Snohomish County

Swamp Creek Drainage Needs Report

APPENDIX B6

Hydraulic Model Development and Application for Chase Lake Subbasin

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Appendix B6 Hydraulic Model Development and Application for the Chase Lake Subbasin

B6.1 Introduction

Two models were used to analyze the hydraulics of stream reaches and conveyance systems within the study area. The models were selected based on the primary type of conveyance system that was being analyzed and budgetary considerations. To simulate the hydraulics of the outlet system from the Chase Lake detention pond, the EXTRAN portion of the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) was used. The SWMM model (based on the EPA SWMM model) includes the north branch tributary to the Chase Lake outlet system. To simulate the hydraulics of two other conveyance systems of interest, one along 84th Avenue W between the end of 83rd Avenue W south of 230th Street SW and approximately 234th Street SW (referred to as Modeling Area 1) and one along 231st Street SW at 88th Avenue W (referred to as Modeling Area 2), the King County Backwater (KCBW) program was used.

B6.2 Data Collection and Field Observations

Data collection included basin reconnaissance and field survey and a meeting with County staff to review historic flooding problems.

In addition, historic drainage complaints occurring within the last six years were compiled. Table B6-1 summarizes the drainage complaints for Chase Lake. Since budget constraints did not allow for all of the drainage systems in the study area to be analyzed, including some with historical flooding problems, County staff needed to select the systems in which detailed hydraulic analyses would be conducted. In general, those systems with more frequent flooding problems, or with a greater impact to the public, were selected for the detailed hydraulic analyses. Attachment B6-1 contains a list of additional drainage systems that will need to be analyzed in the future.

An initial field reconnaissance was conducted to field locate the stream and to observe the condition of the conveyance system and surrounding areas. The initial field reconnaissance was followed by field survey to obtain geometric data for the hydraulic analysis. Pipe system, culvert, and channel data were collected and used to analyze the system capacity of the identified drainage systems in the Chase Lake Subbasin. Figure 3-1f shows the locations where the conveyance systems were surveyed to provide input data for use in the SWMM and KCBW models. The survey data that was collected included enclosed pipe systems and several ditch and culvert sections.

The survey data included road culverts, enclosed pipe systems, and channel cross sections. Road culvert data consisted of culvert upstream and downstream inverts, culvert length, culvert size and shape, culvert material, and top of road (for use in road flooding analysis). Enclosed pipe system survey data included pipe inverts, rim elevations, pipe diameter, shape, and material. Channel cross section data defined the

geometry of the channels immediately upstream and downstream of the road culverts. The field survey data were input into the County's Geographic Information System (GIS).

Table B6-1
Chase Lake Subbasin Drainage Complaints (1996 through 2000)

SWM Number	Address	Drainage Basin	General Problem	Problem Resolution
19960077	22512 80th Ave. W Edmonds 98026	Chase Lake	Private property flooding from road	No County action
19960150	22504 87th Ave. W Edmonds 98026	Chase Lake	Occasional crawlspace flooding	No County action; recommended potential property owner remedies
19960161	22020 83rd Ave. W Edmonds 98026	Chase Lake	Water line leak	Referred to Alderwood Water and Sewer District
19960168	8504 228th St. SW Edmonds 98026	Chase Lake	Water runs off road and washes out driveway	No action; Road Maintenance already addressing problem
19960181	8423 221st Pl. SW Edmonds 98026	Chase Lake	Private property flooding	No County action required; recommended potential property owner remedies
19960460	7712 222nd St. SW Edmonds 98026	Chase Lake	Drainage easement alteration request	No drainage easement found; sent streams brochure to property owner
19960510	7712 224th St. SW Edmonds 98026	Chase Lake	Private property flooding due to undersized culvert	Ranked as potential 1997 project
19970050	8516 231st St. SW Edmonds 98026	Chase Lake	Private property flooding; request to connect to storm drain system	Property owner may connect to system; Road Maintenance performed storm drain system improvements
19970224	8631 231st St. SW Edmonds 98026	Chase Lake	Private property flooding due to possibly plugged culvert	Private drainage system; no County action required
19970461	22930 84th Ave. W Edmonds 98026	Chase Lake	Private property flooding from road runoff	Service request to Road Maintenance to scrape shoulder
19970496	8716 222nd St. SW Edmonds 98026	Chase Lake	Private property flooding from overflowing ditch	Private property; no County action required
19980043	23228 84th Ave. W Edmonds 98026	Chase Lake	Private property flooding from street	Private property; no County action required
19980062	7820 225th Pl. SW Edmonds 98026	Chase Lake	Stormwater flows in cul-de-sac from surrounding properties	Flow is normal; no County action required
19980067	8511 228th St. SW Edmonds 98026	Chase Lake	Private property flooding from street	Service request to Road Maintenance to clean catch basin; catch basin apparently blocked; property owner to replace drainage system

Table B6-1 (continued)
Chase Lake Subbasin Drainage Complaints (1996 through 2000)

SWM Number	Address	Drainage Basin	General Problem	Problem Resolution
19980304	7724 222nd St. SW Edmonds 98026	Chase Lake	Private property flooding from street	Service request to Road Maintenance to scrape shoulder
19980357	22027 80th Ave. W Edmonds 98026	Chase Lake	Private property flooding from neighbor's paved yard	No County action required; conditions have not changed since SWM reviewed same issue in 1994; same recommendations apply
19990104	7908 225th Pl. SW Edmonds 98026	Chase Lake	Private property flooding from street	Service request to Road Maintenance for road repairs; other drainage system improvements ranked as potential 2000 project
19990157	23321 84th Ave. W Edmonds 98026	Chase Lake	Culvert being uprooted by large tree	Private drainage system; no County action required
19990314	8700 222nd St. SW Edmonds 98026	Chase Lake	Private property flooding from street	Recommended property owner do minimal landscaping to direct water to catch basin
20000060	23206 84th Ave. W Edmonds 98026	Chase Lake	Swimming pool lifted from shallow groundwater	Not a drainage problem; no County action required
20000174	7711 224th St. SW Edmonds 98026	Chase Lake	Damaged trash rack	Not a County problem; referred complainant to City of Edmonds Public Works
20010038	22428 80th Ave. W Edmonds 98026	Chase Lake	Erosion and sediment deposits in driveway due to runoff from neighboring driveways	Private property; no County action required

B6.2.1 Drainage System Survey

Global Positioning System (GPS) equipment was used to conduct surveys of existing surface water facilities within the subbasins. This process allows rapid and accurate data collection and the data can be downloaded into computers and viewed within a GIS environment.

The surveys were conducted using high-accuracy, survey-grade GPS equipment, with a horizontal accuracy of ± 2 centimeters and a vertical accuracy of ± 4 centimeters relative to control. In addition, all drainage facilities were directly measured.

GIS coverages were created from the survey data downloaded from the GPS equipment. Data processing program routines were developed by the County to assist in constructing the drainage network from the point features collected by the GPS units. Cross section and drainage feature information collected from the survey were then extracted from the GIS coverage and used in the hydraulic analyses. Table 3-2 and Figure 3-1f show the existing drainage facilities that were surveyed as well as the drainage network that connects these facilities.

B6.2.2 Basin Reconnaissance

Basin reconnaissance was conducted by project staff to "ground truth" surveyed data and other collected basin information. Project staff visited the Chase Lake study area on several occasions during summer and fall of 2001. The purpose was to make qualitative observations to supplement the survey data collected. The information collected and the activities performed during the field visits included:

- Observing the drainage system being modeled to assist in coordinating the survey and data collection effort.
- Assessing the condition of hydraulic structures and stream reaches for model input parameter development.
- Observing identified and suspected problem areas.

Field Observations

The general location and flow path of each of the modeled systems is described in Sections 2.2.1 and 2.2.2 of the main report. The following paragraphs provide additional detail on observations made during several field visits. It was noted that there is an existing stream gage located just downstream of the Chase Lake outlet. The channel between the outlet and the pipe entrance under the church parking lot is shallow with a relatively low and flat floodplain. This area is reported by County staff to be subject to flooding, including up to and into the church parking lot.

A diversion structure is located at the confluence of the Chase Lake outlet system and the north branch along 224th Street SW. It includes a weir placed within a manhole and directs low flows though a short section of 12-inch-diameter pipe south to an open channel. High flows are directed east into an 18-inch pipe system. A neighbor in the area reported geysering (i.e., flows exiting catch basin structures) at the corner of 224th Street SW and 77th Avenue NE, which is part of the high-flow bypass system. As noted in Section 2.0, the high-flow bypass pipeline extends south and then west to reconnect with the channel flow.

Flooding was reported during the summer of 2001 on the north branch tributary of the Chase Lake outlet system. Yard flooding occurred three times during a period of summer rainstorms between June 11 and June 13 on the north branch of this system. Flow in the channel escaped its banks and inundated a backyard located on the east side of the channel just south of 222nd Street SW (7706 222nd Street SW).

Along the north branch, County staff also reported the culvert crossing of 222nd Street SW as a concern and it may have been flooded during other larger events. In addition, flooding has been reported as the channel enters the pipe system just north of 224th Street SW; however, County staff indicated that this may have been a debris barrier problem at the trash rack as the channel enters the pipe system. Drainage complaint number 19960510 indicated that "water is backing up (at the inlet to the pipe system) because of debris and possibly capacity problems in the downstream system. The water is flowing between two lots and then over 224th Street SW before flowing back into the drainage system on the south side of the road."

At the upstream portion of Modeling Area 1, at the end of 83rd Avenue W, it was noted that the catch basin lids and pavement grading are such that some of the pavement is lower than the rims of the catch basin and these catch basins cannot drain properly (Pipe 14 on Figure B6-3 in Section B6.4.2).

For Modeling Area 2, it was noted that the roadside ditch/culvert system is in need of maintenance, and portions of the ditch system along 231st Street SW should be regraded. The worst location is where the system approaches 88th Avenue W. The ditch conveys flows west along 231st Street SW and as it approaches 88th Avenue W, its depth becomes shallower until it becomes indistinguishable and has no defined path. Although a catch basin is at the northeast corner of this intersection, it is suspected that not all ditch flow reaches its grate, which would likely result in ponding and flow across 88th Avenue W.

Problems Noted in Previous Studies

No problems were noted in previous studies for the Chase Lake Subbasin.

B6.3 SWMM Development and Results

The purpose of the SWMM modeling was as follows:

- Facilitate development of FTABLEs for input into the HSPF model.
- Quantify flooding in County-maintained drainage systems for existing and future flows.
- Develop solutions to reduce predicted flooding.

Note that for this DNR, the model and modeling results were developed using XP-SWMM 2000 Version 7.5, which is a modified version of SWMM developed by XP-Software. After the analysis was complete, the model was converted to SWMM. Due to the differences in the XP-SWMM and SWMM computer programs, the future results computed by SWMM may vary slightly from the reported XP-SWMM results presented in this DNR.

B6.3.1 Model Development

SWMM was used to model the dominant stormwater conveyance system in the Chase Lake Subbasin, the Chase Lake outlet system and its north branch tributary. The extent of the system modeled is shown on Figure 3-2f. The model was used to analyze the system for the 2-, 10-, and 25-year events for existing and future land use conditions. The various components used to model the system are described below. A model schematic is shown in Figure B6-1.

B6.3.1.1 Structure, Cross-Section and Pond Data

The conveyance system is comprised mostly of enclosed storm drain pipe with some reaches of open channel and culverts. The data input for the SWMM model used to define these features includes: pipe diameter, material, inverts, and length, channel inverts, channel cross sections and overflow elevations. For the enclosed pipe, the overflow elevation was defined as the rim elevation; for the culverts, the overflow elevation was defined as the top of road elevation; and for the ditches, the overflow was defined as the top of bank. One diversion structure, located on 224th Street SW just west of 77th Avenue W, was included in the model. The structure contains an overflow weir to separate high flow and low flow. The measure-down distance to the weir crest and the weir length were not surveyed for the model development, rather they were measured during a field visit. Chase Lake detention pond and outlet weirs were not included in the model.

Survey conducted as part of this project, field measurements, and mapping from the *City of Edmonds Drainage Study Plan* (Edmonds Plan) (R. W. Beck, 1991) were the primary source of data used to model the system.

Specific sources of model input data are listed in Table B6-2.

Table B6-2
Sources of SWMM Input Data

Type	Description	Year
Surveys	Consultant drainage survey	2001
	Snohomish County survey	2001
Field Measurements	Field measure weir measure down and width	2001
Mapping	County GIS topography	
	City of Edmonds topography	1991

B6.3.1.2 Boundary Conditions

The downstream boundary for this system is the Edmonds city limits. The tailwater elevation for the model assumed that the system in the City of Edmonds is pipe-full.

B6.3.1.3 Dummy Links

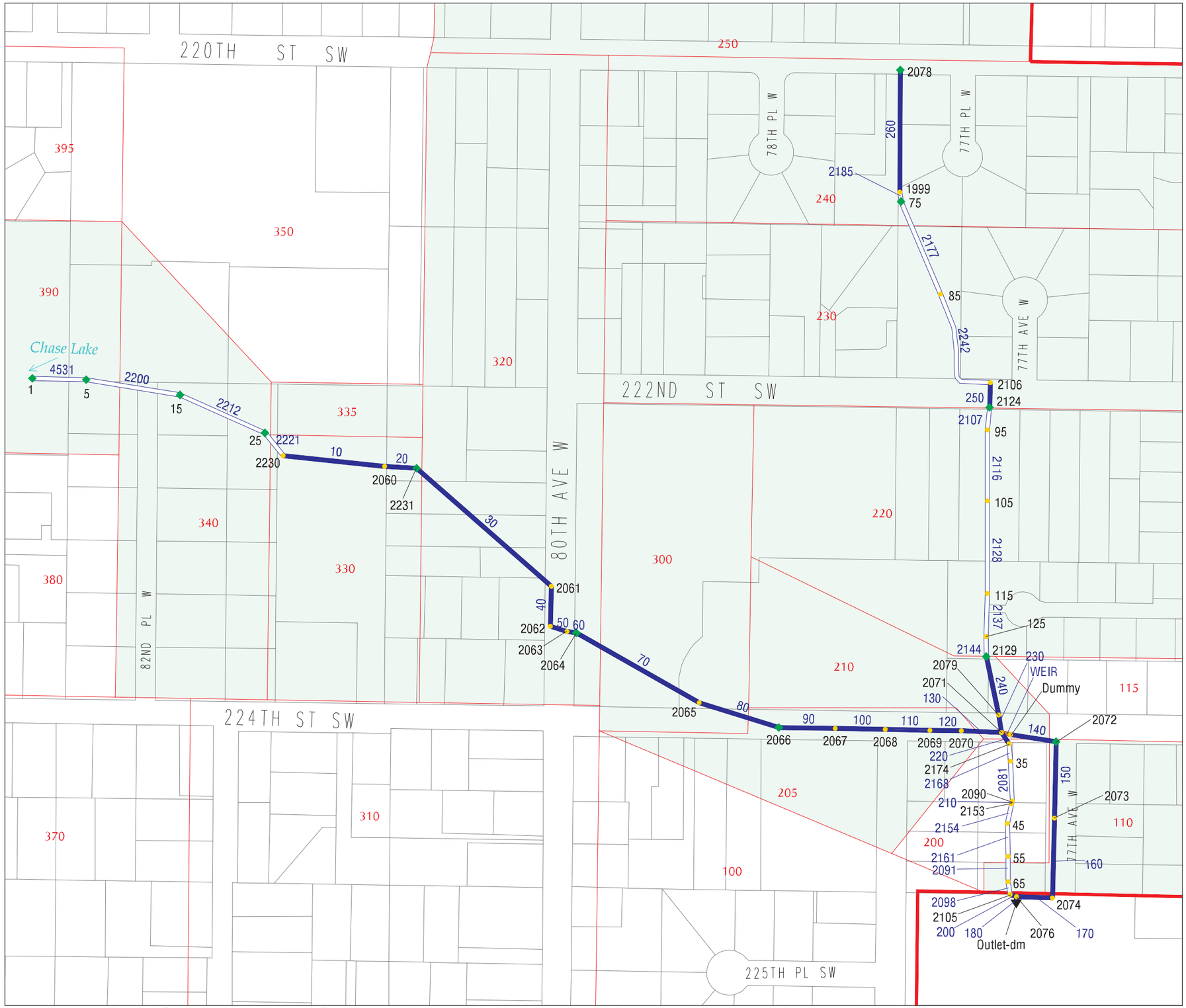
Two dummy links were included in the model. One (link WEIR) is used to represent the diversion weir. The other dummy link (link 180) is at the downstream end of the system. Two branches come together at the downstream end of the system; however, SWMM does not allow multiple flow paths immediately upstream from the downstream boundary. Therefore, a short, horizontal dummy link was added between the multiple flow paths and the downstream boundary.

B6.3.1.4 Roughness Coefficients

Roughness coefficients for the ditch reaches were determined from field observation. Roughness coefficients for the pipes were established as described in the DNR Hydraulic Modeling Protocols in the separately bound Drainage Needs Reports Protocols. The roughness coefficients used for the channels were determined based on information in the United States Geologic Survey Water-Supply Paper 2339, *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains* (Arcement and Schneider, 1989) and *Open-Channel Hydraulics* (Chow, 1959).

B6.3.1.5 Flood Routing

Constant flows were input into the SWMM model to represent the inflow from the surrounding subbasins. The flows were developed using HSPF and included system routing through FTABLEs. The flows used in the model were those established from the hydrologic analysis for the 2-, 10-, and 25-year recurrence frequencies for both existing and future land use conditions. The flows were input into the model according to the subbasin delineation at the nodes identified in the model schematic (Figure B6-1).



Legend

- Basin Boundary
- HSPF Subbasin Boundary
- Parcel Boundary

SWMM Model Catchments

- Chase Lake

Conveyance System

- Open Channel
- Closed Conduit
- Dummy Conduit

Model Nodes

- Storage
- Flow
- Junction
- Outfall

N

100 0 100 200

Scale in feet

Snohomish County
PUBLIC WORKS
SURFACE WATER MANAGEMENT

Figure B6-1

Chase Lake

Hydraulic Model Schematic

for SWMM Model

Swamp Creek Drainage Needs Report

swu-b61.aml

B6.3.1.6 Storage Areas and Overflow Paths

To contain flood flow, storage areas and overflow paths were added to the model. The overflow paths were defined as V-shaped channels. The storage areas were approximated by using the Edmonds Plan topographic mapping (R. W. Beck, 1991) or was based on field observation. Table B6-3 lists the links that are overflow paths or nodes where storage is defined and their location.

Table B6-3
SWMM Model Overflow Paths and Ponding Nodes Defined – Chase Lake Subbasin

Link	Nodes	Location	Method for Handling Overflow
10	2230&2060	Enclosed pipe system under church	v-shaped channel with 2% side slopes
20	2060&2231	Enclosed pipe system under church	v-shaped channel with 2% side slopes
30	2231&2061	Enclosed pipe system under private property	v-shaped channel with 2% side slopes
40	2061&2062	Enclosed pipe on west side of 80th Avenue W	v-shaped channel with 2% side slopes
50	2062&2063	Enclosed pipe across 80th Avenue W	v-shaped channel with 2% side slopes
60	2063&2064	Enclosed pipe across 80th Avenue W	v-shaped channel with 2% side slopes
70	2064&2065	Enclosed pipe on private property	v-shaped channel with 2% side slopes
80	2065&2066	Enclosed pipe along 224th Street SW	v-shaped channel with 2% side slopes
90	2066&2067	Enclosed pipe along 224th Street SW	v-shaped channel with 2% side slopes
100	2067&2068	Enclosed pipe along 224th Street SW	v-shaped channel with 2% side slopes
110	2068&2069	Enclosed pipe along 224th Street SW	v-shaped channel with 2% side slopes
120	2069&2070	Enclosed pipe along 224th Street SW	v-shaped channel with 2% side slopes
130	2070&2071	Enclosed pipe along 224th Street SW	v-shaped channel with 2% side slopes
250	2106&2124	Culvert crossing of 222nd Street SW	v-shaped channel with 2% side slopes
	2230	Entrance to enclosed pipe system upstream of church	Defined storage area based on mapping and observation

B6.3.2 Model Results and Problem Identification with Existing Condition Flows

Peak water surface elevations were computed for the 2-, 10-, and 25-year events under existing land use conditions. Figure 8-1f shows the flooding locations and frequencies. Table B6-4 lists the resulting water surface elevations for the entire model. Locations where the water level exceeded the overflow elevation or came to within 0.2 feet were considered flooding problems.

Along the Chase Lake outlet system, the SWMM model predicts that for the 2-year event property would flood along the open-channel ditch downstream from Chase Lake detention pond, including the church parking lot. This area has been identified by the County as a problem area.

Downstream of the church, the model predicts that the two manholes on the west side of 80th Avenue W north of 224th Street SW would flood during the 10-year event. The portion of the system along 224th Street SW also shows flooding for the 2- to 10-year events.

Table B6-4
SWMM Hydraulic Model Results Summary for Existing System with Existing and Future Land Use Conditions for Chase Lake Subbasin

Problem ID[a]	Location	Node Number[b]	Node Invert	Flooding Elevation[c] (ft)	2-Year Water Surface Elevation (ft)		10-Year Water Surface Elevation (ft)		25-Year Water Surface Elevation (ft)		Flooding Frequency[d]	
					Existing	Future	Existing	Future	Existing	Future	Existing	Future
SW-CH-F-Ex-01	West Branch -Open ditch downstream of Chase Lake detention pond	15	390.16	393.77	397.99	399.18	399.33	399.34	399.38	399.38	2-yr	2-yr
SW-CH-F-Ex-01	West Branch -Open ditch downstream of Chase Lake detention pond	25	390.45	395.38	397.99	399.18	399.33	399.34	399.38	399.38	2-yr	2-yr
SW-CH-F-Ex-01	West Branch - Entrance to pipe system under church	2230	390.35	393.30	397.99	399.18	399.33	399.34	399.37	399.38	2-yr	2-yr
SW-CH-F-Ex-01	West Branch - Manhole on Church Property	2060	390.02	398.82	396.59	398.27	398.87	398.90	398.91	398.91	10-yr	10-yr
SW-CH-F-Ex-01	West Branch - Manhole on Church Property	2231	390.07	397.49	396.14	397.65	397.79	397.79	397.80	397.80	10-yr	2-yr
SW-CH-F-Ex-02	West Branch - Manhole on west side of 80th Avenue W	2061	387.50	390.58	388.83	389.15	391.07	391.12	391.17	391.18	10-yr	10-yr
SW-CH-F-Ex-02	West Branch - Manhole upstream of 80th Avenue W	2062	386.75	390.35	387.82	387.95	390.27	390.40	390.60	390.66	10-yr	10-yr
	West Branch - Manhole in 80th Avenue W	2063	386.08	389.91	387.22	387.33	389.16	389.22	389.43	389.64	none	none
SW-CH-F-Ex-03	West Branch - Manhole downstream 80th Avenue W	2064	385.00	388.42	386.36	386.36	388.57	388.58	388.60	388.76	10-yr	10-yr
SW-CH-F-Ex-03	West Branch - Manhole on north side of 224th Street SW	2065	377.47	379.52	378.43	378.65	379.92	379.93	379.96	379.97	10-yr	10-yr
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2066	371.40	375.37	373.50	374.18	375.49	375.50	375.53	375.58	10-yr	10-yr
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2067	367.73	370.98	371.03	371.07	371.19	371.20	371.22	371.23	2-yr	2-yr
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2068	365.40	367.84	366.57	366.58	367.98	367.99	368.02	368.04	10-yr	10-yr
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2069	361.54	364.11	362.72	363.18	364.27	364.27	364.30	364.32	10-yr	10-yr
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2070	358.32	361.47	361.10	361.53	361.74	361.75	361.76	361.78	10-yr	2-yr
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2071	356.25	360.00	359.03	359.45	360.21	360.21	360.24	360.25	10-yr	10-yr
	West Branch - Manhole in 224th Street SW	2072	354.29	360.12	356.65	357.59	358.17	358.17	358.25	358.26	none	none
	Manhole in 77th Avenue W	2073	352.03	356.03	354.70	355.23	355.59	355.59	355.64	355.64	none	none
	Manhole in 77th Avenue W	2074	349.86	353.56	352.57	352.74	352.86	352.86	352.88	352.88	none	none
	Manhole at Edmonds city limits west of 77th Avenue W	2076	348.57	355.00	351.61	351.61	351.67	351.68	351.71	351.72	none	none
SW-CH-F-Ex-04	North Branch - Outlet of pipe south of 220th Street SW and west of 77th Avenue W	1999	381.20	382.70	382.37	382.39	382.86	382.85	384.85	384.69	10-yr	10-yr
	North Branch - Open ditch south of 220th Street SW and west of 77th Avenue W	75	380.79	393.12	382.25	382.18	382.86	382.85	384.85	384.69	none	none
	North Branch - Open ditch south of 220th Street SW and west of 77th Avenue W	85	376.97	379.98	377.63	377.64	377.77	377.77	377.82	377.82	none	none
	North Branch - Inlet to culvert under 222nd Street SW	2106	369.62	372.63	370.36	370.35	370.73	370.73	370.81	370.79	none	none

Table B6-4 (continued)
SWMM Hydraulic Model Results Summary for Existing System with Existing and Future Land Use Conditions for Chase Lake Subbasin

Problem ID[a]	Location	Node Number[b]	Node Invert	Flooding Elevation[c] (ft)	2-Year Water Surface Elevation (ft)		10-Year Water Surface Elevation (ft)		25-Year Water Surface Elevation (ft)		Flooding Frequency[d]	
					Existing	Future	Existing	Future	Existing	Future	Existing	Future
SW-CH-F-Ex-05	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	95	367.19	368.29	368.98	368.96	369.22	369.22	369.28	369.28	2-yr	2-yr
	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	105	365.55	367.18	366.22	366.23	366.34	366.34	366.35	366.35	none	none
	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	115	363.44	365.22	364.21	364.22	364.43	364.43	364.47	364.47	none	none
	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	125	362.04	364.66	362.71	362.71	362.87	362.87	362.95	362.95	none	none
	North Branch - Inlet to pipe system upstream of 224th Street SW	2129	359.82	363.65	360.62	360.62	361.89	361.91	362.52	362.52	none	none
SW-CH-F-Ex-05	North Branch - Manhole upstream (north) of 224th Street SW.	2079	357.50	360.81	359.30	359.68	360.77	360.77	360.91	360.92	10-yr	10-yr
	Outlet of pipe system south of 224th Street SW west of 77th Avenue W	2174	356.00	368.02	356.98	357.00	357.67	357.56	357.72	357.78	none	none
	Open ditch south of 224th Street SW and west of 77th Avenue W	35	355.96	369.25	356.91	356.94	357.61	357.48	357.64	357.69	none	none
SW-CH-F-Ex-06	Inlet to culvert in the ditch south of 224th Street SW and west of 77th Avenue W	2090	354.19	357.13	355.25	355.31	357.16	357.21	357.33	357.36	10-yr	10-yr
SW-CH-F-Ex-06	Outlet to culvert in the ditch south of 224th Street SW and west of 77th Avenue W	2153	354.09	355.28	354.92	354.95	355.46	355.47	355.58	355.63	10-yr	10-yr
SW-CH-F-Ex-06	Open ditch south of 224th Street SW and west of 77th Avenue W	45	354.03	354.67	354.82	354.85	355.37	355.39	355.49	355.53	2-yr	2-yr
	Open ditch south of 224th Street SW and west of 77th Avenue W	55	352.96	355.16	353.93	353.97	354.58	354.60	354.79	354.86	none	none
	Open ditch south of 224th Street SW and west of 77th Avenue W	65	352.14	355.23	352.89	352.92	353.33	353.35	353.47	353.52	none	none
	Inlet to pipe system near Edmonds' City limits west of 77th Avenue W	2105	351.57	354.46	352.10	352.12	352.43	352.44	352.53	352.57	none	none
SW-CH-F-Ex-01	West Branch - Open ditch downstream of Chase Lake detention pond	5	390.04	393.54	398.00	399.18	399.34	399.36	399.40	399.40	2-yr	2-yr
SW-CH-F-Ex-05	North Branch - Outlet to culvert under 222nd Street SW	2124	368.87	369.14	369.93	369.93	370.15	370.15	370.17	370.17	2-yr	2-yr
SW-CH-F-Ex-01	West Branch - Open ditch downstream of Chase Lake detention pond	1	388.41	393.36	398.00	399.18	399.34	399.36	399.40	399.40	2-yr	2-yr
	Manhole in 220th Street SW west of 77th Place W.	2078	384.80	388.37	385.62	385.64	385.97	385.97	386.88	386.69	none	none

[a] See Section 8.0 for problem ID key.

[b] Refer to Figure B6-1 for SWMM schematic.

[c] Refers to elevation of roadway, property, or channel flooding.

[d] Minimum storm event (of events analyzed) when flooding is expected to occur. The roadway/driveway floods if water surface elevation is within 0.2' of the flood elevation.

Datum = NAVD 88

Along the north branch, the model predicts yard flooding from the open channel immediately downstream of the pipe discharge south of 220th Street SW west of 77th Place W for the 10-year event. In addition, the model predicts flooding in the channel downstream of 222nd Street SW for the 2-year event. The flooding of the channel downstream of 222nd Street SW has been noted by the County.

Yard flooding was also predicted in the low-flow branch of the system downstream from the diversion structure on 224th Street SW. The model indicates flooding of the ditch culvert for the 10-year event and flooding of the ditch downstream of the culvert for the 2-year event with existing land use.

B6.3.3 Model Results and Problem Identification with Future Conditions Flows.

Peak water surface elevations were computed for the 2-, 10-, and 25-year events with future land use conditions. The flooding location and frequencies are the same as for the existing conditions analysis and are shown in Figure 8-1f and Table B6-4.

B6.4 King County Backwater Model Development and Results

Two modeling areas were analyzed using the King County Backwater (KCBW) program. The KCBW program was used because these systems were smaller linear collection systems and they do not have a significant amount of flood attenuation storage. The KCBW models were used to simulate the capacities of pipe reaches and culverts. The capacities of these system elements were defined based on a "flooding elevation." The flooding elevation was generally the grate of a catch basin for pipe systems or the top of road/driveway elevation for culverts. The system capacities were then compared to the projected peak flows developed through the hydrologic analysis to assess flooding problems and the level of protection provided by the system.

B6.4.1 Model Input File

Model input for analyzing pipe systems requires the following user-provided input:

- Downstream boundary condition.
- Pipe system data including diameter, material, length, and upstream and downstream invert elevation.
- Catch basin structure information including size, change in flow direction, inlet type, and flooding elevation.
- Flow change information, referred to in the model as Q-ratios. (The Q-ratio is the ratio of new flow introduced at the structure to the main flow being analyzed.)
- Flow ranges to be simulated (minimum flow, maximum flow, and incremental flow).

Model input information when analyzing channel and culvert systems includes:

- Channel cross section information including dimension, length, and Manning's roughness coefficients.

- Culvert data including diameter, material, length, upstream and downstream invert elevation, inlet type, flooding elevation, and overflow type (weir flow information).
- Flow change information (Q-ratios).
- Flow ranges to be simulated (minimum flow, maximum flow, and incremental flow).

Input data on pipe system information were obtained from field survey, as described above under data collection. Most of the channels simulated are roadside ditches. The representation of ditch cross sections was simplified. In most cases, one cross section was surveyed between culverts rather than at the inlet and outlet of culverts as done where HEC-RAS was used. The one cross section was then used as a representative cross section for the entire ditch reach between culverts. The data for the surveyed cross section was then shifted vertically so that the thalweg matched the invert elevation of the culvert. Using this simplified approach for simulation of backwater through roadside ditches is reasonable, as in most cases, capacity restrictions occur at driveway culverts instead of ditches. For ditch sections, a Manning's roughness coefficient value of 0.05 was used. Attachment B6-2 contains a summary of the system input information for each model area. Unique assumptions about specific system elements are listed in the table under the comment column.

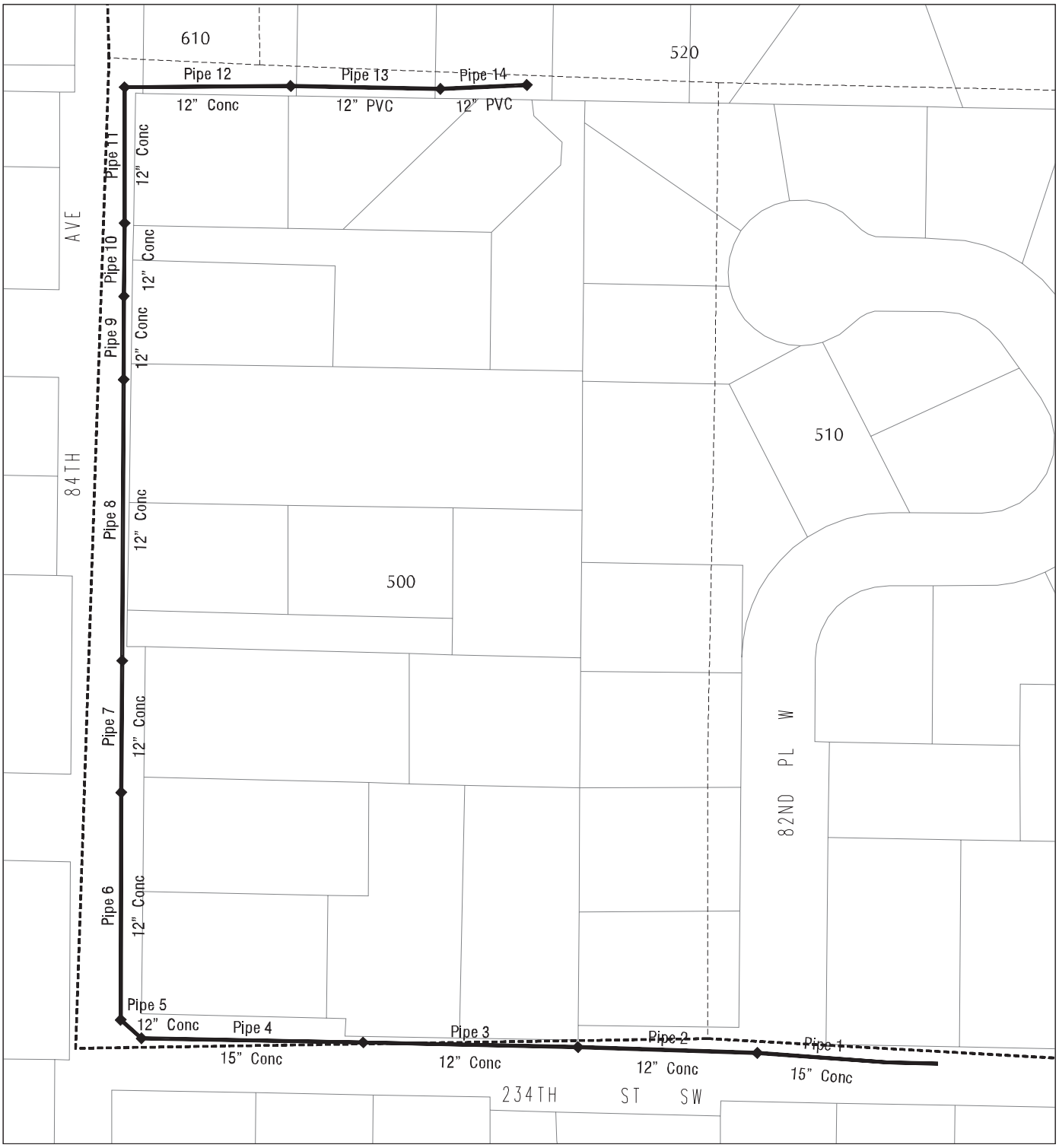
Flow data were developed from the hydrologic analysis. Peak flows for each pipe, channel, or culvert element were chosen corresponding to the applicable HSPF reach. In some cases, flows were adjusted along the system to account for changes in flow within the system and HSPF reach. Spreadsheets, included in Attachment B6-2 were prepared to develop these changes in flow and corresponding Q-ratios. Within reaches, flow was apportioned based upon contributing area. This is a reasonable assumption because the land use is generally consistent. Q-ratios were developed based upon the 25-year peak-flow values. Flow ranges up to the 25-year event were input into the model.

The boundary conditions for each model assumed a free discharge at the most downstream pipe. For Modeling Area 1, field survey data were not collected at the most downstream pipe; however, a conservative slope was assumed because this area is at a location near the crest of a hill, such that the system begins to increase in slope to the east along 234th Street SW.

Modeling Area 2 has two branches. The branch along 231st Street SW is referred to as System A, and the branch that extends north along 88th Avenue W and then to the east is referred to as System B. Separate models were developed for each branch. The lower six pipe reaches are the same in each model.

B6.4.2 System Model Schematic

Figures B6-2 and B6-3 show model schematics for Modeling Areas 1 and 2, respectively. The model schematic is the same for both existing and future land use conditions.



Legend

- Basin Boundary
- HSPF Subbasin Boundary
- Parcel Boundary

Conveyance System

- Pipe
- Culvert
- Channel

Model Nodes

- Catch Basin
- Drain Point

N

50 0 50

Scale in feet

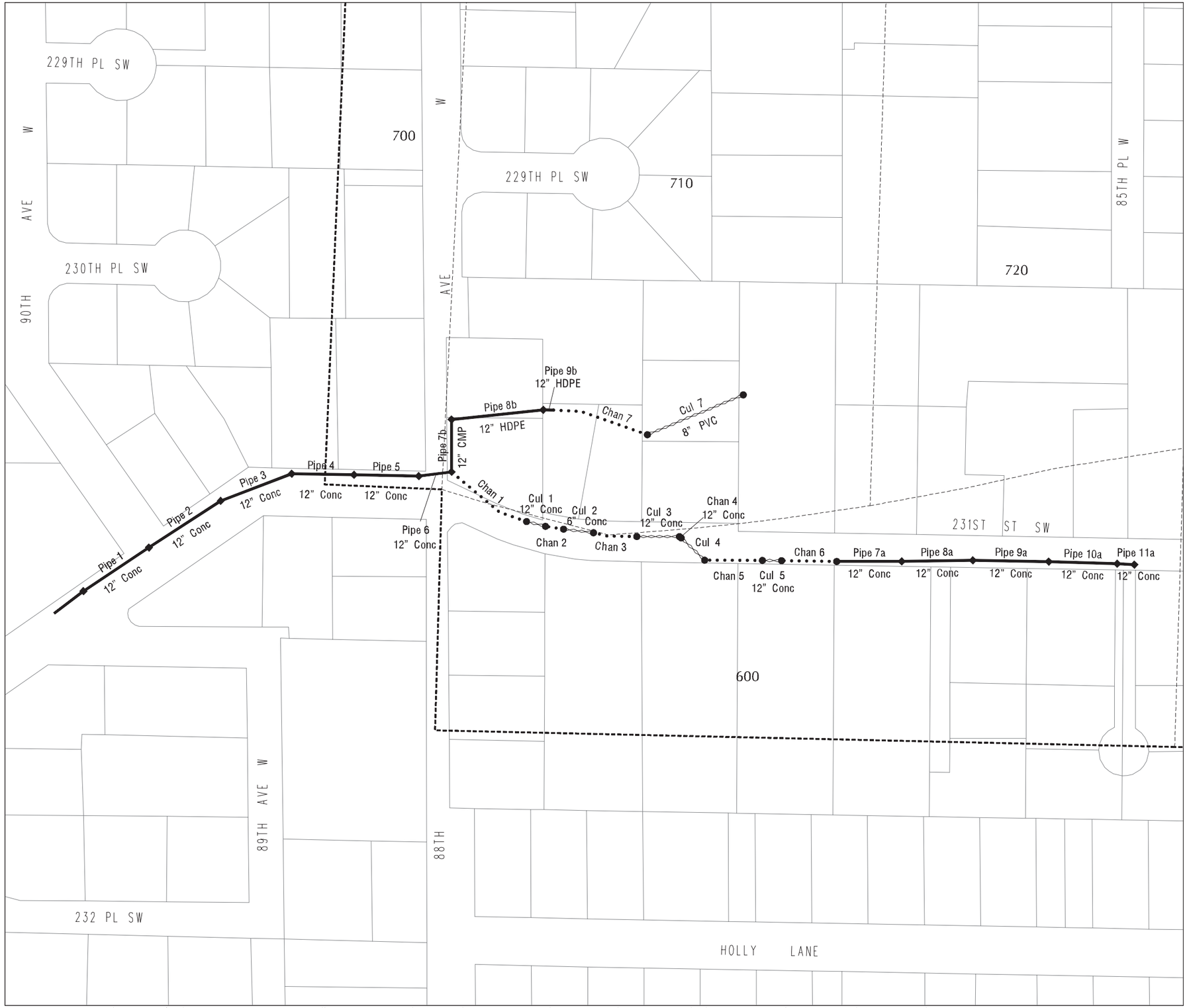
Snohomish County
PUBLIC WORKS
SURFACE WATER MANAGEMENT

Figure B6-2

Chase Lake
Modeling Area 1
KCBW Model Schematic

Swamp Creek Drainage Needs Report

swu-b2a.aml



Legend

- Basin Boundary
- HSPF Subbasin Boundary
- Parcel Boundary

Conveyance System

- Pipe
- Culvert
- Channel

Model Nodes

- Catch Basin
- Drain Point

N

100 0 100

Scale in feet

Snohomish County
PUBLIC WORKS
SURFACE WATER MANAGEMENT

Figure B6-3

Chase Lake

Modeling Area 2

KCBW Model Schematic

Swamp Creek Drainage Needs Report

swu-b2b.aml

B6.4.3 Model Results and Problem Identification with Existing Conditions Flows

The model results are tabulated in Table B6-5 for Modeling Areas 1 and 2. The table summarizes the system data, flooding elevation, existing and future 25-year peak flows, and approximate level of protection.

For Modeling Area 1, the model results predict that much of the system along 84th Avenue W has between the 2-year and 10-year level of protection, while a few pipe elements have between the 10-year and 25-year level of protection. It was noted that ponding has been observed at the end of 83rd Avenue W at pipe 14. This ponding was observed during a field reconnaissance and appeared to occur mostly because the existing catch basins are not at a low point and some of the adjacent paved area cannot drain properly to the catch basins. It is also noted that County staff recalled flooding in the backyards between 84th Avenue W and 83rd Avenue W (at the upstream end of Pipe 12). This pipe element is shown to have a level of protection greater than the 10-year event. It may be possible that low areas exist along the backyards that could flood at a more frequent occurrence.

For Modeling Area 2, several problem areas were simulated. First, the lower pipe system along 232nd Street SW is simulated to have less than a 2-year level of protection. The Edmonds city limits are located just west of 88th Avenue W, so much of this portion of the system is within Edmonds. The portion of the pipe system along 88th Avenue W (Pipe 7B) is also undersized and is predicted to flood at the 2-year event. As discussed above, the ditch system that flows west along 231st Street SW as it approaches 88th Avenue W is a problem. The ditch becomes shallower until it becomes indistinguishable and has no defined path to the catch basin located at the end of Pipe 6. It is also noted that during the field reconnaissance, the ditches along 231st Street SW appeared to be in need of maintenance. The modeling results for the pipe and ditch/culvert system along 231st Street SW showed the system is undersized. Three of the five culverts show flooding or are within 0.2 foot of the flooding elevation for the 25-year event. The upper end of the pipe system (pipes 9 through 11) show flooding for the 10-year event or are within 0.2 foot of flooding for the 25-year event. The entire system for Branch B was simulated to flood for the 25-year event. This is consistent with a flooding complaint (Drainage Complaint 19970224).

B6.4.4 Model Results and Problem Identification with Future Conditions Flows

The model results are tabulated in Table B6-5 for Modeling Areas 1 and 2, respectively. The modeling results for future land use condition flows are almost the same as for existing conditions because there is little to no change in peak estimated flows.

Table B6-5
KCBW Hydraulic Model Results Summary for Existing System with Existing and Future Land Use Conditions for Chase Lake Subbasin

Problem ID[a]	Pipe ID/Location[b]	Pipe Data			Pipe Invert Elevation (ft)		Flooding Elevation[c] (ft)	2-Year Water Surface Elevation (ft)[d]		10-Year Water Surface Elevation (ft)[d]		25-Year Water Surface Elevation (ft)[d]		Flooding Frequency[e]	
		Length (ft)	Size (in.)	Material	Inlet	Outlet		Existing	Future	Existing	Future	Existing	Future	Existing	Future
Modeling Area 1															
	Pipe 1/ 234th St SW at 82nd Pl W	100	15	Conc.	458.71	457.71	465.89	459.69	459.72	460.05	460.10	460.34	460.39	none	none
	Pipe 2/ 234th St SW between 82nd Pl W and 84th Ave W	122.13	12	Conc.	459.15	458.81	463.35	460.12	460.17	461.32	461.47	462.32	462.49	none	none
SW-CL-F-Ex-7	Pipe 3/ 234th St SW between 82nd Pl W and 84th Ave W	146	12	Conc.	459.66	459.20	461.64	460.67	460.77	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 4/ 234th St SW between 82nd Pl W and 84th Ave W	150.68	15	Conc.	459.58	459.66	462.22	460.90	461.00	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 5/ 84th Ave W at 234th St SW	19.83	12	Conc.	459.42	459.56	461.8	461.07	461.20	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 6/ 84th Ave W between at 234th St SW and Maple Ln	156.93	12	Conc.	460.36	459.42	463.01	461.62	461.82	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 7/ 84th Ave W between Maple Ln and Holly Ln	90.67	12	Conc.	460.66	460.41	462.99	462.00	462.25	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 8/84th Ave W between Maple Ln and Holly Ln	193.2	12	Conc.	461.91	460.74	464.34	462.82	462.90	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 9/ 84th Ave W between Maple Ln and Holly Ln	56.5	12	Conc.	462.14	461.87	464.67	462.96	463.05	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 10/ 84th Ave W North of Holly Ln	50.22	12	Conc.	462.23	462.17	464.75	463.10	463.17	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-7	Pipe 11/ 84th Ave W North of Holly Ln	94.16	12	Conc.	463.30	462.24	465.63	464.07	464.10	465.45	465.50	OT	OT	25-yr	25-yr
SW-CL-F-Ex-7	Pipe 12/ East of 84th Ave W near south end of 83rd Ave W	113	12	PVC	463.65	463.25	465.87	464.33	464.36	465.81	OT	OT	OT	10-yr	10-yr
	Pipe 13/East of 84th Ave W near south end of 83rd Ave W	102.55	12	PVC	465.00	463.65	466.77	465.62	465.64	466.15	466.24	466.39	466.43	none	none
SW-CL-F-Ex-8	Pipe 14/ End of 83rd Ave W south of 230th Street SW	60.01	12	PVC	465.16	465.54	466.74	466.32	466.34	466.57	466.57	OT	OT	25-yr	25-yr
Modeling Area 2: Branch A															
SW-CL-F-Ex-9	Pipe 1/ 232nd St SW west of 88th Ave SW	98	12	Conc.	411.79	400.82	413.59	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-9	Pipe 2/ 232nd St SW west of 88th Ave SW	106	12	Conc.	420.04	411.58	422.04	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-9	Pipe 3/ 232nd St SW west of 88th Ave SW	95	12	Conc.	421.37	419.74	423.9	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-9	Pipe 4/ 232nd St SW west of 88th Ave SW	77	12	Conc.	422.46	421.28	425.38	424.58	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-9	Pipe 5/ 232nd St SW west of 88th Ave SW	80	12	Conc.	424.26	422.35	428.34	426.12	427.06	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-9	Pipe 6/ 232nd St SW west crossing of 88th Ave SW	41	12	Conc.	425.50	424.26	429.41	427.50	428.56	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-10	Culvert 1/ 231st St SW east of 88th Ave W	25	12	Conc.	435.17	433.95	436.67	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-10	Culvert 2/ 231st St SW east of 88th Ave W	38	6	Conc.	438.34	436.52	439.04	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-10	Culvert 3/ 231st St SW east of 88th Ave W	53.3	12	Conc.	440.47	440.31	442.41	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-10	Culvert 4/ 231st St SW east of 88th Ave W	40	12	Conc.	441.53	440.20	442.88	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-10	Culvert 5/ 231st St SW east of 88th Ave W	23	12	Conc.	446.00	443.58	447.04	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-10	Pipe 7/ 231st St SW between 86th Ave W and 85th Ave W	81	12	Conc.	455.95	449.54	457.76	457.21	457.26	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-10	Pipe 8/ 231st St SW between 86th Ave W and 85th Ave W	89	12	Conc.	458.31	456.45	461.54	460.17	460.27	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-10	Pipe 9/ 231st St SW between 86th Ave W and 85th Ave W	95	12	Conc.	460.18	458.36	462.27	461.76	461.86	OT	OT	OT	OT	10-yr	10-yr
SW-CL-F-Ex-10	Pipe 10/ 231st St SW between 86th Ave W and 85th Ave W	85	12	Conc.	459.56	459.39	461.59	OT	OT	OT	OT	OT	OT	2-yr	2-yr
SW-CL-F-Ex-10	Pipe 11/ 231st St SW between 86th Ave W and 85th Ave W	22	12	Conc.	459.72	459.46	461.63	OT	OT	OT	OT	OT	OT	2-yr	2-yr

Table B6-5 (continued)

KCBW Hydraulic Model Results Summary for Existing System with Existing and Future Land Use Conditions for Chase Lake Subbasin

Problem ID[a]	Pipe ID/Location[b]	Pipe Data			Elevation		Flooding Elevation[c] (ft)	Elevation		Surface Elevation		Elevation		Frequency[e]	
		Length (ft)	Size (in.)	Material	Inlet	Outlet		Existing	Future	Existing	Future	Existing	Future	Existing	Future
Modeling Area 2: Branch B															
SW-CL-F-Ex-11	Pipe 7B/ 88th Ave W north of 232nd St SW	66	12	CMP	423.90	424.26	428.1	OT	OT	OT	OT	OT	OT	2-yr	2-yr
	Pipe 8B/ private system located east of 88th Ave W and north of 231st St SW	115	12	Conc.	428.76	425.90	430.91	429.58	429.60	429.92	429.91	430.17	430.14	none	none
SW-CL-F-Ex-11	Pipe 9B/ private system located east of 88th Ave W and north of 231st St SW	2	12	Conc.	429.66	429.66	430.91	430.44	430.46	430.85	430.84	OT	OT	25-yr	25-yr
SW-CL-F-Ex-11	Culvert 7/ private system located east of 88th Ave W and north of 231st St SW	129	8	PVC	434.35	432.85	435.85	OT	OT	OT	OT	OT	OT	2-yr	2-yr

KCBW = King County Backwater

CMP = corrugated metal pipe

PVC = polyvinyl chloride

Conc = concrete

[a] See Section 8.0 for problem ID key.

[b] Refer to Figures B6-2 and B6-3 for schematics showing locations.

[c] Refers to elevation or roadway, property, or channel flooding.

[d] If flooding occurs, KCBW does not provide a water surface elevation and "OT" is indicated.

[e] Minimum storm event (of events analyzed) when flooding is expected to occur. The roadway/driveway floods if water surface elevation is within 0.2' of the flood elevation.

Datum = NAVD 88

B6.5 CIP Alternative 1

The objective of CIP Modeling Alternative 1 was to address flooding problems in the area downstream of Chase Lake (problems SW-CH-F-Ex-FU-1 to 5) primarily by increasing the capacity of the conveyance system. This section describes design criteria and solution development approach used to design these channel and pipe system improvements. The following discussion of design criteria is intended to supplement Section 7. Detailed descriptions of each problem are addressed in Section 8.

B6.5.1 SWMM Alternative 1 Model Development

Sizing replacement channels, culverts, or pipes was done using SWMM in steady state using peak flows defined by the hydrologic analysis. FTABLES were developed from the SWMM model for the alternative and used in HSPF to evaluate changes in peak runoff rates associated with the alternative improvements. Hydrologic analysis results of the alternative are included in Appendix A4.

The SWMM model was used to evaluate Alternative 1 conveyance improvements. This area was not identified as having fish habitat; therefore, fish passage criteria were not considered when sizing this alternative. Design criteria for non-fish passage conveyance improvements are described in Section 7.0 for pipe systems and channels. The general objective of this alternative was to address flooding throughout the modeling area by increasing the capacity of the existing conveyance system.

The Alternative 1 conveyance system upgrades are presented in Table B6-6 and include the following:

- Replacing approximately 1,640 feet of existing 18-inch-diameter pipe under the church parking lot, then south and east to 224th Street SW and continuing east to the control structure on 224th Street SW just west of 77th Avenue W with 36-inch-diameter pipe.
- Replacing approximately 475 feet of 24-inch-diameter pipe from the existing control structure on 224th Street SW east to 77th Avenue W, then south along 77th Avenue W to the Edmonds city limits and then west along the city limits with a 36-inch-diameter pipe. This system would reconnect to the existing 36-inch-diameter pipe that conveys runoff south underneath a private storage yard within Edmonds.
- Replacing the existing weir in the control structure on 224th Street SW with a longer 6-foot-long weir.
- Replacing 155 feet of the existing 18-inch-diameter pipe just north of 224th Street SW and west of 77th Avenue W with a 24-inch-diameter pipe.
- Widening 200 feet of channel between 220th Street SW and 222nd Street SW west of 77th Avenue W.
- Widening 200 feet of channel between 222nd Street SW and 224th Street SW west of 77th Avenue W.
- Increasing the depth of 110 feet of channel south of 224th Street SW and west of 77th Avenue W.
- Adding approximately 50 feet of berm 1.5 feet high on the north side of the channel immediately downstream of the Chase Lake detention facility.

Table B6-6
SWMM Model Changes for Modeling CIP Alternatives 1 and 2 for Chase Lake Subbasin

Modeling Alternative		CIP Project ID[a]	Problem ID[b]	Project Title	Project Description	Summary of Changes to SWMM Model
1	2					
X		SW-CH-1	SW-CH-F-Ex-1 SW-CH-F-Ex-2 SW-CH-F-Ex-3	Chase Lake Outlet Pipe Replacement along 224th Street SW	Replace approximately 1,640 feet of existing 18-inch pipe under the Church parking lot south and east to 224th Street and continue east to just west of 77th Ave W (confluence with north branch) with 36-inch-diameter pipe. Portions of the new pipe would be installed at deeper depths.	Pipes between nodes 2230 and 2071 were upsized to 36". The vertical alignment was adjusted such that there is a constant pipe slope between these two nodes. This results in deepening the pipe system.
X	X	SW-CH-2	SW-CH-F-Ex-1 SW-CH-F-Ex-2 SW-CH-F-Ex-3	77th Avenue W Pipe Replacement Project	Replace approximately 475 feet of existing 24-inch-diameter pipe from the control structure on 224th St SW east to 77 Ave W and then south along 77th Ave W to Edmonds city limits and then west along the city limits to connect with the channel section with a 36-inch-dia pipe. In addition, replace the weir in the control structure with a 6-foot-long weir and the 12-inch low-flow pipe with a 10-inch pipe.	Pipes between nodes 2071 and 2076 were upsized to 36". The weir modeled at link WEIR was replaced with a 6-foot-long weir with a crest at 356.75
X	X	SW-CH-3	SW-CH-F-Ex-3	Chase Lake North Branch Pipe Replacement at 224th Street SW	Replace approximately 155 feet of existing 18-inch diameter pipe just north of 224th St SW and west of 77th Ave W with a 24-inch-dia pipe.	Pipes between nodes 2129 and 2071 were upsized to 24".
X	X	SW-CH-4	SW-CH-F-Ex-4	Chase Lake North Branch Channel Widening South of 220th Street SW	Widen 200 feet of channel to a 2' bottom width with 3:1 side slopes and 2' depth between 220th St SW and 222nd St SW west of 77th Ave W	The channel cross section between nodes 1999 and 85 were modifed as described in the project description.
X	X	SW-CH-5	SW-CH-F-Ex-5	Chase Lake North Branch Channel Widening South of 222th Street SW	Widen 200 feet of channel to a 2' bottom width with 3:1 side slopes and 2' depth between 222nd St SW and 224th St SW west of 77th Ave W	The channel cross section between nodes 2124 and 105 were modifed as described in the project description.
X	X	SW-CH-6	SW-CH-F-Ex-6	Chase Lake Outlet Low flow Channel Improvements	Increase the depth of 110' of channel south of 224th St SW and west of 77th Ave W by 1'.	The channel invert was lowered by 1' at node 45 and the channel slope was adjusted accordingly between nodes 2153 and 55.
X		SW-CH-7	SW-CH-F-Ex-1	Chase Lake Outlet Berm	Add about 50 feet of 1.5-foot-high berm on the north side of the channel downstream of the Chase Lake detention pond outlet	No changes were made in the model to reflect the proposed berm
	X	SW-CH-8	SW-CH-F-Ex-1 SW-CH-F-Ex-2 SW-CH-F-Ex-3	Chase Lake Detention Pond Project	Expand existing Chase Lake detention pond by replacing the existing infiltration swale south of the lake with an approximate 80' x 300' pond. The pond would be separated from the existing lake to reduce environmental impacts. The pond would provide an additional 8.2acre-feet of storage for the 25-year flood frequency. It would be a combined wetpond to provide water quality treatment.	No changes were made in the model to reflect the expanded pond. The pond expansion was modeled in HSPF. See Appendix A4 for details.
	X	SW-CH-9	SW-CH-F-Ex-1 SW-CH-F-Ex-2 SW-CH-F-Ex-3	Chase Lake Outlet Pipe Replacement along 224th Street SW (alternative 2)	Replace approximately 1,640 feet of existing 18-inch pipe under the church parking lot south and east to 224th Street and continue east to just west of 77th Ave W (confluence with north branch) with 24-inch-dia pipe. Portions of the new pipe would be installed at deeper depths.	Pipes between nodes 2230 and 2071 were upsized to 24". The vertical alignment was adjusted such that there is a constant pipe slope between these two nodes. This results in deepening the pipe system.

[a] SW-CH-01
SW = Swamp Creek DNR Area
CH = Chase Lake Subbasin
01 = CIP project number

[b] SW-CH-F-Ex-01
SW = Swamp Creek DNR Area
CH = Chase Lake Subbasin
F = flooding (H = habitat, Q = water quality, E = erosion)
Ex = existing (Fu = future)
01 = problem number

The model schematic for the existing conditions was not altered to model Alternative 1 because no new branches or nodes were added.

B6.5.2 Alternative 1 Model Results with Future Conditions Flows

The results of the SWMM modeling for the area downstream of Chase Lake are presented in Table B6-7. This table compares the water surface elevations for existing conveyance system under existing and future land use conditions as well as for CIP Alternatives 1 and 2.

Note that Alternative 1 does not provide one foot of freeboard downstream of 222nd Street SW and 224th Street SW or on the south side of the channel immediately downstream of Chase Lake detention facility. However, at least 0.2 foot of freeboard was provided in all of these areas. Freeboard in these areas was measured to the survey-defined top of bank. In natural channels, the top of bank can often be exceeded and only result in the inundation of adjacent overbank areas which often would not be considered flooding. In several locations, the surveyed cross sections did not extend sufficiently beyond the top of bank to assess these situations. As such, it is recommended that additional surveying as part of preliminary design be completed to ensure adequate freeboard is achieved.

B6.6 CIP Alternative 2

The objective of CIP Modeling Alternative 2 was similar to Alternative 1: to address flooding problems in the area downstream of Chase Lake by increasing the capacity of the conveyance system while adding more storage to the Chase Lake detention facility. The intent of the additional storage at the Chase Lake detention facility would be to reduce the increase in downstream runoff rates resulting from conveyance improvements and to reduce the extent of conveyance improvements required.

This section describes the design criteria and solution development approach used to design pipe system and detention pond improvements. Detailed descriptions of each problem are provided in Section 8.

B6.6.1 SWMM Modeling Alternative 2

The SWMM model was used to evaluate Alternative 2 conveyance and detention improvements in Chase Lake. The SWMM model was run in steady state using peak flows defined by the hydrologic analysis. The Alternative 2 peak flows included the effects of the expanded detention facility. Hydrologic results for Alternative 2 are included in Appendix A4.

Table B6-7
SWMM Hydraulic Model Results Summary for Existing System with Existing and Future Land Use Conditions and for CIP Modeling Alternatives 1 and 2 for Chase Lake Subbasin

Problem ID[a]	Location	Node Number[b]	Flooding Elevation (ft)[c]	2-Year Water Surface Elevation (ft)				10-Year Water Surface Elevation (ft)				25-Year Water Surface Elevation (ft)				Flooding Frequency[d]			
				Existing	Future	Alt 1	Alt 2	Existing	Future	Alt 1	Alt 2	Existing	Future	Alt 1	Alt 2	Existing	Future	Alt 1	Alt 2
SW-CH-F-Ex-01	West Branch -Open ditch downstream of Chase Lake detention pond	15	393.77	397.99	399.18	392.19	392.09	399.33	399.34	392.68	392.38	399.38	399.38	392.97	392.57	2-yr	2-yr	none	none
SW-CH-F-Ex-01	West Branch -Open ditch downstream of Chase Lake detention pond	25	395.38	397.99	399.18	392.14	392.05	399.33	399.34	392.45	392.21	399.38	399.38	392.60	392.27	2-yr	2-yr	none	none
SW-CH-F-Ex-01	West Branch - Entrance to pipe system under church	2230	393.30	397.99	399.18	391.15	391.21	399.33	399.34	391.42	391.38	399.37	399.38	391.57	391.45	2-yr	2-yr	none	none
SW-CH-F-Ex-01	West Branch - Manhole on Church Property	2060	398.82	396.59	398.27	387.12	387.18	398.87	398.90	387.38	387.34	398.91	398.91	387.53	387.41	10-yr	10-yr	none	none
SW-CH-F-Ex-01	West Branch - Manhole on Church Property	2231	397.49	396.14	397.65	385.80	385.85	397.79	397.79	386.06	386.02	397.80	397.80	386.20	386.08	10-yr	2-yr	none	none
SW-CH-F-Ex-02	West Branch - Manhole on west side of 80th Avenue W	2061	390.58	388.83	389.15	378.45	378.53	391.07	391.12	378.72	378.70	391.17	391.18	378.86	380.29	10-yr	10-yr	none	none
SW-CH-F-Ex-02	West Branch - Manhole upstream of 80th Avenue W	2062	390.35	387.82	387.95	376.78	376.86	390.27	390.40	377.06	377.07	390.60	390.66	377.22	379.60	10-yr	10-yr	none	none
	West Branch - Manhole in 80th Avenue W	2063	389.91	387.22	387.33	376.17	376.29	389.16	389.22	376.49	376.56	389.43	389.64	376.65	379.31	none	none	none	none
SW-CH-F-Ex-03	West Branch - Manhole downstream 80th Avenue W	2064	388.42	386.36	386.36	375.81	375.94	388.57	388.58	376.11	376.23	388.60	388.76	376.26	379.06	10-yr	10-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole on north side of 224th Street SW	2065	379.52	378.43	378.65	369.99	370.11	379.92	379.93	370.29	370.40	379.96	379.97	370.44	374.09	10-yr	10-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2066	375.37	373.50	374.18	366.74	366.86	375.49	375.50	367.03	367.15	375.53	375.58	367.18	371.29	10-yr	10-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2067	370.98	371.03	371.07	364.38	364.50	371.19	371.20	364.68	364.77	371.22	371.23	364.85	368.02	2-yr	2-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2068	367.84	366.57	366.58	362.37	362.50	367.98	367.99	362.69	362.74	368.02	368.04	362.88	365.22	10-yr	10-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2069	364.11	362.72	363.18	360.59	360.72	364.27	364.27	360.92	360.93	364.30	364.32	361.10	362.71	10-yr	10-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2070	361.47	361.10	361.53	359.23	359.39	361.74	361.75	359.64	359.65	361.76	361.78	360.16	360.88	10-yr	2-yr	none	none
SW-CH-F-Ex-03	West Branch - Manhole in 224th Street SW	2071	360.00	359.03	359.45	358.00	357.93	360.21	360.21	358.68	358.37	360.24	360.25	359.36	358.61	10-yr	10-yr	none	none
	West Branch - Manhole in 224th Street SW	2072	360.12	356.65	357.59	356.05	355.98	358.17	358.17	356.79	356.46	358.25	358.26	357.63	356.75	none	none	none	none
	Manhole in 77th Avenue W	2073	356.03	354.70	355.23	353.76	353.68	355.59	355.59	354.68	354.26	355.64	355.64	355.28	354.64	none	none	none	none
	Manhole in 77th Avenue W	2074	353.56	352.57	352.74	351.92	351.86	352.86	352.86	352.63	352.31	352.88	352.88	352.92	352.60	none	none	none	none
	Manhole at Edmonds city limits west of 77th Avenue W	2076	355.00	351.61	351.61	351.63	351.63	351.67	351.68	351.74	351.70	351.71	351.72	351.78	351.74	none	none	none	none
SW-CH-F-Ex-04	North Branch - Outlet of pipe south of 220th Street SW and west of 77th Avenue W	1999	382.70	382.37	382.39	381.86	381.86	382.86	382.85	382.02	382.03	384.85	384.69	382.09	382.10	10-yr	10-yr	none	none
	North Branch - Open ditch south of 220th Street SW and west of 77th Avenue W	75	393.12	382.25	382.18	381.52	381.52	382.86	382.85	381.70	381.69	384.85	384.69	381.78	381.77	none	none	none	none
	North Branch - Open ditch south of 220th Street SW and west of 77th Avenue W	85	379.98	377.63	377.64	377.66	377.66	377.77	377.77	377.78	377.78	377.82	377.82	377.85	377.84	none	none	none	none
	North Branch - Inlet to culvert under 222nd Street SW	2106	372.63	370.36	370.35	370.35	370.35	370.73	370.73	370.64	370.65	370.81	370.79	370.73	370.79	none	none	none	none
SW-CH-F-Ex-05	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	95	368.29	368.98	368.96	367.50	367.50	369.22	369.22	367.70	367.70	369.28	369.28	367.80	367.80	2-yr	2-yr	none	none
	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	105	367.18	366.22	366.23	365.72	365.72	366.34	366.34	365.86	365.86	366.35	366.35	365.89	365.91	none	none	none	none
	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	115	365.22	364.21	364.22	364.22	364.22	364.43	364.43	364.41	364.41	364.47	364.47	364.49	364.49	none	none	none	none
	North Branch - Open ditch downstream of 222nd Street SW and west of 77th Avenue W	125	364.66	362.71	362.71	362.72	362.72	362.87	362.87	362.86	362.86	362.95	362.95	362.92	362.92	none	none	none	none
	North Branch - Inlet to pipe system upstream of 224th Street SW	2129	363.65	360.62	360.62	360.52	360.52	361.89	361.91	360.71	360.71	362.52	362.52	360.78	360.79	none	none	none	none
SW-CH-F-Ex-05	North Branch - Manhole upstream (north) of 224th Street SW	2079	360.81	359.30	359.68	358.20	358.17	360.77	360.77	358.66	358.57	360.91	360.92	359.54	358.75	10-yr	10-yr	none	none
	Outlet of pipe system south of 224th Street SW west of 77th Avenue W	2174	368.02	356.98	357.00	356.65	356.64	357.67	357.56	356.73	356.70	357.72	357.78	356.79	356.73	none	none	none	none
	Open ditch south of 224th Street SW and west of 77th Avenue W	35	369.25	356.91	356.94	356.59	356.58	357.61	357.48	356.68	356.64	357.64	357.69	356.74	356.67	none	none	none	none
SW-CH-F-Ex-06	Inlet to culvert in the ditch south of 224th Street SW and west of 77th Avenue W	2090	357.13	355.25	355.31	355.06	355.05	357.16	357.21	355.18	355.13	357.33	357.36	355.28	355.17	10-yr	10-yr	none	none
SW-CH-F-Ex-06	Outlet to culvert in the ditch south of 224th Street SW and west of 77th Avenue W	2153	355.28	354.92	354.95	354.44	354.43	355.46	355.47	354.49	354.47	355.58	355.63	354.53	354.48	10-yr	10-yr	none	none
SW-CH-F-Ex-06	Open ditch south of 224th Street SW and west of 77th Avenue W	45	354.67	354.82	354.85	354.22	354.21	355.37	355.39	354.31	354.29	355.49	355.53	354.36	354.31	2-yr	2-yr	none	none
	Open ditch south of 224th Street SW and west of 77th Avenue W	55	355.16	353.93	353.97	353.59	353.58	354.58	354.60	353.66	353.63	354.79	354.86	353.72	353.66	none	none	none	none
	Open ditch south of 224th Street SW and west of 77th Avenue W	65	355.23	352.89	352.92	352.69	352.69	353.33	353.35	352.76	352.74	353.47	353.52	352.80	352.76	none	none	none	none
	Inlet to pipe system near Edmonds city limits west of 77th Avenue W	2105	354.46	352.10	352.12	352.00	352.00	352.43	352.44	352.06	352.04	352.53	352.57	352.09	352.05	none	none	none	none
SW-CH-F-Ex-01	West Branch - Open ditch downstream of Chase Lake detention pond	5	393.54	398.00	399.18	392.27	392.14	399.34	399.36	392.92	392.56	399.40	399.40	393.34	392.85	2-yr	2-yr	none	none
SW-CH-F-Ex-05	North Branch - Outlet to culvert under 222nd Street SW	2124	369.14	369.93	369.93	367.90	367.90	370.15	370.15	368.11	368.11	370.17	370.17	368.17	368.19	2-yr	2-yr	none	none
SW-CH-F-Ex-01	West Branch - Open ditch downstream of Chase Lake detention pond	1	393.36	398.00	399.18	392.27	392.14	399.34	399.36	392.93	392.57	399.40	399.40	393.36	392.87	2-yr	2-yr	nonee	none
	Manhole in 220th Street SW west of 77th Place W	2078	388.37	385.62	385.64	385.67	385.67	385.97	385.97	386.00	386.01	386.88	386.69	386.25	386.26	none	none	none	none

[a] See Section 8.0 for

[b] Refer to Figure B6-1 for SWMM schematic.

[c] Refers to elevation of roadway, property, or channel flooding.

[d] Minimum storm event (of events analyzed) when flooding is expected to occur. The roadway/driveway floods if water surface elevation is within 0.2' of the flooding elevation.

[e] Berm added at this location for Alternative 1 such that flooding would be eliminated for the 25-year event.

Datum = NAVD 88

The volume of the Chase Lake detention pond would be increased by excavating additional storage in an area containing an inflow vegetated infiltration swale. During the development of this alternative, it was decided to maintain some separation between the lake and the proposed new storage due to potential environmental implications as the lake is considered a sensitive peat bog. The estimated size of the pond would be approximately 80 feet wide by 300 feet long. Outflows from the pond would be routed along the same alignment as the existing water quality swale such that flows would be diverted directly to the constructed pond on the east side of 84th Avenue W rather than discharged into the lake on the west side of 84th Avenue W. The expansion would create about 8.2 acre-feet of additional storage for the 25-year event, reflecting a 95 percent increase. The expansion would be created to form a water quality wetpond. However, since the pond would eliminate the existing water quality swale, no significant increase in water quality treatment is expected.

With two exceptions, the pipe replacements and channel improvements of CIP Modeling Alternative 2 are the same as CIP Modeling Alternative 1. The increase in storage volume at the detention facility reduces the downstream flow. As a result, the size of the improved conveyance system from the church parking lot south and east to 224th Street SW and then east to just west of 77th Avenue W (confluence with the north branch) is smaller (24 inches in diameter) for Alternative 2 than for Alternative 1. In addition, the berm immediately downstream of the detention facility is no longer necessary. Please refer to Section B6.5.1 for a discussion of these improvements.

Because most of the pipe replacements and channel improvements under Alternative 2 are the same as Alternative 1, refer to Section B6.5.1 for a description of the design approach for these improvements. Detailed changes to the model under CIP Alternative 2 are described in Table B6-6.

The model schematic for the existing conditions was not altered to model Alternative 2 because no new branches or nodes were added.

B6.6.2 Alternative 2 Model Results with Future Conditions Flows

The results of the SWMM modeling for Chase Lake study area are presented in Table B6-7. This table compares the water surface elevations for the existing conveyance system under existing and future land use conditions as well as for CIP Alternatives 1 and 2. Additional details about the hydrologic analysis for Alternative 2 are presented in Appendix A4.

B6.7 References

Arcement, Jr., G.J., and V.R. Schneider. 1989. Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains. United States Geological Survey Water-Supply Paper 2339.

Chow, Ven Te. 1959. *Open-Channel Hydraulics.* Reprint, 1988. New York: McGraw-Hill Book Company.

R. W. Beck. 1991. City of Edmonds Drainage Study Plan.

Attachment B6-1 Additional Problem Areas Identified But Not Studied (Chase Lake Subbasin)				
Reach/Area	**Section/T/R**	**Description**	**Quantities**	**Analysis Methodology**
3a	30/27/4	Open channel (bioswale) south of Chase Lake, north of 224th Street and west of 84th Avenue	1000 feet, 3 sections	This reach will not be analyzed under this contract
		84th Avenue crossing	Culvert, 3 sections	
		O/C west from Chase Lake	700 feet, 2 sections	
		South	200 feet, 1 section	
		Piped System		
		South along 86th to 224th Street	350 feet, 2 CBs	
		Along 224th to 96th Avenue	250 feet, 1 CB	
		Southeast from 224th Street/86th Ave intersection	100 feet, 1 CB	
		North along 87th Place from 226th intersection	300 feet, 2 CBs	
		East	100 feet, 1 CB	
		North	50 feet, 1 CB	
		East	200 feet, 1 CB	
		North	250 feet, 1 CB	
		Northeast	100 feet, 1 CB	
		East	100 feet, 1 CB	
		North	250 feet, 1 CB	
		East along 224th	700 feet, 3 CBs	
		North along 84th Avenue between ~227th Street and 222nd Street	1000 feet, 5 CBs	
		East	200 feet, 1 CB	
		Southeast	300 feet, 2 CBs	
		East	200 feet, 2 CB	
		Southeast	350 feet, 2 CBs	
		East along 224th	600 feet, 3 CBs	
		South along 77th	300 feet, 2 CBs	
		North from 224th	100 feet, 1 CB	
	30/27/4 SE ¼	**Open Channel**		
		South and slightly east from 220th to 222nd Street	700 feet, 3 sections	
		222nd Street crossing	Culvert, 3 sections	
		South to 224th	500 feet, 2 sections	
		East along 222nd	500 feet, 2 sections	
		Between 78th and 77th	300 feet, 2 sections	

Snohomish County Drainage Needs Report
BW Pipe Analysis for Chase Lake Modeling Area 1
Pipe Data Summary

Pipe No.	Survey Nodes	Length (ft)	Diameter (in.)	Material	Pipe Type	Outlet IE (NGVD)	Inlet IE (NGVD)	Pipe Slope (ft/ft)	Inlet Type	Upstream Overtopping Elevation (NGVD)	Change In Angle	Structure Diameter (ft)	Comments
1	Dummy	100	15	CP	1	457.71	458.71	-0.010	5	465.89	0	2	See note 1
2	2257-2032	122	12/15'	CP	1	458.81	459.15	-0.003	5	463.35	0	2	See note 2
3	2031-2257	146	12	CP	1	459.2	459.66	-0.003	5	461.64	0	4	
4	2030-2031	151	15	CP	1	459.66	459.58	0.001	5	462.22	39	2	
5	2029-2030	20	12	CP	1	459.56	459.42	0.007	5	461.8	50	2	
6	2028-2029	157	12	CP	1	459.42	460.36	-0.006	5	463.01	0	2	
7	2027-2028	91	12	CP	1	460.41	460.661	-0.003	5	462.99	0	2	
8	2026-2027	193	12	CP	1	460.74	461.91	-0.006	5	464.34	0	2	
9	2025-2026	57	12	CP	1	461.87	462.14	-0.005	5	464.67	0	2	
10	2024-2025	50	12	CP	1	462.17	462.23	-0.001	5	464.75	0	2	
11	2023-2024	94	12	CP	1	462.241	463.3	-0.011	5	465.63	90	2	
12	2022-2023	113	12	PVC	1	463.25	463.65	-0.004	5	465.87	0	2	
13	2021-2022	103	12	PVC	1	463.65	465	-0.013	5	466.77	0	2	
14	2020-2021	60	12	PVC	1	465.54	465.16	0.006	5	466.74	0	2	

Notes:

1. Dummy pipe inserted for Pipe 1, assumed 1% slope. Grade becomes steep at this location and this is considered conservative.
2. Survey shows upstream end of Pipe 2 to be 12" and downstream to be 15". For modeling Pipe 2 is assumed to be a 12" pipe.

Snohomish County Drainage Needs Report
Q-Ratio Summary for Chase Lake Modeling Area 1

			Flow Changes within Subbasins[2]									
Pipe No.	Applicable HSPF Reach	25-year flow[3] (cfs)	Subbasin	Total Subbasin Area	Contributing Subbasin Area (ac)	Percentage	DS Reach Flow (cfs)	US Reach Flow (cfs)	Reach Flow Change (cfs)	Increment Flow Reduction (cfs)	Revised Flow (cfs)	Qratio[1]
1	510	6.57									6.57	0.447
2	500	4.54									4.54	0.000
3	500	4.54	500	5.48	5.48	100%	4.54	2.50	2.04	0.00	4.54	0.000
7	500	4.54	500	5.48	5.48	100%	4.54	2.50	2.04	0.00	4.54	0.175
8	500	4.54	500	5.48	3.66	67%	4.54	2.50	2.04	0.68	3.86	0.193
9	500	4.54	500	5.48	1.98	36%	4.54	2.50	2.04	1.30	3.24	0.000
11	500	4.54	500	5.48	1.98	36%	4.54	2.50	2.04	1.30	3.24	0.295
12	520	2.5									2.50	0.000

1. Q-Ratio: The ratio of new flows coming into a pipe over the flows already in the pipe.

Snohomish County Drainage Needs Report
Approximation of Design Flow Adjustments within HSPF Reaches (based on ratio of Area)
Chase Lake - Backwater Modeling Area 1

Pipe No.	Applicable HSPF Reach		Subbasin	Total Subbasin Area	Contributing Subbasin Area (ac)	Percentage	Existing Land Use 2-Year Return Interval	Existing Land Use 10-Year Return Interval	Existing Land Use 25-Year Return Interval	Existing Land Use 100-Year Return Interval	Future Land Use 2-Year Return Interval	Future Land Use 10-Year Return Interval	Future Land Use 25-Year Return Interval	Future Land Use 100-Year Return Interval
	R500	downstream reach	500	5.48	5.48	100%	2.15	3.70	4.54	5.86	2.30	3.89	4.74	6.05
	R520	upstream reach	520				1.21	2.05	2.50	3.22	1.21	2.05	2.50	3.22
		change in flow					0.93	1.65	2.04	2.64	1.09	1.84	2.23	2.84
7			500	5.48	5.48	100%	2.15	3.70	4.54	5.86	2.30	3.89	4.74	6.05
8			500	5.48	3.66	67%	1.84	3.15	3.86	4.98	1.94	3.28	3.99	5.11
9			500	5.48	1.98	36%	1.55	2.65	3.24	4.17	1.61	2.72	3.31	4.24
11			500	5.48	1.98	36%	1.55	2.65	3.24	4.17	1.61	2.72	3.31	4.24

Notes:

1. Flow for selected pipe no. based on a ratio of the contributing area applied to the change in flow between HSPF reaches.
2. The purpose of this spreadsheet is th estimate changes in flow along an HSPF reach for the range of flows to assess level of protection.

Snohomish County Drainage Needs Report
BW Pipe Analysis for Chase Lake Modeling Area 2
Pipe Data Summary

Pipe No.	Survey Nodes	Length (ft)	Diameter (in.)	Material	Pipe Type	Outlet IE (NGVD)	Inlet IE (NGVD)	Pipe Slope (ft/ft)	Inlet Type	Upstream Overtopping Elevation (NGVD)	Change In Angle	Structure Diameter (ft)	Comments
1	2057-2058	98	12	CP	1	400.82	411.79	-0.1119	5	413.59	0	2	
2	2056-2057	106	12	CP	1	411.58	420.04	-0.0798	5	422.04	0	2	
3	2055-2056	95	12	CP	1	419.74	421.37	-0.0172	5	423.90	34	2	
4	2054-2055	77	12	CP	1	421.28	422.46	-0.0153	5	425.38	0	2	
5	2053-2054	80	12	CP	1	422.35	424.26	-0.0239	5	428.34	0	2	
6	2255-2053	41	12	CP	1	424.26	425.50	-0.0302	5	429.41	0	2	See note 1
7B	2253-2255	66	12	CMP	2	424.26	423.9	0.0055	2	428.10	90	2	
8B	4663-2253	115	12	HDPE	1	425.9	428.76	-0.0249	5	430.91	10	2	Seen note 2
9B	9990-4663	2	12	HDPE	1	429.66	429.66	0.0000	4	430.91	0	2	See notes 2 and 3
7	2047-1997	81	12	CP	1	449.54	455.95	-0.0791	4	457.76	0	2	
8	2046-2047	89	12	CP	1	456.45	458.31	-0.0209	5	461.54	0	2	
9	2045-2046	95	12	CP	1	458.36	460.18	-0.0191	5	462.27	0	2	
10	2044-2045	85	12	CP	1	459.39	459.56	-0.0021	5	461.59	0	2	
11	2043-2044	22	12	CP	1	459.46	459.72	-0.0119	5	461.63	0	2	

Notes:

1. No Pipe In at 2053 according to survey, used information from surrounding pipes.
2. Assumed HDPE=Concrete for Pipe Type.
3. Pipe inlet was covered and could not be surveyed. A short, flat section of pipe was assumed as a conservative representation.

Snohomish County Drainage Needs Report
BW Pipe Analysis for Chase Lake Modeling Area 2
Culvert Data Summary

Culvert No.	Survey Nodes	Length (ft)	Diameter (in.)	Material	Type	Outlet IE (NGVD)	Inlet IE (NGVD)	Slope (ft/ft)	Inlet Type	Overflow El (NGVD)	Overflow Type	Weir Length (ft)	Height Above Overflow (ft)	Comments
1	4561-4562	25	12	CP	1	433.95	435.17	-0.0488	4	436.67	1	15	0.1	See note 1
2	4549-4550	38	6	CP	1	436.52	438.34	-0.0479	4	439.04	1	15	0.1	See note 2
3	2237-4540	53	12	CP	1	440.31	440.47	-0.0030	4	442.41	1	15	0.1	
4	2234-2235	40	12	CP	1	440.20	441.53	-0.0332	4	442.88	1	15	0.1	See note 3
5	2232-2233	23	12	CP	1	443.58	446.00	-0.1052	4	447.04	1	15	0.1	
6	9990-4663	2	12					0.0000		430.91	1	15	0.1	
7	4662-4661	129	8	PVC	1	432.85	434.35	-0.0117	4	435.85	1	15	0.1	See note 4

Notes:

1. In Culvert 1 no overflow elevation is provided in survey. Overflow is estimated to be 1.5 feet over inlet elevation. (to be confirmed prior to Draft Report)
2. In Culvert 2, the overflow was taken based on the lowest of the two driveway elevations provided in the survey.
3. In Culvert 4 Overflow was determined by the grate elevation at adjacent catch basin (EA1998).
4. In Culvert 7 no overflow elevation is provided in survey. Overflow is estimated to be 1.5 feet over inlet elevation. (to be confirmed prior to Draft Report)

Snohomish County Drainage Needs Report
BW Pipe Analysis for Chase Lake Modeling Area 2
Cross-Section Data Summary

Surveyed Cross-Section Data				Data Input					
				Relative to Thalweg			Channel	Stationing[1]	
Name	Station (ft)	Elevation (NGVD)	Location	Direction	Station	Elev.	No.	D/S Invert	U/S Invert
EA4566	0.000	434.01	Start	RT	14.538	1.65	1		
EA4567	11.729	433.71	Top	RT	2.809	1.35	1		
EA4568	13.982	432.66	Toe	RT	0.556	0.30	1	0+00	1+14
EA4569	14.538	432.36	Thalweg	0	0.000	0.00	1	429.41	433.95
EA4570	15.462	432.47	Toe	LT	0.924	0.11	1		
EA4571	16.927	433.60	Top	LT	2.389	1.24	1		
EA4572	27.131	435.76	Ground	LT	12.593	3.40	1		
EA4554	0.000	438.24	Start	RT	15.462	2.45	2		
EA4555	12.168	437.56	Top	RT	3.294	1.77	2		
EA4556	14.968	435.92	Toe	RT	0.494	0.13	2	1+39	1+62
EA4557	15.462	435.79	Thalweg	0	0.000	0.00	2	435.17	436.52
EA4558	16.206	435.87	Toe	LT	0.744	0.08	2		
EA4559	18.159	436.89	Top	LT	2.697	1.10	2		
EA4560	26.595	437.24	Ground	LT	11.133	1.45	2		
EA4544	0.000	441.92	Start	RT	15.735	2.02	3		
EA4545	11.573	441.58	Top	RT	4.162	1.68	3	2+00	2+54
EA4546	15.735	439.90	Thalweg	0	0.000	0.00	3	438.34	440.31
EA4547	18.403	441.88	Top	LT	2.668	1.98	3		
EA4548	34.860	441.52	Ground	LT	19.125	1.62	3		
		Assumed		RT	2.210	2.21	4	5+07	5+10
Drvwy El	442.410	2.21		0	0.000	0.00	4	440.47	440.2
halweg E	440.200			LT	2.210	2.21	4		

Notes:

1. Channel inverts at Downstream and Upstream ends based on culvert/pipe inverts.

Snohomish County Drainage Needs Report
BW Pipe Analysis for Chase Lake Modeling Area 2
Cross-Section Data Summary

Surveyed Cross-Section Data				Data Input					
				Relative to Thalweg			Channel	Stationing[1]	
Name	Station (ft)	Elevation (NGVD)	Location	Direction	Station	Elev.	No.	D/S Invert	U/S Invert
		Assumed		RT	3.460	3.46	5	5+50	6+22
Drvwy El	447.040	3.46		0	0.000	0.00	5	441.53	443.58
Thalweg E	443.580			LT	3.460	3.46	5		
		Assumed		RT	1.040	1.04	6	6+45	7+13
Drvwy El	447.040	1.04		0	0.000	0.00	6	446	449.54
Thalweg E	446.000			LT	1.040	1.04	6		
EA2300	0.000	434.71	Start	RT	9.303	2.04	7		
EA2301	3.453	434.28	Top	RT	5.850	1.61	7		
EA2302	8.233	432.72	Toe	RT	1.070	0.05	7	0+00	
EA2303	9.303	432.67	Thalweg	0	0.000	0.00	7	432.71	
EA2304	10.125	432.63	Toe	LT	0.822	0.00	7		
EA2305	14.349	434.61	Top	LT	5.046	1.94	7		
EA2306	17.986	434.66	Ground	LT	8.683	1.99	7		
EA2307	0.000	433.97	Start	RT	5.744	1.37	7		
EA2308	2.733	433.52	Top	RT	3.011	0.92	7		
EA2309	3.564	432.79	Toe	RT	2.180	0.19	7	1+33	
EA2310	5.744	432.60	Thalweg	0	0.000	0.00	7	432.48	
EA2311	7.680	432.56	Toe	LT	1.936	0.00	7		
EA2312	9.619	433.23	Top	LT	3.875	0.63	7		
EA2313	12.099	433.38	Ground	LT	6.355	0.78	7		

Notes:

1. Channel inverts at Downstream and Upstream ends based on culvert/pipe inverts.

Snohomish County Drainage Needs Report
Q-Ratio Summary for Chase Lake Modeling Area 2

			Flow Changes within Subbasins[2]									
Pipe No.	Applicable HSPF Reach	25-year flow[3] (cfs)	Subbasin	Total Subbasin Area	Contributing Subbasin Area (ac)	Percentage	DS Reach Flow (cfs)	US Reach Flow (cfs)	Reach flow Change (cfs)	Increment flow reduction (cfs)	Revised Flow	Qratio[1]
Leg A												
P1	509	12.40									12.40	0.000
P2	509	12.40									12.40	0.000
P3	509	12.40									12.40	0.000
P4	509	12.40									12.40	0.000
P5	509	12.40									12.40	0.000
P6	509	12.40									12.40	2.523 [4]
CH3	600	3.52									3.52	0.192
CH4	600	3.52	600	6.27	4.23	67%	3.52	1.78	1.74	0.57	2.95	0.000
CH5	600	3.52	600	6.27	4.23	67%	3.52	1.78	1.74	0.57	2.95	0.000
CH6	600	3.52	600	6.27	4.23	67%	3.52	1.78	1.74	0.57	2.95	0.000
P7	600	3.52	600	6.27	4.23	67%	3.52	1.78	1.74	0.57	2.95	0.000
P8	600	3.52	600	6.27	4.23	67%	3.52	1.78	1.74	0.57	2.95	0.265
P9	600	3.52	600	6.27	2.00	32%	3.52	1.78	1.74	1.19	2.33	0.000
P10	600	3.52	600	6.27	2.00	32%	3.52	1.78	1.74	1.19	2.33	0.297
P11	610	1.78									1.80	

Notes:

1. Q-Ratio: The ratio of new flows coming into a pipe over the flows already in the pipe.
2. This potion of spreadsheet is used to estimate change in flow within a subbasin and is based on a ratio of contributing area.
3. Existing Land Use Conditions.
4. Q-Ratio was applied to the channel immediately upstream of Pipe 6.

Snohomish County Drainage Needs Report
Q-Ratio Summary for Chase Lake Modeling Area 2

Pipe No.	Applicable HSPF Reach	25-year flow[3] (cfs)	Flow Changes within Subbasins[2] Subbasin	Total Subbasin Area	Contributing Subbasin Area (ac)	Percentage	DS Reach Flow (cfs)	US Reach Flow (cfs)	Reach flow Change (cfs)	Increment flow reduction (cfs)	Revised Flow	Qratio[1]
Leg B												
P1	509	12.40									12.40	0.000
P2	509	12.40									12.40	0.000
P3	509	12.40									12.40	0.000
P4	509	12.40									12.40	0.000
P5	509	12.40									12.40	0.000
P6	509	12.40									12.40	0.225
P7B	700/710	10.12	700/710	15.15	15.15	100%	12.40	5.28	7.12	0.00	10.12	0.917
P8B	720	5.28									5.28	0.000
P9B	720	5.28									5.28	0.000
CH7	720	5.28									5.28	0.000
CUL7	720	5.28									5.28	0

Notes:

1. Q-Ratio: The ratio of new flows coming into a pipe over the flows already in the pipe.
2. This potion of spreadsheet is used to estimate change in flow within a subbasin and is based on a ratio of contributing area.
3. Existing Land Use Conditions.
4. Q-Ratio was applied to the channel immediately upstream of Pipe 6.

Snohomish County Drainage Needs Report
Approximation of Design Flow Adjustments within HSPF Reaches (based on ratio of Area)
Chase Lake - Backwater Modeling Area 2

Pipe No.	Applicable HSPF Reach		Subbasin	Total Subbasin Area	Contributing Subbasin Area (ac)	Percentage	Existing Land Use 2-Year Return Interval	Existing Land Use 10-Year Return Interval	Existing Land Use 25-Year Return Interval	Existing Land Use 100-Year Return Interval	Future Land Use 2-Year Return Interval	Future Land Use 10-Year Return Interval	Future Land Use 25-Year Return Interval	Future Land Use 100-Year Return Interval
	R600	downstream reach	600	6.27	5.48	87%	1.73	2.90	3.52	4.49	1.82	2.93	3.52	4.42
	R610	upstream reach	610				0.91	1.48	1.78	2.24	0.95	1.51	1.81	2.26
		change in flow					0.82	1.42	1.74	2.25	0.87	1.42	1.71	2.16
CH3			600	6.27	6.27	100%	1.73	2.90	3.52	4.49	1.82	2.93	3.52	4.42
CH4			600	6.27	4.23	67%	1.46	2.43	2.95	3.76	1.53	2.47	2.96	3.71
CH5			600	6.27	4.23	67%	1.46	2.43	2.95	3.76	1.53	2.47	2.96	3.71
CH6			600	6.27	4.23	67%	1.46	2.43	2.95	3.76	1.53	2.47	2.96	3.71
P7			600	6.27	4.23	67%	1.46	2.43	2.95	3.76	1.53	2.47	2.96	3.71
P8			600	6.27	4.23	67%	1.46	2.43	2.95	3.76	1.53	2.47	2.96	3.71
P9			600	6.27	2.00	32%	1.17	1.93	2.33	2.96	1.22	1.97	2.35	2.95
P10			600	6.27	2.00	32%	1.17	1.93	2.33	2.96	1.22	1.97	2.35	2.95

Notes:

1. Flow for selected pipe no. based on a ratio of the contributing area applied to the change in flow between HSPF reaches.
2. The purpose of this spreadsheet is th estimate changes in flow along an HSPF reach for the range of flows to assess level of protection.