CHAPTER 5
STORM SYSTEM ANALYSIS

INTRODUCTION

For the storm system analysis, two modeling software were used and they were WWHM3 Pro Complete and PCSWMM. WWHM3 Pro Complete (WWHM3 Pro) developed by Clear Creek Solutions, Inc. was used for the basin hydrologic analysis. The Western Washington Hydrologic Model (WWHM) was originally developed for site analysis and facility sizing for the Department of Ecology 2005 Stormwater Management Manual for Western Washington. WWHM3 Pro is a continuous simulation model that Clear Creek has since updated the software with the ability to import land coverage data from GIS such as acreage, impervious/pervious areas, land use types and soil types. It has precipitation data records from various rain gages located throughout Western Washington. They have also added modeling analysis for Low Impact Development type facilities such as green roofs, bioretention swales and rain garden. WWHM3 Pro also includes an element to connect with PCSWMM. This element allows flows to be exported from WWHM3 Pro to PCSWMM for the hydraulic analysis and then re-imported into WWHM3 Pro for additional analysis.

PCSWMM was developed by Computational Hydraulic International for hydraulic analysis, sizing of conveyance systems and stormwater facilities. PCSWMM is an interface for the Environmental Protection Agencies Stormwater Management Model (SWMM). PCSWMM allows for data import from GIS. The City has the storm system mapped in GIS and is in the process of updating the map. The data from the GIS storm system inventory map, surveys and project drawings have been used to construct the system model. PCSWMM has a GIS Window that can import GIS layers and is used for creating and editing the storm system input data for the model.

ANALYSIS

The City selected seven storm trunklines to be analyzed. Figure 5-1 shows the location and drainage basin of the trunklines. These trunklines were selected based on known conveyance and/or sedimentation problems and possible future system impacts due to development. Trunkline 1 is on the northwest shore of the Gig Harbor in the Crescent Creek Basin. The other six trunklines are located south of Gig Harbor. Trunkline 2 is in the Puget Sound Basin. Trunklines 4 and 6 are in the Gig Harbor Basin. Trunklines 3, 5 and 7 are in the Wollochet Bay Basin. Trunkline 3 has the only basin that extends outside the City limits and includes an area northeast of 39th Street NW that is within Pierce County.

Hydrologic Analysis

WWHM3 Pro was used to calculate the runoff flows from the trunkline basins and provide the flow frequency analysis to determine the 25-year flow for the capacity analysis. WWHM3 Pro used the McMillian rain gage for the analysis. According to the 2005 Ecology Manual, the source of the McMillian rain gage data is the National Weather Service. This rain gage is used for the Pierce County area and includes 50-years of rainfall data from 1948 to 1998. The flow data was exported to PCSWMM for the hydraulic analysis. After comparing the flow frequency tables with the peak annual flows for each of the basins it was determined that the year 1963 rainfall data best simulated the 25-year flow event.

For this analysis only future build-out land use conditions were modeled. GIS data from the City was used to develop the land coverage data needed for the model. The data included aerials, land use, zoning, soils, topography (Light Detection and Ranging, LIDAR), and drainage basin boundary information. Percent of maximum impervious lot coverage is summarized in Chapter 3, Table 3-1 based on the Zoning Code classifications as defined in the City's Municipal Code Chapter 17. These classifications were then correlated to the Land Use categories for the future conditions. WWHM3 classifies pervious areas as forest, pasture and grass. Aerial maps were used to identify the type of pervious area. Grass was used mostly for the pervious areas with some forest areas since the trunkline basins are located within urbanized areas. Land surface slopes were calculated using the LIDAR data.

Hydraulic Analysis

For the hydraulic analysis, the City's GIS storm system inventory data was used to develop the physical features that are needed for the PCSWMM input file such as pipe diameter, lengths and material (roughness coefficient). Pipe slopes were calculated using the measured depths recorded in the inventory. The City surveyed the rim elevations that were not provided in the GIS data. Record drawings were also used to supplement the rim and invert elevation data. The GIS data provided the depth, top width and material for the open channels. Surveyed cross sections were not available. A trapezoidal cross section was input into the model using a bottom width equal to one-half of the top width and one to one side slopes. Channel slopes were calculated using the topographic information.

All trunklines were modeled in PCSWMM using the Transport module except for Trunkline 5. The Extran module was used for Trunkline 5 to model the natural channel cross sections.

Pipe and open channel materials were included in the GIS storm system map data. A Manning's roughness value was selected based on the material. The pipe roughness value varied from 0.012 for High Density Polyethylene Pipe to 0.024 for Corrugated Metal Pipe. All proposed pipe used a roughness value of 0.012. For open channels, a value of 0.030 was used for the roadside drainage ditches and 0.040 for the natural channels. Lengths were determined using the GIS storm system map and City surveys. Rim elevations were obtained from City

surveys, construction drawings or LIDAR data. Invert elevations were determined using the GIS data that included the depths at the catch basins, City surveys and construction drawings.

Those pipes that were connected end to end without a catch basin typically had the same characteristics and were combined into one pipe. There were also pipes with negative slopes based on the pipe depth information provided in the GIS data. These pipes were assigned a slope of 0.5%. Any changes to the conveyance system were noted in the GIS data and on the trunkline figures provided in this Plan.

The model was not calibrated because current flow data was not available for the trunkline basins. Under future build-out conditions the analysis identified surcharged pipes in Trunklines 1, 2, and 6. Recommended improvements are discussed in Chapter 7, Capital Improvement Plan.

TRUNKLINE 1

Trunkline 1 is located on Peacock Hill Avenue NW between 101st Court NW and North Harborview Drive and discharges into Gig Harbor. This is northeast of the Donkey Creek discharge pipe. It is approximately 4,400 linear feet of pipe with diameters varying from 12- to 18-inches. Pipe material consists mostly of concrete and HDPE. The drainage basin is 62.1 acres. Elevations in this basin vary from approximately 25 feet to 270 feet. Approximately 85% of the basin is residential with 15% commercial business. The outfall for Trunkline 1 is an 18-inch concrete pipe located southeast of Fuller Street/North Harborview Drive. Southwest of Fuller Street, there is an area of Burnham Drive NW that also is conveyed to this outfall. The Burnham Drive NW area is designated as Sub Basin A. Sub Basins B, C and D are conveyed by the Peacock Hill Avenue NW storm system.

Table 5-1 shows the land coverage areas for Trunkline 1.

Table 5-1. Trunkline 1 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	10.7	5.6	5.1	0	0	10.7
B	17.8	8.8	9.0	0	0	17.8
C	19.0	8.0	11.0	0	0	19.0
D	14.7	6.5	8.0	0.2	0	14.7

Table 5-2 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 1 based on the land coverage data. Although the total area of Sub-Basin C is greater than B, the flows are higher in B because of the greater amount of impervious area.

Table 5-2. Trunkline 1 Flow Frequency

	Flow (cfs)			
Event	**A**	**B**	**C**	**D**
2 Year	2.65	4.25	4.14	3.19
5 Year	3.70	5.99	5.92	4.55
10 Year	4.47	7.28	7.24	5.55
25 Year	5.50	9.07	9.10	6.95
50 Year	6.32	10.52	10.62	8.10
100 Year	7.18	12.08	12.25	9.33

System Analysis

The modeled system flows ranged from 2.9 cfs to 30.8 cfs. Based on the flows, the system analysis showed that the pipes within Sub-Basins B and C do not have sufficient capacity to convey the future flows. Recommended pipe size for 310-feet of the Trunkline 1 pipe system on North Harborview Drive between Fuller Street and Peacock Hill Avenue NW is 24-inches. Recommended pipe size is 18-inches for the 1,640-feet of pipe on Peacock Hill Avenue NW between North Harborview Drive and Sutherland Street.

TRUNKLINE 2

Trunkline 2 is located on Soundview Drive between Ryan Street and Hollycroft Street NW and discharges into Puget Sound. It is approximately 4,880 linear feet of pipe with diameters varying from 12- to 36-inches. Pipe material consists mostly of concrete and HDPE. The drainage basin is 153.3 acres. Elevations in this basin vary from approximately 60 feet to 325 feet. Approximately 80% of the basin is residential with 20% commercial business. At the north end of the basin there is City park property which is less than 1% of the basin. The outfall for Trunkline 2 is an 24-inch HDPE pipe located southeast of Ryan Street/Cascade Avenue.

Table 5-3 shows the land coverage areas for Trunkline 2.

Table 5-3. Trunkline 2 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	20.4	8.2	12.3	0	0	20.4
B	26.4	14.5	11.1	0.8	0	26.4
C	20.0	9.6	9.7	0.7	4.7	15.3
D	45.9	27.3	18.6	0	22.3	23.6
E	18.2	11.6	6.5	0	4.7	13.5

Table 5-4 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 2 based on the land coverage data.

Table 5-4. Trunkline 2 Flow Frequency

Event	Flow (cfs)				
	A	B	C	D	E
2 Year	4.04	6.25	4.09	10.57	4.61
5 Year	5.91	8.81	5.79	14.62	6.38
10 Year	7.32	10.71	7.05	17.58	7.68
25 Year	9.34	13.34	8.81	21.62	9.46
50 Year	11.00	15.47	10.24	24.87	10.89
100 Year	12.81	17.75	11.77	28.32	12.41

System Analysis

The modeled system flows ranged from 3.9 cfs to 62.0 cfs. Based on the flows, the system analysis showed that the pipes within Sub-Basins B and C do not have sufficient capacity to convey the future flows. Recommended pipe size is 30-inches for approximately 700-feet of pipe between Soundview Court and Erickson Street.

TRUNKLINE 3

Trunkline 3 is located on Point Fosdick Drive NW between SR 16 and 39th Street NW. It is approximately 2,440 linear feet of pipe with diameters varying from 12- to 18-inches and 1,090 linear feet of open ditch. Pipe material consists mostly of concrete and HDPE with some CMP.

There are two inline detention tanks within this trunkline that are arched CMP. One is located approximately 440 feet south of Olympic Drive, the other is located just south of 45th Street Court NW. The drainage basin is 95.6 acres. Elevations in this basin vary from approximately 200 feet to 290 feet. Approximately 70% of the basin is residential with 25% commercial business. The remaining 5% is Public Institution which includes a Pierce County Library. The outfall for Trunkline 3 is an 18-inch concrete culvert located south of Briarwood Lane NW/ Point Fosdick Drive NW.

Table 5-5 shows the land coverage areas for Trunkline 3.

Table 5-5. Trunkline 3 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	24.4	7.6	15.1	1.6	9.8	14.5
B	40.5	14.9	22.9	2.7	3.3	37.1
C	14.7	11.2	3.5	0	0	14.7
D	3.3	3.0	0.3	0	0	3.3
E	5.3	4.6	0.8	0	0	5.3
F	7.5	5.8	1.7	0	0	7.5

Table 5-6 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 3 based on the land coverage data. Sub-Basins E and F were routed through the Olympic SR 16 Interchange Tank. The discharge flow from the Interchange Tank is combined with Sub-Basin C and routed through the Point Fosdick Drive NW Road Improvement Tank. Sub-Basin B is the Quail Park Residential Subdivision and the runoff flows from this site is detained in the Quail Park detention pond.

Table 5-6. Trunkline 3 Flow Frequency

	Flow (cfs)					
Event	A	B	C	D	E	F
2 Year	3.60	7.11	4.30	1.09	1.70	2.16
5 Year	5.30	10.40	5.90	1.47	2.30	2.96
10 Year	6.59	12.90	7.05	1.74	2.74	3.54
25 Year	8.42	16.45	8.63	2.11	3.33	4.32
50 Year	9.95	19.38	9.89	2.41	3.80	4.95
100 Year	11.61	22.58	11.23	2.72	4.30	5.62

System Analysis

The modeled system flows ranged from 4.2 cfs to 26.3 cfs. The Trunkline 3 storm system was divided into three sections for the PCSWMM model. This was done to model the three detention facilities in WWHM3 Pro. Table 5-7 is a summary of the Trunkline 3 stormwater facilities.

Table 5-7. Trunkline 3 Stormwater Facilities

Facility	Basin Area (ac)	Volume (ac-ft)	Maximum Stage (ft)	Maximum Flow (cfs)
SR 16/Olympic Drive Interchange Tank	12.8	0.33	4.7	8.8
Point Fosdick Drive NW Tank	16.1	0.18	4.7	5.5
Quail Park Pond	40.5	0.52	4.2	20.2

All facilities are overflowing into the storm system during the peak of this storm event. It appears that these facilities were only designed for the 2- and 10-year storm events.

The drainage ditches were modeled as trapezoidal channels based on the top width and depth included in the GIS storm system map with 1:1 side slopes. The drainage channels had capacity to convey the future flows. Based on the flows, the system analysis showed that the culverts within Sub-Basin A and C do not have sufficient capacity to convey the future flows.

In Sub-Basins A and C, the recommended pipe size varies from 18-inches up to 24-inches for the culvert crossing Point Fosdick Drive NW at the downstream end of Trunkline 3.

In Sub-Basin D, the pipe system between the Interchange Tank and the Point Fosdick Drive NW Road Improvement Tank did not show any surcharging. The 18-inch Interchange Tank discharge pipe according to the GIS inventory data is at 0.2 percent. The flat slope of this pipe limits its capacity and should be monitored. It is recommended that both tanks and pond be inspected and maintained on a regular schedule.

TRUNKLINE 4

Trunkline 4 basin is located just north of Trunkline 2 on Soundview Drive between Harborview Drive and Ryan Street. It is approximately 2,790 linear feet of pipe with diameters varying from 12- to 18-inches. Pipe material consists mostly of concrete and HDPE. The drainage basin is 51.7 acres. Elevations in this basin vary from approximately 25 feet to 205 feet. Approximately 40% of the basin is residential with 25% commercial business. The remaining 35% is Public Institution which includes the City Civic Center and Park property. The outfall for Trunkline 4 is an 18-inch concrete pipe located northeast of Harborview Drive/Soundview Drive.

Table 5-8 shows the land coverage areas for Trunkline 4.

Table 5-8. Trunkline 4 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	13.5	9.4	4.0	0	0	13.5
B	11.0	3.3	7.7	0	0	11.0
C	6.1	1.8	4.3	0	0	6.1
D	21.1	10.0	7.6	3.5	2.3	18.8

Table 5-9 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 4 based on the land coverage data.

Table 5-9. Trunkline 4 Flow Frequency

	Flow (cfs)			
Event	A	B	C	D
2 Year	3.85	2.00	1.10	4.35
5 Year	5.28	2.95	1.61	6.05
10 Year	6.30	3.67	2.01	7.27
25 Year	7.65	4.70	2.57	8.92
50 Year	8.72	5.55	3.04	10.23
100 Year	9.84	6.48	3.55	11.61

System Analysis

The modeled system flows ranged from 2.8 cfs to 24.2 cfs. Based on the flows, the system analysis showed that the Trunkline 4 storm system has adequate capacity under the future flow conditions. No pipe improvements are identified for Trunkline 4.

TRUNKLINE 5

Trunkline 5 is a tributary to Garr Creek. It is located east of 38th Avenue between 56th Street NW and Briarwood Lane NW. The majority of this system is a natural channel and it has approximately 980 linear feet of pipe with diameters varying from 12- to 24-inches. The natural cross section data was surveyed by the City. Pipe material consists of concrete and HDPE. The drainage basin is 264.2 acres. Elevations in this basin vary from approximately 100 feet to 300 feet. Approximately 60% of the basin is residential with 40% commercial business. The outfalls for Trunkline 5 are parallel 18-inch concrete culverts located south of Briarwood Lane NW /38th Avenue. The City has observed sediment accumulating at this culvert, decreasing its capacity. Flooding has occurred at this location. The sediment is being transported from the upstream channel.

Table 5-10 shows the land coverage areas for Trunkline 5.

Table 5-10. Trunkline 5 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	48.8	13.2	31.5	4.1	8.8	39.2
B	18.5	6.8	9.4	2.3	0	18.5
C	60.6	28.2	32.4	0	0	60.6
D	1.6	1.4	0.2	0	0	1.6
E	4.8	4.3	0.5	0	0	4.8
F	21.4	16.1	5.3	0	0	21.4
G	108.6	66.2	42.4	0	0.1	108.5

Table 5-11 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 5 based on the land coverage data.

Table 5-11. Trunkline 5 Flow Frequency

Event	Flow (cfs)						
	A	B	C	D	E	F	G
2 Year	7.95	3.54	13.14	0.52	1.64	6.23	27.66
5 Year	11.75	5.06	18.67	0.71	2.21	8.53	38.45
10 Year	14.66	6.20	22.77	0.84	2.62	10.19	46.35
25 Year	18.82	7.80	28.49	1.01	3.18	12.46	57.21
50 Year	22.28	9.10	33.15	1.15	3.62	14.27	65.95
100 Year	26.06	10.51	38.16	1.30	4.08	16.18	75.27

System Analysis

The Extran module of PCSWMM was used to model the natural channels in Trunkline 5. A storm on April 25, 1963 was used to simulate the future 25-year event.

Based on the future flow conditions, the pipes within Trunkline 5 do not have sufficient capacity. At 56th Street NW there are two 72-inch CMP tanks (Tank A and B) that detain road runoff. Table 5-12 is a summary of the Trunkline 5 stormwater facilities.

Table 5-12. Trunkline 5 Stormwater Facilities

Facility	Basin Area (ac)	Volume (ac-ft)	Maximum Stage (ft)	Maximum Flow (cfs)
Tank A	1.6	0.14	3.18	1.01
Tank B	4.8	0.15	5.57	1.73

Tank A at the peak of the storm event was releasing the equivalent of the 25-year flow of sub-basin D. The maximum stage was below the riser overflow elevation.

The three culverts at 47th Street Court NW, 48th Street Court NW and 50th Street Court NW were also analyzed using Culvert Master by Haestad Methods. Using the survey information provided the invert elevations and headwater elevations were used to size the culverts to convey the future flows. There are two culverts crossing 38th Avenue NW at the downstream end of Trunkline 5. The difference in the culverts invert elevations is 2-feet. For the majority of the year the lower culvert is submerged. For this analysis both culverts were sized to convey the 25-year storm event. A study is recommended for Trunkline 5 to determine the locations of erosion and sediment sources and review of upstream existing stormwater facilities. This is discussed in the 6-year CIP in Chapter 7.

As stated previously, Trunkline 5 consists of a natural channel that is an unnamed tributary to Garr Creek. City staff surveyed multiple channel cross sections that were used in the model. Only the upper most channel cross section (9006) upstream of 50th Street Court NW had to be revised to contain the flows. The cross section in this reach is very shallow no greater than 2-feet deep and 200-feet wide. Table 5-13 summarizes the results from the model for the natural channel. There have been concerns about this channel due to sediment deposition at the 38th Avenue NW culvert and reports of bank erosion. The furthest downstream channel with the highest velocity is channel no. 9002 at 10.86 feet per second. This channel is located south of 47th Street Court NW.

Table 5-13. Natural Channel Summary

CHANNEL (CONDUIT) NUMBER	DESIGN FLOW (CFS)	MAXIMUM COMPUTED FLOW (CFS)	MAXIMUM COMPUTED VELOCITY (FPS)	CONDUIT SLOPE (FT/FT)	UPSTREAM (FT)			DOWNSTREAM (FT)		
					INVERT ELEV.	DEPTH (FT)	WATER SURFACE ELEV.	INVERT ELEV.	DEPTH (FT)	WATER SURFACE ELEV.
9006	125.0	101.0	2.81	1.86%	260.36	1.35	261.71	243.74	1.54	245.28
9004	513.0	101.0	9.33	5.27%	237.27	2.16	239.43	208.59	2.01	210.60
9005	272.0	103.0	8.57	6.63%	196.30	1.53	197.83	176.24	2.89	179.13
9002	313.0	103.0	10.86	7.34%	169.29	1.74	171.03	122.54	1.29	123.83

TRUNKLINE 6

Trunkline 6 is located on Stinson Avenue between Harborview Drive and Grandview Street. It is approximately 3,500 linear feet of pipe with diameters varying from 12- to 36-inches. Pipe material consists mostly of PVC and HDPE, with some CMP and concrete. The drainage basin is 94.0 acres. Elevations in this basin vary from approximately 50 feet to 300 feet. Approximately 75% of the basin is residential with 25% commercial business. The outfall for Trunkline 6 is a 36-inch HDPE pipe located northeast of Harborview Drive/ Stinson Avenue.

Table 5-14 shows the land coverage areas for Trunkline 6.

Table 5-14. Trunkline 6 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	10.5	5.3	5.2	0	0	10.5
B	23.6	8.1	15.5	0	0	23.6
C	18.0	9.2	8.8	0	0	15.8
D	31.3	18.2	13.2	0	1.6	29.8

Table 5-15 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 4 based on the land coverage data.

Table 5-15. Trunkline 6 Flow Frequency

Event	Flow (cfs)			
	A	B	C	D
2 Year	2.60	4.43	4.25	8.08
5 Year	3.64	6.46	5.93	11.22
10 Year	4.39	7.99	7.14	13.46
25 Year	5.42	10.17	8.76	16.49
50 Year	6.23	11.96	10.06	18.88
100 Year	7.09	13.91	11.42	21.40

System Analysis

The modeled system flows ranged from 5.2 cfs to 41.2 cfs. Based on the flows, the system analysis showed that the pipes within Sub-Basins C and D do not have sufficient capacity to

convey the future flows. In Sub-Basin C, the recommended pipe size varies from 18- to 24-inches for the storm system between Rosedale Street and Reliance Lane.

In Sub-Basin D, the recommended pipe size is 18-inches for the storm system between Edwards Drive and Foster Street.

TRUNKLINE 7

Trunkline 7 is routed through a series of private properties west of Point Fosdick Drive NW between 50th Street Court NW and Briarwood Lane NW. It is approximately 3,890 linear feet of pipe with diameters varying from 12- to 48-inches. The 48-inch CMP functions as a detention tank for a multi-family residential development. Pipe material consists mostly of HDPE, with some CMP, PVC and concrete. The drainage basin is 111.6 acres. Elevations in this basin vary from approximately 160 feet to 330 feet. Approximately 40% of the basin is residential with 60% commercial business. The outfall for Trunkline 7 is a 24-inch concrete pipe located southwest of Briarwood Lane NW/32nd Avenue Court NW.

Table 5-16 shows the land coverage areas for Trunkline 7.

Table 5-16. Trunkline 7 Land Coverage

Sub Basin	Area (ac)	Impervious Area (ac)	Pervious Area (ac)		Hydrologic Soil Group	
			Grass	Forest	A	C
A	15.4	6.9	8.5	0	0	15.4
B	19.2	8.7	10.6	0	0	19.2
C	14.2	9.3	4.8	0	0	14.2
D	4.7	2.8	1.9	0	0	4.7
E	38.9	27.2	11.7	0	0	11.7
F	8.5	5.9	2.5	0	0	8.5
G	10.8	8.2	2.5	0	0	10.8

Table 5-17 summarizes the flow frequency analysis under future full build-out conditions for Trunkline 7 based on the land coverage data.

Table 5-17. Trunkline 7 Flow Frequency

	Flow (cfs)						
Event	A	B	C	D	E	F	G
2 Year	3.19	4.22	3.91	1.20	10.78	2.42	3.13
5 Year	4.59	6.01	5.38	1.67	14.83	3.32	4.28
10 Year	5.66	7.34	6.43	2.00	17.77	3.96	5.10
25 Year	7.15	9.20	7.83	2.45	21.79	4.82	6.23
50 Year	8.37	10.71	8.94	2.81	25.01	5.49	7.13
100 Year	9.69	12.34	10.10	3.18	28.43	6.19	8.08

System Analysis

The modeled system flows ranged from 8.4 cfs to 21.6 cfs. Based on the flows, the system analysis showed that the pipes within Sub-Basin C do not have sufficient capacity to convey the future flows. Downstream of the Harbor Plaza Pond there is approximately 950-feet of 24-inch CMP. It is recommended that the CMP be replaced with smooth wall HDPE pipe. It is also recommended that all of the 12-inch pipe in Sub-Basin C be replaced with 18- and 24-inch pipe.

There are five detention facilities along Trunkline 7. Table 5-18 is a summary of the Trunkline 7 stormwater facilities.

Table 5-18. Trunkline 7 Stormwater Facilities

Facility	Basin Area (ac)	Volume (ac-ft)	Maximum Stage (ft)	Maximum Flow (cfs)
Harbor Pond	48.2	4.73	5.3	8.3
Harbor Tank	4.7	0.20	3.7	0.7
Quail Run Pond 1	96.3	0.12	3.3	39.0
Quail Run Pond 2	96.3	0.51	9.0	26.7
Quail Run Pond 3	111.7	1.48	7.8	18.6

Harbor Pond was approximately 12-inches below its overflow. Harbor Tank was just beginning to overflow. Harbor Pond and Tank may have been designed for only the 2- and 10-year storm events.

Quail Run Pond 1 was overflowing. It is a shallow pond that functions as a settling pond. Quail Run Pond 2 was at its maximum depth and was overflowing slightly. The maximum depth of Quail Run Pond 3 is 9-feet. It was 1.2-feet below overtopping.

CONCLUSION

The results of the hydraulic analysis from PCSWMM and maps for each trunkline are included in Appendix A. Surcharged pipes are identified on the maps and the recommended pipe size to convey the calculated flow is also shown. Trunkline 4 is the only system modeled that did not show any surcharged pipes. The recommended pipe replacements are included in the Capital Improvement Plan project list in Chapter 7.

The storm system modeling was performed at a planning level to identify system needs under future full build-out land use conditions. Future regional flow control facilities were not considered in the conveyance analysis. Flow control facilities can reduce the amount of flow from a site and eliminate some of the identified conveyance problems. It is critical to require flow control facilities for future development and ensure that they are designed, constructed and maintained properly. Further data gathering, monitoring and calibration for the model is recommended. The following additional information is desirable to refine the model for future use:

- Verification of pipe depths, slopes and materials.
- Monitoring of those pipes that were identified as being surcharged.
- Collection of flow data or depths of flow.
- Hydrologic/hydraulic analysis of existing conditions.