Appendix K

Whipple Creek Watershed-Scale Stormwater Plan Report

Using WWHM to Model Strategies for Full Build-Out Scenario Inside Whipple Creek UGA

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Introduction

Clark County is conducting a watershed scale study of Whipple Creek watershed as mandated under NPDES permit requirements. The project includes development of an HSPF model to represent the hydrologic and stream flow conditions of the watershed under both existing and future land use conditions. The permit also requires identification of stormwater management strategies that can result in hydrologic and water quality conditions to fully support the future build-out conditions. The Western Washington Hydrology Model (WWHM) has been used to model the conditions represented by the application of some of the BMPs identified in these strategies. The hydraulic function tables (FTABLEs) generated by WWHM are used in the HSPF model to reflect these strategic scenarios. The entire watershed is divided into 27 subbasins based on the topography and or hydrologic control points. The subbasin boundaries are shown in Figure 1. The general procedures used to run the model and all the assumptions made are presented in the remainder of this appendix.

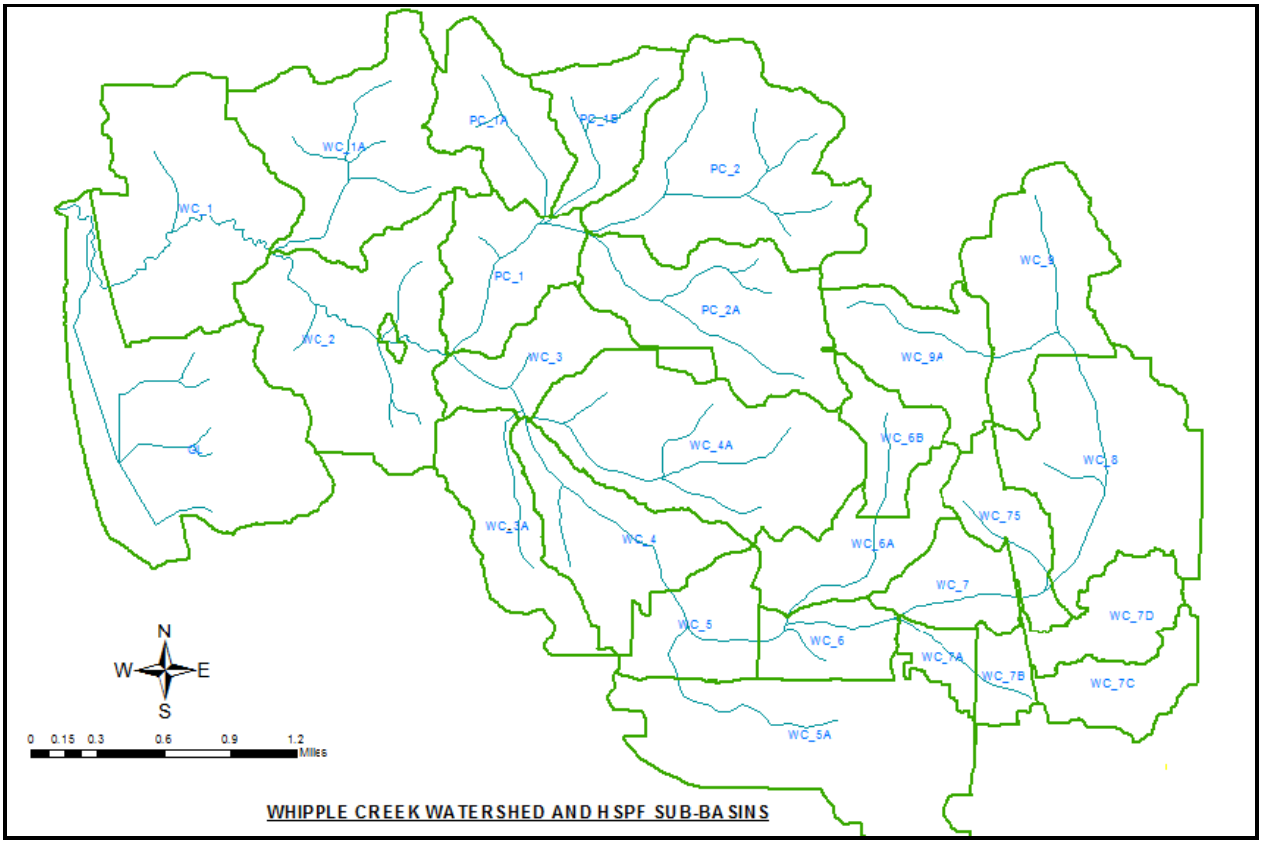

Figure-1. Whipple Creek Watershed HSPF Sub-basins.

Future Development and Minimum Requirements (MR #5, #6, and #7)

There are 27 subbasins that are modeled for future build-out scenario. These 27 subbasins are located in the area where the predominant soil types are either category SG3 or SG4. Table 1 shows the list of these subbasins identified with their predominant soil type. The subbasins with SG3 soil type are considered suitable for low impact development (LID) BMPs that infiltrate while the subbasins with SG4 soil type are considered infeasible for infiltrating LID BMPs. Based on these considerations, applicability of the minimum requirements for modeling purpose has been assumed as follows:

Subbasins with predominantly SG3 soil type trigger:

- LID performance standard (MR#5)
- Water quality standard (MR#6)
- Stream protection standard (flow duration, MR#7)

Sub-basins with predominantly SG4 soil type trigger:

- Water quality standard (MR#6)
- Stream protection standard (flow duration, MR#7)

Table 1: Sub-basins and Soil Types

SG3 Soil Type	SG4 Soil Type
WC_7B	WC_9
WC_7A	WC_9A
WC_7	WC_8
WC_6A	WC_75
WC_6	WC_7D
WC_5A	WC_7C
WC_5	WC_6B
GL	WC_4A
WC_1	WC_1A
WC_2	PC_1
WC_3	PC_1A
WC_3A	PC_1B
WC_4	PC_2
	PC_2A

It is assumed that all the acreages to be developed in the future are subject to both MR#6 and MR#7. Additionally, all the acreages to be developed within the SG3 soil are assumed to be subject to MR#5.

The future development acreages within each subbasin have been calculated as the difference between the existing and future (build-out) land cover data.

WWHM Model Set up and Assumptions

The WWHM2012 bioretention element has been used to represent LID BMPs in each sub-basin in the HSPF model; the WWHM2012 trapezoidal pond element represents the sub-basins' detention ponds. Even for the subbasins with SG4 soil where LIDs are considered infeasible, the bioretention element has been used to achieve the water quality standard (MR #6). Each individual subbasin has been considered a single large drainage basin for the modeling purpose. When future developments occur within these subbasins, there will be multiple bioretention facilities and detention ponds installed throughout each individual sub-basin. However, for modeling purposes, multiple bioretention facilities are represented by a single large bioretention facility inside an individual subbasin. Similarly, a large single detention pond is assumed to represent multiple smaller ponds within the same subbasin.

There is very limited documentation of soil infiltration tests available for the area. The few available tests have revealed infiltration rates ranging from 0 to 2 inches per hour depending on the location and depth of the test. For the modeling of subbasins with SG4 soils, the native soil infiltration rate was assumed to be 0 (zero) inches per hour (in/hr). For the modeling of subbasins with SG3 soils, a long-term soil infiltration rate of 0.50 in/hr has been used. This is calculated based on an assumption of 2 in/hr as the initial infiltration rate, and a correction factor of 0.25 (2 * 0.25 = 0.50).

The general approach used to run each WWHM sub-basin model was as follows:

<u>Subbasins with SG4 soil:</u>

- Runoff is routed into a bioretention facility that is sized using the WWHM2012 'Size Water Quality' feature. To achieve the water quality standard (MR #6), more than 91 percent of the inflow must pass through the bioretention soil layers and discharge through the underdrain.
- Overflow from the bioretention facility riser and flow through the underdrain are routed to a downstream trapezoidal pond. The WWHM0212 'Auto Pond' feature is used to size the pond and to analyze and verify if the pond passes the flow duration standard (MR #7).

<u>Subbasins with SG3 soil:</u>

- The WWHM2012 Predeveloped scenario is run to find the 2-year peak flow.
- 8% and 50% of 2-yr flow are calculated and the Point of Compliance (POC) duration criteria are changed with these values to represent the LID duration criteria.
- Runoff is passed through the bioretention facility and the facility is sized for the stream protection standard (MR #7) using the WWHM2012 'Size Facility' feature. In this case, the stream protection standard is actually the LID performance standard as the duration criteria have been changed to represent the LID duration criteria. The sized bioretention facility must

also be able to filter more than 91 percent of inflow to achieve the water quality standard (MR #6). This includes the portion of runoff that is infiltrated to the native soil and the flow that discharges downstream to the pond via the underdrain.

- The duration criteria are then changed back to the default values (50% of the 2-year peak flow to the 10-year peak flow) based on the predeveloped flow frequency.
- Overflow from the bioretention facility and flow through the underdrain are routed to a downstream trapezoidal pond. The WWHM2012 'Auto Pond' feature is used to size the pond and to analyze and verify if the pond passes the flow duration standard (MR #7).

The WWHM model set-ups for all the subbasins are shown in the following schematics:

Used acronyms/abbreviations:

Res: Residential

NR: Non-residential

POC: Point of Compliance

(All the numbers shown represent areas in acres)

WC_9

					SG4*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	3.22	24.73	25.18	142.72	28.63	0	94.56	0
Existing	2.27	17.43	0.84	14.66	99.05	107.1	77.69	0
Net Increase	0.95	7.3	24.34	128.06	0	0	16.87	0

Pre-developed

Forest = 177.52

POC

Mitigated

Roof = 25.29
Pavement = 135.36
Lawn = 16.87

↓

Bioretention → Underdrain

↓ ↙

Pond

POC

*No native infiltration.

WC_9A

					SG4*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	2.2	16.93	5.82	102.14	15.32	0	82.1	0
Existing	1.27	9.9	2.4	42.3	44.34	47.41	76.89	0
Net Increase	0.93	7.03	3.42	59.84	0	0	5.21	0

Pre-developed

Forest = 76.43

POC

Mitigated

Roof = 4.35
Pavement = 66.87
Lawn = 5.21

↓

Bioretention → Underdrain

↓ ↙

Pond

POC

*No native infiltration.

WC_8

					SG4*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	13.22	101.68	0.19	3.37	138.85	15.17	187.35	0
Existing	7.74	59.56	0	0	179.85	68.29	144.39	0
Net Increase	5.48	42.12	0.19	3.37	0	0	42.96	0

Pre-developed

Forest = 94.12

POC

Mitigated

Roof = 5.67
Pavement = 45.49
Lawn = 42.96

↓

Bioretention → Underdrain

↓ ↙

Pond

POC

*No native infiltration.

WC_75

	Res Roof	Res Pavement	NR Roof	NR Pavement	SG4* Forest	SG4* Pasture	SG4* Lawn	SG4* Water
Future	2.97	22.87	1.06	37.74	14.31	1.7	58.41	0
Existing	2.97	22.87	0.35	6.07	14.31	35.22	57.27	0
Net Increase	0	0	0.71	31.67	0	0	1.14	0

Pre-developed

Forest = 33.52

POC

Mitigated

Roof = 0.71
Pavement = 31.67
Lawn = 1.14

↓

Bioretention → Underdrain

↓ ↙

Pond

POC

*No native infiltration.

WC_7C

	Res Roof	Res Pavement	NR Roof	NR Pavement	SG4* Forest	SG4* Pasture	SG4* Lawn	SG4* Water
Future	3.82	29.36	0	0	8.07	1.67	98.54	0
Existing	3.44	26.49	0	0	28.13	9.19	74.21	0
Net Increase	0.38	2.87	0	0	0	0	24.33	0

Pre-developed

Forest = 27.58

POC

Mitigated

Roof = 0.38
Pavement = 2.87
Lawn = 24.33

↓

Bioretention → Underdrain

↓ ↙

Pond

POC

*No native infiltration.

WC_7B

					SG3*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	0.48	3.66	1.93	34.09	6.5	0	20.2	0
Existing	0.2	1.52	0.84	14.67	12.17	18.93	18.53	0
Net Increase	0.28	2.14	1.09	19.42	0	0	1.67	0

Pre-developed

Forest = 24.60

POC

Mitigated

Roof = 1.37
Pavement = 21.56
Lawn = 1.67

↓

Bioretention

Native infiltration = 2 in/hr
→ Underdrain

↓ ↙

Pond

POC

*native infiltration.

WC_7A

					SG3*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	1.45	11.13	0.43	7.58	14.83	0	28.68	0
Existing	0.9	6.94	0	0	24.42	14.93	16.91	0
Net Increase	0.55	4.19	0.43	7.58	0	0	11.77	0

Pre-developed

Forest = 24.52

POC

Mitigated

Roof = 0.98
Pavement = 11.77
Lawn = 11.77

↓

Bioretention

Native infiltration = 2 in/hr
→ Underdrain

↓ ↙

Pond

POC

*native infiltration.

WC_7

					SG3*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	0.55	4.26	3.52	62.32	41.2	0	27.98	0
Existing	0.35	2.69	1.38	5.71	52.61	50.9	25.97	0.22
Net Increase	0.2	1.57	2.14	56.61	0	0	2.01	0

Pre-developed

Forest = 62.53

POC

Mitigated

Roof = 2.34
Pavement = 58.18
Lawn = 2.01

↓

Bioretention

Native infiltration = 2 in/hr
→ Underdrain

↓ ↙

Pond

POC

*native infiltration.

WC_6A

					SG3*			
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	2.55	19.6	3.46	60.66	31.86	1.77	82.66	0
Existing	1.51	11.58	1.56	18.1	35.8	80.82	52.69	0.5
Net Increase	1.04	8.02	1.9	42.56	0	0	29.97	0

Pre-developed

Forest = 83.49

POC

Mitigated

Roof = 2.94
Pavement = 50.58
Lawn = 29.97

↓

Bioretention

Native infiltration = 2 in/hr
→ Underdrain

↓ ↙

Pond

POC

*native infiltration.

WC_5A

					SG3*			**
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	12.46	95.84	2.68	47.05	66.2	8.06	323.39	0
Existing	8.3	63.9	2.37	41.7	83.06	60.81	293.01	2.53
Net Increase	4.16	31.94	0.31	5.35	0	0	30.38	0

Pre-developed

Forest = 72.14

POC

Mitigated

Roof = 4.47
Pavement = 37.29
Lawn = 30.38

↓

Bioretention

Native infiltration = 2 in/hr
→ Underdrain

↓ ↙

Pond

POC

*native infiltration.

Additional **5.76 SG5 Lawn for both future and existing.

WC_4A

					SG4*			**
	Res Roof	Res Pavement	NR Roof	NR Pavement	Forest	Pasture	Lawn	Water
Future	3.39	23.01	1.07	18.8	10.28	87.47	156.58	0
Existing	1.85	14.19	0	0	37.19	168.15	79.22	0
Net Increase	1.54	8.82	1.07	18.8	0	0	77.36	0

Pre-developed

Forest = 107.59

POC

Mitigated

Roof = 2.61
Pavement = 27.62
Lawn = 77.36

↓

Bioretention → Underdrain

↓ ↙

Pond

POC

*No native infiltration.

Additional **221.70 SG3 Forest for both future and existing.