

## 7. COST ESTIMATES DEVELOPMENT

This section describes the design, constructability, and costing protocols followed to develop capital costs and where applicable, operation and maintenance costs, for the green infrastructure (GI) best management practices (BMPs) and other associated gray infrastructure within the 30 high priority sewersheds and associated areas for the City-Wide GI Assessment.

### 7.1 Field Investigations, Constructability, and Costing Protocols

#### 7.1.1 Green Infrastructure Cost Development

Green infrastructure BMP costs were developed using a detailed and itemized costing spreadsheet tracking the quantities and unit costs for each primary component of the BMPs. Costs were developed and compared to the equivalent cost per 1 acre of impervious surface managed for a reasonableness check. Construction costs without contingency were calculated to be \$150,000 to \$200,000 per acre of impervious area managed. Using the high end of this range, the base construction cost was selected to be \$200,000 per impervious acre managed. These costs were compared to costs from other Mott MacDonald GI projects, costs from other communities implementing GI programs, as well as ALCOSAN's Starting at the Source (August 2015) and the GI and source control report, and found to be in-line with those reported costs. Additional contingencies were added to these construction costs to establish overall capital costs as shown in Table 7-1. Applying these contingencies, the low range cost was set at \$324,000 per acre and the high range cost was set at \$432,000 per acre.

<b>Planning Level Cost Contingencies</b>	<b>Percentage</b>
Construction	25%
Engineering (Planning, Design & CA services)	20%
Overall Project	20%
Class 4 Cost Estimate Range	+20% to -10%

To provide greater confidence in the installation costs and constructability for the GI BMPs, as part of the Shadyside/A-22 Sewershed Flooding Solutions & Green Infrastructure Assessment Project, the project team worked with PWSA and MM to perform field investigations of several of the high yield catch basin drainage areas. The

field investigations identified local site scale BMPs that could be implemented to potentially achieve the required capture volumes. These BMPs were determined based on the available area, amount of stormwater tributary to the location, and type most suitable for the specific locations. Planning level costs were then developed for the site scale BMPs. The site scale BMP costs were then averaged to develop an overall average cost of GI per impervious acre managed. This approach provided further confirmation for using overall costs of \$324,000 - \$432,000 on average per impervious acre managed.

These assumptions are conservative based on the planning level assumptions for the cost estimates. In addition, because of the planning level nature of the cost estimates, a cost range was developed and provided for the GI alternatives based on the estimated overall capital costs.

It should also be noted that the costs for GI included in this report assume 100% is paid by the ratepayers and not offset by the likely benefits of cost-sharing with new development and redevelopment. As the appropriate ordinances are developed and enacted for managing stormwater runoff from new development and redevelopment within the City, the public costs for GI may be reduced. These anticipated mechanisms will ensure that new development and redevelopment will share in a portion of the costs of GI in the City, which may reduce the costs to the ratepayers, while also allowing the new development and redevelopment to realize the triple bottom line benefits associated with GI (discussed in Section 8 of this report) beyond CSO reduction and basement sewage backups.

For example, ALCOSAN's Starting at the Source Report (August 2015) states the following:

*Redevelopment is assumed to affect 0.3% of impervious cover per year over the course of the WWP implementation (through 2046). At this redevelopment rate, runoff from approximately 10% of the impervious cover in the combined sewer area would be managed through stormwater ordinance driven GSI [Green Stormwater Infrastructure] at a rough order-of-magnitude value to the rate payers of \$370 million.”*  
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Using this analysis, private development GI could account for 1,110 impervious acres of privately provided GI through 2046, representing a potential cost reduction of \$420 million for the ratepayers (based on an average capital cost per impervious acre of \$378,000). Over 10 years, the potential cost reduction could be approximately \$140 million for the ratepayers assuming a linear redevelopment rate of 0.3% per year.

### 7.1.2 Private Infiltration/Inflow Removal Disconnection Program

As discussed in Section 3 of this report, the GI analysis included identifying high yield drainage areas tributary to mapped catch basin inlets. These high yield drainage areas include both public and private sources of stormwater. To provide the significant benefits of managing stormwater to reduce CSO, surface flooding, and basement sewage backups, strategic cost-effective disconnection of private property drainage is recommended. The GI cost-basis described in Section 7.1.1 includes a factor for stormwater runoff from private impervious surfaces. While the overall capital cost range for GI of \$324,000 - \$432,000 per impervious acre managed was conservatively estimated to also include strategic cost-effective disconnection of private drainage in the locations of BMPs, it was decided to explicitly include a separate line item cost for downspout disconnections in the combined sewersheds to add additional conservatism to the GI costs.

To estimate the downspout disconnections cost, several sources were evaluated, including:

- A literature review was performed of the various utilities currently conducting downspout disconnection programs, including the Water Environment Federation (WEF) Private Property Library
- Mott MacDonald's experience with private source projects in other communities
- The 3RWW/ALCOSAN Alternatives Costing Tool (ACT) extension for private property infiltration/inflow (I/I) disconnections

Figure 7-1 provides an excerpt from 3RWW / ALCOSAN ACT extension, which includes four technologies for private source removal, based on 2010 costs.

Based on this information, an average cost estimate of \$3,000 per property was used for downspout (exterior roof leader) disconnections where the downspouts are either routed to a right-of-way BMP or disconnected on the property where an adequate discharge location exists. It is anticipated that only cost-effective downspout disconnections falling within this average cost range would be performed. If areas with more expensive downspout disconnections on average were encountered then those locations would be re-examined and other more cost-effective areas for impervious surface runoff capture would be identified.

### C3 Private Inflow and Infiltration Removal

Table C-4 – Private I/I Removal Unit Costs

Technology	Default Unit Cost	Units	User Defined Unit Cost Option?	O&M Cost Estimate
Sump Pump Discharge Rerouting	\$4700	Per sump pump rerouting	Yes	User to input a lump sum value for all Private I/I reduction alternatives where applicable
Footing Drain Disconnection	\$8000	Per disconnection	Yes	
Exterior Roof Leader Disconnection	\$20	Per homeowner disconnection	Yes	
	\$70	Per municipality disconnection		
Private Drain Disconnection	\$600	Per drain disconnection	Yes	

#### ACT User Reference Manual

##### **Exterior Roof Leader Disconnect**

For buildings where roof leaders are tied into the footing drains and make their way to the sanitary lateral, this work includes disconnecting (cutting) the down pipe and providing a discharge to the ground for homes or other establishments with an adequate discharge location and where local codes permit. Basin planners will need to specify the estimated number of roof leaders to be disconnected, and whether the work will be performed by the homeowner or municipality. The user has the ability to change this unit cost, but must provide acceptable documentation of the basis of cost.

##### **Private Drain Disconnection**

This work includes sealing the connection from a driveway drain or other private storm drain to a sanitary sewer. It also includes re-routing the drain line to an existing storm outlet or constructing a new drain outlet. The basin planners will need to specify the estimated number of drains to remove and the total length of new storm sewer required. Based on these assumptions, a default unit cost is applied (\$600 per disconnection). The user has the ability to change this unit cost, but must provide acceptable documentation of the basis of cost.

Figure 7-1: Excerpt from 3RWW / ALCOSAN Costing Tool: Private Source Removal

#### 7.1.3 Gray Infrastructure Component Cost Development

The team conducted field investigations to evaluate and develop costs for each of the flooding hazard locations, direct stream inflow locations, and urban planning areas identified in this study. The cost development included, in some cases, the use of storm sewer piping, underground detention coupled with surface level GI, junction boxes, manholes, etc. to manage the associated stormwater and base flows.

The ALCOSAN ACT tool was used to develop costs for these elements. The ACT tool is a widely used planning level cost estimating template based on local and regional data.

The tool was reviewed, found to provide detailed and comprehensive project costs, and the cost assumptions are reasonable as compared with other similar project cost estimates. The ACT tool has the ability to estimate a wide range of gray infrastructure cost elements. Assumptions were made where applicable for number of utility crossings, spacing of manholes, depth of installations, and number of service laterals encountered with the proposed construction. In cases where the ACT tool did not include the needed cost elements, local costs were obtained. Appendix E provides more detail, including the cost estimate tables. The contingencies added to develop overall capital costs are listed in Table 7-1. Where more uncertainty existed with the planning level cost estimates for the stream daylighting locations, a larger construction cost contingency of 40% was used.

An example cost estimate for the Spring Garden detention and stream daylighting that used a combination of ALCOSAN ACT tool data and local cost data is provided in Figure 7-2. The example estimate contains the quantities and unit costs for the primary project component line items. The unit bid prices for each item of work were obtained from a range of sources, including the Allegheny County Assessment, ACT Tool, RS Means, and recent bid tabulations from PWSA projects. Planning level contingencies were added, as appropriate, to account for project unknowns.

## 7.2 Green Infrastructure Operation & Maintenance Cost Development

As with all assets, routine maintenance is necessary to operate at the designed level of service, and prevent or limit excessive repairs. GI BMPs are no different. In fact, the industry often speaks about the lack of sufficient asset management of the aging sewer and water lines within our communities and the deferred maintenance and lack of funding. GI maintenance may look and feel different than what most sewer and water utilities area accustomed to doing. GI should be considered no different than a sewer or water line in terms of the need for funding and performance of maintenance.

As the Philadelphia Water Department and other cities with GI programs have demonstrated, partnerships with other city departments, local neighbors, and competitive bidding of maintenance contracts may offset and lower costs for GI maintenance. In addition, the creation of a local labor force from the currently unemployed for GI maintenance is being demonstrated in Philadelphia, Pennsylvania; Washington, DC; and Columbus, Ohio, among other cities. The maintenance work is similar to landscaping work, which can be easily taught and trained, also opening the opportunities for new business development within Pittsburgh and Allegheny County.

Spring Garden Solution: Detention Pond & Small Diameter Daylighting Pipe To River					
Control Level: 2.2 MG Storage					
Items of Work	Approx. Quantity	UOM	Unit Bid Price	Total	Assumptions / Costs
Land Acquisition	1	EA	\$ 312,500	\$ 313,000	Costs from Allegheny County Assessment 2016 full market value cost figures with a 25% markup.
Mobilization, Demobilization, and Field Office	1	LS	\$ 268,700	\$ 269,000	5% of the total construction cost.
Field Survey and Engineering	1	LS	\$ 11,240	\$ 12,000	2% of the total construction cost.
Erosion and Sediment Control	1	LS	\$ 11,240	\$ 12,000	2% of the total construction cost.
Grading	5,856	SY	\$ 5	\$ 27,000	1.1 Acre grading with 10% additional added. Costing figure from RS Means estimating data.
Engineered Soil Media & Gravel	3,550	CY	\$ 60	\$ 213,000	1.1 Acre detention area sub base at 2' depth. Cost figure from recent GI projects.
8" PVC SDR-26 Sewer Pipe, Less than 15' Deep	500	LF	\$ 125	\$ 63,000	Installed pipe costs from recent bid tabs.
Excavation 0-15' Deep	16,000	CY	\$ 9	\$ 144,000	From RS Means Item 312316130500 "excavation with no sheeting or dewatering." Costs range from \$3.09 per CY to \$8.66 per CY depending on the excavator size with a 2-1/2 CY excavator as the lowest cost and 0.75 CY excavator as the high cost. Excavation based on the storage footprint, taking into account 15' excavation depth.
Vegetation	30,000	SF	\$ 3	\$ 90,000	Costs from recent, similar projects.
Rock and Obstruction Excavation - All Depths	500	CY	\$ 25	\$ 13,000	Costs from recent PWSA bid tabs.
Outlet Structure	1	EA	\$ 3,000	\$ 3,000	Estimate based on comparable structure costs.
Overflow Structure	1	EA	\$ 8,500	\$ 9,000	Estimate based on comparable structure costs.
Small diameter storm daylight pipe 8"-12"	10,970	LF	\$ 347	\$ 3,807,000	\$3,809,162 current year probable construction cost from ACT tool. Sizing from modeling detention & release (5511' in 8", 4540' in 12"). Assumes utility crossing every 50', manholes every 300', 75% of length in street/25% in sidewalk.
Pipe Tunnel Boring Under Rt. 28	300	LF	\$ 3,211	\$ 964,000	\$963,158 current year probable construction cost from ACT tool.
Maintenance Traffic Protection	1	LS	\$ 16,860	\$ 17,000	3% of the total construction cost.
			Subtotal	\$ 5,956,000.00	
Planning Level Construction Contingency			40%	\$2,383,000	
Engineering (Planning, Design, & CA Services)			20%	\$1,192,000	
Project Contingency			20%	\$1,192,000	
			<b>Total:</b>	<b>\$10,723,000</b>	

**Figure 7-2: Example Cost Estimate for Gray Infrastructure Components of Spring Garden Detention and Stream Daylighting**

To develop operation and maintenance costs for the GI identified as part of the City-Wide GI Assessment, the following primary sources were reviewed:

- *Water Environment Research Foundation's User's Guide to the BMP and LID Whole Life Cost Models* (Lampe et al., 2005). Spreadsheet tools to help users identify and combine capital costs and ongoing maintenance expenditures to estimate whole life costs for stormwater management. The models provide a framework for calculating capital and long-term

maintenance costs of individual best management practices and low-impact development techniques.

- *Green Infrastructure Implementation*, WEF Special Publication, 2014. This source summarizes staff hours and typical annual O&M costs as a percent of construction, obtained from multiple programs, including EPA research, across the country.
- *Philadelphia Water Department Long Term Control Plan Update, Basis of Cost Opinions*, 2009 – GI O&M costs development. This source provides bottom-up cost estimates and equivalent percentages of construction cost for the necessary maintenance activities for various types of GI.
- *The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure – USEPA*, 2013. The report examines the O&M practices of 22 green infrastructure projects funded by the American Recovery and Reinvestment Act Clean Water State Revolving Fund, and highlights both the opportunities and challenges associated with green infrastructure O&M.
- *Green Infrastructure Cost-Benefit Resources – USEPA website*. This resource provides links to findings from other communities demonstrating realized cost savings through their green infrastructure programs, as well as available tools to inform cost-benefit analysis.

Based on these resources, Mott MacDonald's experience on other projects, and the local knowledge from 3RWW and PWSA, the primary maintenance tasks, frequencies, and the estimated hours are in Table 7-2. Associated O&M costs were also developed. Table 7-3 gives an annualized O&M cost estimate per impervious acre managed for three types of GI BMPs.

Primary GI BMPs Maintenance Tasks	Frequency	Total Hours Per Year per Impervious Acre
<ul style="list-style-type: none"> <li>▪ For the first 6 months following construction, the BMP should be inspected at least twice after storm events that exceed 1/2 inch of rainfall to confirm draining and no excessive erosion. Conduct any needed repairs or stabilization.</li> <li>▪ Bare or eroding areas in the BMP area should be stabilized with appropriate cover.</li> <li>▪ One-time, spot fertilization may be needed for initial plantings.</li> <li>▪ Watering is needed once a week during the first 2 months, and then as needed during first growing season (April-October), depending on rainfall.</li> <li>▪ Remove and replace dead plants. Up to 10% of the plant stock may die off in the first year, so construction contracts should include a Care and Replacement Warranty to ensure that vegetation is properly established and survives during the first growing season following construction.</li> </ul>	Upon establishment	6
<ul style="list-style-type: none"> <li>▪ Check curb cuts and inlets and remove accumulated grit, leaves, and debris that may block inflow.</li> </ul>	At least 4 times a year	8
<ul style="list-style-type: none"> <li>▪ Spot weeding, trash removal, and mulch raking.</li> </ul>	Twice during growing season	4
<ul style="list-style-type: none"> <li>▪ Add reinforcement planting to maintain desired vegetation density.</li> <li>▪ Remove invasive plants using recommended control methods.</li> <li>▪ Remove any dead or diseased plants.</li> </ul>	As needed	4
<ul style="list-style-type: none"> <li>▪ Inspect underdrain at Year 1.</li> <li>▪ Verify drain-out time at Year 1.</li> <li>▪ Supplement mulch in devoid areas to maintain a 2 inch layer.</li> <li>▪ Prune trees and shrubs.</li> <li>▪ Remove sediment in pre-treatment cells and inflow points.</li> <li>▪ For permeable pavement, vacuum porous asphalt or concrete surface with commercial cleaning unit.</li> </ul>	Annual	4
<ul style="list-style-type: none"> <li>▪ Remove and replace the mulch layer</li> <li>▪ Inspect underdrain. Clean if required.</li> </ul>	Once every 2-3 years	4
<ul style="list-style-type: none"> <li>▪ Remove and replace soil media.</li> </ul>	Once every 8-10 years depending on loading	8
<b>Estimated Total per Year</b>		<b>38</b>

<b>Type of GI BMP</b>	<b>Annualized O&amp;M Costs (\$ per Impervious Acre Managed per Year)</b>
Porous Pavement	\$3,000
Stormwater Tree Trenches	\$3,600
Bioretention	\$4,000

These annualized O&M costs are between 2% to 3% of the developed GI construction cost of \$150,000 - \$200,000 per impervious acre managed. These costs were carried forward to develop Net Present Value O&M costs for the 480 MGD WWTP Expansion scenario (with GI implementation of 1,835 impervious acres managed in 18 sewersheds) and the Lowered HGL Operation During Wet Weather Conditions scenario (with GI implementation of 1,286 impervious acres managed in 13 sewersheds). An overhaul of the GI BMPs was assumed to be needed on average every 25 years, so a replacement cost at year 25 was included in the Net Present Value O&M Cost analysis.

Long term replacement costs assume significant work is required to restore the functionality of the GI BMPs. At approximately the 25 year mark, excess sedimentation buildup may require replacement of the infiltration soil layers, and geotextile fabric around the storage layer. For example, for bioretention with subsurface storage, this would include excavating the top mulch layer, along with the engineered soil. Excavation around the sides of the storage layer would be required as well to allow for the replacement of geotextile fabric around the sides and top of the storage layer. Rebuilding the BMP includes work items related to aggregate and engineered soil backfill, mulch replacement, plantings, shrubs, and the replacement of rip rap aprons and check dams / berms if used. Table 7-4 provides an example summary of the unit cost items and associated costs for replacement work for a typical bioretention installation. For a typical set of GI BMP installations managing one impervious acre from a residential neighborhood, the 25-year cost estimate to replace the functional layers of each BMP was estimated to be \$36,400 in 2016 year dollars. This cost includes a 10% contingency as a factor for unknowns.

**TABLE 7-4  
ESTIMATED REPLACEMENT COSTS AT YEAR 25 FOR TYPICAL GI  
BMPs, 1 ACRE OF MANAGED IMPERVIOUS SURFACE,  
FOR NET PRESENT VALUE COST ESTIMATING**

<b>Task</b>	<b>Quantity of Work</b>	<b>Unit</b>	<b>Unit Cost</b>	<b>Cost</b>
Remove & set aside rip rap aprons / check dam / berms	16	HR	\$34.00	\$544
Excavate/Remove Plantings and Mulch	16	CY	\$40.00	\$640
Excavate Engineered Soil Layer, and aggregate backfill on sides of Modular storage	166	CY	\$40.00	\$6,640
Replace geotextile around sides and top of storage layer	470	SY	\$6.00	\$2,820
Replace aggregate on side of modular storage	56	CY	\$45.00	\$2,520
Amend Soil & Replace engineered soil in Trench	166	CY	\$45.00	\$7,470
Install 2" thick layer of mulch	16	CY	\$45.00	\$720
Install New Plantings / Shrubs	400	EA	\$28.00	\$11,200
Re-install rip rap apron / check dam/ berms	16	HR	\$34.00	\$544
			Subtotal	\$33,100
			Total Including 10% Contingency	\$36,400

Using the developed operation and maintenance costs, Net Present Value O&M costs were projected over periods of both 25 and 50 years, based on routine maintenance as well as significant replacement work at year 25. An inflation rate of 3.5% and a discount rate of 6% per year were assumed, consistent with Engineering News-Record (ENR) indices. Total construction costs for retrofitting for the Free Outfall scenario with GI in 13 sewersheds (1,286 impervious acres managed) and the 480 MGD (WWTP capacity) scenario with GI in 18 sewersheds (1,835 impervious acres managed) retrofitted scenarios were distributed evenly over the first 10 years, assuming complete build-out of the GI BMPs by year 10. Results are provided in Table 7-5.

<b>TABLE 7-5 25 AND 50 YEAR NET PRESENT VALUE GI O&amp;M COSTS FOR TWO CITY-WIDE GI SCENARIOS (NET PRESENT VALUE)</b>		
<b>Year</b>	<b>Lowered HGL Operation During Wet Weather Conditions Scenario GI in 13 sewersheds 1,286 Impervious Acres Managed</b>	<b>480 MGD WWTP Expansion Scenario GI in 18 sewersheds 1,835 Impervious Acres Managed</b>
25	\$106,900,000	\$153,000,000
50	\$202,000,000	\$288,000,000

Table 7-6 provides the annual O&M costs required during the first 10 years as the GI BMPs are being constructed for either the Free Outfall scenario for GI in 13 sewersheds (1,286 impervious acres managed) or the 480 MGD (WWTP capacity) scenario for GI in 18 sewersheds (1,835 impervious acres managed). An even build-out over 10 years was assumed. The “Net Present Value” column lists the projected costs throughout the first 10 years in present value 2016 dollars. The “Future Cost” column, shows the future year estimated O&M cost required in that year.

Anticipated staffing requirements to complete the O&M tasks outlined in Table 7-2 for each retrofit scenario were also estimated. Table 7-7 outlines the projected staffing requirements during years 1 through 10. The costs assume an average of 38 hours of O&M per impervious acre of GI per year as listed in Table 7-2. To account for vacation, sick time and training, 1,920 hours of labor per year was assumed per staff person.

Table 7-7 indicates that at Year 1 the GI BMPs could be operated and maintained with a staff of 2 to 3 people at an approximate annual cost of \$700,000 - \$1 million depending on the selected GI scenario. A GI program built out over 10 years would create 17 to 25 new O&M jobs depending on the selected GI scenario. These O&M jobs do not include the associated potential new jobs from material supply and construction.

**TABLE 7-6  
O&M COSTS NET PRESENT VALUE OVER 10-YEAR GI BUILD-OUT  
PERIOD FOR TWO CITY-WIDE GI SCENARIOS**

Year	Lowered HGL Operation During Wet Weather Conditions Scenario GI in 13 sewersheds 1,286 Impervious Acres Managed		480 MGD WWTP Expansion Scenario 18 sewersheds 1,835 Impervious Acres Managed	
	Future Cost	Net Present Value (2016 Dollars)	Future Cost	Net Present Value (2016 Dollars)
1	----	\$703,000	----	\$1,000,000
2	\$1,400,000	\$1,400,000	\$2,100,000	\$2,000,000
3	\$2,300,000	\$2,000,000	\$3,200,000	\$2,900,000
4	\$3,100,000	\$2,600,000	\$4,500,000	\$3,700,000
5	\$4,000,000	\$3,200,000	\$5,800,000	\$4,600,000
6	\$5,000,000	\$3,700,000	\$7,200,000	\$5,300,000
7	\$6,100,000	\$4,300,000	\$8,600,000	\$6,000,000
8	\$7,200,000	\$4,800,000	\$10,200,000	\$6,800,000
9	\$8,300,000	\$5,200,000	\$11,900,000	\$7,500,000
10	\$9,600,000	\$5,700,000	\$13,700,000	\$8,100,000

**TABLE 7-7  
GI O&M STAFF REQUIREMENTS OVER 10-YEAR GI BUILD-OUT PERIOD**

Year	Lowered HGL Operation During Wet Weather Conditions Scenario: GI in 13 sewersheds 1,286 Impervious Acres Managed (Cumulative Acres per Year)	480 MGD (WWTP Expansion) Scenario: GI in 18 sewersheds 1,835 Impervious Acres Managed (Cumulative Acres per Year)	Range of Required Employees
1	129	184	2 to 3
2	257	367	4 to 5
3	386	551	6 to 8
4	514	734	7 to 10
5	643	918	9 to 13
6	772	1,101	11 to 15
7	900	1,285	12 to 18
8	1,029	1,468	14 to 20
9	1,157	1,652	16 to 23
10	1,286	1,835	17 to 25

### 7.3 Green Infrastructure Learning Curve and Effects on Costs

Throughout the implementation of the region’s wet weather plans, Stormwater Act 167 requirements, and overall Clean Water Act requirements, the cost of GI BMPs is expected to decline for a number of reasons. The projected cost reductions are credited to improvements in site layouts, reduction in design costs, a reduction in the cost for materials, and reductions in perceived construction risk as incorporating GI into our streets, parking lots, buildings, and homes become the “standard” method of doing business. Communities have spent the last century learning how to remove “nature” – plants, grass, trees, porous soils – from our cities and urban landscapes, and instead have now learned that “nature” is needed in order to prosper, be healthy, and create livable, resilient, and sustainable communities. Therefore, it is not surprising that it will take some time to learn how to re-incorporate nature back into our urban City. As our

learning curve improves on building “nature” back into our communities, the associated costs of GI will decrease.

**Better Site Design:** Site designers currently have limited requirements to manage stormwater within the City and these stormwater requirements are often added as an afterthought to the traditional site design. As stormwater regulations are updated in the City to address CSO reduction, surface flooding reduction, and basement sewage backups reduction, site designers will adopt improved site design techniques. These techniques on average can reduce impervious area on each site by 20% or more compared to the current site designs. Several cities across the country have already implemented similar impervious area reduction requirements for new development and redevelopment to reduce costs.

**Reductions in Design and Construction Administration Costs:** Because GI BMP designs are just starting to be understood by many local engineers and PWSA has not yet developed standard BMP details that can be used as “plug & play” for retrofit designs, design and construction administration and inspection costs are currently high relative to total construction cost. These design and construction-related costs are estimated to be reduced by 5% - 10% compared to current costs, as GI design and construction standards are developed, adopted, and become familiar to users in this region.

**Reductions in Material Cost:** As GI technologies, such as porous pavement, bioretention, and tree trenches, are incorporated into street reconstruction and renewal projects more frequently, materials needed to build them will no longer be considered specialty materials. For example, porous pavement is currently estimated at \$12 per square foot in the Pittsburgh region. In Kansas City and New Orleans where porous pavement has been used on several projects and local suppliers have been trained, costs are about \$7.50 per square foot. In the future, as these materials become standard in our region, unit costs may be reduced.

**Reductions in Perceived Construction Risk:** As GI is incorporated into street reconstruction and renewal projects and new development and redevelopment projects across the City, GI will become the standard method of doing business. Local contractors will learn the techniques to efficiently install the various BMPs, and, construction costs may be reduced. Current GI cost estimates include both a 25% construction contingency and a 20% overall project contingency to account for these perceived risks. These cost contingencies may be reduced by 50% or more over time due to the lowered risk and lower contractor costs.

**Reductions in O&M Costs:** As GI is incorporated into the urban landscape, the associated O&M costs are expected to become more predictable and efficiencies in

maintenance and BMP designs will result in lower overall O&M costs. In addition, if O&M work will be done by a contractor, competitively bid contracts will drive down O&M costs. O&M cost reductions of 10% - 30% may occur, depending on the type of BMPs and associated frequency of O&M required, influenced by stormwater and pollutant loads.

To remain conservative in the overall GI costs developed for the City-Wide GI Assessment, these potential cost reduction efficiencies in materials, construction costs, design costs, O&M costs, and contingencies are not included in the cost estimates for the GI scenarios.

In addition to learning curves that may reduce GI costs, GI also can provide numerous social, economic, and environmental benefits. Section 8 of this report identifies and discusses these associated "Triple Bottom Line" benefits for the analyzed GI scenarios.

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