said that they were definitely aware that the wetland landscape captures and treats stormwater from on and off site, greatly reducing impacts to Neshaminy Creek. 12% (n=8) indicated that they were probably aware of the stormwater function.

Limitations

1. Convenience survey meant that it is possible that only people who already felt positively about the wetland landscape would be inclined to fill out.
2. Anecdotal evidence indicated that many people experience the wetland by driving through it, rather than walking through it. This might be a factor of the age of residents within a retirement community. The questionnaire did not include a question about driving through the wetland but focused on trail use.

Serves as an educational tool for university students and public agencies. Over 300 university landscape architecture students and 12 public agencies have visited the site to learn about non-traditional approaches to stormwater management. Over 100 general university students have learned about the project from lectures by the landscape architect.

Stuart Appel, the principal landscape architect for the project has provided a lecture and field tour to 250 University of Pennsylvania MLA students (25 students per class x 10 years). At least 50 Temple University undergraduate and graduate courses in site engineering visit the site and use it as a case study. Pennswood is included in Site Engineering for Landscape Architects by Steve Strom.

Stuart Appel has lectured on Pennswood to 100 non-landscape architecture majors in a Temple University's The Science of Sustainable Design class. He has also lectured and given tours to at least 12 public agencies, including NJ Department of Environmental Protection and Bucks County Conservation District.

Cost Comparison Methods

- ***The cost of maintaining the 20-acre wetland meadow landscape is approximately $7,000 per year, substantially less than the $54,000 annual cost of maintaining an equivalent area of traditional lawn with ornamental plantings.***

Overall Maintenance Cost:

20 Acres of Wetland Meadow Landscape	20 Acres of Ornamental Garden/Lawn Landscape
$6,916/year	$54,200/year

Breakdown of Maintenance Costs:

20 Acres of Wetland Meadow Landscape

Mowing of Basins (hrs/yr)	Weeding (hrs/yr)	Forebay Clean Out (hrs/yr)	Mowing along Path (hrs/yr)	Pruning (hrs/yr)	Wage	Total (hrs/yr)	Total Cost per Year
40	240	16	78	120	$14.00/hr	494	$6,916

*Grounds Manager Drew Mason provided hourly cost.

20 Acres of Ornamental Garden/Lawn Landscape

Mowing	Weeding	Mulching	Total Cost per Year
$23,000/yr contract	$4,200/yr contract	$27,000/yr contract	$54,200

*Grounds Manager was unable to provide breakdown of hourly cost because outside contractors maintain the ornamental gardens/lawn. Only a total cost was available.

Maintenance of the meadows, wetlands, and walking paths consists of: mowing of basins (completed once a year) totaling 40 man hours, invasive weed control totaling 240 man hours/year, once yearly cleaning out of the front forebay totaling 16 man hours, mowing along sides of walking path totaling 78 man hours/year, and pruning of trees in the meadow totaling 120 man hours/year. Average hourly wage for the completion of the above tasks is $14.00. Based on these numbers, the average cost of maintenance for the meadows, wetlands, and walking paths total $6,916/year with the additional $40,000 every 10 years for asphalt path replacement.

Maintenance of the remaining 20 acres of residential property consisting of primarily lawn and ornamental gardens is broken down in the following ways: mowing contract of $23,000/year (mowing 10 acres of lawn, 24 cuts a year), mulching contract of $27,000/year, and bed maintenance and weeding contract of $4,200/year. Based on these numbers, the cost of maintenance of the residential portion of Pennswood Village totals $54,200/year.

Savings in Maintenance of Wetland Meadows over Lawn and Garden Landscape for a typical year: $54,000 - $6,916 = $47,084

Savings in Maintenance of Wetland Meadows over Lawn and Garden Landscape every tenth year due to replacement of asphalt: $54,000 – ($6,916 + $40,000) = $7,084

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