Assessment of Existing Flow Control Facilities in WRIA 9

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EXECUTIVE SUMMARY

King County was awarded a Puget Sound Watershed Management Assistance Program Fiscal Year 2009 grant by Region 10 of the U.S. Environmental Protection Agency (U.S. EPA) to develop a stormwater retrofit plan for Water Resources Inventory Area (WRIA) 9. The primary goal of this grant-funded study is to develop a plan and associated costs to implement stormwater Best Management Practices (BMPs) in developed areas of WRIA 9, that were built primarily without stormwater controls. Another overall goal of the study is to extrapolate stormwater retrofit costs to all of the developed area draining to Puget Sound. This report is one of the interim project reports needed to complete the overall study goals. This report evaluates, in selected WRIA 9 subwatersheds, the types and runoff storage volumes provided by existing stormwater management installations influencing the project's hydrologic indicators.

The purpose of this report was to quantitatively adjust the planning-level estimates of required new flow controls produced by SUSTAIN modeling, and the associated costs; or at least qualitatively condition the estimates to reflect existing infrastructure. Selected subwatersheds were the Des Moines Creek and Miller/Walker Creek drainages and the city of Covington, lying in the Jenkins and Soos Creek basins. The flow control facilities considered in the assessment were ponds, vaults, tanks, infiltration basins and trenches, and filter strips receiving runway runoff at Seattle-Tacoma International Airport. Data on these facilities were obtained from the files of the jurisdictions in the subwatersheds. Two estimates were made of the volumes provided: (1) low estimates recognizing only the geometric volumes of ponds, vaults, tanks, and infiltration facilities and a lower estimate of rainfall storage by filter strips; and (2) high estimates recognizing potential infiltration and evaporation from ponds and infiltration facilities and a higher estimate of rainfall storage by filter strips. Results were expressed in watershed-inches of storage, computed by dividing total facility volumes by subwatershed developed areas.

Among the three subwatersheds, storage estimates ranged from 0.39 to 0.67 watershed-inch. Compared with the overall study area SUSTAIN-based estimate of 2.7 watershed-inches needed to obtain hydrologic and biological conditions approaching those in a fully forested watershed, 14 to 25 percent of the total needs seem to be served by existing infrastructure. The weight of the available evidence is that the most judicious single value to adjust forecasts of future needs throughout WRIA 9 is 0.5 watershed-inch. If, however, an estimate of existing capacity were to be made for a localized area within WRIA 9, a different choice may be appropriate. A value of 0.4 watershed-inch would be conservative in not risking overestimation where infiltration-restricting glacial till soils predominate. In the Miller/Walker Creek subwatershed, with somewhat greater stormwater infrastructure than elsewhere, a value of 0.6 watershed-inch would be suitable. These small deviations would have little effect on BMP prescriptions and their costs at the planning level.

Beyond the planning level, jurisdictions will have to determine their specific needs to achieve resource protection and improvement goals. An important consideration will be the role that existing infrastructure can play in filling those needs. The assessment found

that no jurisdiction surveyed has the information needed to take full advantage of BMPs already in place. A prudent course of action for the jurisdictions in preparing for the next step would be to move now to make sure that their facility inventories are complete and correct.

1.0 INTRODUCTION

1.1 Objective and Purpose

King County was awarded a grant by the U.S. Environmental Protection Agency to develop a stormwater retrofit plan for most of Water Resources Inventory Area (WRIA) 9. The project's scope is to: (1) identify the most cost-effective low impact development (LID) and other stormwater management techniques to meet in-stream flow and water quality goals in WRIA 9; (2) develop a prioritized retrofit plan for the study area; and (3) extrapolate the results to estimate planning-level costs to retrofit all developed lands in the Puget Sound region. Watershed modeling output from Hydrologic Simulation Program – FORTRAN (HSPF) was used as input to the System for Urban Stormwater Treatment and Analysis INtegration (SUSTAIN) model to optimize the selection of management techniques to achieve the goals.

SUSTAIN's estimation of the types and quantities of needed best management practices implicitly assumes no existing stormwater infrastructure. Therefore, to refine the estimate it is necessary to determine and account in some way for the BMPs already installed. With the primary modeling effort in this project being directed at flow controls needed to maintain selected hydrologic indicators within certain target values[1], the specific existing BMPs of interest are those with a flow control function. From the water quality standpoint, SUSTAIN modeled only total suspended solids (TSS); but in post-processing of the results, turbidity, copper, and zinc were statistically extrapolated from TSS.

While specific numbers are unknown, after more than 20 years of stormwater implementation efforts in the region, it is certain that the 278-square-mile study area contains many hundreds of existing flow control BMPs spread among its 18 jurisdictions. It was judged to be infeasible to catalogue the BMPs fully. Thus, it was decided to perform the most complete assessment possible in selected subwatersheds within the study area and extrapolate the results throughout.

The intention at the outset of the assessment was to quantitatively adjust SUSTAIN estimates, if the results would support numerically reducing the forecasts of future requirements in relation to the infrastructure already present. Even if the findings proved to be inadequate for quantitative use, they would still have value in qualitatively conditioning the projections (e.g., to characterize them as "probably close to the actual future needs," "probably slightly overestimated," "probably moderately overestimated"). It must be kept in mind that the thrust of this project is to establish future stormwater management needs at the planning level. Moving forward to implementation will require site-specific analyses and development of management strategies at the jurisdiction level.

[1] High pulse count (HPC), high pulse range (HPR), and ratio of the 2-year peak flow to mean winter base flow (PEAK: BASE); see Horner (2013).

In summary, the objective of the assessment was to determine, in selected subwatersheds of the study area, the types and runoff storage volumes provided by existing stormwater management installations influencing the project's hydrologic indicators. Its purpose was to quantitatively adjust SUSTAIN estimates of required new flow controls, and the associated costs; or at least qualitatively condition the estimates to reflect existing infrastructure.

1.2 Selected Subwatersheds and Facilities Assessed

Two subwatersheds were chosen in the relatively highly developed western portion of the study area and one in the somewhat less densely developed center. The western selections were the Des Moines Creek and Miller/Walker Creek subwatersheds. The two were picked because the Port of Seattle's Seattle-Tacoma International Airport (STIA) is a major landholder in both. Other jurisdictions draining to Des Moines Creek are portions of the cities of Des Moines and SeaTac. Parts of the cities of Burien, Normandy Park, and SeaTac, along with a small unincorporated King County parcel, drain to the Miller/Walker Creek system.

The central subwatershed choice encompassed the boundary of the city of Covington. Covington falls in the Jenkins Creek and Soos Creek basins (Jenkins being a Soos Creek tributary).

The selected subwatersheds are similar in size and development level:

- Des Moines Creek subwatershed—5.78 square miles total area, 92 percent developed (5.32 square miles developed area);
- Miller/Walker Creeks subwatershed—8.13 square miles in area, 93 percent developed (7.56 square miles developed area); and
- City of Covington subwatershed—5.96 square miles in area, 89 percent developed (5.32 square miles developed area).

Facilities included in the assessment and found throughout the selected subwatersheds were: (1) ponds (specifically, those installed for flow control); (2) vaults; (3) tanks; (4) infiltration basins; and (5) infiltration trenches. Also present at STIA are extensive runway filter strip areas. These filter strips are grass-covered zones planted in soils amended with compost if necessary to improve water storage and infiltration characteristics. Most were installed in connection with the third runway construction about seven years ago. They serve for flow control by infiltrating and evaporating stormwater draining off adjacent runways, as well as rainfall directly on them.

1.3 Summary of Relevant Modeling Results

The principal output of the SUSTAIN model is a set of BMP standard-size units optimized for cost effectiveness to meet selected hydrologic indicator targets. In reality, standard-size BMP units could be installed in any combination to achieve the degree of flow control required to meet a target. As an example, 786 ft^3 of required volume could be provided by two standard-size cisterns (10-ft diameter and 5-ft height) or by one larger cistern of equivalent total volume.

The overall SUSTAIN output for various target scenarios was converted to total volume represented by the optimally selected numbers of the various BMPs. The volume was then divided by the total developed (non-forested) area that would drain to the entire set of BMPs to obtain the quantity of storage they would provide, representing the depth of runoff they could hold, expressed as watershed-inches:

$$Storage\ (watershed - inches) = \frac{BMP\ Volume\ (ft^3)}{Developed\ Area\ (ft^2)} x12\ inches/ft$$

On a study-area-wide basis, the result of SUSTAIN modeling was a requirement for 2.7 watershed-inches of storage for “full stormwater management”; i.e., to create hydrologic conditions and biological integrity approaching a fully forested condition. This requirement varied among the jurisdictions making up the study area, from a minimum of 2.48 to a maximum of 3.02 watershed-inches (King County 2014).

2.0 METHODS AND ASSUMPTIONS

2.1 Data Sources

To compare existing flow control infrastructure to SUSTAIN estimates of future requirements, the principal task of this investigation was to determine the types and volumes of all flow control BMPs in the selected subwatersheds. These data were obtained in different ways among the jurisdictions, as described below. In every case there were missing data, sometimes volumes, or dimensions to calculate volumes, or even the type of BMP corresponding to an entry in a data record. These cases were not included in this analysis.

- Burien—The City provided BMP areal coverage in the form of geographic information system (GIS) data. The database had other dimensions for some facilities, particularly tanks and infiltration trenches, enabling volumes to be computed. Depths were not recorded for ponds, vaults, and some infiltration trenches. In these cases, depths were assumed for ponds and vaults (5 ft) and infiltration trenches (2 ft, except 1 ft for French drains). These assumed depths are typical of such facilities throughout the region.
- Covington—The City provided BMP types and volumes.
- Des Moines—The City provided project files containing as-built and/or design plans, which were scaled to obtain BMP dimensions.
- King County—The County inventory files containing BMP diagrams, which were scaled to obtain dimensions.
- Normandy Park—The City provided a list of BMPs without sizes or dimensions. In tracing their locations it was found that all but two are located outside the selected subwatersheds, and no further work was performed to obtain their sizes.
- Port of Seattle—The Port provided pond, vault, tank and infiltration facility volumes. For filter strips the Port provided their surface areas and the runway areas draining to them.
- SeaTac—The City provided project files containing as-built and/or design plans, which were scaled to obtain BMP dimensions.

2.2 Assumptions and Estimation Methods

It was assumed that ponds, vaults, tanks, and infiltration facilities can hold a quantity of water at least equal to their volumes, but that natural-bed structures can offer more capacity because of infiltration and evaporation. Accordingly, it is reasonable to make low capacity estimates based on the geometric volumes alone and high estimates with an assumption of infiltrative and evaporative losses. Based on experience and professional judgment, those assumptions are 25 percent more than the geometric volumes for ponds and twice the volumes for infiltration facilities.

Discussions with Port of Seattle staff on the operation of the runway filter strips could not identify a specific volume capacity. However, the staff have observed that the strips normally do not discharge surface runoff until November and then attenuate the surface discharge through the remainder of the wet season (Duffner, personal communication). Again based on experience and professional judgment, this water loss pattern would be roughly equivalent to storage capacity of around 0.5-1 inch of runoff.

In summary, the low capacity estimates were based on: (1) geometric volumes for flow control ponds, vaults, tanks, and infiltration facilities; and (2) for airport runway filter strips, 0.5 inch of rain falling on the runways plus the strips. High estimates were based on: (1) geometric volumes for vaults and tanks; (2) 1.25 times the geometric volumes for flow control ponds; and (3) for airport runway filter strips, 1 inch of rain falling on the runways plus the strips.

3.0 RESULTS

Table 1 summarizes the results. The Des Moines, Miller/Walker, and Covington subwatersheds contain, respectively, about 50, 200, and 125 quantifiable flow control structures. Ponds provide the majority of the flow control capacity in all cases. Runway filter strips are estimated to offer substantial storage in the first two subwatersheds, particularly Des Moines. The Miller/Walker and Covington subwatersheds have large numbers of facilities with insufficient information to identify type or quantify capacity.

From this assessment it appears that at least 0.4 watershed-inch of storage has been installed in WRIA 9, and not more than 0.7 watershed-inch. The high estimates for Des Moines and Covington and the low estimate for Miller/Walker fall at about 0.5 watershed-inch.

Table 1. Summary of Assessment Results

Subwatershed	Flow Control Facility Type	No. Quantified	Estimated Volume[a] (thousand ft^3)	No. with Insufficient Data	Estimated Storage[b] (watershed-inch)
Des Moines	Ponds	20	3070-3837	3	0.40 – 0.52
	Vaults and tanks	25	935	2	
	Infiltration	4	19-38	2	
	Runway filter strips	172 acres	868-1735	-	
	Undesignated	-	-	0	
Miller/Walker	Ponds	67	8269-10337	3	0.53 – 0.67
	Vaults and tanks	44	386	15	
	Infiltration	88	142-284	0	
	Runway filter strips	92.2 acres	382-764	-	
	Undesignated	-	-	126	
Covington	Ponds	79	4513-5642	2	0.39 – 0.49
	Vaults and tanks	31	336	0	
	Infiltration	16	16-31	8	
	Undesignated	-	-	39	

[a] Low estimates based on geometric volumes of ponds, vaults, tanks, and infiltration facilities and, for runway filter strips, 0.5 inch of rain falling on runways plus strips; high estimates based on geometric volumes of vaults and tanks, 1.25 x volume for ponds, 2 x volume for infiltration facilities, and, for runway filter strips, 1 inch of rain falling on runways plus strips.

[b] Estimate storage = Estimated volume/Developed area

It is useful to put the results in context, as illustrated in Table 2. The WRIA 9-wide estimate of flow control storage required for full stormwater management is 2.7 watershed-inches

(King County 2014), of which about 14-25 percent is estimated to be available at this time. These quantities can be compared to storage requirements for ponds to provide flow control for different levels of urbanization according to Washington Department of Ecology (2012) requirements. It may be seen in Table 2 that WRIA 9 overall fits between medium and high density urban, closer to the medium level.

Table 2. Estimates of WRIA 9 Storage Required for Full Stormwater Management and Already Existing Compared to Pond Storage Required to Meet Washington Department of Ecology Flow Control Requirements

Case (% impervious)	Flow Control Storage Requirement (watershed-inches)
SUSTAIN estimate for WRIA 9	2.7
Estimate of existing capacity	0.4 – 0.7
Pond for low density urban (9% impervious)	1.6 [a]
Pond for medium density urban (28% impervious)	2.3 [a]
Pond for high density urban (66% impervious)	3.8 [a]
Pond for intensive commercial (85% impervious)	4.8 [a]

[a] To meet Washington Department of Ecology (2012) Minimum Requirement #7: match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the 50-year peak flow; based on HSPF modeling of a100-acre drainage area with glacial till soils and a flat slope (Burkey, personal communication).

4.0 DISCUSSION

4.1 Evaluation of Results

There are reasons why the existing storage estimated in this assessment could be underestimated or overestimated. Possible reasons for underestimation are:

- Approximately 200 facilities in the three subwatersheds are enumerated in the records but are not identified by type or have insufficient data to quantify volumes. Accounting for more than one-third of all installations listed, these facilities are not represented in the storage estimates.
- Infiltration and evaporation could be more than maximum estimates, especially in Covington, where relatively rapidly infiltrating outwash soils are fairly abundant.
- Single-purpose water quality facilities not included in the assessment also offer some storage (e.g., swales, wet ponds).

Overestimation could have occurred because:

- Some locations may not have as much existing stormwater infrastructure as the subwatersheds considered.
- Some facilities may not be not functioning well because of poor care.
- Volumes quantified may not be all "live storage" (e.g., dual-purpose pond with a wet pool for treatment).

These considerations roughly balance one another, although the slightly more than one-third of installations that could not be quantified may throw the weight toward underestimation. The presence of substantial outwash soils in Covington, and attendant greater infiltration, would tend to reinforce this judgment for that subwatershed, thus shifting the storage estimate closer to the high side of its range (~0.5 watershed-inch).

The Miller/Walker Creek subwatershed has a large number of unquantified facilities but less infiltration potential than the Covington area. This basin contains a number of especially large ponds as well as the runway filter strips, not a typical situation for the study area as a whole. In regard to this assessment's objective of using data from the three selected subwatersheds to determine an adjustment of future storage needs applicable broadly, the low side of the Miller/Walker storage estimate (~0.5 watershed-inch) would seem to be conservative in not risking overestimation. However, a higher correction could be applied within this specific subwatershed.

The Des Moines subwatershed has few facilities that could not be quantified, lower infiltration potential than Covington, and existing storage heavily influenced by the runway filter strips. All of these circumstances encourage selection of a storage value lower as opposed to higher in the range estimated for this basin; i.e., closer to 0.4 than 0.5 watershed-inch.

All considered, it seems to be safe to apply an adjustment to future flow control requirements across WRIA 9 of at least 0.4 watershed-inch to account for existing storage. The overall weight of the evidence points toward a greater adjustment, 0.5 watershed-inch, and perhaps higher yet in the case of Miller/Walker Creek. There, a value at the midpoint of its range (0.6 watershed-inch) seems to be a prudent choice recognizing the somewhat greater infrastructure in place while not risking overestimation. On the other hand, should existing storage capacity be estimated for a case with predominantly infiltration-limiting glacial till soils, 0.4 watershed-inch would not likely risk overestimation.

In the end, the choice of one or another value in the range identified in this assessment makes little difference in relation to the 2.7 ± ~0.3 watershed-inch storage capacity needed as forecast by SUSTAIN (e.g., the difference in the new facilities needed would be only 3.6 percent greater with an adjustment of 0.4 compared to 0.5 watershed-inch).

4.2 Extending Results Beyond the Planning Level

As with all project results, these findings can be a guide; but jurisdictions must do site-specific planning and establish what facilities actually exist and their capabilities. The assessment revealed that no jurisdiction surveyed has complete records of existing infrastructure. In preparation for this next level, BMP inventories should be rechecked and completed.

4.3 A Clarification

It is worth reiterating that this assessment concerned flow control facilities only and did not directly investigate water quality facilities. Nevertheless, the SUSTAIN analysis showed that installing the facilities required for hydrologic control would substantially reduce the mass loadings of TSS, copper, and zinc discharged to receiving waters and result in low risks of exceeding the turbidity, copper, and zinc water quality criteria.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The objective of the assessment was fulfilled in determining, within an estimated range, the runoff storage volumes provided by existing stormwater management installations influencing the project's hydrologic indicators. The outcome adequately serves the planning-level purpose of quantitatively adjusting SUSTAIN estimates of required new flow controls, and the associated costs. It is recommended that an adjustment of 0.5 watershed-inch be applied across the study area, with one exception. A value of 0.6 watershed-inch is more appropriate for Miller/Walker Creek subwatershed. However, that small divergence would make little difference at the planning level.

Moving beyond the planning level, the jurisdictions will have to determine their specific needs to achieve resource protection and improvement goals. Existing infrastructure will play a definite role in filling those needs. At present, no jurisdiction surveyed has the information needed to take full advantage of BMPs already in place. Their staff should move now to make sure that their facility inventories are complete and correct.

6.0 REFERENCES

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