Project Name: Developing PWSA's Strategic Plan for Stormwater

Project No.: 2020-025-OPS

Cost Assumptions and Methods for PWSA Stormwater Strategic Plan

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As part of the development of a the PWSA Strategic Plan for Stormwater, estimated order-of-magnitude implementation costs were developed for the following improvements:

- Watershed storage
- Floodplain restoration
- Conveyance improvements

Costs were based on a number of assumptions, many of which may change during the next phases of plan implementation. Therefore, the costs provided should be viewed as a preliminary indication of the magnitude of investment required to achieve meaningful results and the need for significant increases in revenue to support plan implementation.

Construction estimates for each type of improvement were initially developed by priority watershed. Subsequently, construction estimates were marked up to account for design and operations and maintenance costs, escalated to account for inflation, and allocated over a 50-year plan implementation period.

Spreadsheets

Cost calculations are provided in two spreadsheets:

- *TypologiesInvestment.xlsx* – this spreadsheet computes watershed, conveyance, and floodplain restoration costs and then allocates and escalates these costs over a 50-year implementation period

- *Combined Unit Cost.xlsx* – this spreadsheet derives unit costs for watershed storage, floodplain restoration, and conveyance.

These spreadsheets can be used for iterative scenario analysis moving forward, including varying assumptions relating to PWSA cost-share, unit costs, precipitation depth, and other factors. One suggestion would be to develop batch processing capability using visual basic or other similar scripting tools. This would allow PWSA to better understand the envelope of cost possibilities and the sensitivity of the cost model to various inputs.

Method details are provided in the sections below:

Construction Costs

Watershed Storage

Watershed storage estimates were developed for each priority watershed. For each watershed, the total impervious area was computed by multiplying the watershed area by the percentage of the watershed that was mapped as impervious. Both total watershed area and percent impervious cover were derived from GIS data provided by PWSA. For purposes of the analysis all impervious area in each priority watershed was considered to be unmanaged. In future iterations, the percentage of impervious cover managed by existing BMPs could be subtracted from these totals.

Management targets for watershed storage were assigned by priority watershed category as follows:

Priority Watershed Category	Priority Watersheds	Target Impervious Cover Managed (%)
1	Negley Run, Lower Saw Mil Run, Upper Saw Mill Run	30%
2	Becks Run, Four Mile Run, Lower Allegheny North, Two Mile Run	20%
3	Lower Allegheny South, Lower Monongahela North, Woods Run, Streets Run	15%
4	South Side Slopes, Upper Monongahela, Allegheny South, Heth's Run	10%
5	Ohio, Nine Mile Run, Lower Chartiers Creek, Upper Chartiers Creek.	10%

The impervious area to be managed for each watershed was determined per Eq.1:

Eq. 1.

Impervious Area Managed (ac) = Watershed Area (ac) x Percent Impervious (%) x Target Impervious Managed (%)

Due to Pittsburgh's stormwater regulations, which require stormwater management for many of the City's developments, not all future impervious acres managed will require capital investment by PWSA. To determine the impervious area to be managed that will require PWSA capital investment, the impervious area to be managed was reduced by an assumed percentage to account for the managed impervious area that will accrue because of regulated development. This percentage was assumed to be 50% or approximately 1% per year for the 50-year plan implementation period. In future costing exercises, these estimates could be refined by watershed to reflect site specific redevelopment rates and predictions.

To assign unit costs, the impervious area be managed for each watershed was first allocated among five terrain types. For each terrain type, a % suitability ratio was defined that represented the percentage of each terrain that would be suitable for the placement of watershed storage. Suitability ratios were determined by visual inspection of aerial photographs and topographic mapping as well as best professional judgement. Ratios used in the analysis were as follows:

Terrain Type	Suitability Ratio
Floodplain	0.01
Hollow	0.05
Sloped Hillside	0.01
Hilltop	0.10
RiverFlats	0.05

For each watershed, the maximum number of impervious acres that could be managed within each terrain type was calculated as follows:

Eq. 2.

Maximum Impervious Acres Managed (ac) = Terrain Area (ac) x Suitability Ratio (%) x Hydraulic Loading Ratio where:

Hydraulic Loading Ratio = 10. Hydraulic Loading Ratio is the ratio of the contributing drainage area to practice footprint.

The terrain area was determined through manual delineation and visual inspection of terrain types in GIS using a combination of aerial imagery, DEMs, and topographic mapping.

For each watershed, the number of impervious acres to be managed within each terrain type was determined by preferentially assigning acres to terrain types. This allowed for the assignment of terrain specific unit costs. Acres were assigned to the highest priority terrain until the impervious acres to be managed equaled the maximum impervious acres managed. Acres were then assigned to the next highest priority terrain type and so on.

The preference order used for the acreage assignments was as follows:

Terrain Type	Priority
Hilltop	1
Hollow	2
Riverflats	3
Floodplain	4
Sloped Hillside	5

To calculate the required volume of stormwater management required, the impervious area to be managed for each watershed was multiplied by an assumed precipitation depth of 1.66 in.

Unit Costs for Watershed Storage

Unit Costs were developed for each terrain type. Unit costs reflect the estimated cost to construct one unit of watershed storage (in acre-in) within each terrain type. Watershed storage unit costing assumptions and methods generally and by terrain type are listed below. Additional detailed cost assumptions are provided in the referenced excel spreadsheet "Combined Unit Cost.xlsx" provided as a digital attachment to this memo.

General

- Detailed assumptions for conveyance and storage quantities are provided in the excel spreadsheet "Combined Unit Cost.xlsx"
- Aerial photos were used to develop quantity take offs for the total impervious area managed based on several sample drainage areas. Drainage areas for the hilltop and riverflats area were smaller, given the assumption of integrating into a development project with more limited space. Drainage areas for the sloped hillside and hollows areas were assumed to be larger given the setting of the storage practice within existing publicly owned parks, etc.
- Storage area required was determined by dividing the impervious area by an assumed storage depth per acre of 2 ft.
- Storage practices were sized for 1.66 in. of precipitation.
- Except where noted, unit costs for stormwater conveyance and storage (e.g., inlets, piping, excavation, etc.) were determined using unit costs from the 2021 PWSA Sewer Construction, Earthwork, and GI bid sheets and are further detailed in the excel spreadsheet "Combined Unit Cost.xlsx".
- 35% contingency was applied to account for mobilization, closeout, erosion and sediment control, etc.
- Average pipe size was based on 1/3 of the 5 and 10-year intensity storm event from NOAA Atlas 14 estimates.
- Costs for regional storage and conveyance were included – all other costs associated with typology implementation were not included in the base cost estimate

Hilltop and Riverflat

- Costs were based on a regional wetland storage facility integrated with a development project
- Marginal storage costs (the cost of enlarging the on-site practice) was assumed to be equal to the unit cost for the developer incentive provided by the city. This cost was however included as part of the cost estimate.

Floodplain and Sloped Hillside

- Costs were based on a stand-alone (e.g., not integrated with a development project) regional wetland storage facility

Hollow

- Costs were based on a stand-alone (e.g., not integrated with a development project) subsurface storage facility

Unit costs were multiplied by the impervious area to be managed to yield a construction cost for watershed storage for each watershed. This total was then multiplied by the percentage of the construction cost that is assumed to come from direct PWSA investment versus external sources (e,g., grants). This percentage was assumed to be 70%.

Floodplain Restoration

Floodplain restoration costs included the design strategies referenced in the floodplain terrain type. These include excavation and lowering of the floodplain surface, replanting, bank stabilization, land acquisition, building demolition, and bridge/culvert modifications. Additional assumptions and methods associated with cost estimate for floodplain restoration are listed below:

- Quantities for excavation, bank stabilization, demolition, etc. were based on estimates derived from a sample area of floodplain located in Saw Mill Run. Assumptions and specific methods are further detailed the excel spreadsheet "Combined Unit Cost.xlsx"
- Unit cost for determined using unit costs from the 2021 PWSA Sewer Construction, Earthwork, and GI bid sheets, PLI audit information, on-line sources, AKRF estimates, and best professional judgement, and are further detailed in the excel spreadsheet "Combined Unit Cost.xlsx".
- 35% contingency was applied to account for mobilization, closeout, erosion and sediment control, etc.
- Extra features not directly related to flood and stormwater management such as trails were not included in the cost estimates

The unit costs were multiplied by the estimated stream length located within the floodplain terrain type in each priority watershed. This stream length was obtained via GIS analysis. We also assumed an implementation percentage of 25% (this is the percentage of the total stream length that would be subjected to implementation) and that 40% of the costs would be incurred by PWSA.

Conveyance Improvements

Construction costs for conveyance improvements were estimated assuming that the primary conveyance upgrades would consist of increasing pipe sizes to provide an enhanced level of service. Replacement of inlets and laterals were not assumed. Unit costs were developed for each of five pipe diameter groupings (e.g., 8-12 in. sewer, etc.) For each size grouping the average additional capacity needed to accommodate upsizing the pipe from a 1-year storm intensity to a 5-year intensity and 10-year intensity (see tab "Conveyance_Sewer Capacity" within the spreadsheet "Combined Unit Cost.xlsx"). In all cases but one, the size increase (and therefore the marginal cost increase) associated with increasing capacity for the 5-year and 10-year intensity were identical. Unit costs for different size categories were developed using unit costs from PWSA's 2021 Bid Master spreadsheet. Unit cost derivation is provided in the tab "Conveyance_Unit Cost by Size" within the spreadsheet "Combined Unit Cost.xlsx. Unit costs for larger size categories that were outside of the ranges provided in PWSA's Bid Sheet (pipes over 66 in.) were estimated as detailed in the tab "Conveyance_Sewer Size Groupings" within the spreadsheet "Combined Unit Cost.xlsx".

To develop total costs for each size category, the marginal unit costs were multiplied by the length of piping associated with each size classification based on GIS data provided by PWSA. The raw GIS data file provided was first modified to remove sanitary pipes and privately owned laterals. The total percentage of the City's sewer network that would need to be upsized is not known at this time but was estimated to be 30% for costing purposes.

Allocation of Costs by Year

Construction costs were estimated for each year of the 50-year implementation period by assuming a percentage implementation per year for each watershed. The implementation percentages for each year were determined by first allocating the percentage of implementation that would occur in each decade of the implementation period according to watershed priority grouping. Groupings are identical to those described above in the watershed storage construction cost section. Percent allocations by decade are as follows:

Priority Watershed Category	Decade				
	1	2	3	4	5
1	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2
3	0.1	0.1	0.1	0.3	0.4
4	0.1	0.1	0.1	0.3	0.4
5	0.1	0.1	0.1	0.3	0.4

Yearly allocations within a decade were assumed to be 10% of the decade allocation per year. Construction costs were not allocated in years 1 and 2 to account for the time required to design the initial projects. Similarly, design costs were not allocated in years 49 and 50. Operations and maintenance costs were allocated starting in year 4.

Escalation

Allocated raw construction costs were escalated by an assumed inflation rate of 3% per year. As design and O&M costs were calculated as percentages of escalated construction costs, these costs reflect a similar escalation.

Design and O&M Costs

Design and operations and maintenance (O&M) costs were estimated as a percentage of escalated construction costs. Design, which includes all pre-construction work such as planning, outreach, permitting, and bidding was estimated to be 30% of construction. O&M costs were estimated at 1% of construction per year.