EXHIBIT D. SUPPLEMENTAL HYDRAULIC SEWER MODEL ANALYSIS

## EXHIBIT D

# TECHNICAL MEMORANDUM SUPPLEMENTAL HYDRAULIC SEWER MODEL CAPACITY ANALYSIS

This Technical Memorandum describes the supplemental hydraulic modeling analysis performed for the Comprehensive Sewer Plan 2020 Update. For background and details on hydraulic modeling software, model network construction and operation, model sewer loading (flows), and previous capacity analysis performed refer to Exhibit D of the Comprehensive Sewer Plan 2014 Update.

## 1. CAPACITY ANALYSIS

An additional scenario was created in the <u>South Shore</u> model to assess the capacity of the Lake Whatcom Boulevard Interceptor (LWBI) under future projected build out sewer flow conditions without the flows from North Point sub-basin and pump station. North Point flows were excluded from flows to LWBI to simulate redirecting the pump station force main discharge to the Sudden Valley Pump Station. The Sudden Valley Pump Station discharges to the Lake Louise Road Interceptor (LLRI) at all times (formerly only during the wet season).

Model simulations indicate improved conditions with the removal of the North Point flows. There is no flooding in any manholes. The minimum free-board is approximately 2.6-ft in manhole GT-25, which is surcharged (above the crown of the outlet pipe) by 0.6-ft. However, there are still three pipes that do not have adequate capacity (q/Q > 1):

Pipe ID	Diameter	Length	Slope	Total Flow, q	Full Flow, Q	q/Q
	(in)	(ft)	(%)	(gpm)	(gpm)	
12-11	14	374	0.019	771	331	2.33
17-16	14	292	0.038	690	469	1.47
25-24	10	402	0.197	550	437	1.26

There are also three pipes that are approaching capacity (q/Q > 0.85):

Pipe ID Diameter		Length	Slope	Total Flow, q	Full Flow, Q	q/Q
	(in)	(ft)	(%)	(gpm)	(gpm)	
13-12	14	410	0.134	771	886	0.87
16-15	14	321	0.084	690	701	0.98
24-23	14	438	0.064	569	612	0.93

The pipes identified above as over or near capacity are identified in the attached Figure D-1. Modeling output reports (manhole, gravity pipes) are attached as Attachment D-2.

It should be noted that the model simulations were performed using the same flow assumptions as for the Plan 2014 Update. The average daily flow used is 100 gallons per capita day (gpcd). Recent and on-going data analysis indicates that the average daily flow may be less. Lower sewer flows are supported by successful implementation of infiltration and inflow (I&I) reduction and water conservation programs.

The capacity of LWBI should be monitored as development occurs. Also, it is recommended that the average daily sewer flows and build out capacity used in the model be re-evaluated and that the modeling analysis be updated during the next Comprehensive Sewer Plan update, or prior to any significant development that may occur.

### Exhibit D - Attachments

- Figure D-1: South Shore Model, Pipes Over-Capacity and Near-Capacity
- Attachment D-2 South Shore modeling output reports (manholes, gravity pipes)



### Future/Build Out, SV & NP to LLRI

# Manhole Report

		ID	Rim Elevation (ft)	Base Flow (cfs)	Total Flow (cfs)	Storm Flow (cfs)	Grade (ft)	Status	Hydraulic Jump	Unfilled Depth (ft)	Surcharge Depth (ft)
1		3	319.000	0.000	0.000	0.000	309.876	Not Full	No	9.124	1.876
2		7	319.000	0.617	0.630	0.000	310.424	Not Full	No	8.576	1.878
3		AIRJC	1,388.000	0.573	0.584	0.000	419.477	Not Full	No	968.523	37.144
4		BOUJC	1,326.000	0.069	0.070	0.000	382.835	Not Full	No	943.165	60.002
5		GT-11	318.770	0.000	0.000	0.000	310.760	Not Full	No	8.010	0.924
6		GT-12	320.020	0.000	0.000	0.000	311.173	Not Full	No	8.847	1.266
7		GT-13	319.700	0.178	0.182	0.000	311.622	Not Full	No	8.078	1.165
8		GT-14	320.100	0.000	0.000	0.000	311.896	Not Full	No	8.204	1.009
9		GT-15	319.890	0.000	0.000	0.000	312.139	Not Full	No	7.751	0.912
10		GT-16	319.600	0.000	0.000	0.000	312.425	Not Full	No	7.175	0.929
11		GT-17	319.380	0.225	0.230	0.000	312.688	Not Full	No	6.692	1.082
12		GT-18	319.630	0.000	0.000	0.000	312.822	Not Full	No	6.808	0.335
13	$\Box$	GT-19	319.980	0.000	0.000	0.000	313.066	Not Full	No	6.914	0.209
14		GT-20	320.040	0.000	0.000	0.000	313.304	Not Full	No	6.736	-0.163
15		GT-21	319.140	0.038	0.039	0.000	313.831	Not Full	No	5.309	-0.526
16		GT-23	319.200	0.000	0.000	0.000	314.875	Not Full	No	4.325	-0.501
17		GT-24	319.800	0.042	0.043	0.000	315.397	Not Full	No	4.403	-0.259
18		GT-25	319.390	0.000	0.000	0.000	316.711	Not Full	No	2.679	0.598
19		GT-26	321.400	0.000	0.000	0.000	317.989	Not Full	No	3.411	-0.234
20		GT-27	324.460	0.000	0.000	0.000	320.146	Not Full	No	4.314	-0.278
21		GT-28	329.160	0.022	0.023	0.000	322.678	Not Full	No	6.482	-0.266
22		GT-29STP	329.780	0.082	0.084	0.000	325.743	Not Full	Yes	4.037	-0.271
23		GT-30	334.390	0.000	0.000	0.000	329.632	Not Full	No	4.758	-0.372
24		GT-31	361.520	0.000	0.000	0.000	357.397	Not Full	No	4.123	-0.537
25		GT-32	381.730	0.038	0.039	0.000	376.913	Not Full	No	4.817	-0.510
26		GT-34PLUM	1,422.500	0.417	0.425	0.000	416.763	Not Full	No	1,005.737	0.000
27		NORJC	1,386.980	0.000	0.000	0.000	387.928	Not Full	No	999.052	10.905
28		SUDLMH	368.000	0.000	0.000	0.000	358.040	Not Full	No	9.960	2.077

### Gravity Pipe Report - Build Out, SV & NP to LLRI

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	ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpm)	Unpeakable Flow (gpm)	Peakable Flow (gpm)	Coverage Flow (gpm)
1	11-SPCAB	GT-11	7	14.000	299.120	0.004	771.120	771.120	0.000	0.000
2	12-11	GT-12	GT-11	14.000	374.280	0.000	771.120	771.120	0.000	0.000
3	13-12	GT-13	GT-12	14.000	409.600	0.001	771.120	771.120	0.000	0.000
4	14-13	GT-14	GT-13	14.000	305.940	0.001	689.520	689.520	0.000	0.000
5	15-14	GT-15	GT-14	14.000	267.680	0.001	689.520	689.520	0.000	0.000
6	16-15	GT-16	GT-15	14.000	321.460	0.001	689.520	689.520	0.000	0.000
7	17-16	GT-17	GT-16	14.000	292.200	0.000	689.520	689.520	0.000	0.000
8	18-17	GT-18	GT-17	14.000	195.760	0.004	586.500	586.500	0.000	0.000
9	19-18	GT-19	GT-18	14.000	384.240	0.001	586.500	586.500	0.000	0.000
10	20-19	GT-20	GT-19	14.000	372.650	0.002	586.500	586.500	0.000	0.000
11	21-20	GT-21	GT-20	14.000	472.110	0.002	586.500	586.500	0.000	0.000
12	23-21	GT-23	GT-21	14.000	654.890	0.002	569.160	569.160	0.000	0.000
13	24-23	GT-24	GT-23	14.000	437.990	0.001	569.160	569.160	0.000	0.000
14	25-24	GT-25	GT-24	10.000	401.940	0.002	549.780	549.780	0.000	0.000
15	26-25	GT-26	GT-25	10.000	385.400	0.005	549.780	549.780	0.000	0.000
16	27-26	GT-27	GT-26	10.000	313.420	0.007	549.780	549.780	0.000	0.000
17	28-27	GT-28	GT-27	10.000	385.850	0.007	549.780	549.780	0.000	0.000
18	29-28	GT-29STP	GT-28	10.000	479.630	0.006	539.580	539.580	0.000	0.000
19	30-29	GT-30	GT-29STP	10.000	372.870	0.011	501.840	501.840	0.000	0.000
20	31-30	GT-31	GT-30	10.000	398.770	0.070	501.840	501.840	0.000	0.000
21	32-31	GT-32	GT-31	10.000	412.100	0.047	501.840	501.840	0.000	0.000
22	501	3	5	12.000	20.000	0.100	1,053.660	1,053.660	0.000	0.000
23	503	7	SPCAB	14.000	20.000	0.019	1,053.660	1,053.660	0.000	0.000
24	SUDLGP	SUDLMH	SPSUD	10.000	100.000	0.005	0.000	0.000	0.000	0.000

### Gravity Pipe Report - Build Out, SV & NP to LLRI

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	ID	Infiltration Flow (gpm)	Storm Flow (gpm)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpm)
1	11-SPCAB	0.000	0.000	Pressurized	3.286	0.491	0.486	0.573	0.531	0.865	1,588.257
2	12-11	0.000	0.000	Pressurized	1.607	1.000	2.331	1.167	0.342	0.262	330.750
3	13-12	0.000	0.000	Pressurized	2.081	0.721	0.870	0.842	0.531	0.413	886.237
4	14-13	0.000	0.000	Pressurized	2.079	0.652	0.760	0.761	0.501	0.449	906.702
5	15-14	0.000	0.000	Pressurized	1.996	0.677	0.800	0.789	0.501	0.419	861.946
6	16-15	0.000	0.000	Pressurized	1.665	0.805	0.984	0.940	0.501	0.294	700.918
7	17-16	0.000	0.000	Pressurized	1.437	1.000	1.469	1.167	0.410	0.234	469.251
8	18-17	0.000	0.000	Pressurized	3.108	0.416	0.362	0.485	0.461	0.906	1,621.541
9	19-18	0.000	0.000	Pressurized	1.730	0.665	0.781	0.776	0.461	0.368	750.496
10	20-19	0.000	0.000	Free Surface	2.131	0.558	0.599	0.651	0.461	0.516	978.505
11	21-20	0.000	0.000	Free Surface	2.249	0.534	0.559	0.623	0.461	0.561	1,050.079
12	23-21	0.000	0.000	Free Surface	2.076	0.556	0.596	0.649	0.454	0.504	954.475
13	24-23	0.000	0.000	Free Surface	1.448	0.764	0.931	0.891	0.454	0.271	611.499
14	25-24	0.000	0.000	Pressurized	2.246	1.000	1.258	0.833	0.438	0.434	437.121
15	26-25	0.000	0.000	Free Surface	3.274	0.648	0.754	0.540	0.494	0.841	729.549
16	27-26	0.000	0.000	Free Surface	3.611	0.596	0.666	0.497	0.494	0.988	826.070
17	28-27	0.000	0.000	Free Surface	3.511	0.611	0.690	0.509	0.494	0.944	796.820
18	29-28	0.000	0.000	Free Surface	3.469	0.607	0.684	0.506	0.489	0.937	788.833
19	30-29	0.000	0.000	Free Surface	4.150	0.495	0.492	0.413	0.471	1.286	1,019.945
20	31-30	0.000	0.000	Free Surface	8.231	0.297	0.192	0.248	0.471	3.435	2,609.415
21	32-31	0.000	0.000	Free Surface	7.148	0.329	0.234	0.274	0.471	2.819	2,144.241
22	501	0.000	0.000	Free Surface	11.353	0.309	0.208	0.309	0.656	4.230	5,070.159
23	503	0.000	0.000	Pressurized	6.160	0.386	0.316	0.451	0.626	1.874	3,333.691
24	SUDLGP	0.000	0.000	Pressurized	0.000	0.000		0.000	0.000	0.000	717.806

	ID	Coverage Count	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
1	11-SPCAB	0.000	Yes	1.167	1.607
2	12-11	0.000	Yes	1.167	1.607
3	13-12	0.000	Yes	1.167	1.607
4	14-13	0.000	Yes	1.167	1.437
5	15-14	0.000	Yes	1.167	1.437
6	16-15	0.000	Yes	1.167	1.437
7	17-16	0.000	Yes	1.167	1.437
8	18-17	0.000	Yes	1.167	1.222
9	19-18	0.000	Yes	1.167	1.222
10	20-19	0.000	Yes	1.167	1.222
11	21-20	0.000	Yes	0.822	1.623
12	23-21	0.000	No	0.649	2.076
13	24-23	0.000	No	0.891	1.448
14	25-24	0.000	Yes	0.833	2.246
15	26-25	0.000	Yes	0.833	2.246
16	27-26	0.000	Yes	0.577	3.038
17	28-27	0.000	Yes	0.562	3.132
18	29-28	0.000	Yes	0.565	3.053
19	30-29	0.000	Yes	0.512	3.180
20	31-30	0.000	Yes	0.379	4.629
21	32-31	0.000	Yes	0.310	6.051
22	501	0.000	No	0.309	11.353
23	503	0.000	Yes	1.167	2.196
24	SUDLGP	0.000	Yes	0.833	0.000