APPENDIX B. SUPPORTING INFORMATION USED IN THE STATE OF THE SYSTEM EVALUATION

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Appendix B-1. Bellevue Stormwater Basin Fact Sheets

Appendix B-2. Impervious Area and Tree Canopy Cover for Drainage Basins and their Stream Buffers in Bellevue, 2007.

Basin	% Impervious	% Tree Canopy	% Impervious in 100-foot Stream Buffers	% Tree Canopy in 100-foot Stream Buffers
Ardmore Area	43	30	8	83
Beaux Arts Area	34	53	*	*
Clyde Beach Area	47	31	*	*
Coal Creek Basin	20	58	8	85
East Creek Basin	48	35	29	65
Goff Creek Basin	30	59	35	55
Kelsey Creek Basin	40	33	17	55
Lakehurst Area	33	37	21	62
Lewis Creek Basin	29	49	17	69
Mercer Slough Basin	32	43	7	53
Meydenbauer Creek Basin	59	24	36	44
Newport Area	39	30	7	91
North Sammamish Area	32	46	9	86
Phantom Creek Basin	35	33	17	64
Richards Creek Basin	45	36	22	62
Rosemont Area	38	31	6	55
Sears Creek Basin	63	21	52	44
South Sammamish Area	31	48	16	75
Spirit Ridge Area	40	34	24	86
Sturtevant Creek Basin	71	18	62	23
Sunset Creek Basin	42	35	28	60
Valley Creek Basin	34	42	20	56
Vasa Creek Basin	40	40	17	73
West Tributary Basin	46	34	28	49
Wilkins Creek Basin	41	29	16	77
Yarrow Creek Basin	31	53	27	58
City-wide	46	36.2	Not available	Not available

***No streams in this basin.**

Appendix B-3. Basin Evaluation by Available Evaluation Criteria.

	Flood Protection					Water Quality				Aquatic Habitat			Presence or Absence of Key Basin Issues		
Basin	Primary Street Closures per 100-year, 24-hour Storm	Secondary Street Closures per 100-year, 24-hour Storm	Flooded Structures (2000-2009) Note: >4 years less than claims	Flooding Claims (10/1/96-2/28/11)	Area Built prior to Stormwater Control Standards (%)	Total Impervious Area (%)	Phosphorus-sensitive Lake	Impaired Water Body (Ecology 303(d) list 2008)	Water Quality Risk Level (IDDE)	LWD Pieces per Channel Width	Pool Frequency and Quality (deep and cool with cover)	B-IBI Score (most recent)	Flood Protection	Water Quality	Aquatic Habitat
Salmon Spawning Stream Basins															
Coal Creek	0	1	7	6	8	20	No	Yes	Low	Fair	ND	17.6	√	√	√
East Creek	0	0*	2	0	38	48	No	No	High	Poor	Poor	ND		√	√
Goff Creek	0	0	3	0	29	30	No	No	High	ND	ND	6.4		√	√
Kelsey Creek	2	1	14	7	44	40	No	Yes	High	Poor	Poor	8.5	√	√	√
Mercer Slough	0	0	6	4	23	32	No	Yes	Medium	ND	ND	ND	√	√	
Newport Area	0	0	4	0	52	39	No	No	Low	ND	ND	10.2	√	√	√
Richards Creek	1*	0	7	4	27	45	No	No	High	Poor	Poor	15.3	√	√	√
Valley Creek	0	0	4	1	21	34	No	No	High	Poor	Poor	6.4	√	√	√
Vasa Creek	0	0	8	2	32	40	Yes	No	Medium	ND	ND	42.6	√	√	√
West Tributary	0	0	5	2	35	46	No	No	High	ND	ND	17.7	√	√	√
Small and Steep Stream Basins															
Ardmore	0	0	9	1	49	43	Yes	Yes	Low	ND	ND	ND		√	√
Lakehurst	0	0	3	3	16	33	No	No	Low	ND	ND	9.4	√		√
Lewis Creek	1	0	6	1	2	29	Yes	Yes	Medium	ND	ND	39.5	√	√	√
North Sammamish	0	0	8	4	45	29	Yes	No	Low	NA	NA	NA	√		
Phantom Creek	0	0	3	1	34	32	Yes	No	Low	ND	ND	20.5	√		√
Sunset Creek	0	1	7	0	40	35	No	No	High	Poor	Poor	0	√	√	√
South Sammamish	0	0	4	0	17	31	Yes	No	Low	ND	ND	ND			
Wilkins Creek	0	0	4	2	59	41	Yes	No	Low	ND	ND	13	√		√
Yarrow Creek	0	0	10	2	14	31	No	Yes	High	ND	ND	35.6	√	√	√
Closed Conveyance System Basins (>96% piped storm drainage system)															
Beaux Arts Area	0	1	3	0	38	34	No	No	NA	NA	NA	NA	√		
Clyde Beach	0	0	8	1	31	47	No	No	NA	NA	NA	NA	√		
Meydenbauer Creek	0	0	6	7	36	59	No	Yes (Bay)	Medium	ND	ND	ND	√	√	
Redmond 400	NA	NA	5	NA	46	NA	NA	NA	NA	NA	NA	NA			
Rosemont Area	1	0	3	6	40	38	Yes	No	NA	NA	NA	NA	√		
Sears Creek	0	0	3	0	17	63	No	No	High	ND	ND	ND		√	
Spirit Ridge	0	0	4	3	51	40	Yes	No	NA	NA	NA	NA	√	√	
Sturtevant Creek	0	0	3	2	21	71	Yes	No	High	ND	ND	ND	√	√	

Note: See Appendices B-1, B-2, and B-4 through B-14 for additional details and supporting information of the evaluation data.

Appendix B-4. Information used to Evaluate Basins, and for the Evaluation Metrics and Results

Road Closures Due to Storms

Road closures during the five storm events reported below are due to flooding unless otherwise indicated. Other storm-related causes of road closures include landslides and sink holes. The amount of rainfall reported below is the total amount of rain for the duration of the storm event, and the frequency applies to the maximum amount of rain that fell during a consecutive 24-hour period during the storm event. For purposes of evaluating the basins, the range in the number of road closures during an individual storm event are reported by road type, only for primary and secondary roads. Arterial/collector streets and neighborhood streets are included here because they may be addressed after the highest priority recurring road closures are fixed. The following recurring road closures reported for the 2001 and 2003 storm events have been resolved by flood control projects through the Capital Investment Program, and have not been closed during any storms that have occurred since the project was built:

- Kamber Road at East Creek (2004—culvert replacement)
- SE 30th Street at East Creek (2010 to 2011—culvert replacement)

A project to reduce flooding at Factoria Boulevard was constructed in 2003, but this road flooded in a large storm in 2006. It is possible that regular maintenance since that time has prevented flooding in subsequent large storms. A project to evaluate flooding and capacity issues and determine steps to resolve the flooding at 156th Avenue SE at SE 11th Street is in progress as of 2011.

Storm Event			Road Closures (Drainage Basin)			
Date(s)	**Rainfall (inches)**	**Storm Frequency**	**Primary***	**Secondary***	**Arterial/Collector Streets***	**Neighborhood Streets***
Nov. 14-15, 2001	3.5	>10-year, 24-hour	1) West Lake Sammamish Parkway (Rosemont) 2) Factoria Blvd. (Richards) 3) 148th Avenue SE at Larsen Lake (Kelsey)	1) Kamber Road at East Creek (Sunset) 2) 156th Avenue at SE 11th St. (Kelsey)	none	1) NE 21st St. at 140th Avenue NE (Sears) 2) SE 7th Place near Lake Hills Connector (Kelsey) 3) SE 30th at Sunset Creek (Sunset)
Oct. 20-21, 2003	5.1	>100-year, 24-hour	1) Bel-Red Road at 140th Avenue NE (Kelsey) 2) Factoria Blvd. (Richards) 3) 148th Avenue SE at Larsen Lake (Kelsey)	1) Kamber Road at East Creek (Sunset)	none	1) SE 7th Place near Lake Hills Connector (Kelsey)

Storm Event			Road Closures (Drainage Basin)			
Date(s)	**Rainfall (inches)**	**Storm Frequency**	**Primary***	**Secondary***	**Arterial/Collector Streets***	**Neighborhood Streets***
Nov. 5-7, 2006	3.2	<10-year, 24-hour	1) West Lake Sammamish Parkway (Rosemont) 2) Factoria Blvd. (Richards)	none	none	1) NE 21st St. at 140th Avenue NE (Sears) 2) SE 7th Place near Lake Hills Connector (Kelsey) 3) SE 30th at Sunset Creek (Sunset)
Dec. 2-4, 2007	6.1	>100-year, 24-hour	1) Newport Way near Lakemont Blvd. - sinkhole (Lewis) 2) 148th Avenue SE at Larsen Lake (Kelsey)	1) 97th Place SE between SE 11th and SE 15th St. - landslide (Beaux Arts)	none	1) NE 21st St. at 140th Avenue NE (Sears) 2) SE 7th Place near Lake Hills Connector (Kelsey)
Dec. 11-12, 2010	4.6	>100-year, 24-hour	1) West Lake Sammamish Parkway-landslide (Rosemont) 2) 148th Avenue SE at Larsen Lake (Kelsey)	1) 97th Place SE between SE 11th and SE 15th St. - landslide (Beaux Arts) 2) Lakemont/Newcastle Road-landslide (Coal)	none	1) NE 21st St. at 140th Ave NE (Sears) 2) SE 7th Place near Lake Hills Connector (Kelsey)

***Primary and secondary roads are priority routes during emergencies, and are priority areas for preventing closures due to storms where it is not cost-prohibitive. Arterial/collector streets and neighborhood streets are lower priorities for preventing closures during storms.**

Appendix B-5. Count of Flooded Structures from Historic Work Order Database.

Includes flood records from 1/1/2000 to 12/31/2014 that were not coded as having a private cause/remedy. These report numbers may include multiple calls for the same incident, maintenance issues (e.g., leaves blocking catch basins), and other issues involving the public storm system. All reports are investigated and actions taken for public safety and protection of property.

Any areas where recurring maintenance issues occur become part of the Routine Flood Prevention Maintenance Inspection List. Flooding incidents that may require infrastructure changes are reviewed as part of the Capital Investment Program. In rare cases, affected properties may be acquired.

Basin	Number of Flooded Structures	Flooded Structure Evaluation*	Paid Claims (*=Yes)	Additional Actions in Basin
Ardmore	9	Many	*	
Beaux Arts	3	Moderate		
Clyde Beach	8	Many	*	
Coal Creek	7	Many	*	Maintenance surveillance; Capital Investment Program (CIP) flood control projects
East Creek	2	Few		CIP flood control projects
Goff Creek	3	Moderate		
Kelsey Creek	14	Many	*	Maintenance surveillance; CIP flood control projects; acquisition
Lakehurst	3	Moderate	*	Maintenance surveillance
Lewis Creek	6	Many	*	Maintenance surveillance; acquisition
Mercer Slough	6	Many	*	
Meydenbauer Creek	6	Many	*	Maintenance surveillance
Newport	4	Moderate		Maintenance surveillance
North Sammamish	8	Many	*	Maintenance surveillance
Redmond 400	5	Many	NA	
Richards Creek	7	Many	*	
Rosemont	3	Moderate	*	Maintenance surveillance
Sears Creek	3	Moderate		
South Sammamish	4	Moderate		
Spirit Ridge	4	Moderate	*	Maintenance surveillance
Sturtevant Creek	3	Moderate	*	Maintenance surveillance
Sunset Creek	7	Many		Maintenance surveillance; CIP flood control projects
Valley Creek	4	Moderate	*	
Vasa Creek	8	Many	*	
West Tributary	5	Many	*	
Wilkins Creek	4	Moderate	*	
Yarrow Creek	10	Many	*	Maintenance surveillance; CIP flood control projects
Total	155			

***Few (0-2); Moderate (3-4); Many (≥5); NA = Not available**

Appendix B-6. Volume of Storage and other Characteristics of Bellevue's Public Regional Detention Ponds (updated 2009).

Regional Pond	Volume at Overflow (ac-ft)	Tributary Area (ac)	Tributary EIA (ac)	Total Volume/Acre Tributary EIA [1] (ft)	Stage at Overflow (ft, NGVD)	Q at Overflow (cfs)	Overflow Return Period (yrs)	Notes
Kelsey Creek Pond [2] (133)	32.0	1594	476	0.18	247.9	110.0	20.0	Larsen Lake is upstream
Larsen Lake Pond[2] (149)	54.0	833	207	0.26	253.4	23.0	1.5	
Lower West Tributary Pond[2] (164S)	8.0	1423	517	0.07	109.2	85.0	5.0	Goff Creek and Upper West Tributary ponds are upstream
Goff Creek Pond[2] (164N)	8.0	1268	427	0.07	113.4	53.0	2.0	Upper West Tributary pond is upstream
Upper West Tributary Pond[2] (165)	22.0	463	238	0.09	131.2	39.0	10.0	
Valley Creek Pond[2] (197)	15.0	1298	288	0.05	198.5	37.0	5.0	
Overlake Pond[2] (179N)	12.0	514	312	0.05	246.6	55.0	25.0	Commissioners Pond upstream
Commissioners Pond[2] (179S)	2.7	269	116	0.02	282.4	37.0	5.0	
Total Kelsey Basin[2]	153.7	6470	2040	0.08				
Lakemont (Lewis Creek Basin)[3]	31.6	252.4	85.1	0.37	634.6[4]			
I-405 Pond (Coal Creek Basin)[5]	19.5	4550			72.5	585		
Coal Creek Parkway (Coal Creek Basin)[6, 7]	2.0				8.0			

[1] Volume includes all upstream regional pond storage. EIA = Effective Impervious Area, or impervious area that drains directly to the storm drain system and streams.

[2] From Northwest Hydraulic Consultants. 2002. Hydrologic Study of Kelsey Creek Basin, Bellevue, WA.

[3] From City of Bellevue. 2002. Lakemont Stormwater Filtration Facility, Operations and Maintenance Manual, Volume 1: Procedures Manual.

[4] Emergency spillway overflow elevation.

[5] From Jensen, Bruce. 2004. I-405 Rating Curve Development, Entranco, Inc., Bellevue, WA.

[6] From Tetra Tech/KCM. 2006. Coal Creek Stabilization Program Final Environmental Impact Statement, Volume 2: Technical Appendices.

[7] Data added in 2015 plan update.

Appendix B-7. B-IBI Scores at Bellevue Sites in all Sampled Years.

Note: Replicate scores are given, as well as mean B-IBI site scores. To obtain B-IBI site scores, metric values were individually averaged and scored; scores of averaged metric values were summed. Bold B-IBI scores indicate samples collected by King County; others were collected by Bellevue staff.

Stream	River Mile	Site code	Location	1998	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Lewis	2.1	Lewis Above Lakemont	Lewis above lakemont facility spillway														56.4	
Lewis	1.8	LewisUS/ravine	Lewis upstream of I90	37.9	18.7	42.5	60		59.7		38.7				61.1			
Lewis	0.8	LewisI90	Lewis on Lakemont Blvd. at I-90				43.5		47.4	36.9	35.7			13.2		38.1		39.5
Lewis	0.3	LewisElliot	Lewis downstream of I90						43.7	37.5	22.4				26.7			
Vasa		08LAK2827	Vasa between W Lk Samm Pkway & Lake Samm			24			22.3	23.2	24	10	39.2	21.1	23.6	27.2	23	22.4
Vasa	0.38	VasaTribble	Vasa at Gary Tribble's 16455 SE 35TH ST Bellevue 98008												31.1			
Vasa	1.9	UpperVasa	Vasa in Horizon Heights Open Space, upstream of SE 45th St													33.1		
Idylwood		08LAK3121	Idylwood in Redmond, near 175th & NE 34th St															
Phantom	0.2	PhanWeowna	Lower Phantom, just upstream of W Lk Samm in Weowna Park											30.3	20.5			
Wilkins	0.33	WilkUpstr	Upstream of Bypass, at NE 8th & Northup Wy.											13				
Wilkins	0.26	WilkBypass	In bypass reach, near NE 8th & Northup Wy.											10.9				
Coal	4	Cindermines	Coal off Newcastle Road at cinder mine detention site	58.8	31.5	35.9			62.9	52.6	42.6					41		
Coal	2.3	Trailhead	Coal above Coal Parkway	45.5	26.4	27.7			34.4	38.6	31.4					23		
Coal	1.8	CoalPkwy	Coal below Coal Parkway	31.1	17.1	20.4										28.5		
Trib 0273		08EAS2540	Trib 0273, u/s Forest Dr. SE, trib to Coal Cr			25.9					24.4	17.7	21.5	19.6	35.3	15.8	25.1	28.4
Coal	1.3	Anna's Pond	Coal Creek - channel around Anna's Pond														17.6	
Goff	0.1	GoffMouth	Just upstream of confluence w/ West Trib											6.4				
Goff	1.7	GoffUsBp	Goff upstream of bypass	7.5	6.4	9.4												
Goff	1.6	GoffInBp	Goff in bypass area	3.9	13.4	9.6												

Goff	1.4	GoffDsBp	Goff downstream of bypass	19.2	11.9	13.7												
Valley	0.2	Valley	Valley at Highland Park						5.6	6.4								
Kelsey	3.9	Church	Kelsey at Bellevue Christian Church						10	9.3								
Kelsey	3.66-3.81	Peltzer/KelByrne	Kelsey upstream of GCC (1400 block 143rd. Place NE)	15.6	10.5	1.4												
Kelsey	3.6	WAM06600-038087	Kelsey downstream of Peltzer										3	13.5	8.3	8.5	11.9	
Kelsey		08EAS2272	Kelsey d/s of 140th Ave NE near NE 15th St			6.1	0		4.5	2.8	4.4	10.7	9	4.7	13.9	9.2	8.9	24.2
Kelsey	2.4	KelWeirs	Kelsey at GCC within step weirs	8.4	4	9.3												
Kelsey	2.3	KelGCfb	Kelsey at GCC below step weirs	7.7	5.5	3.7												
Kelsey	1.8	Glendale	Kelsey at GCC wooded area	16.5	1.2	4.4			1.9	7.6								
Kelsey	1.6	KelFarm	Kelsey Farm						1.9									8.5
Kelsey	0.2	KelTrstl	Kelsey under trestle and below culvert	10.2	11.2	10.6											20.8	
West Trib	0.4	WTribFarm	West Trib in Kelsey Farm, restored reach											11.4			17.7	
Sunset		08EAS2546	Sunset near SE 32nd St			11.8	10.5		0	0	3.5	0.4		5.2	7	6.1	0.2	4.6
Sunset	0	Sunset/Richards	Confluence of Sunset Creek and Richards Creek, north of SE 30th St												1.4			0
Lakehurst	0.3	Lkhrst405	Just upstream of pond, E of I405											9.4				
Newport	0.4	NewpStab	Stabilized reach d/s of swim club on 119th											12.5			10.2	
Yarrow	0.2	Glory Hole															35.6	
Trib 0160		0160	Just south of Vasa Park															42.6

Appendix B-8. Sunset Creek Sedimentation Study

Stream sediment samples have been collected for a number of years along Sunset Creek at SE 30th Street. Sample locations are shown in Figure B-8A below. This particular segment of Sunset Creek, at SE 30th Street, is the site of a recently constructed sediment trap and culvert replacement. The area has experienced periodic flooding and is a location where the City, with appropriate permits, has been removing builtup sediment directly from the stream. Samples were taken at the same key locations before and after installation of the new culvert and sediment trap.

As discussed in Chapter 6 of the Storm and Surface Water System Plan, too much fine sediment can smother salmon eggs laid in a stream. Table B-8A, taken from the Post Construction/2010 Conditions Report prepared by Herrera Environmental, shows changes in fine sediment content from year to year (pre-project 2007 and 2009 baseline) even before construction. Note that the table not only provides year-to-year direct comparison of fine sediment, it also shows changes in the sediment conditions for salmon spawning with readings of Good, Fair, and Poor.

Table B-8A shows a reduction in fine sediment post-construction. This is generally seen as improving salmon spawning conditions in three of the four sample sites from Poor to Fair. However, proper management of the new sediment trap requires many years of sampling data. Permit conditions from local, state, and federal agencies require that sediment sampling, stream cross-section survey, and a variety of other stream features be monitored for a period of 15 years. Additional downstream projects are planned as part of a comprehensive approach to flood control and stream enhancement along this segment of Sunset Creek, Richards Creek, and East Creek. Data will be collected and reports will be available as construction and monitoring continues.

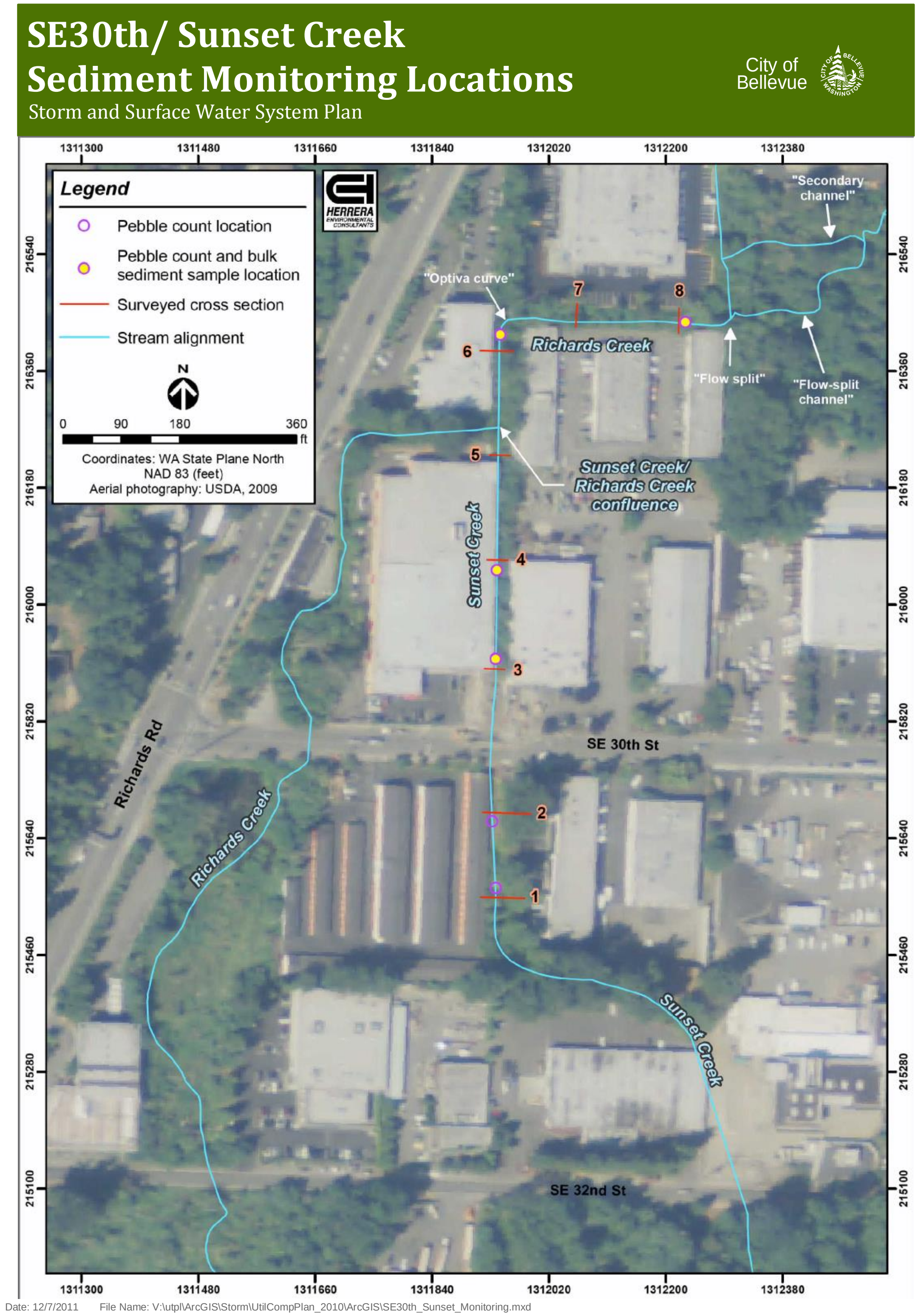

Figure B-8A. Sampling data taken in Sunset Creek.

Table B-8A. Table taken from the Draft Sunset Creek, Richards Creek, and East Creek Channel Monitoring Report, 2012 Conditions prepared by Herrera Environmental Consultants, dated November, 2012.

A comparison of pre-project 2007, baseline, post-construction 2010, 2011, and 2012 bulk sediment sample monitoring results according to the City of Bellevue's monitoring protocol standards.

		% Finer than 0.85 mm[a]					Condition				
Pre-project (2007) Sample Location	Monitoring Cross-Section Location	Pre-project (2007)	Baseline (2009)	Post-con (2010)	Post-con (2011)	Post-con (2012)	Pre-project (2007)	Baseline (2009)	Post-con (2010)	Post-con (2011)	Post-con (2012)
SS-1	3	12	24.2	14.7	15.5	14.4	Good	Poor	Fair	Fair	Fair
SS-2	4	14.5	21.1	15.4	13	12.1	Fair	Poor	Fair	Fair	Fair
SS-3	6	18.5	19.8	13.5	12.1	13.9	Poor	Poor	Fair	Fair	Fair
SS-4	8	28	28.6	18.8	12.5	12	Poor	Poor	Poor	Fair	Fair

[a] Grain size condition is judged as:

Good is <12% finer than 0.85 mm (per Schuett-Hames et al. 199)

Fair is 12 - 17% finer than 0.85 mm

Poor is > 17% finer than 0.85 mm

Appendix B-9. Rates of Pre-spawn Mortality (PSM) in Kelsey Creek Index Reaches (Kelsey Creek, West Tributary, and Richards Creek) from Fall Salmon Spawner Surveys.

Year	Percent Pre-Spawn Mortality Rate (female carcasses only)	Total Number of Observed Adult Spawner Carcasses	Species
2000-2001	74	35 (female)	Coho
2002	0	11 (male and female)	Chinook
2003	0	1 (female)	Chinook
2006	7	200 (male and female)	Chinook
2007	15	193 (male and female)	Chinook
2008	6	16 (female)	Coho
2009	40	5 (female)	Chinook
2010	0	1 (male)	Chinook
2011	0	2 (male and unknown)	Chinook and Sockeye
2012	100	2 (female)	Coho
2013	39	228 (male and female)	Chinook and Coho
2014	56	91 (male and female)	Coho

Appendix B-10. Hydrologic Monitoring Plan

Hydrologic Monitoring Plan Key Recommendations

Hydrologic monitoring data is used by stormwater managers during flood emergency responses for watershed planning, operations, trend assessment, educational needs, and project design. The current array of rain and flow monitoring stations meet the basic operational needs of the Bellevue Utilities Department.

The Utilities Department uses hydrologic monitoring data to:

- Respond to emergency flooding events and road closures;
- Guide operations of regional detention facilities;
- Guide staff safety for in-stream field work;
- Minimize flooding through planning and capital investments;
- Plan for future drainage needs, including Capital Investment Program (CIP) projects;
- Support hydrologic and hydraulic design criteria, facilitate basin planning (model calibration/verification), and analyze pipe capacity;
- Determine the effectiveness of stormwater management strategies;
- Evaluate long-term trends such as climate change or hydrologic variability;
- Support regional monitoring efforts/partnerships, e.g., WRIA 8 salmon recovery efforts;
- Respond to hydrologic information requests from the public, neighboring jurisdictions, and City staff; and
- Provide information for education and outreach.

Hydrologic Monitoring System

The Utilities Department currently operates 29 hydrologic monitoring gauges throughout the city (see figure 6-38). Ten regional detention facility gauges provide real-time stage readings, six in-stream gauges measure the depth of flow, and two lake gauges measure water levels. Additionally, 11 rain gauges stationed throughout the city measure precipitation.

System Recommendations

Bellevue's hydrologic monitoring network evolved based on program and project needs. This monitoring plan recommends the following:

1. Continue monitoring rainfall and water levels at all gauges on Bellevue's telemetry system.
2. Continue partnerships with the U.S. Geological Survey (USGS) and King County to meet shared hydrologic monitoring needs.
3. Conduct a cost-benefit analysis for participating with King County Hydrologic Information Center to increase access to Bellevue rainfall and stream flow data.

Hydrologic Monitoring Needs

Bellevue's hydrologic monitoring program strives to meet a variety of needs and produce high quality data. The monitoring program meets needs for purposes such as routine maintenance to ensure data standards, community access to data, basin studies for developing models, floodplain mapping to assess flood risk. These needs are discusses in more detail below.

Routine Hydrologic Needs

Best management practices for monitoring flow and rainfall include maintenance activities to assure high quality data. These include:

- Continue systematic QA/QC review of rainfall and stream level data at established sites. This includes rainfall data, manual downloaded stream gauge and BSC telemetry gauges.
- Maintain and validate flow rating curves at four established stream gauging sites (Coal Creek Flow site, Kelsey Creek Flow site, Valley Creek Flow site and Vasa Creek at West Lake Sammamish Parkway). This will require a minimum of three flow measurements per site per year to detect rating curve shifts that includes opportunistic stream flow measurements during high flow conditions. Create discharge hydrographs for these four locations and generate annual runoff summaries.

Community Access to Data Needs

Currently the city provides hydrologic data upon request. Consider participating with King County Hydrologic Information Center to increase access to Bellevue rainfall data at real time or monthly levels. As alternative opportunities for improving community access to data are being developed, continue preparing an annual summary report for rainfall data and posting it on the Utilities Department's website for public use.

Basin Study Hydrologic Needs

Basin studies that include developing hydrologic and hydraulic models that require the installation of temporary stream flow gauges for a minimum period of one year before the models are developed. Generally, the timing for these recommendations is not prioritized, and should be pursued as opportunities arise. The storm and surface water basin study priority list ranks the basins; a brief summary of the scope for each follows:

- Vasa Creek Basin: Evaluate flooding, water quality, and habitat conditions. Would include basin scale modeling, floodplain mapping, capacity analysis, and collect habitat data in support of kokanee recovery, as funding allows. This project was completed in 2014.
- Ardmore Basin: Capacity analysis to evaluate opportunities for providing direct discharge opportunities to the basin to reduce erosion. Investigate Ecology's 303(d) listing of the stream, prepare for TMDL study.
- Yarrow Creek Basin: Evaluate flooding, investigate Ecology's 303(d) listing of the stream, prepare for TMDL study, conduct a rapid watershed assessment, and collect habitat data, since salmon access has been restored through Hwy 520.
- Lewis Creek Basin: Evaluate flooding, investigate Ecology's 303(d) listing, prepare for TMDL study, and collect habitat data in support of Kokanee recovery.

Floodplain Mapping Hydrologic Needs

Regulatory floodplain maps display the inundation limits of the 100-year flooding event, also known as the “base flood.” The maps are used to assess flood risk and are based the hydrologic, hydraulic and topographic conditions at the time of the analyses. Like most natural systems, floodplains can change over time due to natural processes in streams and land development activity that increases stream flow volumes and peak flow rates. Each of these factors affects the extent of the regulatory floodplain. Improved mapping technology also affects how floodplains are displayed.

In Bellevue, many of the existing floodplain maps are based upon hydrologic and topographic information from the late 1970s when FEMA conducted its initial study of flood risk in King County. Because land use conditions in Bellevue have significantly changed since that time, the flow rates used to determines floodplains may have also changed, meaning the existing regulatory floodplain maps may not accurately assess flood risk. Physical changes to drainage structures are another factor that could affect the accuracy of floodplain maps. For example when the Utilities Department replaces an existing culvert with a larger one, the floodplain extents may change. Another reason for conducting a floodplain mapping analysis is to create a floodplain map for streams which have no floodplain delineated. Flood risk exists whether it’s mapped or not. Property owners can assess their flood risk more easily if an accurate map exists. Property owners see that their parcel is located on an unmapped stream they are not receiving an accurate assessment of flood risk. Chapter 9 in the Storm and Surface Water System Plan provides more detail on the initiative to update floodplain maps in Bellevue.

Proposal to Remap Existing Floodplains Due to Changed Conditions

Consistent with the eligibility requirements of the National Flood Insurance Program (NFIP)[1], Bellevue recognizes and should further evaluate flood hazards in its jurisdiction as opportunities arise, including the following:

- Mercer Slough from Lake Washington to 118th Avenue Southeast at the fish ladder. Seek confirmation of the existing base flood elevations (BFE) of Mercer Slough taking into account the effects of the managed lake elevations, of Lake Washington.
- West Tributary and lower Goff Creek from the Glendale Golf course to Bel-Red Road. The hydrology was updated in 2003 as part of the Kelsey Creek basin study and refined in 2009 in support of the Bel-Red rezoning effort. Updating the floodplain map for West Tributary and lower Goff Creek requires the development of a hydraulic backwater model and sending to FEMA the requisite Letter of Map Change forms.
- Valley Creek from its confluence with Kelsey Creek to NE 40th Street: The conversion of the large lots into large developed sites has likely changed the hydrology changed significantly in the last 20 years. New hydrologic and hydraulic models need to be developed.
- Lake Bellevue: The hydrologic model was developed in support of the Sturtevant Creek 40/20 Rule analysis[2]. The hydraulic model and requisite LOMC forms would need to be developed.
- Lake Sammamish: The city supports participation in a regional effort to update the base flood elevation for Lake Sammamish because of citizen concerns.

[1] Emergency Management Assistance, 44 C.F.R. § 59.21 (2009)

[2] The 40/20 Rule is when a sub-basin is at least 40 percent impervious for over 20 years. When this condition exists the basin can use the existing conditions as the pre-development hydrologic release rate when determining detention requirements instead of forest conditions for the predevelopment condition. Bellevue conducted a study of Sturtevant Creek and found that the basin complied with the 40/20 rule.

Proposals to map floodplains in locations where capital projects have altered the 100-year water surface elevation (e.g. culvert replacement projects)

- Richards Creek from its confluence with Kelsey Creek to SE Eastgate Way where enlarged culverts have been installed at Bannerwood Park, Kamber Road, and SE 30th Street as well as channel improvements. For Richards Creek, the floodplain mapping initiative includes the need to update the 1999 HSPF hydrology model and the hydraulic model for the creek. Lower Sunset Creek from SE 32nd to the confluence with Richards Creek is recommended for inclusion with this remapping because of the associated capital improvements recently completed for improving conveyance through the stream channel.
- Upper Sunset Creek in the vicinity of SE Allen Road. Hydrologic and hydraulic models need to be developed for this stream reach to evaluate changes due to the installation of a high flow bypass;
- Coal Creek through Newport Shores: the models developed for the design of the new culverts are sufficient for supporting floodplain mapping updates in the area.

Unmapped Floodplain Needs

- Chapter 9 of the Storm and Surface Water System Plan identifies the following locations needing mapped floodplains:
    - Sturtevant Creek- This creek should be mapped after the Bel-Red development is completed.
    - Sears Creek- This creek should be mapped after Redmond completes their regional stormwater facilities that drain to Sears Creek, since these facilities will significantly change the hydrology in the creek.

Conclusion

Adequate hydrologic monitoring is critical for providing information for flood emergency response, health and safety, stormwater management, and the environmental and financial sustainability for Bellevue residents and businesses. Bellevue's monitoring network, with proposed modifications, meets World Meteorological Organization recommendations and will meet Bellevue's needs with a predictable level of effort for many years.

Appendix B-11. Water Quality in Bellevue's Lakes

Lake Sammamish water contains high concentrations of phosphorus, a nutrient which can cause algae blooms and die-offs that reduce the oxygen in the water available for fish and other aquatic life, and reduces water clarity. In 1996, Bellevue, King County, the City of Redmond and the City of Issaquah set a goal of protecting the "ecological health and public benefits of Lake Sammamish." Water quality indicator goals were set at 4.0 meters Secchi disk transparency, 2.8 micrograms per liter chlorophyll-a, and 22 micrograms per liter total phosphorus (Entranco et al. 1996). Since 1997, King County has collected water quality samples of Lake Sammamish in two locations to evaluate whether or not the water quality goals are being met. As of 2006, goals for phosphorus and transparency have been met each year for both stations except in 2004 and 2006 when the phosphorus goal was not met at one of the stations. The goal for chlorophyll-a has consistently not been met at both sampling stations. For more details, see http://green.kingcounty.gov/lakes/LakeSammamish.aspx.

Phantom and Larsen Lakes are much smaller than Lake Sammamish, and are also sensitive to phosphorus input. Phantom Lake is 63 acres, and has 7,392 feet of shoreline. The maximum water depth is 54 feet, and the mean water depth is 21 feet. It holds a volume of 1,450 acre-feet of water. The outlet of Phantom Lake was altered in approximately 1890, when a farmer diverted it from Kelsey Creek (and Lake Washington) by creating a new channel to the east, to Lake Sammamish. Bellevue has monitored the summer (June through September) water quality of Phantom Lake since 1991 for water clarity (Secchi visibility depth), nutrients (phosphorus), and algae (chlorophyll-a). From 1994 through 2008, goals set for the three measures were met for all years for clarity, 10 out of 14 years for nutrients, and 7 out of 14 years for algae; see Figure 6-5 for the Phantom Lake water quality monitoring results and goals from 1994 to 2008. Zooplankton and phytoplankton were monitored in Phantom Lake for over 10 years, beginning in 1997. The goal of the monitoring was to determine if overall aquatic biological conditions in Phantom Lake had improved, declined, or not changed since water quality improvements were implemented in 1990. Based on over 10 years of data, lake plankton conditions have generally improved.

Larsen Lake is near Phantom Lake, and forms the headwaters of Kelsey Creek. It is approximately 10.5 acres in surface area (Huitt-Zollars 2008), and averages about 9 feet deep. Water quality data, similar to Phantom Lake information, have been collected, but not yet analyzed.

Lake Bellevue is a small lake (approximately 10.4 acres) at the headwaters of Sturtevant Creek, which drains into Mercer Slough and ultimately into Lake Washington. The lake is on average 8 feet deep, with a maximum depth of approximately 11 feet. Lake Bellevue is situated within a densely urban (the Sturtevant Creek basin is on average 71 percent impervious surface area) drainage area, with development over the wetlands around the lake, including structures built over the lake itself. There are high phosphorus concentrations in the lake. Phosphorus, oils, water clarity and algae growth were sampled in 2004 and 2005 to determine how to manage algae, odor, and oils in the lake (Tetra Tech 2006). The analysis determined that only 24 percent of the phosphorus came from urban runoff to the lake; the remaining 76 percent was the result of phosphorus cycling among internal lake water, sediment, plants, and biota. Oil sheens were not attributed to stormwater runoff, but were likely from oil spills, creosote pilings, and nearshore parking lots. Water treatment best management practices and low impact development for redeveloping properties, education about spill prevention, lake aerators, alum treatments to reduce phosphorus, and ongoing monitoring were recommended in a 2006 Lake Bellevue water quality study (2006 Lake Bellevue Water Quality Study and Management Recommendations) to meet water quality goals for Lake Bellevue.

Appendix B-12. Pollution Export Coefficients for Bellevue Runoff based on Samples Collected from 1989 to 1993.

Note: Values presented are modified direct averages, estimated based on flow volumes and sampled concentrations during storm events (Storm) and between storm events (Base). Confidence limits, site descriptions, methods and additional analysis can be found in the original report (City of Bellevue 1995).

			TSS (kg/ha-yr)		FC (no./ha-yr)		TP (kg/ha-yr)		Ortho-P (kg/ha-yr)		NO_3+NO_2-N (kg/ha-yr)		NH_3-N (kg/ha-yr)		COD (kg/ha-yr)	
Land Use Type	**% Impervious**	**Site**	**Storm**	**Base**	**Storm**	**Base**	**Storm**	**Base**	**Storm**	**Base**	**Storm**	**Base**	**Storm**	**Base**	**Storm**	**Base**
New MFR	79	Goldsmith Park	21.6	ND	ND	9.55E+08	0.096	0.235	0.03	0.171	0.276	0.706	0.33	0.377	32.7	ND
Food Distribution (Industrial)		Grocery Warehouse	194	33	2.07E+10	2.73E+09	2.19	3.45	0.652	6.76	2.15	0.818	775	1.1	375	58
Comm, Indust, MFR, SFR	50	Meydenbauer Creek	190	6.25	3.71E+10	2.35E+10	0.625	0.176	0.199	0.126	1.93	3.27	1.82	0.126	191	43.9
Comm, Indust, Service, Residential	72	Sturtevant Creek Downstream	340	11.8	2.17E+10	1.21E+10	1.39	0.485	0.301	0.373	2.02	1.86	1.99	0.41	151	37.9
Comm, Indust	71	Sturtevant Creek Upstream	303	14.4	1.34E+10	1.13E+10	1.15	0.422	0.295	0.281	2.28	2.39	2.66	0.597	196	ND
SFR, Light Indust, Service	37	West Tributary Downstream	79.6	16.5	1.99E+10	1.45E+11	0.26	0.46	0.079	0.368	0.656	6.72	0.283	2.85	28	ND
Indust, SFR	50	West Tributary Upstream	288	18.7	4.76E+10	3.15E+10	0.623	0.48	0.189	0.36	0.887	2.76	0.755	4.38	67.7	ND

Appendix B-12, continued.

	Surfactants (kg/ha-yr)		Oil and Grease (kg/ha-yr)		Total Petroleum Hydrocarbons		Cadmium (kg/ha-yr)		Chromium (kg/ha-yr)		Copper (kg/ha-yr)		Nickel (kg/ha-yr)		Lead (kg/ha-yr)		Zinc (kg/ha-yr)	
Site	Storm	Base	Storm	Base	Storm	Base	Storm	Base	Storm	Base	Storm	Base	Storm	Base	Storm	Base	Storm	Base
Goldsmith Park	ND	ND	1.3	ND	0.943	ND	0.0005	1.789	ND	ND	0.0153	ND	0.0044	ND	0.0066	11.02	0.104	0.3605
Grocery Warehouse	2.72	ND	135	ND	90.2	ND	ND	ND	0.0483	ND	0.1393	ND	ND	ND	ND	0.0285	2.362	0.3275
Meydenbauer Creek	0.881	ND	53.3	ND	36.9	ND	0.0024	ND	0.0247	ND	0.12	0.0452	0.0218	0.0062	0.0829	0.012	0.5845	0.1103
Sturtevant Creek Downstream	ND	0.3727	14.6	ND	11.6	ND	0.0035	0.001	0.0273	ND	0.1153	0.0361	0.0384	ND	0.1064	0.0228	0.5993	0.3118
Sturtevant Creek Upstream	ND	0.2811	42.9	ND	35.9	ND	0.0031	ND	0.0269	ND	0.1348	0.0228	0.0532	ND	0.1301	ND	0.6062	0.1861
West Tributary Downstream	ND	ND	3.03	ND	2.54	ND	0.0006	0.0032	ND	ND	0.452	ND	0.0063	ND	0.0286	0.0311	0.1547	0.4068
West Tributary Upstream	ND	ND	7.33	ND	6.19	ND	0.0016	0.0017	ND	ND	0.153	0.1475	0.0219	ND	0.1312	0.0392	0.5661	0.4055

Values are Modified Daily Averages, which is the total discharge volume for the study period multiplied by the mean pollutant concentration, calculated appropriately for a log normal distribution.

Abbreviations used:

TSS	Total suspended solids	kg/ha-yr	kilograms per hectare per year (annual loading)
FC	Fecal coliform bacteria	ND	Not detected in any samples
TP	Total phosphorus	Comm	Commercial
Ortho-P	Orthophosphorus	Indust	Industrial
COD	Chemical Oxygen Demand	MFR	Multi-family Residential
NO_3+NO_2-N	Nitrate-Nitrite	SFR	Single-family Residential
NH_3-N	Ammonia		

Dissolved metals were detected at all sites during storm events (see Table B-13A). Dissolved metals concentrations were generally higher for all metals sampled in basins with more impervious surface area. For example, zinc was highest in Sturtevant Creek, West Kelsey Creek, and Meydenbauer Creek drainage basins. Metal toxicity levels change with the hardness of the water, so determining whether concentrations in samples exceed state standards involves separate calculations for each sample. Additionally, state standards for metals have changed since the 1995 water quality report, so locations and numbers of exceedances were not available for this report.

Table B-12A. Median concentrations (µg/L) and annual yields (kg/ha-yr) for various metals analyzed at Bellevue monitoring locations during the first 6 hours of storm events, 1988-1993, as calculated by Whiley (2009).

Stations	Lead		Cadmium		Zinc		Nickel		Chromium		Copper	
	Median Conc.	Yield	Median Conc.	Yield	Median Conc.	Yield	Median Conc.	Yield	Median Conc.	Yield	Median Conc.	Yield
W. Kelsey Creek Upstream	35.0	0.062	0.70	0.0012	179	0.318	11.0	0.020	>30% nd	==	33.5	0.06
W. Kelsey Creek Downstream	14.0	0.017	0.67	0.0008	84	0.101	5.5	0.007	>30% nd	==	22.0	0.026
Mercer Slough	>30% nd	==	>30% nd	==	46	0.041	>30% nd	==	>30% nd	==	15.0	0.013
Coal Creek	>30% nd	==	>30% nd	==	54	0.097	>30% nd	==	>30% nd	==	20.5	0.037
Meydenbauer Creek	>30% nd	==	>30% nd	==	170	0.394	>30% nd	==	>30% nd	==	28.0	0.065
Sturtevant Creek Upstream	23.0	0.089	>30% nd	==	127	0.492	>30% nd	==	>30% nd	==	23.0	0.089
Sturtevant Creek Downstream	27.5	0.076	0.85	0.0023	140	0.386	9.0	0.025	>30% nd	==	20.0	0.055
Wilkins Creek	>30% nd	==	n<4	==	49	==	>30% nd	==	12.5	==	15.5	==
Phantom Lake	n<4	==	n<4	==	15	0.009	n<4	==	>30% nd	==	10.0	0.006

Shaded data: >30% of reported observations less than detection limit; table value is median of concentrations above detection limit.
<4: Reported observations number less than 4.
= : Yield not calculated.

Appendix B-13. Total Monthly Rainfall for 1962 and 1999 Measured at Sea-Tac Airport.

Precipitation patterns were similar in 1962 and 1999. Total annual rainfall in water year 1962 (October 1, 1962 to September 30, 1963) was 36.2 inches. Total annual rainfall during water year 1999 was 36.8 inches. Daily rainfall records were not available, but monthly rainfall totals indicate that the overall monthly amount of precipitation was similar for most months. Because the rainfall patterns were similar for these 2 years, the stream discharge rate at the Mercer Creek stream gauge was compared in order to analyze differences in stream flow in the same stream before and after urbanization occurred. See the graph below.