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

- B-1. Bellevue Stormwater Basin Fact Sheets
- B-2. Impervious Area and Tree Canopy Cover for Drainage Basins and their Stream Buffers in Bellevue, 2007
- B-3. Basin Evaluation by Available Evaluation Criteria
- B-4. Information used to Evaluate Basins, Evaluation Metrics, and Results
- B-5. Count of Flooded Structures from Historic Work Order Database
- B-6. Volume of Storage and Other Characteristics of Bellevue's Public Regional Detention Ponds, Updated in 2009
- B-7. B-IBI Scores at Bellevue Sites in all Sampled Years
- B-8. Lake Washington Average Water Levels Over a Year Based on Daily Measurements (collected at 8:00 a.m.) at the Ship Canal, Measured between 1979 and 1999
- B-9. Sunset Creek Sedimentation Study
- B-10. Rates of Pre-spawn Mortality (PSM) in Kelsey Creek Index Reaches (Kelsey Creek, West Tributary, and Richards Creek) from Fall Salmon Spawner Surveys
- B-11. Hydrologic Monitoring Plan
- B-12. Water Quality in Bellevue's Lakes
- B-13. Pollution Export Coefficients for Bellevue Runoff Based on Samples Collected from 1989 to 1993
- B-14. Total Monthly Rainfall for 1962 and 1999 Measured at Sea-Tac Airport

Basin Fact Sheets

Appendix B-1. Bellevue Stormwater Basin Fact Sheets

Ardmore Area

Lake Washington Watershed (WRIA 8)
State Stream #08-0143

LAND CHARACTERISTICS

Basin Area: 451 Total Acres (2% of the City)
Drainage Jurisdiction(s):
450.4 Acres - in Bellevue
1.0 Acres - in Redmond

Highest Elevation: 442 Ft
Lowest Elevation: 122 Ft

Total Length of Open Channel: 6,132 Ft
Total Length of Storm Drainage Pipes: 67,485 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

None known

POPULATION

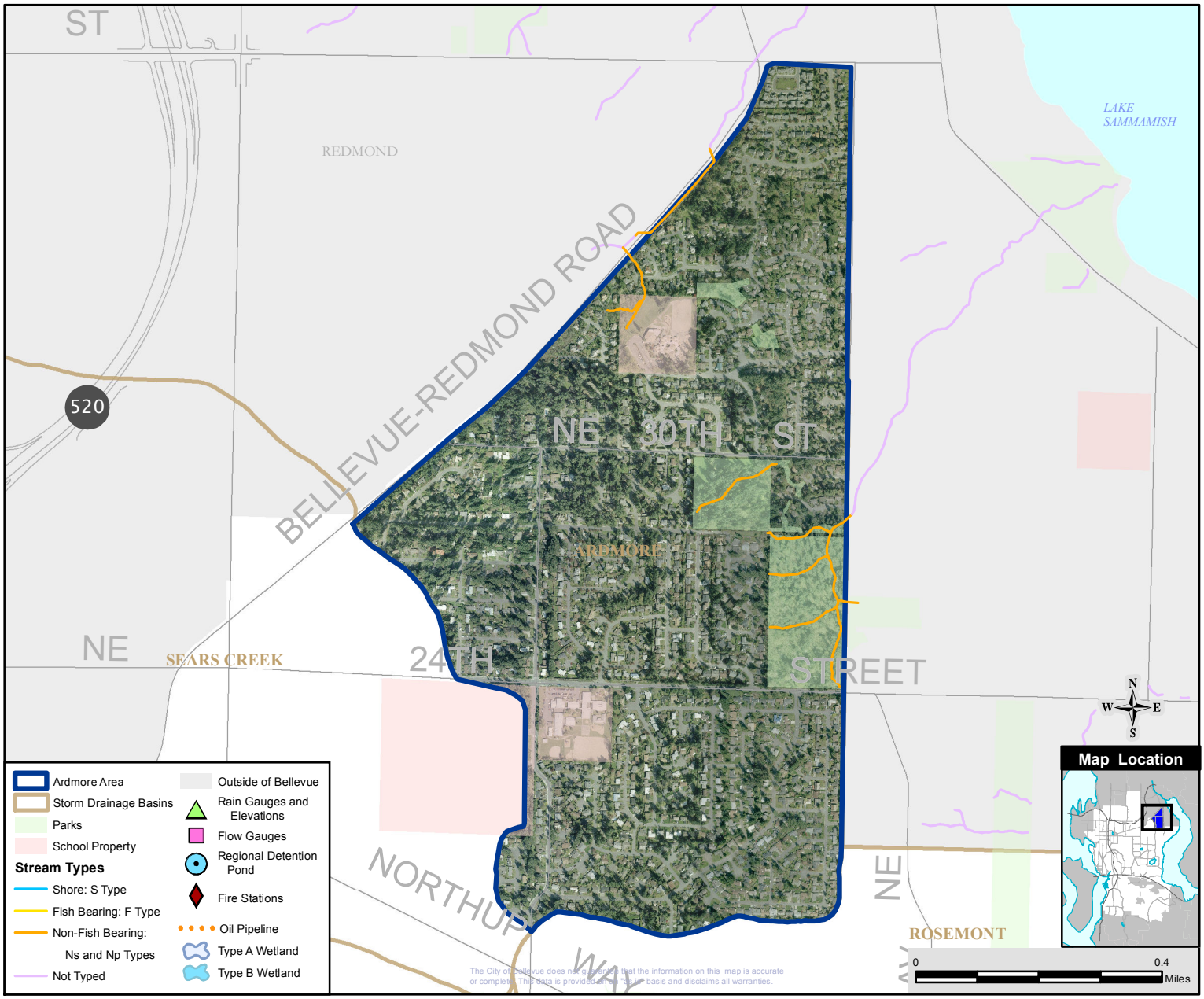
City Basin Population (2000): 3,803 (3.4% of the City)
Basin Population Density: 5,405 People/Square Mile
Number 26 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	20.24%	91.39 Acres
Institutional/Government:	5.02%	22.6 Acres
Open Space/Park:	6.76%	30.4 Acres
Single Family Residential:	65.15%	293.5 Acres
Mixed Use/Misc:	1.15%	5.2 Acres

LAND COVER

Impervious:	43%
Tree Canopy:	30%
Impervious in 100 Ft Stream Buffer:	8%
Tree Canopy in 100 Ft Stream Buffer:	83%



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Plot Date: 8/9/2011

Beaux Arts Area

Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 419 Total Acres (2% of the City)
Drainage Jurisdiction(s):
52.2 Acres - in Beaux Arts
365.6 Acres - in Bellevue

Highest Elevation: 280 Ft
Lowest Elevation: 18 Ft

Total Length of Open Channel: 0 Ft
Total Length of Storm Drainage Pipes: 26,702 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+, Sockeye
Rainbow & cutthroat trout (Lake only)
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

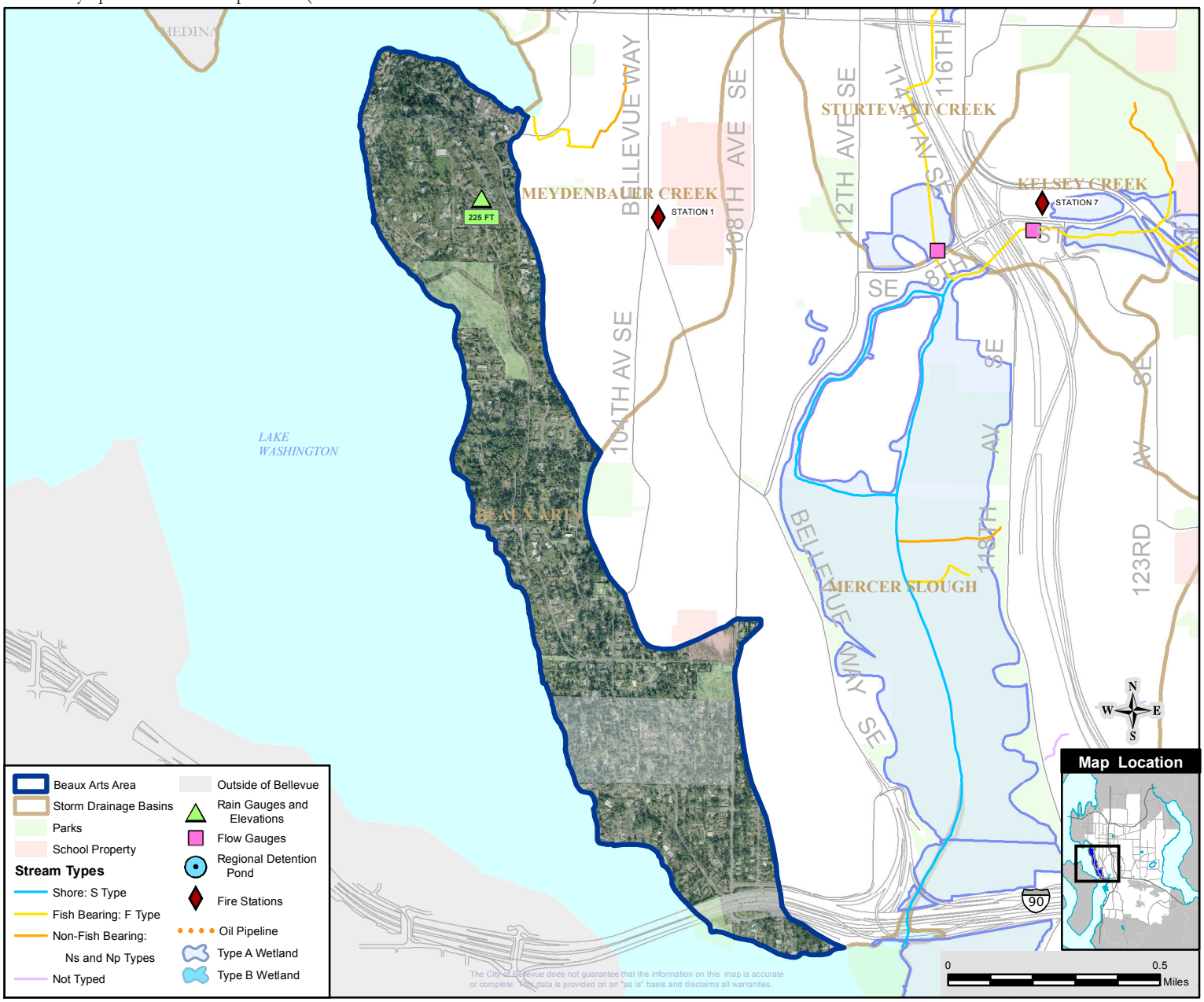
City Basin Population (2000): 1,520 (1.4% of the City)
Basin Population Density: 2,732 People/Square Mile
Number 10 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	14.31%	59.92 Acres
Institutional/Government:	2.19%	8.0 Acres
Multi-Family Residential:	0.19%	0.7 Acres
Open Space/Park:	5.33%	19.5 Acres
Single Family Residential:	66.74%	244.0 Acres

LAND COVER

Impervious:	34%
Tree Canopy:	53%
Impervious in 100 Ft Stream Buffer:	NA
Tree Canopy in 100 Ft Stream Buffer:	NA



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Plot Date: 8/9/2011

Clyde Beach Area

Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 292 Total Acres (1% of the City)

Drainage Jurisdiction(s):

219.5 Acres - in Bellevue

40.4 Acres - in Clyde Hill

32.2 Acres - in Medina

Highest Elevation: 362 Ft

Lowest Elevation: 18 Ft

Total Length of Open Channel: 0 Ft

Total Length of Storm Drainage Pipes: 35,932 Ft

Built Rain Storage Volume per Acre of Impervious Surface: Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+, Sockeye

Rainbow & cutthroat trout (Lake only)

Steelhead (Lake only)

* Listed Federal Endangered Species

\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

City Basin Population (2000): 1,668 (1.5% of the City)

Basin Population Density: 4,293 People/Square Mile

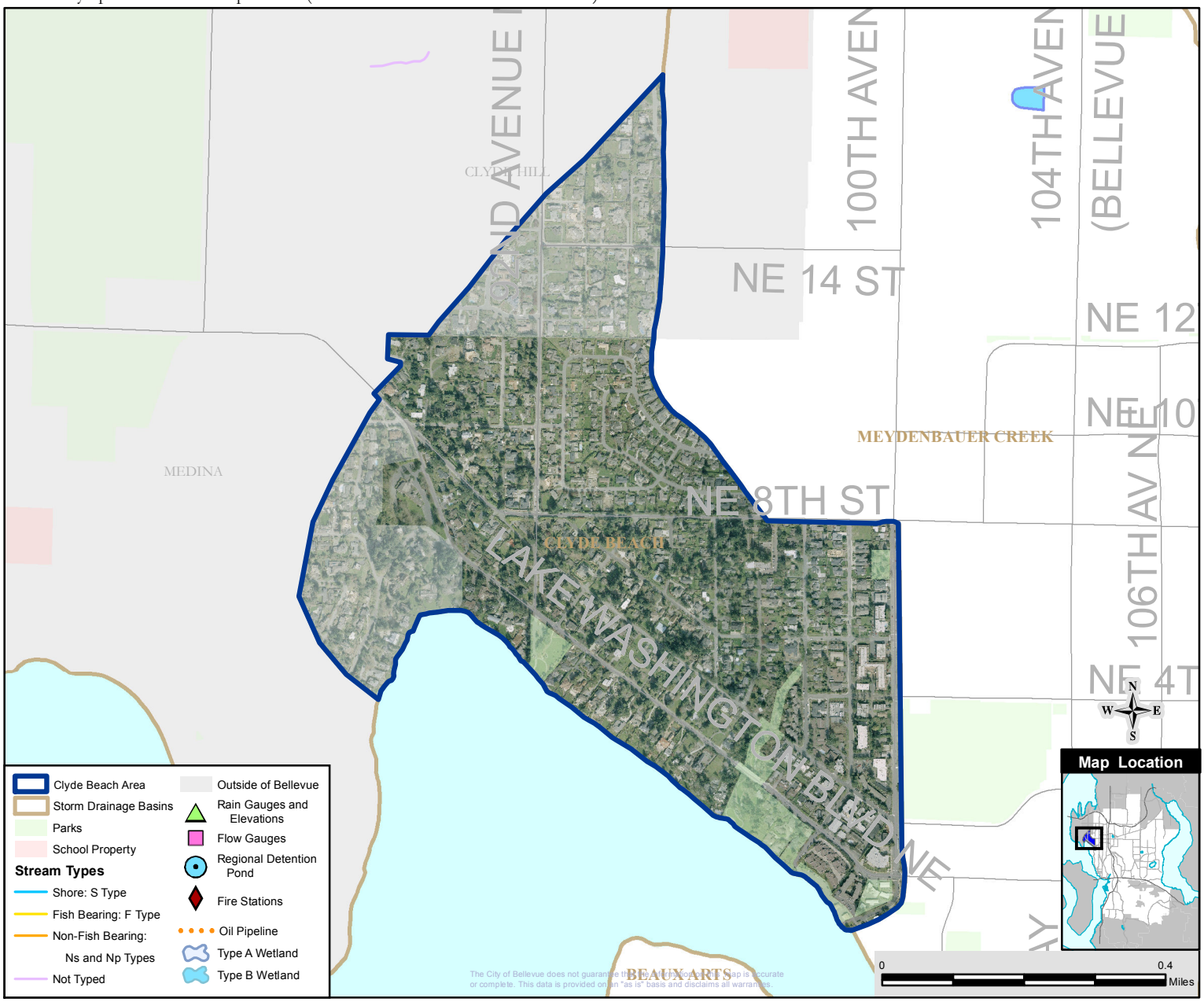
Number 20 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	17.42%	50.95 Acres
Commercial/Office:	0.66%	1.5 Acres
Institutional/Government:	3.12%	6.9 Acres
Mixed Use/Misc:	1.93%	4.2 Acres
Multi-Family Residential:	8.47%	18.6 Acres
Open Space/Park:	1.91%	4.2 Acres
Single Family Residential:	58.33%	128.1 Acres

LAND COVER

Impervious:	47%
Tree Canopy:	31%
Impervious in 100 Ft Stream Buffer:	NA
Tree Canopy in 100 Ft Stream Buffer:	NA



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Plot Date: 8/9/2011

Coal Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0268

LAND CHARACTERISTICS

Basin Area: 3,990 Total Acres (11% of the City)
Drainage Jurisdiction(s):
2,329.1 Acres - in Bellevue
1,128.3 Acres - in King County
532.1 Acres - in Newcastle

Highest Elevation: 1,561 Ft
Lowest Elevation: 18 Ft

Total Length of Open Channel: 97,099 Ft
Total Length of Storm Drainage Pipes: 266,341 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Chinook*+
Rainbow & cutthroat trout
Coho+
Sockeye
Steelhead

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

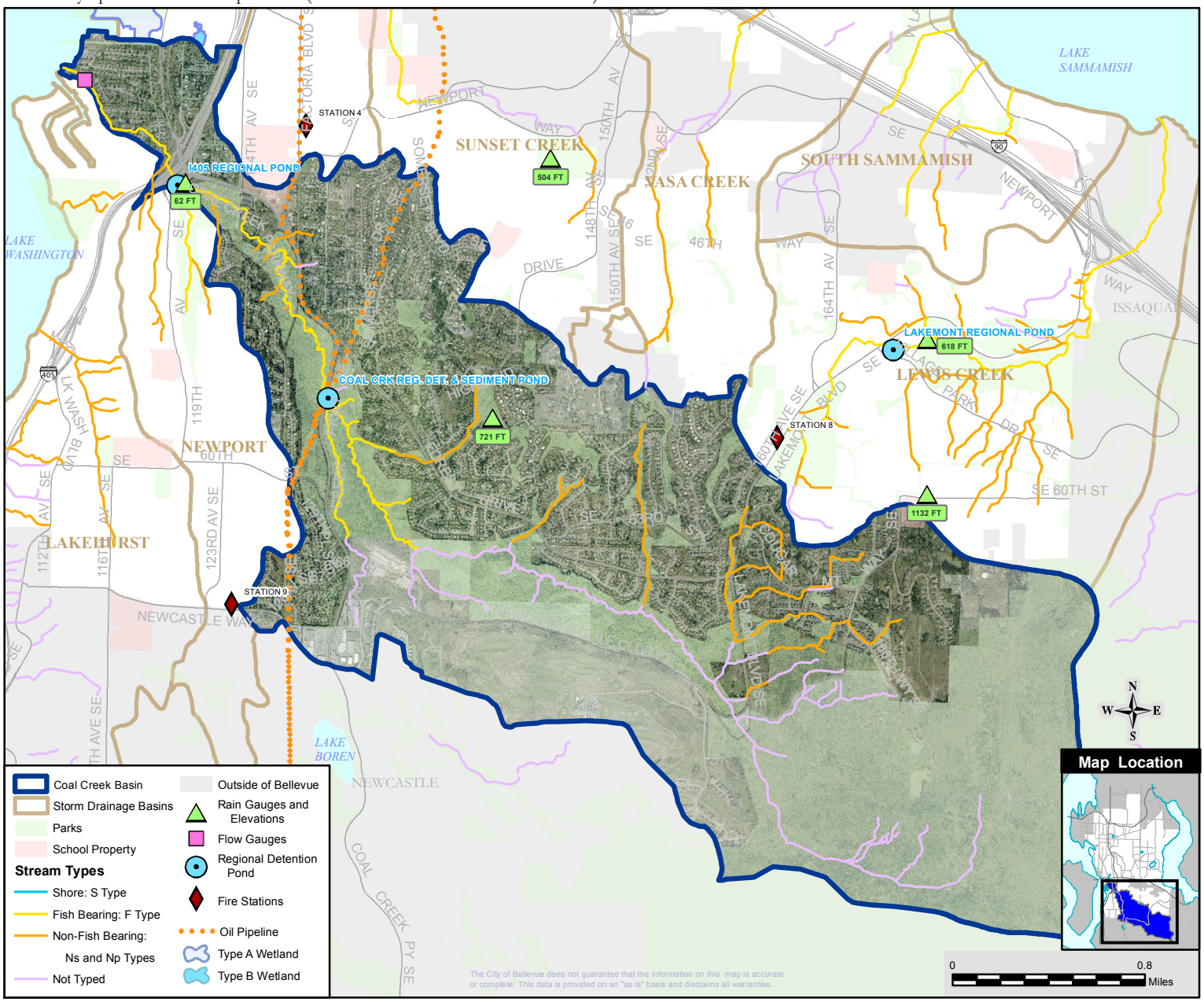
City Basin Population (2000): 10,144 (9.1% of the City)
Basin Population Density: 1,852 People/Square Mile
Number 3 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	9.16%	365.38 Acres
Commercial/Office:	0.03%	0.6 Acres
Industrial:	0.01%	0.3 Acres
Institutional/Government:	3.06%	66.8 Acres
Mixed Use/Misc:	3.77%	82.2 Acres
Multi-Family Residential:	1.44%	31.4 Acres
Open Space/Park:	10.89%	237.7 Acres
Single Family Residential:	50.14%	1,093.9 Acres

LAND COVER

Impervious:	20%
Tree Canopy:	58%
Impervious in 100 Ft Stream Buffer:	8%
Tree Canopy in 100 Ft Stream Buffer:	85%



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Plot Date: 8/9/2011

East Creek Basin

Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 462 Total Acres (2% of the City)
Drainage Jurisdiction(s):
461.6 Acres - in Bellevue

Highest Elevation: 435 Ft
Lowest Elevation: 49 Ft

Total Length of Open Channel: 8,866 Ft
Total Length of Storm Drainage Pipes: 40,913 Ft
Built Rain Storage Volume per Acre of Impervious Surface: 1.1 Inches

SALMON PRESENT in BASIN

Chinook*+
Cutthroat trout
Coho+
Sockeye

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

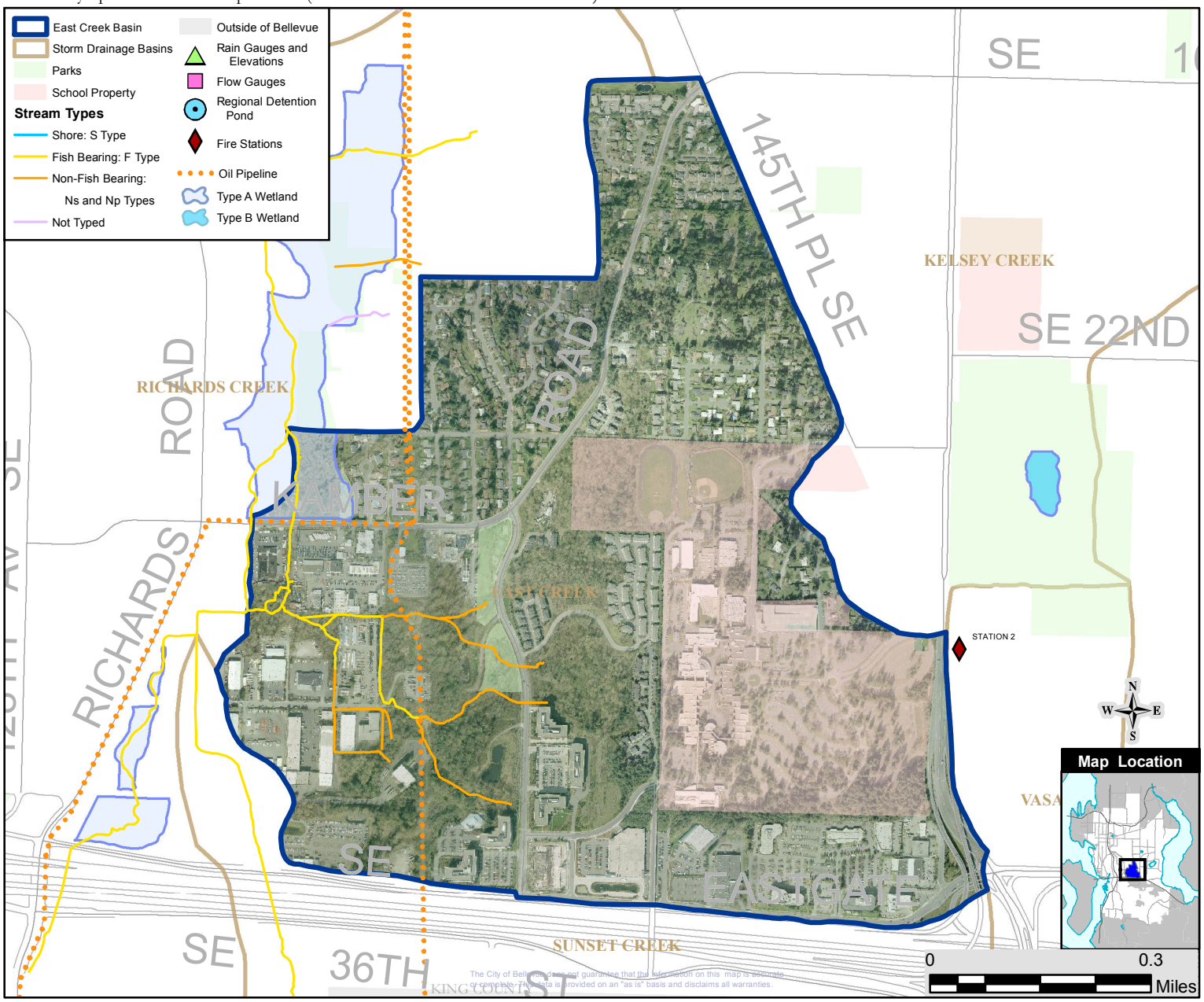
City Basin Population (2000): 1,498 (1.3% of the City)
Basin Population Density: 2,076 People/Square Mile
Number 6 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	10.87%	50.17 Acres
Commercial/Office:	12.70%	58.6 Acres
Industrial:	6.64%	30.7 Acres
Institutional/Government:	20.31%	93.8 Acres
Mixed Use/Misc:	11.37%	52.5 Acres
Multi-Family Residential:	6.03%	27.8 Acres
Open Space/Park:	0.47%	2.2 Acres
Single Family Residential:	20.79%	96.0 Acres

LAND COVER

Impervious:	48%
Tree Canopy:	35%
Impervious in 100 Ft Stream Buffer:	29%
Tree Canopy in 100 Ft Stream Buffer:	65%



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Plot Date: 8/9/2011

Goff Creek Basin

Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 674 Total Acres (2% of the City)
Drainage Jurisdiction(s):
508.0 Acres - in Bellevue
162.6 Acres - in King County
3.8 Acres - in Kirkland

Highest Elevation: 541 Ft
Lowest Elevation: 111 Ft

Total Length of Open Channel: 10,164 Ft
Total Length of Storm Drainage Pipes: 45,962 Ft
Built Rain Storage Volume per Acre of Impervious Surface: 0.7 Inches

SALMON PRESENT in BASIN

Chinook*+
Rainbow & cutthroat trout
Coho+
Sockeye

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

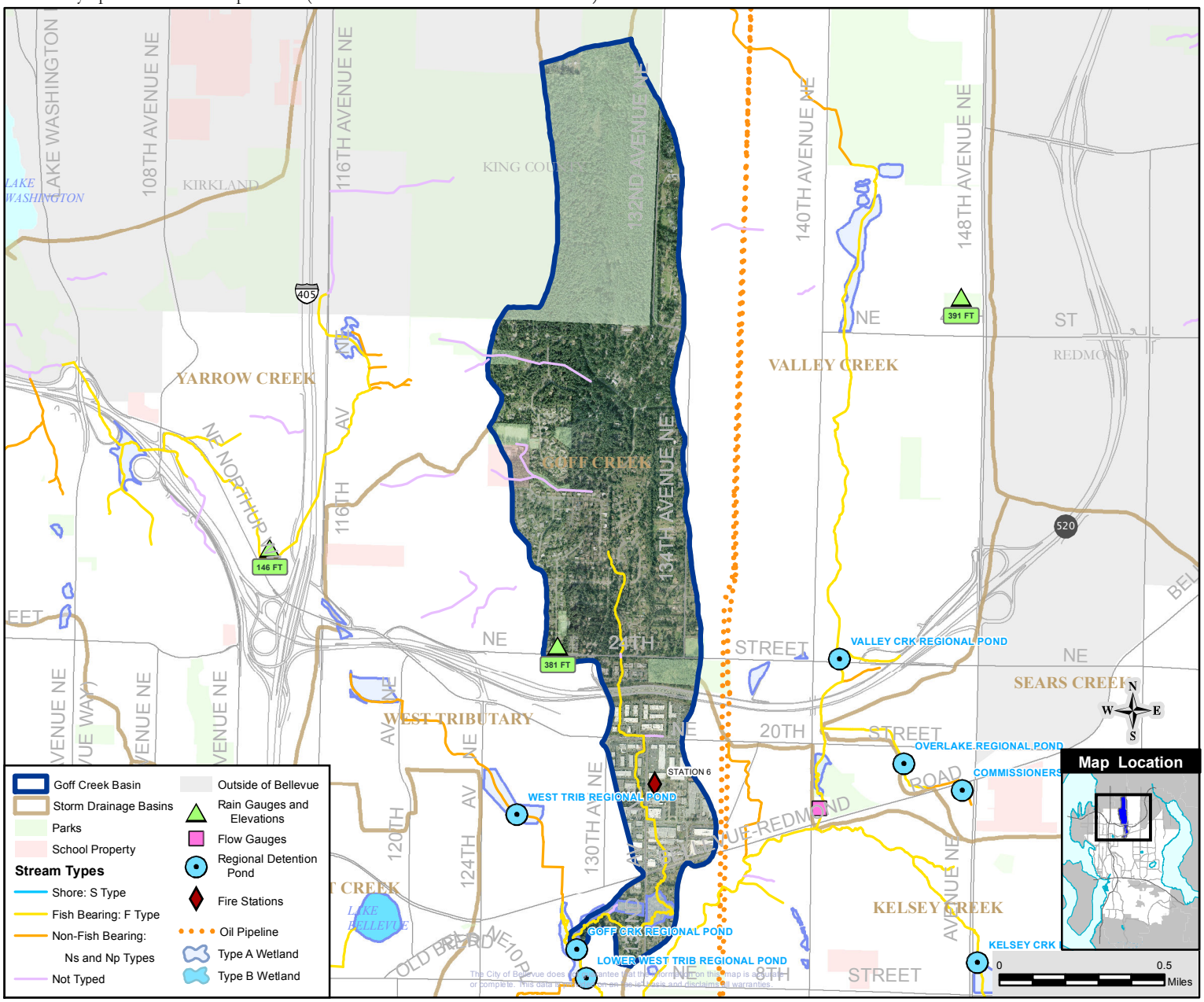
City Basin Population (2000): 1,675 (1.5% of the City)
Basin Population Density: 1,599 People/Square Mile
Number 1 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	10.77%	72.63 Acres
Commercial/Office:	7.07%	35.9 Acres
Industrial:	2.63%	13.4 Acres
Institutional/Government:	1.24%	6.3 Acres
Mixed Use/Misc:	6.05%	30.7 Acres
Multi-Family Residential:	0.26%	1.3 Acres
Open Space/Park:	3.06%	15.6 Acres
Single Family Residential:	59.98%	304.7 Acres

LAND COVER

Impervious:	30%
Tree Canopy:	59%
Impervious in 100 Ft Stream Buffer:	35%
Tree Canopy in 100 Ft Stream Buffer:	55%



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Plot Date: 8/9/2011

Kelsey Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0259

LAND CHARACTERISTICS

Basin Area: 2,822 Total Acres (14% of the City)
Drainage Jurisdiction(s):
2,822.4 Acres - in Bellevue

Highest Elevation: 449 Ft
Lowest Elevation: 19 Ft

Total Length of Open Channel: 54,606 Ft
Total Length of Storm Drainage Pipes: 264,467 Ft
Built Rain Storage Volume per Acre of Impervious Surface: 1.2 Inches

SALMON PRESENT in BASIN

Chinook*+
Chum
Coho+
Cutthroat trout
Sockeye

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

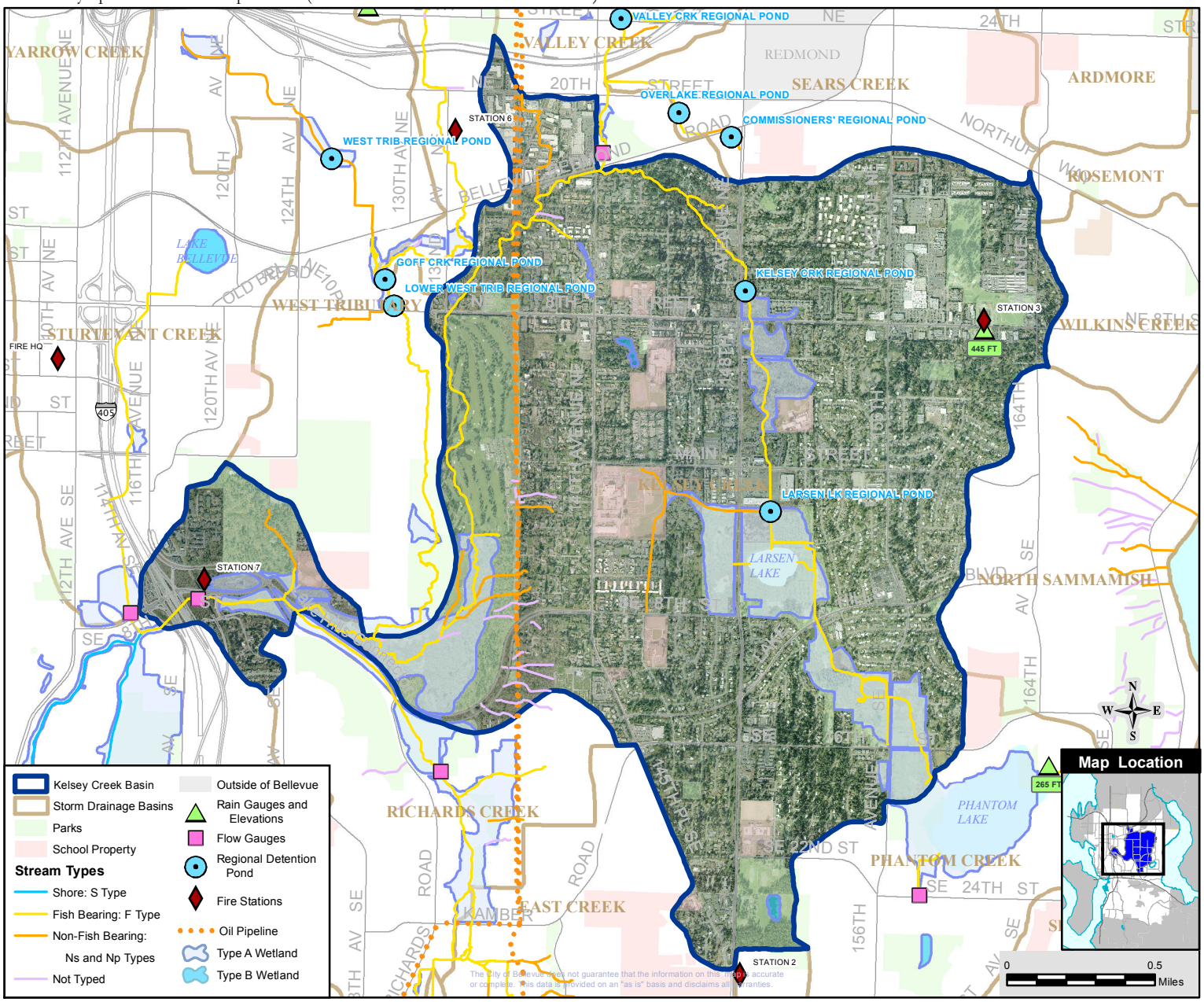
City Basin Population (2000): 22,494 (20.1% of the City)
Basin Population Density: 5,101 People/Square Mile
Number 24 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	14.89%	420.32 Acres
Commercial/Office:	6.18%	174.4 Acres
Industrial:	0.86%	24.4 Acres
Institutional/Government:	6.24%	176.2 Acres
Mixed Use/Misc:	3.42%	96.5 Acres
Multi-Family Residential:	13.34%	376.5 Acres
Open Space/Park:	16.75%	472.9 Acres
Single Family Residential:	32.92%	929.1 Acres

LAND COVER

Impervious:	40%
Tree Canopy:	33%
Impervious in 100 Ft Stream Buffer:	17%
Tree Canopy in 100 Ft Stream Buffer:	55%



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Plot Date: 8/9/2011

Lakehurst Area

Lake Washington Watershed (WRIA 8)

State Stream #08-0281

LAND CHARACTERISTICS

Basin Area: 1,284 Total Acres (3% of the City)

Drainage Jurisdiction(s):

651.0 Acres - in Bellevue

23.2 Acres - in King County

445.5 Acres - in Newcastle

163.6 Acres - in Renton

Highest Elevation: 568 Ft

Lowest Elevation: 17 Ft

Total Length of Open Channel: 34,651 Ft

Total Length of Storm Drainage Pipes: 57,587 Ft

Built Rain Storage Volume per Acre of Impervious Surface: Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+, Sockeye

Rainbow & cutthroat trout (Lake only)

Steelhead (Lake only)

* Listed Federal Endangered Species

\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

City Basin Population (2000): 2,828 (2.5% of the City)

Basin Population Density: 2,371 People/Square Mile

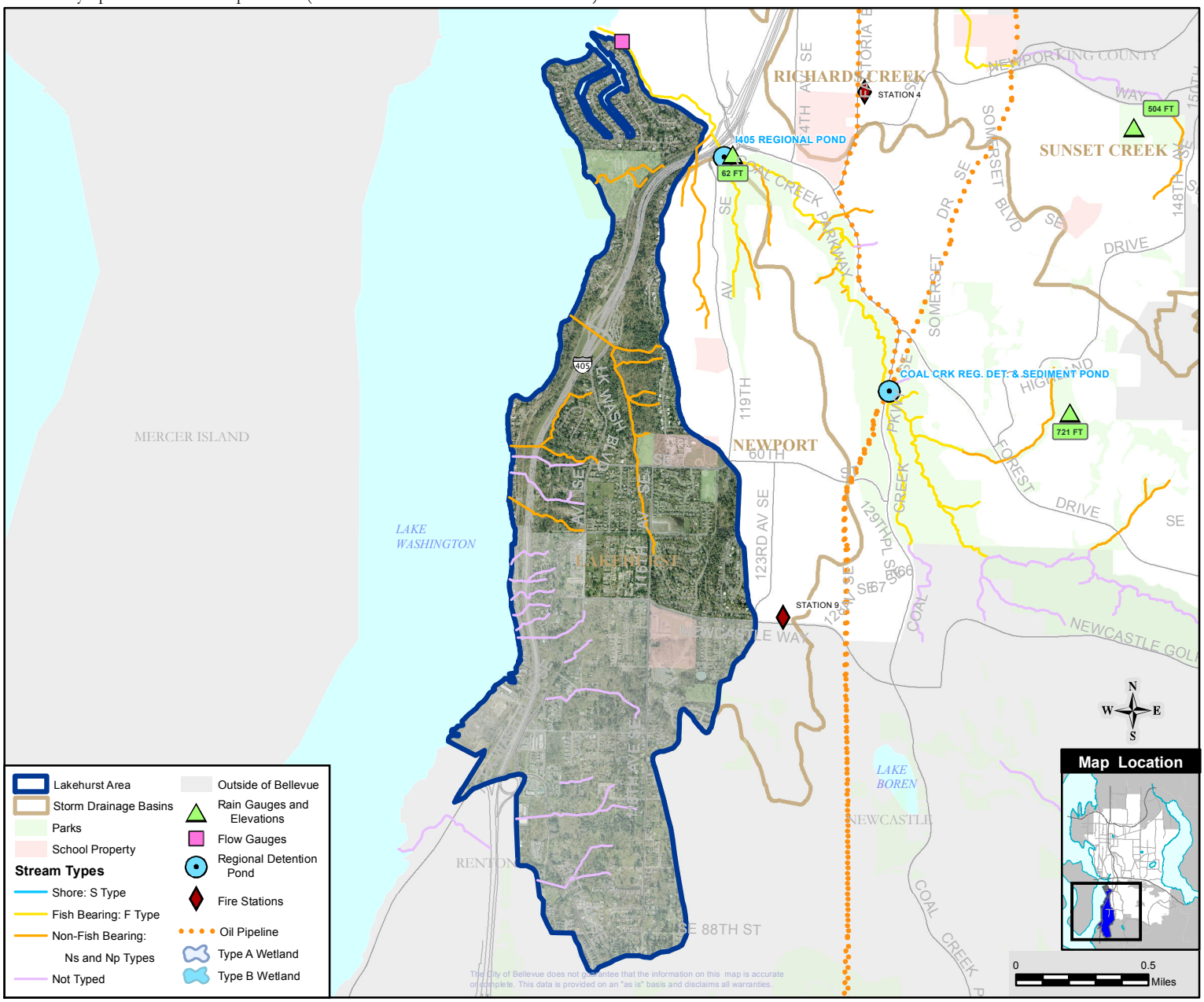
Number 9 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	12.58%	161.45 Acres
Industrial:	0.42%	2.7 Acres
Institutional/Government:	3.47%	22.6 Acres
Multi-Family Residential:	0.12%	0.8 Acres
Commercial/Office:	0.08%	0.5 Acres
Open Space/Park:	4.35%	28.3 Acres
Single Family Residential:	44.38%	288.9 Acres
Mixed Use/Misc:	10.56%	68.8 Acres

LAND COVER

Impervious:	33%
Tree Canopy:	37%
Impervious in 100 Ft Stream Buffer:	21%
Tree Canopy in 100 Ft Stream Buffer:	62%



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Plot Date: 8/9/2011

Lewis Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0162

LAND CHARACTERISTICS

Basin Area: 1,451 Total Acres (5% of the City)
Drainage Jurisdiction(s):
1,003.6 Acres - in Bellevue
355.1 Acres - in Issaquah
91.4 Acres - in King County

Highest Elevation: 1,425 Ft
Lowest Elevation: 30 Ft

Total Length of Open Channel: 50,666 Ft
Total Length of Storm Drainage Pipes: 118,442 Ft
Built Rain Storage Volume per Acre of Impervious Surface: 1.2 Inches

POPULATION

City Basin Population (2000): 4,886 (4.4% of the City)
Basin Population Density: 2,995 People/Square Mile
Number 12 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	10.15%	147.26 Acres
Commercial/Office:	3.36%	33.7 Acres
Institutional/Government:	0.86%	8.6 Acres
Multi-Family Residential:	4.44%	44.6 Acres
Mixed Use/Misc:	9.33%	93.7 Acres
Open Space/Park:	3.28%	32.9 Acres
Single Family Residential:	41.86%	420.1 Acres

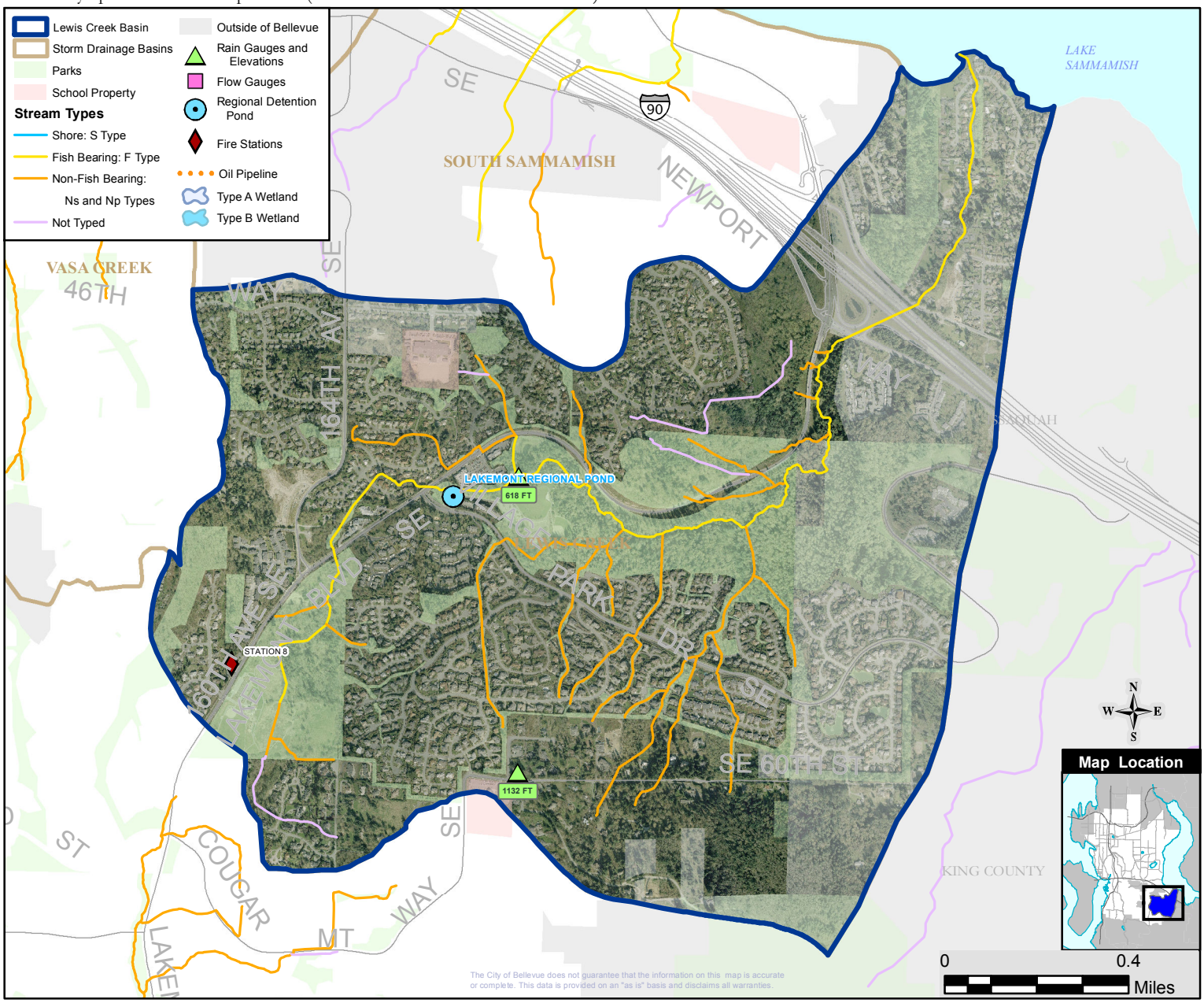
SALMON PRESENT in BASIN

Chinook*+
Rainbow & cutthroat trout
Coho+
Sockeye
Kokanee+
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

LAND COVER

Impervious:	29%
Tree Canopy:	49%
Impervious in 100 Ft Stream Buffer:	17%
Tree Canopy in 100 Ft Stream Buffer:	69%



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Plot Date: 8/9/2011

Mercer Slough Basin

Lake Washington Watershed (WRIA 8)

State Stream #08-0259

LAND CHARACTERISTICS

Basin Area: 1,327 Total Acres (6% of the City)

Drainage Jurisdiction(s):

1,327.0 Acres - in Bellevue

Highest Elevation: 339 Ft

Lowest Elevation: 16 Ft

Total Length of Open Channel: 15,533 Ft

Total Length of Storm Drainage Pipes: 96,145 Ft

Built Rain Storage Volume per Acre of Impervious Surface: Less than 0.5 Inches

POPULATION

City Basin Population (2000): 4,546 (4.1% of the City)

Basin Population Density: 2,192 People/Square Mile

Number 8 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	27.08%	359.33 Acres
Commercial/Office:	5.87%	77.9 Acres
Industrial:	2.86%	38.0 Acres
Institutional/Government:	4.55%	60.3 Acres
Mixed Use/Misc:	2.20%	29.2 Acres
Multi-Family Residential:	4.69%	62.2 Acres
Open Space/Park:	18.14%	240.7 Acres
Single Family Residential:	27.68%	367.4 Acres

SALMON PRESENT in BASIN

Chinook*+

Rainbow & cutthroat trout

Coho+

Sockeye

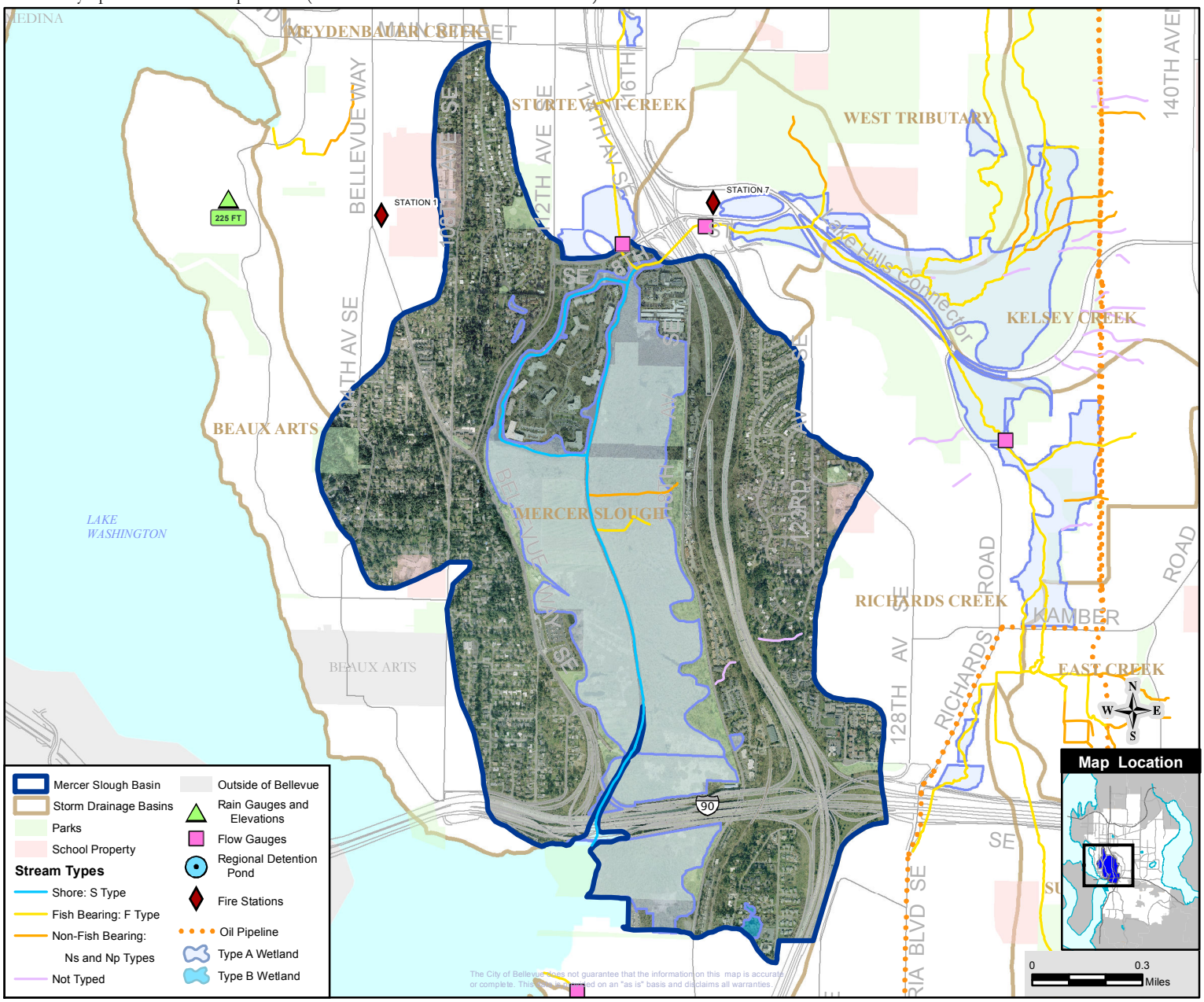
Steelhead (Lake only)

* Listed Federal Endangered Species

\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

LAND COVER

Impervious:	32%
Tree Canopy:	43%
Impervious in 100 Ft Stream Buffer:	7%
Tree Canopy in 100 Ft Stream Buffer:	53%



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Plot Date: 8/9/2011

Meydenbauer Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0258

LAND CHARACTERISTICS

Basin Area: 927 Total Acres (4% of the City)
Drainage Jurisdiction(s):
833.2 Acres - in Bellevue
94.2 Acres - in Clyde Hill

Highest Elevation: 391 Ft
Lowest Elevation: 18 Ft

Total Length of Open Channel: 1,773 Ft
Total Length of Storm Drainage Pipes: 142,906 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

POPULATION

City Basin Population (2000): 6,700 (6.0% of the City)
Basin Population Density: 4,833 People/Square Mile
Number 23 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	16.60%	153.95 Acres
Commercial/Office:	15.23%	126.9 Acres
Industrial:	0.20%	1.7 Acres
Institutional/Government:	5.67%	47.3 Acres
Mixed Use/Misc:	7.70%	64.2 Acres
Multi-Family Residential:	15.03%	125.2 Acres
Open Space/Park:	3.61%	30.1 Acres
Single Family Residential:	31.61%	263.4 Acres

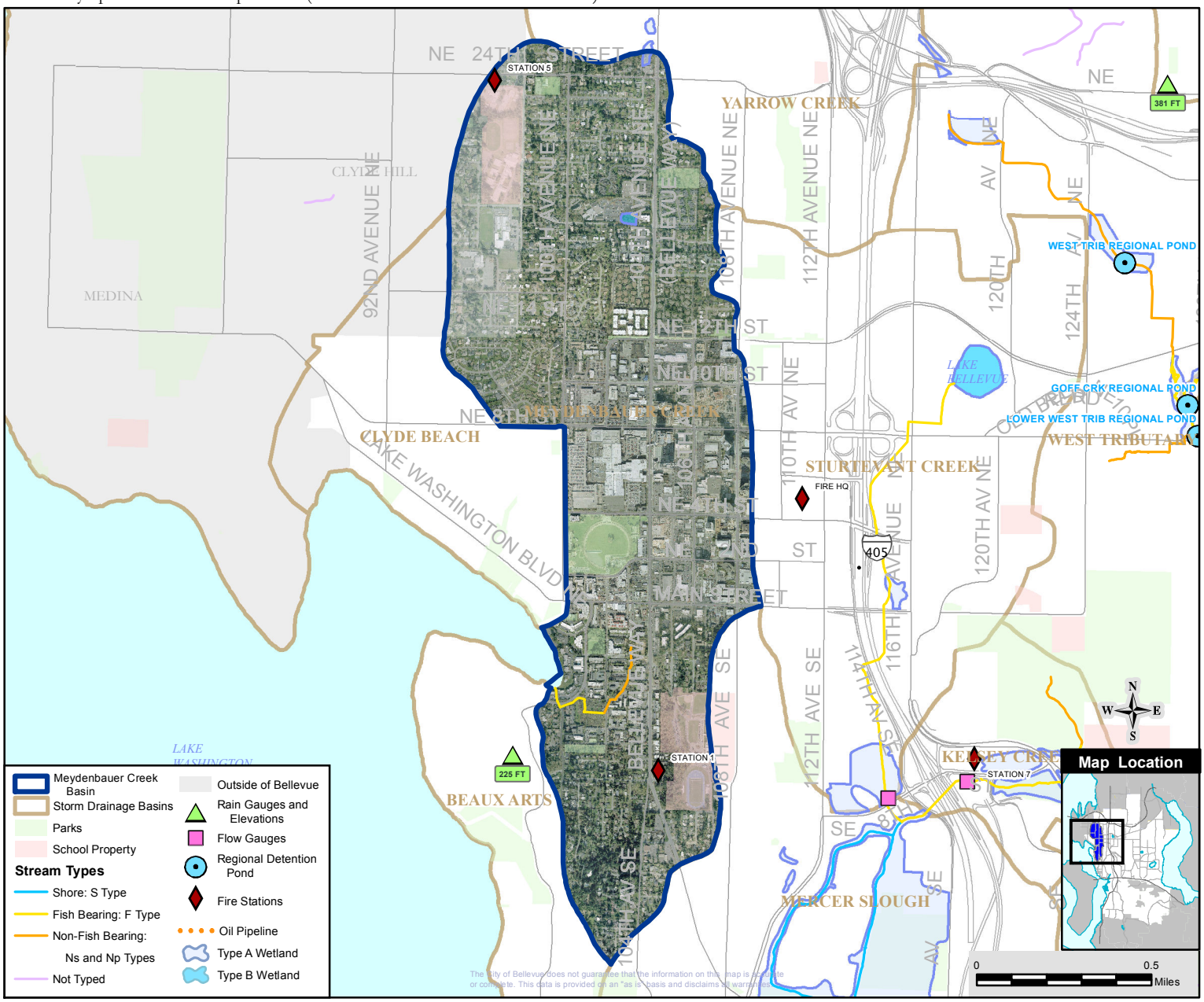
SALMON PRESENT in BASIN

Chinook*+ (Lake only)
Coho+ (Lake only)
Cutthroat trout (Lake only)
Rainbow trout (Lake only)
Sockeye

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

LAND COVER

Impervious:	59%
Tree Canopy:	24%
Impervious in 100 Ft Stream Buffer:	36%
Tree Canopy in 100 Ft Stream Buffer:	44%



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Plot Date: 8/4/2011

Newport Area

Lake Washington Watershed (WRIA 8)

State Stream #08-0269

LAND CHARACTERISTICS

Basin Area: 573 Total Acres (2% of the City)

Drainage Jurisdiction(s):

469.8 Acres - in Bellevue

103.2 Acres - in Newcastle

Highest Elevation: 571 Ft

Lowest Elevation: 51 Ft

Total Length of Open Channel: 8,845 Ft

Total Length of Storm Drainage Pipes: 62,013 Ft

Built Rain Storage Volume per Acre of Impervious Surface: Less than 0.5 Inches

SALMON PRESENT in BASIN

Coho+ (juveniles)

Cutthroat trout

+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

City Basin Population (2000): 3,588 (3.2% of the City)

Basin Population Density: 4,700 People/Square Mile

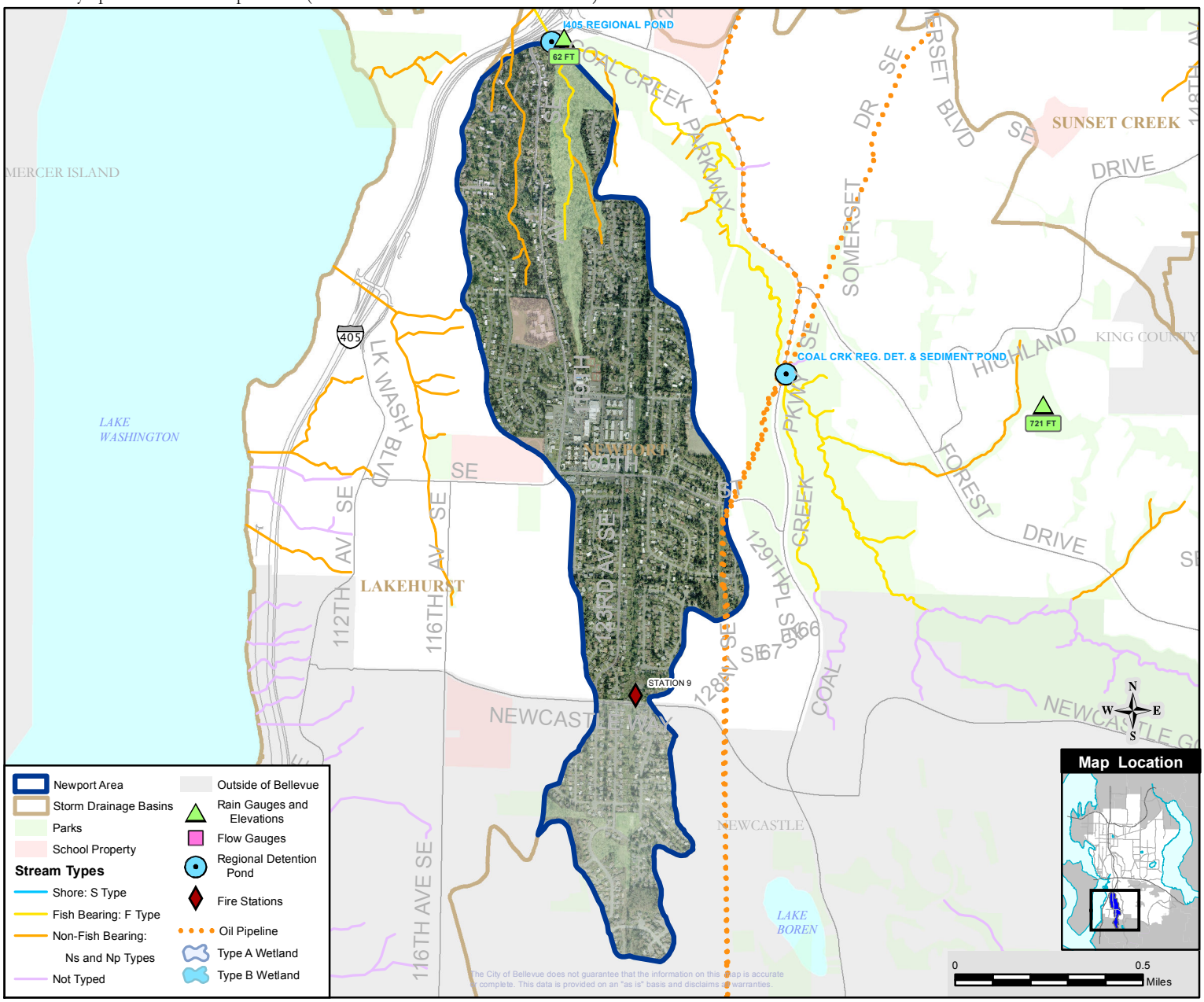
Number 22 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	14.37%	82.38 Acres
Commercial/Office:	1.94%	9.1 Acres
Institutional/Government:	4.35%	20.5 Acres
Multi-Family Residential:	3.25%	15.3 Acres
Open Space/Park:	8.61%	40.5 Acres
Single Family Residential:	60.46%	284.1 Acres
Mixed Use/Misc:	0.32%	1.5 Acres

LAND COVER

Impervious:	39%
Tree Canopy:	30%
Impervious in 100 Ft Stream Buffer:	7%
Tree Canopy in 100 Ft Stream Buffer:	91%



North Sammamish Area

Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 621 Total Acres (3% of the City)
Drainage Jurisdiction(s):
618.5 Acres - in Bellevue

Highest Elevation: 443 Ft
Lowest Elevation: 30 Ft

Total Length of Open Channel: 19,713 Ft
Total Length of Storm Drainage Pipes: 59,355 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+ , Kokanee+, Sockeye
Rainbow & cutthroat trout (Lake only)
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

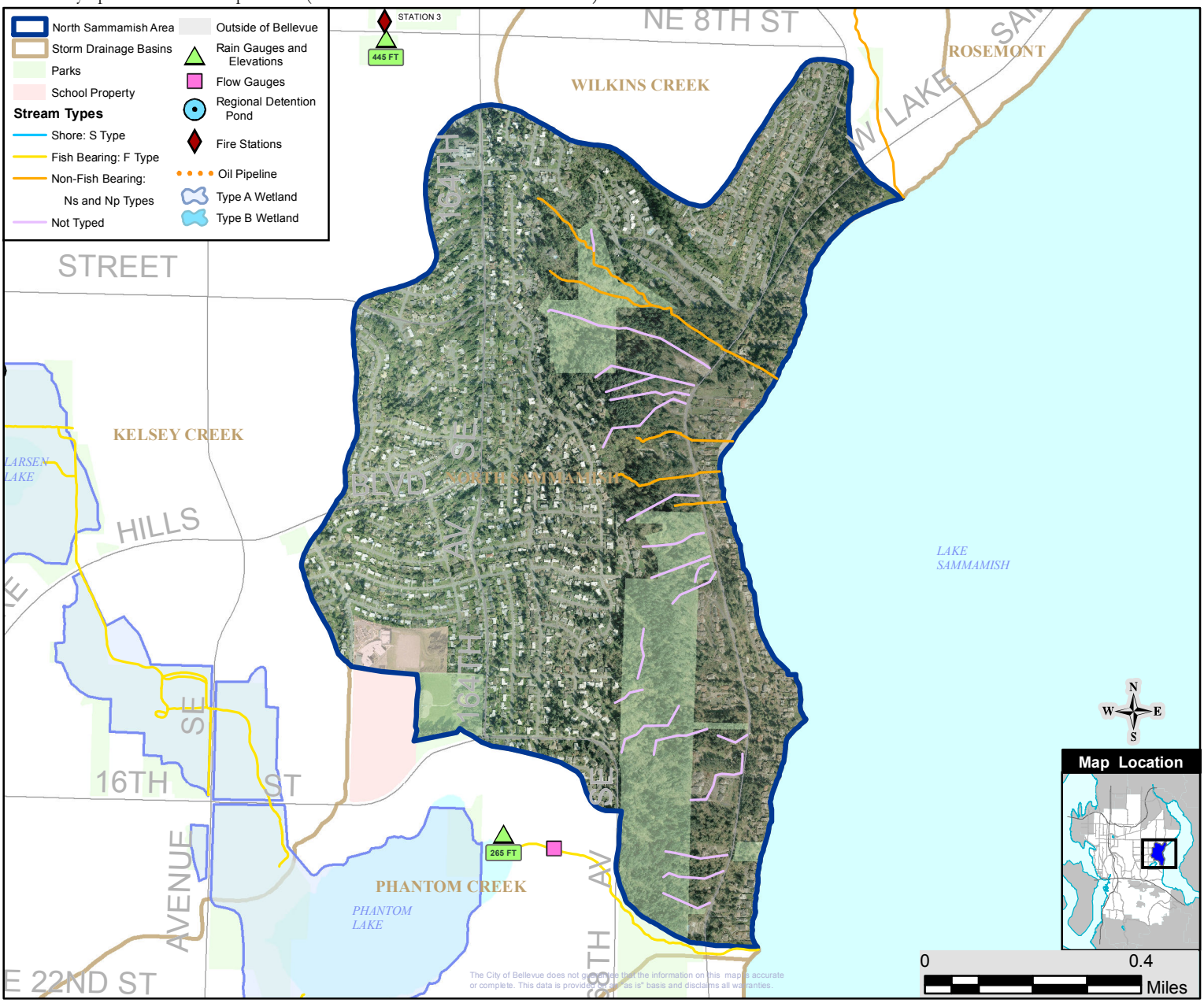
City Basin Population (2000): 3,789 (3.4% of the City)
Basin Population Density: 3,916 People/Square Mile
Number 16 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	15.67%	97.25 Acres
Institutional/Government:	1.78%	11.0 Acres
Multi-Family Residential:	0.05%	0.3 Acres
Open Space/Park:	14.63%	90.5 Acres
Single Family Residential:	54.10%	334.6 Acres
Mixed Use/Misc:	5.70%	35.3 Acres

LAND COVER

Impervious:	32%
Tree Canopy:	46%
Impervious in 100 Ft Stream Buffer:	9%
Tree Canopy in 100 Ft Stream Buffer:	86%



Phantom Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0154

LAND CHARACTERISTICS

Basin Area: 537 Total Acres (3% of the City)
Drainage Jurisdiction(s):
536.5 Acres - in Bellevue

Highest Elevation: 425 Ft
Lowest Elevation: 31 Ft

Total Length of Open Channel: 3,755 Ft
Total Length of Storm Drainage Pipes: 36,058 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake Sammamish only: Chinook*+, Coho+ , Kokanee+, Sockeye
Rainbow & cutthroat trout
Steelhead (Lake Sammamish only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

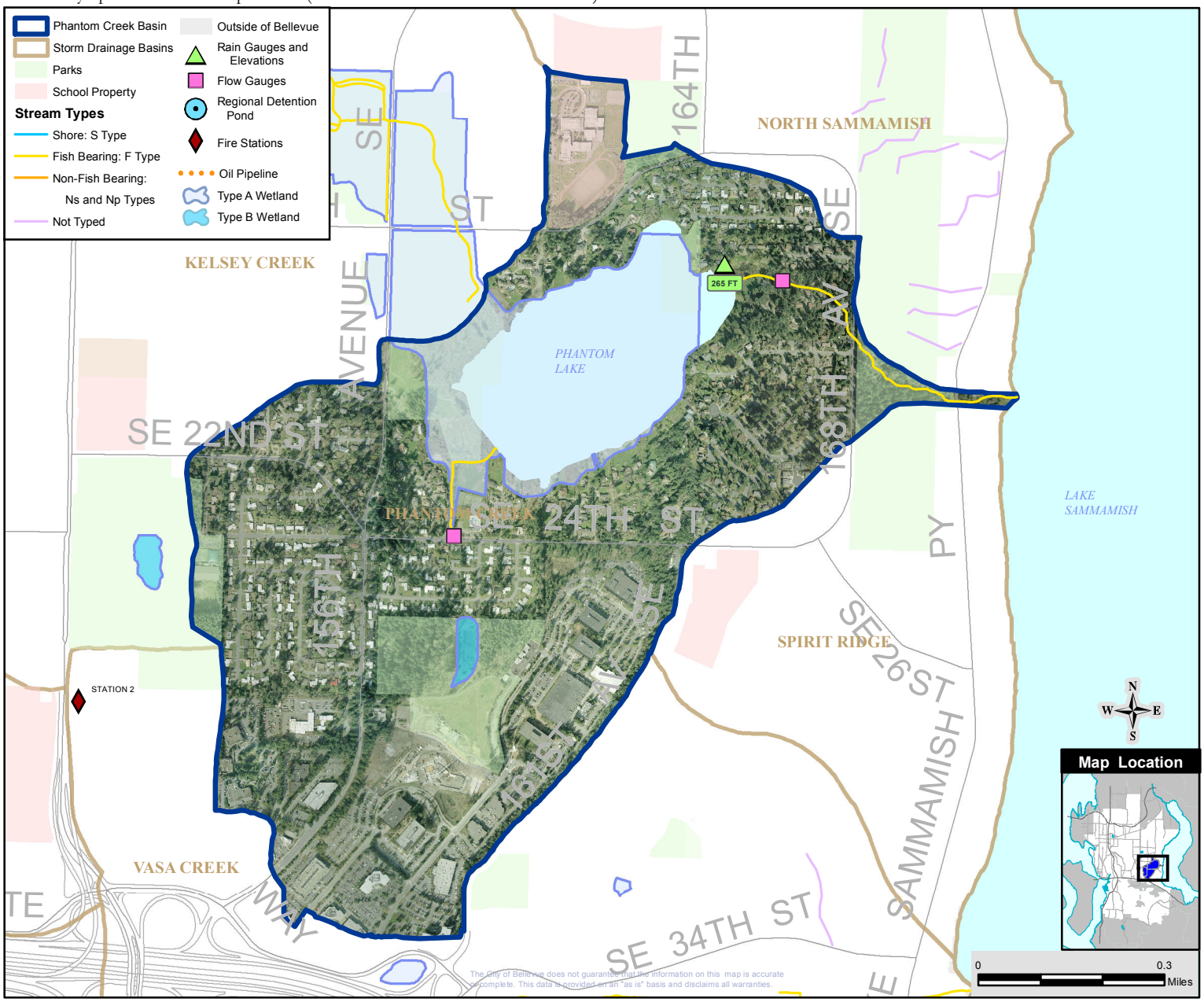
City Basin Population (2000): 1,606 (1.4% of the City)
Basin Population Density: 1,915 People/Square Mile
Number 5 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	10.37%	55.66 Acres
Commercial/Office:	17.72%	95.1 Acres
Mixed Use/Misc:	0.70%	3.8 Acres
Industrial:	3.71%	19.9 Acres
Institutional/Government:	4.68%	25.1 Acres
Multi-Family Residential:	0.09%	0.5 Acres
Open Space/Park:	12.29%	66.0 Acres
Single Family Residential:	42.88%	230.1 Acres

LAND COVER

Impervious:	35%
Tree Canopy:	33%
Impervious in 100 Ft Stream Buffer:	17%
Tree Canopy in 100 Ft Stream Buffer:	64%



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Plot Date: 8/8/2011

Richards Creek Basin

Lake Washington Watershed (WRIA 8)

State Stream #08-0261

LAND CHARACTERISTICS

Basin Area: 901 Total Acres (4% of the City)

Drainage Jurisdiction(s):

901.5 Acres - in Bellevue

Highest Elevation: 397 Ft

Lowest Elevation: 23 Ft

Total Length of Open Channel: 14,561 Ft

Total Length of Storm Drainage Pipes: 99,331 Ft

Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Chinook*+

Coho+

Cutthroat trout

Sockeye

* Listed Federal Endangered Species

\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

City Basin Population (2000): 5,660 (5.1% of the City)

Basin Population Density: 4,018 People/Square Mile

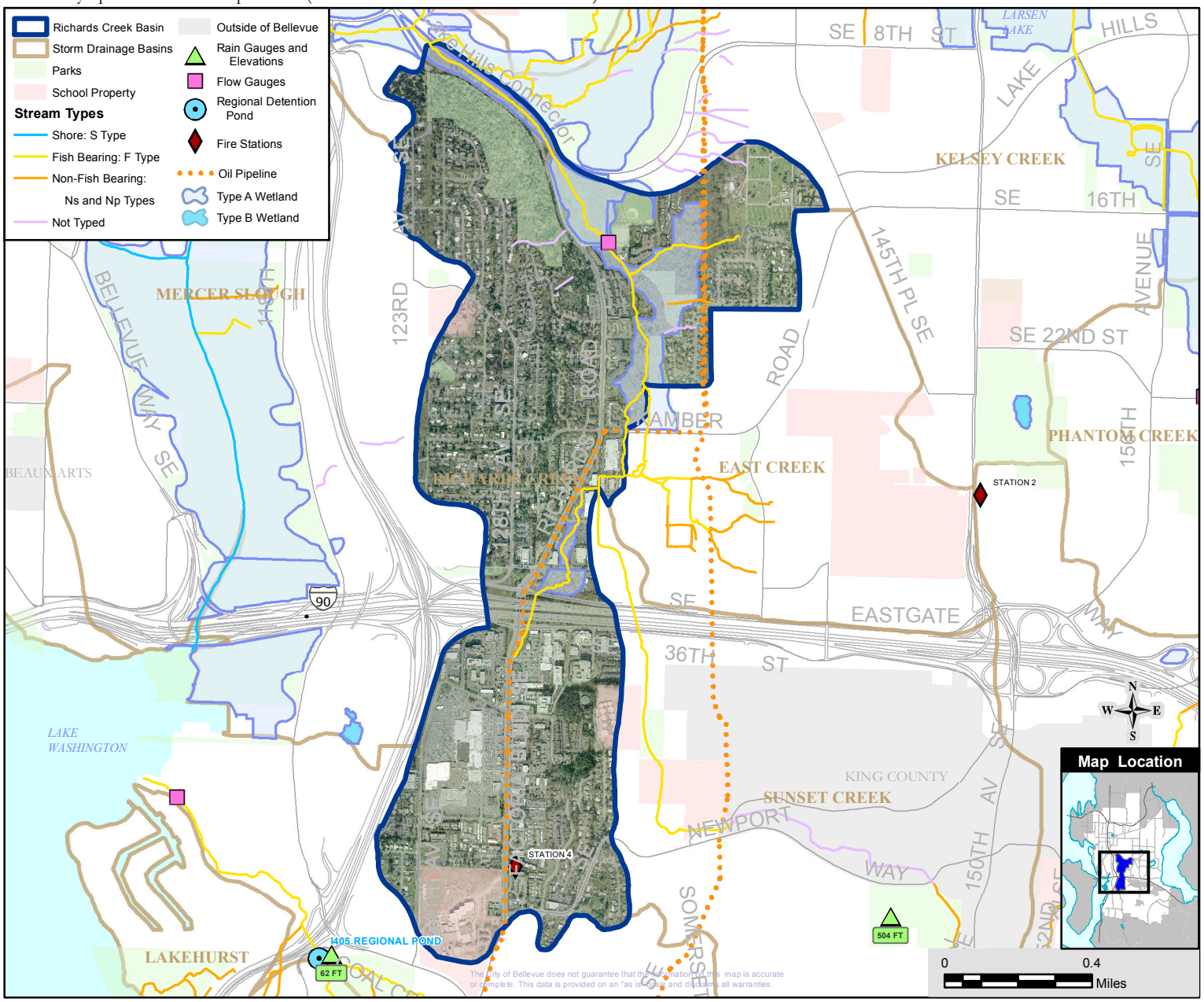
Number 17 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	16.96%	152.88 Acres
Commercial/Office:	10.79%	97.2 Acres
Industrial:	1.63%	14.7 Acres
Institutional/Government:	10.59%	95.5 Acres
Mixed Use/Misc:	7.20%	64.9 Acres
Multi-Family Residential:	12.23%	110.3 Acres
Open Space/Park:	4.50%	40.6 Acres
Single Family Residential:	27.41%	247.1 Acres

LAND COVER

Impervious:	45%
Tree Canopy:	36%
Impervious in 100 Ft Stream Buffer:	22%
Tree Canopy in 100 Ft Stream Buffer:	62%



The City of Bellevue does not guarantee that the information on this map is accurate or complete. This data is provided on an "as is" basis and disclaims all warranties.

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Plot Date: 8/4/2011

Rosemont Area
Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 432 Total Acres (2% of the City)
Drainage Jurisdiction(s):
431.4 Acres - in Bellevue
0.2 Acres - in Redmond

Highest Elevation: 444 Ft
Lowest Elevation: 30 Ft

Total Length of Open Channel: 1,436 Ft
Total Length of Storm Drainage Pipes: 47,399 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+ , Kokanee+, Sockeye
Rainbow & cutthroat trout (Lake only)
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

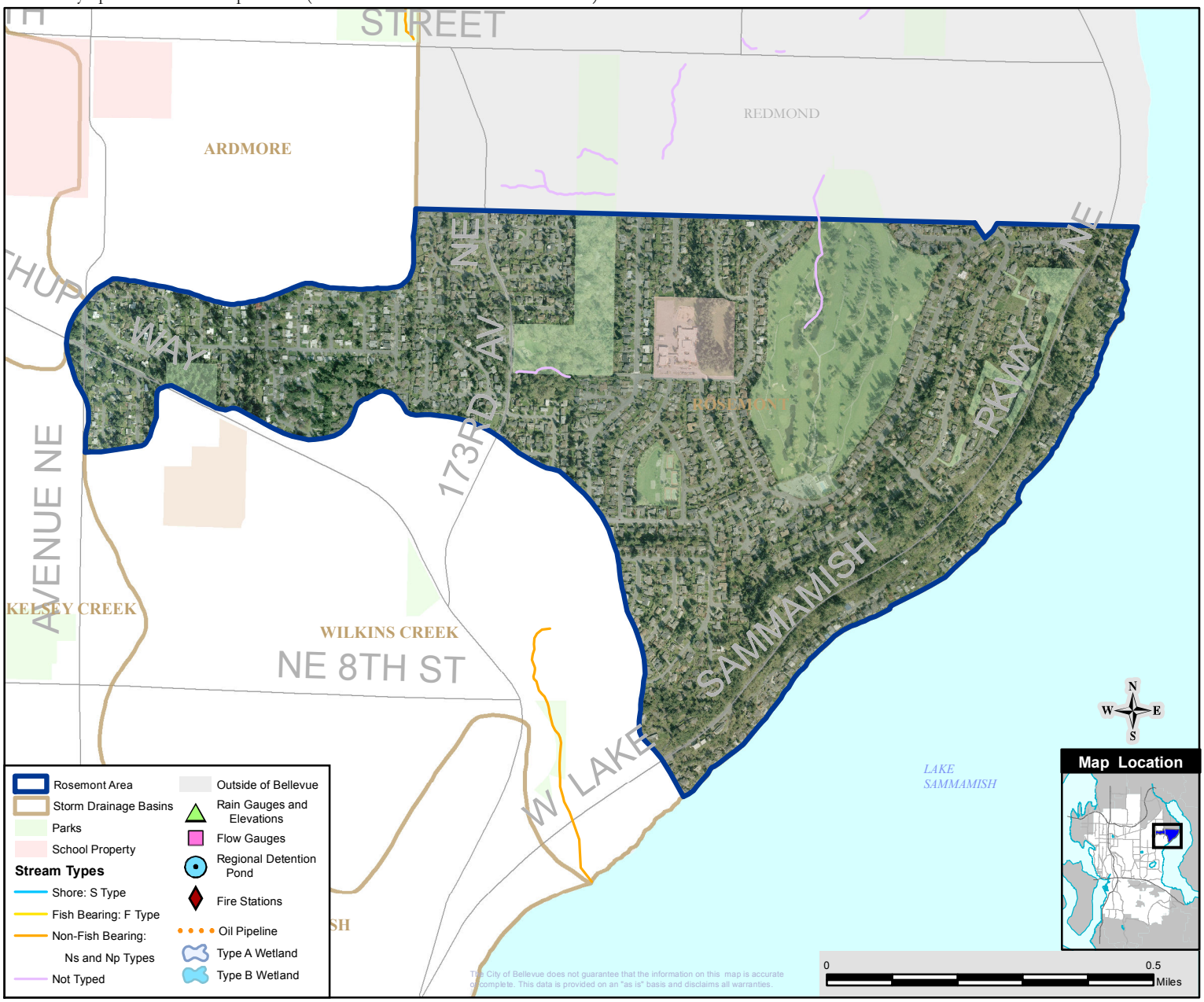
City Basin Population (2000): 2,939 (2.6% of the City)
Basin Population Density: 4,354 People/Square Mile
Number 21 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	16.06%	69.45 Acres
Commercial/Office:	0.09%	0.4 Acres
Institutional/Government:	2.27%	9.8 Acres
Multi-Family Residential:	0.16%	0.7 Acres
Open Space/Park:	4.21%	18.2 Acres
Single Family Residential:	60.71%	261.9 Acres
Mixed Use/Misc:	2.08%	9.0 Acres

LAND COVER

Impervious:	38%
Tree Canopy:	31%
Impervious in 100 Ft Stream Buffer:	6%
Tree Canopy in 100 Ft Stream Buffer:	55%



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Plot Date: 8/9/2011

Sears Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0267

LAND CHARACTERISTICS

Basin Area: 577 Total Acres (2% of the City)
Drainage Jurisdiction(s):
357.5 Acres - in Bellevue
219.9 Acres - in Redmond

Highest Elevation: 444 Ft
Lowest Elevation: 190 Ft

Total Length of Open Channel: 1,878 Ft
Total Length of Storm Drainage Pipes: 43,564 Ft
Built Rain Storage Volume per Acre of Impervious Surface: 0.9 Inches

SALMON PRESENT in BASIN

Chinook*+
Coho+
Cutthroat trout
Sockeye

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

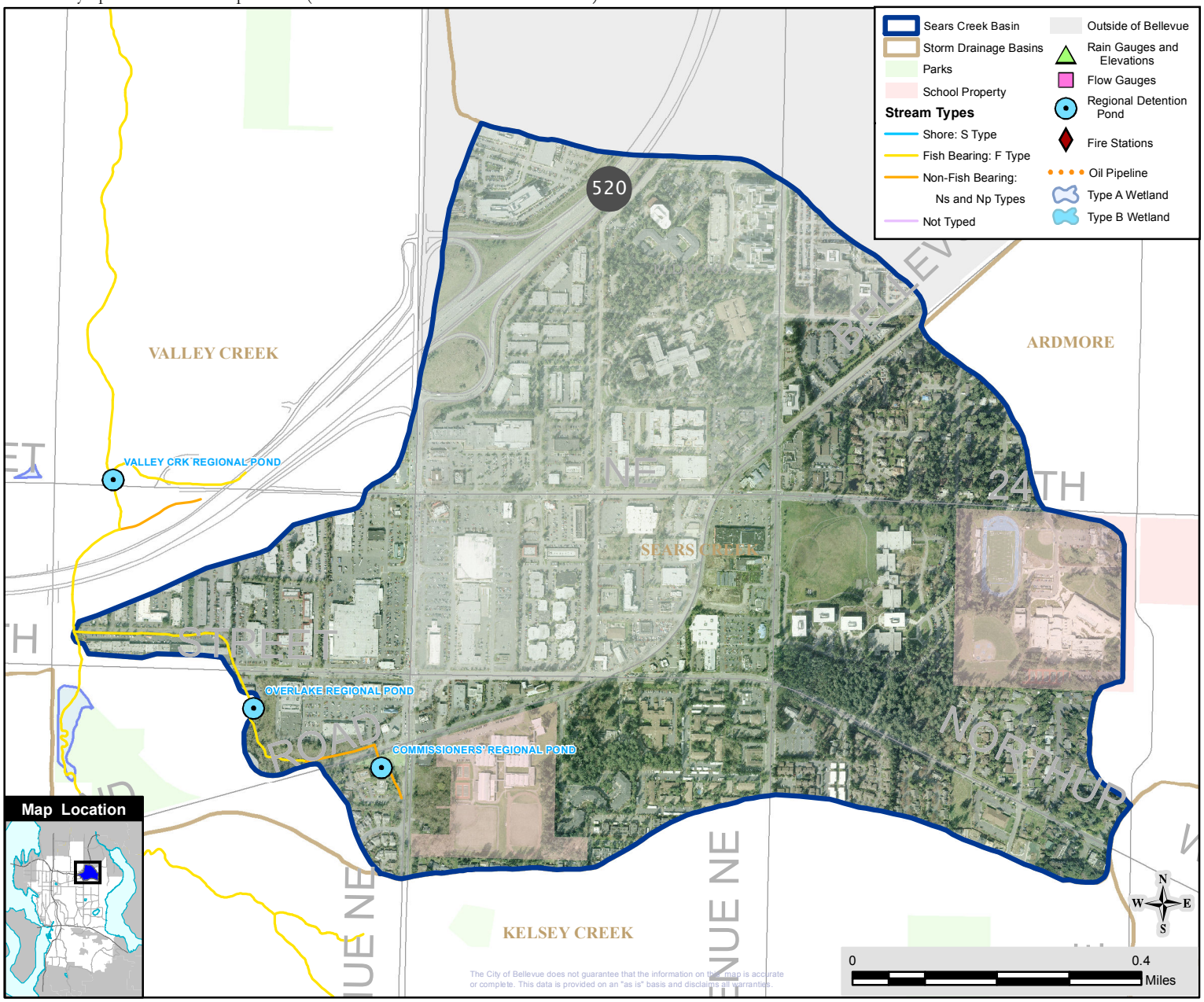
City Basin Population (2000): 2,391 (2.1% of the City)
Basin Population Density: 3,156 People/Square Mile
Number 13 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	7.27%	42.00 Acres
Commercial/Office:	22.21%	79.4 Acres
Mixed Use/Misc:	12.02%	43.0 Acres
Industrial:	1.10%	3.9 Acres
Institutional/Government:	18.37%	65.7 Acres
Multi-Family Residential:	10.64%	38.0 Acres
Open Space/Park:	0.54%	1.9 Acres
Single Family Residential:	12.58%	45.0 Acres

LAND COVER

Impervious:	63%
Tree Canopy:	21%
Impervious in 100 Ft Stream Buffer:	52%
Tree Canopy in 100 Ft Stream Buffer:	44%



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Plot Date: 8/9/2011

South Sammamish Area

Lake Washington Watershed (WRIA 8)
State Stream #08-0160, 08-0161

LAND CHARACTERISTICS

Basin Area: 593 Total Acres (2% of the City)
Drainage Jurisdiction(s):
336.9 Acres - in Bellevue
16.4 Acres - in Issaquah
238.5 Acres - in King County

Highest Elevation: 799 Ft
Lowest Elevation: 30 Ft

Total Length of Open Channel: 17,488 Ft
Total Length of Storm Drainage Pipes: 28,395 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+ , Kokanee+, Sockeye
Rainbow & cutthroat trout
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

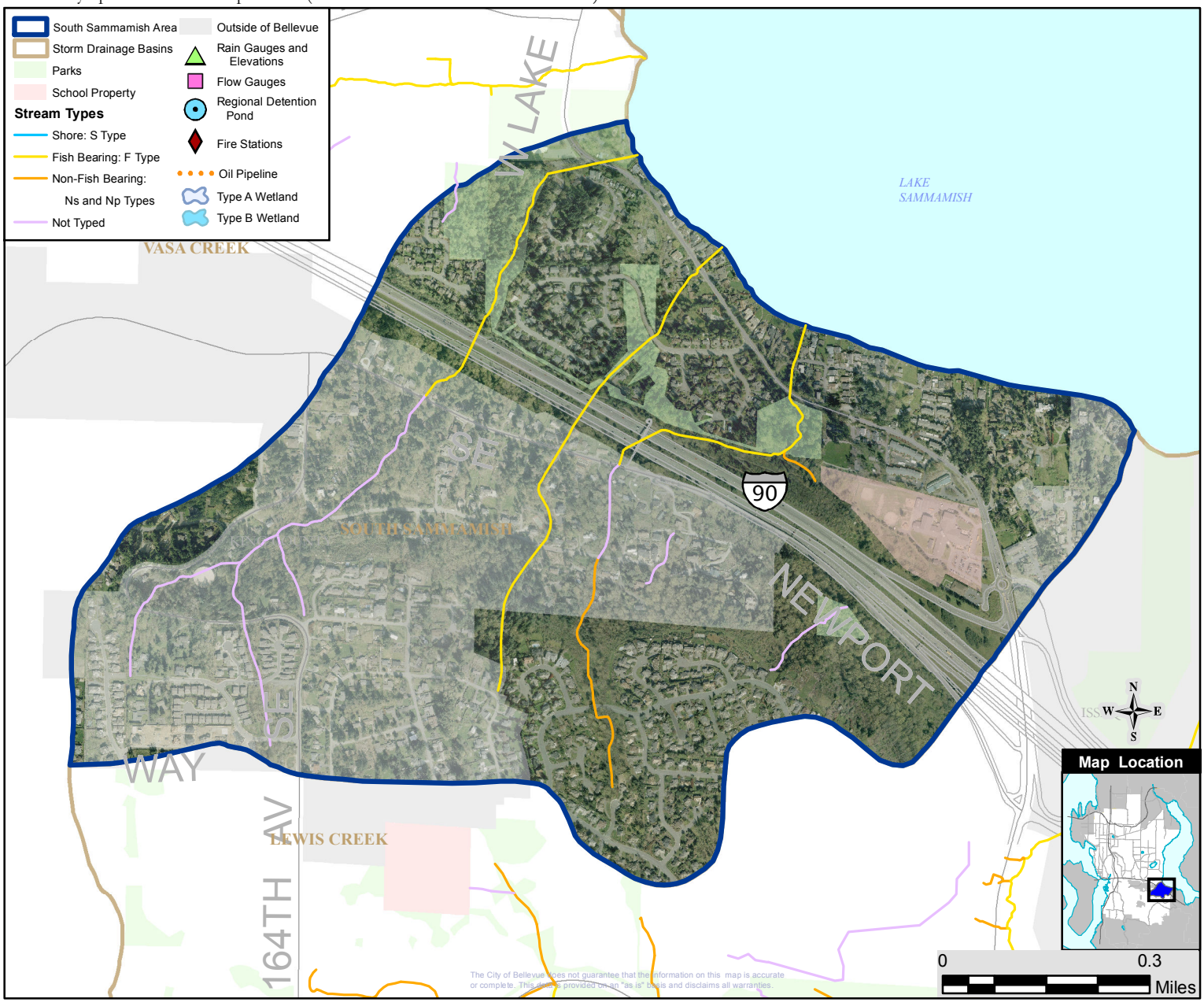
City Basin Population (2000): 1,689 (1.5% of the City)
Basin Population Density: 2,755 People/Square Mile
Number 11 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	22.48%	133.32 Acres
Institutional/Government:	3.65%	12.3 Acres
Multi-Family Residential:	1.53%	5.2 Acres
Open Space/Park:	5.69%	19.2 Acres
Single Family Residential:	41.65%	140.3 Acres
Mixed Use/Misc:	2.80%	9.4 Acres

LAND COVER

Impervious:	31%
Tree Canopy:	48%
Impervious in 100 Ft Stream Buffer:	16%
Tree Canopy in 100 Ft Stream Buffer:	75%



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Plot Date: 8/9/2011

Spirit Ridge Area
Lake Washington Watershed (WRIA 8)

LAND CHARACTERISTICS

Basin Area: 193 Total Acres (1% of the City)
Drainage Jurisdiction(s):
192.1 Acres - in Bellevue

Highest Elevation: 350 Ft
Lowest Elevation: 31 Ft

Total Length of Open Channel: 0 Ft
Total Length of Storm Drainage Pipes: 20,544 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+ , Kokanee+, Sockeye
Rainbow & cutthroat trout (Lake only)
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

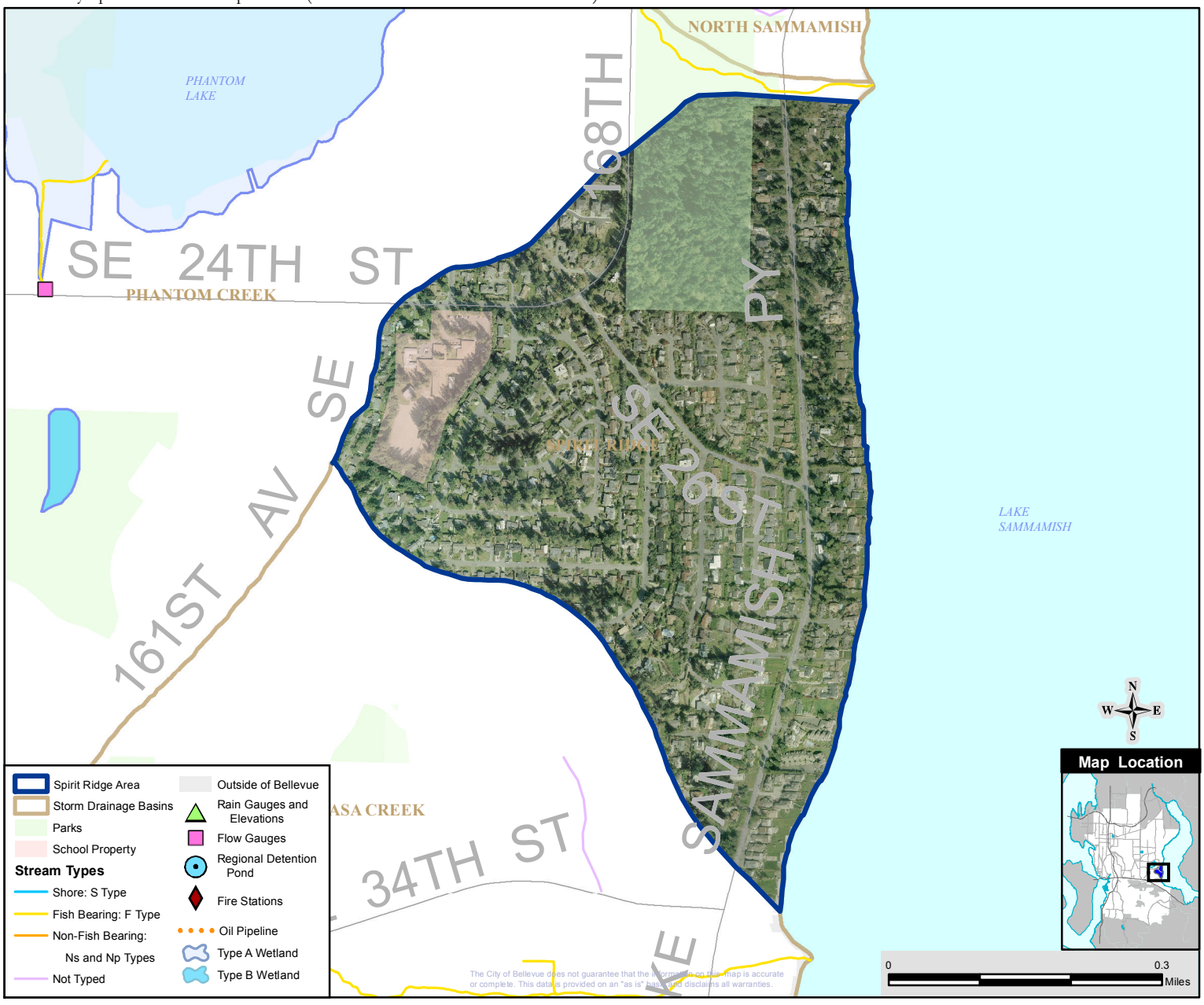
City Basin Population (2000): 1,274 (1.1% of the City)
Basin Population Density: 4,230 People/Square Mile
Number 19 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	15.89%	30.68 Acres
Institutional/Government:	4.30%	8.3 Acres
Multi-Family Residential:	1.32%	2.5 Acres
Commercial/Office:	0.03%	0.1 Acres
Open Space/Park:	10.06%	19.3 Acres
Single Family Residential:	65.45%	125.8 Acres
Mixed Use/Misc:	0.54%	1.0 Acres

LAND COVER

Impervious:	40%
Tree Canopy:	34%
Impervious in 100 Ft Stream Buffer:	24%
Tree Canopy in 100 Ft Stream Buffer:	86%



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Plot Date: 8/4/2011

Sturtevant Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0260

LAND CHARACTERISTICS

Basin Area: 773 Total Acres (4% of the City)
Drainage Jurisdiction(s):
773.0 Acres - in Bellevue

Highest Elevation: 248 Ft
Lowest Elevation: 19 Ft

Total Length of Open Channel: 4,038 Ft
Total Length of Storm Drainage Pipes: 90,833 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Chinook*+ Sockeye
Coho+
Cutthroat trout

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

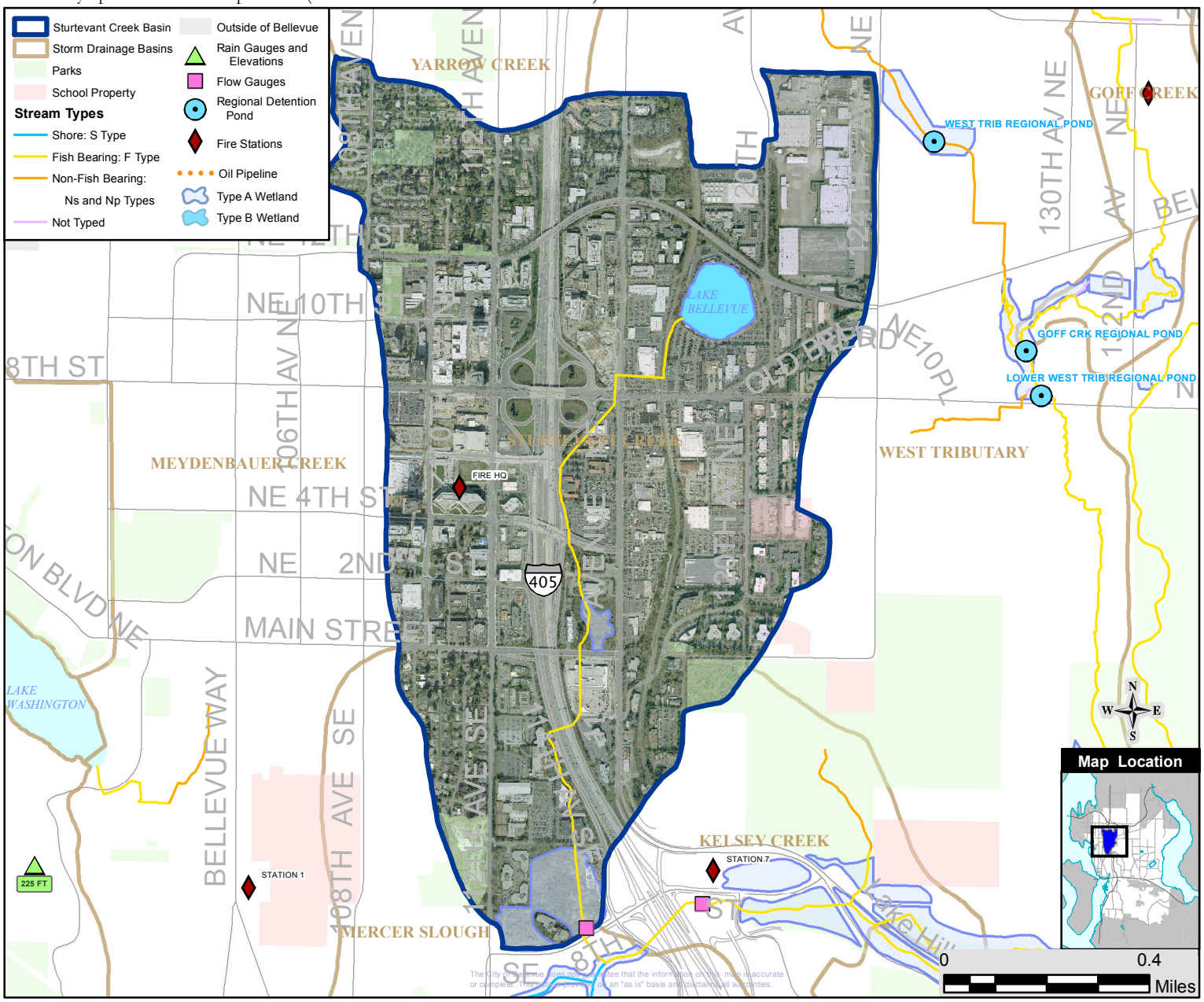
City Basin Population (2000): 2,182 (1.9% of the City)
Basin Population Density: 1,806 People/Square Mile
Number 2 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	24.80%	191.68 Acres
Commercial/Office:	35.64%	275.5 Acres
Mixed Use/Misc:	8.21%	63.5 Acres
Industrial:	7.19%	55.6 Acres
Institutional/Government:	4.04%	31.2 Acres
Multi-Family Residential:	2.71%	20.9 Acres
Open Space/Park:	3.34%	25.8 Acres
Single Family Residential:	8.02%	62.0 Acres

LAND COVER

Impervious:	71%
Tree Canopy:	18%
Impervious in 100 Ft Stream Buffer:	62%
Tree Canopy in 100 Ft Stream Buffer:	23%



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Plot Date: 8/9/2011

Sunset Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0262

LAND CHARACTERISTICS

Basin Area: 890 Total Acres (3% of the City)
Drainage Jurisdiction(s):
536.6 Acres - in Bellevue
353.8 Acres - in King County

Highest Elevation: 1,059 Ft
Lowest Elevation: 63 Ft

Total Length of Open Channel: 9,830 Ft
Total Length of Storm Drainage Pipes: 87,054 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 inches

SALMON PRESENT in BASIN

Chinook*+ Sockeye
Coho+ Steelhead
Cutthroat Trout

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

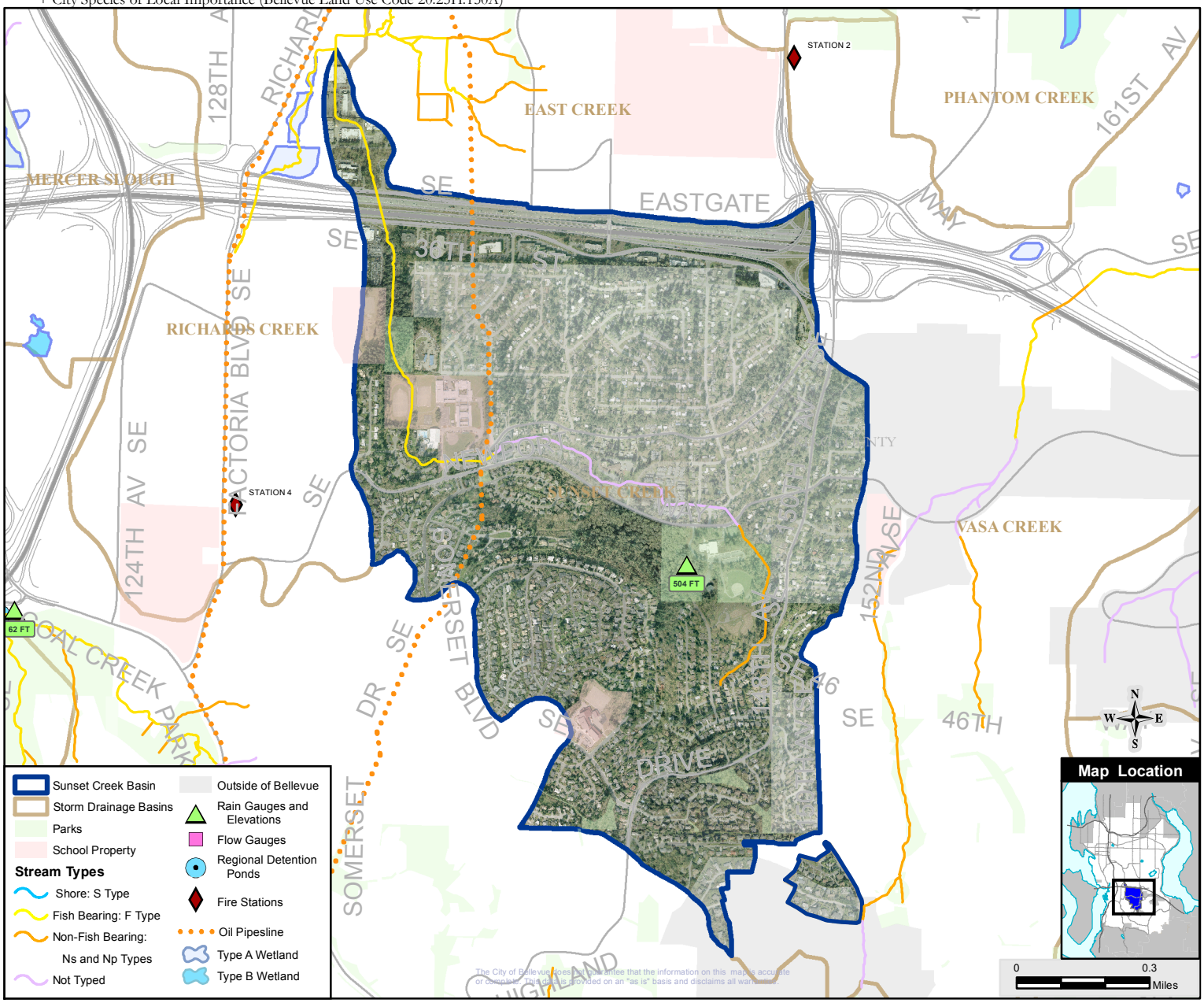
City Basin Population (2000): 3,174 (2.8% of the City)
Basin Population Density: 4,126 People/Square Mile
Number 18 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	25.87%	216.5 Acres
Commercial/Office:	4.39%	23.3 Acres
Industrial:	0.98%	5.2 Acres
Institutional/Government:	14.77%	78.6 Acres
Mixed Use/Misc:	4.05%	21.7 Acres
Multi-Family Residential:	0.38%	2.0 Acres
Open Space/Park:	2.89%	15.4 Acres
Single Family Residential:	44.2%	237.1 Acres

LAND COVER

Impervious:	42%
Tree Canopy:	35%
Impervious in 100 Ft Stream Buffer:	28%
Tree Canopy in 100 Ft Stream Buffer:	60%



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Updated: 8/4/2009

Valley Creek Basin

Lake Washington Watershed (WRIA 8)

State Stream #08-0266

LAND CHARACTERISTICS

Basin Area: 1,391 Total Acres (6% of the City)

Drainage Jurisdiction(s):

1,307.0 Acres - in Bellevue

29.4 Acres - in King County

3.1 Acres - in Kirkland

51.4 Acres - in Redmond

Highest Elevation: 529 Ft

Lowest Elevation: 182 Ft

Total Length of Open Channel: 17,290 Ft

Total Length of Storm Drainage Pipes: 76,677 Ft

Built Rain Storage Volume per Acre of Impervious Surface: 0.8 Inches

SALMON PRESENT in BASIN

Chinook*+ Sockeye

Coho+

Cutthroat trout

* Listed Federal Endangered Species

\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

City Basin Population (2000): 7,605 (6.8% of the City)

Basin Population Density: 3,683 People/Square Mile

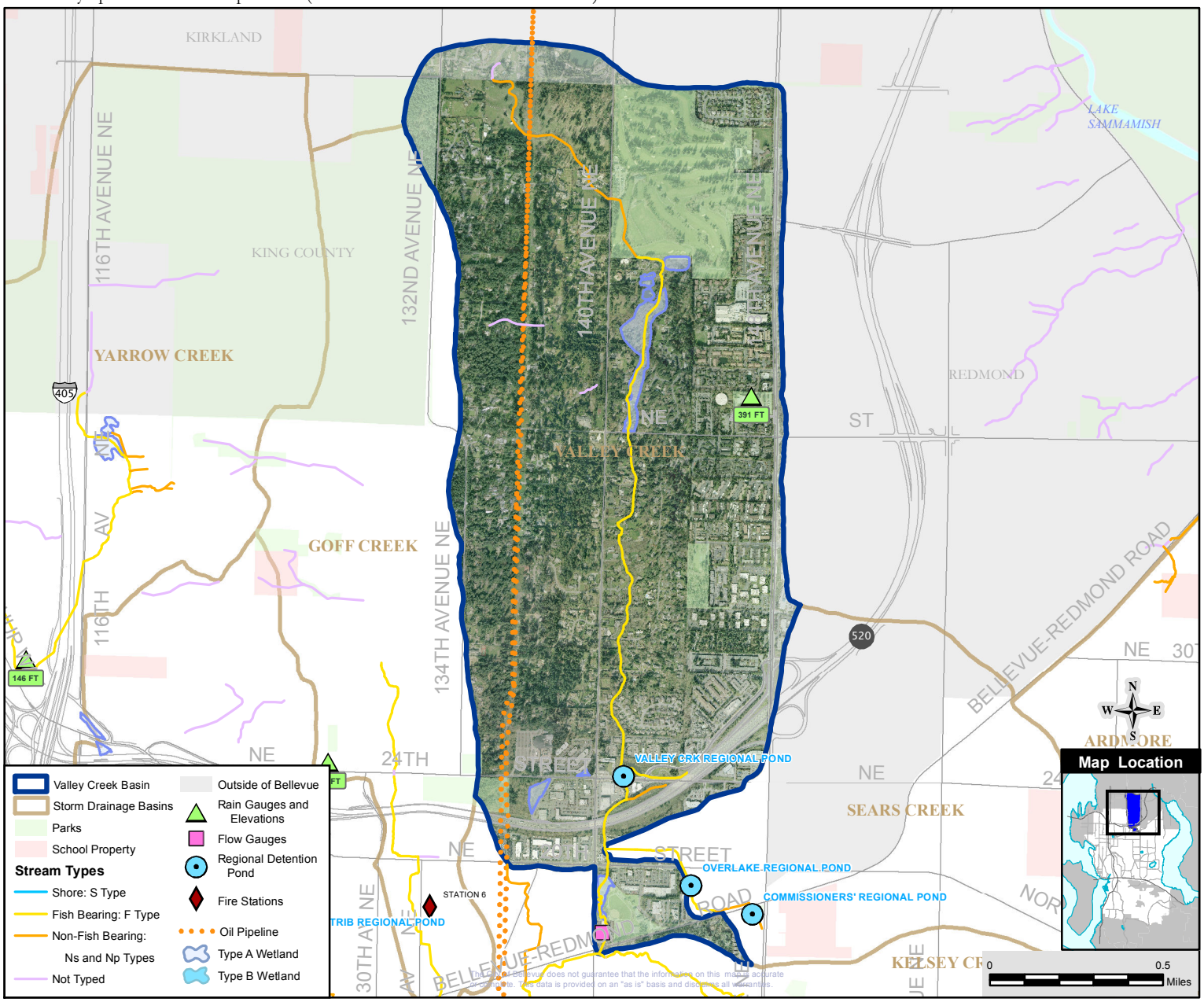
Number 15 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	9.34%	129.89 Acres
Commercial/Office:	6.19%	81.0 Acres
Industrial:	0.22%	2.9 Acres
Institutional/Government:	0.83%	10.9 Acres
Mixed Use/Misc:	2.56%	33.5 Acres
Multi-Family Residential:	11.35%	148.3 Acres
Open Space/Park:	14.67%	191.7 Acres
Single Family Residential:	46.50%	607.7 Acres

LAND COVER

Impervious:	34%
Tree Canopy:	42%
Impervious in 100 Ft Stream Buffer:	20%
Tree Canopy in 100 Ft Stream Buffer:	56%



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Plot Date: 8/10/2011

Vasa Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0156

LAND CHARACTERISTICS

Basin Area: 1,085 Total Acres (4% of the City)
Drainage Jurisdiction(s):
841.0 Acres - in Bellevue
243.9 Acres - in King County

Highest Elevation: 1,195 Ft
Lowest Elevation: 31 Ft

Total Length of Open Channel: 18,002 Ft
Total Length of Storm Drainage Pipes: 103,034 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

SALMON PRESENT in BASIN

Chinook*+ (Lake only)
Rainbow & cutthroat trout
Coho+
Sockeye (Lake only)
Kokanee+
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

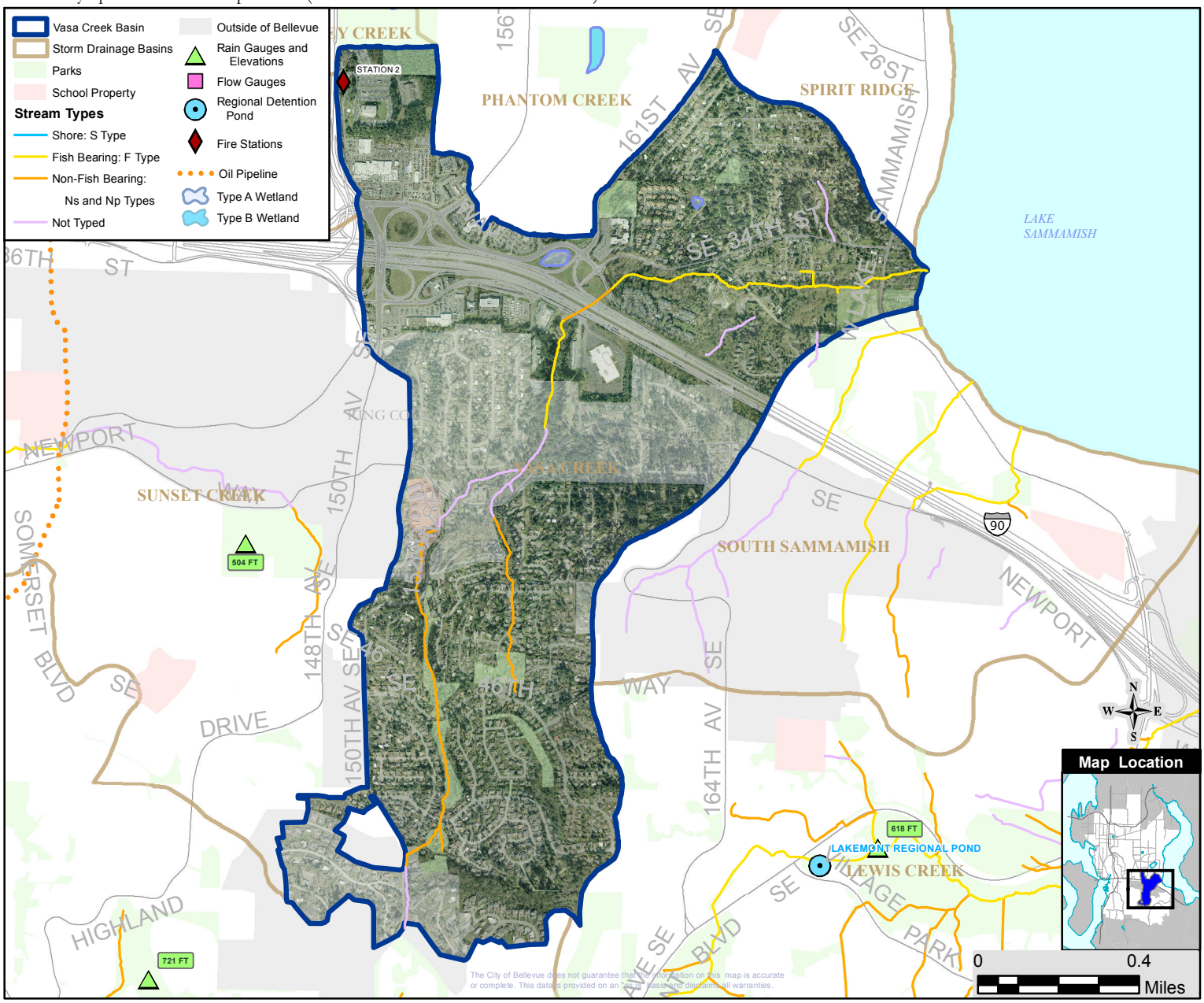
City Basin Population (2000): 4,586 (4.1% of the City)
Basin Population Density: 3,504 People/Square Mile
Number 14 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	23.12%	250.97 Acres
Commercial/Office:	8.12%	68.3 Acres
Mixed Use/Misc:	2.94%	24.7 Acres
Industrial:	0.43%	3.6 Acres
Institutional/Government:	5.48%	46.1 Acres
Multi-Family Residential:	3.77%	31.7 Acres
Open Space/Park:	2.43%	20.5 Acres
Single Family Residential:	46.13%	387.9 Acres

LAND COVER

Impervious:	40%
Tree Canopy:	40%
Impervious in 100 Ft Stream Buffer:	17%
Tree Canopy in 100 Ft Stream Buffer:	73%



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Plot Date: 8/9/2011

West Tributary Basin

Lake Washington Watershed (WRIA 8)

State Stream #08-0264

LAND CHARACTERISTICS

Basin Area: 1,006 Total Acres (5% of the City)

Drainage Jurisdiction(s):

1,005.8 Acres - in Bellevue

Highest Elevation: 496 Ft

Lowest Elevation: 26 Ft

Total Length of Open Channel: 18,121 Ft

Total Length of Storm Drainage Pipes: 86,842 Ft

Built Rain Storage Volume per Acre of Impervious Surface: 1.2 Inches

SALMON PRESENT in BASIN

Chinook*+

Sockeye

Migratory & resident cutthroat trout

Coho+

* Listed Federal Endangered Species

\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

City Basin Population (2000): 3,329 (3.0% of the City)

Basin Population Density: 2,118 People/Square Mile

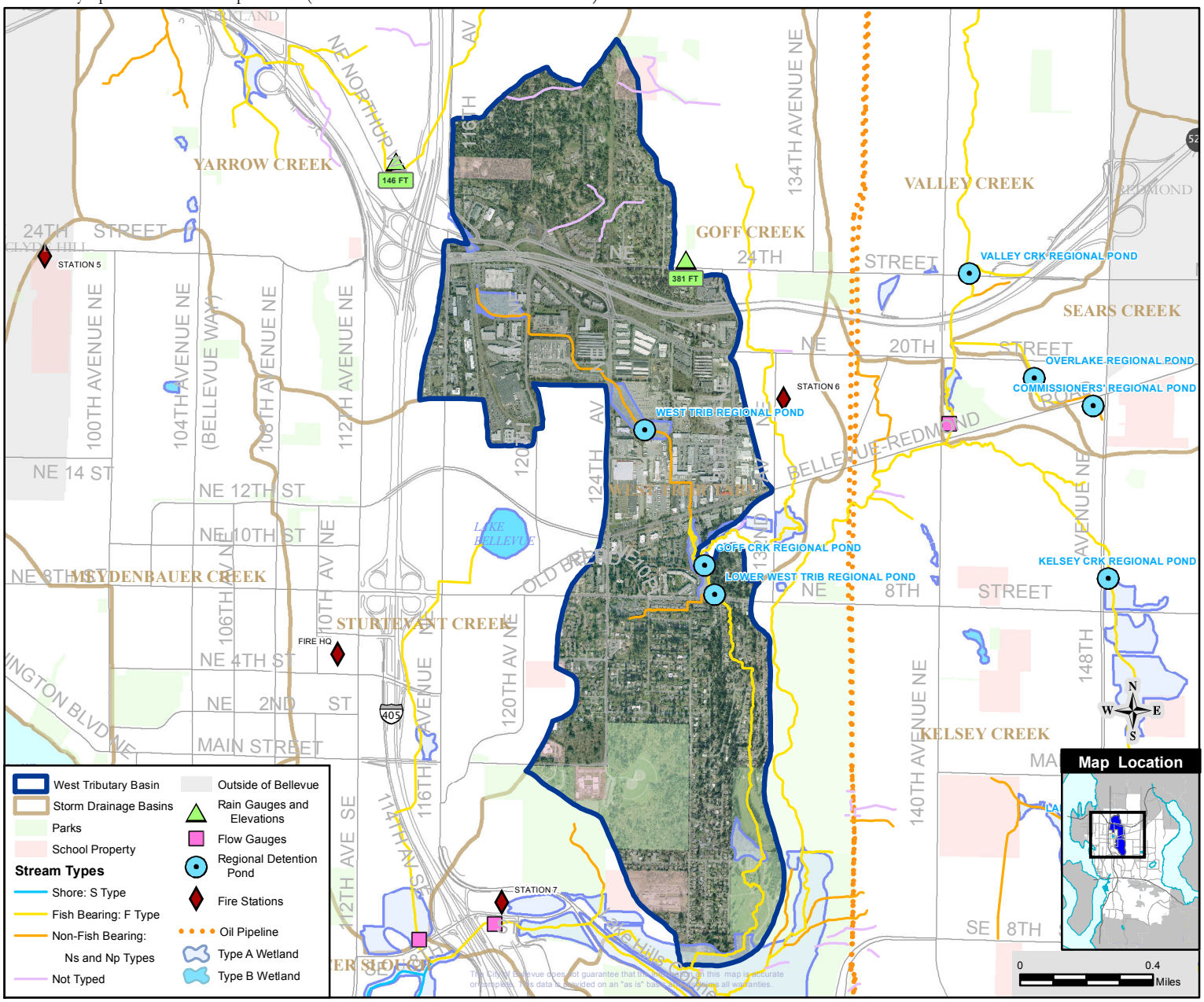
Number 7 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	16.18%	162.73 Acres
Commercial/Office:	9.03%	90.9 Acres
Industrial:	15.09%	151.8 Acres
Institutional/Government:	4.62%	46.5 Acres
Mixed Use/Misc:	4.54%	45.7 Acres
Multi-Family Residential:	4.84%	48.7 Acres
Open Space/Park:	12.46%	125.3 Acres
Single Family Residential:	29.34%	295.1 Acres

LAND COVER

Impervious:	46%
Tree Canopy:	34%
Impervious in 100 Ft Stream Buffer:	28%
Tree Canopy in 100 Ft Stream Buffer:	49%



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Plot Date: 8/9/2011

Wilkins Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0151

LAND CHARACTERISTICS

Basin Area: 306 Total Acres (1% of the City)
Drainage Jurisdiction(s):
305.4 Acres - in Bellevue

Highest Elevation: 446 Ft
Lowest Elevation: 31 Ft

Total Length of Open Channel: 1,654 Ft
Total Length of Storm Drainage Pipes: 43,625 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
0 Inches

SALMON PRESENT in BASIN

Lake only: Chinook*+, Coho+ , Kokanee+, Sockeye
Rainbow & cutthroat trout (Lake only)
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

POPULATION

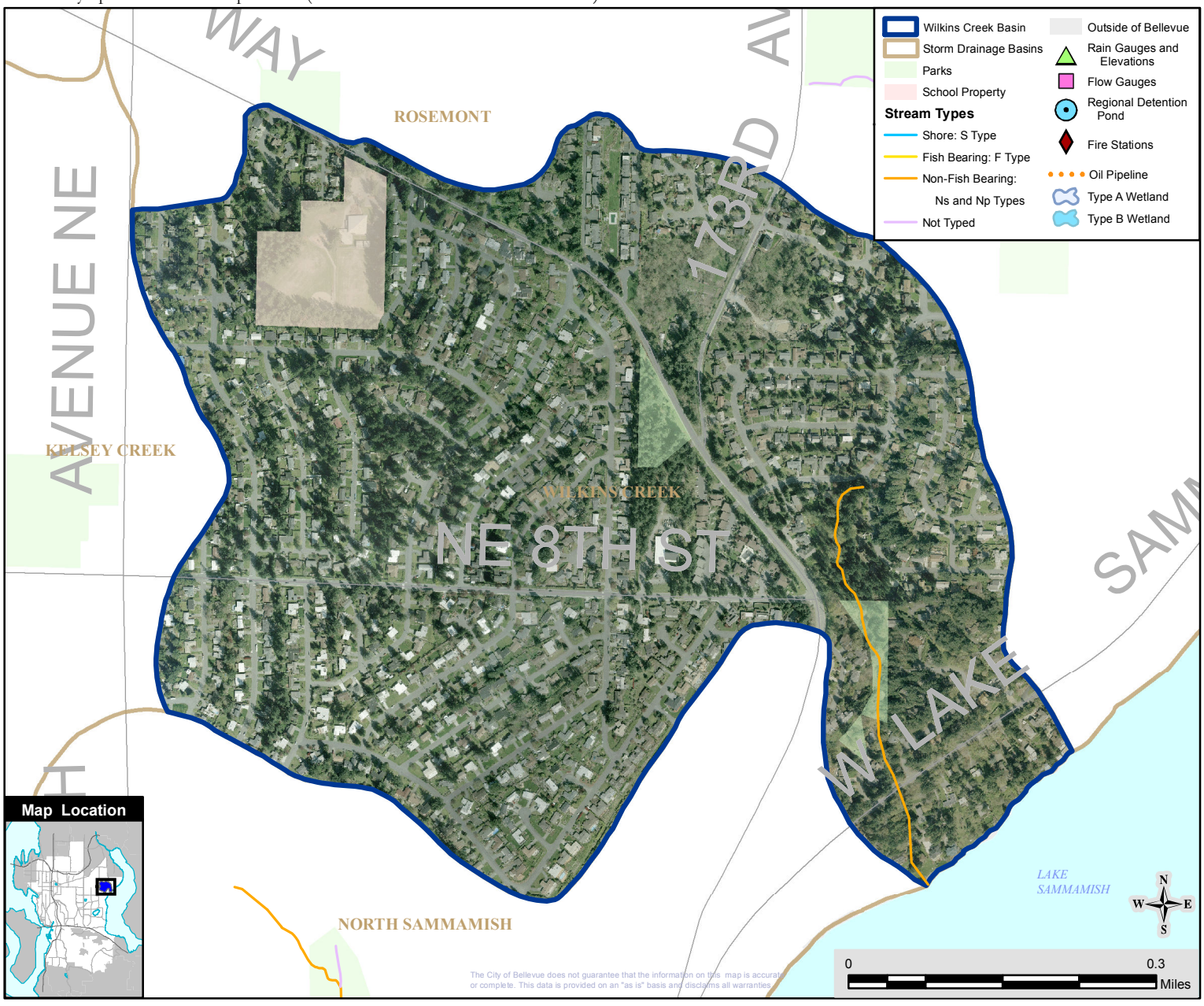
City Basin Population (2000): 2,560 (2.3% of the City)
Basin Population Density: 5,363 People/Square Mile
Number 25 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	21.24%	64.91 Acres
Institutional/Government:	2.84%	8.7 Acres
Mixed Use/Misc:	0.86%	2.6 Acres
Multi-Family Residential:	3.60%	11.0 Acres
Open Space/Park:	3.81%	11.6 Acres
Single Family Residential:	65.23%	199.2 Acres

LAND COVER

Impervious:	41%
Tree Canopy:	29%
Impervious in 100 Ft Stream Buffer:	16%
Tree Canopy in 100 Ft Stream Buffer:	77%



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Plot Date: 8/9/2011

Yarrow Creek Basin

Lake Washington Watershed (WRIA 8)
State Stream #08-0252

LAND CHARACTERISTICS

Basin Area: 1,667 Total Acres (5% of the City)
Drainage Jurisdiction(s):
926.4 Acres - in Bellevue
0.8 Acres - in Clyde Hill
281.2 Acres - in King County
457.1 Acres - in Kirkland

Highest Elevation: 534 Ft
Lowest Elevation: 9 Ft

Total Length of Open Channel: 25,143 Ft
Total Length of Storm Drainage Pipes: 78,411 Ft
Built Rain Storage Volume per Acre of Impervious Surface:
Less than 0.5 Inches

POPULATION

City Basin Population (2000): 3,772 (3.4% of the City)
Basin Population Density: 1,911 People/Square Mile
Number 4 of 26 Basins (One is the lowest density)

LAND USE (within Bellevue city limits)

Public Right of Way:	16.49%	274.94 Acres
Commercial/Office:	10.23%	94.8 Acres
Industrial:	1.73%	16.0 Acres
Institutional/Government:	2.25%	20.9 Acres
Mixed Use/Misc:	5.49%	50.9 Acres
Multi-Family Residential:	6.87%	63.6 Acres
Open Space/Park:	2.52%	23.3 Acres
Single Family Residential:	39.36%	364.6 Acres

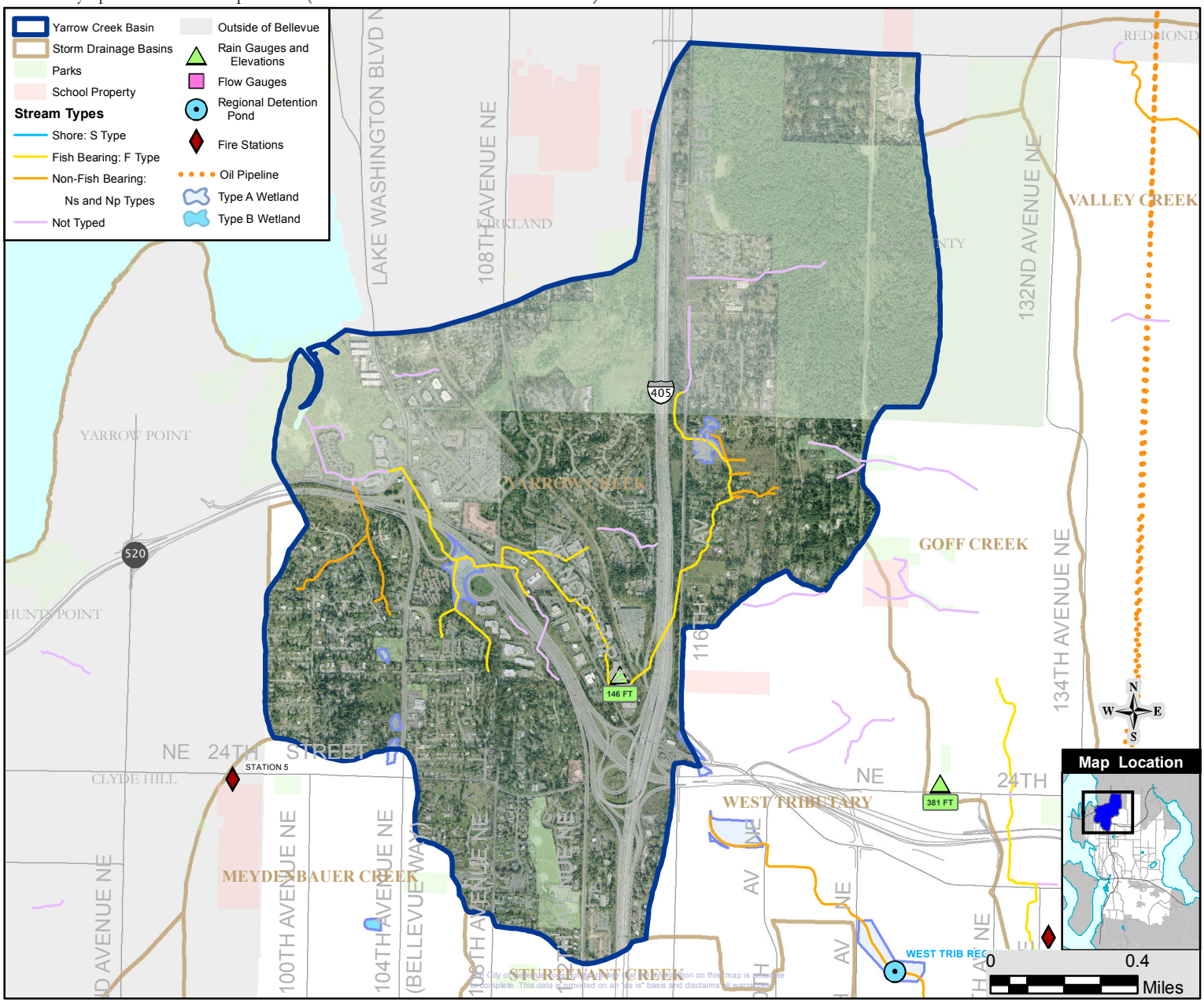
SALMON PRESENT in BASIN

Chinook*+ (Lake only)
Rainbow trout (Lake only)
Coho+ (Lake only)
Sockeye (Lake only)
Cutthroat trout
Steelhead (Lake only)

* Listed Federal Endangered Species
\+ City Species of Local Importance (Bellevue Land Use Code 20.25H.150A)

LAND COVER

Impervious:	31%
Tree Canopy:	53%
Impervious in 100 Ft Stream Buffer:	27%
Tree Canopy in 100 Ft Stream Buffer:	58%



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Plot Date: 8/9/2011

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	>5	6	16	20	No	Yes	Low	Fair	ND	20	√	√	√
East Creek	0	0*	<2		45	48	No	No	High	Poor	Poor	ND		√	√
Goff Creek	0	0	<2		46	30	No	No	High	ND	ND	18		√	√
Kelsey Creek	2	1	3-4	7	57	40	No	Yes	High	Poor	Poor	18	√	√	√
Lewis Creek	1	0	<2		4	29	Yes	Yes	Medium	ND	ND	20	√	√	√
Mercer Slough	0	0	<2	2	38	32	No	Yes	Medium	ND	ND	NA	√	√	
Newport Area	0	0	3-4		82	39	No	No	Low	ND	ND	16	√	√	√
Richards Creek	1*	0	3-4	4	32	45	No	No	High	Poor	Poor	ND	√	√	√
Valley Creek	0	0	<2	1	36	34	No	No	High	Poor	Poor	16	√	√	√
Vasa Creek	0	0	3-4	1	36	40	Yes	No	Medium	ND	ND	24	√	√	√
West Tributary	0	0	3-4	2	51	46	No	No	High	ND	ND	18	√	√	√
Small and Steep Stream Basins															
Ardmore	0	0	<2		63	43	Yes	Yes	Low	ND	ND	22		√	√
Lakehurst	0	0	<2	3	37	33	No	No	Low	ND	ND	20	√		√
North Sammamish	0	0	<2	2	56	32	Yes	No	Low	NA	NA	NA	√		
Phantom Creek	0	0	<2	1	35	35	Yes	No	Low	ND	ND	26	√		√
Sunset Creek	0	1	>5		47	42	No	No	High	Poor	Poor	14	√	√	√
South Sammamish	0	0	<2		22	31	Yes	No	Low	ND	ND	ND			
Wilkins Creek	0	0	<2	2	76	41	Yes	No	Low	ND	ND	22	√		√
Yarrow Creek	0	0	3-4	2	40	31	No	Yes	High	ND	ND	ND	√	√	√
Closed Conveyance System Basins (>96% piped storm drainage system)															
Beaux Arts Area	0	1	<2		53	34	No	No	NA	NA	NA	NA	√		
Clyde Beach	0	0	<2	1	62	47	No	No	NA	NA	NA	NA	√		
Meydenbauer Creek	0	0	>5	4	48	59	No	Yes (Bay)	Medium	ND	ND	ND	√	√	
Rosemont Area	1	0	3-4	8	55	38	Yes	No	NA	NA	NA	NA	√		
Sears Creek	0	0	<2		32	63	No	No	High	ND	ND	ND		√	
Spirit Ridge	0	0	3-4	2	65	40	Yes	No	NA	NA	NA	NA	√	√	
Sturtevant Creek	0	0	<2	2	34	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 9/30/2009 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	2	Few		
Beaux Arts	0	Few		
Clyde Beach	2	Few	*	
Coal Creek	5	Many	*	Maintenance surveillance; Capital Investment Program (CIP) flood control projects
East Creek	1	Few		CIP flood control projects
Goff Creek	1	Few		
Kelsey Creek	4	Moderate	*	Maintenance surveillance; CIP flood control projects; acquisition
Lakehurst	1	Few	*	Maintenance surveillance
Lewis Creek	2	Few		Maintenance surveillance; acquisition
Mercer Slough	2	Few	*	
Meydenbauer Creek	13	Many	*	Maintenance surveillance
Newport	3	Moderate		Maintenance surveillance
North Sammamish	1	Few	*	Maintenance surveillance
Rosemont	4	Moderate	*	Maintenance surveillance
Sears Creek	0	Few		
South Sammamish	2	Few		
Spirit Ridge	3	Moderate	*	Maintenance surveillance
Sturtevant Creek	0	Few	*	Maintenance surveillance
Sunset Creek	5	Many		Maintenance surveillance; CIP flood control projects
Valley Creek	1	Few	*	
Vasa Creek	4	Moderate		
West Tributary	3	Moderate	*	
Wilkins Creek	1	Few	*	
Yarrow Creek	3	Moderate	*	Maintenance surveillance; CIP flood control projects
Total	68			

***Few (0-2); Moderate (3-4); Many (≥5)**

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				
I-405 Pond (Coal Creek Basin)[3]	19.5	4550			72.5	585		
Lakemont (Lewis Creek Basin)[4]	31.6	252.4	85.1	0.37	634.6[5]			

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

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

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

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

[5] Emergency spillway overflow elevation.

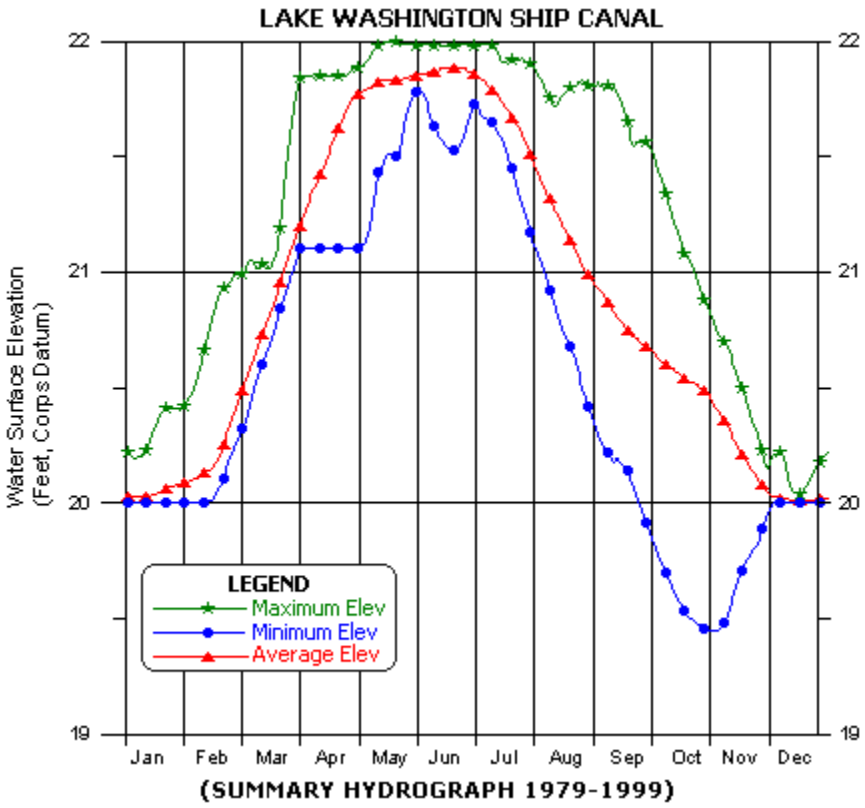
Appendix B-7. B-IBI Scores at Bellevue Sites in all Sampled Years.

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
Lewis	1.8	LewisUS/ravine	Lewis upstream of I-90				30		32		22	24	26	
Lewis	0.8	LewisI90	Lewis on Lakemont Blvd. at I-90	28	26	24	30		24	26	24	22		20
Lewis	0.3	LewisElliot	Lewis downstream of I-90						24	28	22		22	
Coal	4.0	Cindermines	Coal off Newcastle Road at cinder mine detention site	32	20	22			30	30	24	24		
Coal	2.3	Trailhead	Coal above Coal Creek Parkway	26	22	22			22	26	22	22	20	
Coal	1.8	CoalPkwy	Coal below Coal Creek Parkway	26	22	20						20		
Trib 0273	0.3	08EAS2540	Trib. 0273, upstream of Forest Dr. SE, trib. to Coal Creek										20	
Goff	1.7	GoffUsBp	Goff upstream of bypass	18	16	12								
Goff	1.6	GoffInBp	Goff in bypass area	18	18	14								
Goff	1.5	GoffDsBp	Goff downstream of bypass	18	14	18								
Goff	0.1	GoffMouth	Just upstream of confluence with West Trib.											18
Valley	0.2	Valley	Valley at Highland Park						18	16				
Kelsey	3.9	KelByrne	Kelsey upstream of Glendale Country Club (GCC) (1400 block 143rd Place NE)	20	18	16								
Kelsey	3.7	Peltzer	Upstream of Glendale 14434 NE 14th Bellevue						18	18		18	14	
Kelsey	3.6	WAM06600-038087	Kelsey downstream of Peltzer										18	
Kelsey	3.2	08EAS2272	Kelsey downstream of 140th Avenue NE near NE 15th St.										14	
Kelsey	2.3	KelWeirs	Kelsey at GCC within step weirs	12	10	10								
Kelsey	2.1	KelGCfb	Kelsey at GCC below step weirs	12	10	12								
Kelsey	1.8	Glendale	Kelsey at GCC wooded area	18	16	16		15	14	18		16	18	
Kelsey	1.6	KelFarm	Kelsey Farm						18				16	
Kelsey	0.2	KelTrstl	Kelsey under trestle and below culvert	16	18	14								
West Trib	0.4	WTribFarm	West Trib. in Kelsey Farm, restored reach										16	18
Sunset	0.3	08EAS2546	Sunset near SE 32nd St.									14		
Vasa	0.1	08LAK2827	Vasa between West Lake Sammamish Parkway and Lake Sammamish										24	
Idylwood	0.3	08LAK3121	Idylwood in Redmond, near 175th and NE 34th St.										22	
Lakehurst	0.3	Lkhrst405	Just upstream of pond, east of I-405											20

Stream	River Mile	Site Code	Location	1998	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Newport	0.4	NewpStab	Stabilized reach downstream of swim club on 119th											16
Phantom	0.2	PhanWeowna	Lower Phantom Lake, just upstream of West Lake Sammamish in Weowna Park											26
Wilkins	0.33	WilkUpstr	Upstream of Bypass, at NE 8th and Northup Way											22
Wilkins	0.26	WilkBypass	In bypass reach, near NE 8th and Northup Way											22

Appendix B-8. Lake Washington Average Water Levels over a Year based on Daily Measurements (collected at 8:00 a.m.) at the Ship Canal, Measured between 1979 and 1999.



Notes:

1. The Lake Washington Ship Canal is operated primarily as a navigation facility connecting Puget Sound and Lakes Union and Washington. Project authorization documents state that under normal operation the Lake Washington Ship Canal should be maintained within a 2-foot range between 20.0 feet and 22.0 feet (U.S. Army Corps of Engineers Datum), respectively. The minimum elevation is maintained during the winter months to allow for annual maintenance on docks, walls, etc., by businesses and lakeside residents, minimize wave and erosion damage during winter storms, and provide storage space for high inflow. The storage between 20 and 22 feet is used to augment Lake Washington Ship Canal inflows for use in operating the locks, the saltwater return system, the smolt passage flume, and the fish ladder facility.
2. The locks and spillway dam regulate the elevation of Salmon Bay, Lake Union, Lake Washington, and the Lake Washington Ship Canal. The level of Lake Washington was lowered about 8 feet by the construction of the Lake Washington Ship Canal, but it is still the second largest natural lake in the state, with a surface area of 22,138 acres and shoreline of about 91 miles at elevation 22 feet.

Source: U.S. Army Corps of Engineers (2004)

Appendix B-9. 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-9A 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-9A, 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-9A 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 PoortoFair. 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.

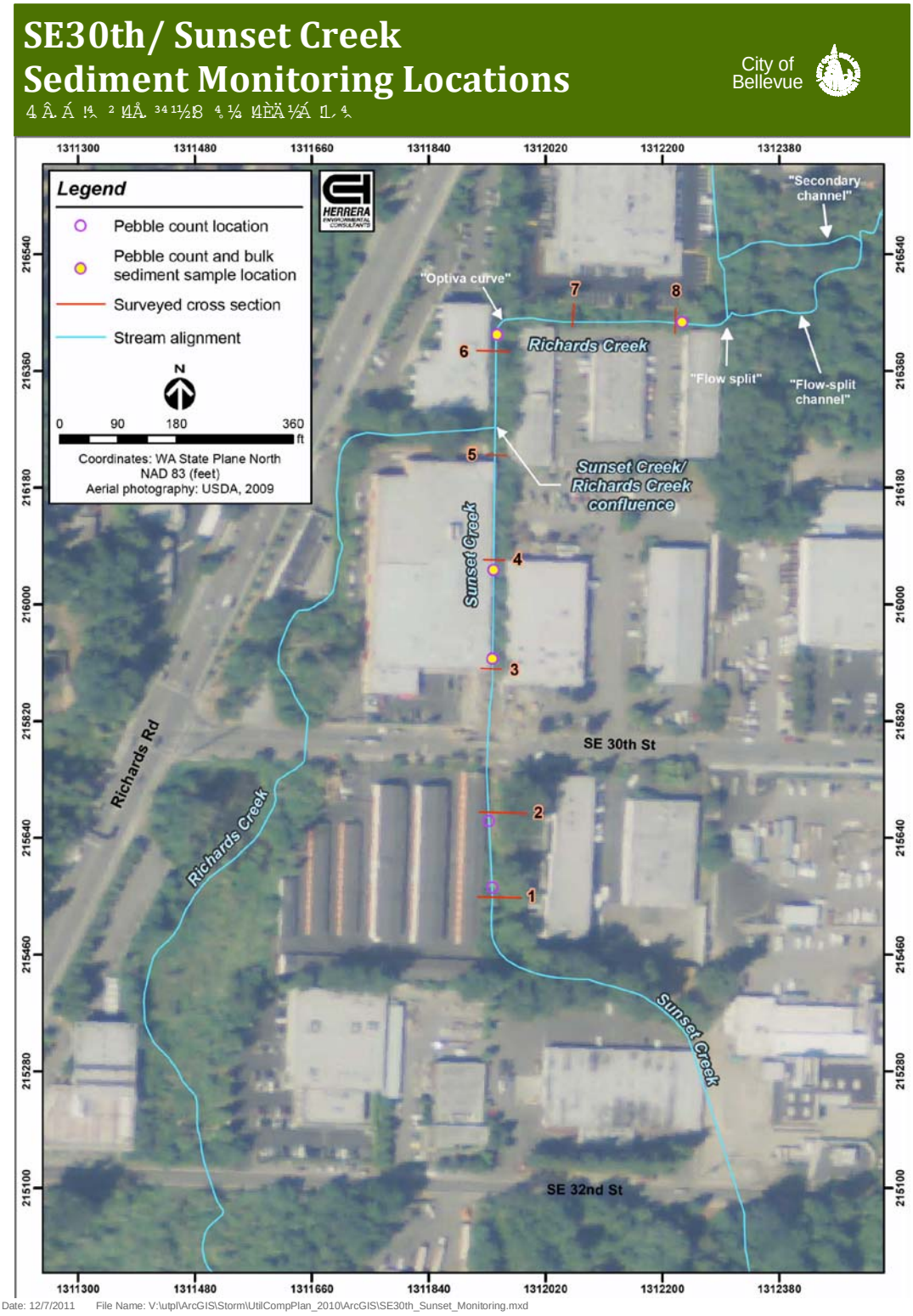


Figure B-9A. Sampling data taken in Sunset Creek.

Table B-9A. Table taken from the Sunset Creek and Richards Creek Channel Monitoring Report, Post-Construction / 2010 Conditions prepared by Herrera Environmental Consultants, dated December 2010.

A comparison of pre-project 2007, baseline, and post-construction / 2010 bulk sediment sample monitoring results according to the City of Bellevue's Monitoring Protocol standards (2009), 1 of 3.

Cross-section Location		% Finer than 0.85 mm			Condition		
Pre-project (2007)	Monitoring	Pre-project (2007)	Baseline (2009)	Post-con (2010)	Pre-project (2007)	Baseline (2009)	Post-con (2010)
SS-1	3	12.0	24.2	14.7	Good	Poor	Fair
SS-2	4	14.5	21.1	15.4	Fair	Poor	Fair
SS-3	6	18.5	19.8	13.5	Poor	Poor	Fair
SS-5	8	28.0	28.6	18.8	Poor	Poor	Poor

[a] Grain size condition is judged as:
Good is <12% finer than 0.85 mm (per Schuett-Hames et al. 1999)
Fair is 12 - 17% finer than 0.85 mm
Poor is >17% finer than 0.85 mm

Appendix B-10. 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 Adult Spawners	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

Hydrologic Monitoring

Table of Contents

Executive Summary

Hydrologic monitoring data are 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 operational needs of the Bellevue Utilities Department.

The Utilities Department currently operates 29 hydrologic monitoring gauges throughout the city. Ten regional detention facilities 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.

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; and
2. Continue partnerships with the U.S. Geological Survey (USGS) and King County to meet shared hydrologic monitoring needs.

There are outstanding gaps and opportunities to gain efficiency and effectiveness with operating and maintaining the monitoring network. The following recommendations will improve the effectiveness and efficiency of current activities:

3. Reevaluate the need for the Pinewood Apartment (PNW) staff gauge on Kelsey Creek if a volunteer is no longer available to monitor the gauge.
4. Conduct quality assurance/quality control reviews of data that are downloaded.
5. Create and post annual summarized rainfall data online for efficient public access.
6. Maintain and validate flow discharge measurements and rating curves at three stream gauging sites (CCF, KCF, and VCF) and one facility gauge site (133).
7. Upgrade the Coal Creek Flow (CCF) gauge at Newport Shores to connect to the Bellevue telemetry system for improved data accessibility for emergency response.
8. Re-activate the Valley Creek Flow (VCF) gauge telemetry system to provide greater operational capabilities for the Valley, Sears, and Overlake regional facilities.
9. Conduct a 2-year overflow study of the outlet gate settings for two regional facilities (197 and 179N) to evaluate non-structural approaches for solving downstream flooding.
10. Relocate the Richards Creek Flow (RCF) gauge to avoid backwater conditions.
11. Conduct and maintain storm event-stage relationship analyses for five chronic flooding sites.
12. Install a new, long-term manual download gauge at Vasa Creek near Lake Sammamish to improve information for basin planning, stormwater management, and project design.

If all proposed recommendations were implemented, hydrologic monitoring labor hours are estimated to require 301 hours per year (0.15 FTE). Additional one-time costs of recommendations are estimated to total $10,500 for gauge upgrade, replacement, and installation, and 55 hours per year for a 2-year regional facility overflow analysis (0.03 FTE).

1 Introduction

The Bellevue Utilities Department is responsible for coordinating the management of the storm and surface water system in the city. Bellevue's storm and surface water system consists of a combined network of public and private open streams, natural features, pipe systems, constructed drainage facilities, and lakes. Hydrologic monitoring activities are necessary to help the Utilities Department meet its storm and surface water mission, which is to control damage from storms, protect surface water quality, support fish and wildlife habitat, and protect the environment. Hydrologic monitoring provides essential data for operations and assessing the overall functioning of the storm and surface water system.

This hydrologic monitoring plan (Flow Plan) is a comprehensive analysis of the priorities and criteria for the gauge network; the existing hydrologic monitoring network; issues and gaps; and recommendations for improvement. This Flow Plan was developed following a 10-step iterative hydrologic monitoring review process established by the World Meteorological Organization (1994). A description of the review process is available in Attachment A.

The Flow Plan was developed with input from stakeholders within the Utilities Department and other partners. Stakeholders include Engineering Division staff involved with project design, planning, and development inspection, as well as Operations and Maintenance (O&M) staff involved with operating and maintaining the storm and surface water system. The Utilities Department is also partnered with the U.S. Geological Survey (USGS) and King County in response to the Water Resource Inventory Area 8 (WRIA 8) Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Recovery Program.

2 Flow Plan Purpose and Objectives

The purpose of this Flow Plan is to assess the existing hydrologic monitoring network, and to provide a comprehensive strategy for current and future hydrologic monitoring activities. Hydrologic monitoring is currently conducted by the Utilities Department on a widespread but informal basis. This Flow Plan is designed to establish a formal hydrologic monitoring program that can be used to guide stormwater management staff to perform hydrologic monitoring activities in an organized, coordinated, and systematic way.

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.

The Flow Plan is intended to provide staff with the necessary tools to evaluate the effectiveness of stormwater management activities for both long-term and short-term needs. A detailed discussion of the long-term and short-term needs for a hydrologic monitoring plan is provided in Attachment B.

3 Existing Hydrologic Monitoring Network

Bellevue's storm and surface water system consists of a network of public and private open streams, natural features, pipe systems, and constructed drainage facilities. The network covers 31 square miles, with 79 miles of open and piped stream length within the city limits. The original hydrologic gauge network was established in the late 1970s and early 1980s. The network has since evolved based on program and project needs, improved technology, and as available staffing and financial resources permitted.

The existing network of active and inactive gauges and their functions are described below. Rain gauges are included as part of the existing network of hydrologic monitoring activities. Other hydrologic monitoring activities include variably maintaining flow rating curves and conducting a quality assurance/quality control review on preliminary data for specific projects.

Active Gauges

There are 29 hydrologic monitoring gauges currently in operation in Bellevue (shown in Figure 3-1 and listed in Table 3-1). Of these, 10 regional detention facilities gauges, 6 stream gauges, and 2 lake gauges measure water levels, and 11 rain gauge stations measure precipitation.

In Table 3-1, gauge data collection equipment has evolved over time with advancements in technology or changes in available resources. The Coal Creek Flow (CCF) station, the Mercer Creek Flow (MCF) station, the Richards Creek Flow (RCF) station, and the Valley Creek Flow (VCF) station show two periods of data before and after gauge equipment was upgraded. For example, the CCF, RCF, and VCF gauges previously collected stage height by chart equipment. Currently, the data are collected by manual download from data loggers.

Regional Detention Facilities and Stream Gauges

The regional detention facility gauge stations and stream gauge stations measure stage height using continuous or instantaneous recording gauge equipment and data collection methods described below.

Telemetry-Bellevue Service Center

Ten regional detention facility gauges and one stream gauge (Kelsey Creek Flow [KCF]) are monitored and operated remotely by a continuous recording telemetry system from the Bellevue Service Center (BSC). The telemetry system automatically records the 'real time' stage heights for these stations every 15 minutes.

The supervisory control and data acquisition (SCADA) system includes an automated alarm system that alerts BSC staff when water levels meet or exceed pre-determined thresholds, acting as a flood warning alarm system.

The telemetry system at the Kelsey Creek Flow (KCF) gauge was re-activated in March 2011 after partnering with King County as part of the Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Recovery Program. The WRIA 8 Chinook Salmon Recovery Plan was adopted by the Bellevue City Council in 2005, and is funded from Bellevue and other local governments. The City agreed to collect telemetry stage height data while King County agreed to collect stream discharge data at the station. Together, these data can be used to develop a stage-discharge flow rating curve. King County agreed to create and maintain the KCF flow-rating curve for 3 years, beginning in 2011 to 2014. These data, along with data from other participating local governments, will be used by the WRIA 8 Chinook Salmon Recovery Program to evaluate the status and trends of salmon habitat in freshwater streams.

Telemetry - USGS

The stream gauge known as Mercer Creek Flow (MCF) gauge, located on lower Kelsey Creek beneath the Wilburton railroad trestle, is jointly funded by the USGS and City of Bellevue, and is solely operated and maintained by the USGS. This telemetry system automatically records discharge and stage, with a web interface that is updated hourly. The data are available on the USGS Real-Time Water Data for Washington website (referred to as USGS 12120000 MERCER CREEK by the USGS).

Manually Download

Three stream gauges (Valley Creek Flow [VCF], Coal Creek Flow [CCF], and Richards Creek Flow [RCF]) are equipped with data loggers that continuously record stage heights every 15 minutes. The battery-operated data loggers are capable of storing several months of data. Staff manually download data at these sites three or more times per year.

Staff Gauge

One stream gauge (Pinewood Apartments/148th Avenue NE [PNW]) is equipped with a staff gauge, which provides an instantaneous water level reading. A volunteer collects these data one to two times per week, and submits it to the City on a monthly basis.

Lakes Gauges

Bellevue has two lake gauges. The Lake Sammamish (LSAMM) gauge is maintained and operated by the USGS with funding support from the Cities of Bellevue, Sammamish, and Issaquah, and King County. The gauge is operated automatically using a telemetry system that reports lake water level data hourly, and is also available on the USGS Real-Time Water Data for Washington website (referred to as USGS 12122000 SAMMAMISH LAKE by the USGS).

The Phantom Lake (PLG) gauge is located on City-owned lakefront property at Heintze Point on Phantom Lake. The real-time gauge monitors water levels and reports the data via a telemetry connection port to the BSC. The data are used for operations with the water quality weir at the outlet.

Larsen Lake and the surrounding areas are owned by the City and used for recreation, wildlife, and as a regional detention facility. Water levels at Larsen Lake are monitored through the regional detention facility telemetry gauge station (No. 149) located at the flow control structure for Larsen Lake.

Rain Gauges

Eleven rain gauges measure precipitation throughout Bellevue. These gauges are monitored by the BSC telemetry system. The data for these gauges are updated every 15 minutes.

Inactive Gauges

Bellevue has 38 inactive gauges (shown in Figure 3-2 and listed in Table B.11-3-2): 30 stream gauges, 7 groundwater gauges, and 1 lake gauge all measured water levels. These gauges were de-activated for various reasons, whether there was a lack of resources to continue operations or the project need no longer existed. Table 3-2 identifies which gauges have equipment and housing remaining in place. Equipment was not removed to save costs associated with decommissioning the gauge and/or provide a cost-saving opportunity if the gauge were re-activated.

Flow Rating Curves

Flow rating curves graphically relate stage height data to a volume of water flowing in the stream (discharge) for a station. In order to maintain a flow rating curve, stream discharge measurements must be collected at a different stage height ranges to verify the correlation. Once established, a flow rating curve reduces or eliminates the need for stream discharge measurements to determine the volume of flow.

Currently, 13 active stream gauges have flow rating curves (see Table 3-1 for gauges). These rating curves are not regularly maintained or verified due to limited staffing resources. Rating curve data are stored electronically and updated per project need or as staff resources permit.

Data Quality Assurance/Quality Control

Hydrologic monitoring data are considered preliminary until a quality assurance/quality control (QA/QC) review of the data is conducted. Typically, this is done before the data are used for specific projects.

Hydrologic data from the two USGS-operated gauges (Mercer and Lake Sammamish) are QA/QC reviewed by the USGS annually. Final water reports for these gauges are available on the USGS website.

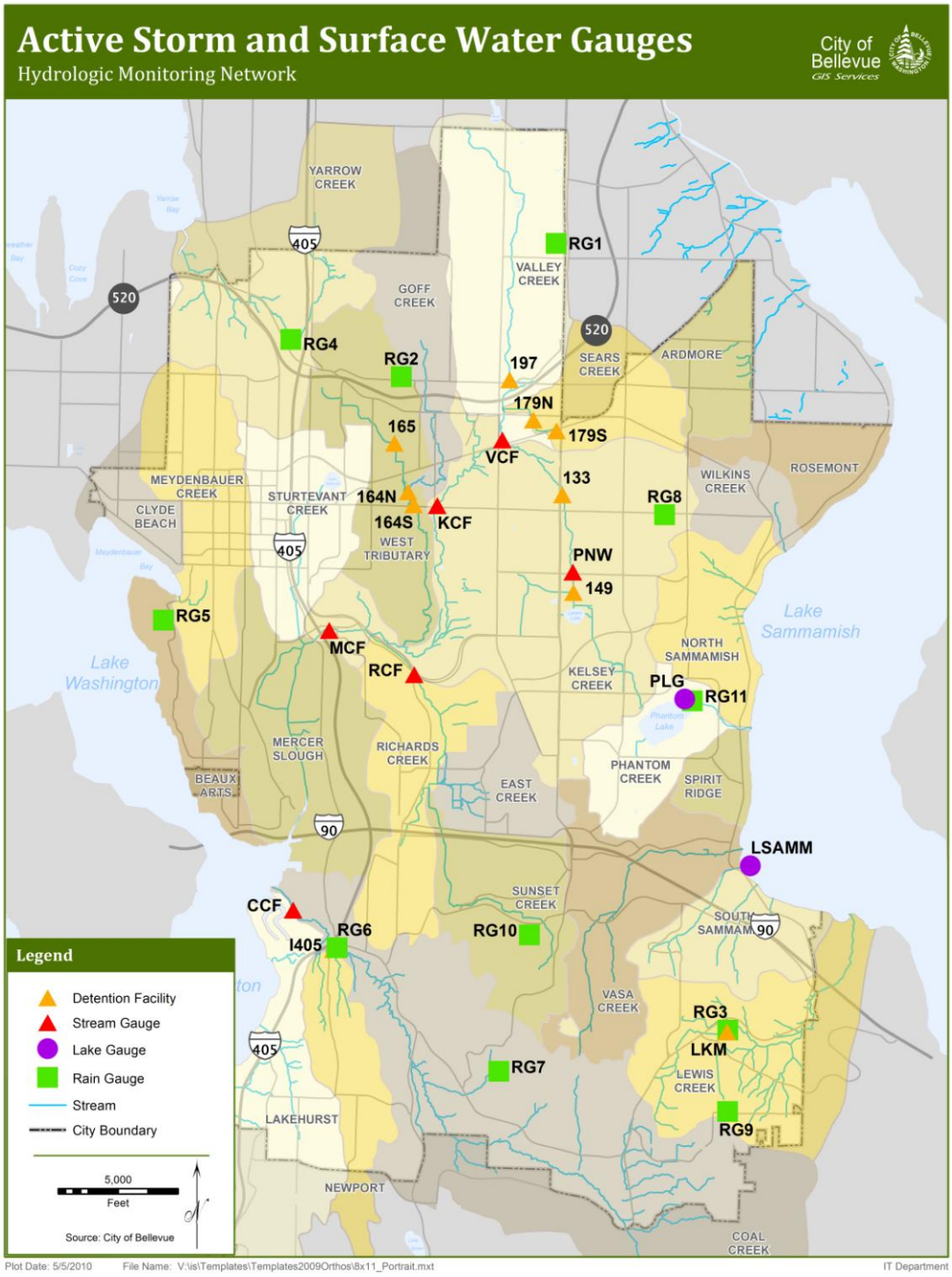


Figure B.11-3-1. Stream, facility, lake, and rain gauges in Bellevue that are actively in use as of December 2011.

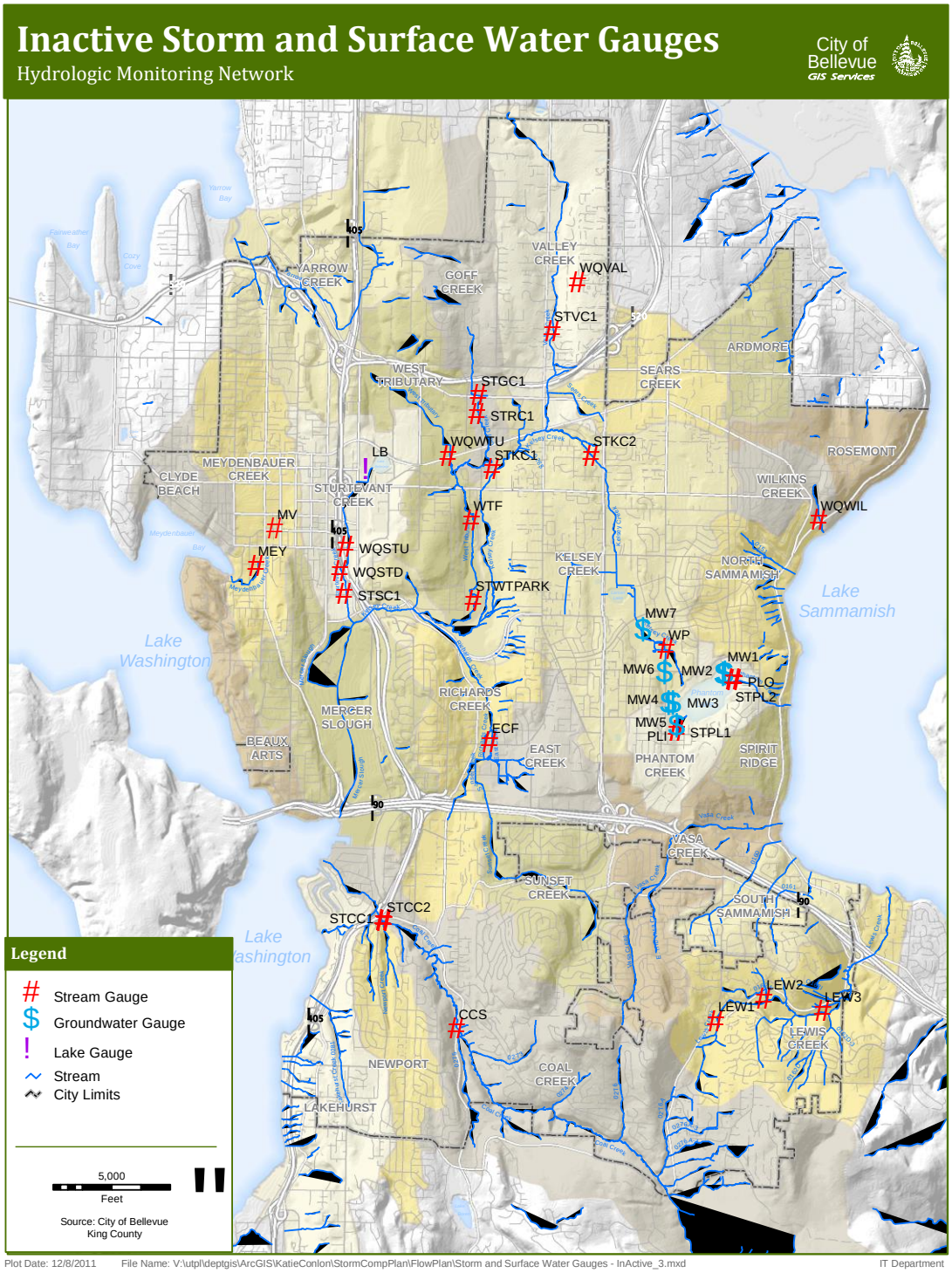


Figure B.11-3-2 Inactive hydrologic monitoring stations or gauge equipment in Bellevue as of December 2011.

Table B.11-3-1. Active Gauges in the Existing Hydrologic Monitoring Network

Basin	Station ID	Station Name(s)	Station Type	Gauge/ Equipment Type1	Data Collection2	Purpose				Period of Record		Flow Rating Curve Available
						Trend	Project	Operations	Effectiveness	Start	End	
Coal Creek	I405	I-405 Regional Detention Facility	Facility	DF	T	●	○	●	●	1998	Present	Yes
	CCF	Coal Creek Flow	Stream	SG	SC	●	○	●	●	1989	2003	--
					MD	●	○	●	●	2004	Present	Yes
	RG6	Coal Creek/ I-405 Regional Detention Facility	Rain	RG	T	●	○	●	●	1992	Present	--
	RG7	Forest Hills	Rain	RG	T	●	○	●	●	1992	Present	--
Goff Creek	RG2	Cherry Crest	Rain	RG	T	●	○	●	●	1992	Present	--
Kelsey Creek	133	Kelsey Creek/148th/Piano Ranch	Facility	DF	T	○	○	●	○	1988	Present	Yes
	149	Larsen Lake/Kmart	Facility	DF	T	○	○	●	○	1988	Present	Yes
	MCF	Mercer Creek Flow-Bellevue Historic Site	Stream	SG	SC	●	○	●	●	1989	2003	No
		Mercer Creek - USGS 12120000			T-USGS					1956	Present	Yes
	KCF	NE 8th/ Fucheck/Fish Ladder	Stream	SG	T	●	●	○	●	1988	1998	No
										2011	Present	Yes
	PNW	Pinewood Apartments	Stream	SF	S	○	○	●	○	1983	Present	No
	RG8	Crossroads	Rain	RG	T	●	○	●	●	1994	Present	--
Lewis Creek	LKM	Lakemont	Facility	DF	T	○	○	●	●	1992	Present	No
	RG3	Lakemont	Rain	RG	T	●	○	●	●	1992	Present	--
	RG9	Cougar Mt. #2	Rain	RG	T	●	○	●	●	1994	Present	--
Meydenbauer Creek	RG5	Meydenbauer	Rain	RG	T	●	○	●	●	1992	Present	--
Phantom Creek	PLG	Phantom Lake	Lake	LG	T	○	○	●	○	2000	Present	--
	RG11	Phantom Lake	Rain	RG	T	●	○	●	●	1996	Present	--
Richards Creek	RCF	Bannerwood Park/Pardee Lumber	Stream	SG	SC	●	○	○	●	1996	1998	Yes
					MD					2007	2012	No
		Richards Creek at LakeHills Connector			MD					2012	Present	No

Basin	Station ID	Station Name(s)	Station Type	Gauge/ Equipment Type1	Data Collection2	Purpose				Period of Record		Flow Rating Curve Available
						Trend	Project	Operations	Effectiveness	Start	End	
South Sammamish	LSAMM	Lake Sammamish – USGS 12122000	Lake	LG	T-USGS	●	○	●	●	1939	Present	--
Sears Creek	179N	Overlake/Sears Creek	Facility	DF	T	○	○	●	●	1988	Present	Yes
	179S	Commissioners	Facility	DF	T	○	○	●	●	1998	Present	No
Sunset Creek	RG10	Parksite	Rain	RG	T	●	○	●	●	1995	Present	--
Valley Creek	197	North Valley Creek/ Valley Creek/Henry Bacon	Facility	DF	T	○	○	●	●	1988	Present	Yes
	VCF	Valley Creek Flow	Stream	SG	SC	○	○	●	●	1988	2004	Yes
					MD	○	○	●	●	2007	Present	Yes
	RG1	NE 40th	Rain	RG	T	●	○	●	●	1992	Present	--
West Tributary	165	West Tributary/ Metro Base/Safeway	Facility	DF	T	○	○	●	●	1988	Present	Yes
	164N	Goff Creek/West Tributary Upstream	Facility	DF	T	○	○	●	●	1988	Present	Yes
	164S	LW Tributary/ NE 8th, West Tributary Down	Facility	DF	T	○	○	●	●	1988	Present	Yes
Yarrow Creek	RG4	BSC/Previously at MSC (1989)	Rain	RG	T	●	○	●	●	1980	Present	--

[1] Gauge/Equipment Type:
DF = Detention facility gauge
SG = Stream gauge
LG = Lake gauge
SF = Staff gauge
RG = Rain gauge

[2]Data Collection:
MD = Manual download
S = Site visit - Instantaneous readings only
T = Bellevue BSC Telemetry
T – USGS = Telemetry, in partnership with USGS

Table B.11-3-2. Historic hydrologic monitoring stations and equipment in Bellevue.
Note: These stations are currently inactive, or in some cases, the data collection equipment is retired.

Basin	Station ID	Station Type	Gauge/ Equipment Type1	Data Collection2	Period of Record		Housing Equipment Left in Place
					Start	End	
Coal Creek	CCS	Stream	SF	S	1995	2000	No
	STCC2	Stream	SF	S	1989	1992	No
	STCC1	Stream	SF	S	1989	1992	No
East Creek	ECF	Stream	SG	MD	2005	2010	Unknown
Goff Creek	STGC1	Stream	SF	S	1989	1993	No
Kelsey Creek	WP	Stream	SF	S	1995	1998 (est.)	Unknown
	STKC2	Stream	SF	S	1989	1993	No
	STKC1	Stream	SF	S	1989	1990	No
Lewis Creek	LEW1	Stream	SG	MD	1991	1995	No
	LEW2	Stream	SG	MD	1991	1995	No
	LEW3	Stream	SG	MD	1991	1995	Unknown
Meydenbauer Creek	MEY	Stream	SC	CH	1989	1996	Unknown
	MV	Stream	SG	MD	2006	2011	No
Phantom Creek	PLI	Stream	SC	CH	1989	2003	Yes
	PLO	Stream	SC	CH	1989	2003	Yes
	STPL2	Stream	SF	S	1988	1989	No
	STPL1	Stream	SF	S	1989	1989	No
	MW1	Groundwater	P	MD	1985	1986	Yes
	MW2	Groundwater	P	MD	1985	1986	Yes
	MW3	Groundwater	P	MD	1985	1986	Yes
	MW4	Groundwater	P	MD	1985	1986	Yes
	MW5	Groundwater	P	MD	1985	1986	Yes
	MW6	Groundwater	P	MD	1985	1986	Yes
	MW7	Groundwater	P	MD	1985	1986	Yes
Richards Creek	STRC1	Stream	SF	S	1988	1992	No
Sturtevant Creek	WQSTU	Stream	SG	CH	1989	1992	No
	WQSTD	Stream	SG	CH	1989	1992	No
	STSC1	Stream	SF	S	1988	1992	No
	LB	Lake	SF	S	2009	2011	Yes
Valley Creek	STVC1	Stream	SF	S	1988	1995	No
	WQVAL	Stream	SG	CH	1989	1992	No
West Tributary	WTF	Stream	SG	T	1988	1989	Yes
	STWTPark	Stream	SF	S	1993	1994	No
Wilkins Creek	WQWIL	Stream	SG	CH	1989	1992	No

[1]Gauge/Equipment Type:
SC = Strip Chart
SF= Staff Gauge
SG = Stream Gauge
P = Piezometer

[2]Data Collection:
CH = Chart
MD = Manual download
S = Site visit - Instantaneous readings only
T = Bellevue BSC Telemetry

4 Priorities and Criteria for Gauge Network

This Flow Plan evaluates and prioritizes the existing hydrologic monitoring gauge network using criteria that represent how the hydrologic data are used for stormwater management. Rain gauges and temporary, short-term gauges were not included in this evaluation. The current network of rain gauges is meeting staff needs. Temporary gauges are installed and removed based on specific project need.

Installation of new, long-term gauges for geographic coverage require additional consideration and recognition that they would need ongoing resources for equipment maintenance and labor. If representative hydrologic data are not available for a stream and/or drainage basin and the data are necessary for operations and planning purposes, a monitoring gauge may be warranted.

Removal of long-term gauges may be recommended based on the value of the data provided. If a long-term gauge is determined not to add value to the hydrologic monitoring network and no longer meets the needs of the Utilities Department, then removing the gauge may be warranted.

Six criteria were developed for evaluating the value of the City's existing long-term stream, facility, and lake monitoring gauges. Each gauge was subjectively scored from 1 to 5, lowest to highest in importance. Evaluation results are shown in Table 4-1. The following criteria and assumptions were made:

1. **Flood Response, Operations, and Flood Reporting:** Flooding poses potential risks to public and staff safety and personal property. O&M directly uses real-time gauge data for responding to flooding, operations, and flood reporting. Gauges used directly by O&M score highest (5). Other gauges, those not equipped to report real-time data, may be used by O&M for these purposes. Those gauges were given an intermediate score (3). All other gauges not used for flooding risks were scored with the lowest score (1).
2. **Multi-purpose:** Gauges with more than three purposes scored highest (5). Gauges with two purposes were moderately important (3), and gauges with only a single purpose scored low (1).
3. **Period of Record:** Gauges with a long period of record can be used for long-term trend and hydrologic variability analyses. Gauges with more than 20 years of record score the highest (5). Gauges with a period of record between 5 to 20 years are moderately important (3), and gauges with less than 5 years of record scored low (1).
4. **Partnerships:** Collaborating with other agencies on hydrologic monitoring needs is encouraged, where feasible. Coordinated partnerships are a more cost-effective use of limited hydrologic monitoring funds and staffing resources; thus, they score higher (5) than gauges funded solely by Bellevue (1).
5. **Type of Data Collection:** The type of data collection equipment and technology used may provide value and efficiencies for limited staff resources. Gauges with a telemetry system score highest (5), gauges that require manual downloads score moderately (3), and gauges with a staff gauge scored low (1).
6. **Opportunity to Increase Value:** The value of a gauge may be increased based on the opportunity to upgrade the gauge to telemetry (5), develop a rating curve (3), maintain an existing rating curve (1), or no additional opportunity exists (e.g., the USGS maintains the gauge and rating curve for MCF).

These criteria were further prioritized, by a weighted value, which were determined based on prioritization of categories to operational needs. Criteria scores were multiplied by the weighted value to determine a weighted score. Weighted scores were then totaled for each gauge, and sorted by the highest weighted score to lowest (shown in the last column in Table 4-1).

The results of the evaluation can be summarized as follows:

- The USGS partnered gauges at Kelsey Creek and Lake Sammamish rank highest among the existing network of facility, stream, and lake gauges. The result of the ranking supports current activities to contract with USGS for operating these gauges.
- The I-405 gauge ranks highest among facility gauges that report real-time data. This gauge is a vital gauge for O&M responding to flooding in the Newport Shores community and its other operations.
- The Coal Creek in-stream gauge (CCF) at Newport Shores ranks highest among gauges that are not equipped to report real-time data. This gauge ranks higher than two facility gauges (133 and 149), because it complements the I-405 gauge on Coal Creek for emergency response. This gauge would be more efficient and valuable if equipment was upgraded so that it can report real-time data (via a telemetry data-port connection) during rain events.

Table B.11-4-1. Hydrologic monitoring gauges (shown in order of importance based on evaluation).

Criterion weight	*Total:*	*100*		*30*		*25*		*17*		*13*		*10*		*5*	
Basin	**Station Type**	**Station ID**	**Flooding Response, Operations, Flood Reporting[1]**		**Multi-Purpose[2]**		**Period of Record[3]**		**Partnership[4]**		**Type of Gauge[5]**		**Opportunity to Increase Value[6]**		**Gauge Total Weighted Score by Rank**
			Score	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	
Mercer Slough	Stream	MCF	5	150	5	125	5	85	5	65	5	50	0	0	475
South Sammamish	Lake	LSAMM	3	90	5	125	5	85	5	65	5	50	0	0	415
Coal Creek	Facility	I405	5	150	5	125	3	51	1	13	5	50	1	5	394
Kelsey Creek	Stream	KCF	3	90	5	125	3	51	5	65	5	50	0	0	381
Sears Creek	Facility	179N	5	150	3	75	5	85	1	13	5	50	1	5	378
Sears Creek	Facility	179S	5	150	3	75	5	85	1	13	5	50	1	5	378
Valley Creek	Facility	197	5	150	3	75	5	85	1	13	5	50	1	5	378
West Tributary	Facility	165	5	150	3	75	5	85	1	13	5	50	1	5	378
West Tributary	Facility	164N	5	150	3	75	5	85	1	13	5	50	1	5	378
West Tributary	Facility	164S	5	150	3	75	5	85	1	13	5	50	1	5	378
Coal Creek	Stream	CCF	3	90	5	125	5	85	1	13	3	30	5	25	368
Lewis Creek	Facility	LKM	5	150	3	75	3	51	1	13	5	50	0	0	339
Kelsey Creek	Facility	133	5	150	1	25	5	85	1	13	5	50	1	5	328
Kelsey Creek	Facility	149	5	150	1	25	5	85	1	13	5	50	1	5	328
Valley Creek	Stream	VCF	3	90	3	75	5	85	1	13	3	30	5	25	318
Richards Creek	Stream	RCF	3	90	3	75	3	51	1	13	3	30	5	25	284
Phantom Creek	Lake	PLG	3	90	1	25	3	51	1	13	5	50	0	0	229
Kelsey Creek	Stream	PNW	1	30	1	25	5	85	5	65	1	10	0	0	215

Criterion Scoring:

Low to High Importance = 1 to 5

Not Applicable = 0

[1.] **Flooding Response, Operations, Flood Reporting (30%):**

(5) Regional facilities are directly used for flooding response, operations, and flood reporting.

(3) Gauge is indirectly used for this criterion.

(1) Gauge not used for this criterion.

[2.] **Multi-Purpose* (25%):**

(5) Three or more purposes

(3) Two purposes

(1) Single purpose

*Data for multi-purpose determined from Table 3-1.

[3.] **Period of Record (17%)**:

(5) More than 20 years of records

(3) Between 5 and 20 years of record

(1) Less than 5 years of record

[4.] **Partnership (13%)**:

(5) Shared costs (labor and/or financial assistance) with other agency

(1) Bellevue only

[5.] **Type of Gauge (10%):**

(5) Telemetry

(3) Manual download

(1) Staff gauge

[6.] **Opportunity to Increase Value (5%):**

(5) Upgrade to telemetry

(3) Develop rating curve

(1) Maintain rating curve

(0) No opportunity

5 Hydrologic Monitoring Network Issues and Gaps

Engineering and O&M staff identified several issues and gaps during this evaluation of Bellevue's hydrologic monitoring network. The issues and gaps identified include:

1. A QA/QC review of the data is not conducted on a consistent and systematic basis. The data are collected and stored electronically, but generally are not analyzed or reviewed for quality until needed for a specific project. This has resulted in duplication of efforts for multiple projects, and sometimes data quality problems are not found in a timely manner.
2. Public records requests (PRR) for rainfall data are frequently made by consultants, residents, and students. Because there is no systematic process to check the data as it is collected, efforts to fulfill the PRR can result in significant and duplicated efforts over time.
3. Flow rating curves are not regularly maintained and validated, which reduces the confidence in accuracy of the relationship between stage height and discharge data. For example, Richards Creek flow site (RCF) at Bannerwood Park is ineffective due to frequent backwater inundation as a result from downstream constraints (e.g., beaver dams).
4. Regional detention facility outlet gate settings are based on design recommendations, and most are functioning as expected by preventing downstream flooding. Based on field observations by O&M staff during storms in late 2010, two regional detention facilities (Station IDs 179N and 197) were frequently overflowing, posing flooding concerns downstream.
5. O&M staff have a number of chronic flooding sites to respond to during storm events. Developing a flood response time for flooding sites would provide valuable information for operations and planning purposes.
6. No data are available for any Bellevue salmon spawning streams that flow into Lake Sammamish. Vasa Creek is of particular concern because it flows through a steep ravine and is subject to erosion and sedimentation problems.
7. Some existing data are not being used because it is not accessible electronically. For example, some older stream stage height data were recorded and archived on paper charts. Converting these data to electronic format would be too costly, unless specifically requested.

6 Recommendations

Recommendations for increasing efficiency and effectiveness within the hydrologic monitoring network and activities include non-action and action items. Non-action recommendations do not have additional labor hours or costs associated. Action recommendations include an estimate of number of hours per year and/or associated cost.

Estimates include time for downloading data, data QA/QC, reporting, equipment repair, telemetry programming, maintenance, and calibration that are in addition to current monitoring activities. Where applicable, estimates are based on staff time spent in 2010. Estimates do not include time and costs required to set up or take down sites because very few new sites are proposed. New equipment costs will vary depending on equipment vendors, site access, and the availability of electricity and telephone utilities. Equipment costs for new gauge sites should therefore be considered planning estimates.

Non-action recommendations:

1. Continue to collect real-time rainfall and water level data at all gauges linked to Bellevue's BSC telemetry system. No additional cost or labor is required.
2. Continue to partner with USGS and King County to meet shared hydrologic monitoring needs. Where appropriate, seek opportunities for additional partnerships similar to these for additional cost savings and expertise. No additional cost or labor is required.
3. Re-evaluate the need for the Pinewood Apartments (PNW) gauge on Kelsey Creek if a volunteer is no longer available to monitor the gauge. No additional cost/labor required.

Action recommendations:

4. Conduct a systematic QA/QC review of data per download transmittal. This includes rainfall data, manual downloaded stream gauges, and BSC telemetry gauges.
    a. Rainfall data are currently collected from the BSC telemetry each month. An estimated 22 hours per year would be required to QA/QC these data.
    b. Data are collected from manual downloaded stream gauges about five times a year. Fifteen hours per year would be needed to QA/QC these data.
    c. Bellevue BSC telemetry gauge data are not downloaded regularly. Downloading the data monthly along with rainfall data, plus conducting a QA/QC of the data, would require an estimated 90 hours per year.
5. Create an annual summary report for rainfall data and post on the Utilities Department's website for public use. This would reduce the time spent responding to data requests. An estimated 16 hours per year will be required to complete this task.
6. Maintain and validate flow rating curves at three stream gauging sites (CCF, KCF, and VCF) and one facility gauge (133) on an annual basis. Use flow rating curves to create tables and charts of stream discharge rates, and generate summary statistics annually. Maintaining the flow rating curves would validate the accuracy in the data, and increase efficiency and cost-effectiveness for the department. An estimated 48 hours per year would be required to maintain, validate, and summarize rating curve data.
7. Upgrade the stream gauge equipment at the Coal Creek Flow (CCF) from manual download equipment to the BSC telemetry system to help O&M staff respond to flooding emergencies and reduce potential loss of data from undetected equipment failure. Upgrading the gauge equipment is estimated to cost $5,000. Equipment stand and housing is currently in place. Costs associated reflect a one-time installation cost for a probe, electricity, and telephone line. Labor hours associated with data download transmittal and data QA/QC are estimated at 28 hours per year.
8. Re-activate the BSC telemetry system and maintain the flow rating curve at Valley Creek Flow (VCF), near the confluence with Kelsey Creek, in order to monitor system response from regional facilities 197, 179N, and 179S located upstream. Reactivating the telemetry connection would require an estimated 10 hours per year for data download transmittal and QA/QC.
9. Conduct a short-term (approximately 2 years) analysis to determine if changing the outlet gate settings would reduce flooding at Valley Creek at NE 21st Street and the Sears Creek Overlake regional detention facilities. The analysis would require monitoring at two facility gauges (179N and 197) and one downstream gauge (VCF), and developing two short-term flow rating curves for the facilities. Modify operation plans based on results of the analysis. The labor associated with this study is estimated at 55 hours per year for 2 years.
10. Relocate Richards Creek Flow (RCF) station at Bannerwood Park to a site not influenced by beaver activity. Potential new locations are upstream at Kamber Road on the upstream side of

the culvert or at the intersection of Richards Road and Lake Hills Connector. Costs are estimated at $3,000 for demolition of the existing gauge and relocation of the new gauge. Costs do not include permitting fees.

11. Conduct a storm event-stage response analysis at five chronic flooding sites, including Richards Creek at Kamber Road, Valley Creek at NE 21st Street, Larsen Lake at 148th Avenue, Kelsey Creek near SE 7th Street and Lake Hills Connector, and Coal Creek at Newport Shores. Analyze the relationship between the 24-hour rain event, antecedent conditions, and the extent of flooding. The analysis was calculated for Coal Creek between the I-405 gauge and the gauge at Newport Shores in December 2010 at O&M's request. This analysis provided a flood response time for crews. The analysis and maintaining the relational data for these sites would require an approximately 10 hours per year.
12. Add a new, long-term manual download flow station on Vasa Creek near West Lake Sammamish Parkway to meet multi-purpose objectives identified within the basin needs discussion (planning, stormwater management, and CIP). This small stream on the east side of Bellevue flows into Lake Sammamish. It is in a steep ravine and is subject to erosion and sedimentation issues. Gauges are not recommended for similar streams that drain to Lake Sammamish (Ardmore or Wilkins) because they do not have spawning kokanee, and projects to stabilize them have already been completed. Adding this gauge is estimated to cost $2,500 for installation (not including permitting fees) and an estimated 15 hours per year for data download and QA/QC.

If all proposed recommendations were implemented, hydrologic monitoring labor hours are estimated at 301 hours per year (0.15 FTE). Additional one-time costs are estimated to total $10,500 for gauge equipment upgrade and/or replacement, and installation. The estimate for the 2-year overflow study is 55 hours per year (0.03 FTE).

7 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.

8 References

World Meteorological Organization. 1994. Guide to Hydrological Practices—Data Acquisitions and Processing, Analysis, Forecasting and Processing. *In*: Chapter 20 *Design and Evaluation of Hydrological Networks*.

Attachment A. World Meteorological Organization's Process for Conducting a Hydrologic Network Review and Redesign

The World Meteorological Organization (1994) lays out a 10-step iterative process for conducting a review and/or redesign of an existing hydrological network. The Utilities Department is generally following a similar process for this review of the hydrologic monitoring system. A short description of each step and how it pertains to Bellevue stream gauging needs follows.

Institutional Set-up

The various stakeholders from the Engineering and Operations and Maintenance Divisions and any potential partner organizations and regulatory requirements should be identified. NPDES requirements are currently being defined by a regional monitoring consortium in which Bellevue participates.

Purposes of the Network

The purposes of the network in terms of users and uses of the data should be identified. Data users and uses can vary temporally and spatially. Debate must occur with the stakeholders to ensure the purposes for the existing network gauges are still valid. For Bellevue to develop a plan, present-day needs and purposes for the gauge network must be discussed so that an appropriate network design can be proposed for approval.

Objectives of the Networks

Based upon the purposes established above, a set of objectives can be established in terms of the information required. An indication of the consequences of not being able to provide this information should be documented.

Establish Priorities

Priorities among objectives should be identified. Priorities will change over time, and some stations or needs will be short term. Current priorities should be assessed, and a plan for revisiting these priorities should be created, possibly aligned with the budget and work planning cycle.

Assess Existing Networks

Existing networks will be tabulated and assessed, and a determination made of the adequacy to meet current objectives.

Network Design

Depending upon the available information and the reviewed objectives, a proposal with options to meet these objectives will be prepared.

According to the World Meteorological Organization, the design of a hydrologic network answers the following questions pertaining to the collection of hydrologic data:

1. What hydrologic variables need to be observed?
2. Where do they need to be observed?
3. How often do they need to be observed?
4. What is the duration of the observation program?
5. How accurate should the observations be?

Technical criteria used to choose a particular site will include:

- Accessibility—The station should be accessible during all weather conditions, particularly during floods.
- Adequacy—The station must be able to measure the full range of flows.
- Stability—The stage-discharge relationship must be stable or with little variation over time, otherwise regular verification measurements should be made.
- Permanency—For long-term stations, the station must remain undisturbed.

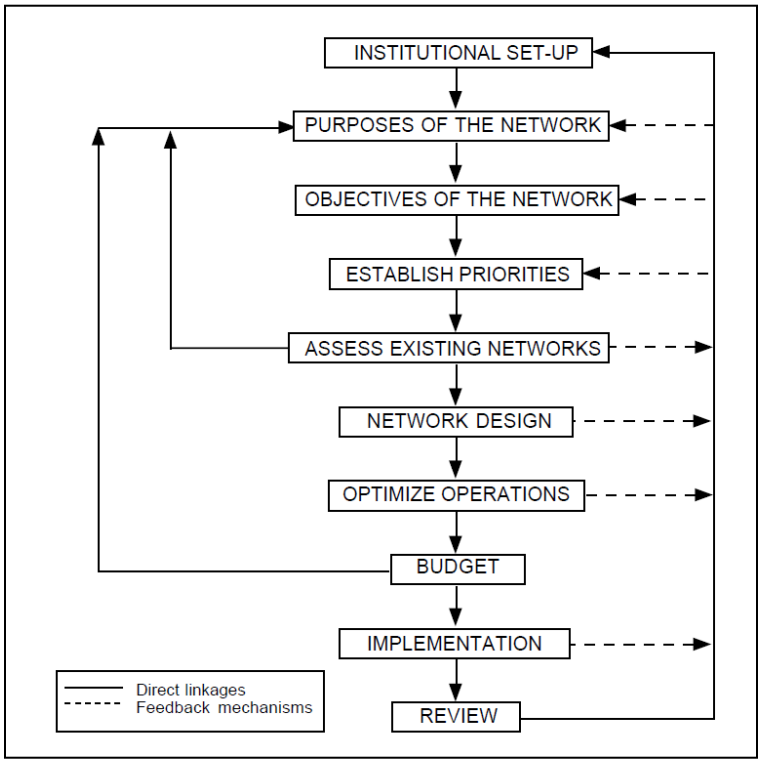


Figure A-1. A framework for network analysis and redesign of a hydrologic monitoring program (World Meteorological Organization 1994).

Operations

An optimization process will be conducted to minimize the cost of the data collection. This includes strategically locating monitoring stations to meet multiple needs, and partnering with other organizations when possible.

Determine Costs

The cost to implement the recommended network will be estimated, and operational costs will be determined separately (e.g., maintaining rating curves). Estimated costs will be compared to the current budget. If the budget is too low, the plan will investigate additional funding approaches or reduced monitoring.

Implementation

The redesigned network will be implemented. If a phased approach is required, both short- and long-term plans may be developed.

Review Networks

Reviews will occur in the future to make sure the plan is working. These reviews should occur in the off-budget year so that if changes are necessary, the redesigned network can be implemented in the next budget.

Attachment B. Business Case in Support of a Hydrologic Monitoring Plan

Long-Term Needs

Long-term hydrologic monitoring generally requires a record of several decades, depending on the objective. Long-term data can provide information on hydrologic variability and the overall condition of the storm and surface water system; changes in the system due to land use and natural storm events; and information for flood frequency and forecast modeling.

The Utilities Department uses long-term data for purposes that include planning, operations, stormwater evaluation and effectiveness, trend analysis, and education and outreach needs.

Planning

Flood prediction statistics are used for storm response and for studies in basins prone to flooding. This includes determining the frequency and intensity of rain events and correlating those events to discharge rates that result in street or structural flooding. Such information can help Operations and Maintenance staff plan for flood response, including issuing warnings, distributing sand bags and pumps, and closing streets. Planning to resolve recurring erosion, flooding, or sedimentation issues also requires long-term flow and precipitation records. Planning efforts that require hydrologic monitoring data include:

- Basin studies;
- Identifying basins to target for specific stormwater management programs, e.g., low impact development opportunities;
- Flood prevention and drainage system capacity analysis;
- Floodplain mapping;
- CIP projects;
- Emergency storm response; and
- Climate change impacts.

Operations

Operating the City's storm and surface water system requires ongoing, real-time data as well as periodic short-term, intensive monitoring that lead to improved operations. Regional stormwater facilities such as regional detention facilities, sand filters, and other facilities with gates or weirs require ongoing data collected by telemetry to efficiently verify that the system is operating as designed, and to check system status remotely during storm events. Periodically, long-term data may be used to verify effectiveness or determine when to make adjustments to reduce flooding and/or improve water quality conditions.

Stormwater Management Evaluation and Program Effectiveness

Hydrologic monitoring is used to assess the long-term effectiveness of stormwater management practices. Stormwater management practices include on-site detention or infiltration of water, regional detention facilities, and water quality treatment facilities designed to reduce the speed, quantity and duration of stormwater runoff and associated pollutants. Effectiveness can be evaluated by using hydrologic measurements, including direct measurements of stream flows in response to storms and during base flow conditions, as a surrogate to indicate the condition of physical, water quality, and biological systems.

Hydrologic flow monitoring is critical for water quality analysis because the amount and concentration of pollutants are dependent on the amount of flow. The next NPDES Phase II Municipal Stormwater Permit (2012–2017) will require Bellevue to participate in regional storm and surface water quality and quantity monitoring. These new regional monitoring requirements and implementation options are currently under development. Local monitoring can both contribute to and benefit from the effort.

Biological indicators of stream health, such as fish and benthic macroinvertebrates, are dependent on seasonally appropriate flow regimes. The relationship between flow monitoring and ecological indicators can be used to help stormwater managers evaluate basin issues and needs, prioritize and sequence programs, and determine program success. Long-term hydrologic monitoring is useful to interpret how biological indicators are responding to stormwater management activities.

In addition, the Utilities Department may, as part of an adaptive management program, evaluate various low impact development techniques to determine which are most effective for managing stormwater. Both long- and short-term hydrologic monitoring may be required for evaluating the effectiveness of these techniques. The Utilities Department will coordinate with regional efforts to avoid duplication of effort.

Long-Term Trends and Climate Change

Long-term rainfall and stream discharge records will be useful to determine the effects of climate change. Climate change research suggests that given the uncertainties, it is premature for resource managers to make changes to stormwater design standards, but recommend building resiliency into the stormwater system. Changes in precipitation patterns may in turn alter the flow regimes and capacity thresholds of Bellevue's storm and surface water system. Multiple monitored sites with long-term records would be useful for comparing trends between drainage basins; targeting areas for projects to address runoff capacity, flooding, or habitat; and modifying operations. This information, linked with regional efforts, will help inform future stormwater management approaches.

Education and Outreach

Long-term stream flow, precipitation, and various hydrologic summary statistics are presented in the Utilities Department's Basin Fact Sheets, which are used by students, teachers, interested citizens, consultants, and staff. The Basin Fact Sheets are available in Appendix B-1 of the Storm and Surface Water System Plan and on the City's website.

Short-Term Needs

Short-term hydrologic monitoring generally involves a period of record of less than 5 years. Short-term monitoring may be conducted at permanent or temporary gauges. The need for short-term monitoring is determined on a project-by-project basis. Occasional special projects may require that discharge and/or precipitation data be collected over short time periods. Once a project is completed, short-term monitoring systems may be discontinued or moved to address another need.

The Utilities Department uses short-term hydrologic data for purposes that include operations, stormwater evaluation and effectiveness, CIP design and evaluation, and customer request needs.

Operations

In some cases Operations and Maintenance require intensive, short-term monitoring for adjusting the operations of regional facilities. The regional detention facilities have adjustable outlets, which can be changed to modify the amount of storm and surface water detained to prevent downstream flooding during high flows or to help sufficient flow to support fish during summer months. In many cases the outlet structure settings were designed to contain the 100-year, 24-hour rain event, and the facility performs well without adjustments. In other cases, regional detention facility water levels may need to be

adjusted seasonally or periodically to compensate for storage limitations such as sedimentation or other changes.

Some gauges are used to guide staff for when stream water levels are safe to perform in-stream fieldwork. For instance, prior to conducting in-stream activities, staff will check the USGS Mercer Creek stream gauge to determine if stream flow is too high to safely walk and work in the streams.

Stormwater Management Evaluation and Effectiveness

In addition, the Utilities Department may, as part of an adaptive management program, evaluate various low impact development techniques to determine which are most effective for managing stormwater. Both long- and short-term hydrologic monitoring may be required for evaluating the effectiveness of these techniques. The Utilities Department will coordinate with regional efforts to avoid duplication of effort.

Capital Investment Program Design and Evaluation

The Utilities Department's Storm and Surface Water CIP represents a significant investment of resources for infrastructure repair and replacement, habitat improvements, flood control, water quality, and meeting regulatory requirements, settlement and easement agreements, and court orders. Projects are prioritized and constructed based on criteria specific to each program. In addition to the long-term data and modeling information, the CIP also includes short term, one-time projects with specific objectives.

Short-term flow monitoring can provide calibration and verification data for the hydrologic and hydraulic computer models that are used to identify solutions and properly size each project, thus making the CIP and investments more effective and the system more efficient in the long term.

Customer Requests

The Utilities Department will provide collected hydrologic monitoring data to customers, internal and external to the City, upon request. Customers include consultants, agencies, institutions, and residents. Consultants periodically request hydrologic data, including precipitation and discharge rates, for engineering design and hydrologic modeling calibration for both private and public contracts. Customer requests include both long-term and short-term data ranges.

Appendix B-12. 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-13. 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).

Land Use Type	% Impervious	Site	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)	
			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-13, continued.

Site	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)	
	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-13A. 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-14. 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.